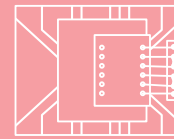
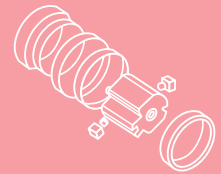


# CORE TECHNOLOGIES 2022

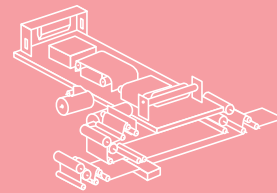
## KOREA INSTITUTE OF MACHINERY & MATERIALS



Ultra-Thin Flexible Semiconductor  
Package Interconnection and 3D  
Stacking Technology



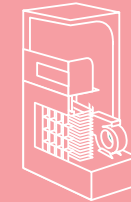
High Resolution Dispenser  
for Fine Powder of Particle  
Size 10  $\mu\text{m}$



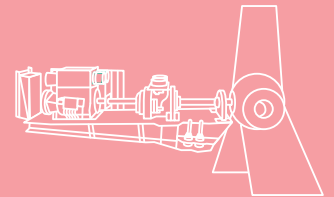
Precise Roll-to-Roll Reverse  
Offset Printing Technology



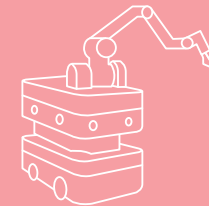
High-Efficiency Hydraulic  
Turbine Technology



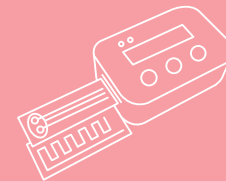
Filter-Free Large-Area  
Indoor Air Purifying  
Technology



Mechanical System Status  
Monitoring and Failure  
Diagnosis Technology



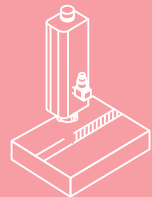
Mobile Autonomous Operating  
Machinery Technology



Biosignal Detection Sensor  
and Control Technology



Knee-Type Robot Prosthetic  
Leg Technology



Surface Hardening and  
Homogenization Technology for  
Metallic Materials Using High-  
Power Diode Laser

# CORE TECHNOLOGIES 2022

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**KOREA  
INSTITUTE OF  
MACHINERY &  
MATERIALS**



CONTENTS

Department of  
Ultra-Precision  
Machines and  
Systems

- 018**
- Built-In Type Vision Measuring Tool for Autonomous Setting of Initial Machining-Origin
- 020**
- Active Vibration-Control Device for Precise Boring of a Deep Hole for Large Integral Structure
- 022**
- A Core Technology for Fine Metal Formation Targeting for Flexible/Stretchable Device and Display
- 024**
- Automated CAE Analysis to Evaluate the Structural Rigidity and Motion Performances of Mechanical Systems
- 026**
- Micro Milling-Applied Surface Texturing Module Technology
- 028**
- Tool Holder Using Shape Memory Alloy and Tool Holding Method
- 030**
- Active Tool Technology for High-Speed Micro-Patterning Inside Cylinders
- 032**
- Capsule Type Reconfigurable Multifunctional Machine Tool
- 034**
- Ultra-thin Flexible Semiconductor Package Interconnection and 3D Stack Technology
- 036**
- Build-up/Bump-less Ultra-thin Wafer Stacking Technology without Carrier Wafer

Department of  
Laser &  
Electron Beam  
Technologies

- 038**
- Manufacturing Technology for Board Type Flexible Fine Die Allowing Precise Patterning and Thermal Deformation Prevention
- 040**
- 5-Axis Mechanical Machining System and 3-Axis Scanner Connection Technology
- 042**
- Laser Machining Device with Focus Measuring Function
- 044**
- High-Speed Large-Area Micro Patterning Technology Using Pulse Laser Intervention
- 046**
- Long-distance Night Monitoring System Technology Using Pulse Laser Lighting
- 048**
- Laser High Aspect Ratio Drilling Technology Using Tilt Angle Control Optic (Hole Depth: 5mm or less, Hole Diameter: over 10μm)
- 050**
- Real-Time Production Facility Information Collection System
- 052**
- Laser Patterning Technology for Microelectrode Fabrication on Various Surfaces
- 054**
- Scanner-Stage On-the-Fly System for Continuous Laser Process on Large Area
- 056**
- Electron Microscope with Moving Chamber
- 058**
- Multi-beam Technology for Improving Laser Machining Speed and Efficiency of Transparent Substrates
- 060**
- Micro Part Manufacturing Technology with Laser Glass Direct Bonding and Laser-induced Selective Etching

Department of  
Robotics and  
Mechatronics

- 062**
- Wearable Walking Assist Device
- 064**
- Anthropomorphic Robot Hand
- 066**
- Smart Safety Cover
- 068**
- Hollow Driving Module Technology for Slim Robot Arm
- 070**
- Gripper for Assembly and Assembling Technology Applicable for Wide Use Industrial Robot
- 072**
- Counterbalance Robot Arm for Human-Robot Safety
- 074**
- High Payload Dual Arm Robot with Detachable Forearm Module for Performing Multipurpose Duties
- 076**
- Smart Robot Teaching Device
- 078**
- Harmonic Reducer Design/Analysis Technology
- 080**
- Clamp-Type Omnipotent Gripper
- 082**
- Suction-Type Omnipotent Gripper
- 084**
- Independent Activity Supporting Robot for Those with Lower Extremity Disability
- 086**
- Compliant, Light-Weight, High-Power, High-Contraction, Fabric muscle and Clothing-Type Wearable Robot Technology
- 088**
- Dual Arm Robot Controller
- 090**
- Module-based Robot Software Technology (Optimal Combination Search, Inverse Kinematics Auto-generation, Automatic Gain Tuning)
- 092**
- Metal Mesh Foil Air Dynamic Pressure Bearing
- 094**
- Ultrahigh-speed High-precision Magnetic Bearing Technology
- 096**
- Electronic Pipe Scale Removing Device and Corrosion Prevention Device
- 098**
- Nanoparticle Manufacturing Device
- 100**
- Air Cushion Device Technology for Safely Handling Heavy Weight Object
- 102**
- Induction Heating Technology
- 104**
- Hot Embossing Apparatus for Large Surface using Hybrid Roll
- 106**
- Ozone Generator Technology with High-Efficiency and High-Concentration Characteristics

Department of  
3D Printing

- 108**
- High Resolution Dispenser for Fine Powder of Particle Size 10μm
- 110**
- Hybrid PBF Printing Technology with Powder Removal Device

2.

Nano-  
Convergence  
Manufacturing  
Systems  
Research  
Division

Department of Nano-Manufacturing Technology	114	Low-Temperature Ultra-Thin Film Coating Technology for Nanostructure Fabrication and Surface Functionalization
	116	Mass Manufacturing Micro-Channel Device Technology for On-Site Diagnosis
	118	Liquid Transfer Imprint Lithography (LTIL) Typed Continuous Nanoimprint Lithography Technology
	120	UV/Thermal Composite Nano-Patterning Equipment technology With Ultrafine Shape Patterning
	122	Laser Direct Lithography System and Nano-/Micro-Structure Fabricaion Technology
	124	Various Apparatus for Cell and Particle Separation and Its Method
	126	Smart Shoes for Both the Disabled and the Non-Disabled
	128	Femtosecond Laser-Based Heat Treatment Technology
	130	Micropatterned mold core Ultra-precision machining technology
	132	AMOLED TV Non-Thermal Repair Technology
	134	Transparent Material (Sapphire, Slass) Cutting Technology Using a Hibrid Ultra-Short Pulse Laser System Integrated With a Vibrator
Department of Nano-Mechanics	136	Roll Transfer Technology for Manufacturing Micro/Mini-LED Displays
	138	Omnitex Device Manufacturing Process Equipment Technology
	140	Thin-Film Thermoelectric Energy Conversion Module
	142	Hybrid Solar Energy Power Generation System
Department of Printed Electronics	144	Flexible OLED Roll-to-Roll Deposition System Technology
	146	Eco-Friendly, Ultra-Fast Patterning Technology for Highly Flexible Functional Electrode
	148	High-Speed Roll-to-Roll Printing Technology for Manufacturing Electronics Devices
	150	Precise Roll-to-Roll Reverse Offset Printing Technology
	152	High-speed Closed Loop Linear Motor Track
	154	High-Performance Supercapacitor Manufacturing Technology Using Cross-Linkable Polymer Binder
	156	Heating Sheet Using Printed Electrode (Heating sheet)
	158	Thermal-Roll Imprinting System and Process Technology
	160	Transparent Electrode and Transparent Electrode Film Manufacturing Technology
Department of Nature-Inspired Systems and Application	162	Anti-Reflective & Water-Repellent Colored Glass
	164	High Performance Dehumidification Apparatus (Dehumidifier) Significantly Reducing Power Consumption With Functional Surface
	166	Flexible Pressure/Tactile Sensing Technology
	168	Water-Repellent/Self-Cleaning Technology Based on Superhydrophobicity
	170	Anti-Reflection in Visible Light Range and IR Filter Technology
	172	PDO (Polydioxanone) Dental Barrier Membrane
	174	3D Bio-Printing System Technology
	176	Nanofiber Web Measurement and Assessment Technology
	178	MEMS Microphone and Manufacturing Method

3.

Energy Systems  
Research  
Division

Department of Energy Conversion Systems	182	Stirling Cryocooler
	184	High-Performance Compressor/Blower Technology
	186	Pulse Tube Cryocooler
	188	Pump Development Technology
	190	High-Efficiency Hydraulic Turbine Technology
	192	Cryogenic Cooling System Design Technology
	194	High-Performance Turbine Technology
Department of Thermal Systems	196	Joule-Thompson Cryocooler
	198	Low GWP Refrigerant Heat Pump Technology
	200	Membrane Heat Pump Technology
	202	Ultrasonic Generation and Cleaning Technology
	204	Ultrasonic Machining System for Surface Reformation and Milling Process
	206	Thermal Storage Heating and Cooling System Technology
	208	Pressure Sensor Using Contact-Resistance Change
	210	High-Temperature Steam Heat Pump Technology
	212	Wet Electrostatic Precipitator Applied Heat Pump Technology
	214	Polymer Heat Exchanger Technology
	216	PCHE (Printed Circuit Heat Exchanger) Technology
	218	Disc Shape Control Technology for High-Differential Pressure Control Valve for Offshore Plant
	220	Ground System for CO <sub>2</sub> Geological Sequestration
	222	Plate Heat Exchanger Technology
	224	2D Heat Flux Gauge Block
	226	Gas Hydrate Resistant Inline Heater
	228	Thermal Storage Material and Thermal Storage System for High Temperature Heat Storage
	230	Gondola Robot (WallBot) Design Technology for Tall Plant's Vertical Outer Wall
	232	Needle-Free Injection Syringe Design Technology
Department of Plant Technology	234	High Viscosity Liquid Jet Dispensing Head Design Technology
	236	Multidirectional Tennis Simulator Technology
	238	Underwater Breathing Apparatus Using Dissolved Oxygens
	240	Cooling System for Thick Plate or Steel Plate
	242	Seawater Desalination System with Small and Medium Capacity Using Solar Energy
LNG and Cryogenic Technology Center	244	Test Equipment to Evaluate the Performance and Durability of LNG Cryogenic Equipment and Related Systems

4.

Environment  
System  
Research  
Division

Department of Environmental Machinery	248	Coal Combustion System Including Pulverizer
	250	Simultaneous Flue Gas Condensing and Sulfur Oxides Removal
	252	Diesel Particulate Filter Using Metallic Filter Combined with Electrostatic Agglomerator
	254	Filter-Free Indoor Air Purification Technology
	256	Simultaneous Reduction of Harmful Gas and Ultrafine particulate matters
	258	Oil Mist Eliminator
	260	Micro Bubble Generation Technology and Its Devices
	262	Low Pollution Combustion Technology Using High Temperature FGR With a Nozzle With the Coanda Effect
	264	Intelligent Nitrogen Oxide Control Technology Using Multi-Stage Combustion Gas Recirculation
	266	Indoor Electrostatic Air Cleaning System Using Carbon Fiber Ionization Process
Department of Clean Fuel & Power Generation	268	Gas Turbine Combined Cycle Performance Analysis Technology
	270	Low-NOx Combustor Design by Using Laser Diagnostics Techniques
	272	High-Efficiency Hybrid Power Generation System Integrating Fuel Cell and Internal Combustion Engine
	274	Power Generation System that Minimizes the Decrease in Efficiency using Oxyfuel Combustion Technology
	276	Gas Fuel-Based Integrated Greenhouse Energy System Technology (TRI-GEN System)
	278	Biocrude-oil Production System
Department of Engine Research	280	Engine Waste Heat Recovery Generation System
	282	System Configuration and Operation Method of Supercritical CO <sub>2</sub> Power Cycle with Improved Exergetic Efficiency Using Both High-Temperature Heat Source and Low-Temperature Heat Source
	284	Solid Ammonium SCR System for NOx Reduction in Diesel Engine
	286	Urea SCR System Technology for Diesel Engine NOx Reduction
	288	Hydrogen-Natural Gas Blending Fuel (HCNG) Engine for City Bus Complying with Post EURO-6
	290	High-Efficiency Direct Injection Type Ultra Lean LPG Engine
	292	High Flow Rate Methane-Based Gas Fuel Injection Valve
Department of Plasma Engineering	294	Remote Plasma Generator
	296	Regeneration Technique of Diesel Particulate Filter Using Plasma Burner
	298	Flow Controller with Enhanced Flow Control Property
	300	Plasma Combustor with Low-NOx Generation
	302	VOC and Low-Concentration Contaminants Removal Technology

5.

Mechanical  
Systems Safety  
Research  
Division

Department of System Dynamics	306	Ship Noise/Vibration/Shock and Survivability Improvement Design Technology
	308	AI-based Predictive Diagnosis and Damage Management Techonoly
	310	Sound-Absorbing and Insulation Metamaterials
	312	Hybrid Mount System Technology for Improvement of Vibration Reduction Performance
	314	Wind Turbine Drive Train Condition Monitoring and Fault Diagnosis/Prognosis Technologies
	316	Floating Offshore Wind Turbine Dynamic Analysis Program-WindHydro
Department of Smart Industrial Machine Technologies	318	Unmanned Vehicle Control Technology for Land-Air Cooperation
	320	High-Speed and Lightweight Power Train Design and Testing/Evaluating Technology
	322	Gear Train and Bolt Design Optimization Technology
	324	Machine's Environment Recognition and Collision Prevention Safety Control Technology
	326	Gear Geometry Design and Analysis Technology
	328	Virtual Operation Technology for Autonomous Driving of Agricultural Tractors
	330	Omnidirectional Ground Motion Generating Simulator Technology
	332	Structural Stability Assessment Technology
Department of AI Machinery	334	Magnetic Levitation Conveyance Device
	336	Repulsive Maglev Technology
	338	Mobile Manipulator Technology
	340	Motion Control Technology for Fast Movement with Less vibration by using Input Shaping Technique
	342	Facility Disaster Safety Management System Using AI and IoT Sensors
Department of Reliability Assessment	344	Vibration Data SRS/FDS Analysis App
	346	Open Source-Based Machine Parts Analysis Program Technology
	348	Prognostics and Health Management Technology of Mechanical Structure Under Fatigue Load
	350	Oil Reservoir for Hydraulic System Equipped With Return Line With Easy Gas Separation
	352	Hydraulic Servo Actuator Using Hydrodynamic Bearing for Turbine Control at Nuclear and Thermal Power Plants
	354	High Power Hydrostatic Transmission

6.

Daegu Research Center for Medical Devices and Green Energy

Department of Medical Device	358	Fully-automated Molecular Diagnostics System with All-in-One cartridge for Point-of-Care testing
	360	Biosignal Detection Sensor and Control Technology
	362	Complex Health Management System Technology for Early Diagnosis/Treatment/Rehabilitation of Chronic Respiratory Disease
	364	Active Knee Prosthesis
	366	Peripheral Nerve Signal Processing Technology

Department of Medical Assistant Robot	368	Non-Face-to-Face Medical Examination Robot System
	370	Robotic Ankle-Foot Prosthesis for Lower-limb Amputees
	372	Smart Workout Equipment and Exercise Managing Platforms for Home Gym & Fitness Centers

7.

Busan Machinery Research Center

Laser Industrial Technology Research Group	376	Laser Shock Peening Technology for Surface Hardening and Residual Stress Control for Metallic Materials
	378	Surface Hardening and Homogenization Technology for Metallic Materials Using High-Power Diode Lasers

KOREA INSTITUTE OF MACHINERY & MATERIALS

Advanced Manufacturing Systems Research Division	We develop cutting-edge machine technology to make industrial fields smarter.	We are conducting research to innovate the manufacturing process based on ultra-precise positioning technology, energy beam processing technology, ultra-light and high-power actuators, and multi-layered convergence manufacturing technology. The related technologies developed through the research are the core of manufacturing equipment such as next-generation processing systems, semiconductors, displays, robots, 3D printing systems, and general machinery.
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NanoConvergence Manufacturing Systems Research Division	Nano and machinery meet to lay the foundation to a new industry.	We conduct research with the goal of securing nano fusion-based source technology and core technology and commercializing into a new future industry. Through this, we aim to secure the competitiveness of the domestic industry and lead the scientific technology to pursue the Fourth Industrial Revolution and sustainability.
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Energy Systems Research Division	We research energy machine technology for the future.	In order to secure future energy technology, we are developing process and safety technologies to ensure high performance and reliability of industrial energy systems and various plants. In addition, we are developing cryogenic cooling systems such as liquid hydrogen plants and performing tests and certifications for LNG and cryogenic machinery by developing hydraulic machines such as pumps, compressors, turbines and gas turbines, and thermal fluid mechanical parts such as heat exchangers, reactors, and valves.
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Environment System Research Division	We take the lead in developing eco-friendly technologies for the earth.	In order to respond to environmental issues such as particulate matter and the new climate system, we research environmental devices and system technologies that aim for high efficiency and cleanliness. We retain source technologies for environmental devices such as plasma, dust collection, water treatment, post-treatment, gas turbine, engine, and combustor to prevent air and water pollution. We aim to develop eco-friendly and high-efficiency driving and power systems using such technologies.
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Mechanical Systems Safety Research Division	We add safety and reliability to large and complex mechanical systems.	Based on safety and reliability technology, we are developing core element technology and integrated system technology necessary for the design and engineering of large, complex machinery system and new mechanical systems equipped with such technologies.
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Daegu Research Center for Medical Devices and Green Energy	We enrich people's lives through medical device technology.	We were established to support the advancement of high-tech medical industrial complexes in Daegu and Gyeongsangbuk-do regions by researching and developing cutting-edge medical devices and medical support robot that improve the quality of life of the people and to contribute to fostering leading industries in the Daegu and Gyeongsangbuk-do regions. We support the nurturing of manufacturing in mechanical industry-specialized regions and play a pivotal role in establishing regional bases.
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Busan Machinery Research Center	We open up a better future through the technological advancement of key industries in the southeast region.	We were established for the purpose of R&D and corporate support for technological advancement of major industries in the southeastern region of Busan and creation of new industries. We aim to achieve high added value in the machinery parts and materials industry by distributing laser processing technology, automobile parts technology, and nuclear safety technology to local companies, and supporting testing and certification.
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# OBJECTIVE & FUNCTION

- Purpose of Establishment and Major Functions

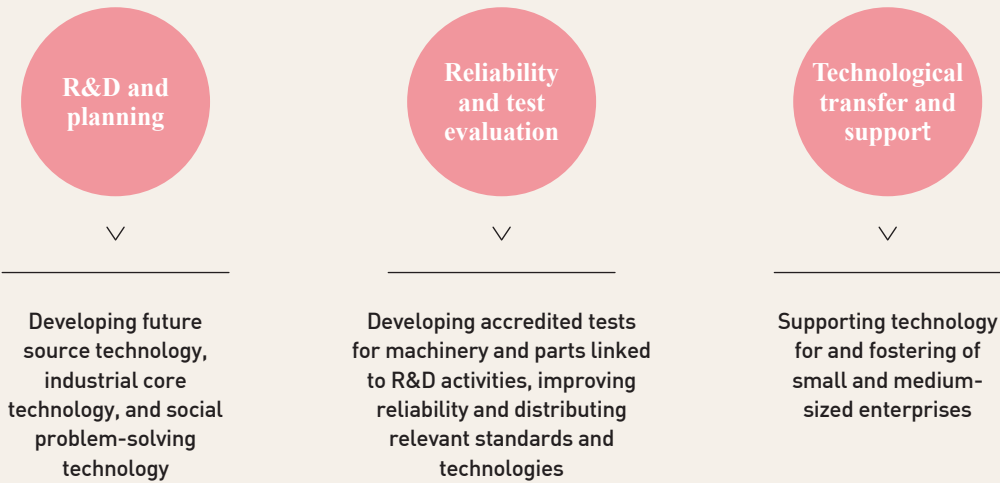
## Grounds for Establishment

Article 8 of the Act on the Establishment, Operation, and Fostering of Government-Funded Science and Technology Research Institutes, Etc.

## Purpose of Establishment

Contribute to the national and industrial development through R&D, performance diffusion, and reliability evaluation in the machinery sector (Article 2 of the Articles of Incorporation)

## Major Functions



# HISTORY

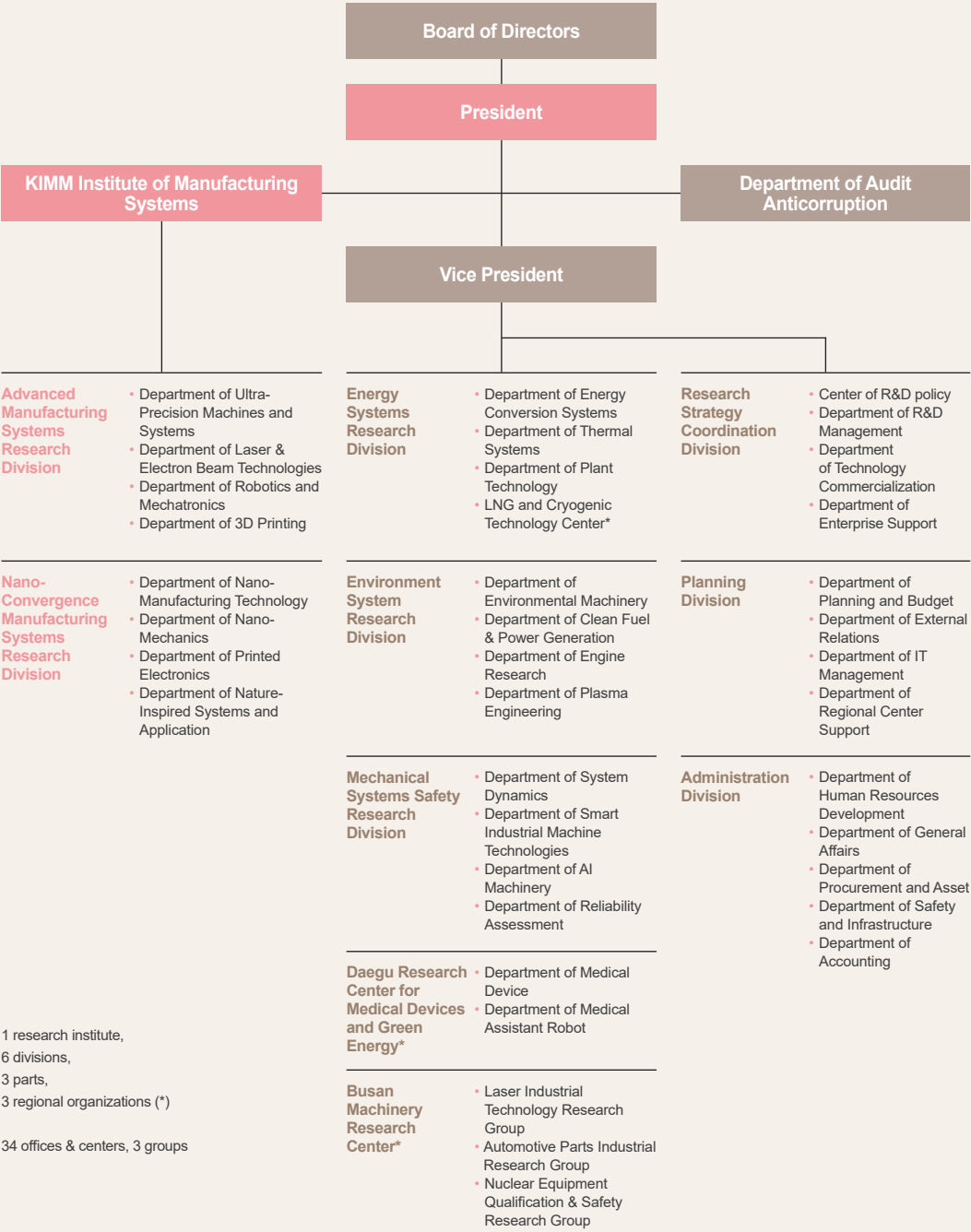
- History

1970'S 1980'S	1976.12.	Established as Korea Test Institute of Machinery and Metals
	1979.04.	Merged with Korea Fine Instruments Center
	1981.01.	Launched as Korea Center for Machinery and Materials
		Established Korea Research Institute of Ships & Ocean Engineering (KRISO) and the Korea Aerospace Research Institute (KARI) as affiliated institutes
	1989.10.	
1990'S	1992.03.	Renamed as Korea Institute of Machinery and Materials (KIMM)
		Relocated the headquarters from Changwon to Daejeon
		Integrated the affiliated KRISO
	1993.04.	Spun off KARI as an independent institute
	1996.11.	Transferred under the Jurisdiction of the Prime Minister's Office
	1999.01.	
	1999.03.	Transferred KRISO under the auspice of the Korea Ocean Research & Development Institute (KORDI)
2000'S	2004.10.	Transferred under the Jurisdiction of the Ministry of Science and Technology
	2007.04.	Established Korea Institute of Materials Science (KIMS) as an affiliated institute
	2008.02.	Transferred under the Jurisdiction of the Ministry of Knowledge Economy
2010'S 2020'S	2010.12.	Established Daegu Research Center for Medical Devices and Green Energy
	2013.02.	Established Busan Laser Application Support Center
	2013.03.	Transferred under the Jurisdiction of the Ministry of Science, ICT and Future Planning
	2017.07.	Transferred under the Jurisdiction of the Ministry of Science and ICT
	2020.11.	Spun off KIMS as an independent institute



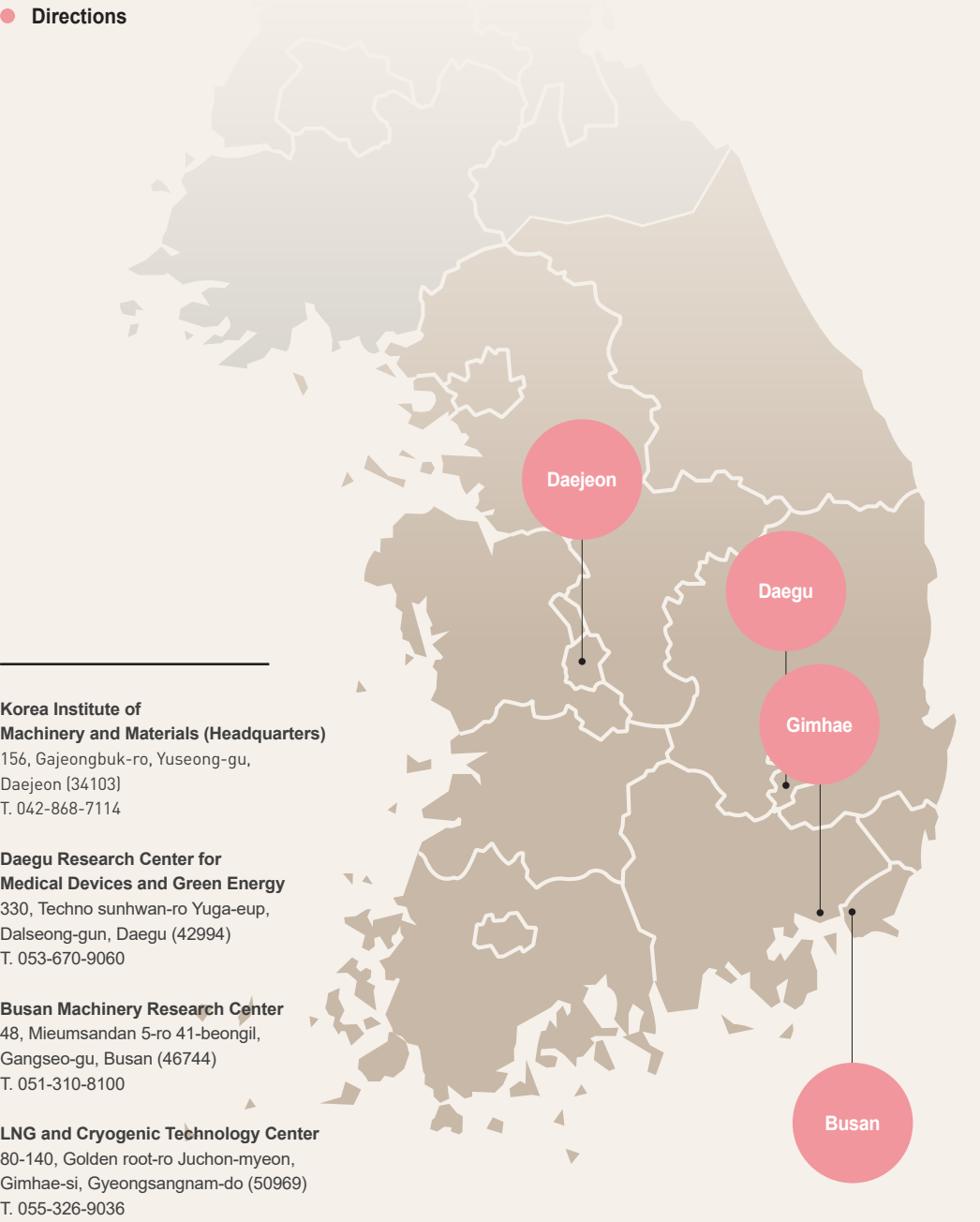
# ORGANIZATION 2021

● Organization chart



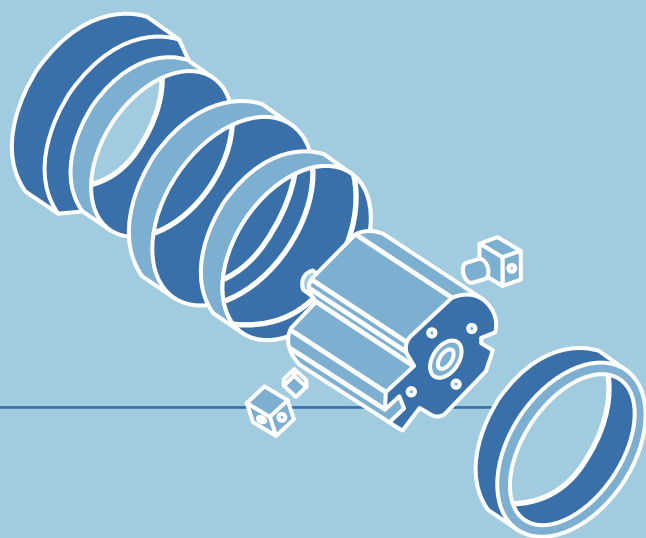
# LOCATION GUIDE

● Directions



1

Advanced  
Manufacturing Systems  
Research Division



High Resolution  
Dispenser for  
Fine Powder of  
Particle Size 10  $\mu\text{m}$

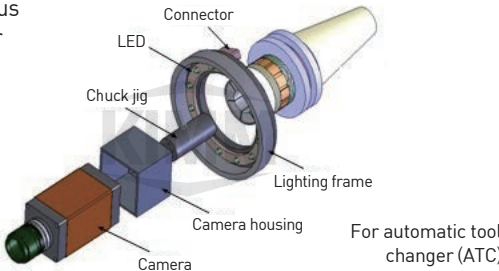
- 018 • Department of Ultra-Precision Machines and Systems
- 038 • Department of Laser & Electron Beam Technologies
- 062 • Department of Robotics and Mechatronics
- 108 • Department of 3D Printing

# Built-In Type Vision Measuring Tool for Autonomous Setting of Initial Machining-Origin

▶ Department of Ultra-Precision Machines and Systems ▶ Researcher: Donghoon Kim ▶ Contact: +82-42-868-7148

Technology Overview

- Autonomous recognition of machining origin and simultaneous self-correction module with built-in machining chuck holder designed for unmanned machining setup process



Customer / Market

- Manufacturers utilizing/processing machine tools, markets related to precision machining systems and unmanned/automated smart factory

Problems of Existing Technology or Necessity of this Technology

- Need for a mechanism to control the visibility of the built-in tool holder structure
- Automatic recognition & autonomous correction function/mechanism was developed where vision and lighting module is built in on the tool holder enabling on-machine measuring; automatic recognition of location and size of the specimen for machining and the z-axis auto-focusing function enables autonomous correction of the initial machining origin with 3-axis of width, length, and height to suit the changed specimen (compares not only the width/length vision measuring but also the thickness (height) of the material through visibility control)
- It is required to develop a dedicated measuring tool that can be inserted to the processing tool (or chuck) holder to proceed with a fully automated line by being structurally linked to the automatic tool changer (ATC) and apply on-machine such as hollow (spindle machining tool) cylindrical DSP board that can control lighting device and firmware software development.
- Regarding specification, CNC-linked autonomous identification function with the degree of precision of 0.09 mm and the sampling time within 1ms and CNC-linked auto-focusing control function were promoted to be applied.
- Integrated chuck holder built-in module structure, the machining origin autonomous identification mechanism, and CNC-linked on-machine autonomous correction functions are required.

Technical Distinctiveness

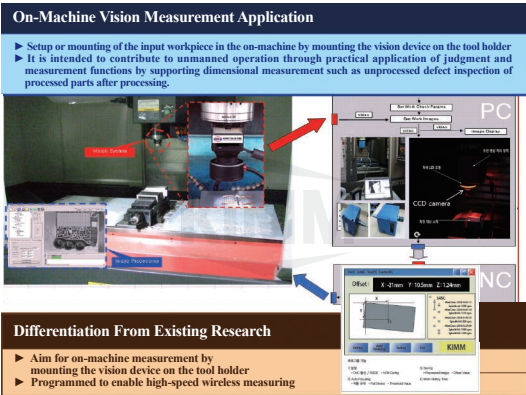
- From the control aspects, 3-axis automatic identification measurement + Z-axis auto-focusing, autonomous correction control mechanism are linked (CNC-linked)
- From the structural aspects, the remodeled machining tool holder built-in chuck type is applied.
- From the mechanism aspects, the new concept of measurement identification and correction control through the visibility and lighting control is introduced.
- From the interface aspects, wired/wireless data high-speed/high-resolution data collection and filtering is possible.

Use	Current Global Status	Goal of the Technology
Functional aspect	Measurement	Touch sensor (only measurement)
	Applicable machining	FMC machining
	Related commercial items/ flexibility	No commercial item/ No flexibility
Method	Method	Semi-automatic

- Vision measuring tool is made to be built into the device like the automatic tool changer (ATC)
- Setup or mounting of the input workpiece in the on-machine by mounting the vision device on the tool holder
- Machining origin automatic identification following change of the material is supported to realize unmanned machining through allowing the actual machine to judge and measure. (Accuracy and productivity are improved by excluding human workers, reducing the setup time, and minimizing the error occurrence.)

Excellence of Technology

- The automatic machine tool automatically identifies the machining origin for initial machining (diversification of material) and reprocessing of existing processed product to rid of the time required for setting the machining origin at the jog mode for various forms and improve the setting accuracy of existing automatic machine tool that depend on the initial setting; productivity is enhanced through separate settings set automatically.
- Proved the excellence of technological excellence by publishing a number of SCI-level related/based papers (1 author), etc. such as IEEE-ASME TRANSACTIONS ON MECHATRONICS (within top 5% of SCI), JMST, IJPEM, Key Eng. (published on SCI-level journals multiple times)
- Has over 20 years of research experience in machine tool intellectualization and IT integration.
- Received the 2013 Minister of Science, ICT and Future Planning Award (Scientist of the Month Award), 2012 Korea Society of Mechanical Engineers Baekbong Technology Excellence Award, 2011 KIMM Academic Award, and 2007 ICROS Academic Award.



On-Machine Vision Measurement Application  
▶ Setup or mounting of the input workpiece in the on-machine by mounting the vision device on the tool holder  
▶ It is intended to contribute to unmanned operation through practical application of judgment and measurement functions by supporting dimensional measurement such as unprocessed defect inspection of processed parts after processing.

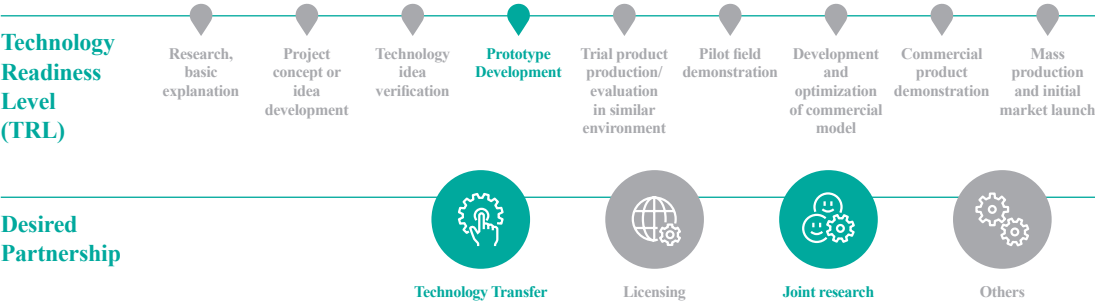
Differentiation From Existing Research  
▶ Aim for on-machine measurement by mounting the vision device on the tool holder  
▶ Programmed to enable high-speed wireless measuring

Automated Vision Recognition Built-In System With Changed Materials in XYZ Axes

Current Intellectual Property Right Status

- PATENT
- Built-In Type Vision Measuring Tool for Autonomous Setting of Initial Machining-Origin
  - Positioning device and method for positioning an article (KR1106575)
  - Method for Making Standard Defect Sample (KR1140422)

- KNOW-HOW
- Machine-tools pattern-matching based machining-origin identification technology for processing machining-material change
  - Unmanned autonomous setup and measurement technology in machining process, etc.



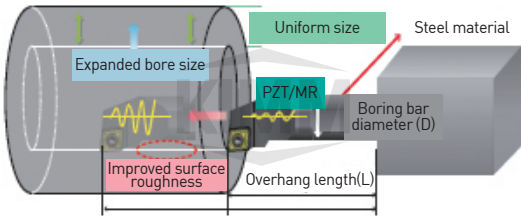


# Active Vibration-Control Device for Precise Boring of a Deep Hole for Large Integral Structure

▶ Department of Ultra-Precision Machines and Systems ▶ Researcher: Donghoon Kim ▶ Contact: +82-42-868-7148

Technology Overview

- Reduce vibration and improve surface roughness through active vibration proof during precise boring of a deep hole for large integral structure (aspect ratio over 7D)



Customer / Market

- Machining tool manufacturer/machine tools manufacturer, boring and lathe machining, precision machining company

Problems of Existing Technology or Necessity of this Technology

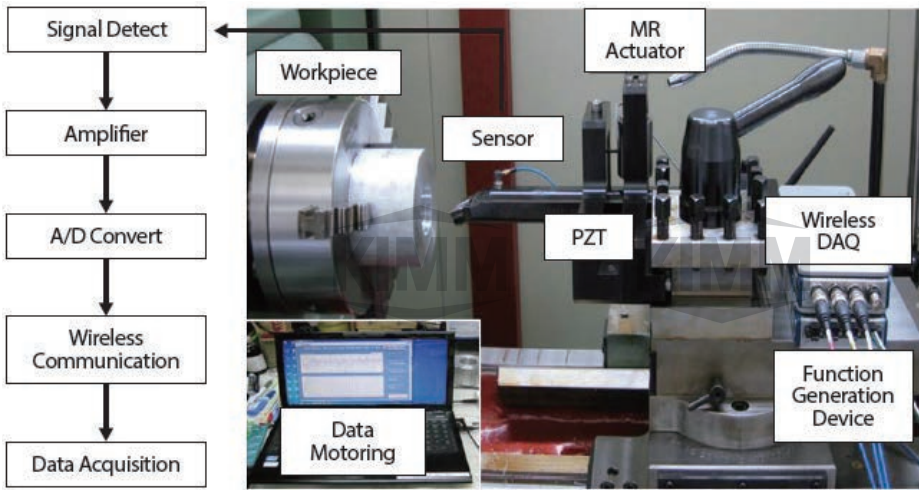
- Vibration and low surface roughness intensity while boring a deep hole in a large integral product is an issue.
- With the aspect ratio over 4D, it is difficult to secure surface roughness due to vibration that the parts are processed with the module and then welded. Passive methods using damper or vibration proof machine are usually adopted, but it cannot be used for a hole greater than 7D.
- Recently, deep hole processing has become frequent for a large integral product (aircraft landing gear, large motor/display, wind power facility, etc.).
- In particular, boring process requires precision, and to secure surface roughness (usually up to 2 μm), periodic damping (damping ration over 30%) is required during the deep hole work.
- Active vibration proof technology is an alternative technology.

Technical Distinctiveness

- By measuring the vibration real-time using the adaptive active damping with antivibrating of frequency of occurred vibration and offsetting such vibration (destructive interference through deducting the main frequency and phase modulation of frequency in possession), the accuracy of machine tools process work can be improved, and the life of the machine tools can be extended by reducing vibration, and these lead to a great cost reduction effect.
- Under the aspect ratio over 7D, precise boring of a large integral product can be done with the roughness between 1.8 μm and 2.0 μm; since the process of disassembling and welding back is no longer necessary, reduced number of processed parts and frequency of processing lead to short processing time and improved precision and productivity.
- From the control aspects, the embedded active vibration control and CNC-linked autonomous correction control mechanism are excellent.
- From the structural aspects, the detachable design of vibration proof boring device is excellent.
- From the process expansion aspects, fixed/rotary periodic damping can be done.
- From the interface aspects, wired/wireless data high-speed/high-resolution data collection and filtering is excellent.

Excellence of Technology

- After measuring the frequency and wave packet estimated level for estimating the main frequency and wave speed and the actual vibration amplitude of the vibration source by acquiring the vibration magnitude and using Fourier transform signal, active damping control can be enabled by determining the destructive interference cancellation amplitude.
- In the existing precision machining field, passive methods such as vibration dampeners or dampers were used, but this method is the world's first active method.
- JMST, IJPEM, Key Eng. Published 5 SCI-level related/fundamental theses (1 author), and hold 20 years of research experience in the field of machine intelligence.
- Won the 2012 Korean Society of Mechanical Engineers Baekbong Technology Award, 2011 KIMM Academic Award, and 2007 ICROS Academic Award.



Current Intellectual Property Right Status

PATENT

- Machine Tools Vibration Reduction Device and Method (KR1436984, PCT/KR2013/008236, US14/128709, JP2014-539893)
- Detachable Active Vibration Proof Device and Method Using MR Vibrator and Piezo Vibrator (KR1510638)
- Machine Tools Chatter Vibration Compensating Device (KR1015058)
- Active Vibration Reduction Device Using MR Fluid (KR1321468)

KNOW-HOW

- Active vibration-control based machining technology for large integral product
- High-speed precision boring processing and active chatter vibration reduction technology

Technology Readiness Level (TRL)



Desired Partnership

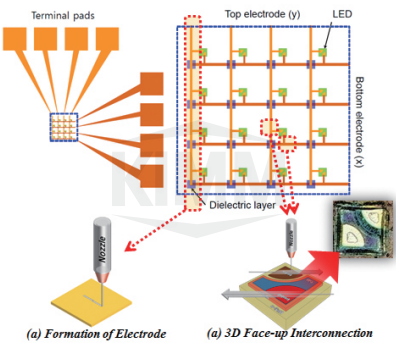


# A Core Technology for Fine Metal Formation Targeting for Flexible/Stretchable Device and Display

▶ Department of Ultra-Precision Machines and Systems ▶ Researcher: Yongkin Kim, Seungman Kim, Junyeob Song ▶ Contact: +82-42-868-7597

Technology Overview

- Developing a new concept for High device performance/high flexibility The formation of Fine metal patterns( $\leq 100\text{ }\mu\text{m}$ ) for FHE(flexible hybrid electronics) and the fabrication of 3D step height metal interconnection
- DI (direct imaging) technology (step height coverage $\leq 50\text{ }\mu\text{m}$ ) for forming non-damaging fine pattern ( $\leq 100\text{ }\mu\text{m}$ )/Pitch( $\leq 20\text{ }\mu\text{m}$ ) for realizing stretchable device and display



Customer / Market

- Device Technology field for FHE (flexible hybrid electronics)
- Technical field for DI (direct imaging) fine pattern/pitch formation for non-damaging flexible/stretchable display areas

Problems of Existing Technology or Necessity of this Technology

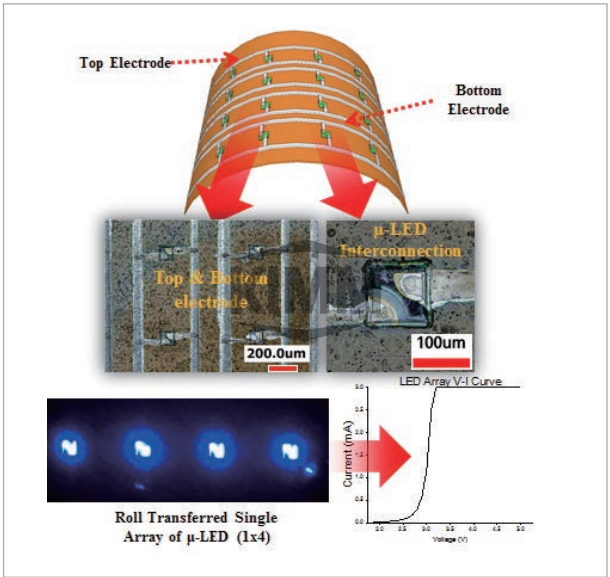
- When using existing mass production MEMS Fab. process/equipment, the process cannot be performed if there is step height ( $\geq 5\text{ }\mu\text{m}$ ) between the substrate and the thin chip (equipment / process compatibility issue).
- In forming 3D interconnection, wire-bonding creates mechanical damage of less than  $50\text{ }\mu\text{m}$  to the thin chip due to heat, pressure, and ultrasonic energy.
- Absence of face-up 3D metal interconnection technology to fabricate fine pattern ( $\leq 100\text{ }\mu\text{m}$ ) pitch ( $\leq 20\text{ }\mu\text{m}$ )
- Absence of technology that can form flexible/stretchable pattern without damaging low Tg flexible/stretchable substrate (wiring printing and sintering technology)
- Therefore, to overcome such problems, it is necessary to develop DI type nondamaging fine pattern/pitch creation technology.

Technical Distinctiveness

- Technology to effectively form 3D interconnection masklessly without causing mechanical damage to the thin chip with thickness below  $50\text{ }\mu\text{m}$  mounted on the flexible/stretchable substrate
- Technology to create fine pattern ( $\leq 100\text{ }\mu\text{m}$ )/pitch ( $\leq 20\text{ }\mu\text{m}$ ) with the DI (direct imaging) method
- Technology to sinter ink material on the flexible/stretchable substrate without thermal damage
- Technology for intrinsically/geometrically robust metal pattern formation for stretchable display
- Technology to rework and repair for mass production yield improvement

Excellence of Technology

- Formation of  $100\text{ }\mu\text{m} \times 100\text{ }\mu\text{m}$  (thickness $\approx 5\text{ }\mu\text{m}$ ) micro-LED top & bottom electrodes and securing face-up 3D metal interconnection (line width  $\leq 30\text{ }\mu\text{m}$ )
- Securing DI micro metal pattern method when line width is below  $10\text{ }\mu\text{m}$
- Establishment of database by ink material for overcoming 3D step height in the flat ( $0\text{ }\mu\text{m}$ ) to  $50\text{ }\mu\text{m}$  area
- Securing sample production technology for micro step height (flat ( $0\text{ }\mu\text{m}$ ) to  $50\text{ }\mu\text{m}$ ) control for DI process and ink property evaluation
- Performance of laser sintering test for non-damaging ink sintering on polymer substrate



Current Intellectual Property Right Status

PATENT

- Wearable Dry Patch Type Hybrid Substrate and Manufacturing Method (KR1756847)
- Non-penetrating, Superhydrophobic Polyimide Film Manufacturing Method (KR1641207)
- Elastic Device Manufacturing Method and Elastic Device Manufactured with the Method (KR2017-0133265)
- Electrode Pattern Formation Using Laser Sintering and Electrode Pattern Formation System for the Method (KR2017-0060814)

KNOW-HOW

- Non-damaging, DI fine pattern/pitch formation technology
- Face-up 3D step-covered metal interconnection technology
- Intrinsically/geometrically flexible or stretchable metal formation technology
- Repair and maskless process technology for yield improvement

Technology Readiness Level (TRL)



Desired Partnership



# Automated CAE Analysis to Evaluate the Structural Rigidity and Motion Performances of Mechanical Systems

▶ Department of Ultra-Precision Machines and Systems   ▶ Researcher: Chang-Ju Kim   ▶ Contact: +82-42-868-7534

Technology Overview

- CAE analysis automation technologies to enable mechanical designers to perform complicated CAE analysis of mechanical motion systems
- Technology that quantitatively evaluates the key performance indices of mechanical equipment such as static/dynamic structural rigidity and kinetic performance by analyzing basic analysis results

Customer / Market

- Manufacturers of machine tools requiring high stiffness structure
- Manufacturers of high-speed, high-precision motion stages for semiconductor or flat-panel display applications

Problems of Existing Technology or Necessity of this Technology

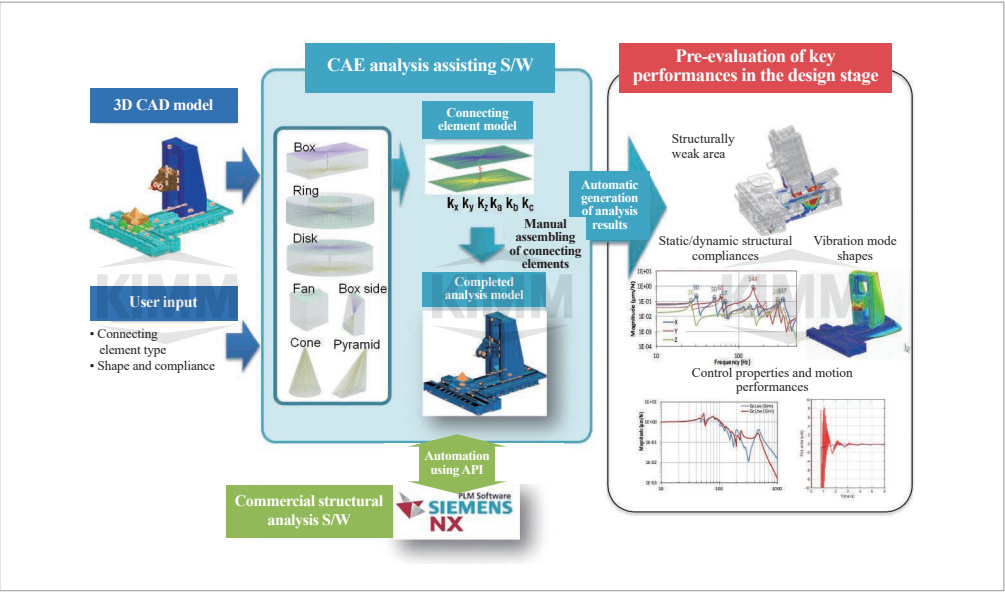
- The CAE structural analysis is a widely used technique to evaluate the designs of mechanical systems. However, evaluating the key performances of a complicated mechanical motion system is too complicated for mechanical designers in SMEs.
- To guarantee validity of the structural analysis result, connecting elements such as LM blocks, ball screws, servo motors, and encoders should be modeled with appropriate level of details and accuracy; which requires extensive know-hows and empirical data.
- It is necessary to improve the availability of the structural analysis technology by eliminating complex and labor intensive tasks including connecting element creation.

Technical Distinctiveness

- Can evaluate the key performances of an entire mechanical motion system, not a single unit or a part.
- Equipped with know-hows and empirical data to realistically model mechanical connecting elements including linear motion blocks, ball screws, servo motors, and encoders.
- Improved usability and reliability of structural analysis technology by reducing the manual work required for handling difficult connections and simplifying the structure.

Excellence of Technology

- A mechanical designer without expertise on CAE analysis can build the analysis model of a complicated mechanical motion system with minimum user input thanks to automation of complex processes such as modeling connecting elements, geometry simplification and assembly of finite element models.
- Once the primary structural analysis model is built, the same type of analysis can be repeated in multiple positions automatically to evaluate the position dependent performances.
- The basic structural analysis results are automatically processed into more insightful performance indices, such as structural loop stiffness, gravity induced machine accuracy, and motion performances.



Current Intellectual Property Right Status

PATENT

- Finite Element Analysis Techniques for Machine Tools (KR1729589)
- Vibration Transmission Analysis Method in a Precision Machine (KR1551183)

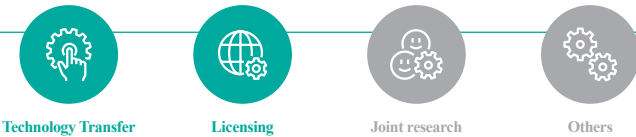
KNOW-HOW

- Analysis technology on gravity induced motion accuracy using static structural analysis
- Component contribution analysis technology on static/dynamic structural stiffness
- Analysis technology on control and motion performances using structural analysis results

Technology Readiness Level (TRL)



Desired Partnership



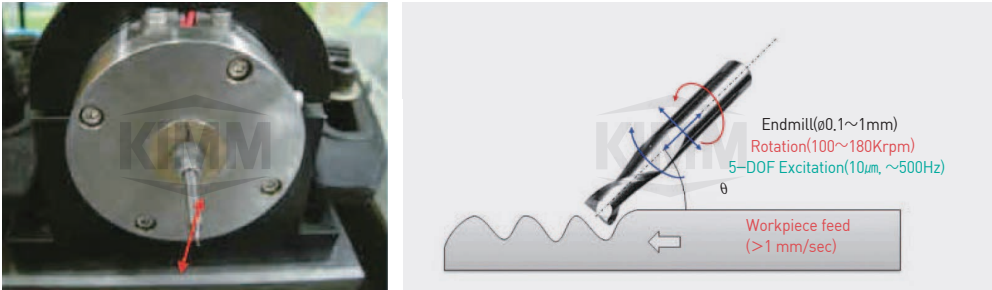


# Micro Milling–applied Surface Texturing Module Technology

▶ Department of Ultra–Precision Machines and Systems ▶ Researcher: Seungkook Ro ▶ Contact: +82–42–868–7115

## Technology Overview

- Device and module for surface texturing using micro milling, etc.



## Customer / Market

- Micro die and molds, ultra–precision machining system and components market

## Problems of Existing Technology or Necessity of this Technology

- Micropattern generation and texturing using cutting with a non–rotating tool has limits regarding its form and processing direction; using milling/grinding for texturing through feed control of the machine tool takes a long time and is ineffective.

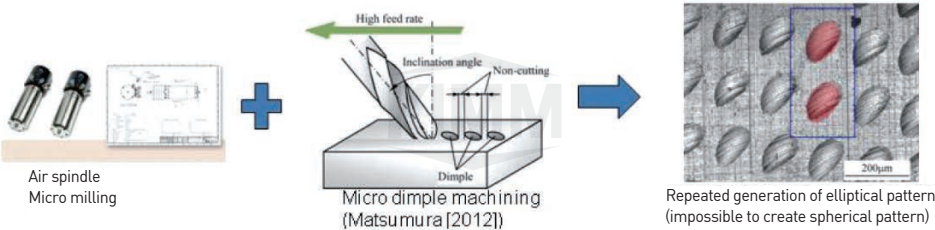
## Technical Distinctiveness

- Texturing using milling does not limit machining direction; shorten processing time.
- Possible to generate various patterns using ball end mills and various tools
- Possible to apply various materials using micro milling
- Possible to generate patterns on a relatively large area using the grinding with prepatterned wheels
- Texturing using milling module that allows 5–DOF vibration displacement during rotation
- Micro machining using micro–patterned grinding wheels

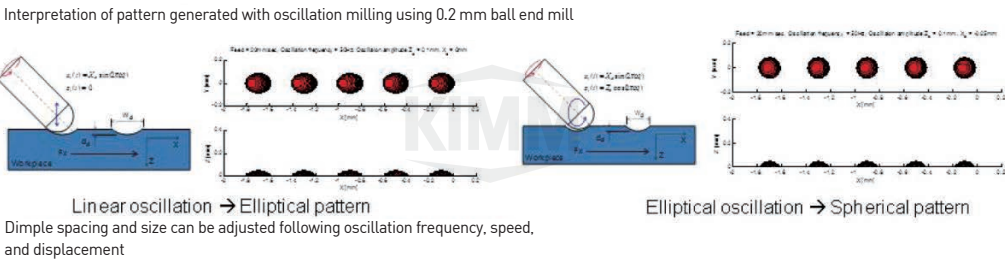
## Excellence of Technology

- Existing micro milling–applied dimple processing cannot realize spherical patterns.
- With this technology, repeated generation of spherical dimples expected to become possible by synchronizing the work feeding speed.

### MICRO MILLING-APPLIED PATTERN PROCESSING (EXISTING RESEARCH)



### INTERPRETATION OF OSCILLATION MICRO MILLING-APPLIED DIMPLE MACHINING (PROPOSED METHOD)



## Current Intellectual Property Right Status

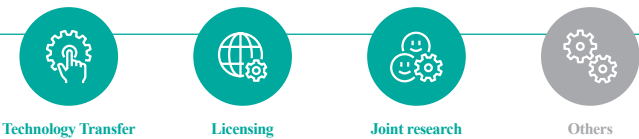
### PATENT

- Apparatus for Micro Surface Texturing Machining and Its Method (KR1463803)
- Grinding apparatus for surface texturing and the grinding method thereof (KR1400876)
- Apparatus for micro surface texturing (KR1476815)

## Technology Readiness Level (TRL)



## Desired Partnership

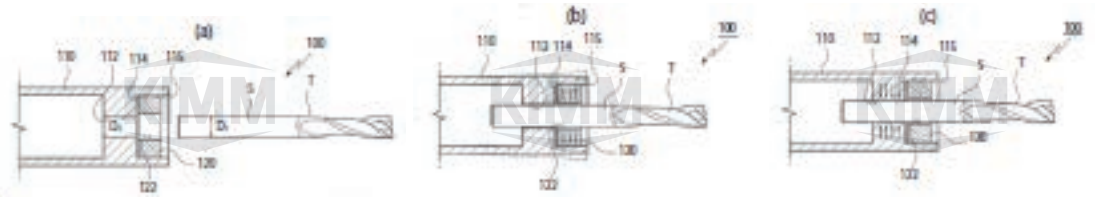


# Tool Holder Using Shape Memory Alloy and Tool Holding Method

▶ Department of Ultra-Precision Machines and Systems ▶ Researcher: Seungkook Ro ▶ Contact: +82-42-868-7115

Technology Overview

- Ultra-small tool clamping device, cutting tool holder, etc. using compact shape memory alloy with high rotational precision during high-speed rotation by applying shape memory alloy ring



Customer / Market

- Tool and tool holders, precision cylindrical part clamping system, precision and micro-machinig

Problems of Existing Technology or Necessity of this Technology

- Need for simple structure and reduced tool changing time
- Existing taper collet-chuck method made the entire design of the tool holder complex; accumulating taper collet geometric errors increase the geometric tool setup errors
- Shrink-fit method requires changing tools by moving to a separate hightemperature heating system, which complicates the system configuration and adds extra expenses.
- Need to reduce the number of tools for a small tool holder device and miniaturize with a compact design
- Increased demand for tool holder and tool holding method using shape memory alloy that would shorten the tool changing time

Technical Distinctiveness

- Simple structure with steel holder and SMA(Shape Memory Alloy) ring
- Only requires a simple additional facility of a spray type cooling device for cooling to 0 to 30 ℃
- Huge reduction in tool changing time as a result of small temperature difference
- Miniaturization realized by reducing the number of clamping device components with shape memory alloy
- Minimized mass imbalance factors with the axially symmetric clamping design to improve rotation precision
- Reduction of components in the tool holder reduces accumulated tolerance and realizes high-precision operation

Excellence of Technology

- This technology realizes compact design and shortened tool changing time and satisfies the market's demand.
- Has 3 international patents and 34 other patents
- Received multiple awards including Award Certificate of Director of Patent and Trademark Office (No. 4778, 2009) and Order of Science and Technological Merit (Jinbo Medal) (No. 94, 2011)

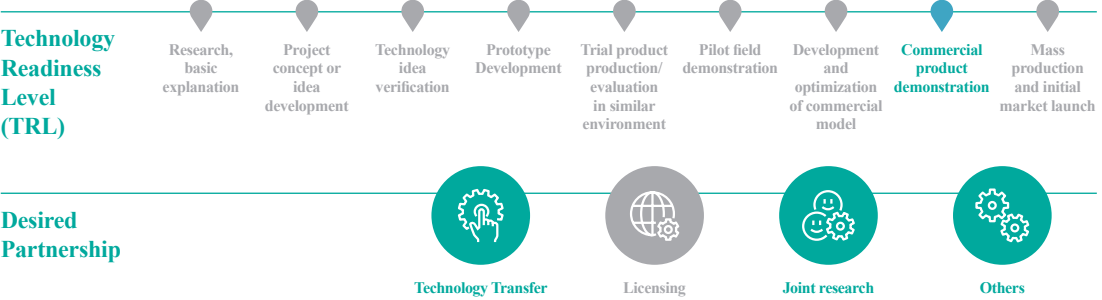
SMA Tool Clamping System Prototype



Current Intellectual Property Right Status

PATENT

- Tool Change Apparatus and Tool Change Method of Tool Holder Using Shape Memory Alloy (KR105527)
- A Fixture System For machine tools Using A Shape Memory Alloy (KR0987814)
- Tool Holder Using Shape Memory Alloy and Tool Holding Method (KR1136382 PCT/ KR2010/008768 13/509135)
- Collet Chuck Using Shape Memory Alloy (KR1144617)
- A Cutting Tool Holder Using Shape Memory Alloy (KR1136381)
- A Cutting Tool Holder Using Shape Memory Alloy (KR1117579)
- Tool Holder Using Shape Memory Alloy (KR2014-0035057)
- Cutting Insert Holder Using Shape Memory (KR1117580)
- Spindle-tool Assembly Using Shape Memory Alloy and Machine Tool Having the Same (KR1284286)

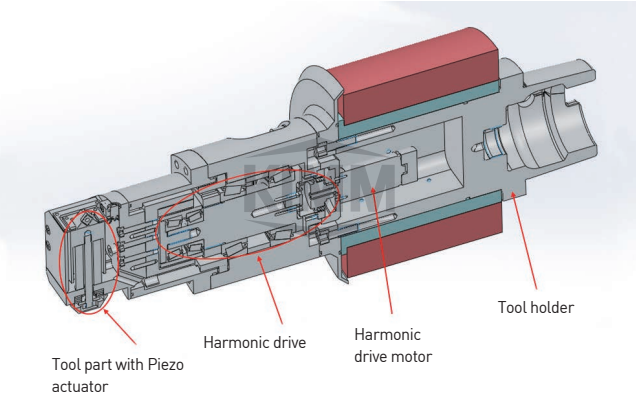


# Active Tool Technology for High-Speed Micro-Patterning Inside Cylinders

▶ Department of Ultra-Precision Machines and Systems ▶ Researcher: Seungkook Ro ▶ Contact: +82-42-868-7115

Technology Overview

- Technology for high-speed patterning of micro dimples and grooves on the inner surface of cylinders, such as journal bearings and engine cylinder blocks



Customer / Market

- Combustion engine production, journal bearings, pistons, etc.

Problems of Existing Technology or Necessity of this Technology

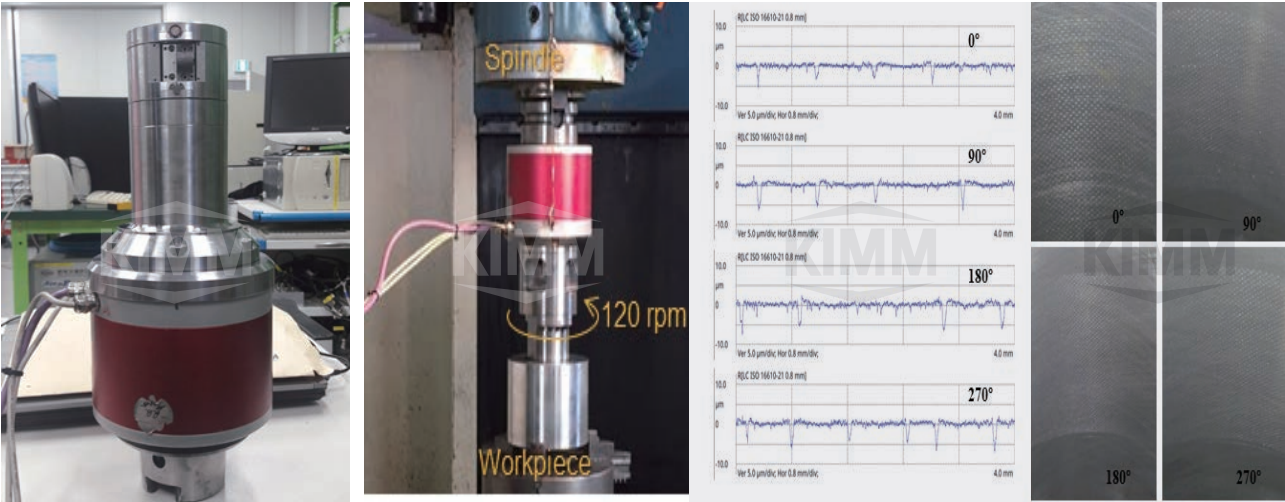
- It is a technology for patterning dimples and grooves with a depth of 10 μm or less in the inner cylinder. When using the laser machining, sandblasting and etching, it takes a long time to process or has a problem of contamination, which makes it difficult to be applied to an automated production line. In addition, if there is an error in the shape of the cylinder surface to be processed, it is difficult to process a uniform pattern.

Technical Distinctiveness

- Capable of high – speed pattern processing of 2,000 or more per second by using a tool that rotates on the cylinder inner wall – Rotation speed of up to 900 rpm, up to 3,000 (3 kHz) of patterning speed per second, and cylinder diameter of 70 or more
- Creating various patterns of ellipse, round dimple and groove by controlling the shape and vibration waveform of the tool
- Active compensation of the shape error and alignment errors inside the cylinder in real-time during patterning
- Capable of controlling the automated production line through communication control

Excellence of Technology

- This technology can be implemented by attaching the active tool for micro-patterning to the existing machining (milling, honing or turning) equipment through tool clamping system.
- The productivity can be secured through high-processing speed and automation.
- Pattern accuracy can be secured by applying real-time error correction technology during processing

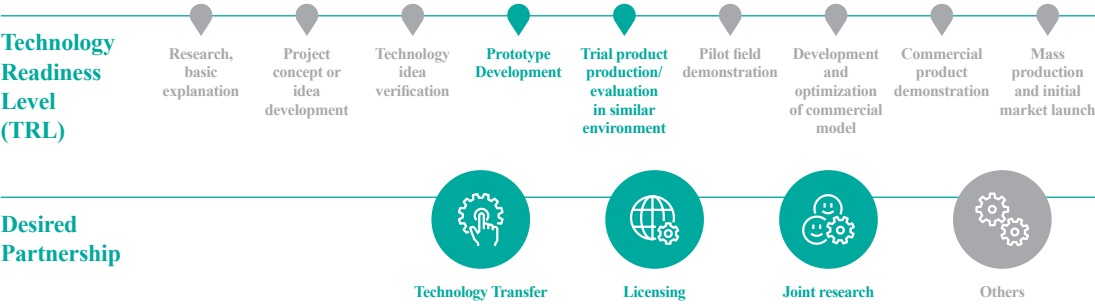


〈 Active tool and inner cylinder patterning example 〉  
(front grooving with uniform depth of 5μm)

Current Intellectual Property Right Status

PATENT

- Hybrid cutting apparatus and groove cutting method using the same (KR1934691, US10391564)
- Grinding apparatus for surface texturing and the grinding method thereof (KR1400876)
- Apparatus for micro surface texturing (KR1476815)



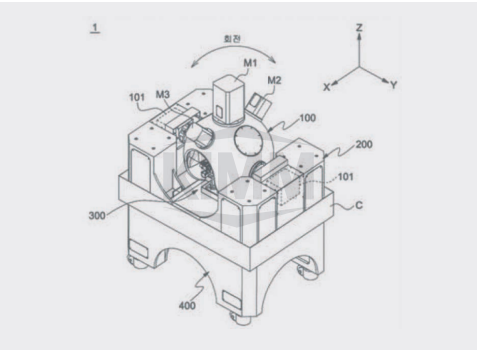


# Capsule Type Reconfigurable Multifunctional Machine Tool

▶ Department of Ultra-Precision Machines and Systems   ▶ Researcher: Seongcheol Lee   ▶ Contact: +82-42-868-7896

Technology Overview

- Capsule type reconfigurable multifunctional machining using machine mechanism with maximized rotary motion for various machining (laser machining, milling and grinding machining, etc.)



Customer / Market

- Micro electronic component manufacturer

Problems of Existing Technology or Necessity of this Technology

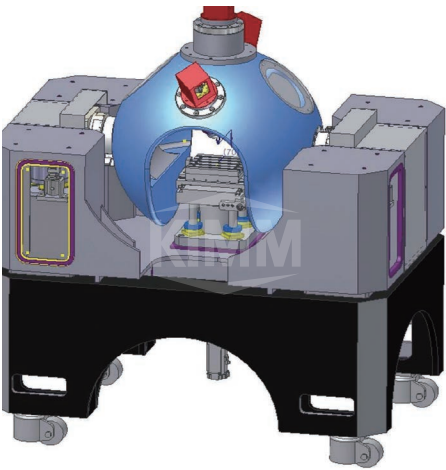
- Many machines are used for 3D machining including laser machine and multi-axis machining device, however, the demand for improving the product function by laser surface processing after the machining is increasing; therefore, there is a need for developing multifunctional machining that could handle various processes (milling, laser, grinding) at one setup to produce products in complex forms.
- Multi-axis machining devices mostly performed the process by moving the tools with the multi-axis translational motion; due to the complex device structure containing many components, they were sold at an expensive price.
- Existing multi-axis machining devices required the tools to move more to process a product with a complex shape, which increased energy consumption unnecessarily.
- It is required to develop optimized movement of the tools and various converged processes.

Technical Distinctiveness

- Reduction in the production time as milling, laser, and grinding machining operations are performed in one setup
- Small initial setup error as it does not require multiple setups; improved precision
- Improved work environment with one machine handling works that were to be performed by multiple machines; only requires a small work space; eco-friendly machine processing
- Milling, laser and grinding machining processing various shapes as surface patterns

Excellence of Technology

- This invention is capsule type multifunctional machining device using machine mechanism with maximized rotary motion for various machining (laser processing, milling and grinding processing, etc.).
- 3 international patents and 34 other patents
- Received multiple awards including Award Certificate of Director of Patent and Trademark Office (No. 4778, 2009) and Order of Science and Technological Merit (Jinbo Medal) (No. 94, 2011)



〈 Capsule-Type Complex Processing Device 〉

Current Intellectual Property Right Status

PATENT

- Capsule Type Reconfigurable Multifunctional Machining Apparatus (KR1423500 US13/707982 JP2013-216958 EP13178243.5)
- Stage Unit for Capsule Type Reconfigurable Multifunctional Machining Apparatus (KR1407519)
- Capsule Type Reconfigurable Multifunctional Machining Apparatus (KR1423499)
- Prevention of Vibration Body Structure for Capsule Type Reconfigurable Multifunctional Machining Apparatus (KR1449465)
- Capsule Type Reconfigurable Multifunctional Machining Apparatus Having Body Structure for Prevention of Vibration (KR1449464)

Technology Readiness Level (TRL)



Desired Partnership

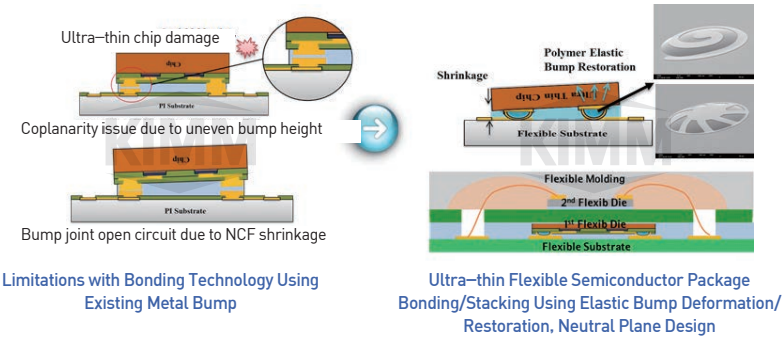


# Ultra-thin Flexible Semiconductor Package Interconnection and 3D Stack Technology

Department of Ultra-Precision Machines and Systems   Researchers: Jaehak Lee, Junyeob Song   Contact: +82-42-868-7362, 7144

Technology Overview

- Interconnection/stacking technology for ultra-thin flexible semiconductor package with flexible substrate using polymer elastic bump, neutral plane design for package



Customer / Market

- Semiconductor manufacturer (Foundry, OSAT (Outsourced Semiconductor Assembly and Test))
- Display manufacturer

Problems of Existing Technology or Necessity of this Technology

- Along with development of wearable device performance and rapid growth of its market, the need for ultra-thin, high-performance, high-flexibility, and humanfriendly flexible semiconductor package has increased.
- To create a flexible semiconductor package, a thin silicon chip with the thickness between 20 to 50 μm needs to be bonded on a flexible substrate.
- Conventional bonding process using solder bump to bond the chip under high temperature has a problem of flexible substrate damage and thin silicon chip damage due to thermal stress. With another bonding technology, a rigid metal bump can be bonded with a pad using NCF adhesive, however, it leads to issues such as chip damage due to stress concentration caused by uneven bump height, joint coming off due to NCF shrinkage, and declined flexibility due to hard joint.

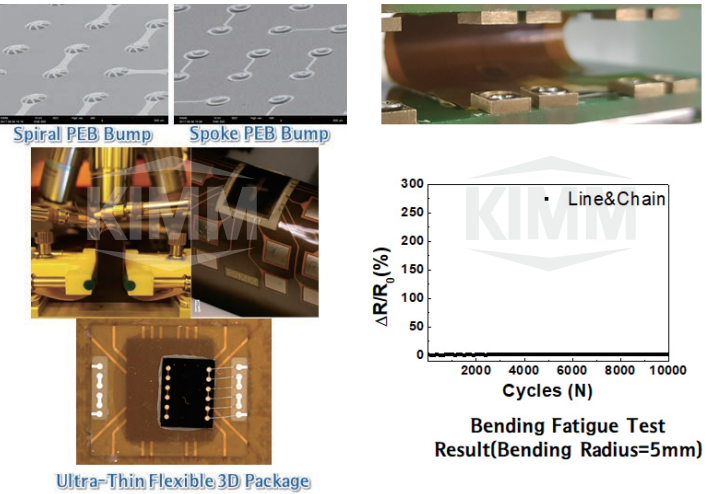
Technical Distinctiveness

- This technology uses the wafer transfer technology to design the neutral plane for the chip to minimize stress while bending and make handling chip during bonding easy to enable production of ultra-thin flexible silicon chip that is thinner and more flexible than the conventional chip.
- By applying the polymer elastic bump structure, which boasts easier elastic deformation and restoration, for the thin flexible silicon chip, damage to the thin flexible chip from uneven bump height during chip bonding is minimized with the elastic deformation and stress relaxation.

Excellence of Technology

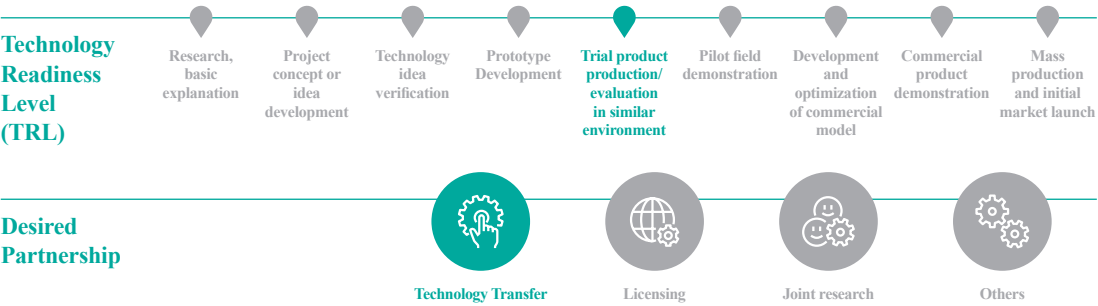
- Also, this bonding technology has excellent reliability and low contact resistance as the contact between the bump and the pad is maintained with the elastic restoration even when the adhesive shrinks. With the flexible bonding interface composed of polymer bump and adhesive, this technology is able to realize higher flexibility compared to conventional bonding technology.
- With wafer transfer technology, neutral plane for chip/package is designed to allow handling and bonding of thin flexible chip with thickness less than 10 μm without damage.
- By applying the polymer elastic bump structure that boasts easy elastic deformation and restoration to thin flexible silicon chip, a flexible semiconductor package with bending radius of 5 mm and bending fatigue of over 10,000 cycles was created.
- Using the bonding technology above, the 3D ultra-thin flexible semiconductor package trial product was manufactured to prove the technology.

Ultra-thin Flexible Semiconductor 3D Package Trial Product and Bending Reliability Test Result



Current Intellectual Property Right Status

PATENT	KNOW-HOW
Face-down Type Flexible Electronic Device Manufacturing Method and Flexible Electronic Device Manufactured Using the Method (KR1511023)	Polymer elastic bump fabrication technology Flexible chip neutral plane design and thinning technology Thin wafer transfer technology for neutral plane design Flexible semiconductor package 3D stacking and low-temperature bonding technology



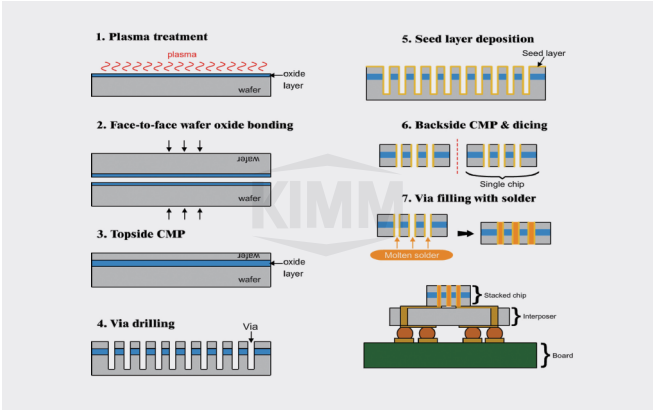


# Build-up/Bump-less Ultra-thin Wafer Stacking Technology without Carrier Wafer

▶ Department of Ultra-Precision Machines and Systems ▶ Researchers: Junyeob Song, Jaehak Lee ▶ Contact: +82-42-868-7144, 7362

Technology Overview

- Improve 3D package yield by stacking ultra-thin wafers with the build-up method



Customer / Market

- Device manufacturer (foundry, fabless, assembly)/semiconductor

Problems of Existing Technology or Necessity of this Technology

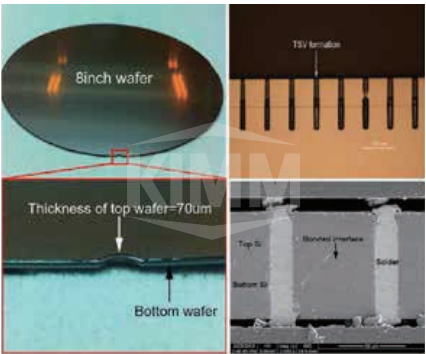
- When manufacturing stacking package, there are handling, yield, productivity issues in stacking ultra-thin wafers.
- Existing technology for fabricating an ultra-thin chip bonds the thin wafer temporarily to the carrier wafer to prevent damage and proceeds with follow-up process, and the process cost is high. Since bonding and stacking using a bump by chip unit, yield and productivity is low.
- Mobile AP and other semiconductor packages are becoming high performance, light weight, and thin and small.
- Currently used 2D interconnection package manufacturing method has reached technical limits regarding scaling down to meet the consumer demand and stacking package technology is becoming popular as alternative technology.

Technical Distinctiveness

- Since the thin wafer is not bonded temporarily to the carrier wafer, and the ultra-thin wafer stacking package is manufactured with the build-up method, handling ultra-thin wafer becomes easy and yield improves.
- Producing wafer level stacking packages with the build-up method leads to high yield and mass production, and it can achieve fine pitch as it simultaneously realizes TSV and vertical interconnection bumplessly.
- Wafer level stacking method can easily handle and stack ultra-thin wafer without using additional carrier wafer and boasts higher yield and mass production compared to chip level stacking technology.
- Vertical interconnection of bumpless TSV can achieve fine pitch and secure bonding reliability.

Excellence of Technology

- The technology uses the lowermost device wafer without temporary bonding to additional carrier wafer to easily handle ultra-thin wafer and stacking with the build-up method to form interconnection of TSV.
- The lowermost device wafer is used as the carrier, and bond and backgrind the wafer with the build-up method to thin the wafer from each layer.
- On multilayered wafers stacked with the method above, a through hole is created across the wafers, and using molten metal or plating method, form TSV interconnection on each layer without bumps.
- The head researcher has over 20 years of research experience.



〈 Wafer Level Build-up Bumpless Stacking Technology 〉

Current Intellectual Property Right Status

PATENT

- Semiconductor Chip Stacking Package and Manufacturing Method (KR1036441, PCT/KR2011/001166, SP201201174-8, US8722513)
- Semiconductor Chip Pickup Device (KR1186799)
- Semiconductor Chip Stacking Package and Manufacturing Method (KR1172533)
- Chip Stack and Interconnection Method using Electric Plating including the Chip, Stacking Chip and TSV for Chip Interconnection (KR1225253)
- Semiconductor Chip Stacking Package and Manufacturing Method (KR1036441)
- TSV for Semiconductor Device 3D Package and Manufacturing Method (KR1071993)
- TSV for Semiconductor 3D Package Using Electroplating and Manufacturing Method (KR1049380, US8513061)
- Chip Stacking Method Using Insulating Film, Chip Stacked with the Method, Insulating Film for the Method and Manufacturing Method (KR1242281)
- Manufacturing Method for TSV for Semiconductor Device 3D Package (KR1103275)

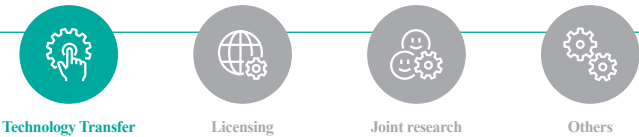
KNOW-HOW

- Void free wafer direct bonding technology
- Wafer surface pre-treatment technology
- Bumpless TSV (Through-Silicon Via) formation and ultra-thin wafer build-up stacking technology

Technology Readiness Level (TRL)



Desired Partnership



# Manufacturing Technology for Board Type Flexible Fine Die Allowing Precise Patterning and Thermal Deformation Prevention

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Heeshin Kang ▶ Contact: +82-42-868-7456

Technology Overview

- Technology with patterning and thermal treatment process that reduces cost by minimizing the use of chemicals compared to existing film work



Customer / Market

- Flexible fine die manufacturer and semiconductor manufacturer

Problems of Existing Technology or Necessity of this Technology

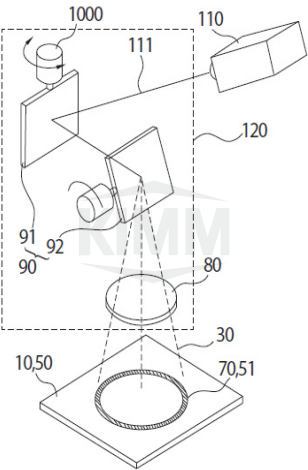
- Existing fine die manufacturing method of film work requires high initial investment and material cost yet has low pattern precision and causes environmental pollution with chemicals used during process.
- Due to complex process and need for film printer for film making, initial investment is high. With massive use of films and chemicals used during process, the risk of environmental pollution is high.
- Film work cannot precisely control the location; therefore, precision of patterning is low.
- To extend the life of flexible fine die and increase its solidity, heat treatment is inevitable, but during this process, the die deformation may occur.
- There is a need for technology for creating a die at a low cost that allows precise location control and does not deform during heat treatment.
- Required conditions include cost reduction, precise location control, and die deformation prevention during heat treatment.

Technical Distinctiveness

- Production cost can be reduced as the process does not require film, developing solution and other chemicals.
- Precise patterning is possible using laser, and the die defective rate is reduced as the life and solidity of the die is extended without deformation caused during heat treatment.
- Harmful fluid used for film printing is not required; level of pollution at the manufacturing site is improved leading to better work environment.
- The film method is replaced with the photocuring patterning method using laser, which easily enables precise patterning on thin foil.
- Heat treatment using laser is done with laser scanner; therefore, flexible fine die can be produced at minimal thermal deformation.

Excellence of Technology

- The laser photocuring process creates a polymer pattern of desired shape and corrodes parts other than the pattern to create a bulging polymer pattern. With the primary machining, a blade is added to the bulging part and the blade is made solid with the secondary laser heat treatment.
- Laser beam emitted from the laser generator (110) is reflected on to two rotating reflectors (91, 92), which sends the laser to the die through the f-θ lens (80) to perform laser heat treatment.
- By replacing the photocuring patterning process that requires films and various chemicals and the heat treatment process requiring high-temperature heat with the laser method. Above laser beam output can be adjusted from several hundred Ws to several kW.
- The head researcher has 10 years of research experience in printing field.
- As a part of 'Customized Technology Service Project' of Korea Research Council for Industrial Science and Technology, the 'laser heat treatment and printing for flexible fine die' technology was applied at a flexible fine die manufacturer, which was proven to have cost reduction and environment improvement effect.



Current Intellectual Property Right Status

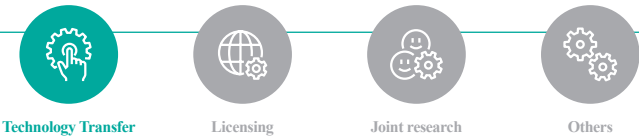
PATENT

- Flexible Fine Die Manufacturing Method Using Laser (KR2012-0002666)

Technology Readiness Level (TRL)



Desired Partnership

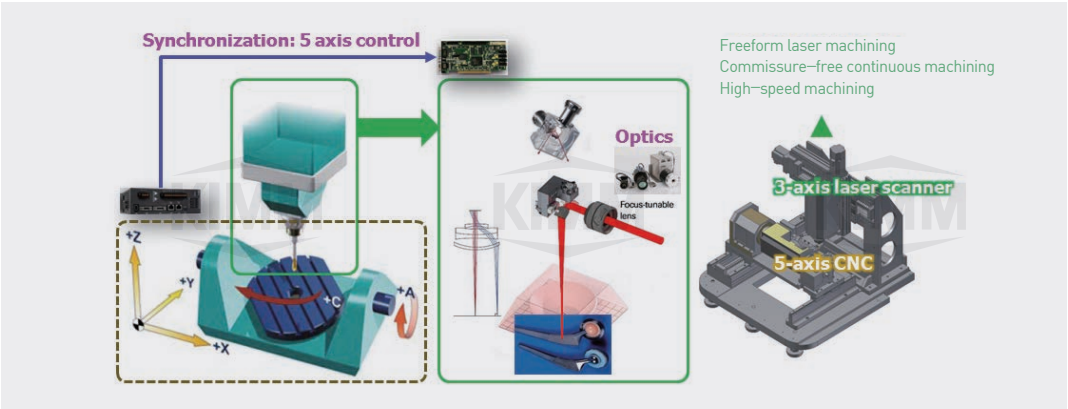


# 5-Axis Mechanical Machining System and 3-Axis Scanner Connection Technology

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Gyeonghan Kim ▶ Contact: +82-42-868-7310

## Technology Overview

- New breakthrough technology surpassing the limit of existing laser machining area and speed through real-time synchronization of 5-axis mechanical machining module and 3-axis laser scanner
- With this technology, micropatterning of size 15  $\mu\text{m}$  at the continuous machining speed over 280mm/s can be performed on a freeform surface.



〈 Concept Map for Real-time Synchronization System for 5-Axis Mechanical Machining Module and 3-Axis Laser Machining Module 〉

## Customer / Market

- Functionality of home appliances/market requiring aesthetic surface, cellfriendliness improving implant/hip surface treatment, cutting and boring of automobile/aircraft surface component
- 5-axis cutting/boring laser machining market, real-time synchronization controller market, laser CAM SW market

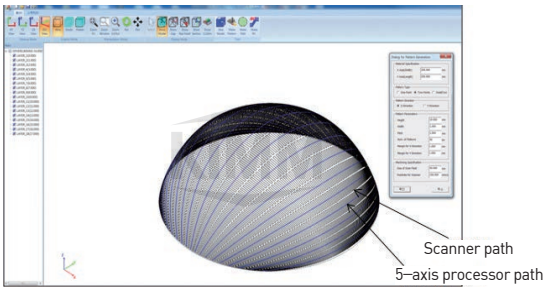
## Problems of Existing Technology or Necessity of this Technology

- 3-axis laser scanner cannot cope with a completely freeform due to the depth factor of process.
- Foreign machine tool companies commercialize a simple combination of 5-axis processor with 3-axis scanner.
- The manufacturing speed decreases and a commissure issue occurs with the step and scanning method used with a simple combination of 5-axis processor and 3-axis laser scanner.



## Technical Distinctiveness

- Control unit for real-time synchronization by entering the position/speed of 5-axis processor into the scanner control board
- World's first scanner control board for 5-axis signal input
- CAM SW development for separation of heavy weight 5-axis processor transfer route and high-speed 3-axis laser scanner route/speed acceleration



〈 CAM SW for 5-Axis Processor and 3-Axis Laser Scanner Route Separation/Speed Acceleration 〉

## Excellence of Technology

- Real-time synchronization of 5-axis mechanical machining module and 3-axis laser scanner to surpass the limit of machining area and speed of existing laser.
- With this technology, micropatterning of size 15  $\mu\text{m}$  at the continuous machining speed over 280mm/s can be performed on a freeform surface of material difficult for processing, Ti.



〈 5-Axis Laser Real-time Synchronizer(top) and Patterning Result(bottom) 〉

## Current Intellectual Property Right Status

### PATENT

- 3D Laser Irradiator and 3D Laser Irradiation Method (KR1769550)

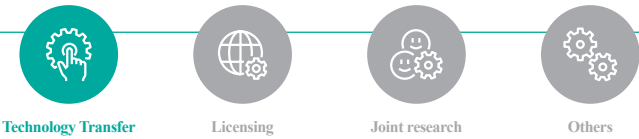
### KNOW-HOW

- Scanner control board design technology for 5-axis processor signal input and real-time correction calculation
- 5-Axis processor and 3-axis laser scanner route and speed acceleration algorithm

## Technology Readiness Level (TRL)



## Desired Partnership



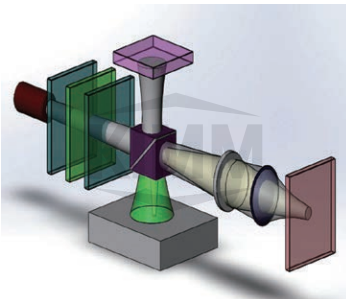


# Laser Machining Device with Focus Measuring Function

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Jihwan Noh ▶ Contact: +82-42-868-7915

Technology Overview

- Focus finding device with micro pattern technology on curved 3D surface using a different concept from existing confocal, WDI method



Customer / Market

- Laser machining equipment

Problems of Existing Technology or Necessity of this Technology

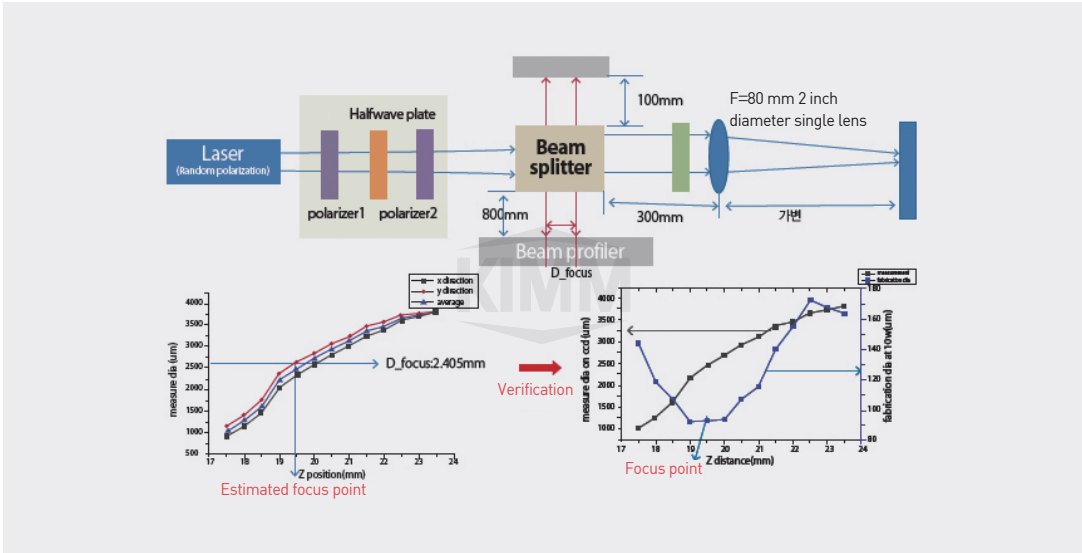
- Various laser machining methods are used such as irradiating laser to the subject to cut a furrow on its surface, to create a damaged layer inside, or to apply heat to change its properties.
- The 3D curve measurement methods include using confocal or the WDI method, however, since the machining laser's focus position and the measuring laser's focus position are different, it is difficult to use them, and the optical components are complex.

Technical Distinctiveness

- Only uses one machining laser—therefore easy to find the focus position
- Simple optical components; able to monitor the status of machining laser
- Easy to find the focus position as there is no offsetting
- Simpler optical components compared to other methods
- Able to check the change in the machining laser (point stability, divergence angle)
- Able to check the change in the angle or roughness of the specimen
- Can be used on scanner
- Able to accurately line up the center of the printing roll and the center of the scanner

Excellence of Technology

- Does not use a separate measuring laser; only uses the machining laser to measure the step height of the specimen
- After measurement, increase the laser power for machining (existing method required a separate laser for measurement).
- Beam splitter splits the laser beam irradiated from the light source into reflection beam and penetration beam, and the focusing lens concentrates the penetrating beam to the subject of machining.
- Beam profiler receives the laser beam reflected from the subject and went through the focusing lens and the beam splitter and measure the change in the beam profile depending on the subject's position change.



Current Intellectual Property Right Status

PATENT

- Laser Machining Device with Focus Measuring Function and Laser Machining Method (KR2014-0097629)
- Laser Machining Device with Focus Measuring Function and Laser Machining Method (KR2014-0097629)
- Laser Machining Device with Focus Measuring Function and Laser Machining Method (KR1480162, PCT/KR2014/007026)

Technology Readiness Level (TRL)



Desired Partnership

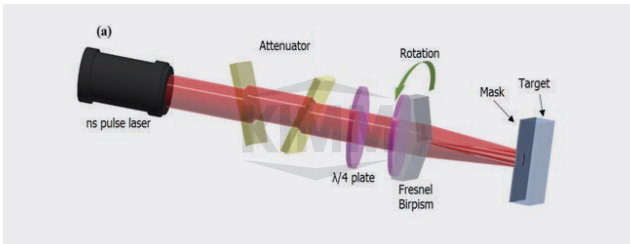


# High-Speed Large-Area Micro Patterning Technology Using Pulse Laser Intervention

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Jihwan Noh ▶ Contact: +82-42-868-7915

Technology Overview

- Night monitoring system technology using pulse later lighting to detect an object at a long distance



Customer / Market

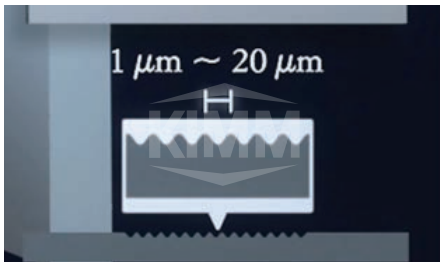
- Laser machining device
- High-speed micro pattern maker users (e.g. anti-forgery pattern making, pattern making for catalyst contact area increase for fuel cell or solar cell)

Problems of Existing Technology or Necessity of this Technology

- Existing focus type laser machining has limits regarding diffraction that machining of small patterns is difficult and the machining time is long due to stage moving, etc.
- Research on laser intervention machining is being conducted to overcome the problem of above focus type laser machining, however, the research is limited to continuous wave laser with excellent coherency that it can only be applied to a photosensitizer.
- Therefore, a high-speed micro patterning technology that can be directly applied for various materials-metal surface, in particular-is demanded.

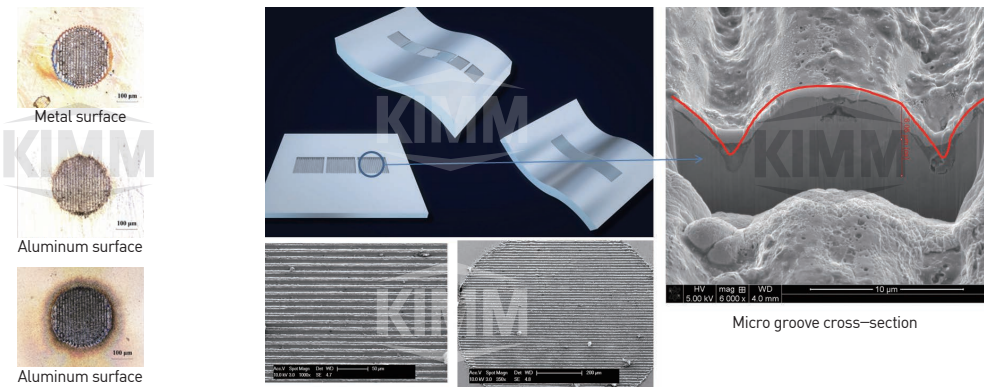
Technical Distinctiveness

- Passible to perform one-shot patterning onto a large area-high-speed patterning with the speed of 5 n sec
- Possible to create micro patterns with the pattern pitch size between 1 and 20 μm
- Possible to perform patterning on all materials where the surface can be polished including metal surface



Excellence of Technology

- High-speed, large-area patterning technology is expected to shorten the processing time approximately up to 100 times compared to the existing method.
- Possibility of creating very small line or dot patterns with the pattern pitch size between 1 and 20 μm has been confirmed.
- Pattern making with this technology on various materials including metal, aluminum, and silicon wafer surface has been verified.
- The optical system can be easily rotated that it can create a line pattern with different column direction continuously at a high speed. Patterns generated with this method can be matched according to the serial number to be used for anti-forgery.
- A repetitive pattern can be created on a roll or curve by using this technology.



◁ Direct Patterning on Various Materials ▷

◁ Micro Patterning of 1 to 20 μm on Flat or Curved Plate ▷

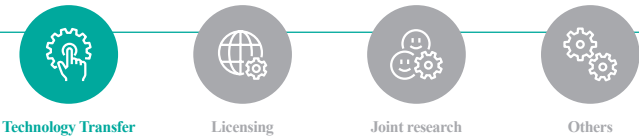
Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Anti-forgery Pattern Generation Device and Method (KR1764835)</li><li>• Anti-forgery Pattern Generating Device and Method (KR1688613)</li><li>• Anti-forgery Pattern Detection Device and Method (KR1685617)</li><li>• Anti-forgery Pattern Detection Device and Method (KR1597754)</li><li>• Anti-forgery Pattern Generation Device and Method (KR1528345)</li></ul>	<ul style="list-style-type: none"><li>• Synchronization technology for pulse laser, rotary optical system, etc.</li><li>• Pattern commissure precision machining technology</li></ul>

Technology Readiness Level (TRL)



Desired Partnership



# Long-distance Night Monitoring System Technology Using Pulse Laser Lighting

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Jihwan Noh ▶ Contact: +82-42-868-7915

**Technology Overview**

- Night monitoring system technology using pulse laser lighting to detect an object at a long distance

**Customer / Market**

- Domestic companies with demand for night monitoring device (surveillance camera, security system, etc.)
- Companies with demand for portable day/night monitoring device for military use
- Civilian industry (securing vision through smoke during fire, night vision for car, object alarm system for driving in fog or rain, unmanned night safety and security field, etc.)

**Problems of Existing Technology or Necessity of this Technology**

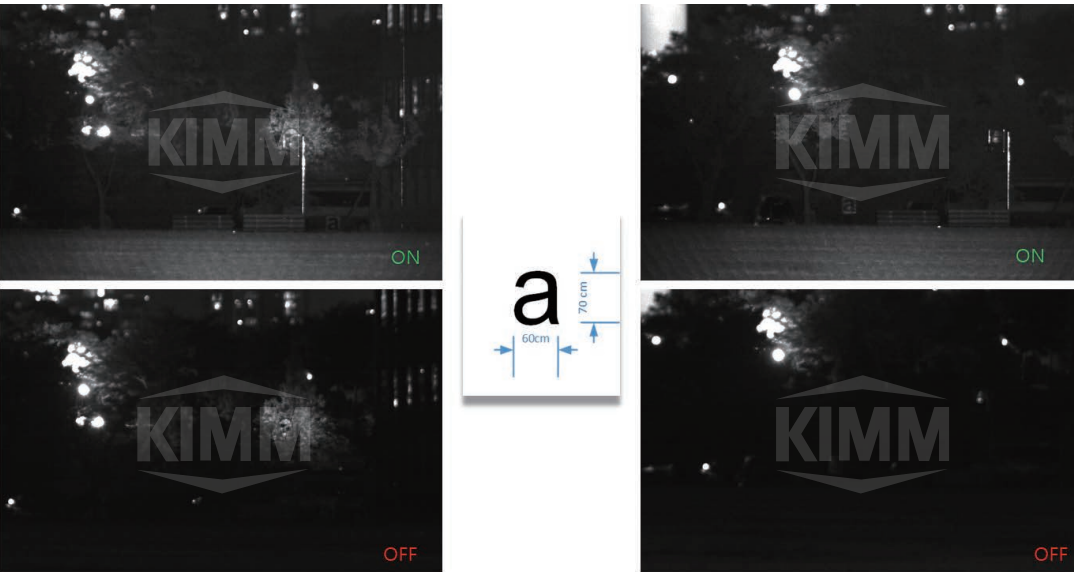
- Existing night monitoring system uses a large lamp or LED with a large divergence angle, which is insufficient for seeing objects at a long distance.
- The U.S. currently has the best technology for long distance night monitoring system, but the country has banned exporting this system, and it is unlikely that ban will be lifted in the future. If long distance night monitoring system can be developed in Korea, it will be a promising exporting item due to the export prohibition of corresponding system in the U.S.

**Technical Distinctiveness**

- Existing night monitoring system used a lamp or LED, but this technology uses laser which boasts better straightness than other light sources and enables to see objects from afar.
- Using near infrared laser that cannot be seen with eyes, it can visualize objects in the far distance, which makes it suitable for military use.
- Power consumption decreases with the use of pulse laser.
- Portable-size module is developed.

**Excellence of Technology**

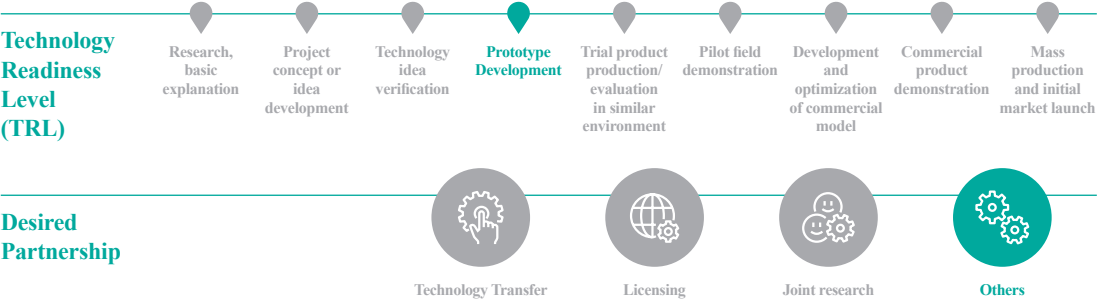
- Development of long-distance night imaging source using surface light emitting diode (VCSEL) is completed.
- With the narrow wavelength range, image can be obtained using a filter in fog or when interrupted with flame.
- Can be used for far distance up to several hundred meters.
- Using a device with this technology applied, the lower-case letter 'a'-size of 70 cm× 60 cm-was photographed from approximately 500m ahead at night both when the IR laser was on and off. It was confirmed that the letter 'a' could be detected when the IR laser is on.



**Current Intellectual Property Right Status**

**KNOW-HOW**

- Pulse laser lighting optical system design technology
- Pulse laser and image sensor synchronization technology
- Laser speckle removal technology
- Optics and jig design technology for optical system miniaturization
- Battery miniaturization technology



# Laser High Aspect Ratio Drilling Technology Using Tilt Angle Control Optic (Hole Depth: 5mm or less, Hole Diameter: over 10μm)

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Jihwan Noh ▶ Contact: +82-42-868-7915

Technology Overview

- Laser machining device for easy control of laser beam focus
- Groove machining method for adjustment of tilt angle using laser

Customer / Market

- Laser machining device
- Companies with demand for high aspect ratio drilling technology (e.g. engine nozzle manufacturers, etc.)

Problems of Existing Technology or Necessity of this Technology

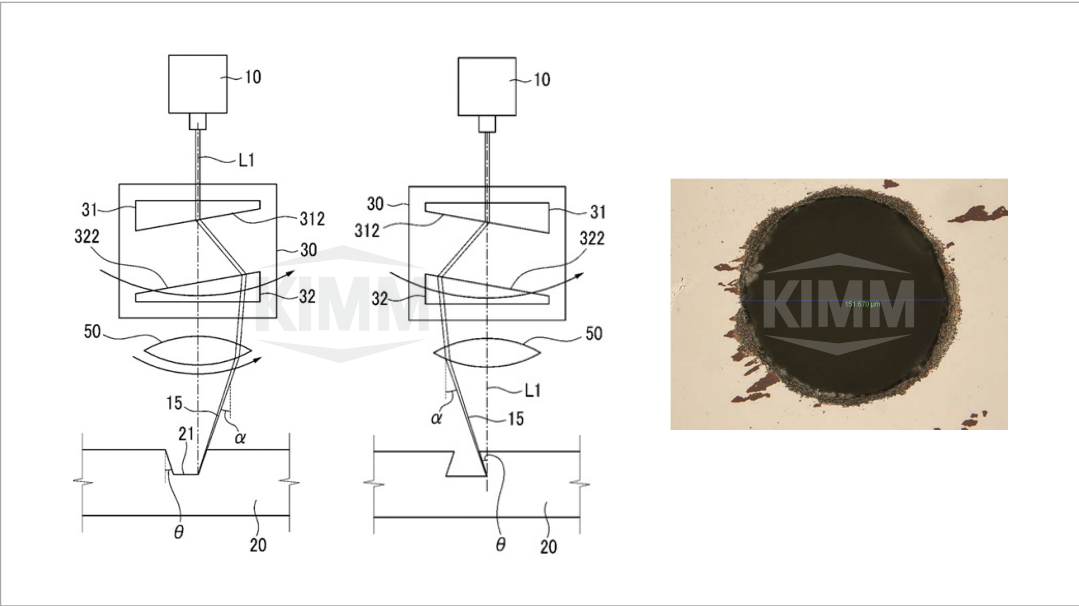
- Existing mechanical drilling has an issue of the high strength material easily breaking during drilling.
- Existing laser drilling adjusts the gaussian distribution of the beam strength to control the groove angle. In this case, the groove angle cannot be controlled precisely.
- With existing laser drilling, the laser beam or material can be tilted to adjust the angle, but in this case, the large device has to be adjusted, therefore precise angle change in micro units is difficult. Also, with the angle change, the reference point of the device changes, which also changes the focus and decreases the machining precision.
- The price for purchasing Germany's Trepanning laser product is considerably high.

Technical Distinctiveness

- Overcame the limitations of existing laser drilling
- The side tilt angle of groove can be adjusted through the axial precession using trepanning optics, which allows precise and easy side tilt adjustment.
- By rotating polarized light of laser beam, the processing speed and efficiency is improved.
- Miniaturized optical system
- Can be supplied at a lower price compared to existing trepanning laser products

Excellence of Technology

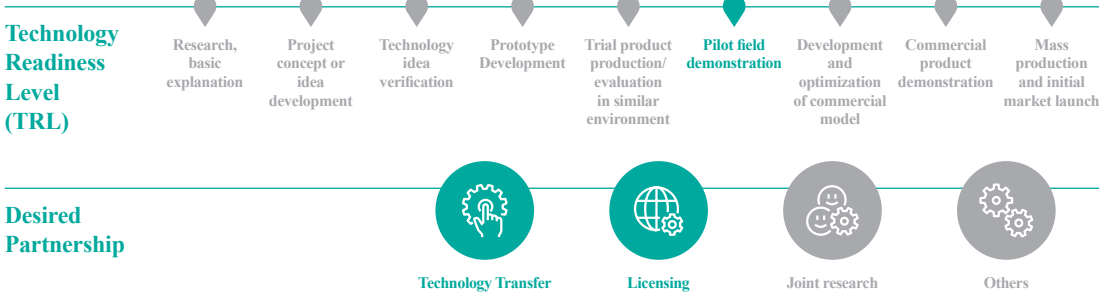
- Possible to perform high aspect ratio drilling-hole depth less than 5 mm and diameter over 10 μm
- Possible to process grooves in various forms
- Possible to process grooves in a difficult shape that cannot be processed with existing drilling technology
- Possible to easily adjust the groove's side angle



Current Intellectual Property Right Status

PATENT

- Groove Machining Method for Tilt Angle Adjustment Using Laser (KR1269835)



# Real-time Production Facility Information Collection System

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Seungwoo Lee ▶ Contact: +82-42-868-7147

**Technology Overview**

- System to collect and process production facility (machine tool) status information real-time System to collect the status information with system interface regardless of the facility type

**Customer / Market**

- Machine tool manufacturer
- Companies needing production information management system establishment (MES, Manufacturing Execution System) and process management system and SI companies

**Problems of Existing Technology or Necessity of this Technology**

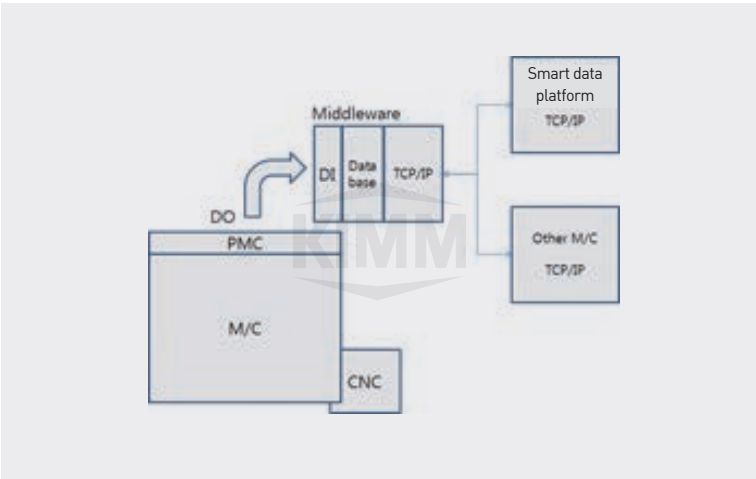
- Generally applying and extracting the status information is difficult as the specifications differ depending on the NC mounted on the machine tool.
- Regardless of the specifications of the NC mounted on the machine tool, desired status information is extracted and provided to the manager to process tertiary information.

**Technical Distinctiveness**

- Existing development extracts the status information from NC that the method of using and S/W are different depending on the NC type.
- Such methods require high cost or are inconvenient as the license for related S/W needs to be purchased separately.
- This development can collect status information from the machine tool's PLC (PMC) interface regardless of the NC type that limitations caused by NC type are surpassed and related cost is significantly decreased.

**Excellence of Technology**

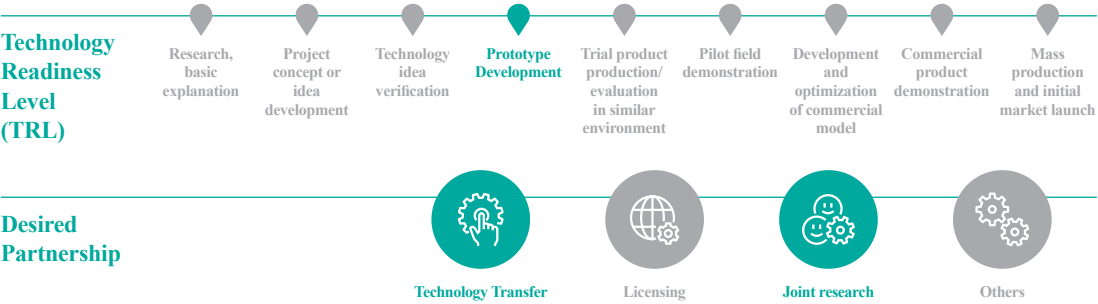
- The purpose of this technology is to use PLC (PMC) mounted to the machine tool to extract the status information of the machine tool; it can be mounted to the machine tool regardless of the NC specifications.
- This enables communication with other machine tools, and accumulated status information can be used as the foundation for establishing big data on status information of the machine tool.
- This enables establishment of 4th industry data platform and utilization of the information as backdata of related ICT program to lead to smartification of the machine tool.
- Provides convenience to the user by displaying the status information real-time



**Current Intellectual Property Right Status**

**KNOW-HOW**

- Heterogeneous machine tool interface standard design



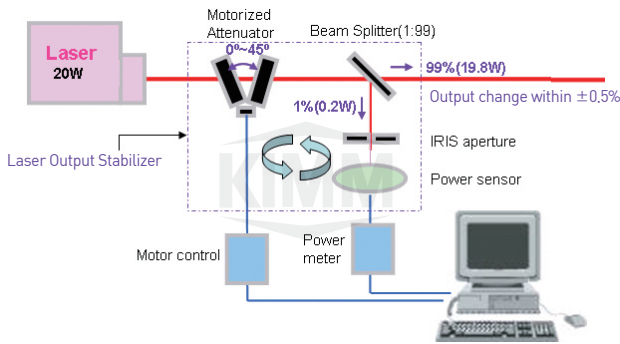


# Laser Patterning Technology for Microelectrode Fabrication on Various Surfaces

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Jehoon Lee ▶ Contact: +82-42-868-7471

Technology Overview

- Laser technology is able to realize electrodes (seed) on a curved or complex-shaped surface and produce micropatterns stably with a size under 20 microns using electroless plating



Customer / Market

- PCB-based electronic components, automobile industry
- Plastic-based manufacturing industry

Problems of Existing Technology or Necessity of this Technology

- Recently, the field of printing technology is expanding from 2-dimensional flat surfaces to 3-dimensional spaces, but a patterning technology on printed-curvedsurfaces is yet to be realized.
- For existing technologies including photolithography and printed electronics, various technologies have been developed based on planography, but due to fundamental technical limitations, it is impossible to print on the complex shaped-surfaces such as a curve.
- Also, there are issues such as the cost rise from a material waste, the increase in investment for complex processes, the environmental pollution problem from chemical processes, and low printing quality due to technical limitations.
- The new technology aims to expand the possible printing area, improve printing quality, reduce high production cost, and realize an eco-friendly process.

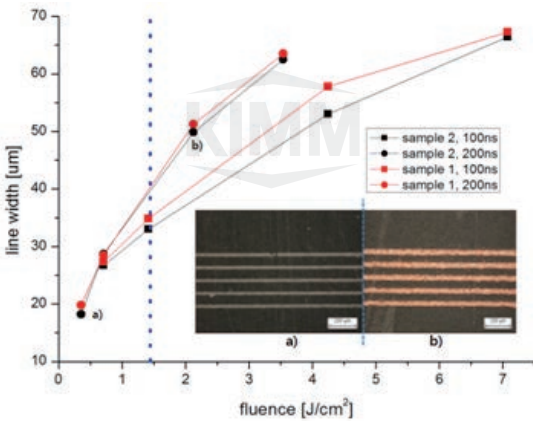
Technical Distinctiveness

- As the printing area is expanding using a high-performance laser, patterning can be done on a 3D structures that have curve or other complex shapes such as electronic clothes and new products can be developed and released.
- With the benefits of laser-high reproducibility and consistency, the highly stable printing technology can be achieved, resulting in great reduction of the defect rate.

- By minimizing the use of consumable materials such as various solutions and inks used for chemical processes, the cost of process can be reduced down to 20% in comparison to the current process cost.
- As the chemical process is minimized, the polluted wastewater can be significantly reduced and an Eco-friendly technology can be realized.
- As it enables realization of complex patterns, more freedom is given in terms of designing electronic circuits or components. As a result, it is also favorable for customized productions and small quantity batch productions.
- Existing technology only allowed plane-to-plane patterning, but with this technology, the focus of the laser can be adjusted to enable precise patterning on surface of any kind of shape (even complex surfaces).
- An existing printed electronics method has serious problems. Uneven line width and short circuit can be occurred for micropatterning. However, this laser technology will able to achieve less than 20 μm of micro line width and uniform the width of line width with high quality.
- The process is based on the direct patterning which is consisted of two stages; seed generation with laser irradiation and electroless plating. Therefore, the process is significantly simple and stable.

Excellence of Technology

- This technology is a type of LDS (laser direct structuring) patterning method whose key factors are the high-performance laser and photo-reactive insulation material.
  - High-performance laser should be able to pattern with a consistent line width. The photo-reactive material should be metallized after react with the laser, and act as a plating seed (aluminum) for electroplating.
- By exhibiting this technology at 'Nano Korea 2012' with the company that participated in the technology development, the excellence of the technology was proven.
- The senior researcher has over 20 years of research experience.



〈 Line Width Depending on Laser Intensity 〉

Current Intellectual Property Right Status

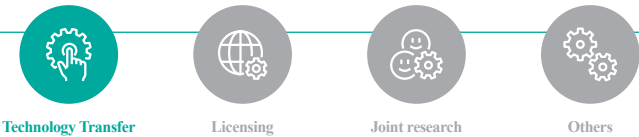
PATENT

- Manufacturing System of Flexible Printed Circuit Board using Laser and Manufacturing Method Thereof (KR1377273)
- Flexible Printed Circuit Board Having Conductive Circuit Pattern by Laser Direct Writing Method and Manufacturing System and Method Thereof (KR0906408) and Others

Technology Readiness Level (TRL)



Desired Partnership

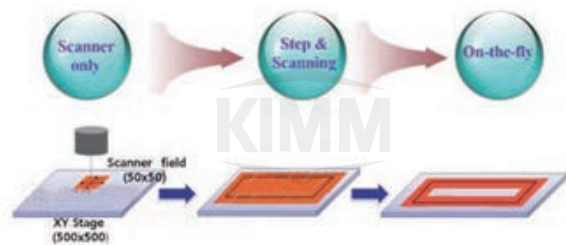


# Scanner-Stage On-the-Fly System for Continuous Laser Process on Large Area

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Jehoon Lee ▶ Contact: +82-42-868-7471

Technology Overview

- Real-time synchronization of scanner and stage enables continuous and high-speed processing for a large area, and is also able to obtain consistent quality for patterning and short process time (20 % of reduction).



Customer / Market

- Laser processing market

Problems of Existing Technology or Necessity of this Technology

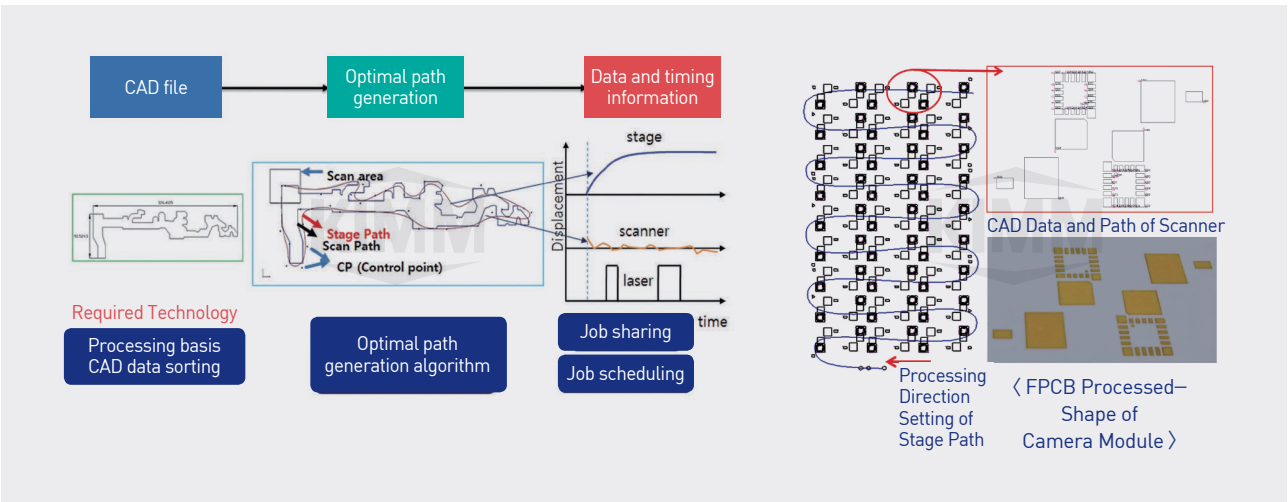
- To design a system for continuous high-speed/precise laser processing for a large area, a scanner control board, synchronization algorithm, and on-the-fly system need to be developed.
- An existing laser processing using a scanner had a limitation regarding to working area, and processing on a large area was impossible.
- To overcome this limitation, the step & repeat method using a stage and a scanner has been used, but the unevenness (discontinuity) at the boundary cannot be eliminated. Decreasing the degree of precision at the corners due to acceleration and deceleration of the stage is still a challenge.
- Recently, the industries demand higher degree of precision and larger processing area in the laser micro processing field

Technical Distinctiveness

- The laser micro processing has been applied to a limited area, but this technology enables the continuous processing on a large area.
- For a process that uses laser, the technology enhances the quality uniformity, resulting in increase of the yield rate. With the continuous processing, the process time is shortened by approximately 20%.
- Beyond the limitations of the size of laser processing, the scanner and the stage are synchronized to eliminate an inconsistency that occurred with the scanner process. With the continuous processing method, the shorten process time and the increase of degree of precision can be achieved.

Excellence of Technology

- Technology uses a large area CAD file, and separates the paths for the scanner and the stage for processing
- The algorithm for drawing the stage and scanner paths and the simulator to realize it were developed.
- Applied to large cover glass pole film cutting (Technology transfer).
- The technology has been published multiple times including 7 international journals.
- The stage and scanner paths for camera module cover layer cutting were deduced.
- The developed on-the-fly technology is able to achieve high precision and short process time by the continuous processing.
- Has over 20 years of research experience in laser-related technologies



Current Intellectual Property Right Status

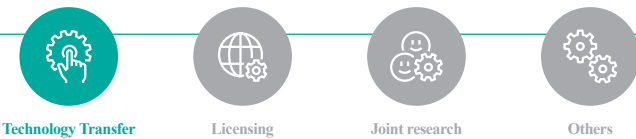
PATENT

- Auto-paging Method Having Scanner-stage Synchronization (KR2012-0058715)
- Synchronization Method for Stage and Scanner (KR1244218)

Technology Readiness Level (TRL)



Desired Partnership

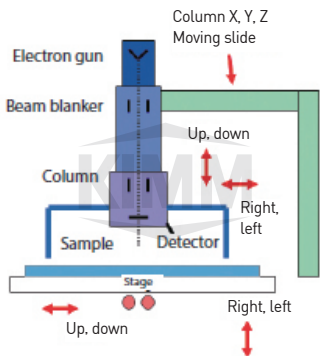


# Electron Microscope with Moving Chamber

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Sunjong Lim ▶ Contact: +82-42-868-7133

Technology Overview

- Electron microscope with vacuum chamber of moveable structure.



Customer / Market

- Nano industry

Problems of Existing Technology or Necessity of this Technology

- Amid its high resolution, electron microscope requires the specimen to be placed in the vacuum chamber to acquire images of the specimen. Therefore, if the size of the specimen is large, the specimen has to go through pre-treatment such as cutting that specimen.
- When vacuum is formed inside the vacuum chamber, the entire space inside the above-mentioned vacuum chamber must be formed in a vacuum at all times, requiring more costs to create a vacuum system.
- Currently, most electron microscope uses the method of placing the specimen in the chamber, which limits the specimen size.
- The only way to see a large sample is to have a large chamber.
- The production cost (chamber, vacuum pump) increases greatly as the size of vacuum chamber increases.
- Depending on the environment, the optical design needs to redesign for a large chamber.

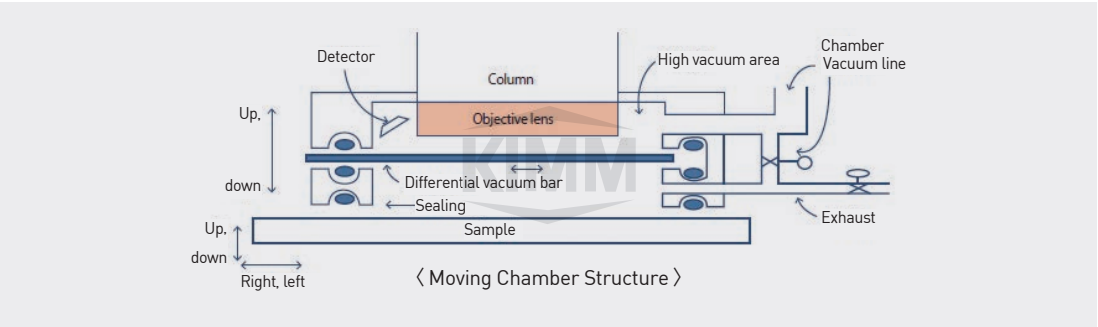
Technical Distinctiveness

- With the moving chamber, the original object can be directly observed without preparing sample specimen.
- Possible to observe a large specimen.
- Observation of large samples compared to conventional electron microscopy
- Advantageous in the aspects of vacuum forming speed

- Inspection method: How to test: Insert the air blanker inside the vacuum chamber unit./Put air in the space between the air blanker and the specimen or stage and then move the electron microscope./Vacuum the space between the air blanker and the specimen or the stage and move the beam blanker backwards./Observe the specimen.
- When the chamber moves, the air breaker is closed. The bottom chamber is filled with air entering through the exhaust. The atmospheric pressure in the bottom chamber makes the chamber movement smooth (up, down, left, right)
- When observing the sample, the chamber come down, the exhaust is closed, and air breaker and the bottom vacuum line open to form vacuum.

Excellence of Technology

- The column can move up, down, left, and right along the slide.
- The stage can also move along the x, y, and z-axis.
- Moving chamber is composed of two small chambers.
- The upper chamber (near object lens) is separated from the lower chamber (near sample) by the air breaker.
- The air breaker is always closed to allow the upper chamber to maintain a highdegree vacuum and is only opened for specimen observation.
- The exhaust port on the lower chamber is where air is injected to create atmospheric pressure when the chamber moves.
- The vacuum line in the lower chamber quickly creates vacuum of the lower chamber during sample observation.



Current Intellectual Property Right Status

PATENT

- Electron Microscope with Detachable Vacuum Chamber Unit and Testing Method (KR1395258)
- Electron Microscope with Detachable Vacuum Chamber Unit (KR1421090)
- Deflection Coil of Electron Microscope (KR1421094)
- Electron Microscope with Mobile Vacuum Chamber and Specimen Testing Method (KR1395261)

Technology Readiness Level (TRL)



Desired Partnership

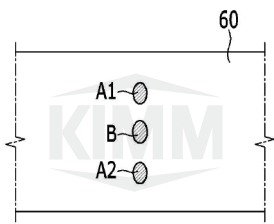


# Multi-beam Technology for Improving Laser Machining Speed and Efficiency of Transparent Substrates

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Jiyeon Choi ▶ Contact: +82-42-868-7536

Technology Overview

- Generating a multi-focus laser beam inside the transparent substrate to enable cutting a substrate thicker than the depth of focus or drilling of micro holes with high aspect ratio.



Customer / Market

- Laser machining system manufacturer, display manufacturer, companies using precise cutting or micro machining of glass/sapphire/wafer

Problems of Existing Technology or Necessity of this Technology

- Technology for high speed cutting a transparent substrate thicker than the depth of the single focus laser beam with one scan is needed.
- To cut a transparent substrate thicker than the depth of focus of the laser beam, a focusing lens with lower magnification needs to be used to increase the depth of focus, or laser beam has to be scanned multiple times with readjusted focus point to cover the thickness of the substrate.
- When using a focusing lens with low magnification, the cutting width is broadened, and machining becomes less precise.
- When processing multiple times by adjusting the focus along the substrate, the overall cutting speed becomes slow, which leads to decreased productivity.
- A multi-beam with adjustable number of focus and spacing between the focal points depending on the substrate thickness needs to be created.

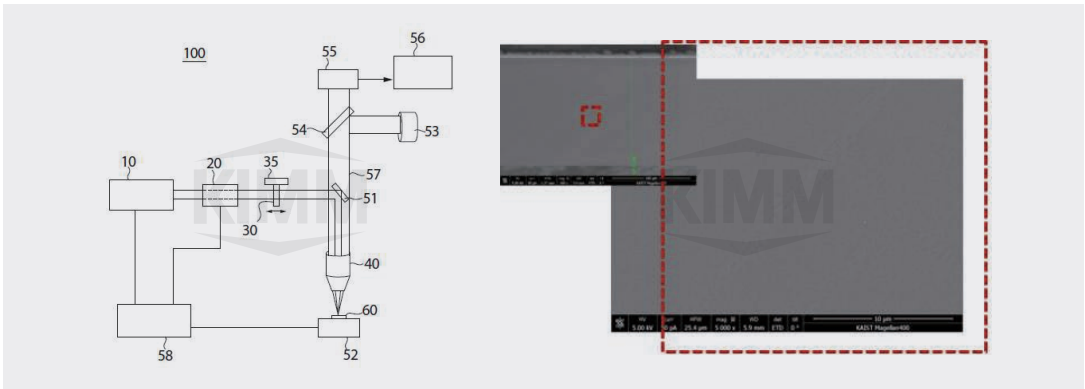
Technical Distinctiveness

- By splitting the laser beam into two or more beams and adjusting the spacing between the focal points to efficiently align them to suit the thickness of the object, and then cut or bore with the multi-focus beam, the process time is shortened as the process speed is faster compared to a laser machining system that uses a single focus.
- If a high-power laser is used as single-focus beam, the optimal output for machining is lower than the maximum laser output that the laser output needs to be lowered, which means the laser's capability is not exercised 100%. However, by machining with multi-beam, the laser intensity is maintained at its optimal output and the laser's maximum capacity is utilized.

- Compared to existing beam splitter (divided into interference method and birefringent lens splitting method), the multi-focus device using diffractive optical element (DOE) splitter has following benefits.
  - By using the DOE splitter as the beam splitter, all beams propagate same optical path until being split by the object lens. The optical configuration becomes simple, and beam alignment is easy.
  - Maintaining the polarization direction, which is not possible with polarization splitting
  - Possible to adjust the number of focal points and spacing: By adjusting the DOE optical system, multiple beams set according to the number assigned are aligned, and the spacing between the beam inside the glass is easy-favorable for cutting and micro machining of glass of various thickness.

Excellence of Technology

- The purpose of this technology is to adjust the number and distribution of laser beams according to the substrate thickness for cutting, drilling, or bonding transparent materials and achieve optimal energy distribution of the beam for machining inside the substrate.
- Optical configuration is simple as DOE acts as a laser beam splitter and a lens.
- Split beams propagate along the same optical path, and are precisely split at the object lens focus point to form multiple focal points inside the object along the thickness of the substrate.
- The number of beams can be assigned as desired to be applied on thin or thick glass plates.



Current Intellectual Property Right Status

PATENT

- Substrate Cutting Method Using Fresnel Zone Plate(KR1015826320000)

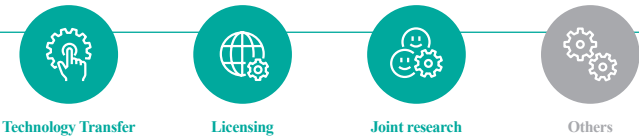
KNOW-HOW

- Ultrashort pulsed laser-based micromachining technology of brittle materials (glass, sapphire, quartz, silicon wafer)

Technology Readiness Level (TRL)



Desired Partnership





# Micro Part Manufacturing Technology with Laser Glass Direct Bonding and Laser-induced Selective Etching

▶ Department of Laser & Electron Beam Technologies ▶ Researcher: Jiyeon Choi ▶ Contact: +82-42-868-7536

Technology Overview

- Laser glass direct bonding: Laser sealing technology where two glass plates are directly welded without adhesive to seal
- Laser-induced selective etching: creating micro 2.5D/3D structures by maskless laser direct patterning of desired patterns on the transparent brittle plate such as glass plates (fused silica, borosilicate) or sapphire followed by laser-induced selective etching with the area where laser is irradiated

Customer / Market

- Device manufacturer requiring alternatives to MEMS process
- Medical device and component manufacturer
- Display, aerospace, sensor device manufacturer

Problems of Existing Technology or Necessity of this Technology

- Existing glass bonding technology:
  - The existing technology using glass frit between two glass plates to bond and melting the frit with laser leads to significantly lower bond strength compared to direct bonding of the plates as moisture and air can penetrate the gap between the plates where the frit has been applied.
  - It is difficult to apply the conventional method of heating the entire area for bonding if the plate has patterns that are vulnerable to heat.
- Laser-induced selective etching:
  - It is difficult to drill a micro through hole of high aspect ratio on brittle materials like glass and quartz plates using mechanical machining.
  - Also, it is impossible to form a 3D embedded channel inside the plate.
  - Micro machining with laser ablation requires expensive high-powered system, and to adjust the taper angle, expensive trepanning optical system is required.

Technical Distinctiveness

- Laser glass direct bonding:
  - This technology uses tightly focused ultrashort pulsed laser beam to instantaneously melt local zone of the glass plate to directly bond the interface of two glass substrates, and it does not require adhesive, frit, or absorption layer, which means clean bonding and the bonded area remains transparent.
  - The bond strength is superior than bonding with heterozygous materials.
  - The size of welding seam from bonding is only dozens of micrometer and following the premachined pattern on the plate surface, bonding can be done locally with the direct writing method. Heat-sensitive device and circuit are protected while welding around the pattern.
- Laser-induced selective etching:
  - This technology uses less energy than ablation that it can be run with low-power laser system. The depth of machining on the transparent plate is determined by the focus point that various shape of 3D structures can be manufactured.

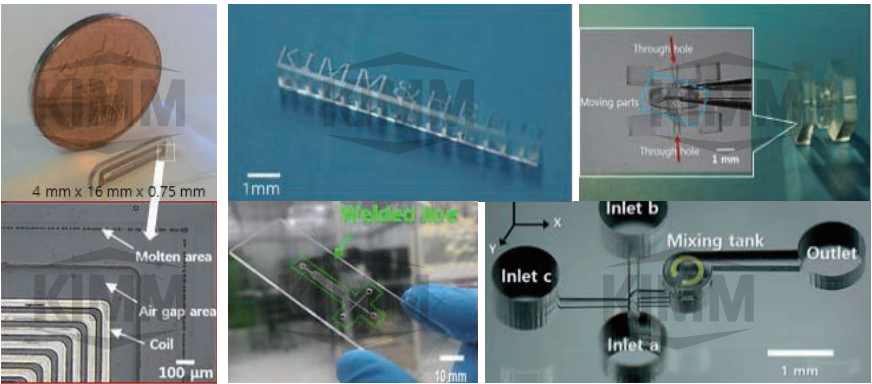
- Laser glass direct bonding:
  - Enables hermetic sealing of MEMS components and organic component vulnerable to air and moisture
  - Possible to manufacture implantable subminiature sensor and medical components as the device can be manufactured using bio compatible glass-without using harmful adhesive
- Laser-induced selective etching:
  - Possible to process a through hole, blind hole with high aspect ratio through selective etching (aspect ratio over 1:10)

Excellence of Technology

A Through Hole (Thickness: 2 mm) and a Nozzle (Thickness: 3 mm) Created on a Glass Substrate With Laser-Induced Etching



Blood Pressure Sensor, Lab-on-a-Chip and Micro Mixer Made With Laser-Induced Selective Etching and Laser Direct Bonding Technology



Current Intellectual Property Right Status

PATENT

- Bonding Method of Multiple Member Using Ultra Short Pulse Laser (KR1453855)
- Bonding Device Using Laser and Bonding Method of Multiple Member Using the Device (KR1528344)
- Micro mixer (KR2020-0088744)

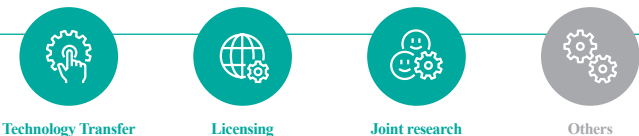
KNOW-HOW

- Ultrashort pulsed laser-induced glass selective etching technology (ultrashort pulsed laser direct writing technology and maskless etching process know-how)
- Ultrashort pulsed laser glass direct bonding know-how
- Bond strength and quality assessment know-how

Technology Readiness Level (TRL)



Desired Partnership



Wearable Walking Assist Device

▶ Department of Robotics and Mechatronics ▶ Researcher: Seyoung Kim ▶ Contact: +82-42-868-7614

Technology Overview

- A wearable walking assist device refers to a wearable device that is coupled to the lower extremities of the human body and assist propulsion to reduce energy consumption during walking/running or amplify propulsion to overcome limitations in motor ability.
- Wearable walking assist devices are largely divided into a powered exoskeleton that uses electric, pneumatic or hydraulic actuators, and an unpowered exoskeleton that operates in synchronization with the movement of the human body without a power source.



Customer / Market

- Workers who walk for a long time in logistics/factories/supermarkets and related industries
- The elderly and patients who have difficulty in walking, hospitals or businesses related to the rehabilitation equipments
- General public who enjoy hiking/trekking and sports/leisure-related businesses

Problems of Existing Technology or Necessity of this Technology

- It is bulky and heavy, and cannot practically assist or strengthen motor ability.
- It restricts the degree of freedom of motion of the human body when worn, preventing natural movement.
- For methods that use the ground collision energy, the mechanical part is located under the bottom of the foot, causing the height-increasing phenomenon and unstable posture.
- For the powered exoskeleton, it is difficult to respond effectively in situations other than the operation scenario, and the installed battery is consumed fast.
- For the unpowered exoskeleton using passive elastic elements, it is difficult to increase the stiffness of the elastic elements by more than a certain level as it can inevitably interfere with the natural motion in the process of storing energy as the energy must be stored first to use the released energy.

Technical Distinctiveness

- By using the independently developed clutch, the energy storage and release time of the elastic body is synchronized with the change in the gait phase, thereby effectively and practically supporting the walking function of the human body without an actuator [Figures 1 and 2].
- The ankle joint and metatarsophalangeal (MTP) joint movement is not restricted, the height from the ground is minimized, and the ground impact energy is utilized for propulsion [Figure 3].
- Equipped with a mechanism that generates high power during walking/running without interfering body movement [Figure 4].

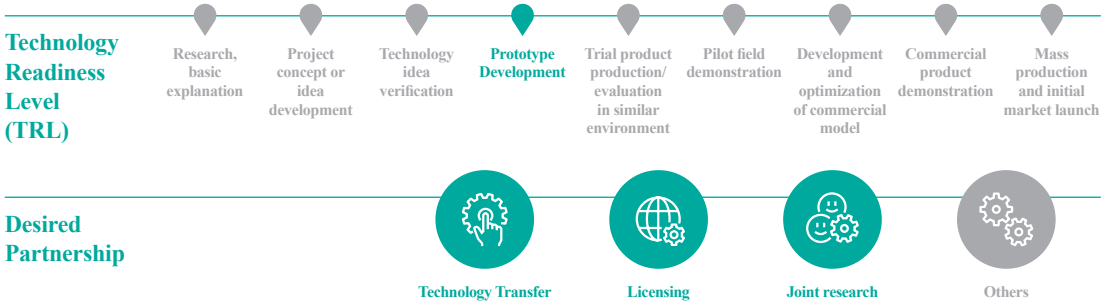


Excellence of Technology

- By recycling the rotational force of the lower limb generated during walking as the driving force necessary for movement, it is a device that maximizes the aided driving force through a design based on biomechanics.
- Discomfort in movement is minimized by limiting the operation of the device other than when energy is stored and released through the clutch mechanism.
- It contributes to practically enhancing motor ability and saving energy by using curved footrests and springboard mechanisms.
- Practical propulsion is amplified by mounting a high elastic energy storage and release mechanism.
- It improves motor function and fatigue strength of lower extremities and prevents musculoskeletal disorders through effective exercise assistance.
- A compact and lightweight wearable device can be used as an entry-level wearable locomotion platform.
- Registered 11 patents for wearable walking assist device-related mechanisms.
- Produced prototype and verified the basics as a research outcome of institution-specific project and Alchemist project

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Torque clutch mechanism for passive elastic ankle exoskeleton (KR1855838)</li><li>• Passive Elastic Ankle Exoskeleton Capable Biofeedback (KR2035510)</li><li>• Wearable device for supporting ankle stiffness and that method (KR1650101)</li><li>• Ankle foot orthosis for supporting ankle joint power (KR1696771)</li></ul>	<ul style="list-style-type: none"><li>• Biomechanics-based clutch design and application to maximize propulsion assistance/amplification</li><li>• Design and application of high power mechanism for ankle propulsion</li></ul>



# Anthropomorphic Robot Hand

Department of Robotics and Mechatronics   Researchers: Hyunmin Do, Uikyum Kim   Contact: +82-42-868-7130

## Technology Overview

- The anthropomorphic robot hand is a robotic technology that aims to mimic the function of a human hand capable of handling various objects and tools in daily life. It imitates human hand movements, not just simple gripping movement, to have high flexibility in operation.
- In addition, it can be used as an end-effector with high potential for application from service robots to industrial robots.



## Customer / Market

- Service/Industrial robot development/manufacturing company
- End-effector research platform developer company
- Robot SI company

## Problems of Existing Technology or Necessity of this Technology

- Anthropomorphic robot hand technology is highly in need in various fields, but its use is limited due to difficulties in manufacturing, high price, and lack of functions.
- Previously developed robot hands are difficult to be attached to the robot arm (manipulator) as they require an additional space for actuation unit in a shape similar to that of the forearm to implement many degrees of freedom.
- Intuitive control is difficult, and most of them have difficulties in manufacturing and maintenance due to complex parts. In addition, there are limitations in securing strong gripping force and high degrees of freedom.



## Technical Distinctiveness

- By developing a mechanism with the same degree of freedom as a human hand using the link-driven method, simple configuration and easy maintenance are possible.
- Since all actuation units are embedded inside the palm and modularized, it can be easily mounted on a variety of robot arms.
- Strong gripping force and high durability are realized based on the developed mechanism, and the structure is easy to attach the tactile sensor. Intuitive control is possible due to the link-driven structure, which makes it highly useful.

## Excellence of Technology

- As shown in the figure below, although it is a modularized form that can be easily attached to the robot arm, it has very important features such as strong gripping force, size and degrees of freedom similar to that of human hand, and easy maintenance.
- The strong gripping force that can crush an aluminum can and the delicate manipulation that can handle eggs or tweezers are all verified through experiments.
- It is possible to operate even high-level tools such as scissors, sprayers, and tweezers. In addition, it can handle objects of various shapes in a stable manner as shown in the figure below.
- The detailed mechanism for fingertip force sensor technology in the robot hand has been applied for a separate patent.
- Prototype was implemented and verified as a result of research on Industrial Technology Innovation Project (Apr. 1, 2018-Dec. 31, 2019) and Creative Seed-Type Project (Jan. 1, 2020-Dec. 31, 2020).



## Current Intellectual Property Right Status

### PATENT

- Finger Apparatus and Robot Hand Having the Finger Apparatus(KR2018-0158272)
- Finger Apparatus Being Close to Human Finger and Robot Hand Having the Finger Apparatus (KR2019-0167204)
- FINGER APPARATUS AND ROBOT HAND HAVING THE FINGER APPARATUS (PCT/KR2019/017390)

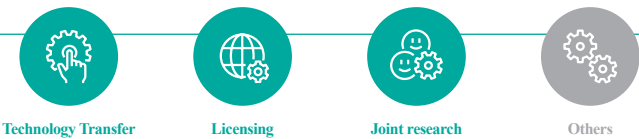
### KNOW-HOW

- Control algorithm for robot hand

## Technology Readiness Level (TRL)



## Desired Partnership



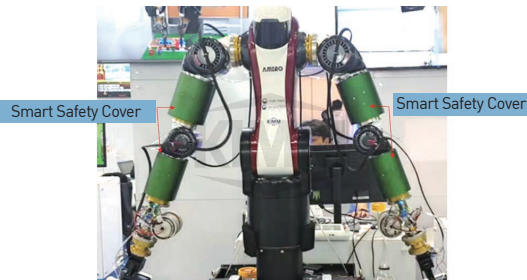


Smart Safety Cover

▶ Department of Robotics and Mechatronics ▶ Researchers: Euigyeom Kim, Chanhoo Park ▶ Contact: +82-42-868-7130

Technology Overview

- Smart safety cover is a device that can measure the magnitude, direction, and position of force when it comes into contact with an object while being used as a cover for various mechanical structures including robot manipulators.
- In particular, as it can be installed on a robot manipulator and used as a safe cooperative robot, it is possible to provide an environment where robots and humans can coexist. It enables human-robot collaborative work by measuring abundant information on human distance and contact force.



Customer / Market

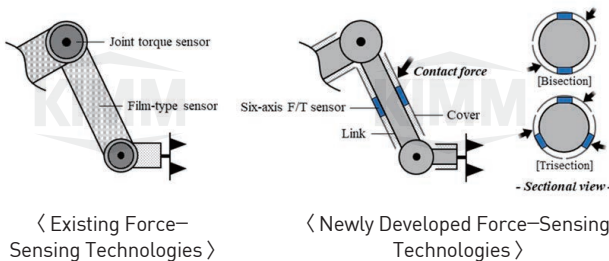
- Industrial robot development/manufacturing company
- Instruments requiring force measurement
- Robot SI companies

Problems of Existing Technology or Necessity of this Technology

- Although various force sensor coupling studies are being conducted to equip the robot manipulator force measurement function, the technology so far is difficult to couple the sensor to the robot skin (cover), and there are limitations in measuring various force information.
- When using a joint torque sensor, it is difficult to obtain detailed force information as only one joint torque is measured, and there is a problem that the precision of the robot is degraded according to the stiffness of the sensor.
- Film-type sensor, in particular, is difficult to be applied in a large area, which can cause an increase in cost. Moreover, there is a big limit in terms of actual robot utilization as wiring is difficult.

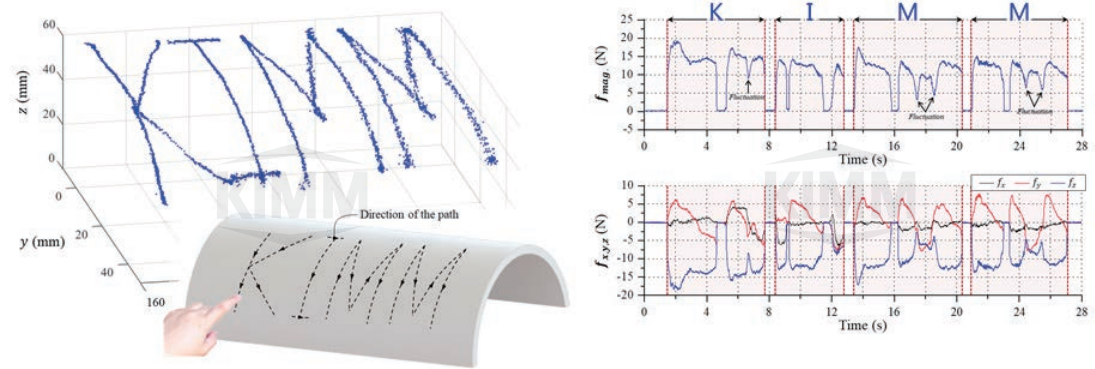
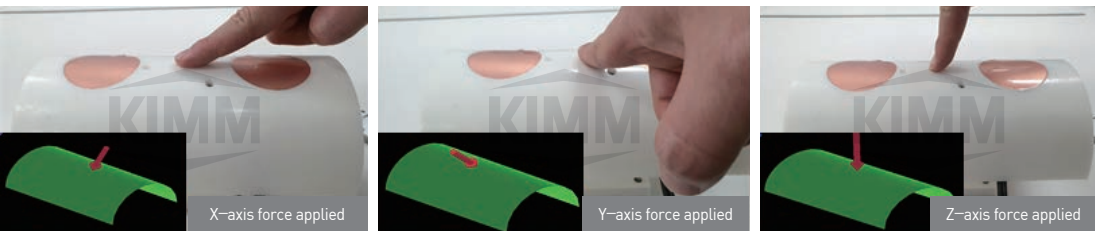
Technical Distinctiveness

- It can realize the force sensing function without changing the outer shape of the cover necessary to protect the inner part of the robot or mechanical device.
- Since only one multi-axis sensor is used per cover, the configuration is very simple and wiring is easy, which is very advantageous in terms of robot coupling.
- It not only measures the normal force, but also measures the force of three orthogonal axes. It is very useful in that it can measure even the three-dimensional contact position.



Excellence of Technology

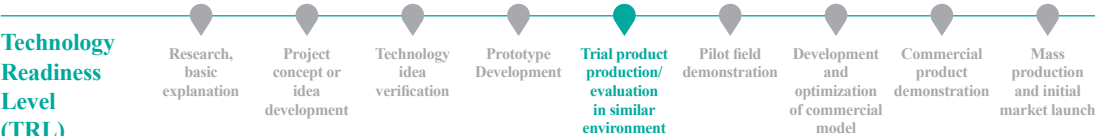
- The contact force of all 3 axes can be measured, making it possible to detect force in multiple directions. As shown in the figure below, X, Y, and Z directions can be detected, and even the position of the force can be measured very precisely.
- Since only one sensor is combined with the cover and the inner part of the robot, the structure is very simple, which lowers the cost and makes combination advantageous.
- As shown in the figure below, the accuracy is high enough to write letters on the cover with contact force information, and it is also possible to precisely measure the 3-axis force information while writing.
- The 6-axis force/torque sensor technology related to this device has been applied for a separate patent.
- Prototype production and verification have been completed as a research result of Human-Friendly Robot Technology Development Project for Human-Robot Coexistence Production Environment (Jan. 1, 2018-Dec. 31, 2020)



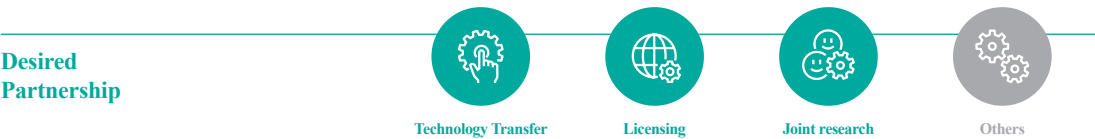
Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Robot manipulator (KR2076907)</li><li>• Structure for Sensing External Force Applied to Robot (KR2019-0126391)</li></ul>	<ul style="list-style-type: none"><li>• Force-measuring algorithm according to cover shape</li></ul>

Technology Readiness Level (TRL)



Desired Partnership



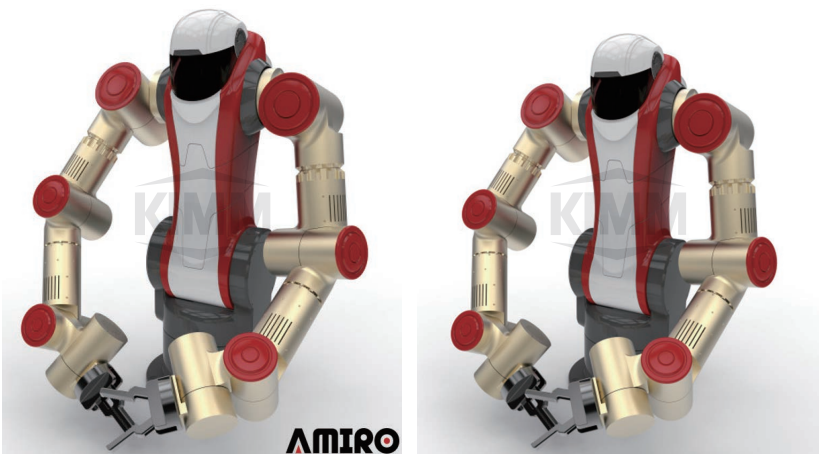


# Hollow Driving Module Technology for Slim Robot Arm

▶ Department of Robotics and Mechatronics ▶ Researchers: Euigyeom Kim, Chanhoon Park ▶ Contact: +82-42-868-7208

Technology Overview

- Modularized robot technology for various specifications and applications that users can easily produce
- Hollow Driving module that allows cables (or wires) to pass directly through the axis of rotation axis of robot arm which constructed with multiple modules.



Customer / Market

- Robot manufacturer

Problems of Existing Technology or Necessity of this Technology

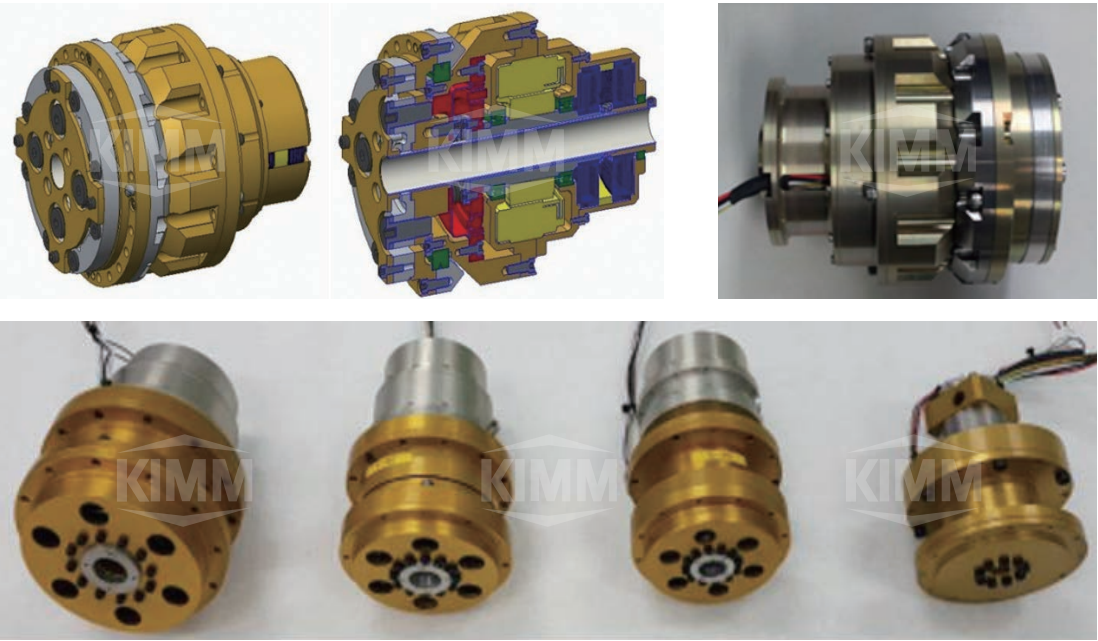
- In the past, there was a problem of having to manufacture various types of robots in the manufacturing stage to meet various specifications and applications.
- Cables had to be installed externally, which caused issues with appearance/safety.
- Cable/wire limits the range of movement/rotation of the robot.

Technical Distinctiveness

- Only the module with an issue can be taken out for inspection-easy maintenance/ repair.
- As an independent product, a module with motor, reducer, encoder, brake, and driver can be provided.

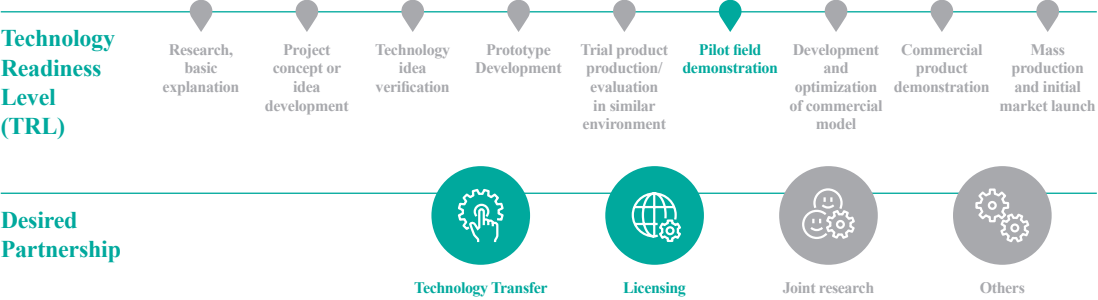
Excellence of Technology

- Simple design secured with application of the hollow driving module
- Development of dual arm robot hardware platform and controller, robot element technology, and driving component commercialization completed
- Serialization by driving capacity
- Reliability evaluation standard established and life test completed



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Hollow driving module(JP5659446)</li><li>• Structure of Modular Robot Actuation System (JP5541600, CN102307708)</li><li>• Hollow Driving Module (US9293962, JP5659446, CN103358316)</li></ul>	<ul style="list-style-type: none"><li>• Joint sagging compensation through composite encoder arrangement</li><li>• Lightweight/compact robot joint module design</li><li>• Motor, reducer, encoder, brake and controller integration technology</li></ul>

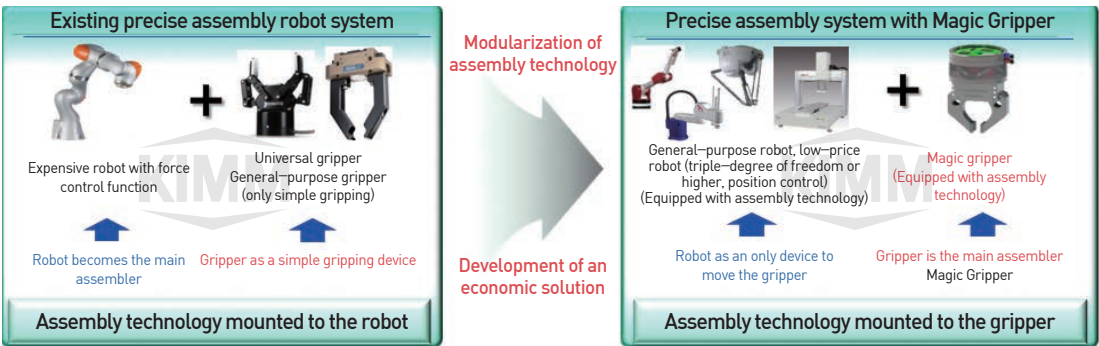


# Gripper for Assembly and Assembling Technology Applicable for Wide Use Industrial Robot

▶ Department of Robotics and Mechatronics ▶ Researchers: Hwisu Kim, Chanhoon Park, Dongil Park ▶ Contact: +82-42-868-7208

Technology Overview

- All-in-one magic gripper for precision component assembly and assembly process technology using the gripper
- Passive compliance gripper integrating teaching technology, correction technology, and assembly strategy for precision IT product components assembly, assembly robot system and assembly technology
- Assembly process analysis and gripping mechanism
- Practical assembly strategy for precision component assembly
- Passive compliance gripper for assembly process
- Vision solution strong against external environment



Customer / Market

- Robot manufacturer

Problems of Existing Technology or Necessity of this Technology

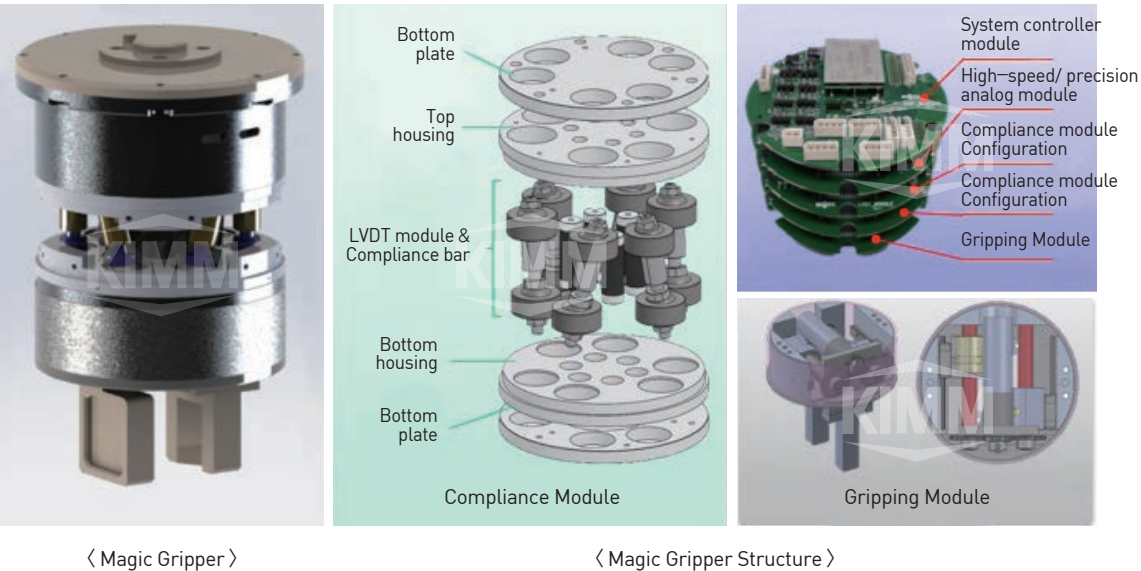
- Existing gripper can only perform grabbing works
- It is not able to apply appropriate stiffness for assembly and calculate the deviation from the target position that it is not suitable for precise assembly.

Technical Distinctiveness

- Magic gripper enables position control based robot can be used for precise assembly tasks.
- Deviation from the target position can be calculated without force-torque sensor
- Precise assembly is possible as the deviation is reflected in the robot's paths.

Excellence of Technology

- Can be applied in various fields including IT component assembly for mobile phone and smart pads, assembly of small precision components like connector, and precision machine component assembly
- Performance test completed



Current Intellectual Property Right Status

PATENT

- Assembly Teaching Method Using Variable Passive Compliance Gripper (KR1688866)
- Passive Compliance Gripper with Displacement Measurement Function and Variable Passive Compliance Gripper (KR1688867)
- Variable Passive Compliance Gripper (KR1682358)
- Assembly Control Method Using Passive Compliance Gripper with Displacement Measurement Function (KR1684894)

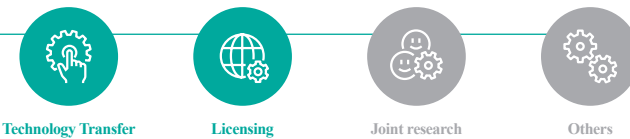
KNOW-HOW

- Magic Gripper realization for using existing position control-based robot for assembly work
- Gripping module, compliance module and controller integration technology
- Precision component assembly technology

Technology Readiness Level (TRL)



Desired Partnership

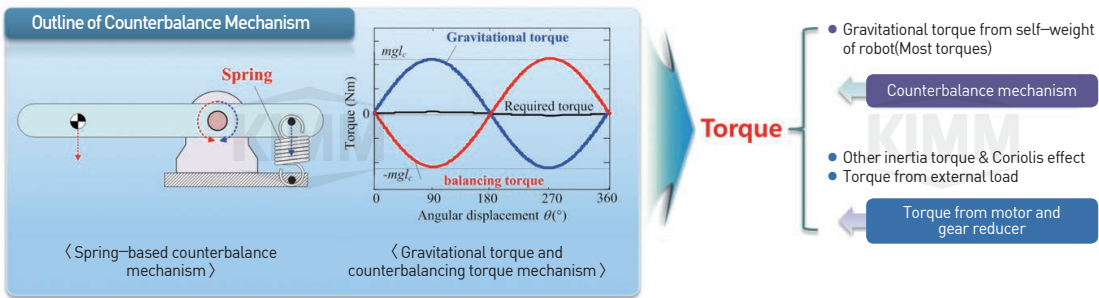


# Counterbalance Robot Arm for Human–Robot Safety

▶ Department of Robotics and Mechatronics ▶ Researchers: Hwisu Kim, Dongil Park ▶ Contact: +82–42–868–7208

## Technology Overview

- Counterbalance mechanism to minimize required power to operate robot arms and human–friendly manufacturing robot platform with intrinsic safety.
- Technology for designing counterbalance robot arm



## Customer / Market

- Robot manufacturer

## Problems of Existing Technology or Necessity of this Technology

- With increasing interest in collaborative robots that work together with human, safety of collaborative robot has become an important issue.
- Existing robot was designed to stop or move in the opposite direction when it detects a collision to reduce collision force, but this is costly, and the sensor may have an error that it cannot be a fundamental solution.
- Also, robots with lower specifications (low–powered robot, low–stiffness robot) are not dangerous but have less precision and degraded performance.

## Technical Distinctiveness

- This robot technology maintains the performance of robot but significantly reduces the actuator mass required for robot movement to secure safety.
- Counterbalance for multi–degree of freedom composed of various types of joints
- Counterbalance mechanism that available for mobile manipulator operated in various topography.
- Counterbalance mechanism
- Minimization of required torque to operate robot arm with counterbalance mechanism.
- Improved intuitiveness with direct teaching that does not require existing force sensor and complex force control algorithm

## Excellence of Technology

- Minimization of actuator capacity → Realize human–friendly collaboration through maximized robot safety → Energy saving
- Counterbalance mechanism + joint back–drivability → Direct teaching (Does not require expensive F/T sensor, complex force control)
- Counterbalance mechanism applicable for other industrial devices
- Counterbalance mechanism performance verifications and prototype completed



## Current Intellectual Property Right Status

### PATENT

- Variable Multi–DOF Counterbalance Mechanism (KR1801242)
- Variable Counter Balance Mechanism (KR2016–0006402)
- Adjustable Counterbalance Mechanism and Control Method Thereof (KR2016–0041633)
- Variable Gravitational Torque Compensation Device and Control Method Thereof (PCT/KR2017/002317)

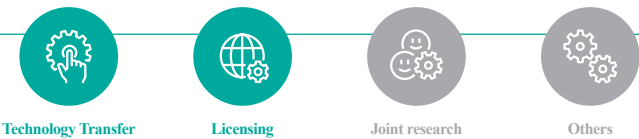
### KNOW-HOW

- Realization of self–weight compensation mechanism for complex multi–DOF joint
- Technology for self–weight compensation device design for change in floor angle
- Realization of variable gravitational compensation device with self–weight compensation ability
- Safe direct teaching technology using gravitational compensation device

## Technology Readiness Level (TRL)



## Desired Partnership



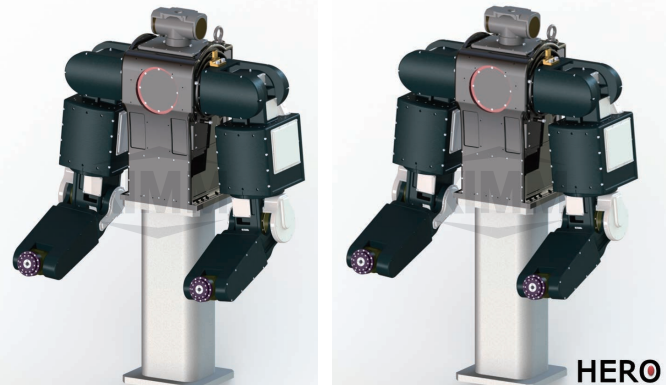


# High Payload Dual Arm Robot with Detachable Forearm Module for Performing Multipurpose Duties

▶ Department of Robotics and Mechatronics ▶ Researchers: Hwisu Kim, Chanhoon Park, Dongil Park ▶ Contact: +82-42-868-7208

Technology Overview

- Payload (approx. 30 kg/arm) robot technology with the best specifications in Korea
- Robot with a simply detachable forearm for various use such as dangerous object handling and injured rescue



Customer / Market

- Robot manufacturer

Problems of Existing Technology or Necessity of this Technology

- Existing dual arm robots had fixed forearm that they could be used for one purpose only.

Technical Distinctiveness

- Dual arm robot with high payload
- Can be installed in a small space
- Dangerous article handling safety secured with back-driving prevention design
- Module type driving part design
- 7-axis/arm redundant operation
- Jigless handling/combination of heavy weight load
- The forearm includes the spring mechanism that when it collides with a person while rescuing an injured, it moves in the axial direction or pulled inside to prevent injury.
- Very economical as one robot can be used for two different use

Excellence of Technology

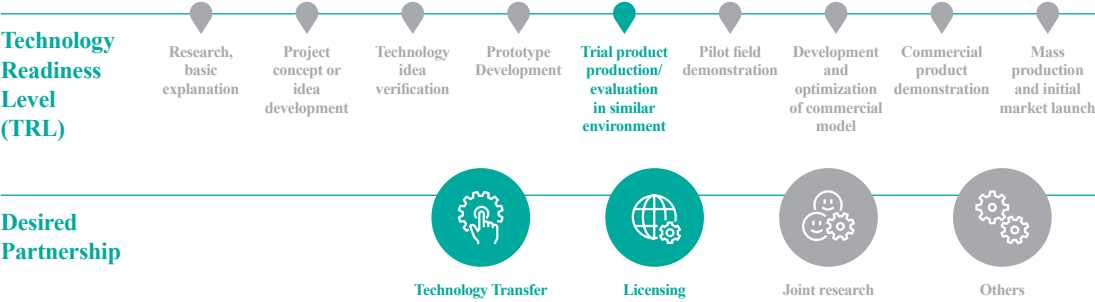
- One robot can be used for very different purposes simply by replacing the forearm module.



Injured human rescue		Dangerous object handling	
High payload required	Payload	High payload required	
–	Precision	High stiffness required	
–	Stiffness	High stiffness required	
Securing of safety of human	Safety	–	
grabbing and lifting human (3 to 4 DOFs)	DOF	additional DOF for smooth object handling (over 7 DOFs)	
stable holding of the injured	Shape	–	

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• High Payload Dual Arm Manipulator with Anti-backdrivability (KR1740979)</li><li>• Module Type Dual Arm Robot (KR2017-0062682)</li></ul>	<ul style="list-style-type: none"><li>• Highy payload dual arm manipulator design technology</li><li>• Safe dual arm manipulator design using worm gear</li><li>• Same robot for multiple purposes using manipulator forearm replacement</li></ul>



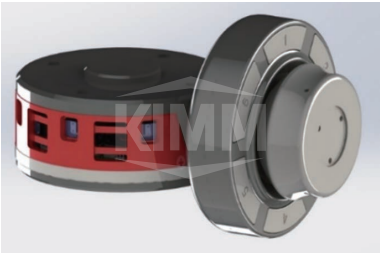


Smart Robot Teaching Device

▶ Department of Robotics and Mechatronics ▶ Researchers: Hyunmin Do, Taeyong Choi, Hwisu Kim ▶ Contact: +82-42-868-7507

Technology Overview

- Robot teaching refers to the work of setting or changing of operation sequence, position or velocity of manipulator in industrial robot.
- Robot teaching can be largely divided into two methods; one is the method that manipulator is controlled by separate teaching pendant, the other is the method that a user holds the end-effector or a link of manipulator and teaches the waypoint (direct teaching).



Customer / Market

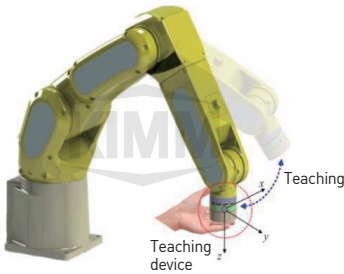
- Industrial robot and collaborative robot development/manufacturing company
- Robot SI companies

Problems of Existing Technology or Necessity of this Technology

- The market of human collaborative robot is rapidly growing. Intuitive interface is needed for effective use of collaborative robot
- When teaching using a teaching pendant for robot teaching, robot motion can be realized through button or dial manipulation. In general, however, a manipulator with multiple degrees of freedom requires teaching in various directions and orientations, and thus, it is difficult for non-professionals to teach a robot motion intuitively and it is also time consuming.
- Direct teaching can only be applied for a robot with the direct teaching function in the robot controller and thus it cannot be applied to general industrial robots. Also, force sensor for detecting the human command at the end effector needs to be added, which increases the cost. With the effect of sensor noise and sensitivity, it is difficult to precisely detect the teaching direction and distance.

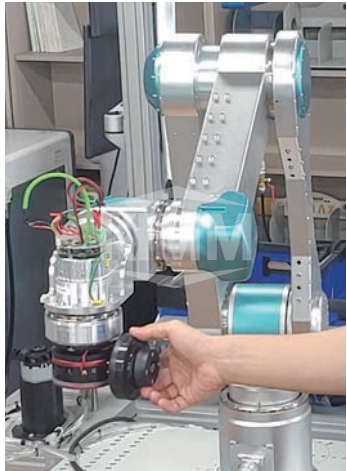
Technical Distinctiveness

- Improvement of user intuitiveness with the proposed teaching device attached to the end effector of the robot
- Improvement in sensor noise and sensitivity issue by realizing an input unit with a physical interface such as button, dial or jog that the user can operate
- Improvement in operability by applying a 6D mouse-based teaching handle
- Improvement of safety by including a detachable collision prediction module based on a distance sensor that can predict collision situations during robot operation
- Improvement in teaching accuracy and efficiency



Excellence of Technology

- Intuitive teaching of robot position and orientation is enabled by jog motion with a 6D mouse-based teaching handle.
- The motion setting unit is equipped with functions necessary for robot teaching such as operation mode change, coordinate setting, inching mode setting, partial path correction, and waypoint saving through user's button input, thereby enabling efficient teaching.
- As the collision prediction unit with a built-in non-contact distance sensor can secure a safe distance between the teaching operator and the surroundings and predict the collision situation when the robot is operating, the safety of the robot can be further improved.
- The impact of robot load and precision is minimized due to the lightweight and miniaturization through modularization of teaching and safety functions and detachable structure. (weight of always attached device 290 g out of overall 430g.)
- Both direct teaching and remote teaching are possible by implementing the detachable function of the teaching module.
- Prototype was implemented and verified as a result of research on Robot Industry Core Technology Development Project (May 1, 2016 to April 30, 2019)



Current Intellectual Property Right Status

PATENT

- Robot Teaching Device (KR1740898)
- Teaching device for human-robot co-operation (KR1921687)
- Removable teaching device (KR2148251)
- Robot Teaching Device (PCT/KR2017/015143)

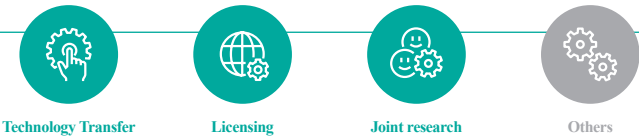
KNOW-HOW

- Implementation of teaching command and feedback of robot status through the external interface of the robot controller

Technology Readiness Level (TRL)



Desired Partnership

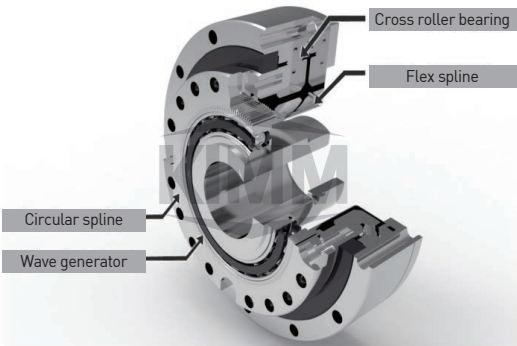


# Harmonic Reducer Design/Analysis Technology

▶ Department of Robotics and Mechatronics ▶ Researchers: Dongil Park, Junho Lee ▶ Contact: +82-42-868-7984

Technology  
Overview

- Harmonic reducer is one of the key driving parts used in industrial robots, precision machinery, and equipment. It is a reducer that can be designed to be relatively lightweight and has high precision and low backlash to overcome the limitations of existing reducers.
- The harmonic reducer is composed of three core parts: wave generator (W/G), flex spline (F/S), and circular spline (C/S). Unlike a reducer of a general form, it has a structure in which three core parts are assembled on the same axis.



Customer /  
Market

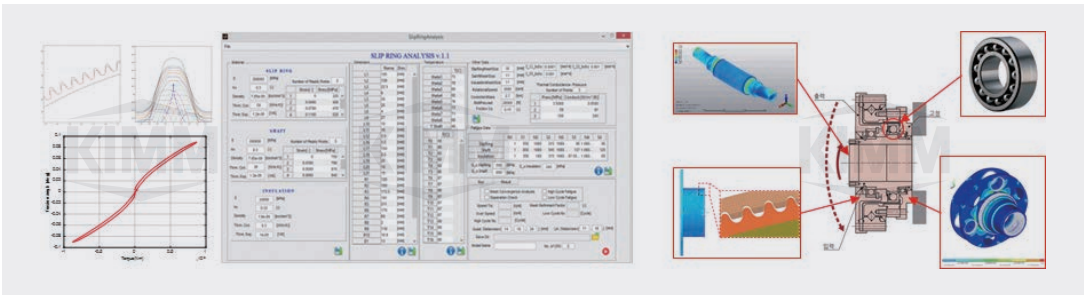
- Industrial robot development/manufacturing company
- Robot, automation and related SI companies

Problems  
of Existing  
Technology or  
Necessity  
of this  
Technology

- The performance of the reducer depends on the smoothness of the tooth engagement or motion trajectory of the flex spline and circular spline, which are the core parts of the harmonic reducer, but systematic tooth design considering the sophisticated tooth engagement is not done in Korea.
- The tooth shape used in the harmonic reducer is a special shape different from that of the general industrial gear, and the calculation methods used in general industrial gear cannot be applied, and thus, a special tooth shape study dedicated to the harmonic reducer is required. Optimal design considering contact and deformation analysis is required to analyze the performance difference of finished products.
- It is difficult to predict product performance and secure quality through the adjustment of design factors with the existing trial & error design method. Therefore, it is necessary to develop a source analysis technology that can predict performance from the design stage by model number, reduction ratio, and type, and secure systematic design/production technology.

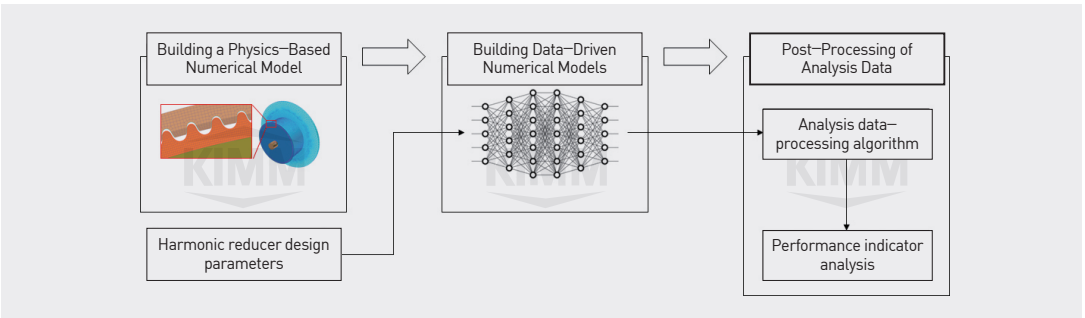
Technical  
Distinctiveness

- Improvement of the tooth engagement performance of the reducer through the tooth design process in which the machining technique and the toothed tool are linked
- Improvement of harmonic reducer design method through design program that can predict reducer performance by model number, reduction ratio, and type



Excellence of  
Technology

- Through the tooth design process, it is possible to predict the motion trajectory of the harmonic reducer and the transmission error due to tooth bite.
- By learning data-based numerical models, it can overcome the limitations of analytic techniques using existing physical models and analyze real-time performance predictions for various design factors such as model number, reduction ratio, and type.
- It can compare and analyze the performance of the harmonic reducer according to the design factor, and it can be used to predict the design factor to have the optimal performance.
- Applied to the R&D stage of harmonic reducer, it is expected to reduce R&D cost and period.



Current  
Intellectual  
Property  
Right Status

PATENT

- Real-time analysis system for harmonic reducer design and performance prediction (pending)

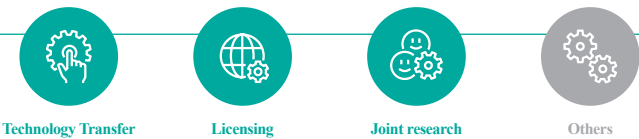
KNOW-HOW

- Tooth design process considering elastic deformation
- Building a contact integrated analysis model of harmonic reducer and learning method of a data-based numerical model

Technology  
Readiness  
Level  
(TRL)



Desired  
Partnership



# Clamp-Type Omnipotent Gripper

▶ Department of Robotics and Mechatronics ▶ Researchers: Seonghyeok Song, Chanhoon Park ▶ Contact: +82-42-868-7127

Technology Overview

- The robot gripper has a function of stably holding a target object to move its position, which aims to perform a target operation using the gripped object.
- Generally used grippers can be classified into a method of gripping an object by directly applying a force (clamp-type gripper) and a method of gripping using suction (suction-type gripper).
- When gripping by applying a direct force, it can be classified into a parallel gripper and an angle gripper depending on the type of operation. Both types grip the object by compressing the tip of the gripper end.

Customer / Market

- Industrial robot development/manufacturing company
- Service robot gripper developer/manufacturer

Problems of Existing Technology or Necessity of this Technology

- In the field of smart factories and service robots, where the market is rapidly growing in recent years, there is a growing need to stably hold and work with various atypical objects of which information about the shape and stiffness is difficult to obtain in advance.
- For conventional clamp-type grippers, it is effective to grip a predetermined object to be gripped, but there is a problem in that it is difficult to stably grip an object other than that. In particular, for a fragile target object, the compressive force applied to the object should be minimized during gripping. In this case, there is a problem of the holding force getting lower at the same time.
- A gripper incorporating soft robot technology has been proposed for gripping fragile objects, but these grippers have a problem with low rigidity of the material itself, limiting the increase of the holding force. Therefore, it is difficult to perform tasks beyond moving simple objects.

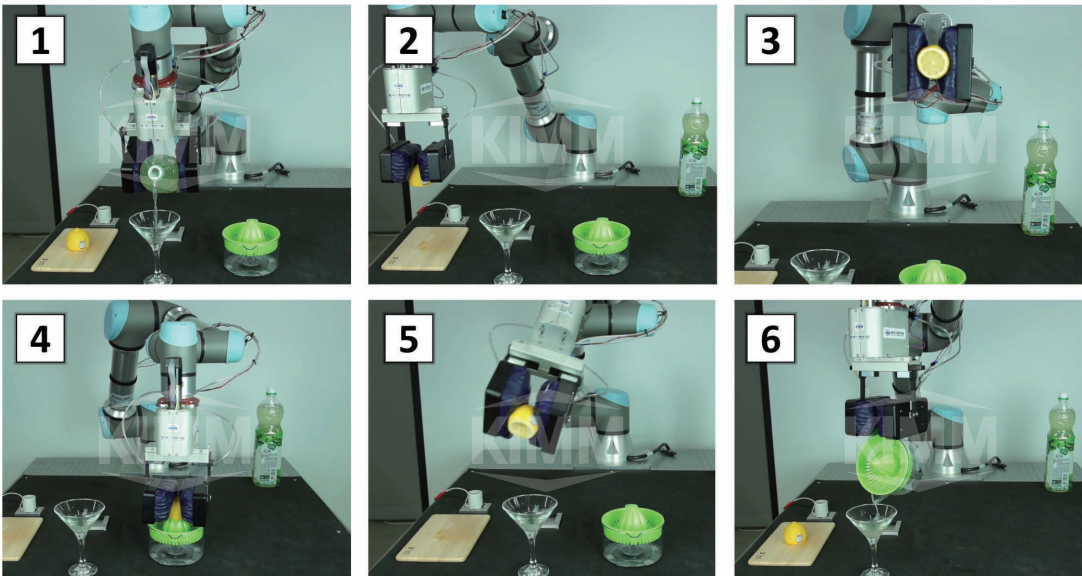
Technical Distinctiveness

- Objects of various shapes, sizes, and strengths can be easily gripped with clamp-type gripper without complicated control.
- Since the gripping object is compressed and gripped with minimal force, the possibility of damage to the object and the risk of operator injury can be fundamentally prevented.



Excellence of Technology

- The rigidity of the gripper tip (jaw) in contact with the object is as soft and fluffy as that of the head, but when gripping the object, the surface shape is deformed and becomes identical with the object.
- After an object is gripped, the gripper surface changes to a deformed state, and the object is firmly caught in the deformed groove, enabling firm grip.
- Due to these features, it is possible to implement a high holding force even with a small clamping force, which further enables to hold an object that can be easily damaged in a stable manner.
- Compared to the conventional gripper, which required complex controls and sensors to grip irregular objects, this technology can simplify the system as it only needs to control the tip to be transported up to the target compression distance.
- Since only the tip of the gripper needs to be replaced with the tip developed in this technology in the existing parallel open/close gripper module, it can be easily applied to the field and stable operation can be achieved.



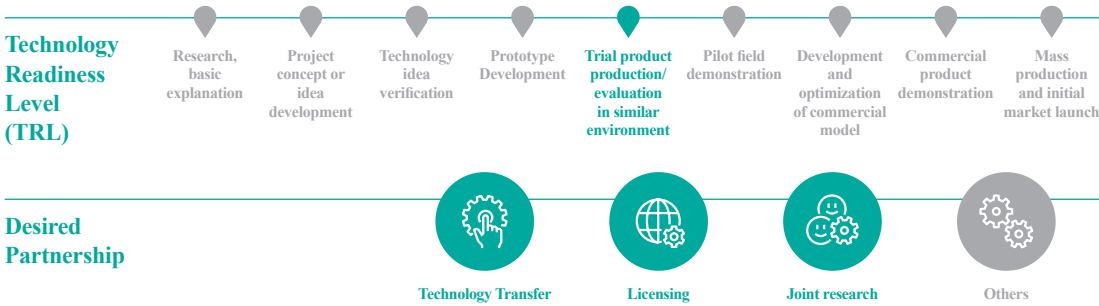
Current Intellectual Property Right Status

PATENT

- Structure and construction method related to clamp-type omnipotent gripper (KR2152467, KR2152469, KR2178907, KR2019-0074041, KR2020-0091159)

KNOW-HOW

- Characteristics and manufacturing technology of omnipotent gripper tip (jaw) according to design parameters





# Suction-Type Omnipotent Gripper

▶ Department of Robotics and Mechatronics ▶ Researchers: Seonghyeok Song, Chanhoon Park ▶ Contact: +82-42-868-7127

Technology Overview

- The robot gripper has a function of stably holding a target object to move its position, which aims to perform a target operation using the gripped object.
- Generally used grippers can be classified into a method of gripping an object by using suction (suction-type gripper) and a method of gripping by directly applying a force (clamp-type gripper).
- Suction-type grippers are mainly applied when it is necessary to grip objects located in a narrow space, such as when gripping objects placed in a basket (bin), or when there is not enough space for clamp-type grippers to grip.

Customer / Market

- Industrial robot development/manufacturing company
- Service robot gripper developer/manufacturer

Problems of Existing Technology or Necessity of this Technology

- In the field of smart factories and service robots, where the market is rapidly growing in recent years, there is a growing need to stably hold and transfer various atypical objects, of which information about the shape and stiffness is difficult to obtain in advance.
- However, the existing suction-type vacuum gripper for gripping atypical objects is difficult to grip sharp or large objects, and therefore, expensive vision system is combined to precisely identify the grippable surface, and then the suction gripping method is used.
- Existing vacuum suction grippers, which are highly dependent on the vision system, are difficult to implement stable gripping under environmental disturbances, and the shape of grippable objects is also limited.

Technical Distinctiveness

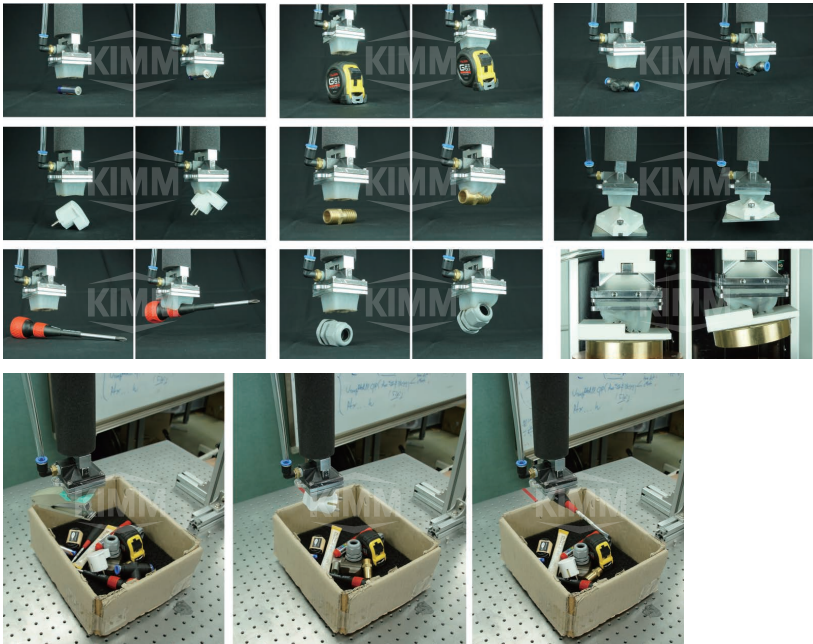
- By applying a soft honeycomb structure capable of large deformation to the suction-type gripper, it has the advantage of stably holding sharp objects or objects with large bumps.
- Since the suction-type gripper can be deformed while covering the surface of an object just like the tip of an elephant's trunk that can grip an object, effective gripping can be realized without accurate location information of the object.



〈 Just like the movement of the tip of the trunk of an elephant, it can hold an object by covering the outer shape of it 〉

Excellence of Technology

- By applying a large deformable soft honeycomb structure to the suction-type gripper, not only objects smaller than the gripper's cross-sectional area can be gripped, but also the gripper tip can be deformed according to the shape of the object, thereby enabling efficient gripping with complete adhesion to the shape of the target object.
- There is no need for complex strategic algorithms for gripping, nor the need to rely on high-performance vision systems to accurately locate objects; approximate information of an object's center location is everything that is needed.
- Compared to existing bin-picking solutions that are highly dependent on vision, stable gripping and transporting operations can be realized even in environmental disturbances.



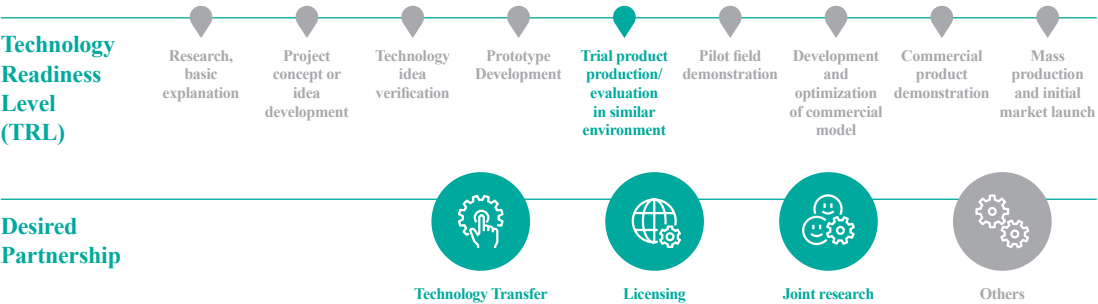
Current Intellectual Property Right Status

PATENT

- Structure and configuration of suction-type omnipotent gripper(KR2020-0005811, KR2020-0024948, KR2020-0106250, KR2020-0099140, KR2020-0106251, KR2020-0106252)

KNOW-HOW

- Characteristics and manufacturing technology of omnipotent gripper according to design parameters





# Independent Activity Supporting Robot for Those with Lower Extremity Disability

▶ Department of Robotics and Mechatronics ▶ Researchers: Chanhoon Park, Dongil Park, Hwisu Kim, Seyoung Kim, Seonghyeok Song, Jongwoo Park ▶ Contact: +82-42-868-7127

Technology Overview

- A technology that enables the independent daily life of the paraplegics by organically realizing stable standing/sitting and free movement of the paraplegics within one platform.
- A technology that transforms the shape of a wheel to match the shape of an obstacle so that the paraplegic can easily overcome obstacles such as uneven road surfaces, bumps, and stairs when moving.
- A technology that uses a two-wheel-based module with a small occupancy area, thereby enabling people with lower extremity disability to live freely without being limited by the size of the space. It also makes long-distance traveling possible by realizing lightweight wheelchair, foldable structure and car mounting function.
- A technology that realizes stable standing/sitting motions, adjustment of the standing angle, and retention of standing position by enabling the stable conversion from sitting to standing for the paraplegic in the minimum power-light structure.



Customer / Market

- Medical device company for persons with disabilities
- Robot SI companies

Problems of Existing Technology or Necessity of this Technology

- As the importance of the welfare of the persons with disabilities has risen significantly, the paradigm of welfare policy needs to be changed to enable economic independence of persons with disabilities by letting them participate in actual economic activities beyond the level of financially supporting or providing benefits.
- To this end, it is necessary to introduce a robot to support efficient autonomous activity that helps the efficiency of economic activity of the persons with disabilities at worksite to be maintained at a level similar to that of the persons with no disabilities.
- There is an urgent need to develop robots that support the persons with physical disabilities among the persons with disabilities as the population with physical disabilities is significantly higher among the population of persons with disabilities and the number of persons with disabilities is continuously increasing due to the increase in the elderly.
- Assistive device for the persons with physical disabilities and related robot technologies are in great need in line with the global aging trend, but the related domestic industries are very small and remain in the initial R&D stage. In other words, a technological preparation for the super-aging society that Korea will face is very insufficient.

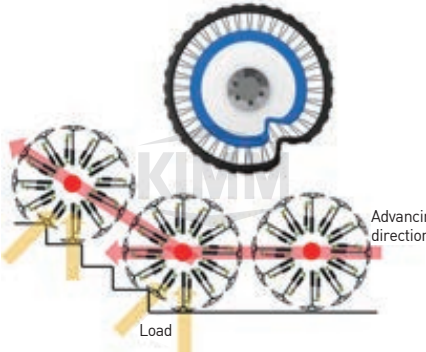
Technical Distinctiveness

- The standing device for persons with physical disabilities capable of sensing user motion information can be used for the development of a sit-to-stand assistance system to support indoor and outdoor activities of the elderly or as a core technology of a wearable robot worn on the lower extremities, which can further lead to various follow-up studies.
- The two-wheel-based mobility platform capable of climbing stairs and overcoming obstacles can be used as a core technology for the next-generation smart mobility device as it enables narrow indoor activities and driving on rough terrain. Follow-up studies can be realized in mobility device-related fields that enable utilization in a narrow space.
- The developed morphing wheel technology can be applied to various wheel-based mobility devices as well as two-wheel-based mobility platforms. It can be used for R&D of new types of mobility devices that go beyond the limitations of existing wheels.



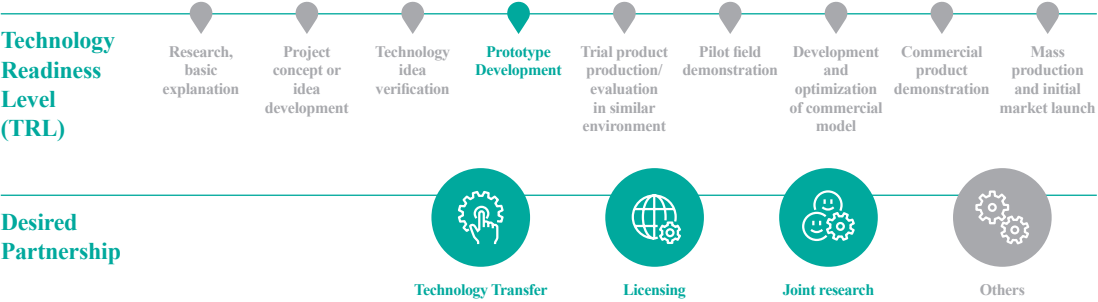
Excellence of Technology

- The only mobility platform that supports stair-climbing and upright/standing posture for the people with lower extremity disability at the same time.
- Applicable to various mobile platforms as well as robotic wheelchairs through technology that overcomes obstacles in daily life such as climbing stairs with minimum power using morphing wheel technology.



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Morphing wheel technology for overcoming obstacles(KR2020-0073164, KR2020-0073165, KR2021-0004080, KR2021-0001421)</li><li>• Two-wheel wheelchair technology with leg structure of multiple degrees of freedom for stair climbing (KR2020-0183226)</li></ul>	<ul style="list-style-type: none"><li>• Two-wheel balancing control technology for mobility devices for the paraplegics</li><li>• Stair-climbing control technology using a leg-type auxiliary device</li><li>• Balancing control technology of two-wheel mobility module considering user's riding comfort</li></ul>



# Compliant, Light-Weight, High-Power, High-Contraction, Fabric muscle and Clothing-Type Wearable Robot Technology

▶ Department of Robotics and Mechatronics ▶ Researcher: Cheolhoon Park ▶ Contact: +82-42-868-7980

Technology Overview

- It is a fabric-type artificial muscle with high muscle-level power and high contraction rate while exerting dozens of times the strength of human muscle. It is a clothing-type wearable robot that can be applied to rehabilitation devices, health care devices, etc.



Customer / Market

- Wearable robot companies
- Healthcare, rehabilitation device manufacturers
- Industrial, service robot companies
- Actuator components supplier

Problems of Existing Technology or Necessity of this Technology

- Existing motor actuators must be used in combination with a gear-mechanism, etc., leading to an increase of mass, volume, and price of wearable robots and rehabilitation devices.
- There is a need for noiseless, high-power, high-contraction artificial muscle module that is light and flexible as human muscle but able to generate tens of times more force than human muscle and can move beyond the limits of human muscle.
- Unlike heavy, solid motor-based on rotary motion, linear contraction-expansion motion like skeletal muscles
- It is possible to create a new market and popularize the product as it is possible to design inexpensive and lightweight clothing-type wearable robots and rehabilitation devices.
- It can contribute to improving the quality of life by reducing workers' avoidance of labor, preventing musculoskeletal disorders, and reducing fatigue through the distribution of inexpensive and comfortable wearable robots for courier service, caregivers, and sanitary workers and supporting muscle strength.

Technical Distinctiveness

- Fabric-type artificial muscle dozens of times stronger than human muscle, formed with a bundle of shape memory alloy springs
- A simple method of supplying current enables contraction without causing any driving noise (no noise, low noise driving)
- By applying this technology, a clothing-type wearable robot that can receive great power while wearing it comfortably like everyday clothes was developed. The robot including the battery, controller, etc. weighs 1 kg or less, which is about the same as an ordinary jacket.

Excellence of Technology

- Wearable robot technology that can be easily distributed at a low price by applying it to assistive or rehabilitation devices for upper and lower extremities
- Existing wearable robots are hard wearable robots similar to the exoskeleton of insects. Most of them are motor or pneumatic driven, and the disadvantages are that they are heavy, noisy, and relatively expensive. On contrary, clothing-type wearable robots are soft wearable robots that are light-weight and low-cost, perfect for every day activities.

- Fabric-type artificial muscle (fabric muscle) that can lift a weight of 10 kg, which is 1,000 times its weight, by making a bundle of 10 g of shape memory alloy spring into a garment form and contracting it like a muscle.
- When applied to a mannequin without any power after applying fabric-type artificial muscles to a jumper-type wearable robot, it can lift up to 4 kg.
- The clothing-type wearable robot, including the flexible actuator, battery, and controller, weighs about 1 kg, which is equivalent to the weight of a jumper worn by an average adult. In addition, the robot and the body can be selectively linked only when muscle support is needed, resulting in reduction of power wastage, and even if the battery is exhausted, it can be worn as a daily outfit.



< 20g Fabric Muscle Lifting a 10kg Load >

< Lifting a 4 kg barbell by a mannequin wearing a clothing-type wearable robot >

Current Intellectual Property Right Status

PATENT

- Artificial Muscle Module (KR1696880)
- Artificial Muscle Module Equipped with Displacement Measuring Device (KR1731491)
- Shape Memory Alloy Spring Manufacturing Device and Method (KR1712958)
- Apparatus for manufacturing shape memory alloy spring continuously (KR1967214)
- Muscle strength assistance device using the shape memory alloy spring (KR1922556)
- Artificial muscle assembly, muscle strength-enhancing garment including the same, and control method of artificial muscle assembly (KR2129519)
- Cloth for enhancing muscular strength and method of controlling the same (KR1967215)

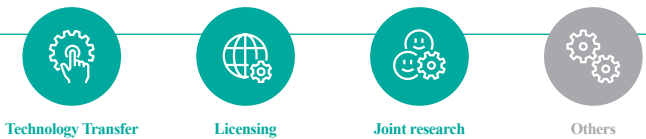
KNOW-HOW

- Shape memory alloy spring mass production technology
- Fabric-type artificial muscle manufacturing technology
- Clothing-type wearable robot design-manufacturing technology

Technology Readiness Level (TRL)



Desired Partnership



# Dual Arm Robot Controller

▶ Department of Robotics and Mechatronics   ▶ Researcher: Taeyong Choi, Hyeonmin Do, Jinho Gyeong   ▶ Contact: +82-42-868-7778

**Technology Overview**

- Technology for dual arm robot controller used in the industrial site in recently developed markets
- Unlike existing vertical articulated robot, the robot has two arms and two end-effectors. The technology includes dual arm robot language and dual arm robot teaching function

**Customer / Market**

- Dual arm robot development companies

**Problems of Existing Technology or Necessity of this Technology**

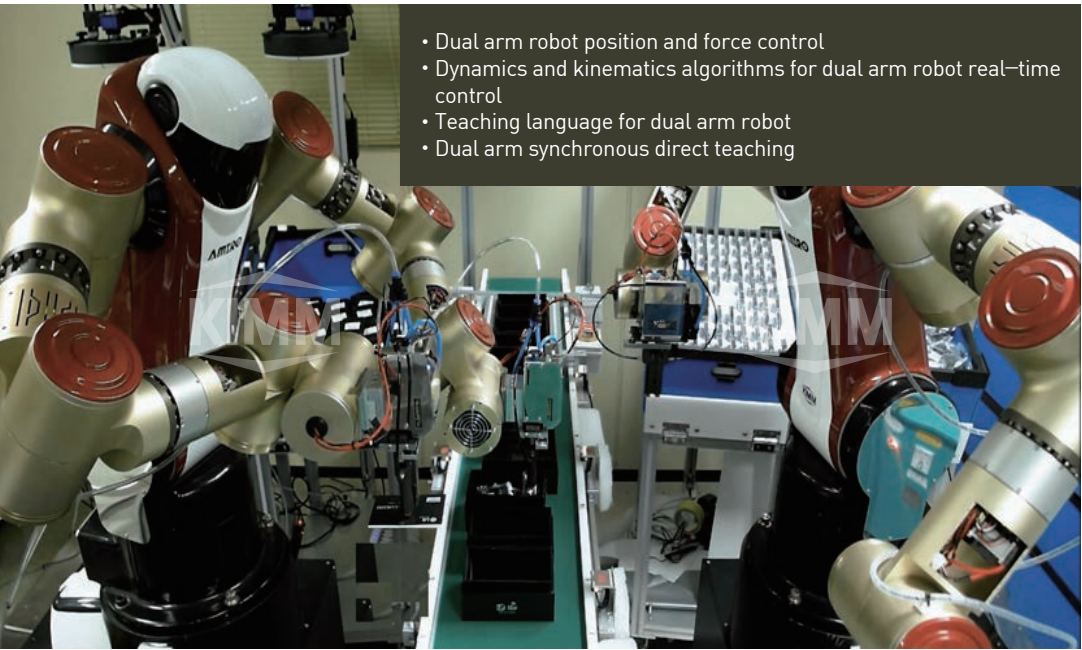
- Existing industrial vertical articulated robot had one arm and one end-effector, therefore the controller was used to teach and control only one arm robot.
- However, a dual arm robot has two arms that it requires high-level controlling algorithm for two arms control, teaching method to teach both arms, and robot language for two arms.

**Technical Distinctiveness**

- Dual arm synchronous direct teaching
- Position and force control with the dynamics and kinematics algorithm for realtime control of the dual-arm robot
- The institute has been developing dual arm robot-related controller for 6 years since 2010.
- For application at industrial sites, experiments were conducted for various processes to improve completeness of the control algorithm and teaching method.
- Equipped with real-time control algorithm (dynamics, kinematics) for dual arm robot applicable for industrial robots

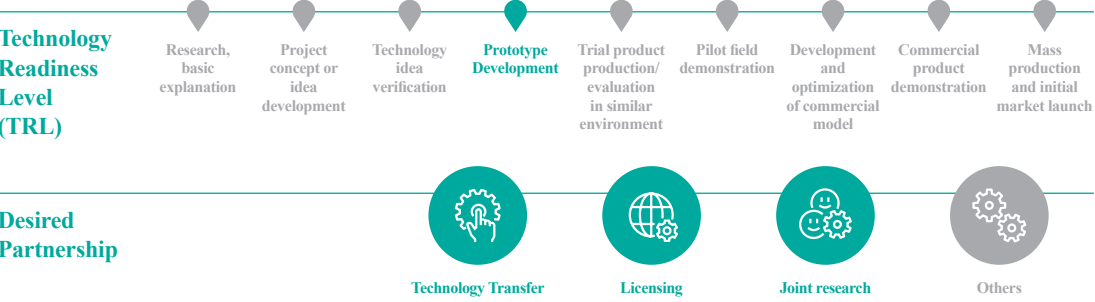
**Excellence of Technology**

- By conducting research on application of dual arm robot in the industrial sites for 6 years, dual arm robot real-time control algorithm (dynamics, kinematics), dual arm robot teaching language and direct teaching function that the industries need were developed.
- The technology developed by the institute was actually applied on a dual arm robot, and its excellence was verified.



**Current Intellectual Property Right Status**

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Robot Teaching Device (KR1263487)</li><li>• Dual Arm Robot Direct Teaching Method (KR1193211)</li></ul>	<ul style="list-style-type: none"><li>• EtherCAT Communication</li><li>• Realtime control</li></ul>



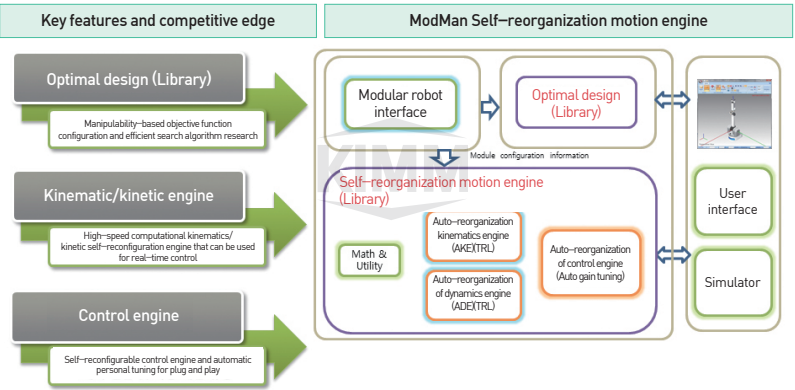


# Module-based Robot Software Technology (Optimal Combination Search, Inverse Kinematics Auto-generation, Automatic Gain Tuning)

▶ Department of Robotics and Mechatronics ▶ Researcher: Taeyong Choi, Hyeonmin Do, Dongil Park ▶ Contact: +82-42-868-7915

Technology Overview

- Modular robot software technology consists of
  - Optimal module combination search software for composing a robot fulfilling the purpose,
  - Control algorithm(Kinematics and Dynamics) automatic generation software for controlling the robot produced with the optimal module combination,
  - Joint gain tuning automatization software for the actual robot produced with the optimal module combination for making a vertical articulated robot
- This technology is a software technology that enables non-experts to perform works that require advanced knowledge (deciding module combination for the purpose, development of control algorithm, joint gain tuning) for reorganization of modular robot when developing a robot using modules,
- Automatic generation of control algorithm and joint gain tuning secures real-time control and precision for industrial applications.



Customer / Market

- Robot company
- Module-based robot manufacturer

Problems of Existing Technology or Necessity of this Technology

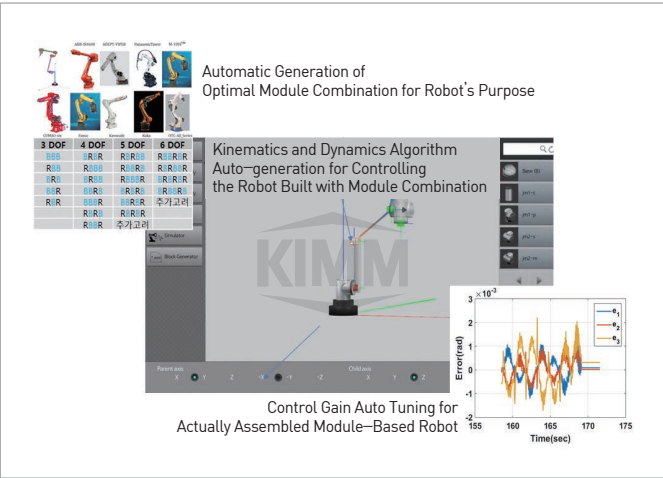
- Hardware module sellers for existing robot development like SCHUNK and ROBOTIS only provide a simple program for joint space control for module operation.
- Therefore, the user experiences inconvenience regarding selection of module that satisfies the purpose and having to develop the module for controlling the actual work space.

Technical Distinctiveness

- This technology enables non-expert with hardware module to get optimal combination design and automatic work space control as well as automatic gain tuning for precision level similar to that of industrial robots.
- Automatic generation(world-first) of robot control algorithm (kinematics, dynamics)
- Auto-generated control algorithm, and automatic gain tuning are secured at the level for industrial robots with real-time and precision.

Excellence of Technology

- This technology allows non-experts to easily decide on the module hardware composition and automatically generates a appropriate highperformance control algorithm and automatically tunes the gain of the actual hardware.
  - The output has sufficient ability to be used as an industrial robot.
  - Control algorithm is auto-generated within 10 minutes.
  - Auto gain tuning is completed within 30 minutes.
  - Recently, robot companies have been producing module-type actuator and link to lower the cost of maintenance and development and combining these to make various types of robots. In this case, a lot of development and labor cost is invested into robot control algorithm and gain tuning, but with this software, the cost can be lowered significantly.
  - Also, companies using robots can use the development software to see a great cost reduction effect.
- A company can purchase a modular robot to reorganize the robot for various production purposes when needed to reduce the production line reorganization cost and radically lower the cost going into purchasing multiple robots to meet different purposes.



Current Intellectual Property Right Status

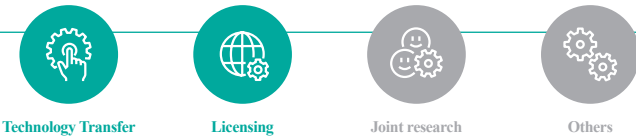
PATENT

- Device and Method of Mechanics Software Auto Generation for Module-based Robot (KR2017-0116516)

Technology Readiness Level (TRL)



Desired Partnership



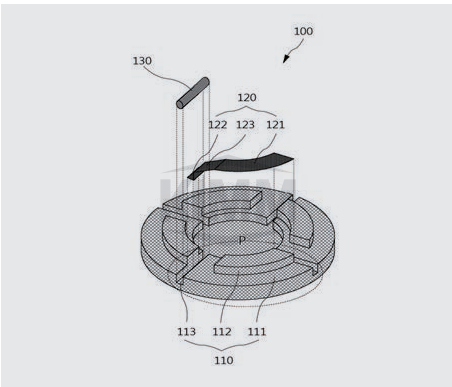


# Metal Mesh Foil Air Dynamic Pressure Bearing

▶ Department of Robotics and Mechatronics ▶ Researcher: Cheolhoon Park ▶ Contact: +82-42-868-7980

Technology  
Overview

- Metal mesh foil thrust bearing with simple structure to maximize axial load capacity



Customer /  
Market

- Air foil bearing manufacturer, manufacturer of turbo machinery like turbine/ compressor/blower

Problems  
of Existing  
Technology or  
Necessity  
of this  
Technology

- It is widely known that the rotational speed of a small turbo machine's rotor is from 100,000 to 400,000 rpm to obtain desired output.
- The thrust bearing is a must for the small high-speed turbo machinery. The problem is that they are too small to connect the lubricant-supplying devices due to the issue of volume, etc.
- In the case of small high-speed rotor like micro gas turbine, in particular, whose actual use is increasing, a need for thrust bearing that meets additional requirements of being contactless and oil-less on top of the basic requirement (reduction of vibration in axial direction, available for use in high temperature, high durability).
- Also, existing thrust air foil bearing has low axial load capacity therefore inappropriate for high-powered turbo machines. And the bump foil for damping is a thin bump structure therefore also weak to support axial load.

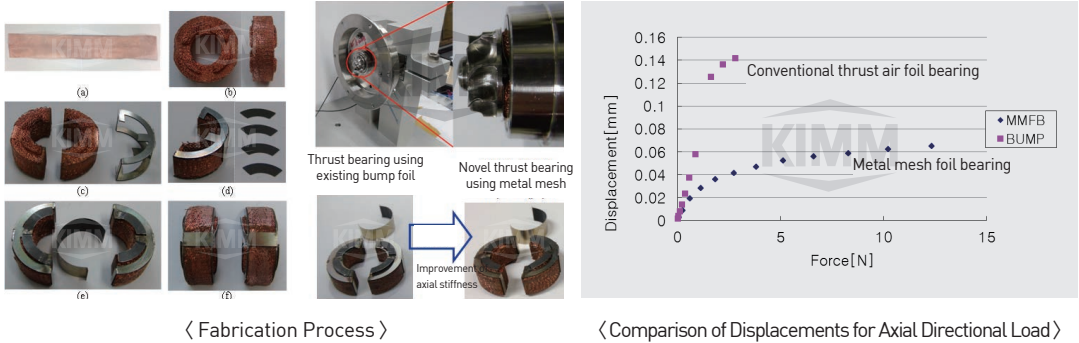
Technical  
Distinctiveness

- Realization of simplified structure and low production cost/It is a small, light contactless and oil-less thrust bearing in metal mesh foil that can be installed for a small high-speed rotor.
- By applying press metal mesh instead of bump foil of conventional air foil bearing, the axial load capacity was improved at least 8 times with high damping and stiffness.

- With a simple structure consisting of pressed metal mesh, top foil and fixing pin, which is different from conventional air foil thrust bearing, it is unnecessary to make bump foil, which makes the structure simple and easy to make. Thus, it can be easily applied on a small rotor, and compared to the conventional bearing, the range of application can be extended much further.
- It can also be applied for high-powered turbo machine where axial directional load is high.

Excellence of  
Technology

- The issue of conventional air foil thrust bearing with having weak axial load capacity as the bump foil created with a thin plate was used as damper was improved by using a pressed metal mesh of specific density to support the top foil of thrust bearing. With this method, the axial load capacity was highly improved.
- Comparing the axial displacement for axial directional load under the rotational condition of 170,000 rpm, the metal mesh foil bearing had 8 times the stiffness compared to the conventional air foil bearing and excellent load capacity.



Current  
Intellectual  
Property  
Right Status

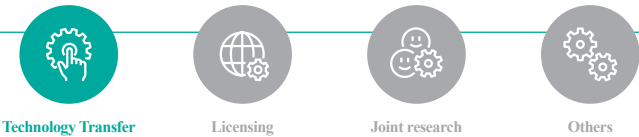
PATENT

- Metal Mesh Damper Manufacturing Device and Manufacturing Method (KR1378778)
- Combo Metal Mesh Foil Bearing (KR1409815)
- Split Combo Bearing Including Air Foil Thrust Bearing and Metal Mesh Foil Radial Bearing (KR1443036, US14/264221)
- Combo Bearing Including Air Foil Thrust Bearing and Metal Mesh Foil Radial Bearing (KR1445063)
- Metal Mesh Bearing Damper Manufacturing Device (KR1528460)
- Metal Mesh Foil Radial and Thrust Integral Bearing (KR1517818)
- Metal Mesh Foil Thrust Bearing (KR1517793)

Technology  
Readiness  
Level  
(TRL)



Desired  
Partnership

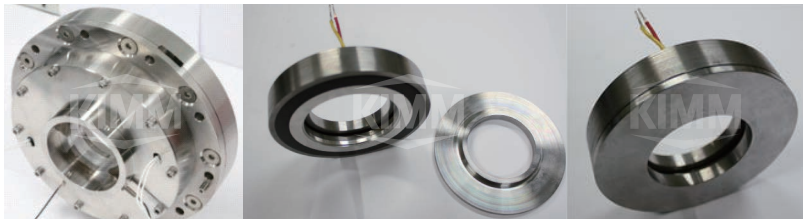


# Ultrahigh-speed High-precision Magnetic Bearing Technology

▶ Department of Robotics and Mechatronics ▶ Researcher: Cheolhoon Park ▶ Contact: +82-42-868-7980

Technology  
Overview

- Magnetic bearing technology using the principle of magnetic levitation for the rotor to rotate in the state of complete levitation to enable high-speed rotation at 100,000 rpm or faster and highprecision rotation with rotating vibration below 2μm



Customer /  
Market

- Magnetic bearing manufacturer
- Turbo machine (compressor, blower, turbine, pump) company
- High-speed spindle company, ultracentrifuge company
- Precision roller (for printed electronics, nano imprint) manufacturer and application company

Problems  
of Existing  
Technology or  
Necessity  
of this  
Technology

- Existing ball bearing has limits regarding high-speed and precision of rotary machine.
- When applying ball bearing for a rotor with a diameter of 50 mm, rotation at up to 30,000 rpm can be achieved.
- In the case of a low-speed precision roller where ball bearing is applied, rotating vibration of 20 to 40 μm occurs.
- To develop a high-speed, high-precision rotary machine with rotating speed over 100,000 rpm and rotating vibration of 2 μm, a magnetic bearing that enables contactless rotation in the state of complete levitation needs to be applied.

Technical  
Distinctiveness

- Energy efficient magnetic bearing using a permanent magnet and electromagnet
- Homopolar structure to eliminate the high heating issue of heteropolar magnetic bearing
- The volume of entire system reduced by integrating the auxiliary bearing and sensors with magnetic bearing and achieving a shorter length for magnetic bearing
- With a short length for rotor, the primary bending mode frequency can be increased for enhancement of rotation stability at high speed.
- Minimization of usage of the electric current and rotational vibration by applying self-weight compensation and permanent magnet for bias force
- Lubricant is not required because it is contactless and frictionless, and clean bearing of which life time is semi-permanent
- Smart bearing with real-time vibration/load monitoring to cope with dangerous situations

Excellence of  
Technology

- Applied for an ultra-high-speed spindle with rotor with a diameter of 41 mm and achieved rotation speed of 120,000 rpm and linear velocity of 49.2 Mil-DN
- Applied for a low-speed high-precision roller and achieved rotation speed of 30 rpm, and rotating vibration below 2 μm under the condition of 300 N load
- External vibration and load is monitored real-time to detect abnormality in system in advance.



High-speed spindle with rotational speed of 120,000 rpm

Radial vibration at 120,000 rpm rotation speed

Precision Roller with Magnetic Bearing

Rotating Vibration Under 30 rpm, Load of 300 N

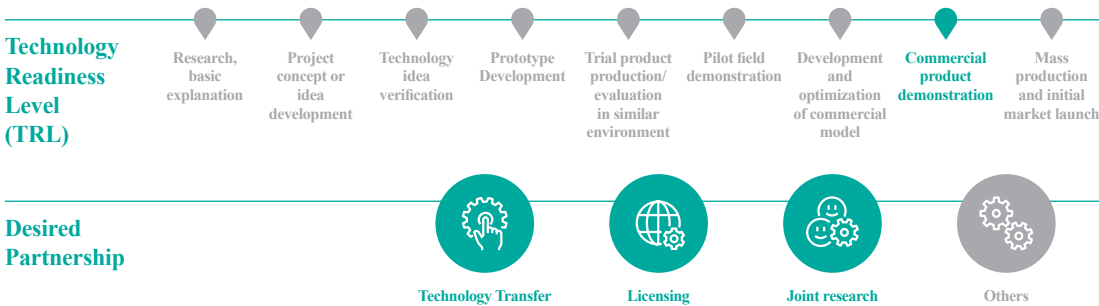
Current  
Intellectual  
Property  
Right Status

PATENT

- Turbo Machine Equipped with Magnetic Bearing (KR1287057)
- Magnetic Bearing Using Permanent Magnet and Electromagnet (KR0976631)
- Magnetic Bearing System (KR1133560)
- Magnetic Bearing Structure and Turbo Machine Equipped with this Magnetic Bearing (KR1166854, US9041266, SE536808, CNZL201180013360.X)
- Composite Magnetic Bearing Having Auxiliary Bearing Coupled Thereto (KR1408060, US9273723, CNZL201380006733.X)
- Composite Magnetic Bearing Having Sensor and Auxiliary Bearing Coupled (KR1444139)
- Thrust Magnetic Bearing for Deflecting Force Compensation (KR1552350, US14/674022, CN201510196685.6)
- Roller Module Equipped with Magnetic Bearing and Permanent Magnet (KR1809104, US15/554729, UK1708962.4)

KNOW-HOW

- Ultra-high-speed rotor design, manufacturing technology
- Ultra-high-speed, high-precision magnetic bearing control technology
- Inductive displacement sensor technology
- Real-time vibration, load monitoring and emergency situation handling technology

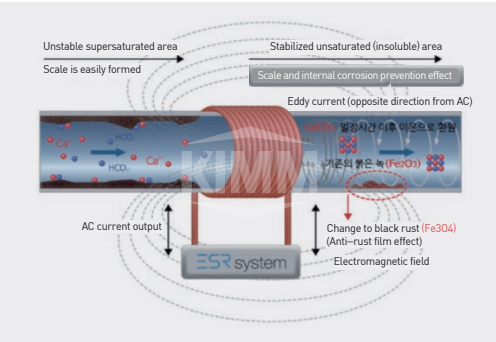


# Electronic Pipe Scale Removing Device and Corrosion Prevention Device

▶ Department of Robotics and Mechatronics ▶ Researcher: Heechang Park ▶ Contact: +82-42-868-7612

Technology Overview

- It is a device for descaling and anti-corrosion by using electromagnetic field Lorenz Force with induction coil installed outside the piping without the use of chemicals.



Customer / Market

- General industrial facilities and all structures requiring fluid transmission for cooler, heat exchanger, boiler, and compressor

Problems of Existing Technology or Necessity of this Technology

- Comparison of scale removal method

Method	Detail	Drawback
Magnetic type	Have fluid pass through the magnetic field to disturb molecular binding of Ca++, Mg++ ion and prevent solvent from adhering to the pipe wall	Effect is insignificant unlike stated in the theory; issue of durability of magnet force
Electronic type	Neutralize and eliminate the potential difference in water-metal surface to disperse ion on the heating surface	Effectiveness in limited space
Supersonic type	Continuously apply micro vibration to the water with ultrasonic waves from the ultrasonic oscillator for removal	Can be used only within the limited range where ultrasonic wave can reach
Ion exchange resin method	Remove scale by converting hard water into soft water	Needed for corrosion prevention with Na+ ion
Ion type	Prevent oxygen in advance by adhering metal with higher oxidizing power than steel to control rusting and remove scale	Effect differ depending on water potential level and pH, expensive cost Pipe cutting issue during installation
Catalyst type	Change the magnetic properties of water to prevent rust and scale, Weaken coherence of rust and scale for removal	
Inductive coil method	Using Lorentz force in the magnetic field to accelerate CaCO <sup>3</sup> union in the water to drain, and disassemble existing scale with CO <sup>2</sup>	

Technical Distinctiveness

- High-efficiency inductive coil type does not require replacement of existing pipe nor injection of chemicals.
- By having electricity flow through the coil installed outside the pipe, scale inside the pipe is removed with Lorentz force in the electromagnetic field.
- Smooth fluid flowing in the pipe such as coolant by removing scale at all times
- Energy saving effect from reduction in pipe loss in various systems including cooling system
- High-efficiency heat exchange can be maintained by removing scale from the heat exchanger surface
- Red rust inside the pipe is changed into black rust (magnetite) to prevent corrosion.
- The effect is exercised up to 1 to 2 km downstream from the location where inductive coil is installed.
- The composition is simple consisting of inductive coil, power supply, and controller.

Excellence of Technology

- Possible not only to suppress the formation of scale, but also to remove the existing scale
- Applicable from several centimeters to several meters in pipe diameter
- Not only removes scale but also prevents corrosion of piping
- Existing district heating heat exchanger of apartment applied on site to confirm scale suppression and increase in heat exchange efficiency (improved by 6.1% in test room heat transfer rate)
- Corrosion inhibition performance confirmed by applying water pipe corrosion prevention on site (confirmed improvement of ER sensor by 50%-80%)
- Possible to monitor operation state by displaying related data while operating the scale remover
- Installation of current meter for easy check of operating point during installation and operation
- Control device displaying voltage, coil connection, operation signal, error and other alarm signals
- Possible to control the operating point by measuring the fluid running velocity when necessary
- Possible to control operating signal frequency and waveform for optimal scale removal



〈 Existing Pipe Scale and Newly Developed and Installed Scale Removal Device 〉

Current Intellectual Property Right Status

PATENT

- Scale Measurement Device for Pipe and Method (KR1379934)
- Electronic Pipe Scale Removal Device (KR1438765)
- Scale Measurement Device for Pipe and Method (KR1379934)

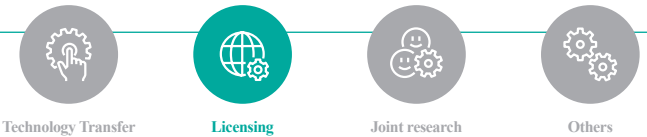
KNOW-HOW

- High-efficiency switching inverter driver design and manufacturing technology
- System installation technology for simultaneous scale removal and corrosion prevention
- Technology for sweep frequency domain setting according to pipe and fluid type

Technology Readiness Level (TRL)



Desired Partnership



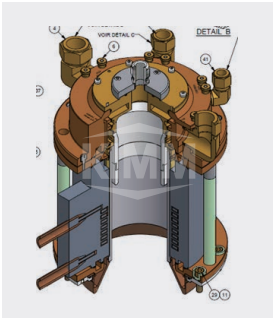


# Nanoparticle Manufacturing Device

▶ Department of Robotics and Mechatronics ▶ Researcher: Heechang Park ▶ Contact: +82-42-868-7612

Technology Overview

- Continuous electroless nanoparticle manufacturing technology extracting various metal or CIGS metal particles used for thin film solar cell or general nano metal particles using metal salt
- A metal nanoparticle generation technology by large-diameter high-power plasma torch through combining ICP (Inductive Coupled Plasma) and simultaneous dual frequency driving technology



Customer / Market

- Metal nano particle manufacturer, metal powder manufacturer, CIGS thin film solar cell manufacturer

Problems of Existing Technology or Necessity of this Technology

- Metal dry extraction technology, high capacity production process, economic feasibility verification, and CIGS production uses nano ink manufacturing technology.
- CIGS thin film solar cell is manufactured with vacuum sputtering process for CIGS particle fusion, however, this process is complex, costs a lot, and is difficult to control the fusion rate of the material.
- This technology uses ink printing method for CIGS metal nanoparticle manufacturing for simple CIGS thin film manufacturing.
- Inexpensive and simple process needed to produce other metal nanoparticles
- As for ICP, high-power torches of 100 kW or more are essential for large-diameter processing of materials.
- In the case of low frequency-large diameter, the plasma radius is reduced and low quality plasma can be generated. As for high frequency-large diameter, there is difficulty of obtaining high output of 30 kW or more from a semi-conductor element, and thus, adopting vacuum tube-type expensive/low-efficiency high frequency power cannot be avoided.

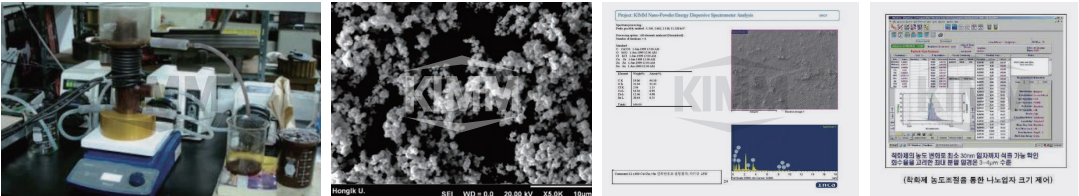
Technical Distinctiveness

- Nanoparticle can be generated continuously with metal salt at a low cost,
- With the ink printing method using CIGS nanoparticle, material for thin film production is saved and the process is cheap.
- By extracting multiple metals at once, the process is easy, and the productivity is high.
- In the copper particle generating test using copper salt, particles in size of several hundred nm to few dozen μm were generated.
- Existing CIGS thin film solar cell manufacturing methods include co-evaporation, sputtering, and MOCVD, but they require expensive vacuum sputtering process or RTP process as mandatory. Also, these processes are expensive and have difficulty in controlling the CIGS fusion rate.

- CIGS ink printing method makes ink with CIGS nanoparticles and prints on the substrate with the printing technique, and this is much simpler compared to the sputtering method. This method barely wastes any material, and advanced countries have been investing heavily in this process.
- Existing metal nanoparticle generating methods include mechanical mill method, solvothermal, solvochemical methods, but their economic feasibility is low or they require high temperature and high pressure.

Excellence of Technology

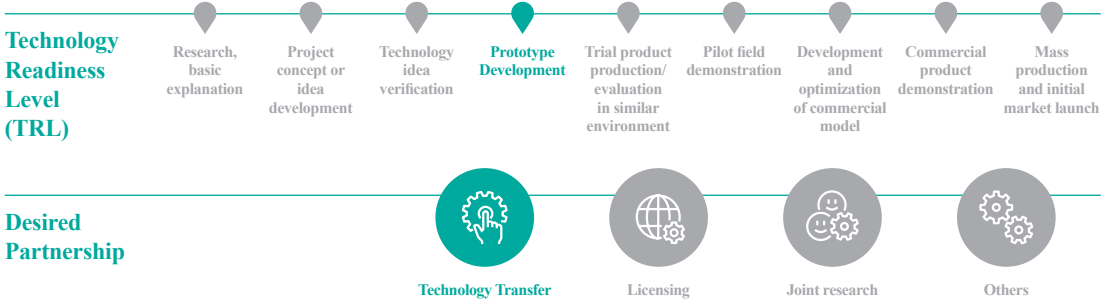
- The method uses hydrazine (N2H4) to return metal salt of the metal subject for extraction (e.g. Cu, In, Ga, Se Chloride), and it can achieve single or multiple extractions.
- By adding complexing agent, specific amount of metal salt reaction is maintained, and the particles extracted from the reactor and overflown are collected; and the Cu nano particles photographed with the SEM.
- The particles are dried in vacuum condition, go through gold coating (sputtering) and then photographed with the SEM.
- It was confirmed that the nanoparticle size was reduced and became consistent.
- In the case of ICP, in accordance with the coupling efficiency optimization criteria, low-frequency and high-frequency power can be supplied to one induction coil, thereby overcoming the limitations of the conventional low-quality plasma method of low-frequency large-diameter torch design.
- By operating the torch through simultaneous application of dual frequencies, it has the advantage of being able to use a high-frequency power source of a solid-state semi-conductor device method that is inexpensive and has good power conversion efficiency even at high output of 100 kW or more.



〈 Shape and Size Measurement of Nanoparticles from Single and Multiple Electroless Coprecipitation Generation 〉

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Continuous Electroless Coprecipitation Nanoparticle Manufacturing Device Using Electromagnetic Field (KR1393542)</li><li>• Continuous Electroless Coprecipitation Nanoparticle Manufacturing Device (KR1513927)</li><li>• Induction Plasma Torch with Dual Frequency Power and Nano-sized Particles Production Apparatus using the Same (P15140US)</li></ul>	<ul style="list-style-type: none"><li>• Possible to apply new concept agitator technology and magnetophoretic technology</li><li>• Possible to manufacture metal nano powder for 3D printer material</li><li>• Possible to improve purity in metal nanoparticle manufacturing</li></ul>





# Air Cushion Device Technology for Safely Handling Heavy Weight Object

▶ Department of Robotics and Mechatronics ▶ Researcher: Heechang Park ▶ Contact: +82-42-868-7612

Technology Overview

- The air cushion device is also called air caster. It is a device that injects high pressure compressed air inside a flexible and durable diaphragm made of urethane and spouts high pressure compressed air on the bottom similar to the principle of air bearing to reduce friction with the floor and levitate a cargo (e.g. hovercraft, air hockey) for easy transportation of heavy weight object. hovercraft, air hockey) for easy transportation of heavy weight object.
- With barely any friction, a 500 kg cargo can be moved only with 5 kg of strength. It is 10 times more effective compared to existing wheel or caster method.

Customer / Market

- Can be applied in almost all industrial fields for transporting heavy weight objects–shipbuilding industry, aircraft, machine tool, packaging, iron manufacture, mechanical machining, tire, national defense, marine plant, railroad car, construction machine, etc.

Problems of Existing Technology or Necessity of this Technology

- Distribution welfare issue about active prevention of safety accident in labor–intensive workplace, reduction of damage from truck traffic accident, distribution security strengthening, expansion of distribution services in isolated areas, and improvement of quality of life for workers in the distribution industry has recently become an important issue that require political support.
- Improvements are needed to create human–centered, convenient work environment by improving situations at work that prioritize work and efficiency and considering the distribution laborers from the noise and safety aspects.
- Cranes are classified into fixed hoist and mobile, and regarding the work area, fixed hoist crane can only work within a specific distance while mobile crane can freely move. However, spacious safety distance needs to be secured for work.
- Forklifts are the best in terms of changeability for work and are widely used in general in the goods handling device market. The changeability is high for work area and work route, but there is a limit regarding the load weight and center of gravity that it is difficult to transport large objects. Also, depending on the center of gravity of the object, the carrying capacity of the forklift changes, which also limits transporting large objects.
- Air cushion device technology discharges high pressure compressed air from the bottom to reduce friction without a separate mechanism to lift a heavy cargo even over 30 tons. With a person simply pushing the carbo, it is likely to be applied for short distance cargo transportation or execution of work with high variability.
- This air cushion device technology surpasses the limitations regarding weight and volume experienced with forklifts that it can be specialized for variable, one–time transportation.

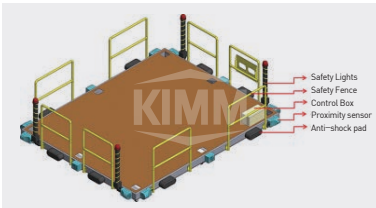
Technical Distinctiveness

- With barely any friction against the floor, a heavy weight object can be easily transported without damaging the floor or wall.
- The life of floor and wheel (when using together with this device) is extended as the heavy weight can be dispersed.

- It can be used in any direction, and it can spin 360 degrees on the spot, which allows for easy loading of a heavy weight object.
- With less vibration during transportation, it is favorable for transporting extremely sensitive heavy weight object such as aircraft components.
- It enables safe transportation inside a small place where high crane or forklift cannot enter or a space with height limit.
- Cost is low compared to existing crane and heavy equipment, and the volume is much smaller than the cargoes that working is easy.
- It can be used both indoor and outdoor.

Excellence of Technology

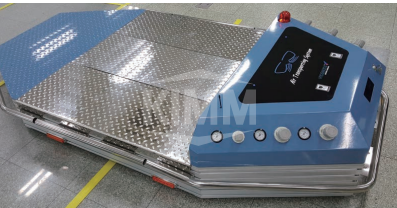
- Secured air cushion module design data through a CFD analysis
- As a result of the floatage test of the air cushion prototype by the performance testing device, it was measured that one air cushion can lift up to 6.2 ton, and when six are used in parallel, it can transport about 36 ton. It was measured that the air cushion can float an object 8 mm from the floor when 6.2 ton of floatage is generated.
- By measuring the friction that occurs when transporting a 10–ton load using this air cushion device, the maximum static frictional force (Fs) was 146.8 kgf, and here, the coefficient of static friction (μs) was 0.0147. Considering that the coefficient of friction of the regular office flooring is 0.8, the rubber material of air cushion was only 1/63, and this confirms that the air film on the bottom of the air cushion is formed stably.
- Comparing the performance with a transportation device with wheels, the coefficient of friction for such device was approximately 0.1 that it was confirmed that the coefficient of friction for the air cushion is 1/8 times smaller. This means the air cushion has 8 times better transportation ability compared to a wheeled device.
- It was measured that the friction increased as the load (floatage) applied to the air cushion increased, and with 5 ton of load applied (when floatage is 5,000 kgf), the friction measured was 367 N. And the coefficient of friction here was 0.013. The friction coefficient tended to decrease as applied load increased.



〈 Prototype of Air Cushion Transportation Device for 35 ton 〉



〈 Air Cushion Unit 〉



〈 Prototype of Air Cushion Transportation Device for 10 ton 〉

Current Intellectual Property Right Status

PATENT

- Air Cushion Transportation Device (KR1777198)
- Air Cushion Transportation Device for Diaphragm Abrasion Prevention (KR1684390)

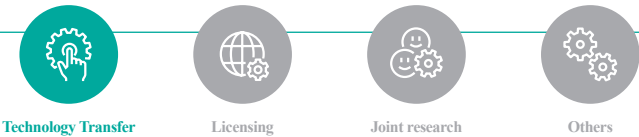
KNOW-HOW

- Technology for diaphragm material manufacturing and adhesion of shape from die
- Technology for design and analysis of optimal type of diaphragm based on capacity

Technology Readiness Level (TRL)



Desired Partnership



# Induction Heating Technology

Department of Robotics and Mechatronics    Researcher: Heechang Park    Contact: +82-42-868-7612

## Technology Overview

- Induction heating refers to the process of coiling inductive coil around the object to heat and have the alternating current flow to create flux, and when eddy current created with the change in flux flows through the surface of the object, the material is heated by Joule heating created through the resistance. Electronic equivalent circuit is a transformer with short-circuit in secondary side. The conductive coil is primary side while the subject for heating is secondary side.
- The use of such inductive heating technology is expanding in various areas such as electric melting furnace, metal surface heat treatment, pipe electric welding, heating roll, and induction cooker.

## Customer / Market

- Can be applied in various industries—functional film, printing, packaging, laser printer, copy machine, metal melting, welding, surface heat treatment, shipbuilding, atomic power waste treatment, induction cooker, shoe leather, construction material, aircraft, medical devices, etc.

## Problems of Existing Technology or Necessity of this Technology

- Inductive heating roll inserts inductive coil inside the cylinder to have eddy current induced through a magnetic field that occurred through current flow heat the cylinder itself. Heat is generated directly from the surface of the roll and delivered to the film. Therefore, it has benefits of high thermal energy use efficiency, maximization of quality of film with consistent heat distribution on the roll surface, and simple and clean surroundings.
- When applying high frequency to the existing method of using inverter and matching circuit, only the upper part is heated, and when operated with low frequency, only the lower part is heated. The simultaneous dual frequency inductive heating technology that solves this problem allows for quick heating, prevention of through-hardening, and simplification of heat treatment process and contributes to improvement of productivity and precision of heat treatment.
- Inductive heating type far infrared ray rubber cross linking facility uses the property of infrared ray where heat is penetrated quickly and deeply. The infrared radiation heater concentrates the radiation of the infrared ray in the cylindrical form, and the heating source of the heater uses the indirect induction heating technology to minimize the energy consumption. Until now, the hot-air blowing method of forming a mold by radiating heat from the surface of the rubber to the inside has been used for cross-linking of rubber material parts, but using far-infrared rays can minimize chemical changes to the rubber itself compared to the conventional hot-air blowing method, which is more effective for improving the quality.

## Technical Distinctiveness

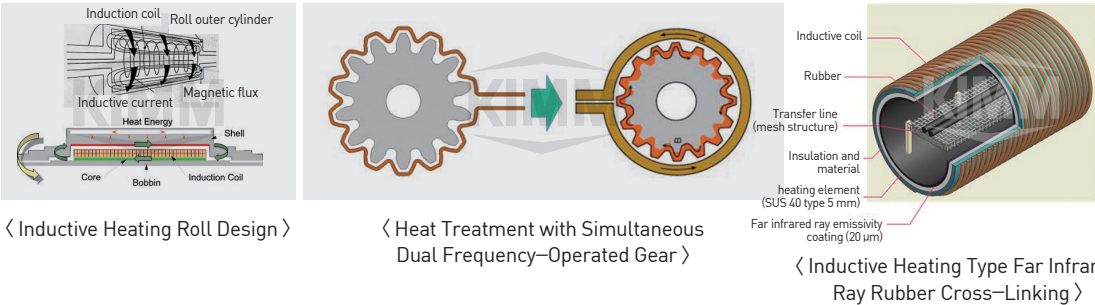
- With the contactless energy delivery property, the inductive coil does not have to be directly in contact with the object. Therefore, it enables effective and quick heating of various objects.
- No exhaust is generated as the process does not require oxygen for heating—heating done in clean environment.
- The entire or a part of object can be heated speedily as desired. With heat treatment of the surface or a specific area, it can be applied in various ways in the machinery and metal industry.
- Heating characteristic differs based on the material of the object, and the frequency and output can be adjusted to suit the material.
- Heating characteristic differs depending on the distance, and with the skin effect, heating can be done on the surface of the object, which enables surface treatment on a specific area.

## Excellence of Technology

- Recently, it began to be utilized for contactless energy delivery in the IT industry for delivery of electric power for magnetic levitation train, electric car charging, and mobile phone charging

- Inductive heating roll
  - The surface temperature difference of the roll can be precisely controlled up to  $\pm 2$  degree in the longitudinal direction that it can be used for superfine film heat treatment line such as functional film and FCCL line.
- Simultaneous dual frequency operating inductive heating technology
  - Austenite treatment is possible for the tooth and tooth bottom of the gear at the same time (to prevent through-hardening), and it is simplified by using one circular coil (previously, each coil-shaped induction coil was required). Distortion or run-out of the gear was minimized, meaning post-processing is unnecessary. In addition, energy saving and productivity were improved through instantaneous heat treatment. Energy can be saved by 50 % compared to the conventional carburizing heat treatment method.
- Inductive heat type cylindrical far infrared cross-linking facility for extruded rubber
  - Compared to existing hot-air drying facility, it saves energy over 30%, and compared to existing infrared ray facility using recently applied super steam's drying characteristics, additional 10% of energy saving is expected.
  - The field of application of the crosslinking machine for extruded rubber is wide, such as rubber hose, cable, XL pipe, belt, and sealing band for automobiles, and the possibility of commercialization is very high.
  - As the result of measuring the tensile strength—the criteria for assessing the rubber quality, and 100% Modulus, the cross-linking quality of the rubber was found to be have improved by approximately 20%.

### | Fields Applying Inductive Heating Technology |



## Current Intellectual Property Right Status

### PATENT

- Inductive Heating Roll Design and Manufacturing Technology (KR0345157)
- Simultaneous Dual Frequency-operated Inductive Heating Technology Development (KR1136352)
- Far Infrared Ray/Super Steam Hybrid Heating Cross-linking Device for Extruded Rubber (KR1287572)

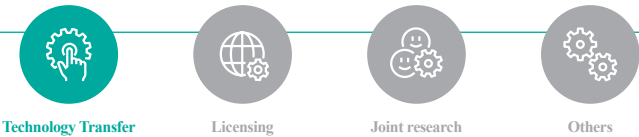
### KNOW-HOW

- Inductive heating roll design program
- Slit type core inductive heating roll technology

## Technology Readiness Level (TRL)



## Desired Partnership

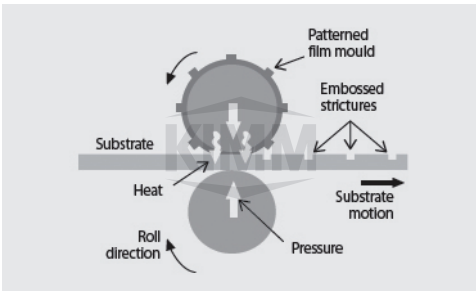


# Hot Embossing Apparatus for Large Surface using Hybrid Roll

▶ Department of Robotics and Mechatronics ▶ Researchers: Youngsu Son, Heechang Park, Seyoung Kim ▶ Contact: +82-42-868-7712

Technology Overview

- Technology for development of hybrid heating and cooling roll with 600 mm in width easily handling various hot embossing process conditions and ultrafine pattern formation



Customer / Market

- Next generation semiconductor requiring fine pattern, display device, bio device, optical communication component and high energy component

Problems of Existing Technology or Necessity of this Technology

- To realize high performance and high density, ultrafine shape processing of several hundred nm to several dozens  $\mu\text{m}$  is crucial. However, existing LIGA process or fine mechanical machining are encountering financial, technical limitations that there is a demand for new technology and device that will enable ultrafine shape production (below several dozens  $\mu\text{m}$ ).
- Compared to low and middle temperature embossing that can treat 300 mm wafer, high temperature embossing has technical difficulties with adding uniform temperature and pressure throughout the entire working area. Press type high temperature embossing can easily add uniform temperature and pressure throughout a small area but has limits in continuously handing a large area.
- UV curing type of roll embossing process requires a vacuum facility and specific resin that reacts to UV. The cost for process design, process maintenance/production is high.

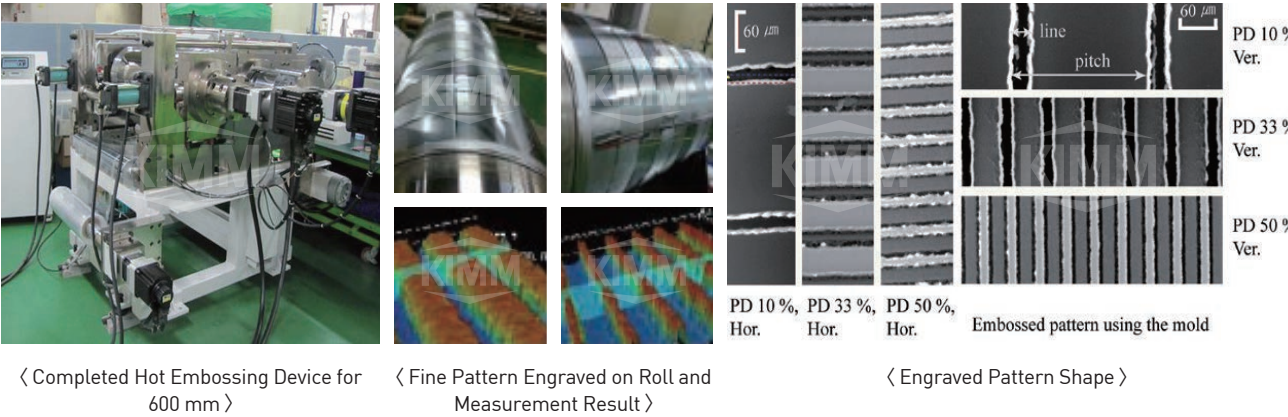
Technical Distinctiveness

- The technology heats the polymer beyond the glass transition temperature, uses a roll-to-roll mechanism while polymer is soft, and then cools and cures. Ultrafine patterning with a size below micron can be performed.
- It is easy to manufacture optical components like beam splitter, lens, and hologram and non-reflective substrate, and optical filter. When used in solar cell manufacturing, it can be applied for polymer embossing process in the insulator layer or the active layer.
- It can also be widely used for general industry other than hot embossing such as textile and paper manufacturing.
- With heating and cooling function inside the roll, the surface temperature can be adjusted quickly so that it enables active process design.

- Surface temperature consistency secured for hybrid roll of 600 mm in width for micropattern on large area (Temperature deviation:  $\pm 2^{\circ}\text{C}$ , Maximum temperature:  $250^{\circ}\text{C}$ )
- The result of experiment with the hot embossing device showed pattern densities up to 70% where the material was PMMA and line width was  $20\text{ }\mu\text{m}$ .

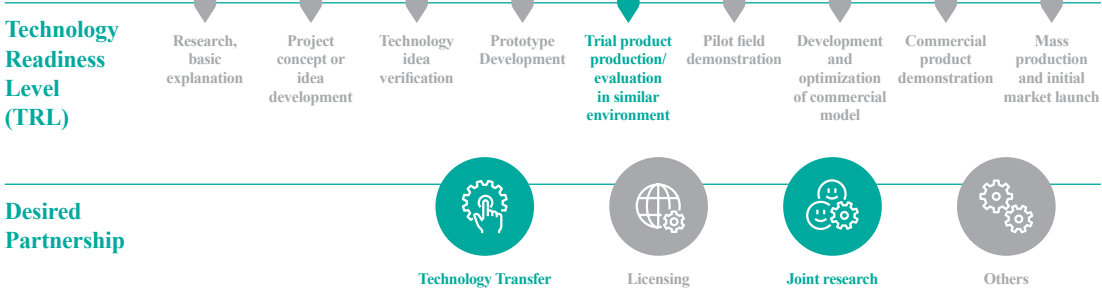
Excellence of Technology

- Hybrid roll was used as a pattern roll and heating roll, and a cooling device was added to improve cooling effect after patterning. By adding a few mechanical parts, the contact amount of the film and roll was simply adjusted for better pre-heating effect.
- A sensor part was added to monitor the roll transformation and contact status during pressurization.



Current Intellectual Property Right Status

PATENT		KNOW-HOW	
<ul style="list-style-type: none"><li>• Apparatus for manufacturing optical film (KR1064492)</li><li>• Impact print type hot embossing apparatus (KR0999538, JP5604633)</li><li>• Pressure roller for uniform pressing of roll-to-roll apparatus (KR1537517- 0105199)</li><li>• System for patterning using roll-to-roll (KR2013-0122058)</li><li>• Monitoring apparatus for nip pressure of roll-to-roll device (KR1519846)</li><li>• Apparatus for manufacturing sheet member having line type micro pattern (KR1221830)</li></ul>		<ul style="list-style-type: none"><li>• Technology for designing hybrid roll with heating and cooling function</li><li>• Hybrid roll-based hot embossing device design technology</li></ul>	





# Ozone Generator Technology with High-Efficiency and High-Concentration Characteristics

Department of Robotics and Mechatronics    Researcher: Youngsu Son    Contact: +82-42-868-7712

Technology Overview

- Development of high efficiency, high concentration ozone plasma generation device which minimize footprint and maximizes ozone generation efficiency in order to replace the non eco-friendly hazard-ous chemical solution process in the next-generation semiconductor/ OLED/ solar cell manufacturing industry to the eco-friendly ozone plasma(called green chemical) process.



Customer / Market

- Semi-conductor/OLED/silicon solar cell cleaning process, semi-conductor ALD process/oxide film formation process/photo-resist film removal process, medical device disinfection/sterilizer, water treatment industry and advanced oxidation treatment of waste water., etc.

Problems of Existing Technology or Necessity of this Technology

- In order to apply ozone plasma technology to the semi-conductor/OLED/solar cell manufacturing process, a device technology that can efficiently generate high-concentration ozone plasma of 14 wt% or more with high oxidizing power that can replace the existing chemical solution process is required. Low footprint devices are required to occupy minimal space in the clean room.
- In addition, high-capacity ozone generators for use in advanced oxidation treatment in the water treatment industry mostly use foreign products. In particular, when high-capacity ozone is required, ozone generator technology with high energy efficiency is essential.
- Ozone plasma generators meeting the above requirements in the industry are mostly imported, and the use of ozone is gradually increasing in various industrial fields, and therefore, domestic development of ozone generator technology with high efficiency and high concentration characteristics is required.
- The domestically-made ozone generator products are mainly used for daily life and environmental industru such as food, beverage and water treatment because of the low concentration characteristics.

Technical Distinctiveness

- The main idea of this technology is to increase the conversion electric field strength by forming an extremely fine discharge gapor for obtaining high concentration ozone by generating plasma with high efficiency.
- Minimize the size of ozone generation to make a design that allows stacking and expansion according to the amount of ozone generation to fulfill minimization of the area occupied by the device inside the clean room.
- Designed as a modular type for large-capacity ozone generation required for water treatment industry applications, it is easy to expand the ozone generation amount, and all equipments can be operated from the main controller.

Excellence of Technology

- It possesses high-concentration ozone generation characteristics of over 18 wt%, it is possible to apply the semiconductor ALD processes requiring extremely high-concentration ozone.
- The high-efficiency ozone generation yield of 180 g/kWh reduces the power energy consumption by more than 30 % compared to foreign leading products. So, by replacing foreign ozone generation products with the developed generator, it is expected to save maintenance costs in water treatment industrial field that consume high energy costs from the use of high capacity ozone.

Performance of Developed Ozone Generator

Product	Pinnacle	Ozonla/Wedeco	Fuji/Mitsubishi	Primozone	MKS	KIMM
O <sub>2</sub> Condition	Oxygen (>99%)	Oxygen (>99%)	Oxygen (>99%)	Oxygen (>99%)	Oxygen (>99%)	Oxygen (>99%)
Cooling	water	water	water	Water (10°C)	Water (17°C)	Water (20°C)
Ozone wt%	0-12 wt%	0-12 wt%	0-15 wt%	0-20 wt%	0-24 wt%	0-20 wt%
Power Supply	Integrated Hi-Frequency	External Low Frequency	External Low Frequency	Integrated HI-Frequency	Integrated HI-Frequency	Integrated HI-Frequency
Ozone Cell	Modular Planar	Tubular	Tubular	Modular Planar	Modular Planar	Modular Planar
Unit Cell Performance (O <sub>3</sub> 10wt%)	Generated amount 64g/hr O <sub>2</sub> flux 7.5LPM Discharge power 650W	Generated amount 13g/hr O <sub>2</sub> flux 136LPM Discharge power 14kW		Generated amount 55g/hr O <sub>2</sub> flux 6.4LPM Discharge power 600W	Generated amount 58g/hr O <sub>2</sub> flux 6.8LPM Discharge power 7W	Generated amount 81.5g/hr O <sub>2</sub> flux 6LPM Discharge power 280W
Applied Industry	Water treatment	Water Treatment	Water treatment	Water treatment	Semiconductor FPD	Semiconductor Water treatment
Ozone Yield (g/kWh)	98.5	92.8	93 (estimate)	91.66	?	184.4

Current Intellectual Property Right Status

PATENT

- Apparatus for Producing High Concentration and Purification Ozone Gas with Micro Discharge Gap (KR1109552)
- Apparatus for Generating High Density Ozone Gas Dissolved Water Using Electromagnetic Field (KR2014-0003109)
- Coincident Surface Discharge Type Apparatus for Generating Ozone Using Water- Electrode (KR1001858)
- Ozone Discharge Method of Using Coolant as Electrode and the Apparatus (KR515692)

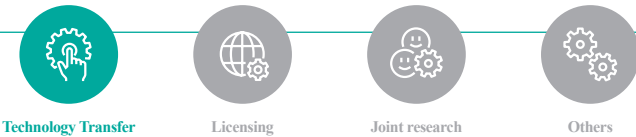
KNOW-HOW

- High concentration ozone generator design and manufacturing technology
- High efficiency power supply device design and manufacturing technology

Technology Readiness Level (TRL)



Desired Partnership



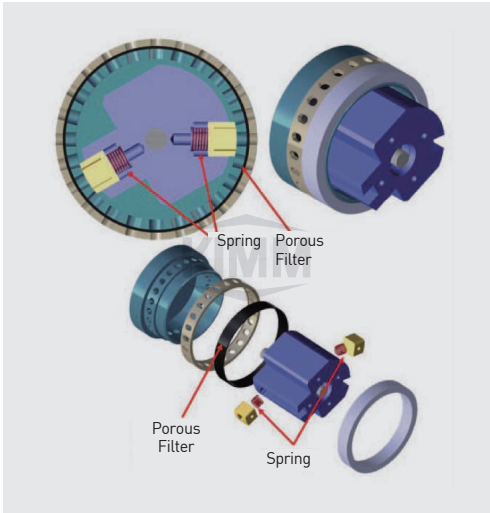


# High Resolution Dispenser for Fine Powder of Particle Size 10 μm

▶ Department of 3D Printing   ▶ Researcher: Changwoo Lee   ▶ Contact: +82-42-868-7146

Technology Overview

- A fine powder dispenser for particle size of 10 μm with the life extended 10 times the existing device and has resolution of mg.



Customer / Market

- LED manufacturer, pharmaceutical company, Laser cladding, other industries using fine powder including dying companies.

Problems of Existing Technology or Necessity of this Technology

- Using a metal filter and the forced insertion and discharge structure, resolution and life of the dispenser—limitations of current technology—were greatly improved.
- To control fixed quantity of fine powder, power is filled inside a frame with a certain volume and extra powder overflowing the frame is scraped. However, this method has following issues.
  - If the frame size is smaller than a certain size, powder cannot be filled inside the frame, therefore the frame size has to be greater than a specific size—difficult to improve resolution of the dispenser
  - Life of dispenser is shortened as the frame wears out as powder gets stuck during scraping.
- Fine powders are used widely for LED fluorescent body, medicines in powder form, metal power used for laser cladding, and dying.
- In cases like LCD fluorescent body and medicines where a slight difference in quantity can change the performance and function of the product, the quantity control is crucial.

Technical Distinctiveness

- The metal filter is located on the bottom of the frame so that the powder can be inhaled and discharged by force using vacuum and pressure; even with a small frame, fine powder can be filled inside the frame.
- By filling the frame by force, powder can be inserted from the side.
- The design where powder can be filled from the side has the frame inside a cylinder; as the power filled from the side rotates, the powder is scraped automatically due to gravity that the dispenser is not worn off from powder getting stuck during scraping; therefore the life of dispenser is extended.
- If automatic scraping cannot be applied, a smooth material like sponge can be used for scraping that it only applies relatively mild abrasion, which leads to longer life.
- Since powder can be filled inside a small frame with forced insertion using the metal filter and vacuum, high resolution becomes possible. The automatic scraping by gravity barely wears off the dispenser, therefore longer life is expected.

Excellence of Technology

- The table on the right shows the result of experiment conducted 30 times using metal powder.
- The scale used has resolution of 0.01 g, and the highest result was 2.75 g and the lowest result was 2.7 g with the maximum deviation of 0.05 g—only 1/4 of the maximum deviation from existing powder dispenser of 0.2 g. With the average result of 2.73 g and standard deviation of 0.0108 g or 0.39%, its high precision has been proven.
- Other than this quantitative result, the powder dispensing device developed with this patent is expected to have life 10 times longer than the existing powder dispensers.

2,74	2,75	2,73	2,74	2,73	2,73
2,75	2,73	2,72	2,72	2,73	2,72
2,73	2,74	2,72	2,72	2,74	2,73
2,72	2,71	2,72	2,73	2,72	2,74
2,73	2,72	2,73	2,73	2,7	2,73



〈 Dispensing Performance Evaluation and Powder Control Test Device Using Metal Powder 〉

Current Intellectual Property Right Status

PATENT

- Fixed Quantity Powder Dispenser (KR1332312)
- Fixed Quantity Powder Supply Control Device (KR1453953)
- Powder Dispenser (KR1398110)
- Powder Spraying Control Device (KR1261588)
- Fixed Quantity Powder Collection Device (KR1170645)

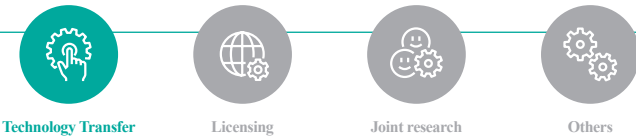
KNOW-HOW

- Low density fine powder dispensing technology

Technology Readiness Level (TRL)



Desired Partnership

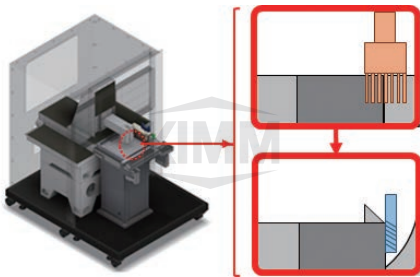


# Hybrid PBF Printing Technology with Powder Removal Device

▶ Department of 3D Printing ▶ Researcher: Pilho Lee ▶ Contact: +82-42-868-7786

Technology Overview

- Milling-PBF hybrid system and process technology to improve surface roughness and shape precision of 3D printing samples
- Hybrid PBF printing device including powder removal device and process technology using the same



Customer / Market

- Mold industry
  - When developing an injection molding mold, it can achieve injection molding cycle time by shortening the cooling time through making a three-dimensional cooling path for the part with a thick shape and applying it to actual mass production. However, the conventional metal 3D printing technology cannot be directly applied to the mold field due to limitations in securing surface roughness and shape precision. The milling-PBF hybrid device and powder removal device technology proposed in this technology have the potential to solve the above-mentioned barriers to market entry.
- Military/aviation industry
  - Milling-PBF hybrid device and powder removal device technology can be applied to parts that couldn't satisfy the mechanical precision with conventional PBF printing, such as parts that require high dimensional precision and surface roughness of the internal flow path.

Problems of Existing Technology or Necessity of this Technology

- In the case of a 3D printer including a previously developed milling device, the milling device intervenes during the 3D printing process to process the inside and outside of the product. Here, the milling cutter installed in the milling device enters the powder bed together with the unsintered powder and performs machining, so the powder gets stuck in the cutter blade, resulting in tool wear and deterioration of machining quality. In order to solve the above problem, a method of suction or spraying powder has been devised and applied by a Japanese company.

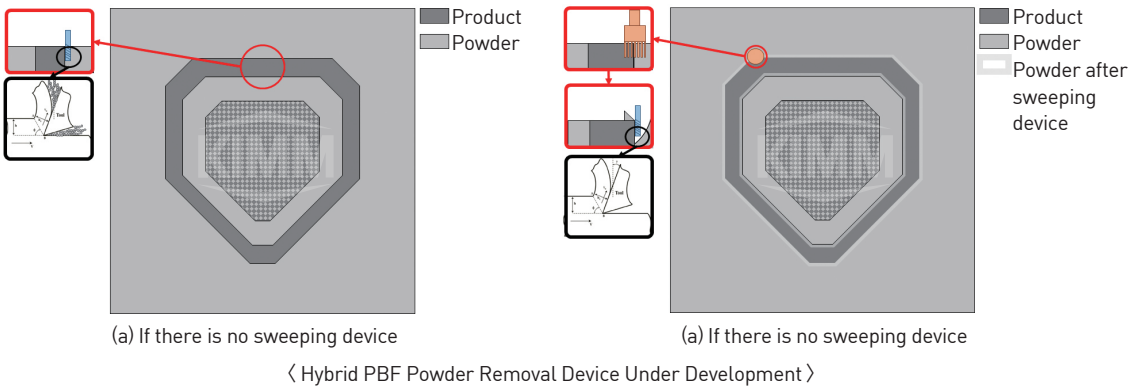


◁ Existing Hybrid PBF Powder Removal Device, Matsuura, Japan ▷

- 3D printing technology must maintain an inert gas or vacuum environment to prevent oxidation and remove fumes generated during the melting process of materials. Maintaining internal pressure and generating a constant laminar flow are essential. However, existing technology is not suitable for inert gas environment or laminar flow maintenance.

Technical Distinctiveness

- Including a device and part that can sweep powder onto a 3D printer with a milling device, it prevents powder from sticking to the cutter blade during the milling process, thereby improving the quality of machining and reducing tool wear.
- There is no need for separate pneumatic/mechanical installation/maintenance as the device can be inserted into the existing ATC (tool changer).



Excellence of Technology

- When this technology is applied, the quality of machining is increased through suppression of tool wear, the cost of using tools and replacement time are reduced, and there is no need for installation and maintenance of separate pneumatic devices and instruments.

Current Intellectual Property Right Status

PATENT

- 3D printer including a sweep device or a milling device including a sweep unit, and a printing method using the same (KR2020-0173385)

KNOW-HOW

- Hybrid PBF printing equipment development and process technology including this research

Technology Readiness Level (TRL)

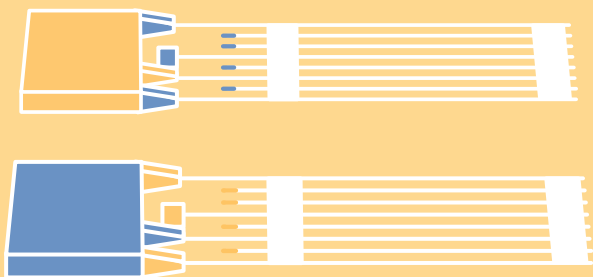


Desired Partnership



2

Nano-Convergence  
Manufacturing Systems  
Research Division



3D SENSOR  
ASSEMBLY

- 114 • Department of Nano-Manufacturing Technology
  - 136 • Department of Nano-Mechanics
    - 144 • Department of Printed Electronics
- 162 • Department of Nature-Inspired System and Application

# Low-Temperature Ultra-Thin Film Coating Technology for Nanostructure Fabrication and Surface Functionalization

▶ Department of Nano-Manufacturing Technology ▶ Researcher: Eunji Gwak ▶ Contact: +82-42-868-7347

Technology Overview

- Technology to coat functional metal/oxide thin films at low temperature on high polymer-based substrate surface like flexible display or polymer membrane

Customer / Market

- Flexible display, transparent electrodes, TFT manufacturer, membrane manufacturer, hydrophilic/hydrophobic film manufacturer

Problems of Existing Technology or Necessity of this Technology

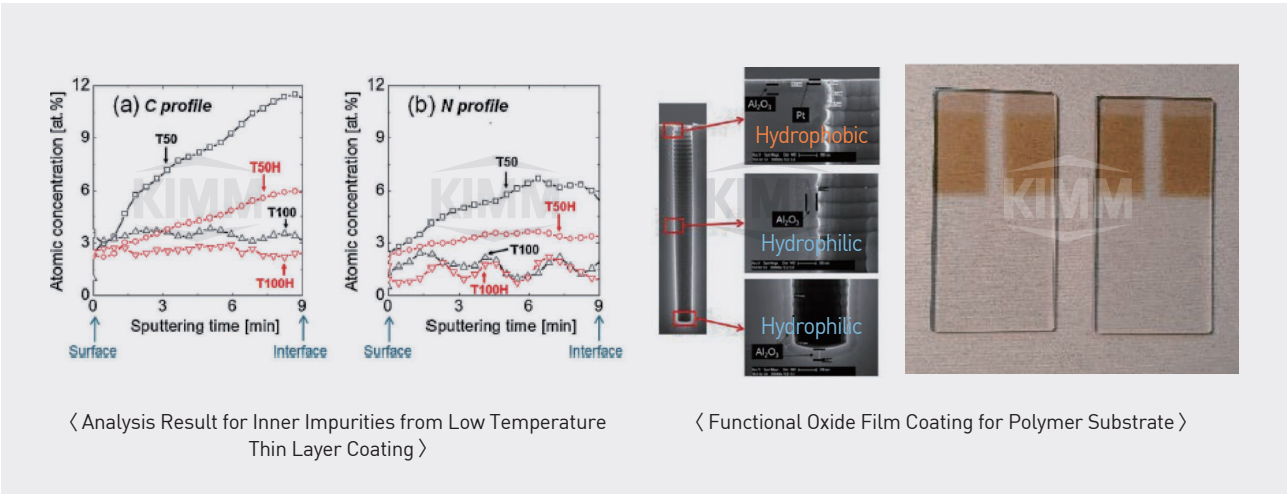
- Existing ultra-thin film coating technology, such as chemical vapor deposition or metal sputtering, are performed at high temperature.
- Flexible display, transparent electrodes, and TFT manufacturing uses a flexible polymer film or glass plate, but polymer or glass plates are relatively vulnerable to heat that high temperature process cannot be applied. Therefore, a low temperature process for thin film coating is demanded.
- For a polymer membrane, the issue of permeability reduction occurs due to the hydrophobicity of the surface. To solve this issue, surface functionalization process (e.g. the oxygen plasma surface treatment) is used to modify the membrane surface to the hydrophilic surface.
- However, since oxygen plasma treatment effect decreases with time, surface coating with a hydrophilic substance is needed to maintain the surface hydrophilicity permanently. Moreover, a low temperature ultra-thin film coating technology is required to avoid the pore size reduction of polymer membrane during coating process.

Technical Distinctiveness

- Ultra-precise control of ultra-thin film thickness with resolution of 0.1 nm is possible within the temperature range where the polymer substrate is not damaged. (usually below 150°C)
- Various ultra-thin film coating technologies such as atomic layer deposition (ALD), chemical vapor deposition (CVD), electron-beam evaporation, and DC/RF sputtering can be applied according to substrate and required film material and coating thickness.
- Surface functionalization is capable through functional metal/oxide thin film coating on the polymer substrate.
- Surface modification of 3D nanostructure is possible through additional wet etching and dry etching processes

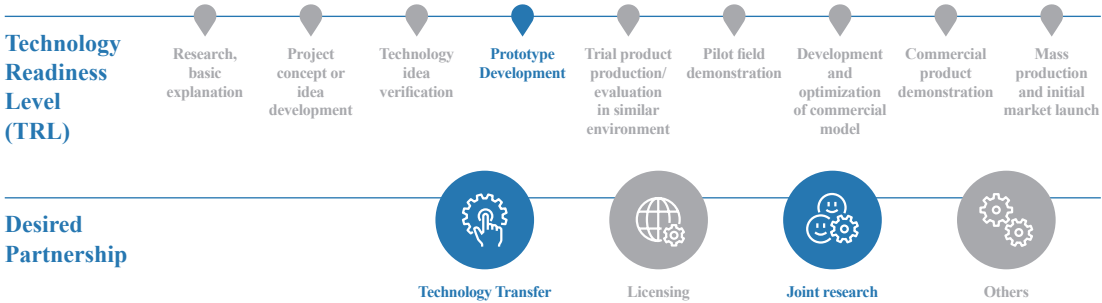
Excellence of Technology

- Coating a functional ultra-thin metal/oxide film on the surface of the nanostructure through low-temperature process and precise thickness control (thin film coating temperature below 150°C, thickness precision level 0.1 nm, thickness uniformity over 95%).
- Various ultra-thin film coating technologies can be integrated to coat functional materials in/outside of the high aspect ratio channel structure
- Surface functionalization is capable through functional metal/oxide thin film coating on the polymer substrate.
- It can modify and control the surface micro-structure according to the process.



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Photonic Crystal Nano Structure Method for Making the Same (KR1501005)</li></ul>	<ul style="list-style-type: none"><li>• Coating a functional ultra-thin film at low temperature without deformation/ damage to flexible polymer substrate</li><li>• Applying customized ultra-thin film coating technology to suit demanded ultra-thin film material and thickness</li><li>• Coating of functional metal/oxide thin film on polymer material surface</li><li>• Surface nanopattern and surface area control through etching process</li></ul>



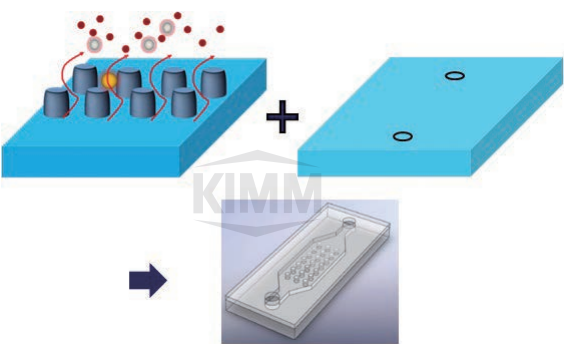


# Mass producible micro-fluidic chip technology for Point-of-care Diagnosis

Department of Nano-Manufacturing Technology    Researcher: Youngeun Yoo    Contact: +82-42-868-7883

Technology Overview

- Design and processing technology for packaging of micro-fluidic chip, one of the core technologies for manufacturing of plastic micro-fluidic chip using microchannel with a size ranging from dozen nanos to several hundred micros, that seals microchannel to prevent leaking of liquid sample and minimizes deformation of the channel.
- Irreversible packaging technology including plastic plate welding and adhesion and reversible packaging technology allowing sealing and unsealing repeatedly.



Customer / Market

- Diagnostic device, medical device companies

Problems of Existing Technology or Necessity of this Technology

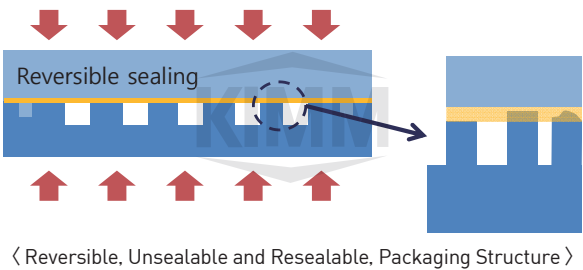
- Conventional adhesion or welding packaging technology for plastic material has difficulty in sealing and maintaining precisely nano/microchannels on the surface due to heat, pressure, or chemical solvent used during the process that affect the surface structures and properties.
- Due to the high temperature and chemicals during the packaging process that may cause damage in various biochemical substance including protein, it can be used only for very limited applications.
- When irreversible packaging is done with adhesion and welding, unsealing and resealing is difficult in the middle of using the micro-fluidic chip or pre/postprocess for using the device when it is needed.
- Packaging done with mechanical clamping, the microchannels are hard to be sealed uniformly, which results in leakage from some of channels frequently.
- It is necessary to apply the optimal packaging design and process technology that considers the shape and size of the microchannel depending on the purpose, requirement, and use environment of the microchannel.

Technical Distinctiveness

- Capable of various irreversible packaging process technologies such as ultrasonic welding, thermal or adhesive bonding that prevents leaking and minimizes deformation of the microchannel on a plastic plate.
- Capable of reversible packaging process technology, heating-free and chemicalfree, that can seal the microchannel hermetically and maintain the microchannel shape and size precisely.
- With the reversible packaging process technology, the device can be unsealed or resealed repeatedly while the device is in use or in pre- or post-process, which makes the device be applied to more diversely.

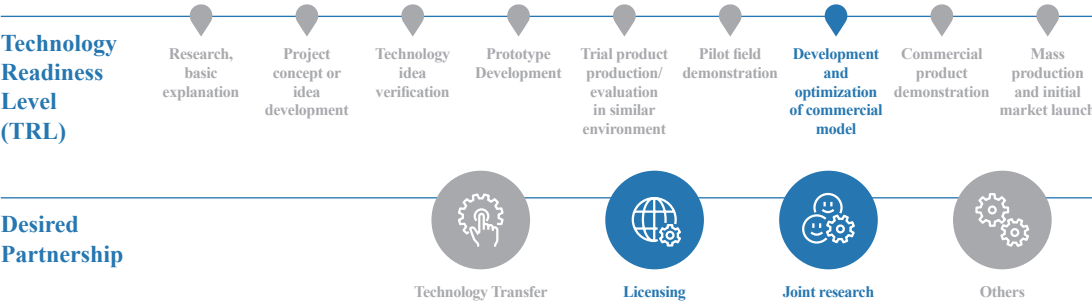
Excellence of Technology

- Reversible packaging technology, prevents negative effect on biochemical substances like protein and cell due to its heating-free and chemical solvent-free process, which is a great benefit regarding development of bio-chips.
- As a mass producible packaging technology using plastic material, productivity that is equivalent to that of injection molding can be realized-over 90% yield and processing time of 1 minute or less.
- Based on this reversible packaging technology, the lead time for a device can be reduced to from few days to a month, which enables rapid development.



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Micro-Channel Device and Manufacturing of Micro-Channel Device (KR1392426, PCT/KR2014/005141, to be registered in the U.S. and Europe)</li><li>• Local Pressurization Typed Microchannel (KR2017-0184209)</li><li>• Microchannel with Joints (KR2017-0184201)</li><li>• Microchannel (KR1882078)</li></ul>	<ul style="list-style-type: none"><li>• Microchannel ultrasonic welding process</li><li>• Microchannel film adhesion packaging process</li><li>• Thermal and chemical welding for microchannel</li></ul>

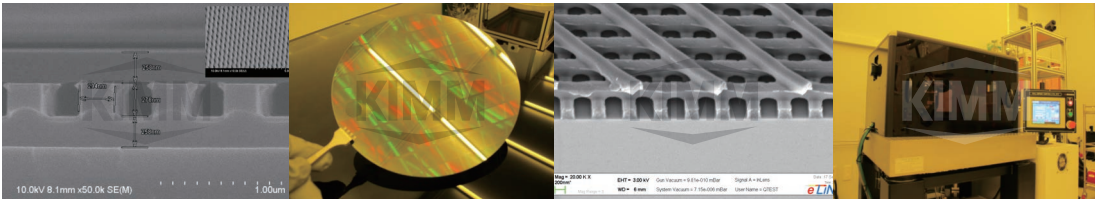


# Liquid Transfer Imprint Lithography Typed Continuous Nanoimprint Lithography Technology

▶ Department of Nano-Manufacturing Technology ▶ Researcher: Jaejong Lee ▶ Contact: +82-42-868-7145

Technology Overview

- Multilayer nano-imprint equipment and process technology that able to continuously transfers nano-patterns with some resists on 6-inch size to some kinds of substrates by converging the solution transfer and nano-imprint processes using the key technology.



Customer / Market

- Flexible electronic device, display, solar cell, WGP, functional biosensor, functional medical device

Problems of Existing Technology or Necessity of this Technology

- Conventionally developed multi-layer nanoimprint system can perform waferbased nanoimprint process that it uses a stamp with nanopatterns, cure the coated UV/Thermal resist by means of UV and heat sources. It can be done up to 8-inch substrate. The minimization of the residual layer thickness for a large area substrate is required absolutely.
- A technology that can continuously transfer nanopatterns with almost no residual layer on a 6-inch or larger wafer based on a solution transfer process is required.
- The biggest problem in pattern transfer using nanoimprint is the thickness of the residual layer. When transferring the pattern to the applied resist, the difference in thickness between the area with and without the pattern is determined by the stamp, but the pattern of an area without the pattern is largely dependent on the thickness of the initially applied resist. There have been many attempts to reduce this.

Technical Distinctiveness

- As a result of the experiment, since about half of the thickness of the polymer supplied to the donor side can be removed, unlike the existing nano-imprint process, the thickness of the residual layer can be significantly reduced. Since patterning without residual layer is possible depending on the designed polymer used, the etching process is unnecessary, and the subsequent process implementation is easy.
- Depending on the shape of the stamp used, the process is carried out with continuous line contact (using roll stamp) or surface contact (using face stamp) between the stamp and the substrate, allowing the process to be performed on a large area and a flexible substrate with a relatively low pressure of 2 kgf/cm2.
- Liquid transfer type roll nanoimprint process uses the roll-shaped stamp to strip off the polymer applied on the donor side at a uniform thickness and transfers on the acceptor side, which is similar to the inking process, but is very different in a sense that it can transfer nanopatterns and transfer polymer in multiple layers using UV.

- Resist on the donor side is supplied through the spin coating process, and it peeloff using the soft material stamp is transferred to the acceptor side. The pattern transferring is able to do on the acceptor side even the surface is non-flat or lower uniformity.
- Unlike existing nanoimprint process, the thickness of residual layer can be reduced significantly, which means etching is not necessary and realization of follow-up process is made easy.

Excellence of Technology

- In the process of transferring the resist applied on Plate 1 with the roll-shaped stamp and retransferring it to Plate 2, the surface pattern on the roll-shaped stamp is copied onto the resist applied on Plate 2, and this enables stable performance of liquid transfer nanoimprint process on a large plate or flexible plate.
- There is a donor-side station that continuously supplies polymer and an acceptor-side station where patterning is performed using the polymer removed from the donor. It is a process where the polymer is removed from the donor using roll nano stamp, transferred to the acceptor station, and transferred with UV.



〈 Process Diagram 〉

Current Intellectual Property Right Status

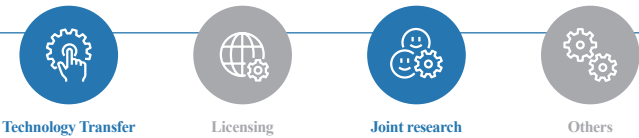
PATENT

- Apparatus and Method for Liquid Transfer Imprint Lithography Using a Roll Stamp Method (KR1303194, PCT/KR2013/012297)
- A Construction/Separation Type Individually Actuating Imprinting Apparatus (KR585951)
- Imprinting Apparatus for Making Uniform Contact Between Stamp and Wafer and/ or Substrate (KR784827)
- Individually Actuating Nanoimprint Lithography Apparatus (KR1093820)
- Continuous Nanoimprint System Using Rotatable Angulated Roll Stamp (KR1238628)
- Nanoimprint Apparatus and Nanoimprint Method (KR1299919)
- Roll Stamp Manufacturing Apparatus and Roll Stamp Manufacturing Method and Clone Stamp Manufacturing Stamp Using the Apparatus (KR1332323)
- Nanoimprinting Lithography Apparatus Using Roll Stamp (KR784826)

Technology Readiness Level (TRL)



Desired Partnership

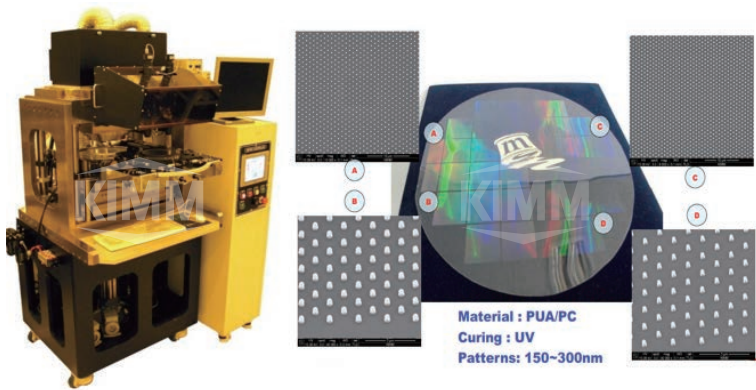


# UV/Thermal Hybrid Nano-Patterning Equipment technology able for Ultrafine Shape Patterns

▶ Department of Nano-Manufacturing Technology ▶ Researcher: Jaejong Lee ▶ Contact: +82-42-868-7145

Technology Overview

- UV/thermal composite nano-patterning process/equipment technology that can produce nano-micro hybrid structures with high reliability on 6-inch or larger substrates



Customer / Market

- Display manufacturer, flexible plate device manufacturer, Si solar cell and thin film solar cell manufacture, nano/bio device field and nano-manufacturing systems company

Problems of Existing Technology or Necessity of this Technology

- Technology of an apparatus for patterning on a 6-inch wafer or flexible polymerbased substrate has been developed, but there is no any automated system technology that includes the ability to automatically and/or continuously feed substrates
- Suss Microtec in Germany and EVG in Austria have developed and commercialized the high temperature thermal-nanoimprint systems.
- As these technologies are intended to use the same silicon wafer and use a vacuum atmosphere, there are restrictions on the types of substrates.
- By using a vacuum chamber, it is limited by the size of the substrate and the material of the stamp, and when the size is large, it is difficult to work, and the working pressure cannot be controlled.
- The nanopatterning process is not able to perform continuously by single stamp without any additional surface treatment to get high throughput and it has low system adaptability for roll-shaped imprint process for mass production.
- Therefore, this technology could be overcome the limitations regarding the flexible stamp and enhances the pattern uniformity on the large area substrates.

Technical Distinctiveness

- It can be applied in various filed, because it has more various types of stamp or flexible stamps i.e. Ni, Si, Glass, PMMA, PC, PET can be utilized compared to existing apparatus. Also, the its extendibility can be enhanced through loading and unloading the flexible plate and adjustment of heating/cooling plate size to be applied for various research areas.
- By adjusting the size of the UV/heating/cooling device, it can work on a size larger than 8 inches (large area), and after applying a polymer to a 6-inch Si substrate, more than 95 % of the pattern uniformity can be maintained in a 50 nm pattern through UV or high-temperature embossing process.
- It is expandable from 6 inches to 8 inches, and the heating and cooling rate is fast. When UV is used, the process time can be significantly reduced.
- Nano-patterning with aspect ratio of 7 or more of the nano-micro hybrid structures to be fabricated is possible.
- It can be applied in various filed, because it has more various types of stamp or flexible stamps i.e. Ni, Si, Glass, PMMA, PC, PET can be utilized compared to existing apparatus. Also, the its extendibility can be enhanced through loading and unloading the flexible plate and adjustment of heating/cooling plate size to be applied for various research areas.

Excellence of Technology

- As a result of high-temperature embossing process of coating PMMA and thermoplastic polymer on a substrate such as Si, quartz, glass, etc. using a stamp with various nano-patterns, pattern transfer uniformity of up to 95 % was secured. It can transfer the pattern directly to the PUA and polycarbonate (PC) film, and transfer the same pattern to PMMA by using the transferred polycarbonate film as a stamp.
- Functional lenses can be realized without a separate process by patterning functional lenses on polycarbonate film.
- Nano-micro hybrid structure can be fabricated on the surface of flexible PC, PET film and thin glass film substrates.
- In addition, it was confirmed that it can be used for patterning Si solar cells and thin film solar cells.
- Proven technology excellence by publishing a number of SCI papers

Current Intellectual Property Right Status

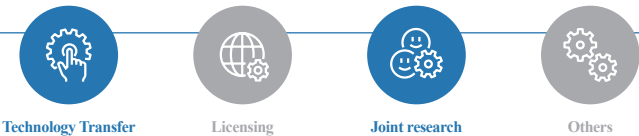
PATENT

- Hot Plate and hot Embossing Nano Imprinting Lithography Apparatus Using Above Hot Plate (KR0761212)
- Hot Embossing Apparatus Using Automatic Transfer Method (KR0885670)

Technology Readiness Level (TRL)



Desired Partnership





# Laser Direct Lithography System and Nano-/Micro-Structure Fabricaion Technology

▶ Department of Nano-Manufacturing Technology ▶ Researcher: Hyungjun Lim ▶ Contact: +82-42-868-7072

Technology Overview

- A semi-conductor laser-based direct lithography system capable of fabricating functional microfluidic channels, nano-bio devices and 3D nano-/micro-optical component structures



Customer / Market

- Manufacturing and equipment fields of functional devices such as bio/medical, optical and display

Problems of Existing Technology or Necessity of this Technology

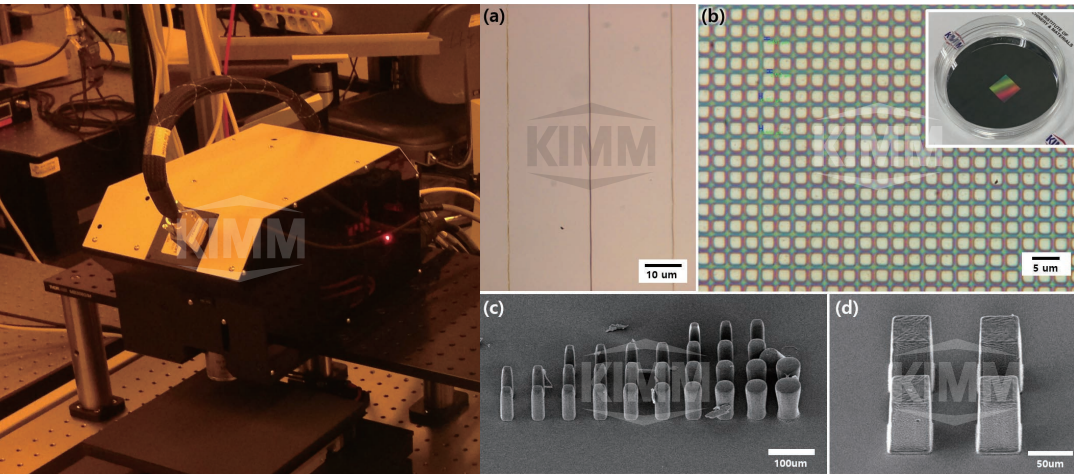
- Photolithography and imprint lithography are technologies that duplicate patterns formed on masks or stamps. There are fundamental limitations in manufacturing arbitrary shapes.
- Conventional 3D printing equipment can produce various types of 3D structures, but in general, the minimum shape size that can be produced is several tens of μm, and the price of equipment for high-resolution processes increases exponentially.

Technical Distinctiveness

- Development of core technology and systemization technology for performing laser lithography process that can perform patterning directly on a substrate without a stamp or mask
- Implementation of a tabletop system through the design and development of a compact optical head that integrates focusing servo, beam steering, aberration compensation, illumination and imaging devices,
- It is a technology that directly draws and fabricates a structure of a desired shape using a focused laser beam. It can form a structure with a level of several hundred nm, which is similar to the wavelength of a light source.
- By carrying out process development using this system, the performance of manufacturing various types of structures, including the implementation of a minimum line width of 400 nm for a substrate of up to 200 mm in size, has been confirmed.

Excellence of Technology

- By controlling the focus of the laser beam to follow the surface of the substrate during the processing time, free processing can be realized not only for flat substrates but also for curved substrates.
- It is easy to change to high-resolution (400 nm class) mode and low-resolution (2 μm class) mode depending on the shape to be manufactured. The process speed is dramatically improved by applying the technology that can continuously change the focused laser beam to overcome the limitations of speed due to the use of single focused laser beam for each mode.
- It can be applied to the fabrication of advanced devices such as micro-optical devices and functional fluid channels, and is expected to create a new market through small-scale production of various types, deviating from the conventional 2D-based lithography technology.
- Secured domestic technology with competitive performance and price in a situation where companies from Europe such as Germany and the Netherlands are leading the related market with expensive equipment.



〈 Optical Head for Laser Direct Lithography Developed Own Technology〉

〈 Fabrication Results for 2D and 2,5D Structures 〉

Current Intellectual Property Right Status

PATENT

- Photolithography Apparatus and Method using Collimated Light (KR2151134)
- Optical lithography apparatus and controlling method for the same apparatus (KR2119165)
- Focusing error detecting apparatus and method thereof (KR1867316)
- Optical Layout Apparatus for Lithography (KR1658985)

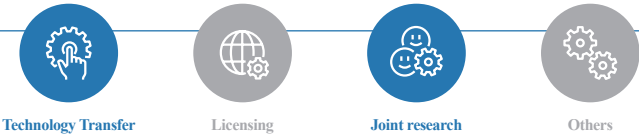
KNOW-HOW

- Optimized laser direct lithography process conditions for various substrates and resists

Technology Readiness Level (TRL)



Desired Partnership



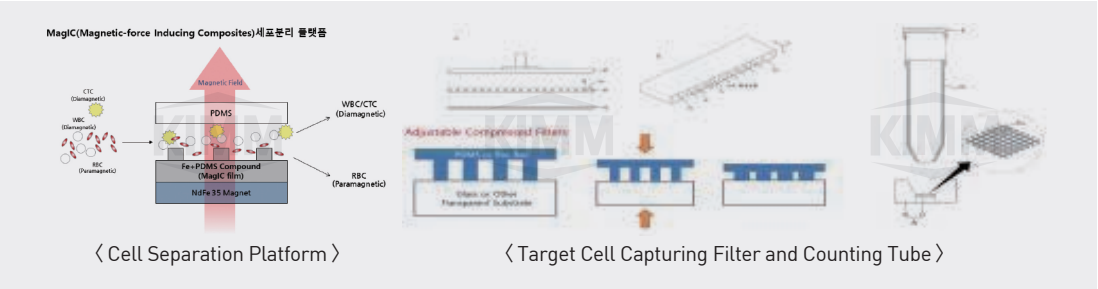


# Various Apparatus for Cell and Particle Separation and Its Method

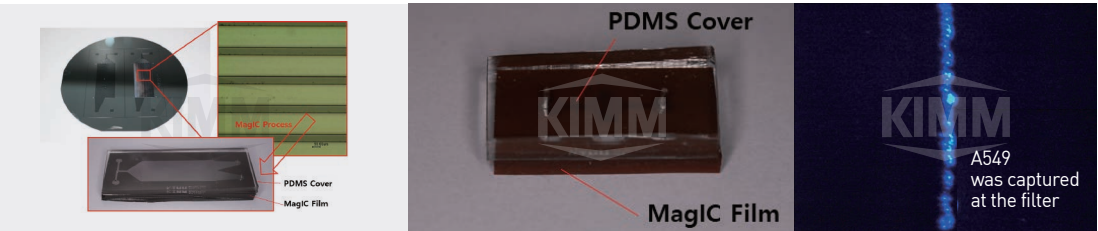
▶ Department of Nano-Manufacturing Technology ▶ Researcher: Seonghwan Jang ▶ Contact: +82-42-868-7793

Technology Overview	<ul style="list-style-type: none"><li>Various methods of platform technology for separating cells or target particles by size and property and the ways of application</li></ul>
Customer / Market	<ul style="list-style-type: none"><li>Liquid biopsy or blood-based cancer diagnosis</li><li>Hemocyte separation and analysis</li><li>Blood plasma separation for biosensor</li></ul>
Problems of Existing Technology or Necessity of this Technology	<ul style="list-style-type: none"><li>Effective cell and particle separation is possible by using a different separation method depending on the blood sample amount, treatment time, purpose of use before and after separation.</li><li>The clinical blood cell and plasma separation method separates the cell by putting the blood and the solution with a different density inside the centrifugal separator; however, this works well for separating a large amount of sample, but it is difficult to separate the target cell from a small sample.</li><li>arious cell and particle separation methods have been developed to solve this problem. Typically, there are methods for separating cells by magnetic force by binding a biomarker and magnetic particles to a target cell, a method for measuring the physical properties (size, deformability, density, electrical / magnetic properties, etc.).</li><li>However, the individual techniques proposed to solve the above problems are difficult to be used in accordance with the amount of various samples, the processing speed, the purpose of use before and after the separation, and mainly used for the lab-on-a-chip platform.</li></ul>
Technical Distinctiveness	<ul style="list-style-type: none"><li>This technology provides the lab-on-a-chip platform as well as cell and particle separation platforms that utilize membrane, tube and various sample sizes, treatment speeds, and interfaces.</li><li>Also, according to the purpose of cell separation, it offers continuous separation, and phased separation using the filter and frequency process in order to provide various cell and particle separation solutions that cannot be handled with individual technologies.</li><li>Distinctiveness of detailed technology<ul style="list-style-type: none"><li>Cell separation device using magnetism: Cell separation using magnetism: Form a local magnetic field inside the microchannel using a complex containing ferromagnetic particles to separate cells by magnetic properties.</li><li>Self-cell extraction device using magnetic field: A filter is made from a composite containing ferromagnetic particles, and an external magnetic field is used to create a local magnetic field within the filter. Through this, the effect of cell filtering is increased, or large cells stuck in the filter are extracted (e.g. CTC, circulating tumor cells).</li><li>Filter for capturing target cells: A filter with a bypass flow path to prevent large cells from getting caught in the filter. This filter was incorporated with flow resistance to prevent other cells from passing through a filter where the flow path is blocked by large cells.</li><li>Filter device for capturing target cells: Target cell capturing filter apparatus: A filter apparatus that solves the issue of larger cells getting caught in the filter to block and disturb collection. The filter is made with flexible</li></ul></li></ul>

- material, and the filter width is narrowed while pressure is being applied to filter the cells, and then the cells are collected after the pressurization stops.
- Filter element for capturing target cells: Target cell capturing filter device: A filter device that includes a temperature sensing layer, where the solubility changes as it reacts to the temperature, between the filter that after the cells are filtered, the temperature is changed to collect the cells caught in the filter.
  - Tubes for counting target cells: A cell counting tube with a cap containing a grid for cell counting at the bottom, unlike a typical centrifugal tube. It has the advantage of being able to separate and count particles at the same time.
  - Membrane filter for target particle detection: Target particle detecting membrane filter: A new concept membrane filter that has the cell filtering effect monitoring benefit using microchannel of the lab-on-a-chip and the fast treatment speed benefit of the membrane.

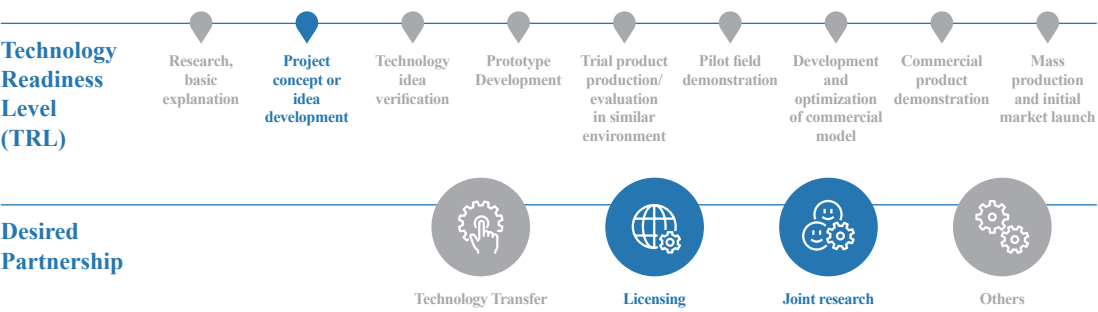


## Excellence of Technology



## Current Intellectual Property Right Status

- PATENT**
- Apparatus for Separating Cells Using Magnetic Force and Method for Separating Cells Using the Same (KR1212030, US13 / 546187)
  - Apparatus for Self-Extracting Cells Using Magnetic Force and Method for Self-Extracting Cells Using the Same (KR1211862, US13 / 546106, EP12176073.0, JP5512754)
  - Filter for Capturing Target Cells and Collecting Method of Using the Same (KR1690455)
  - Filtering Equipment for Capturing Target Cells and Collecting Method of Using the Same (KR1697457)
  - Filtering Device for Capturing Target Cells and Collecting Method of Using the Same (KR1712770)
  - Tube for Target Cells Counting and Target Cell Counting Method Using the Same (KR1776536)



# Smart Shoes for Both the Disabled and the Non-disabled

▶ Department of Nano-Manufacturing Technology ▶ Researcher: Seonghwan Jang ▶ Contact: +82-42-868-7793

**Technology Overview**

- Wearable smart devices that can be used by both disabled people and ordinary people at low prices and various functions

**Customer / Market**

- Assistive device for visually impaired
- Pedestrian navigation
- Wearable entertainment device

**Problems of Existing Technology or Necessity of this Technology**

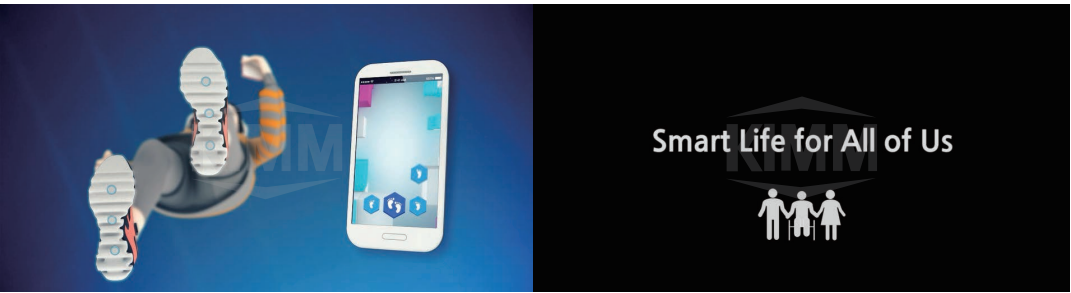
- Hands can act like eyes for visually impaired. For visually impaired, their hands replace the roles of the eyes. In order to use Braille pads, which are used by the visually impaired, for outdoor activities, one hand should be placed on the braille pad and one hand should be carrying a stick.
- In other words, since both hands are used, it is difficult to cope with emergency situations
- In addition, assistive devices for the visually impaired are not cheap in price because there are not many users, and the development of the products is not fast.

**Technical Distinctiveness**

- This technology is equipped with a supplementary device in the shoe insole, providing the convenience of one hand for the visually impaired.
- We construct six driving units that can transmit braille information to shoes. It can be linked with a smart device such as a smart phone to perform navigation functions when moving, or to provide simple braille information based on location to blind people.

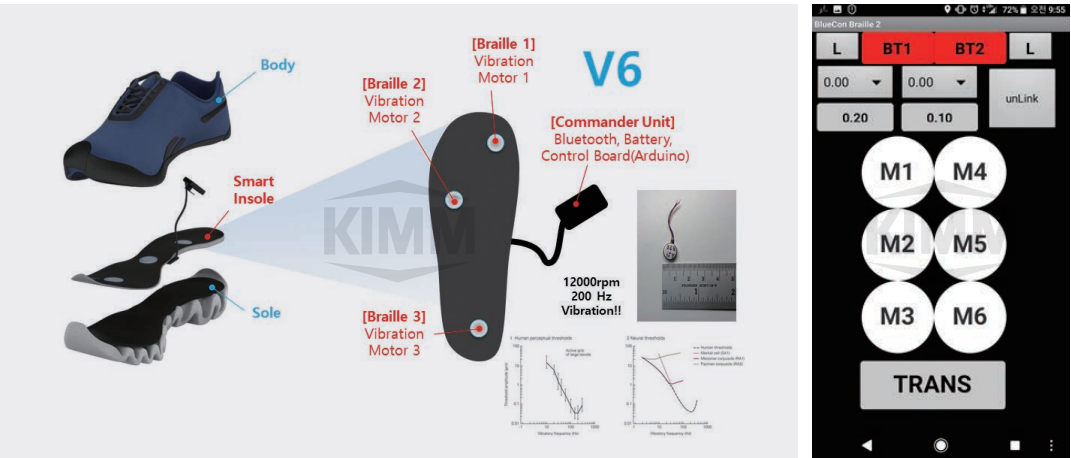


- Navigation through shoes can be a very useful technique for the general public. As a smart device, various sensors can be inserted in module form to be used for entertainment (health, gait analysis, etc.).



**Excellence of Technology**

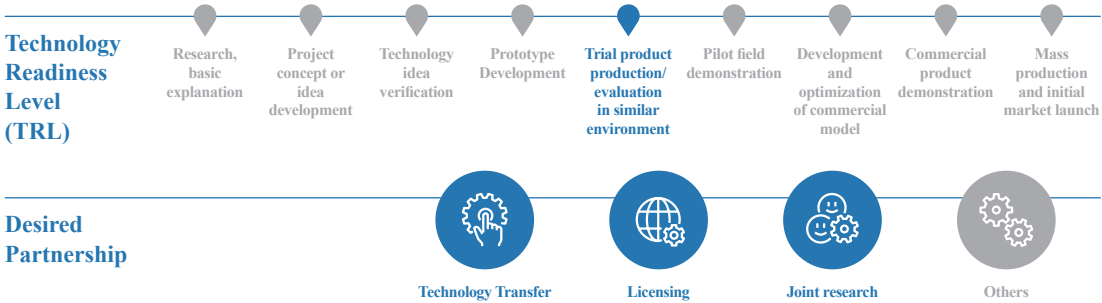
- Various consumers can be secured as it can be used both by the disabled and the non-disabled.
- Realizes a social value where a better life is shared using a smart device.
- Design, production, and module-level performance verification is completed.
- Completed a demo version that reflects the opinion of the disabled.



**Current Intellectual Property Right Status**

**PATENT**

- Smart Shoes Having Function of Information Transfer and Method of Providing Information Using the Same (KR1757377) and 3 others

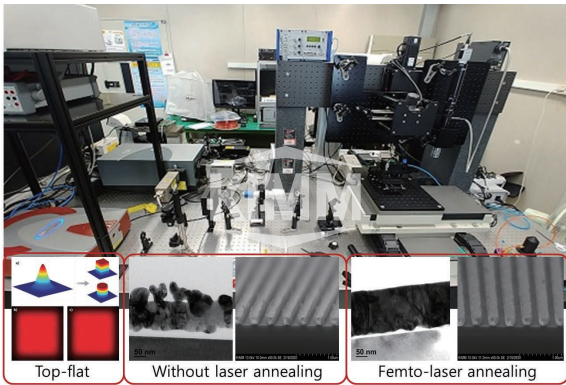


# Femtosecond Laser-Based Heat Treatment Technology

▶ Department of Nano-Manufacturing Technology   ▶ Researcher: Wonseok Jang   ▶ Contact: +82-42-868-7134

Technology Overview

- A technology to improve performance through heat treatment of femtosecond laser-based metals and semiconductors without causing thermal damage to the periphery by rapidly increasing heat on the irradiated surface unlike other heat treatment processes and long-wavelength lasers



Customer / Market

- Manufacturing and equipment fields of functional devices such as semiconductors, optics and displays

Problems of Existing Technology or Necessity of this Technology

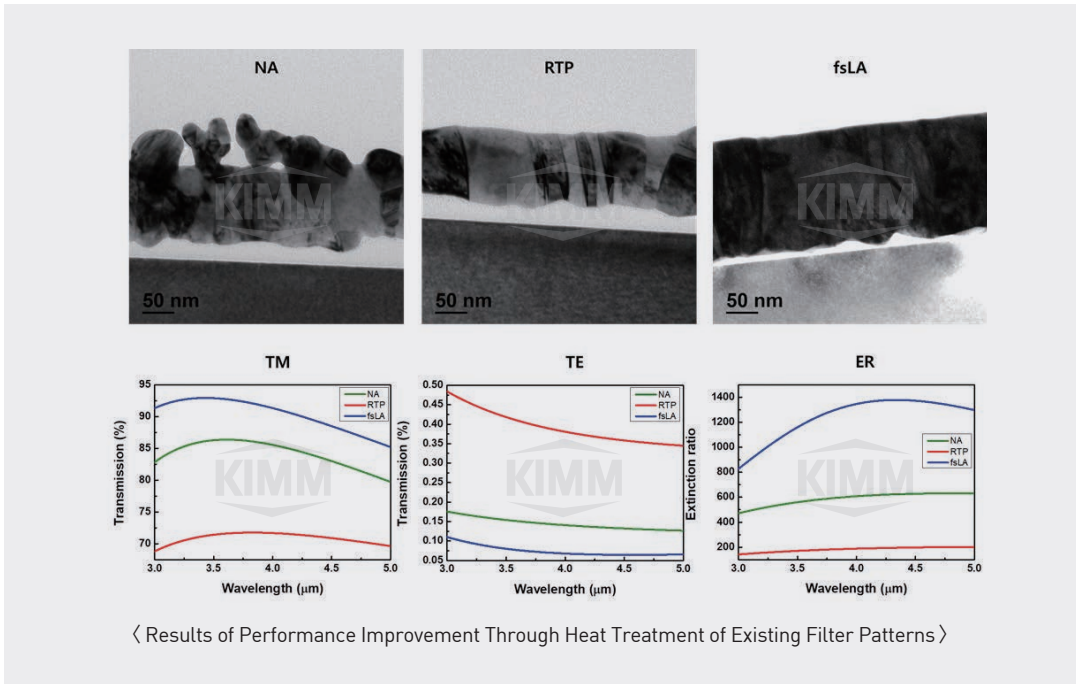
- The deposition technology used for the production of the existing metal pattern has a small crystal structure of the metal pattern, meaning that there are limitations in conductivity and optical properties.
- Various lasers used in the laser heat treatment process for the heat treatment process of semi-conductor materials are difficult to carry out selective heat treatment, causing thermal damage to the surrounding area.
- The process technologies used for the heat treatment process apply heat to the entire device, causing thermal damage to the substrate or other devices that are weak to heat.

Technical Distinctiveness

- A key technology for performing selective femtosecond laser annealing technology that can perform direct patterning at high processing speed without stamps or masks
- It realizes the heat treatment process without changing the shape of metals and semiconductors due to the rapidly lowering heat after the heat treatment process through the instantaneous heat rise by the laser
- Technology that performs heat treatment process using laser parameters suitable for uniform materials through various wavelengths and square beam system
- Unlike other lasers, the heat treatment process technology using a femtosecond laser rapidly increases the heat on the irradiated surface and then decreases it, enabling selective heat treatment without thermal damage to surrounding devices or substrates.

Excellence of Technology

- Fast heat treatment process can be performed by combining high-speed scanning technology using galvano scanner, and uniform heat treatment process can be realized by irradiating the same laser energy to the surface using a square beam.
- Suitable laser wavelength and laser energy can be adjusted according to the material to be subjected to the heat treatment process, and thus, heat treatment of various materials is possible.



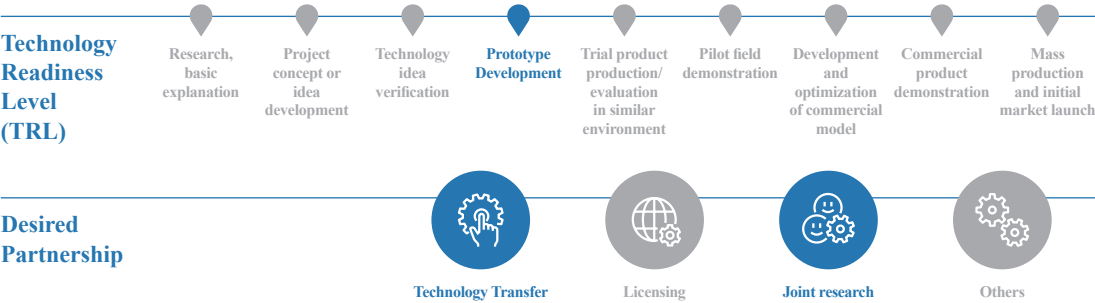
Current Intellectual Property Right Status

PATENT

- Apparatus of Separating and Collecting Dissolved Gases (KR1980839)
- Patterning Apparatus and Method of Conductive Material (KR1877452)
- Photoconductive Transcription Method Using Sacrificial Layer (KR2212422)
- Manufacturing Apparatus of Fine Devic (KR1801312)

KNOW-HOW

- Optimized heat treatment process conditions for various substrates and various metal and semi-conductor materials





# Micropatterned mold core

## Ultra-precision machining technology

▶ Department of Nano-Manufacturing Technology ▶ Researchers: Taejin Je, Doosun Choi ▶ Contact: +82-42-868-7142, 7124

Technology Overview

- Technology to manufacture ultra-fine micro/nano pattern metal core required mandatorily to improve the special functions of high-performance advanced products based on ultra-precision machining technologies (turning, planing, end milling, indentation machining) with nano-level precision.

Customer / Market

- Advanced core components market such as optical elements for advanced display (LCD/LED, OLED, AR/VR) and solar energy, meta structure, hologram, optical lens and optical communication, high-performance core element for medical/bio and mechanical component

Problems of Existing Technology or Necessity of this Technology

- The demand from various advanced industries for high performance ultra-precision fine patterned components are rapidly increasing. However, the foundation technologies of ultra-precision machining technology for fine pattern are weak to effectively handle such demands.
- To achieve with performance advancement of high-quality products and the demands for high-performance products required for next-generation advanced industries, a high-efficiency micro-pattern mold core machining technologies based on ultra-precision machining technology of nano level is required.

Technical Distinctiveness

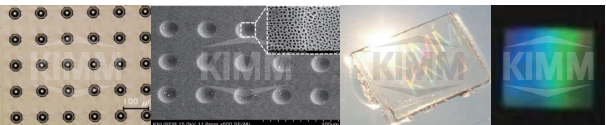
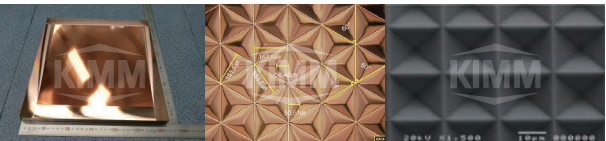
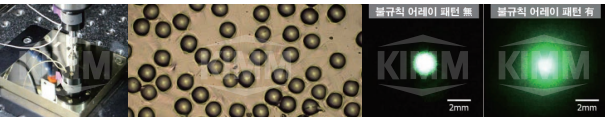
- Possible to manufacture various high-quality, high-profile micro-pattern from a few dozen nanometers to a few hundred micrometers required depending on properties and functions of core devices.
- Possible to manufacture an ultra-precision micro-pattern mold core to cope with roll-to-roll process, injection molding, and press forming required for mass production of high-performance advanced products
- Possible to apply integrated machining technology such as micro/nano complex shapes and high-dimensional shapes and fabrication of micro-pattern having irregular shapes and arrangement that can be utilized for next-generation advance industries

Excellence of Technology

- Ultra-precision machining technology on large area micro pattern roll mold for optical film manufacturing.
  - The mold core for ultra-precision groove patterns, random stepped profile surface, lenticular patterns of several dozen nanometer to several dozen micrometer level for optical film manufacturing



- Ultra-precision indentation machining technology for irregular lens array patterned mold core to improve light diffusion property.
  - Irregular lens array pattern processed to a minimum diameter of 15  $\mu\text{m}$  and fill-factor of up to 50 % to improve light diffusion characteristics up to 12 times
- Ultra-precision cutting technology with 3-directional crossing micro pattern largearea mold core for high-brightness retro-reflection property
  - Intersection error less than 1  $\mu\text{m}$ ; pattern shape error less than 1  $\mu\text{m}$
- Mold core machining technology of micro pore lens array pattern for structural color revelation
  - Micro/nano patterning technology for structural color revelation using mechanical/chemical integration machining
- Array pattern machining technology for aspheric, high aspect ratio paraboloid condensing lens mold
  - Solar energy short-circuit current density enhanced by 10% with increased lightharvesting effect
- Ultra-precision machining technology of micro slit array for a meta-surface
  - Ultra-precision micro slit array machining with shape error within 1  $\mu\text{m}$  and position error within 1  $\mu\text{m}$
  - Realizing a meta-surface to converts longitudinal wave into transverse wave Micro end milling technology of optical patterns for realizing 3D image



Current Intellectual Property Right Status

PATENT

- Processing Method for Aspheric Light Guide Plate Mold (KR1630021)
- Method for Manufacturing Working Tool of Mold for Manufacturing Optical Film (KR1767311)
- Method for Designing Random Dot Pattern and Method for Manufacturing Lens Array Member (KR2017-0142784)
- Micro Pattern Machining Method Using Tool Angle Control (KR1474974)

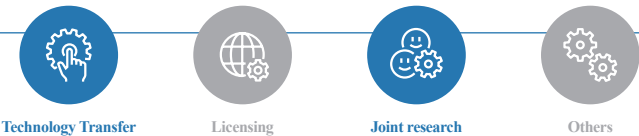
KNOW-HOW

- Pattern forming roll machining system and micro pattern formation method
- Discontinuous micro pattern formation device using indenter and the method
- Micro wave pattern machining system and method
- Stepped shape, right/left or top/bottom direction micro pattern design and machining technology
- Cutting tool design technology for micro pattern machining/measurement analysis and performance evaluation technology of micro pattern

Technology Readiness Level (TRL)



Desired Partnership





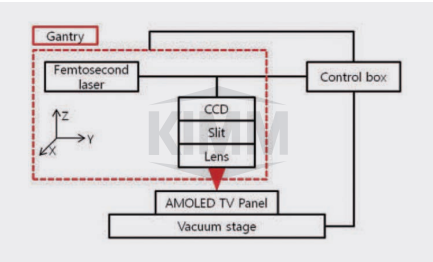
# AMOLED TV

## Non-thermal Repair Technology

▶ Department of Nano-Manufacturing Technology ▶ Researcher: Seonghak Cho ▶ Contact: +82-42-868-7077

Technology Overview

- Ultrashort pulse laser-based AMOLED TV non-thermal repair technology and repair device



Customer / Market

- Companies interested in non-thermal repair machining technology of large size AMOLED panel

Problems of Existing Technology or Necessity of this Technology

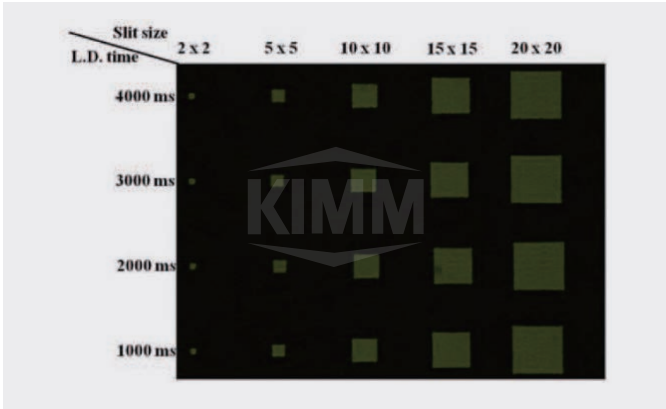
- Non-thermal repair process is necessary, and a system for large size processing needs to be established.
- Repair process using nanosecond laser inevitably causes thermal damage to the object.
- In case of processing an organic matter that is very sensitive to the processing temperature, unnecessary damages are caused from heat around the processing unit.
- When defect or error occurs during large size AMOLED panel manufacturing, the entire quantity is discarded. From the production yield perspective, this is a serious downside, therefore a repair technology is needed.

Technical Distinctiveness

- Ultrashort pulse laser has relatively short pulse width compared to nanosecond laser and can be used for non-thermal processing to minimize damage from heat on the object.
- With the ultrashort laser machining system using a gantry, a large size AMOLED panel can be repaired.
- The beam size can be adjusted with the motorized slit to adjust the beam shape in the light path of the ultrashort pulse laser-based machining system, and with the square-shaped beam, machining of area requiring repair can be executed with the minimum line width of 500 nm.
- Using the gantry established for this system, the defective area of the large size AMOLED panel is detected and is quickly repaired using the ultrashort pulse laser.

Excellence of Technology

- The process irradiates the femtosecond laser beam to the target layer and processes the desired area. It is utilized for partial repair of a specific defective area.
- For this, the beam shape and the machining size is adjusted through the slit.
- It is the blueprint that roughly shows the active organic self-illuminator TV's femtosecond laser repair system. For large area repair, the gantry system is used to adjust the laser beam location, not the target for repair, for machining.
- The repair target is fixed with the vacuum chuck of the stage to minimize the elevation difference error.
- The head researcher for this technology has over 10 years of research experience in ultrashort femtosecond laser-applied superprecision micro machining field.

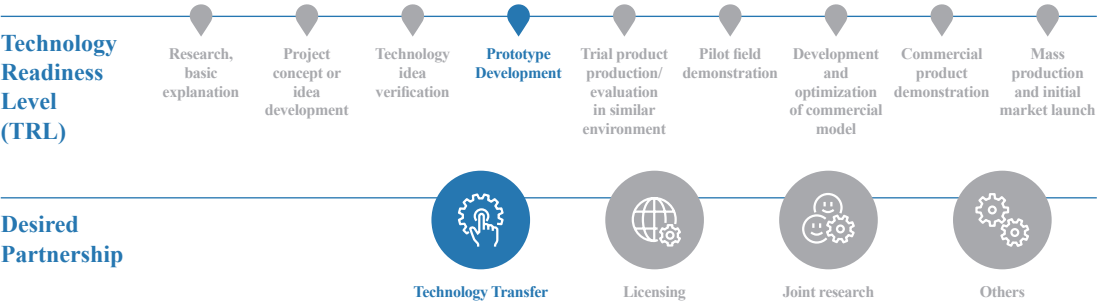


〈 Example of Slit Machining 〉

Current Intellectual Property Right Status

PATENT

- Non-thermal Repair Method and Device for Full HD High Resolution Mobile Active Organic Self-illuminator (KR1477005)
- Non-thermal Repair Method and Device for Active Organic Self-illuminator Using Selective Pulse Width Tunable Laser (KR1450767)
- Thermal and Non-thermal Converged Repair Device for Active Organic Selfilluminator (KR1387996)
- Non-thermal Repair Method and Device for Transparent Active Organic Selfilluminator Using Ultrashort Pulse Laser (KR2012-0042367)
- Non-thermal Repair Method and Device for Large Size Active Organic Selfilluminator Using Ultrashort Pulse Laser (KR2012-0056576)
- Non-thermal Repair Method and Device for Active Organic Self-illuminator Using Ultrashort Pulse Laser (KR2012-0016303)
- Non-thermal Repair Method and Device for Flexible Active Organic Self-illuminator Using Ultrashort Pulse Laser (KR2012-0016139)

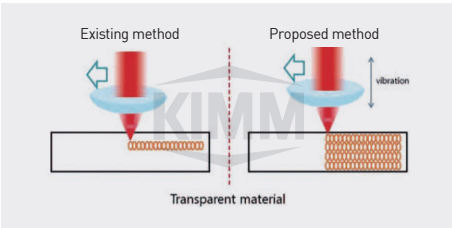


# Transparent Material(Sapphire, Slass) Cutting Technology Using a Hibrid Ultra-Short Pulse Laser System Integrated with a Vibrator

Department of Nano-Manufacturing Technology    Researcher: Seonghak Cho    Contact: +82-42-868-7077

Technology Overview

- Femtosecond laser creates a micro-sized furrow or performs drilling on all materials.
- With the focusing lens rapidly vibrating, the micro-sized furrow or drilling process efficiency increases.



Customer / Market

- Companies interested in transparent material

Problems of Existing Technology or Necessity of this Technology

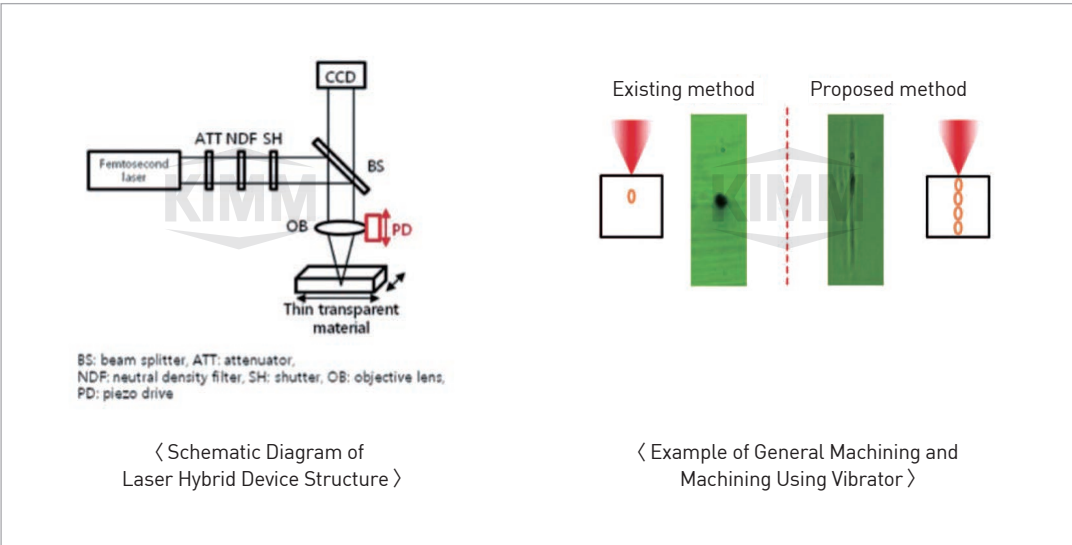
- The goal is to simplification of the machining stages and improvement of machining quality.
- There are limitations with mechanical process and quality for machining of transparent materials such as glass and sapphire plates.
- When attempting to machine transparent substance using a general laser, machining does not work as the laser beam penetrates through the substance or creates an unnecessarily large crack.
- An alternative other than existing machining method for transparent material is needed to realize simplified machining stages and higher quality.

Technical Distinctiveness

- Laser machining is a method using non-contact machining method, and compared to mechanical machining, it can minimize unnecessary damage to the processed object.
- When machining a transparent object, due to the non-linear properties of femtosecond laser, it enables deeper machining on the same axis in the direction of clamping of focusing lens.
- One process achieves the effect of repeating several processes.
- When creating vertical vibration in the focusing lens of the femtosecond laser system using a vibrator, the focus position is adjusted vertically, and by machining vertically with this method, the part for machining on the object is intentionally extended in the longitudinal axis direction. Unlike general laser cutting machining where the machining restarts after focus adjustment, this process eliminates unnecessary steps.

Excellence of Technology

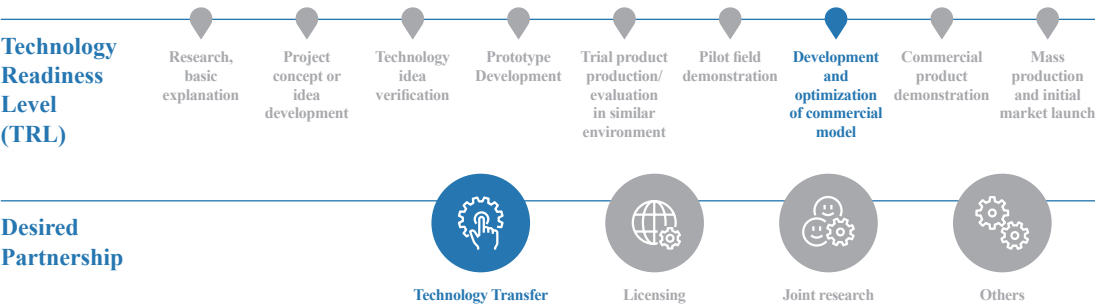
- The machining process realizes longer machining on the part of the transparent substance for machining in the longitudinal axis direction compared to the machining method with the general laser machining system as it uses the non-linear machining characteristic of femtosecond laser and the vibration system of focusing lens with the vibrator.
- The method ultimately cuts the object by maximizing machining in the direction of depth.
- The head researcher for this technology has over 10 years of research experience in ultrashort femtosecond laser-applied super-precision micro machining field.



Current Intellectual Property Right Status

PATENT

- Hybrid Laser Machining Device Using Vibrator (KR1273462)
- High Aspect Ratio Micro Shape Machining Device Utilizing Ultrashort Pulse Laser (KR1285717)
- Selective Plate Thin Film Remover Using Laser Machining Technology (KR1285876)
- Hybrid Laser Machining Device Using Ultrasonic Vibration (KR1049381)



# Roll Transfer Technology for Manufacturing Micro/Mini-LED Displays

▶ Department of Nano-Mechanics   ▶ Researcher: Jae-Hyun Kim   ▶ Contact: +82-42-868-7550

Technology Overview

- In order to manufacture a display panel using micro/mini-LED, it is necessary to transfer a large number of micro/mini-LEDs onto a circuit board. This technology is used to transfer the micro/mini-LED onto the circuit board using the roll stamp with high productivity.



Customer / Market

- Micro-LED display, mini-LED digital signage, mini-LED BLU for local dimming, flexible micro-LED display, transparent micro-LED display

Problems of Existing Technology or Necessity of this Technology

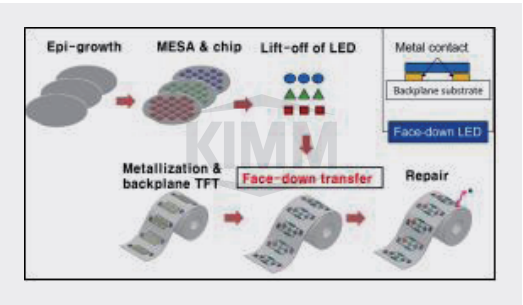
- Conventionally, there was a die-bonder technology that transfers and connects mini-LED devices one by one to the board.
- A die-bonder can transfer LEDs to the display substrate at a rate of 2 to 10 per second.
- Roll-transfer technology can transfer multiple mini/micro-LEDs in a certain area at once using a roll stamp. Compared to the existing die-bonder, the transfer area and transfer speed can be greatly improved.
- The transfer speed depends on the size of the roll stamp and the number of LEDs attached at a time, and it can transfer LEDs at a level of 100 to 10,000 per second.

Technical Distinctiveness

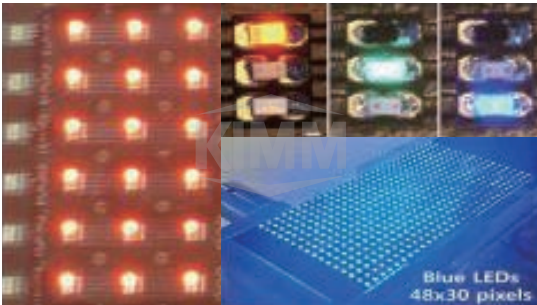
- Mini/micro-LED transfer technology is being developed by Apple and Uniqarta in the U.S., PlayNitride, ITRI, and Foxconn in Taiwan, and X-Celeprint in Ireland. In Korea, Samsung and LG are actively developing the transfer technology using die-bonder.
- Currently, the roll-type transfer technology has been independently developed by the Korea Institute of Machinery and Materials, securing more than 50 patents.
- Other transfer technologies have the disadvantage that the transfer area is 1-2 inches or the transfer speed is very slow as the LED is transferred individually.
- Roll transfer technology can realize the highest transfer speed and transfer area among transfer technologies reported so far.

Excellence of Technology

- Panel manufacturing business in LCD and OLED displays was only possible for large companies, but mini/micro-LED is a display technology that allows small and medium-sized companies to manufacture display panels by collaborating circuit board and LED companies.
- Currently, the mini-LED market is growing rapidly, and the micro-LED market is expected to form in 3 to 4 years.
- In 2019, YTS Micro-Tech, a research institute that manufactures mini-LED display panels using roll-based mass transfer, was established.
- Securing around 50 intellectual property rights to secure roll transfer equipment, transfer process technology, and stamp technology specialized for each application field, technology transfer according to the application field of the demanding company can be realized.



〈 Schematic Diagram of LED Panel Manufacturing Process 〉



〈 Roll-Transferred Mini-LED 〉

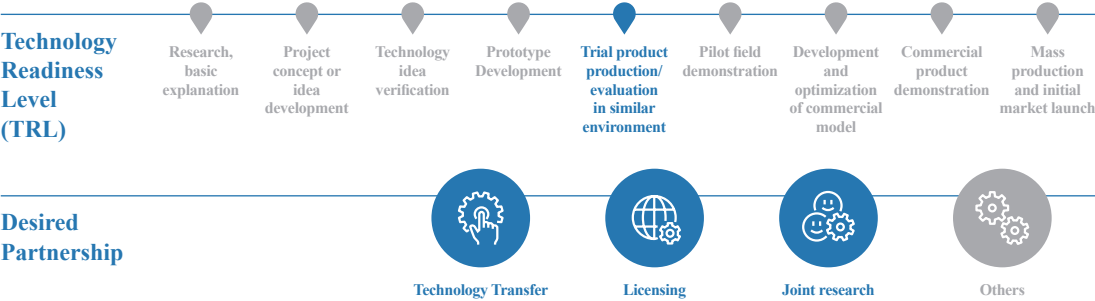
Current Intellectual Property Right Status

PATENT

- Apparatus for Transferring Micro Device (KR2164090)
- Transfer Printing Method of Adjusting Spacing of Micro Device (KR2152459)
- Method of Transferring Micro Device on Curved Surface and Apparatus for Transferring Micro Device on Curved Surface (KR2108385)
- Micro-Device Transfer Apparatus Capable of Selective Transfer (KR2108105)
- Apparatus for Transferring Micro Device and Method of Transferring Micro Device (KR2012692)
- Method of Transferring Micro-Device Array (KR2012237)
- Applied/registered a total of around 50 domestic and foreign patents related to the transfer technology, including a method of transferring a micro-device and micro-device substrate manufactured by the same (KR1800367)

KNOW-HOW

- Transfer process technology depending on micro/mini-LED interconnection method



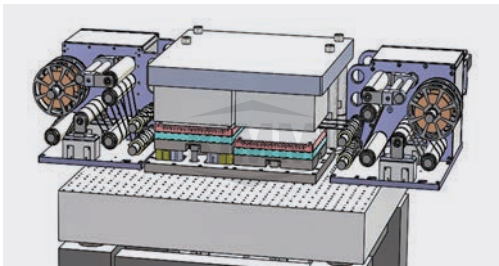


# Omnitex Device Manufacturing Process and Equipment Technology

▶ Department of Nano-Mechanics   ▶ Researcher: Seungmin Hyun   ▶ Contact: +82-42-868-7981

Technology Overview

- Development of original technology for fiber and yarn-based devices and manufacturing process equipment to overcome the limitations of the manufacturing of existing flexible and stretchable device and to strengthen the related manufacturing base



Customer / Market

- Smart textile manufacturing

Problems of Existing Technology or Necessity of this Technology

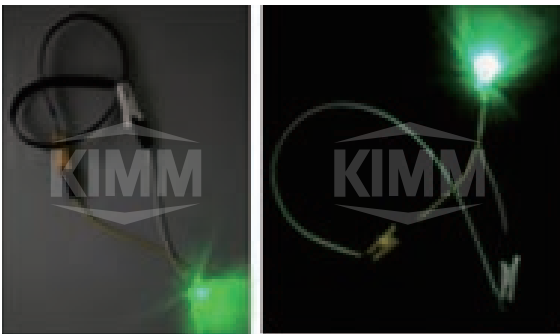
- The wearable market related to consumer electronics has grown rapidly to form a large market and is expected to grow steadily (IDTechEx (2019), E-textile technology, markets, players)
- In addition, interest in a new type of smart wearable textile is increasing and relevant research is being conducted, but manufacturing issues are constantly being raised. In particular, there are many difficulties in research and development of manufacturing basic unit material device leading to fiber, yarn, and fabric and imposing functionality. Applying element technology manufactured and processed on a solid substrate based on wafer is a difficult task, and current level of technology is mainly limited to laboratory researches.
- Interest in energy devices to operate smart wearable electronic components is increasing, and the development of device technologies in the form of fibers and yarns can have a significant impact on the wearable market.

Technical Distinctiveness

- Intensive research on fiber-type energy devices (e.g. batteries) is in progress worldwide. Most of the fiber-type energy devices up to date are at the level of realizing devices on fiber or cables, and most of them are manufactured by hand, resulting in many limitations in length and diameter.
- The small size of the fibers and the non-flat structure increase the complexity of device fabrication, while the performance is very poor compared to planar device. In other words, it is very difficult to implement high-performance energy devices at low cost.
- In addition, by weaving a number of individual fiber-type energy elements into a fabric, it is possible to manufacture a fabric with easy air/moisture permeation control, which is expected to be utilized as a flexible power supply suitable for wearable electronic devices.

Excellence of Technology

- Development of energy storage device technology with a structure that is flexible, stretchable and capable of implementing large capacity by manufacturing textile-based energy storage devices
- Fiber-type energy storage device



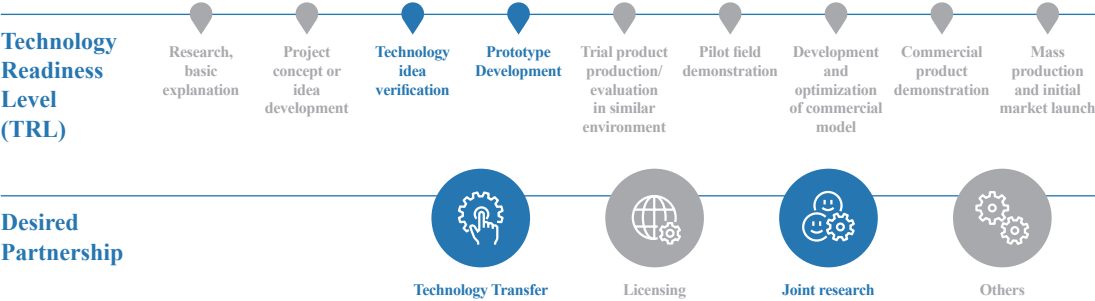
〈 LiCoO<sub>2</sub>-Graphite Li-ion Fiber Battery 〉

Current Intellectual Property Right Status

PATENT

- Flexible electronic device having three-dimensional array structure and method for manufacturing the device (KR2019-0077855)

KNOW-HOW

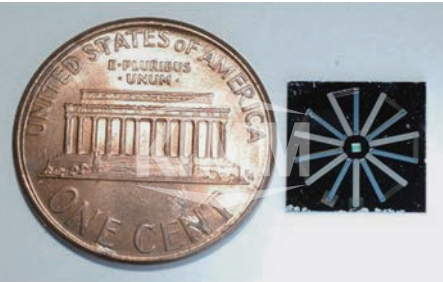


# Thin-film Thermoelectric Energy Conversion Module

▶ Department of Nano-Mechanics   ▶ Researcher: Seungwoo Han   ▶ Contact: +82-42-868-7426

## Technology Overview

- Thin-film thermoelectric module applicable for hot spot cooling and as micro power supply



## Customer / Market

- Small portable power supply for WSN (Wireless sensor node), wireless electronics, portable electronics, MEMS, wearable computer, cardiac pacemaker

## Problems of Existing Technology or Necessity of this Technology

- Micropelt of Germany developed a micro-thermoelectric module using Bi-Te thin films and Bi-Sb-Te thin films and applied it as a power source of sensor node.
- Laird (formerly Nextreme) of the USA developed a micro thermoelectric module that can be applied for hot spot cooling.
- GreenTEG of Switzerland developed a micro thermoelectric module and applied for a heat flux sensor.
- Enhanced strength and reliability of the joint on thermoelectric legs are needed.

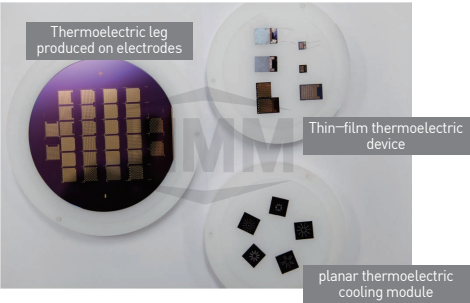
## Technical Distinctiveness

- Thermoelectric thin films with power factor of 3.07 mW/K<sup>2</sup>m for Bi-Te films (N-type) and 4.41 mW/K<sup>2</sup>m by Bi-Sb-Te films (P-type) are developed.
- The power output of thermoelectric module is 7.5 mW/cm<sup>2</sup> when the temperature difference is 50 degrees.
- It can be used as a wireless sensor power source for monitoring systems used in environments where battery replacement is difficult such as high temperature, high pressure, underground, or high above the ground in intelligent plant, smart building, transport machine, etc..

- It can be applied to hot spot cooling technology where demand for portable hotspot cooling technology has been increased due to the recent slim and small size of portable electronic products such as smartphones, tablet PCs, micro-packages, and LED lighting.
- Secured core elementary technologies
  - Thermoelectric module analysis and design technology
  - Thermoelectric thin films deposition technology
  - thin-film Thermoelectric module process technology
  - Performance evaluation technology of Thermoelectric thin films and thin-film thermoelectric module

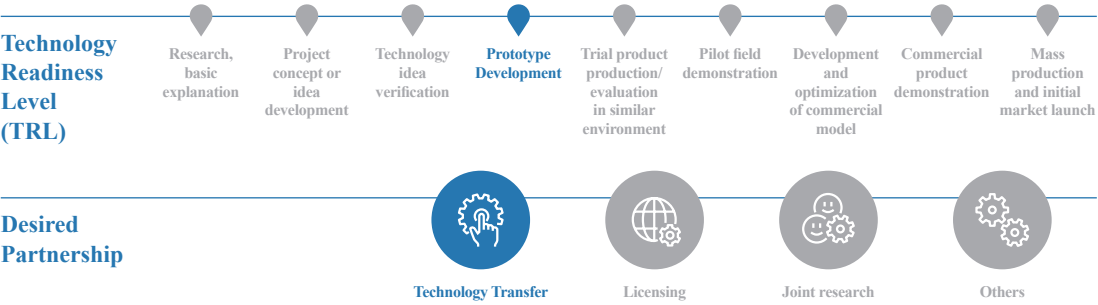
## Excellence of Technology

- Finite element analysis technique is used for design to determine the structure and size of the thermoelectric module.
- Optimal deposition conditions for thermoelectric thin films using co-sputtering and co-evaporating are secured.
- A measurement technology is developed to assess the performance of developed thin-film thermoelectric module.
- A bonding process is developed with an exclusive jig designed and produced for bonding process, and by selecting and evaluating the bonding materials and then optimizing the bonding conditions.



## Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>Thermoelectric Energy Conversion Module Having Spring Structure (KR1068647) / Thin-Film Thermoelectric Module Manufacturing Using Transfer Process (KR0984108) / Method for Manufacturing the Thin-Film Thermoelectric Energy Conversion Module (KR1068490) / Method for Manufacturing a Thin-Film Flexible Thermoelectric Module Using Peeling Process (KR0975628) / LED Package Embedded With Thermoelectric Module (KR1004746, PCT/KR2010/009132) / LED Package With the Function of Thermoelectric Cooling (KR1064870)</li></ul>	<ul style="list-style-type: none"><li>Analysis-based thermoelectric module design technology</li><li>Thermoelectric thin films optimized deposition technology using vacuum deposition method</li><li>Thermoelectric module manufacturing technology using thermoelectric thin films</li><li>Cooling and power generation performance evaluation technology for thin-film thermoelectric module</li></ul>

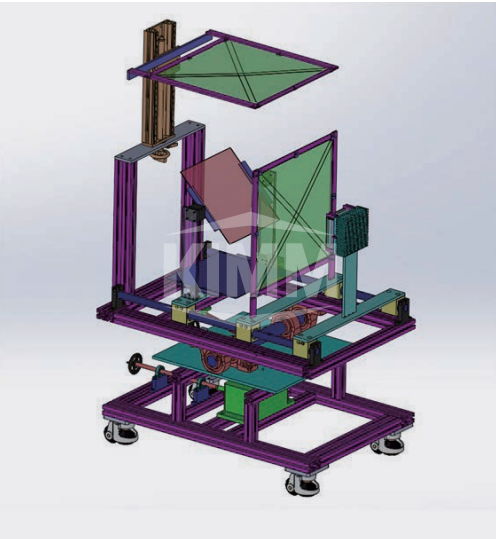


# Hybrid Solar Energy Power Generation System

▶ Department of Nano-Mechanics   ▶ Researcher: Seungwoo Han   ▶ Contact: +82-42-868-7426

Technology Overview

- Solar energy power generation system with outstanding power generation efficiency in high temperature environment



Customer / Market

- Solar power generation in high temperature environment such as Southeast Asia and desert area, and thermoelectric power generation in various thermal energy sources such as solar energy, geothermal, industrial waste heat

Problems of Existing Technology or Necessity of this Technology

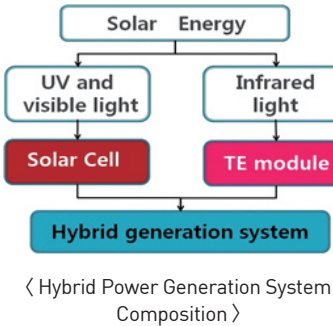
- Assuming the efficiency of a general solar cell is 15.6%, the efficiency drops down to 12.3% under high temperature of 70°C in the Southeast Asian climate.
- In the solar spectrum, light with a wavelength of 200 to 3000 nm is 99% of the total energy. Among them, the wavelength of 200~800 nm is about 58% of the total energy by UV (ultraviolet) and visible light, and the wavelength of 800~3000 nm is about 42% of the total energy by infrared rays.
- Here, in the case of a polycrystalline silicon solar cell, most of the photovoltaic energy conversion takes place in a wavelength range of about 300 to 1,100 nm, and the remaining is discarded as heat energy

Technical Distinctiveness

- Since only about 60% of the solar energy is transferred to the solar cell, the cooling effect prevents the degradation of the power generation efficiency due to the degradation of the solar energy in the high temperature environment.
- By separating the part of ultraviolet ray and visible light and generating electricity by solar cell (PV) for 58% of the solar energy, and collecting 42% of the solar energy corresponding to the remaining wavelength range including the infrared ray and generating electricity by the thermoelectric (TE) power generation module, PV-TE hybrid power generation system was developed to achieve higher efficiency than general solar cells.
- By designing and producing the hybrid power generation system, 16.93% efficiency was achieved.
- By designing and producing the TE power generation system, 3% efficiency was achieved.
- By developing a solar cell module using AR coating and heat-radiating sheet, 14.07% efficiency was achieved at 70°C.
- AR coating with the penetration rate over 97% was applied to enhance the efficiency of solar cells.
- Lens with 95% efficiency for the hybrid and TE power generation system was applied.
- Optical filter with 99% reflection rate for the hybrid power generation system was applied.

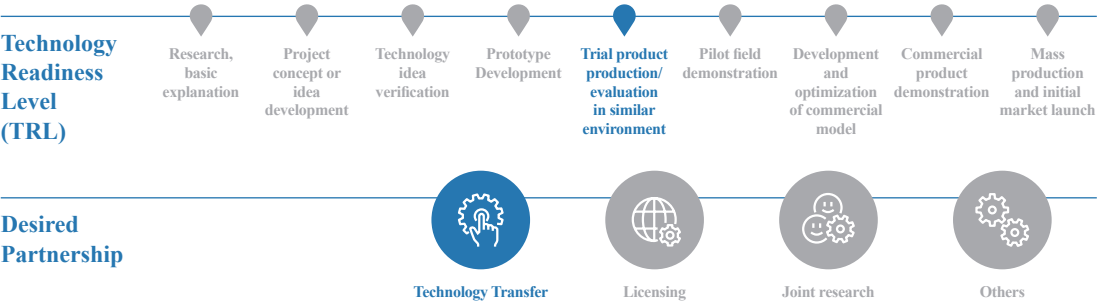
Excellence of Technology

- By generating electricity after separating the solar energy into solar light and solar heat through reflection and penetration, a high efficiency of solar ray-solar heat hybrid generation is achieved.
- A lens unit consisting of a filter that reflects solar light of solar energy to the solar cell and a lens that collects the solar heat of the solar energy transmitted through the filter to the thermoelectric module unit



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>Solar Energy Power Generation System for High Temperature Environment (KR1232120, PCT/KR2012/007543, EP12876498.2) / Solar Energy Thermoelectric Power Generator (KR1385493) / Multistage-Type Thermoelectric Power Generator Which Using Solar Heat (KR1015608) / Hybrid Power Generator Using Solar Energy (KR1001328) / Hybrid Power Generator Using Solar light and Solar Heat (KR0999513)</li></ul>	<ul style="list-style-type: none"><li>Power generation performance measurement and evaluation technology on TE device</li><li>TE power generation systemization and performance advancement technology using a TE device</li><li>TE power generation system performance evaluation and data collection/treatment technology</li></ul>





# Flexible OLED Roll-to-Roll Thermal Evaporation System Technology

▶ Department of Printed Electronics   ▶ Researcher: Sin Kwon   ▶ Contact: +82-42-868-7219

Technology Overview

- Core technology for continuous production of flexible OLED based on roll-to-roll method; roll-to-roll vacuum evaporation system technology for creating multiple thin films of organic, inorganic, metal material with pattern suitable for OLED panel

Customer / Market

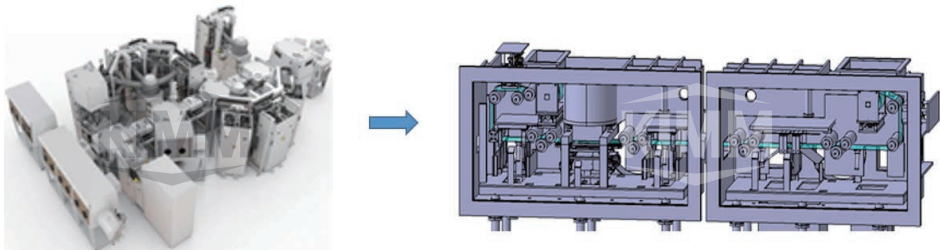
- Flexible OLED lighting (indoor lighting, interior, automobile, entertainment, etc.)
- Flexible OLED display (signage, wearable, mobile phone, etc.)

Problems of Existing Technology or Necessity of this Technology

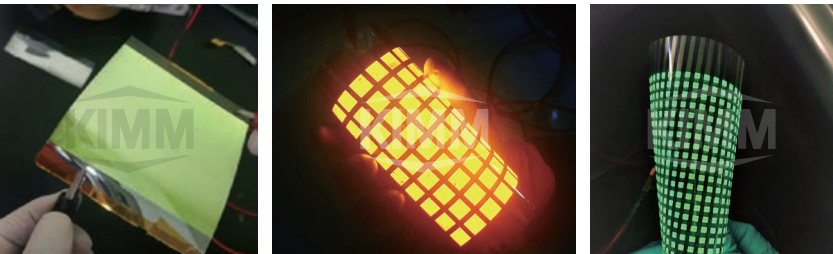
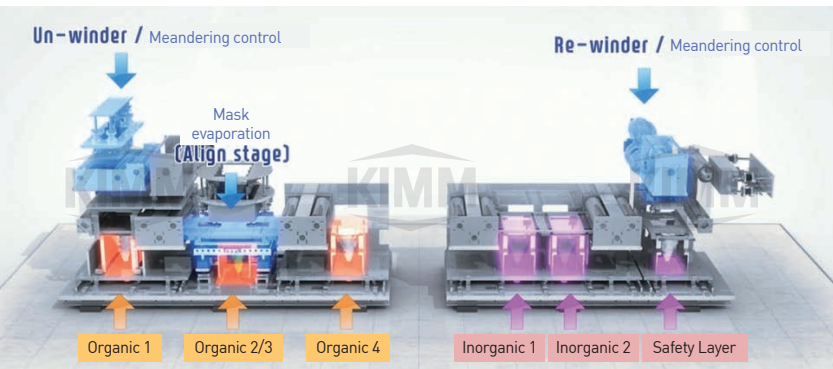
- The current technology for flexible OLED production using glass carrier forms a film on top of glass through PI (polyimide) coating or heat treatment or adhere a separate film onto the glass and use the existing glass process to manufacture OLED. Additional processes and expensive devices are required for flexible OLED separation using LLO (laser lift off).
- If the film substrate is handled directly with the roll-to-roll method for continuous process, it can achieve significant cost reduction.
- In particular, productivity can improve largely if this technology of roll-to-roll based continuous method for OLED production instead of existing cluster method consisting of multiple chambers.

Technical Distinctiveness

- Directly process on the film roll without glass carrier
- Single chamber roll-to-roll composition instead of existing cluster type vacuum evaporation system

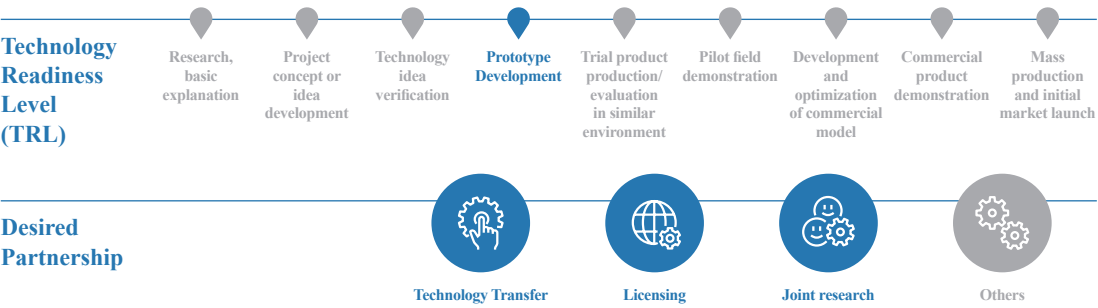


Excellence of Technology



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Roll-to-Roll Vacuum Evaporation System for Flexible Plate (KR1658957, DE10-2015-117344-2015-117344)</li><li>• Roll-to-Roll Vacuum Evaporation System (KR2017-0065916)</li><li>• Non-contact Roll-to-Roll Web Transfer Device (KR2017-0080213)</li></ul>	<ul style="list-style-type: none"><li>• Real-time pattern mask align/gap control technology</li><li>• High vacuum roll-to-roll speed/tension precise control technology</li></ul>

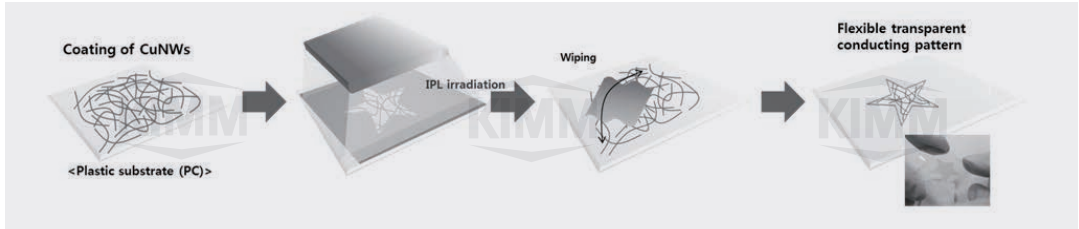


# Eco-Friendly, Ultra-Fast Patterning Technology for Highly Flexible Functional Electrode

▶ Department of Printed Electronics   ▶ Researcher: Gyuhee Woo   ▶ Contact: +82-42-868-7615

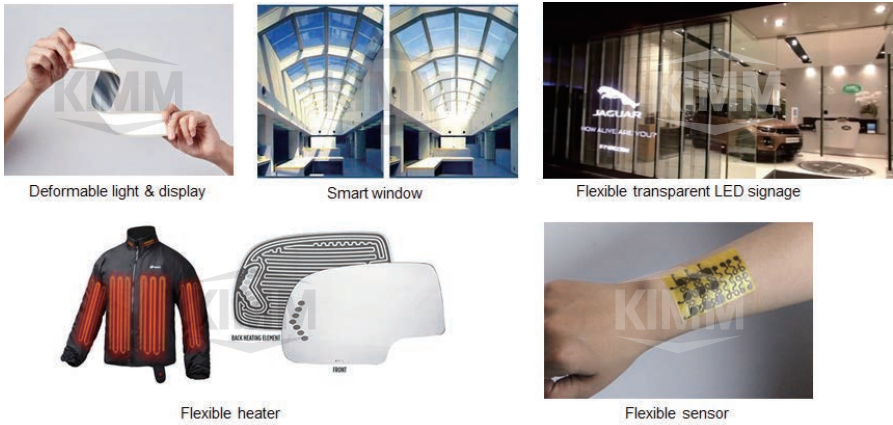
Technology Overview

- Fast and eco-friendly process and system technology to produce highly flexible metal (transparent) electrode pattern with simple 3 steps (coating → selective light radiation → wiping)



Customer / Market

- Flexible lighting, flexible solar cell, flexible display, smart window film, heating film, flexible sensor, etc.



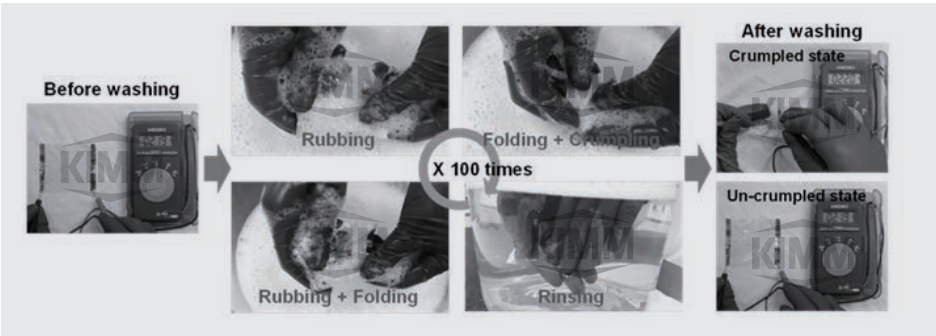
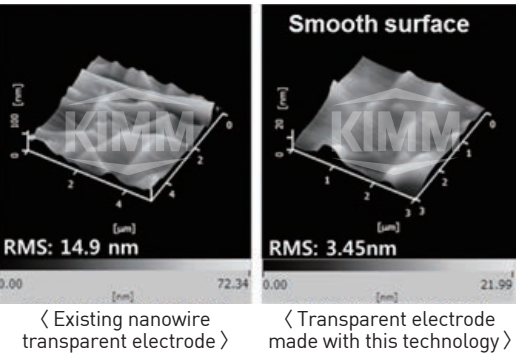
Problems of Existing Technology or Necessity of this Technology

- Requiring expensive infrastructure for photolithography.
- Complex patterning process, large amount of chemical waste (PR/etching solution/ developing solution, etc.) and difficulty to apply fast and scalable (roll-to-roll) process
- Difficult to use metal materials that can easily be oxidized (generally requires vacuum condition or inert gas atmosphere)
- Quality issues such as high surface roughness and low adhesion to the substrate

Technical Distinctiveness

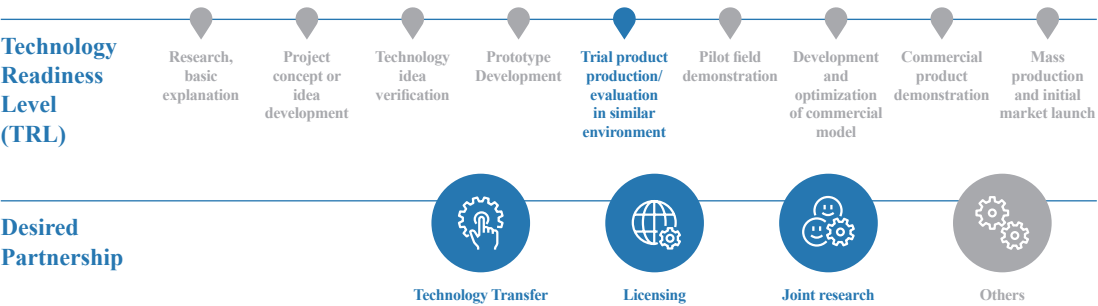
- This technology can produce high performance flexible (transparent) electrode patterns with high-speed and eco-friendly simple 3 steps.
- The fabricated electrodes exhibit high mechanical flexibility, high adhesion to substrates and low surface roughness
- Metals that are easily oxidized in the air can be applicable without any atmospheric control
- It is feasible to fast and scalable production

Excellence of Technology



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>Patterning Process Using Photo Sintering on Flexible Substrate (KR1704693)</li><li>System for Conductive Pattern Forming by Light Irradiation on Conductive Metal Ink-Coated Plate (KR1773148)</li><li>Roll-to-Roll Patterning System (KR1821766)</li><li>5 related domestic, international patents applied</li></ul>	<ul style="list-style-type: none"><li>Large quantity synthesis and refinement technology for metal nano structure (0D, 1D)</li><li>Fabrication of highly dispersed nano conductive ink</li><li>Electrical, mechanical, optical property evaluation technology for printed and flexible film</li><li>Low temperature photo sintering process for various thin films</li></ul>



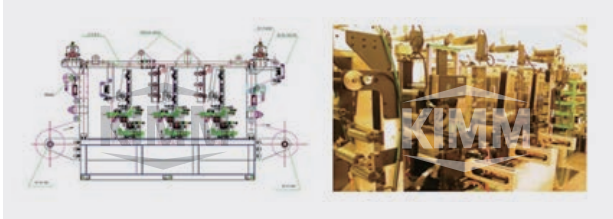


# High-speed Roll-to-Roll Printing Technology for Manufacturing Electronics Devices

▶ Department of Printed Electronics   ▶ Researcher: Taikmin Lee   ▶ Contact: +82-42-868-7451

Technology Overview

- Gravure offset printing system to be used in printed electronics by securing the precise overlay accuracy at 10 μm level



Customer / Market

- Manufacturer of printing system for printed electronics

Problems of Existing Technology or Necessity of this Technology

- New machine structure for the μm-level alignment technology at is needed
- Precision machine technology to reduce run-out error of printing cylinder is needed
- Machine control technology using microscopic vision is needed
- Equipment and process for rapid drying is needed for high-speed manufacturing
- Conventional printing method can be applied for the media printing, with the overlay accuracy of only 100 to 150 μm.
- Conventional rotary printing technology has a low overlay accuracy and thus cannot be used for the multi-layer structure for an electronic device. Previously developed printers for printed electronics are mostly used for single layer printing.

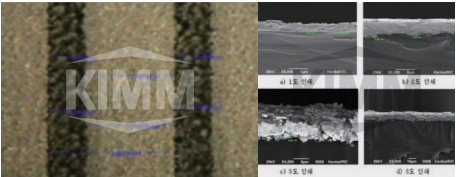
Technical Distinctiveness

- Can dominate the rotary printer market for printed electronics that require multilayer structure
- Provides overlay accuracy within 10 μm by capturing and manipulating overlay error based on the measuring of fine register marks using microscopic vision system
- Provides a printing technology that secured productivity by inline printing multilayered electronic devices
- Inline overlay printing of printed electronics with multi-layered structure
  - Multi-layered micro electronic circuit patterns with micro line width, such as capacitor and transistor, can be mass produced with the roll-to-roll inline overlay printing method.
- The unique transfer method where the micro-patterns from the gravure cylinder are transferred to the printing cylinder with soft silicon rubber and then transferred 100% as-is on the printing subject with low contact pressure shows the benefits of 3D ink layer formation.
- Printed fine register marks are captured with the microscopic camera vision system, and the position error are adjusted and corrected continuously by operating the motor to realize the overlay level within 10 μm-level.

- Analog printing techniques for printed electronic devices such as gravure have high productivity but cannot form micro-patterns. The digital printing techniques like inkjet can create micro-patterns greater than 10 μm but have low productivity.
- However, this roll-to-roll rotary printer offers both benefits-micro-pattern formation and high productivity.
- In addition, the limit of existing overlay printing technique, overlay accuracy of 100 to 150 μm, was enhanced to achieve a precision at the 10 μm level, and the 3D overlapping printing, which was previously unrealizable with existing rotary printing, is made possible.

Excellence of Technology

- The size of the gravure cylinder installed in the roll-to-roll inline rotary printer, with 3 gravure offset printing units, is 150 mm in diameter (Φ) and 260 mm in width.
- The result of producing an electronic circuit through the 3-layer printing with paste Ag ink showed a satisfactory conductivity of 200 mΩ/m.

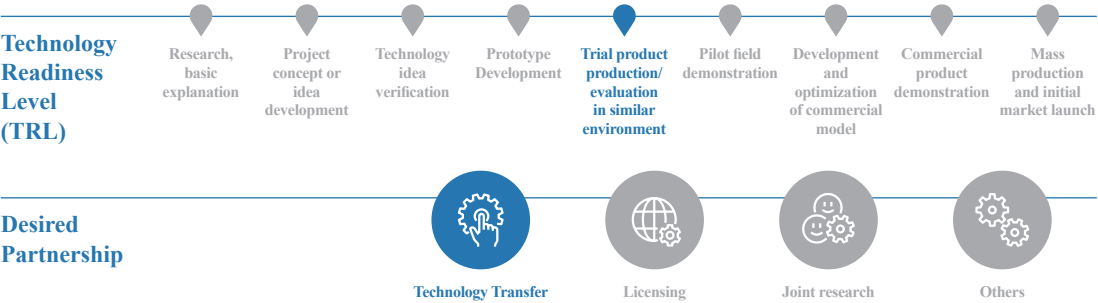


〈 Result of 3-Layer Printing with Ag Ink 〉

Current Intellectual Property Right Status

PATENT

- Electronic Element Production Device Using Roll-to-Roll Rotary Printing Method (KR1014363)
- Line Pressure Control Device for Roll-to-Roll Rotary Printing System (KR0911214)
- Electronic Element Production Device Using Roll-to-Roll Rotary Printing Method and the Manufacturing Device (KR0634327 EP06112095.2)
- Blanket Cylinder for Offset Printing (KR2007-0101925)
- Gravure Printing Cylinder Enabling Ink Cleaning Without Vibration (KR2009-0055371)
- Printing Unit for Offset Printer Composed of Non-vibrating Rotating Cylinder (KR2009-00553713)
- Electronic Element Production Method and Production Device Using Roll-to-Roll Rotary Printing Method (PCT/KR2008/006168)
- Arraying Method for Printed Electronic Layer by Different Register Marks (KR1071630)
- Electronic Element Production for Rotary Press and Method (KR1096529)
- Lateral Registration Drive Device of Gravure Offset Plate Cylinder for Printed Electronics (KR2013-0021549)
- Overlapping Printing Method for Rotary Printing of Printed Electronics (KR1300192 /627523)
- Overlapping Printing Apparatus and Method for Rotary Printing of Printed Electronics (KR1288135)
- True Rolling for Electronic Element Production Device (KR1152775)
- Register Marking Method and Its Device for Printed Electronics on Roll-to-Roll Gravure Offset Printing Process (KR2013-0094982)
- True Rolling by Page Length in Gravure-Offset Printing Unit (KR1393537)
- Electronic Element Production Device Using Roll-to-Roll Rotary Printing Method and the Manufacturing Device (KR0634327)



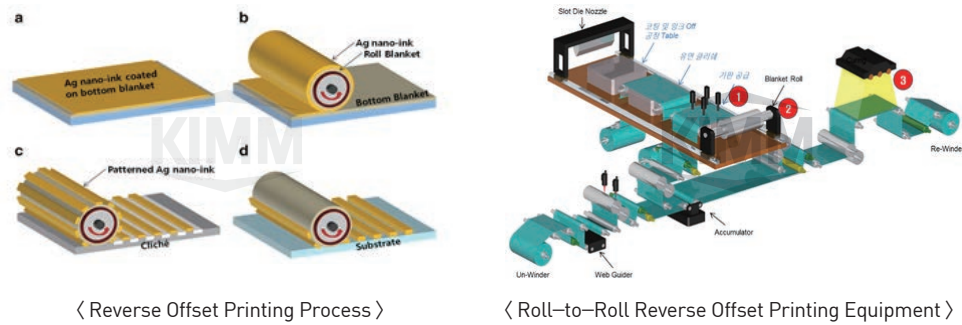


# Precise Roll-to-Roll Reverse Offset Printing Technology

▶ Department of Printed Electronics ▶ Researchers: Dongwoo Gang, Taikmin Lee ▶ Contact: +82-42-868-7237

Technology Overview

- Manufacturing technology for ultrafine conductive pattern on film transferred in roll-to-roll with the step & repeat method



Customer / Market

- Next generation flexible TFT backplane requiring high precision conductive pattern on plastic film (utilized as next generation flexible display, photo detector and sensor)

Problems of Existing Technology or Necessity of this Technology

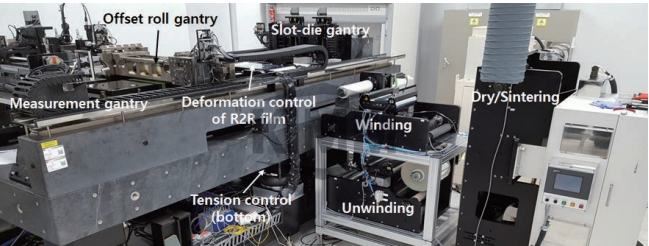
- Today's roll-to-roll patterning technology fails to satisfy the market demand and expectations on new electronic devices like flexible display and sensor, and demand for reliable roll-to-roll patterning technology development for quick commercialization continues.
- Due to such technical limitations, display manufacturers such as Samsung and LG are executing mass production by manufacturing flexible displays on plastic film-coated glass substrate and then peeling off the plastic film. However, such additional process leads to loss in process cost.
- Current roll-to-roll printing technology can only form relatively a simple circuit and has weak electrical properties. With low reliability, its market entry is limited.
- There is a need for a precision patterning technology for roll-to-roll, low-cost mass production of large, complex structures that the flexible display and other markets demand.

Technical Distinctiveness

- Possible to create ultrafine patterns (below 3 μm) on large area roll-to-roll films (width over 200 mm)
- Reverse offset process uses 100% ink transfer process that the pattern thickness is consistent, and the pattern quality including line edge roughness (LER) is outstanding.
- By precisely calculating the position of patterns on the plate/substrate before printing and the registration error of patterns after printing, the print registration error is automatically corrected to realize precise registration on roll-to-roll film with width of 200 mm resulting in error less than 5 μm.
- Technology to measure and control the registration errors can automatically compensate for the inevitable thermal contraction of plastic film during heat treatment following printing.
- The technology also can be utilized for roll-to-roll production of security protectionfilm requiring precise registration of lens and pattern

Excellence of Technology

- Transparent electrode forming 3 μm mesh patterns on large plastic film
- Development of precise roll-to-roll reverse offset printing machine device realizing automatic measurement/correction of registration error; verified registration accuracy less than 5 μm on roll-to-roll film and less than 2 μm on glass sheet.



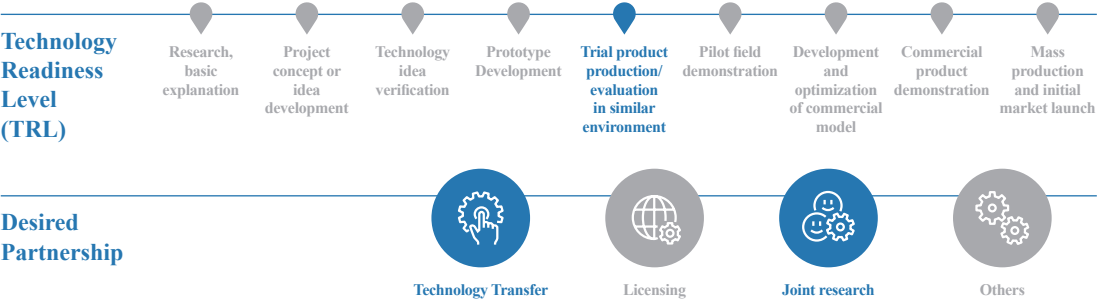
◀ Precise Roll-to-Roll Reverse Offset Printing Device ▶



◀ Mesh Type Transparent Electrode Using Reverse Offset Printing ▶      ▶ Roll-to-Roll Reverse Offset-Printed Registration Print Sample and Registration Accuracy Measurement Result (Registration error vector map)

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Printing apparatus and method being available to measure and compensate synchronization error (KR1445064, US9421753)</li><li>• Printing apparatus being available to compensate synchronization error (KR1445065)</li><li>• Printing Apparatus and Method Being Available to Measure and Compensate Synchronization Error Using Motor Feedback Signal (KR1519843)</li><li>• Method for compensating precision of print-position (KR1527721)</li><li>• Reverse Offset Printing Method of Partial Off Type (KR1211992, US8820239, JP5500743)</li><li>• Roll to roll reverse offset printing apparatus and method of alignment for using the same (KR1855844)</li></ul>	<ul style="list-style-type: none"><li>• Precise reverse offset printing process and formulation of conductive ink forming fine patterns</li><li>• Registration error autocorrection S/W technology based on the precision measurement/analysis of the registration errors</li></ul>



# High-speed Closed Loop Linear Motor Track

▶ Department of Printed Electronics   ▶ Researcher: Hyunchang Kim   ▶ Contact: +82-42-868-7378

**Technology Overview**

- A system of moving magnets based on a linear motor capable of individually controlling multiple movers without moving cables
- An intelligent transfer system capable of fast transfer with individual control of multiple movers, which is quick to adapt to procedural changes by easily creating and modifying motion profiles

**Customer / Market**

- Transport system for display and battery manufacturing line
- High-speed production inline packaging system for food, pharmaceutical, industrial products, etc.
- Various smart automated manufacturing process lines

**Problems of Existing Technology or Necessity of this Technology**

- In the case of a transfer device such as a conventional conveyor, productivity and flexibility for process changes are low, which increases time/cost burden.
- This technology can transport individual movers at high speed and flexibly change the mover’s motion profile, enabling improved productivity and flexible process operation.

**Technical Distinctiveness**

- High-speed movement of individual movers is possible based on a linear motor
- Infinite closed loop formation with moving magnet without moving cable
- A transport system that can respond to multiple processes by individually controlling each mover
- A modular system that enables controlling and expanding the transportation distance and the number of movers to suit the process
- It is easy to change the motion profile of each mover, making it highly adaptable to the change of process.

**Excellence of Technology**

- Individually drive multiple movers without cables on a linear motor track that constitutes a closed loop
- Each mover’s absolute location can be sensed and high-speed motion can be controlled individually.
- Creation of motion profiles of multiple movers and control of collision avoidance



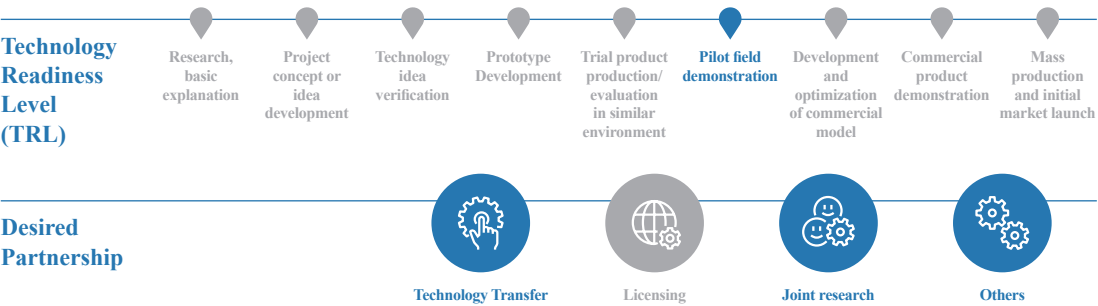
**Current Intellectual Property Right Status**

**PATENT**

- Linear motor and controlling system of the same (KR2164594)

**KNOW-HOW**

- Multiple three-phase driver hall switching technology
- Multi-mover individual location information acquisition and control technology

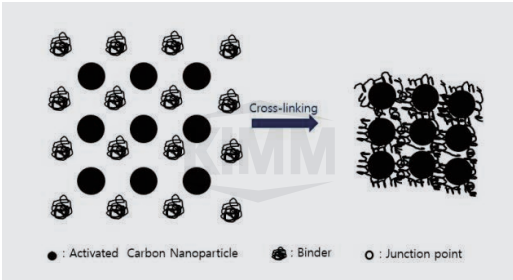


# High Performance Supercapacitor Manufacturing Technology Using Cross-linkable Polymer Binder

▶ Department of Printed Electronics   ▶ Researcher: Yunseok Jang   ▶ Contact: +82-42-868-7469

Technology Overview

- Technique to improve the performance of supercapacitor by preventing hydrophilic activated carbon from dissolving in electrolyte solution and improving affinity with electrolyte by using cross-linkable polymer binder
- Technology to improve the performance of supercapacitor by using cross-linkable polymer binder to reduce the content of binder, which is an insulator



Customer / Market

- Supercapacitor/battery manufacturer

Problems of Existing Technology or Necessity of this Technology

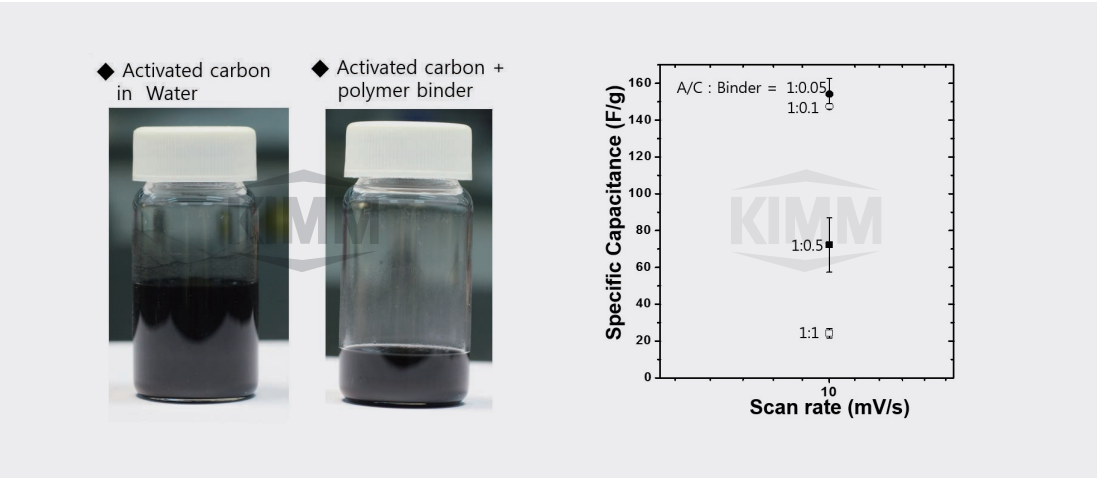
- Most supercapacitors use water-based electrolyte.
- In order to increase the affinity between the electrolyte and the activated carbon, it is recommended to substitute the hydroxyl group on the activated carbon surface to make it hydrophilic.
- When using existing materials, the hydrophilic group on the activated carbon surface causes the electrode to dissolve in the electrolyte.
- Increases the affinity of the water-based electrolyte and the activated carbon to help form an electric double layer on the surface of the activated carbon.
- Enhanced electric double layer helps improving capacity of the supercapacitor.
- Unlike existing binder, cross-linkable polymer binder prevents the hydrophilic electrode from dissolving in electrolyte.

Technical Distinctiveness

- Activated carbon shows a capacity of 100 ~ 120 F/g in 1M H2SO4 electrolyte.
- When using activated carbon with hydroxyl group on the surface and a cross-linkable polymer binder, a high capacity of 154 F/g was obtained in 1 M Na2SO4 electrolyte.
- Supercapacitors can be manufactured by overcoming the limitation of existing materials.

Excellence of Technology

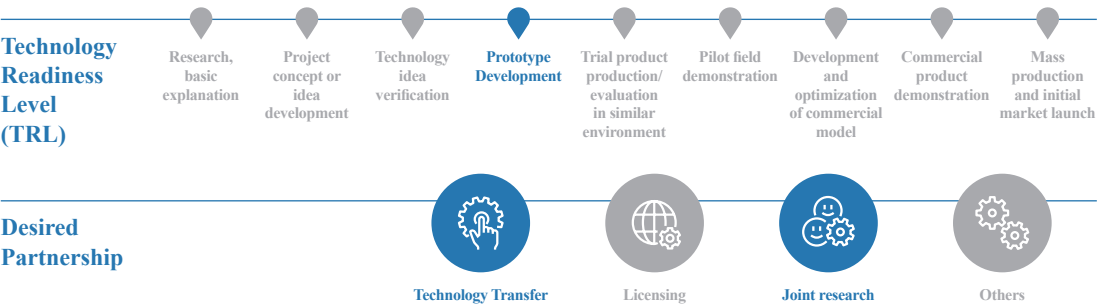
- High stability of ink due to high affinity of solvent, electrode and binder
- High capacity of 154 F/g in 1 M Na2SO4 electrolyte
- Publication : Y. Jang et. al, Activated carbon nanocomposite electrodes for high performance supercapacitors, Electrochimica Acta 102 (2013) 240-245



Current Intellectual Property Right Status

PATENT

- High Performance Functionalized Activated Carbon Supercapacitor by Using Curable Polymer Binder (KR1325952)
- Electrode Composition for Supercapacitor, Electrode including Cured Material, and Supercapacitor including Electrode (US9318276)
- High Performance Functionalized Activated Carbon Supercapacitor by Using Curable Polymer Binder (Japan-in process)
- Manufacturing Method for Silver Membrane with Non-woven Tissue and Silver Membrane Manufactured Thereof, Manufacturing Method of Current Collectors for Supercapacitor or Battery Using Silver Membrane with Non-woven Structure (KR1597535)





# Heating Sheet Manufacturing Using Printed Electrodes(Heating sheet)

▶ Department of Printed Electronics   ▶ Researchers: Kwangyoung Kim, Jeongdai Jo   ▶ Contact: +82-42-868-7162

Technology Overview

- Heating devices and sheets using a method of printing or imprinting periodic patterns without coating textiles or films with electrical properties materials



Customer / Market

- Heated seats, car seats, heating appliances and facilities, leisure products, biotherapeutic products, etc.

Problems of Existing Technology or Necessity of this Technology

- Carbon-coated textile (carbon textile) is arranged in grid pattern at irregular distance on the film.
- Carbon textile is created by putting regular fiber inside the carbon ink container.
- Here, the distance is inconsistent or controlling distance is difficult.
- The amount of ink coated on the fiber is inconsistent or controlling thickness is difficult.
- The amount of power generation differs by distance and amount of ink coated.
- Degradation occurs at a lump, and due to different amount of heat generated, the film peels off.
- Resistance is great where the line is thin, and it causes short circuit.
- Difficult to generate electricity and heat of the same size.

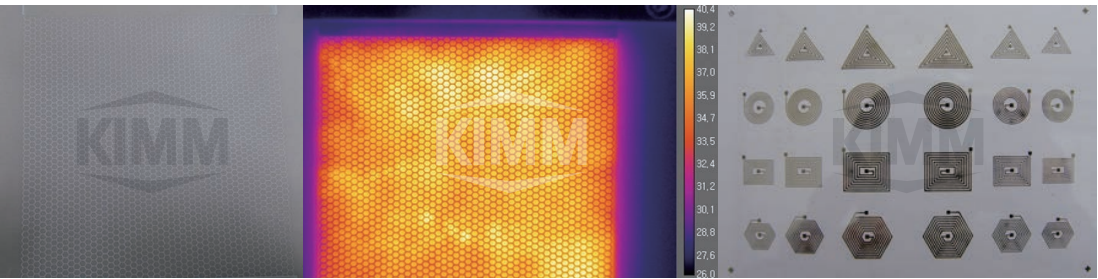
Technical Distinctiveness

- Manufactured by arranging grid patterns at regular intervals by printing (imprinting) carbon ink on a film, which is different from the existing process (soaking in an ink bottle, carbon textile coating, etc. is not required).
- Place the conductive printing electrodes between the thin flexible film and the protection film, and connect outsider power to the power plug connected to the printing electrodes to generate heat at the electrodes.
- Pattern distance is made consistence through printing (imprinting).
- With the option of various thickness adjustment, the size of electricity quantity and heat quantity can be adjusted.
- A uniform amount of electricity and heat can be obtained, and the occurrence of short circuit due to deterioration

and resistance is low.

Excellence of Technology

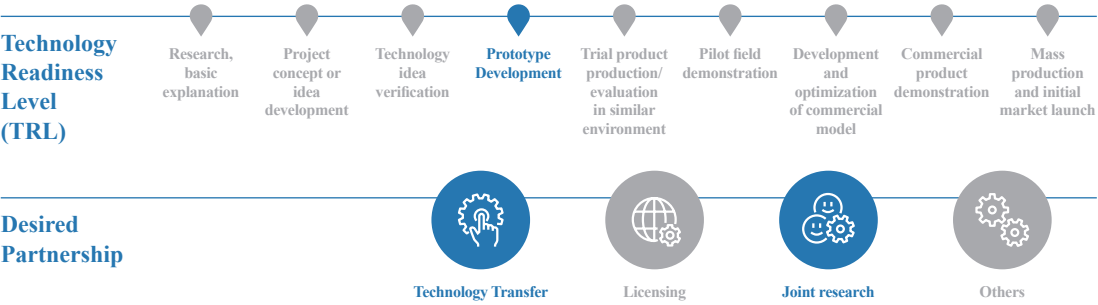
- Since it is a printed (imprinted) pattern, it can produce a pattern of uniform and reproducible thickness and line width in the same process.
- It has excellent electrical/mechanical performance. As it has a uniform line width, it has a constant resistance value, and the occurrence of deterioration and peeling due to different amounts of heat are very low; there is almost no short circuit.
- Temperature can be controlled between 0℃ and 200℃, and it can be manufactured up to several tens of meters in length.
- It can be manufactured in various forms (form factor free) of patterns on fibers or films.
- Post-processing such as laminating for commercialization of protective film is easy.



〈 Heating Sheet Manufacturing Using Printed Electrodes 〉

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Heating Sheet Using Printing Electrodes (KR1480160)</li><li>• Electric Oscillation Generator Using Printing Electrodes (KR1450212)</li></ul>	<ul style="list-style-type: none"><li>• Surface treatment technology of flexible (film, textile)/stretchable substrate</li><li>• Electrical/Mechanical property assessment technology for flexible/stretchable device</li></ul>



# Thermal-roll Imprinting System and Process Technology

▶ Department of Printed Electronics   ▶ Researchers: Jeongdai Jo   ▶ Contact: +82-42-868-7162

Technology Overview

- Micro or nanoscale mask is amounted on thermal-roll imprinting system to place pressure and heat to the lower roll to directly create micro patterns on flexible/stretchable substrate; and device manufacturing method using this technology

Customer / Market

- Transparent electrode, optical film, protection/ security film, next generation display, bio sensor, microlens, membrane plate, 3D sensor, energy device and radar absorbing structure, etc.
- Roll-to-roll and roll-to-plate printer's functional micro plate and hybrid device making

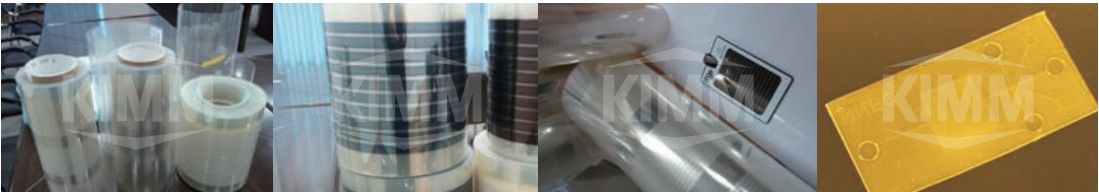


Problems of Existing Technology or Necessity of this Technology

- Existing imprint and hot embossing process technology does not directly engrave on the flexible plate but imprint on photo register or resin and go through secondary and tertiary processes such as development and etching to make the device.
- Existing technology requires a large number of equipment, process costs, and process steps, and there is a limit to mass production.
- The technology cannot be applied for a flexible and stretchable substrate.

Technical Distinctiveness

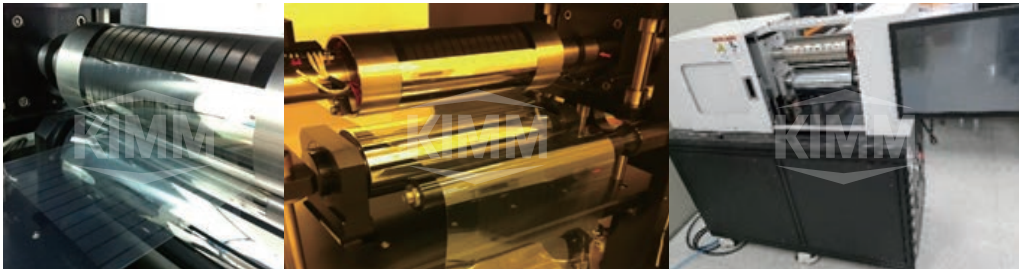
- A method of directly imprinting fine patterns on flexible/stretchable substrates in a way that both roll-to-roll/roll-plate are possible
- Since micro patterns are directly imprinted on flexible/stretchable substrates, the process steps are dramatically reduced and applying to mass production is easy.
- Flexible/stretchable devices can be manufactured with one device, and it has high scalability due to modular system such as coating equipment and laminating equipment.
- Imprinting of various patterns in micro/nano size is possible using flexible metal (SUS)/electroplating mask
- Possible to apply to micro/nano complex pattern manufacturing technology
- Uniform imprinting is possible by applying remolding technology
- Possible to achieve high imprint rate using heat and pressure press roll



< Roll-to-Roll Imprinting Film and Various Application Prototypes >

Excellence of Technology

- There are many sizes of thermal engraving device or roll-to-roll thermal engraving device including 5000×1500×2000 mm, small and medium size. The pattern resolution that can be engraved is 600 nm-20 μm, and the film width range is 300 mm-100 mm. Up to 1 Tonf of engraving pressure can be applied, and the temperature can reach up to 300°C. The engraving depth can be up to 20 μm.
- The shape of the line width is more uniform than the patterning by the existing printing and imprint process (excellent optical properties).
- Various types of flexible substrates (PET, PEN, PC, etc.) and flexible substrates can be used without limiting the use of substrates.
- Used for manufacturing devices such as transparent electrode, security film, optical film, TSP, NFC, OPV substrate and energy storage device current collector



Current Intellectual Property Right Status

PATENT

- Printing Device Using Thermal Roll Imprinting and Patterned Plate and Microfluidic Device and Film Laminating Device for Sensor and Printing Method Using the Printing Device (KR1022015, PCT/KR2011/002505, EP112010003566.0, US13/394182)
- Film Product Manufacturing Method Using Thermal Roll Imprinting and Blade Coating, and Protection Film and Electric Device Comprising Film (KR1022015, US13/582530, EP11766198.3, PCT/KR2011/002505)
- Printing Device Using Thermal Roll Imprinting and Patterned Plate and Microfluidic Device and Film Laminating Device for Sensor and Printing Method Using the Printing Device (KR0957622)
- Roll Imprinting Device and Method (KR1552935)
- Roll Imprinting Device (KR0988935, China, Germany, USA)

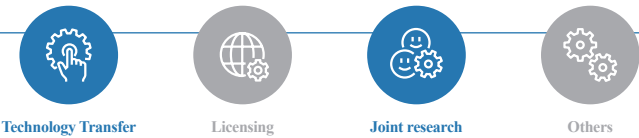
KNOW-HOW

- Ink/Paste inking and removing technology on engraved flexible/stretchable substrate
- Flexible/stretchable substrate surface treatment technology
- Electrical/Mechanical property assessment technology for flexible/stretchable device
- Remolding process technology for consistent imprint

Technology Readiness Level (TRL)



Desired Partnership

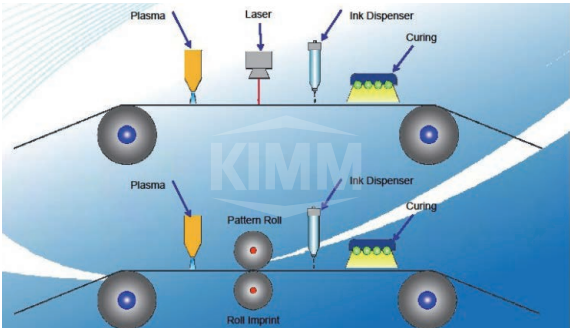


# Transparent Electrode and Transparent Electrode Film Manufacturing Technology

▶ Department of Printed Electronics   ▶ Researchers: Jeongdai Jo   ▶ Contact: +82-42-868-7162

Technology Overview

- Technology to easily fill metal ink/paste into the pattern grooves imprinted on a flexible/elastic stretchable substrate to simplify transparent electrode film manufacturing or fabrication process



Customer / Market

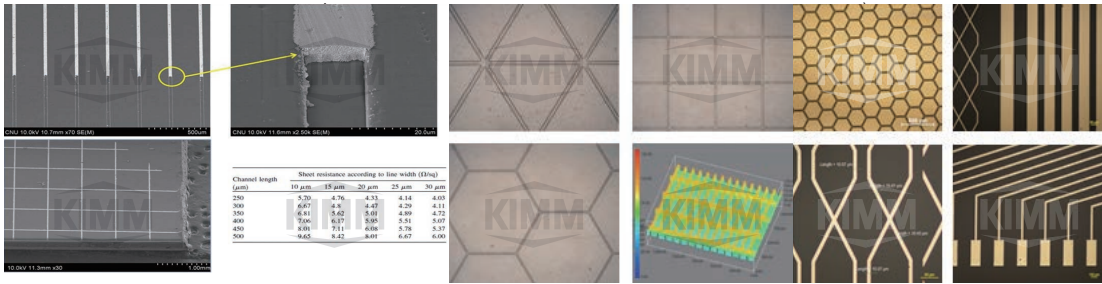
- Touch panel next generation display, optical film, security/ protection film, bio sensor, microlens, membrane plate, 3D sensor, energy device radar absorbing structure, etc.

Problems of Existing Technology or Necessity of this Technology

- Generally, a micro pattern is formed on a flexible/stretchable substrate, and metal ink/ paste is filled inside the micro pattern to create a transparent conductive film.
- For example, a micro pattern of concave grooves is created on a synthetic resin film, and the grooves are filled with metal ink/paste to form a transparent electrode.
- The process of creating transparent electrode becomes complex as the grooves are filled with metal paste using a blade, and overflowing paste is removed—blading process and cleaning process are added.
- For a large area, the conductive ink needs to be spread throughout the entire area—a great ink consumption.
- Difficult to spread the ink evenly with a blade on a large area
- After inking, the areas outside the pattern needs to be cleaned—additional process requiring a long time.
- Difficult to implement patterns with arbitrary shapes

Technical Distinctiveness

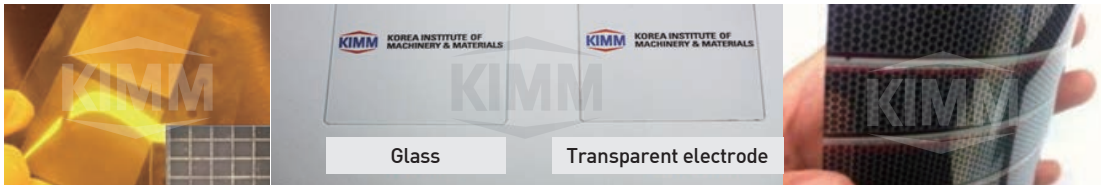
- Able to create sub-micrometer (500 nm) pattern (below 5 μm), which was difficult with existing roll printing
- Using laser, various patterns can be created—shortened pattern mask making time.
- There is no film damage from patterning, therefore various types of films can be used.
- Conductive ink is only filled inside the pattern; less ink consumption
- Without the blading and cleaning process, the number of process is reduced.
- Inking is easy and does not require separate inking device and cleaning device.
- Design and manufacture of engraving plate (line width, spacing and shape) are carried out in consideration of ink transfer characteristics and conductivity and transmittance characteristics after device manufacturing (pattern



〈 Method of Forming Transparent Electrode and Various Patterns of Transparent Electrode 〉

Excellence of Technology

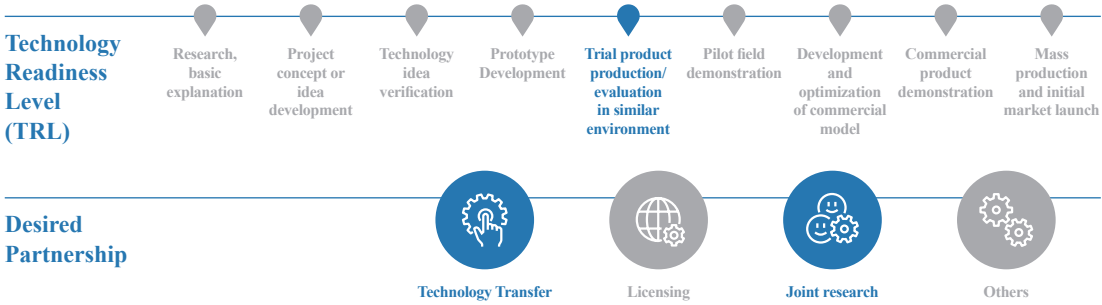
- Currently capable of designing and producing 500 nm–20 μm class (line width, spacing, shape) engraving
- No limits regarding materials to be used as various types of flexible (PET, PEN, PC, etc.) and stretchable substrates can be used.
- After plasma treatment of the film surface to create (ultra) hydrophobic surface with the contact angle over 100 degrees, laser or roll imprint is processed to create patterns.
- Conductive ink on film surface/Drop paste inside the concave pattern groove to form a micro pattern and immediately dry/cure.



〈 Result of Transparent Electrode Production/Transparent Electrode Film/Flexible Organic Solar Cell (Application) 〉

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Transparent Conductive Film Manufacturing Method, Device and the Transparent Film (KR1357284, EP14168884.6)</li><li>• Method for Manufacturing Transparent Electrode Using Metal Grid Based Printing and Transparent Electrode of the Same (US8912086)</li><li>• Transparent Electrode Manufacturing Method Using Metal Pattern Based Print and Transparent Electrode Thereby (KR1659462)</li><li>• Transparent Electrode Manufacturing Apparatus Using Metal Grid Based Printing (US13/223365)</li></ul>	<ul style="list-style-type: none"><li>• Pre/post-processing technology of for transparent electrode manufacturing</li><li>• Flexible/stretchable substrate surface treatment technology</li><li>• Electrical/Mechanical property assessment technology for flexible/stretchable device</li></ul>

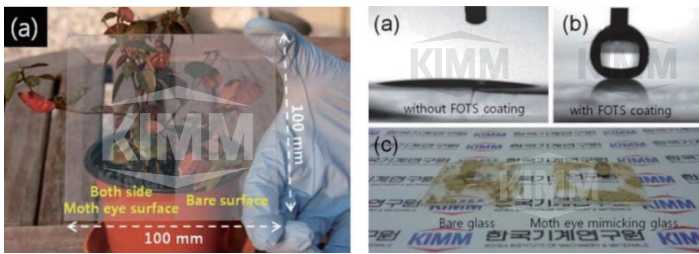




# Anti-Reflective & Water-Repellent Colored Glass

▶ Department of Nature-Inspired System and Application ▶ Researchers: Hyuneui Lim, Seungcheol Park, Seonju Yeo ▶ Contact: +82-42-868-7106

Technology Overview	<ul style="list-style-type: none"><li>• Technology related to functional surface which controls the reflectance of the surface by modulating the structural dimensions such as periodicity, height, and shape of the nanostructures on the surface</li><li>• Technology can provide the self-cleaning effect by using robust superhydrophobic nanoparticles</li><li>• Technology to control the reflectance in visible range by the nanostructures on the surface without a chemical coating layer</li><li>• Color can also be added by using inorganic particles</li></ul>
Customer / Market	<ul style="list-style-type: none"><li>• All surfaces that need anti-reflective coating and hydrophobic surfaces such as glass window, mirror, glasses, optical components, display cover glass, and solar cell cover glass</li></ul>
Problems of Existing Technology or Necessity of this Technology	<ul style="list-style-type: none"><li>• Creating a transparent and excellent water repellency surfaces with self-cleaning effect where impurities do not get stained and are removed easily</li><li>• Many attempts were made to form a nanostructure on a transparent surface to realize enhanced transparency and super water repellency, but the most frequently used method was the nanostructuring of transparent polymer film, which had drawbacks such as difficulty to form nanostructures on the surface densely or being easily broken from contact.</li><li>• For a glass installed outdoor, the significant high cost is needed to remove dust piled on the surface, therefore, a glass that is easy to clean with small amount of water (rain) and has the enhanced light transmittance.</li></ul>
Technical Distinctiveness	<ul style="list-style-type: none"><li>• (Nanostructureing method) As it uses the self-assembly nanoparticles layer as a mask for etching, the cost for processing is cheap, and the process time is relatively short. The glass surface is etched to form nanostructures, the structures are relatively mechanically robust and the properties are less affected by external environment.</li><li>• (Nanoparticle coating method) Technology also uses the nanoparticle coated layer for the water-repellent colored gass with simple coating methods.</li></ul>
Excellence of Technology	<ul style="list-style-type: none"><li>• (Nanostructureing method) A self-assembly nanoparticle layer is used as a mask, and then the plasma etching process is followed to make nanostructures on the transparent glass substrate.</li><li>• This nanostructured glass has 2 to 3% higher transmittance compared to a glass without nanostructures.</li><li>• The nanostructured glass after the plasma process shows super-hydrophilic properties as shown in Figure (a) on the right, and after the low surface energy chemical coating, superhydrophobic properties with the water contact angle over 150° is realized as shown in Figure (b).</li></ul>

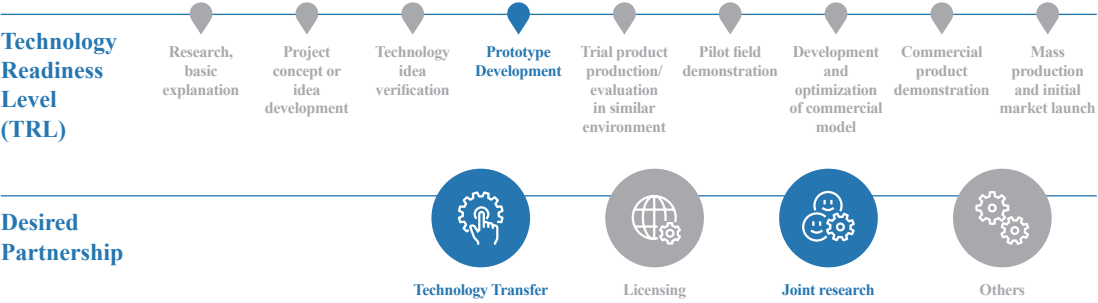


- (Nanoparticle coating method) Development of high value-added colored glass with self-cleaning function for the development of building-integrated photovoltaic modules for urban use
- Wet and large-area process technology for colored glass with self-cleaning (contact angle: 90°), multicolor (8 colors), and reflection reduction (transmittance: 85 %) functions developed
- Development of colored photovoltaic modules with 80 %in output efficiency compared to existing modules
- The researcher for these technology has over 15 years of research experience.



## Current Intellectual Property Right Status

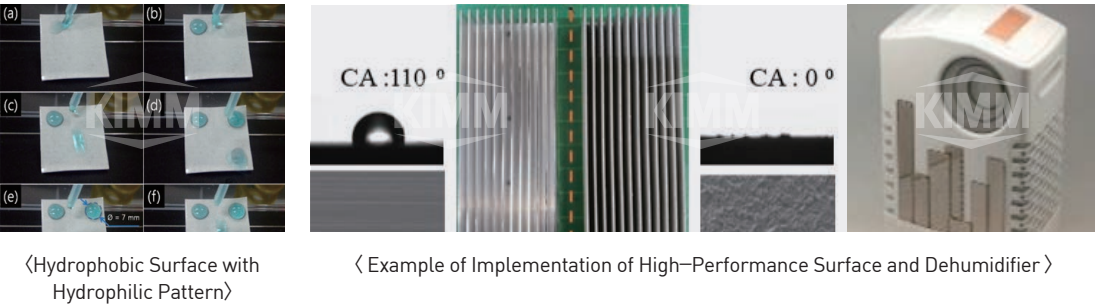
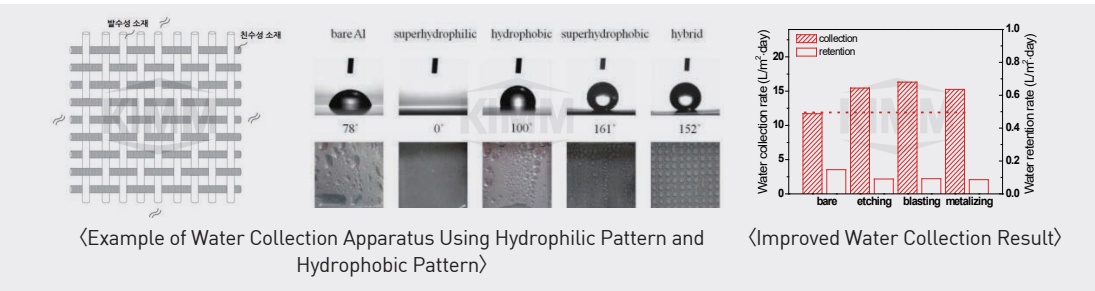
PATENT
<ul style="list-style-type: none"><li>• Fabrication Method for Functional Surface (KR1340845) / Fabrication Method for Functional Surface (KR1340874) / Fabrication Method for Functional Surface (KR1103264, JP5220066, US8728571) / Method for manufacturing superhydrophobic surface and super water-repellent face product manufactured by the same (KR1165606) / Manufacturing method for super water-repellent surface (KR0854486, US8,216,483, CNZL 200780052518.8, EP07851416.3) / Manufacturing method for anti-reflective surface and super water-repellent surface (KR1014277) / Patterning Method for Nano-Structure (KR1168250 ) / Bio chip and method for manufacturing thereof (KR1337504)</li><li>• Functional Cover for Solar Cells (KR2019-0053292)</li><li>• Coating head with multi coating modes and method for functional coating solution by using the coating head (KR2019-0177374)</li><li>• Nano Particle Coating Apparatus for Large Area Substrate (KR2013-0142142)</li></ul>



# High Performance Dehumidification Apparatus (Dehumidifier) Significantly Reducing Power Consumption with Functional Surface

▶ Department of Nature-Inspired System and Application ▶ Researchers: Hyuneui Lim, Sunjong Oh ▶ Contact: +82-42-868-7106

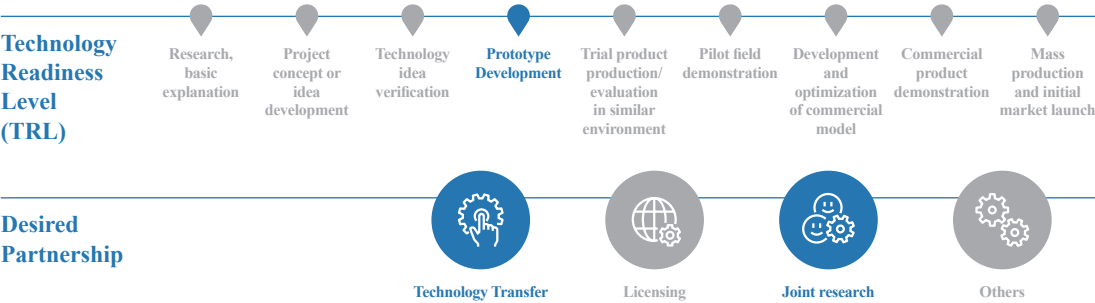
Technology Overview	<ul style="list-style-type: none"><li>• Cooling fin shape design of dehumidifier and surface modification method for cooling fin wettability to improve dehumidification efficiency and amount</li><li>• Dehumidification efficiency can be improved by removing the condensed water drops quickly from the cooling fin in the thermoelectric module assembly of dehumidifier.</li><li>• Dehumidifier having the anti-bacterial function in cooling pin and the cool wind</li></ul>
Customer / Market	<ul style="list-style-type: none"><li>• Dehumidifier manufacturer, air conditioner manufacturer, HVAC field</li></ul>
Problems of Existing Technology or Necessity of this Technology	<ul style="list-style-type: none"><li>• Current HVAC used moisture absorbent to absorb moisture in the air or used the refrigerant to condense moisture on the surface with single wettability for removing moisture from the atmosphere Therefore, there is a room for improvement in the efficiency to save the energy.</li><li>• Absorption dehumidifier uses chemical absorbent, and when the absorbent is no longer able to absorb moisture in the air, it needs to be reheated, so the additional cost occurs in this process.</li><li>• Therefore, an energy-efficient dehumidifier must be developed.</li></ul>
Technical Distinctiveness	<ul style="list-style-type: none"><li>• This technology provides the dehumidification technology using a practical highperformance surface of hybrid wettability.</li><li>• A hydrophilic material that condense moisture into water drops and a hydrophobic material that let fall down the condensed water drop are combined and each wettability of the surface are maintained their wetting property to collect moisture effectively. These surfaces show the better efficiency compared to existing hydrophilic or hydrophobic material surface.</li></ul>
Excellence of Technology	<ul style="list-style-type: none"><li>• In this technology, the hydrophilic pattern acts as the core to collect water vapor in the atmosphere, and as water drop grows into a certain size, the drop falls down along the hydrophobic pattern to be collected.</li><li>• With various ideas, condensed water drop grows faster.</li><li>• Cheap processes are used to realize high performance surface to enable commercialization.</li><li>• Contaminants and residual water droplets in the cooling fin of the dehumidifier is instantly sterilized by using high temperature. (removing the bacteria 100% with the 15-second sterilization)</li><li>• The dehumidifier makes the cold wind of temperature of 21.9°C at the outlet of dehumidifier.</li><li>• The researcher has over 10 years of research experience in the surface treatment field.</li></ul>



## Current Intellectual Property Right Status

PATENT	
<ul style="list-style-type: none"><li>• Artificial Tree for Environmental Risk Reduction (KR2018-0025845)</li><li>• Thermoelectric Module for Heat Recovery Attachable to Refrigerating and Air Conditioning Apparatus (KR2016-0120604)</li><li>• Dehumidifier with Heat Recovery Function (KR1750403)</li><li>• Fog Collecting Filter (KR1688982)</li><li>• Method and Apparatus for Sterilizing Heat Sink of Thermoelectric Device Assembly (KR1818729)</li><li>• Conductible Fin Having Micro and/or Nano Bump (KR1739049)</li><li>• Cooling Fin Block and Thermoelectric Module Assembly Having the Same (KR1679219)</li><li>• Thermoelectric Module Assembly for Dehumidifier (KR1519071)</li></ul>	<ul style="list-style-type: none"><li>• Hybrid Heat Conductible Pin with Hydrophilic and Hydrophobic Characteristics and Method Thereof (KR1519071)</li><li>• Conductible Fin for Evaporator (KR1303565)</li><li>• Moisture Collecting Apparatus (KR1059738)</li><li>• Water Repellent heat Sink and Method for Manufacturing Thereof (KR1136391)</li><li>• Moisture Collecting Apparatus (KR1077939)</li><li>• Portable water collection device (KR2020-0133541)</li><li>• A filter composition containing diatomaceous earth, a diatomite filter manufacturing method, and a multi-stage filter device having a diatomite filter (KR2020-0133687)</li><li>• Dehumidifying apparatus and method using thermoelectric module (KR2222265)</li></ul>

KNOW-HOW	
<ul style="list-style-type: none"><li>• Fabrication method for hybrid pattern of controlled wettability on aluminum surface (hydrophilic: contact angle below 10°/superhydrophobic: contact angle over 160°)</li><li>• Understanding on condensation behavior of various surfaces</li></ul>	



# Flexible Pressure/Tactile Sensing Technology

▶ Department of Nature-Inspired System and Application ▶ Researchers: Hyuneui Lim, Youngdo Jung, Sunjong Oh ▶ Contact: +82-42-868-7106

**Technology Overview**

- Biomimetic tactile sensors inspired by the sensing principle of human skin
- High-performance flexible tactile sensor capable of measurement under various extreme environments

**Customer / Market**

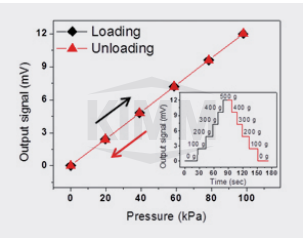
- Welfare/medical field : Artificial hand/arm with tactile feedback for patients that lost tactile sense from disease/accident
- Industrial field: Tactile feedback for remote assembly, test and diagnosis

**Problems of Existing Technology or Necessity of this Technology**

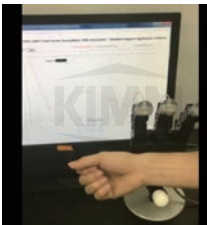
- Many high-performance tactile sensors have been developed, but suffered from several performance issues in the field test where they are actually used due to the impact of temperature, humidity, radiation.
- There is demand to control the pressure sensing range and sensitivity for the highperformance sensors to be used in various fields.

**Technical Distinctiveness**

- There is no hysteresis phenomenon in the sensor performance, and it is highly reliable even when used repeatedly.



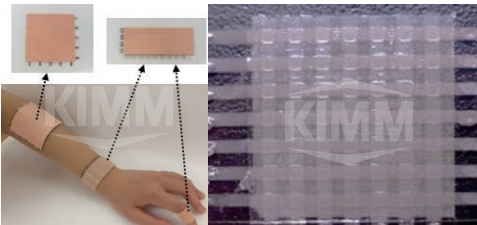
- The measurable tactile pressure sensing range can be easily controlled, and it can be used in various environments.



High Sensitivity  
: Feeling Pulse on the Wrist



Performing in Extreme Environment  
: Capable of Measuring Tactile Pressure Underwater



Skin-Type Large-Area Digital Sensor (left),  
Skin-Type Large-Area Multi-Step Sensor (right)

**Excellence of Technology**

- Visually measuring temperature by using a 3D printing method-based technology and thermal chromic based color which is similar to the skin
- Skin-type tactile sensor with free form and optimizing pressure range
- Low hysteresis and minimal effect under temperature change
- Development of a hybrid large-area sensor that minimizes the impact of pre-contact approach



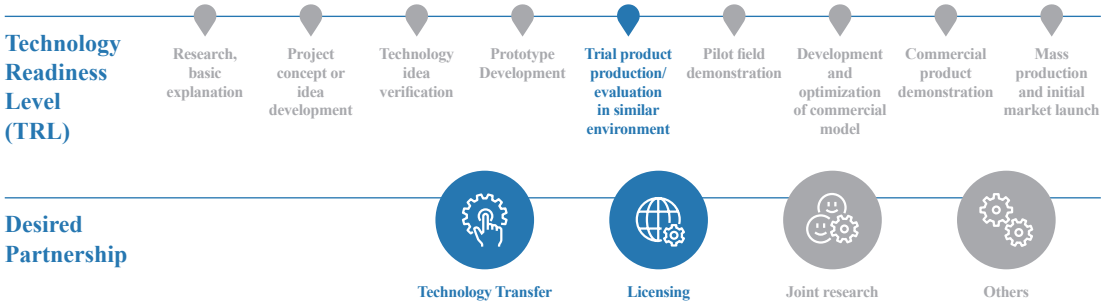
〈 3D Sensor Assembly 〉

- As the first integrated tactile sensor system, it is capable of simultaneously detecting, classifying and judging multiple contact physical quantities, such as contact vertical pressure (dynamic/static), shear force, vibration, and contact temperature, generated at one point on the X-Y plane in real time.

**Current Intellectual Property Right Status**

**PATENT**

- Multi-step tactile pressure sensor (KR2090684)
  - Air Cleaning Device and Driving Method of the Same (KR2020-0132260)
  - Tactile Sensor for Shear Force and Making Method of the Same and System of Tactile Sensor (KR1879811)
  - Stretchable printed circuit board and stretchable printed circuit board manufacturing method (KR2020-0132261)
  - Stretchable substrate and manufacturing method of the same (KR 2020-0132259)
  - Tactile sensor (KR2019-0097402), Tactile sensor (KR2171596)
  - Tactile sensing system (KR2020-0003229)
  - Quantum Dot and Manufacturing Method of the Same (KR2183137)
  - 3D printer with changing shape of printing plate and its operation method (KR 2020-0077234, KR2020-0077235, KR2020-0082235) and 10 other cases





# Water-Repellent/Self-Cleaning Technology Based on Superhydrophobicity

▶ Department of Nature-Inspired System and Application ▶ Researcher: Hyuneui Lim, Youngdo Jung, Seungcheol Park ▶ Contact: +82-42-868-7106

Technology Overview

- Manufacturing for high contact angle using surface nanostructure and chemical coating
- Manufacturing for easily cleaning surface with less contamination
- High-temperature, durable, superhydrophobic surface replacing perfluorinated compounds (Teflon)

Customer / Market

- All surfaces that needs to be maintained clean, all hydrophobic surfaces
- Home appliances: Cooling equipment such as frying pan, interior material of bathroom wall, glass material for window, kitchen furniture surface
- Industrial products: External material for ship, car, aircraft surface, nuclear energy fuel rod surface, spacecraft glass surface, heat exchanger, insulator, solar cell protection glass, external material for construction

Problems of Existing Technology or Necessity of this Technology

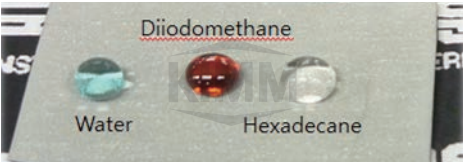
- Superhydrophobic property that reduces the surface’s contact with water results from the chemical property of low surface energy and the surface structure with less contact. This technology can be applied for home/ living products as well as different industries that a lot of studies are being conducted for it. Most of the existing technologies use chemical coating based on fluoride compounds that have durability and long-term safety issues for using various environments (including high temperature and pressure).

Technical Distinctiveness

- High-durability, eco-friendly, superhydrophobic surface treatment technology that can be used under 500℃
- Customized coating is possible for each end-item and applications with various temperature conditions
- One step process for surface nanostructure formation and chemical coating to reduce the manufacturing time and cost

Excellence of Technology

- High heat-resistance superhydrophobic coating technology with superhydrophobic property under 500℃ or higher
- High wear-resistance coating that tolerates scratches and shocks



〈Aluminum Surface with Superhydrophobic, Super-oleophobic Property〉

Current Intellectual Property Right Status

PATENT

- Gas Sensor having Nano-Wire Network Structure and Method for Manufacturing the Gas Sensor (KR2017-0048405)
- Film for Blocking Bacteria, Manufacturing Method Thereof and Medical Care Including the Same (KR2173034)
- Method for Making Superhydrophobic Metal Surface (KR1424995)
- Hydrophobic De-icing Tip for LPLi Injector (KR2012-0106459)
- Surface treatment method and apparatus for making superhydrophobic and high temperature resistant surface (KR2210567)
- Waterproof coating composition and waterproof coating method using the same (KR2021-0016268)
- F-DLC coating method for substrate having micro structure and substrate manufactured by the method (KR1546361)
- A manufacturing method for a film having a microstructure for inhibiting the formation of a biofilm, and a film using the same (KR2021-0003540)

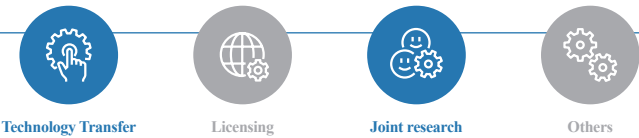
KNOW-HOW

- Equipped with process technology that can be applied for various materials
- Possible to generate a customized contact angle in wide range
- Conducted various experiments on water condensation and dew condensation

Technology Readiness Level (TRL)



Desired Partnership



# Anti-Reflection in Visible Light Range and IR Filter Technology

▶ Department of Nature-Inspired System and Application ▶ Researcher: Hyuneui Lim, Seungcheol Park ▶ Contact: +82-42-868-7106, 7661

Technology Overview

- Manufacturing and design of anti-reflecting flat/curved (lens) glass for the visible light range and metal nanostructure-based selective filter for the IR range
  - Manufacturing and design of flat glass with reflectance below 1% in 380 nm–780 nm (visible light range)
  - Antireflecting lens technology for anti-flare/ghost effect
  - Metal nanostructure-based selective filter design and fabrication for heat blocking and emission in NIR range

Customer / Market

- Antireflective flat glass: Internal and external materials for construction, glass for display, glass for viewing at zoo, automobile glass, photovoltaic device, etc.
- Antireflective curved glass (lens): Optical lens, microscope lens, optical equipment for military use, etc.
- IR filter: Solar ray-related new and renewable energy device, heat shield, hot and cold insulation material

Problems of Existing Technology or Necessity of this Technology

- It is too hard to make antireflecting surface with low cost and simple fabrication method based on existing chemical coating process due to the complexity of refractive index matching.
- The simple nanoparticle coating method can decrease the cost lower than existing method, but the reflectance can be reduced 1 to 2% in the visible light range (for 550 nm).

Technical Distinctiveness

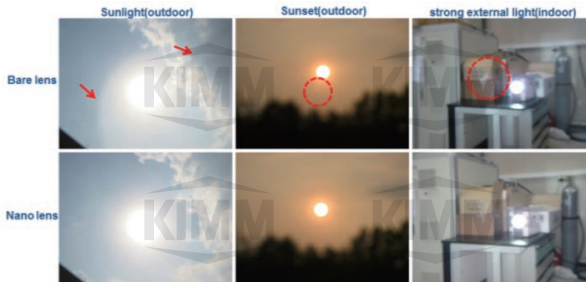
- With a lower production cost than the conventional methods, lower than 1% reflectance can be achieved in visible light range.
- Even for various scale and curvature of the substrate, stable antireflecting surface structure can be formed by applying the existing surface structure formation method.
- The surface nanostructure formed lens can prevent the flare and ghost image which are made by the internal reflection of lens spontaneously.
- With periodic surface nanostructure formation on substrate, regardless of the type of substrate, antireflection effect for a broad wavelength can be induced.
- The antireflection can be made by the surface nanostructure that the property can be maintained under various environments such as chemical, humidity, and UV rays.
- Metal nanostructure based selective IR filter produced with a similar process to the antireflection surface formation can be applied as the selective IR filter in various IR range.

Excellence of Technology

- Lower than 1% of reflectance in visible light range can be achieved, and not only flat surface but also curved surface can provide antireflection effect with gradient refractive index

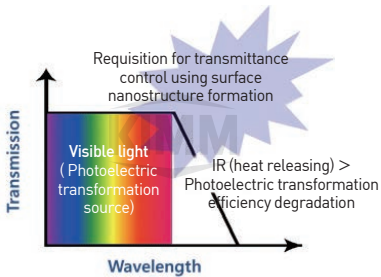


〈 Bare Lens and Nano Lens 〉



〈 Image Distortion in a Picture Taken with a Bare Lens and a Nano Lens 〉

- Based on the selective IR filter using regulating of surface metal nanostructures such as size, shape, and materials can decrease the heat releasing for enhancement of efficiency of photovoltaic devices.



〈 Concept of Antireflection in Visible Light Range & IR Reflection (IR filter) Technology 〉

5 sun	J <sub>sc</sub> (mA/cm <sup>2</sup> )	V <sub>oc</sub> (V)	Fill factor (%)	Efficiency (%)
Bare quartz_5sun	58.9	0.87	31.0	15.9
Au10nm_1.3um	49.2	0.97	38.6	18.4
Au10nm_1.5um	53.0	0.96	35.8	18.2
Chemical coating 800-1100	42.2	0.93	40.5	15.9
Chemical coating 1100-1400	37.6	0.97	45.8	16.7
Chemical coating 2000-2300	37.6	0.96	44.3	16.0

〈 Efficiency Enhancement of Photovoltaic devices using Metal Network Electrode 〉

Current Intellectual Property Right Status

PATENT

- System for Condensing Sunlight and Anti-Reflection and Low-Reflection IR Filter With Used in the Same (KR1525474)
- Optical Filter with Function of Frequency-Selective Transmission and Reflection (KR1688186)
- Patterning Method for Nano-Structure (KR1437862)

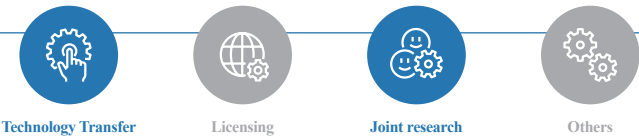
KNOW-HOW

- Particle-based surface nanostructure formation method
- RIE-based surface nanostructure formation method
- Metal nanonetwork formation method
- Surface nanostructure based transmittance simulation for antireflection effect

Technology Readiness Level (TRL)



Desired Partnership

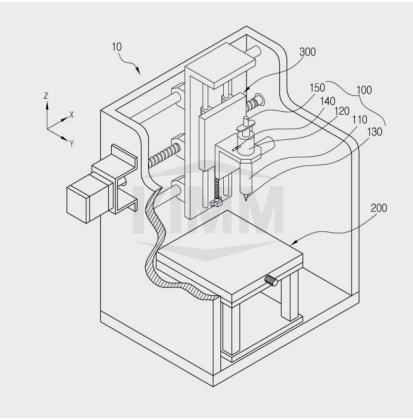


# PDO(Polydioxanone) Dental Barrier Membrane

▶ Department of Nature-Inspired System and Application ▶ Researcher: Su A Park ▶ Contact: +82-42-868-7969

Technology  
Overview

- Dental barrier membrane with porous membrane using a bioplotting device



Customer /  
Market

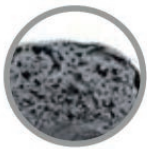
- Customized medical scaffold

Problems  
of Existing  
Technology or  
Necessity  
of this  
Technology

- It is a 3D scaffold fabrication for reconstruction of the defected parts in the body.

Coventional methods of scaffold fabrication

- solvent-casting particulate-leaching
- gas foaming/salt leaching
- Fiber meshes/Fiber bonding
- phase separation
- Melt molding
- freeze drying



- 3D shape is not sophisticated.
- Pore structure is not uniform.
- Does not have an internal connection structure.
- Reproducibility is low.

- In the 3D scaffold fabrication for tissue engineering and regenerative medicine, there are different types of manufacturing with appropriate strength, biodegradability, and non-toxicity, but there is no standardized method, and this is an actual obstacle to product commercialization (item approval, etc.)
- It needs to be biocompatible and non-toxic.
- Different mechanical, physical properties and fabrication are required for different purpose of use.
- Volume, porosity and biodegradability for a large surface area is needed.

Technical  
Distinctiveness

- Structural characteristics (pore size, porosity), materialistic characteristics (biocompatibility, degradation), and mechanical properties of the scaffold can be adjusted to suit the convenience of the user.
  - Using a bio-plotting device, manufacturing is simple, and scaffolds of various size and shape can be manufactured.
  - It is easy to control the thickness of certain part (perhaps requiring strength maintenance) or the pore size during manufacturing.
- Bio-plotting system equipment has the benefit of being able to use desired materials to manufacture various types of scaffolds under different conditions and allows for easy reproduction.
- After covering the bone graft material-filled gum surface, it takes 2 to 3 months until it is absorbed and degraded that the bone graft material maintains necessary shape and protects from the outer environment until the area is recovered. As it is absorbed and degraded at the appropriate time, the effect of the treatment is enhanced and the user satisfaction is also improved.
- Not only PLC, but various combinations can be used artificial scaffolds (PCL/HA, PCL/TCP) for different bio fields.

Excellence of  
Technology

- Dental barrier membrane is formed with multi-layers of porous membranes by adjusting the transfer stage and jet stage of the bio-plotting apparatus.



〈 Dental Barrier Membrane 〉

Current  
Intellectual  
Property  
Right Status

PATENT

- Dental Barrier Membrane (KR1352366)
- Apparatus for Forming of Sliding Prevention of Artificial Lacrimal Canaliculus and Method for Manufacturing Artificial Lacrimal Canaliculus (KR1368850)
- Plotting Apparatus for Hydrogel (KR1306264)
- The Method for Preparation of Cell Culture Scaffold (KR1270143, US13/160577, SP201104380-9)
- The Method for Preparation of Hybrid Scaffold for Bone-Cartilage Regeneration (KR1284080)
- Apparatus for Manufacturing Regeneration of a Three-Dimensional Tissue (KR1271238)
- Three-Dimensional Manufacturing Apparatus for Cell Culture Product (KR1185506)
- Manufacturing Apparatus and Manufacturing Method for Cell Culture Scaffold (KR1153728)

Technology  
Readiness  
Level  
(TRL)



Desired  
Partnership



Technology Transfer



Licensing



Joint research



Others



3D Bio-printing System Technology

▶ Department of Nature-Inspired System and Application ▶ Researcher: Junhee Lee ▶ Contact: +82-42-868-7937

Technology Overview

- 3D printing system (3D printer) is an equipment that manufactures products by stacking materials layer by layer using various methods. Various types of 3D products can be manufactured. There are no wasted resources when manufacturing products, and it has the advantage that it can be applied to various fields depending on the materials.
- 3D bio-printing system (3D bio-printer) is a device that uses biomaterial or cell to make 3D tissues and organs.
- Although the demand for artificial organs is rapidly increasing in an aging society along with the development of medicine and the improvement of living standards, the supply of artificial organs is insufficient. 3D bioprinting technology is expected to solve this problem.

Customer / Market

- Medical and healthcare industry-hospital, doctor
- Artificial tissue/organ market

Problems of Existing Technology or Necessity of this Technology

- Research on artificial organ is being conducted actively in the tissue engineering field. Tissue engineering is the use of a combination of cells, engineering and materials methods, and suitable biochemical and physicochemical factors to improve or replace biological tissues.
- Stem cell has been used to solve the lack of tissue and organ problems, but stem cells may not be able to be manipulated to produce all tissues and organs.
- 3D bio-printing has the potential to overcome the drawbacks by direct 3D printing the biomaterials and cells to produce the artificial tissue and organs.

Technical Distinctiveness

- Scaffold for artificial tissue/organ can be made based on a medial image (CT, MRI, etc.).
- Can print with various biomaterials (biodegradable/biocompatible polymers, hydrogels, etc.).
- Can print cells in three dimensions (artificial organ/tissue production)
- Can print various materials simultaneously by using multi-axis printing head
- Can print scaffolds and tissues in the shape of conduits with a minimum diameter of 1 mm
- Can print minimum line width of 100 μm



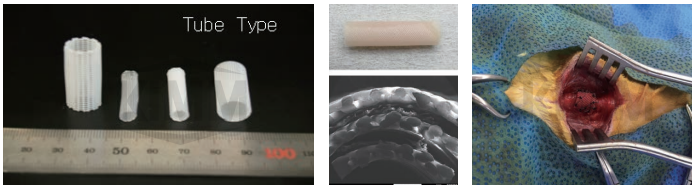
Description	Capacity
Working Area (mm)	100X100X100
Resolution (um)	1
Position Accuracy (um)	< 10
Velocity (mm/s)	< 30
Polymer Disp. Temp. (°C)	< 300
Hydrogel Disp. Temp. (°C)	4 ~ 60
Base Temp. (°C)	< 100
Polymer Head	Air
Hydrogel Head (Cell)	Air + Screw
Needle Dia. (mm)	0.1 ~ 0.5
Head Num.	1 ~ 4

Excellence of Technology

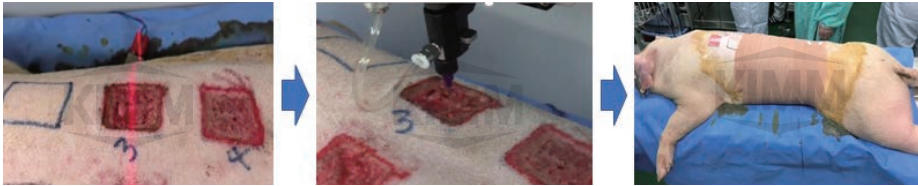
- Possible to manufacture various shapes of scaffolds and artificial tissues based on medical images



- Possible to manufacture tube-shape scaffolds and artificial tissues



- Damaged tissues can be regenerated by scanning the damaged area and printing cells directly on the affected area.



Current Intellectual Property Right Status

PATENT

- Tube Shape Scaffold Manufacturing Device and Scaffold Made by the Device (Patent registered, 9730817)
- Fabrication method of hybrid scaffold and the scaffold made by the method (US9821500)
- Apparatus for manufacturing regeneration of a three-dimensional tissue (KR0916633)
- Cell plotting apparatus for manufacturing three dimensional scaffold (KR1110797)
- Artificial vessel and Manufacturing Method of the Same (KR1855806)
- Holding 12 patents including the method for biological tissue manufacturing and biological tissue manufactured by the same (KR2097784)

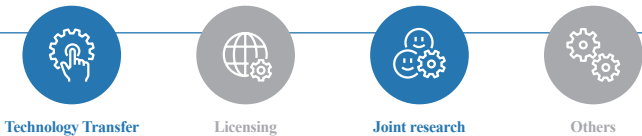
KNOW-HOW

- Bio-printing materials and conditions (temperature, speed, pressure, etc.)

Technology Readiness Level (TRL)



Desired Partnership



# Nanofiber Web Measurement and Assessment Technology

▶ Department of Nature-Inspired System and Application   ▶ Researcher: Junhee Lee   ▶ Contact: +82-42-868-7937

**Technology Overview**

- Technology to find defects in the nanofiber web and measure its size and thickness real-time

**Customer / Market**

- Nanofiber, fiber laminating, paper, film manufacturing site

**Problems of Existing Technology or Necessity of this Technology**

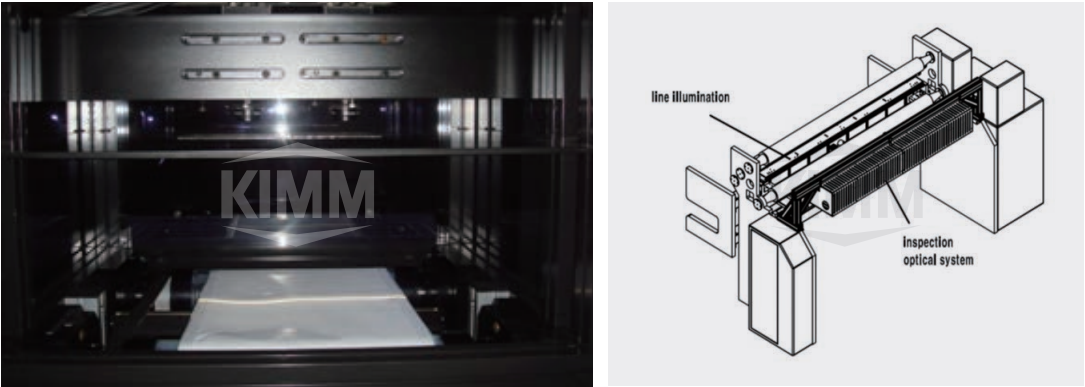
- Defects in nanofiber web fabricated with electrospinning process has adversely affect the per on nanofiber web's penetration and filtration function.
- There is a need to test and analyze the nanofiber web's defects to control the production process.

**Technical Distinctiveness**

- Defect detection method: Comparing the intensity of the concentrated light that pass through the defects in the opaque nanofiber web.
- Thickness measuring method: Observing the change in the average intensity of the concentrated light that pass through the opaque nanofiber web.

**Excellence of Technology**

- Concentrated light is illuminated as a line to minimize noise occurrence and can test the nanofiber web at a high speed.
- Concentrated light is illuminated as a line, and the contrast difference is great between the part with defect and the part without a defect that the location of the defect can be precisely measured.
- The location and number of defects can be measured in real time, and the thickness of the nanofiber web can be measured simultaneously.



〈 Nanofiber Defect Measuring Apparatus 〉

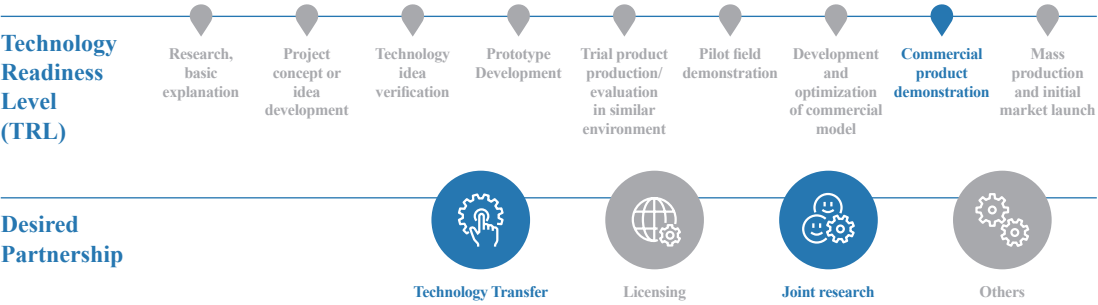
**Current Intellectual Property Right Status**

**PATENT**

- Apparatus for Monitoring and Repairing of Multi Nozzle Electro Spinning, and Method for Monitoring and Repairing Using the Thereof (Patent registered, 0836274)
- Testing Apparatus of Nanofiber Web and Testing Method the Same (KR0893933)
- Apparatus and Method of Checking Defect of Nanofiber and Repairing the Defect (Patent registered, 1056345)

**KNOW-HOW**

- Measurement variable such as speed, intensity and diameter, etc

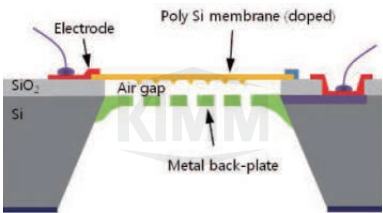


# MEMS Microphone and Manufacturing Method

▶ Department of Nature-Inspired System and Application ▶ Researcher: Shin Heo ▶ Contact: +82-42-868-7886

Technology Overview

- MEMS microphone is realized with the vibrating plate that responses to the sound and the back plate on the opposite side used as stationary electrode, and the back plate used for this invention is made thick and solid using electroplating. The process and the cost is expected to be reduced significantly with this technology.



〈Diagram of MEMS Microphone Cross Section〉

Customer / Market

- Microphone manufacturer, mobile device manufacturer, hearing aid manufacturer, entertainment device company, noise diagnostic instrument company

Problems of Existing Technology or Necessity of this Technology

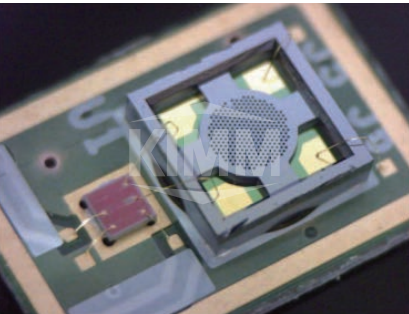
- Adoption of a cheap, simple process is needed by using electroplating for thick and solid back plate.
- Generally, for existing MEMS microphone, the electrode in the thin back plate is made with surface micromachining, which causes fundamental sensitivity degradation.
- Also, air hole etching process for the back plate adds cost.
- Miniature microphone applied for mobile phones and devices is replaced from ECM (electret condenser microphone) to MEMS microphone, and in 2016, the market is expected to achieve 2 billion products sales and 1.5 billion dollars in size.
- Currently, the domestic market depends completely on imported miniature MEMS microphones. With the explosive increase in smart phones, a steep increase in demand for MEMS microphone is expected. It is necessary to develop a cheap, highperformance product with domestic technology.

Technical Distinctiveness

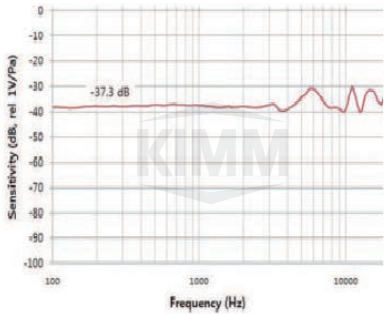
- When the stationary back plate is processed using electroplating, the sensitivity of microphone is expected to be enhanced while the production stage and cost is expected to be reduced.
- It induces domestic technology development and production in the miniature microphone that entirely depends on import at the moment.
- By using electroplating for a thick back plate to create a MEMS microphone with a solid back plate, sensitivity enhancement compared to existing microphone is realized.
- By applying electroplating for the back plate no in the surface micromachining but bulk micromachining, the number of processes will be reduced compared to existing process, which means lower cost.

Excellence of Technology

- It is a miniature MEMS device composed of the vibrating plate (moving electrode) facing the back plate (stationary electrode), and when sound is input in the variable condensing state while voltage is applied for both ends, the distance from the electrode of the back plate changes as the vibration plate starts to vibrate.
- Following this, the capacitance change is detected for the output.
- For a general MEMS microphone, surface micromachining is applied to have a relatively thin stationary back plate, but the thick, solid back plate proposed in this research is expected to have a rapid increase in sensitivity. Also, by applying body etching and metal-plating in the back plate manufacturing process, the entire process and the cost are reduced.
- MEMS microphone applying the back plate in the image above combined with developed CMOS ASIC chip showed outstanding sensitivity of approximately 37.3 dB.



〈 Developed MEMS Microphone Package 〉



〈 Sensitivity of Developed MEMS Microphone 〉

Current Intellectual Property Right Status

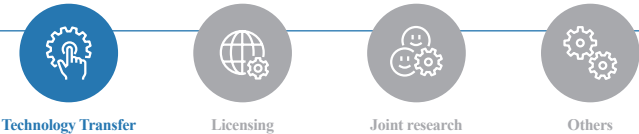
PATENT

- MEMS Microphone Package and Manufacturing Method of the Same (KR1118624)
- MEMS Microphone and Manufacturing Method (KR1118627)
- MEMS Microphone Based on Graphene Membrane and Fabrication Method Thereof (KR1058475, PCT/KR2011/003584)
- Ultra-small-size Microphone Based Hearing Aid Apparatus (KR1031113)
- 1-Chip-type MEMS Microphone and the Method for Making the 1-Chip-Type MEMS Microphone (KR1472297)
- MEMS Microphone with Dual-backplate and Method the Same (KR1379680, PCT/ KR2012/010259)
- Sound Measuring Apparatus Having Flexible Substrate Using MEMS Microphone and Method for Making the Apparatus (KR1346583)
- MEMS Microphone (KR1462375)
- Making Method for 1-chip-type MEMS Microphone and the 1-chip-type MEMS Microphone by the Method (KR1407914)

Technology Readiness Level (TRL)



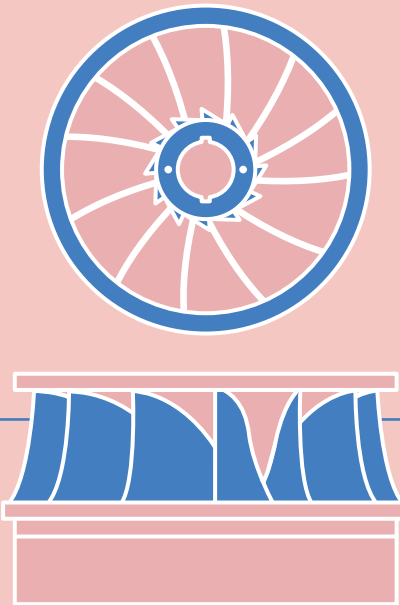
Desired Partnership





3

Energy Systems  
Research Division



HIGH-EFFICIENCY HYDRAULIC  
TURBINE TECHNOLOGY  
HIGH-EFFICIENCY 50 MW  
FRANCIS RUNNER DESIGN

- 182 • Department of Energy Conversion Systems
- 198 • Department of Thermal Systems
- 240 • Department of Plant Technology
- 244 • LNG and Cryogenic Technology Center

# Stirling Cryocooler

▶ Department of Energy Conversion Systems   ▶ Researcher: Junseok Ko   ▶ Contact: +82-42-868-7391

## Technology Overview

- Stirling cryocooler is a machine that creates cold environment and composed of a set of a compressor, an expander and heat exchangers.
- This regenerative refrigerator that mainly uses helium as a refrigerant, unlike vapor-compression refrigerators, is not limited by the operating temperature and can be cooled down to a cryogenic temperature of -200℃ or below.
- The technology can be utilized for various temperature ranges (from under -200℃ to -15℃) and cooling capacities (from under W-class to kW-class).

## Customer / Market

- Stirling cryocooler can be applied in various fields depending on operating temperature and required cooling capacity.
  - Infrared (IR) thermal imaging sensor cooling device for military and space
  - Cooling systems for superconducting power applications (superconducting cable, superconducting fault current limiter; SFCL, superconducting transformer)
  - Small-scale LNG liquefaction/re-liquefaction (-160℃) system
  - Ultra-low temperature refrigerator for bio storage
  - Low GWP (global warming potential) refrigerant-applied refrigeration/freezing system

## Problems of Existing Technology or Necessity of this Technology

- Stirling cryocooler has the highest efficiency among low-power cryocoolers.
- There is no risk of breakdown due to impurities hardening under an ultra-low temperature below -60℃.
- The system can be compact as all components-compressor, expander and heat exchangers-are a single unit.

## Technical Distinctiveness

- Stirling cryocooler technologies on various types
  - By driving mechanism : rotary compressor, linear compressor
  - By piston and displacer arrangement : alpha-type, beta-type, gamma-type stirling cryocooler
  - Our work group has remarkably worked and secured toward on a ‘free piston Stirling cooler (FPSC)’ accompanied by a linear compressor.
- Cooler design that considers electro-magnetic, thermo-hydraulic and dynamic characteristics including reciprocating compressor for the entire cooler development process
- Ease of temperature and capacity controlling under an extensive temperature range with high turn-down ratio
- This technology utilizes Helium as a refrigerant with GWP (global warming potential) of zero so that it agrees to the Paris Agreement.

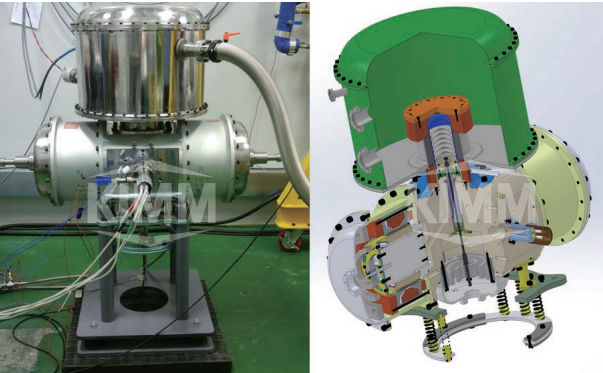
## Excellence of Technology

- Development of Stirling cryocooler for infrared (IR) thermal imaging sensor cooling
  - Rotary compressor and linear compressor adopted Stirling cryocooler with cooling capacity of 0.4~1.0 W (at -200℃)
  - Development of day-night observation facilities for military use and tank panoramic sight
  - Approval for military use following the development and operation test based on the military standards



〈 Stirling Cryocooler for Sensor Cooling 〉

- Development of high-power Stirling cryocooler for superconducting power application cooling system
  - kW-class linear compressor driven Stirling cryocooler for liquid nitrogen cooling
  - Ease of miniaturization and maintenance compared to conventional cryocooler driven with crank-cam reciprocating compressor lubrication involved
  - Performance test of 2 kW (at -200℃) verified through the liquid nitrogen (LN2) circulation test



〈 High-power Stirling Cryocooler 〉

## Current Intellectual Property Right Status

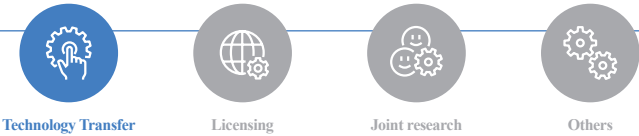
### KNOW-HOW

- Linear motor design and optimization technology for Stirling cryocooler
- Compressor and low-temperature expansion device optimization technology
- Stirling cryocooler dynamics and thermal design, layout creation and assembly technology
- Stirling cryocooler operation control and performance analysis technology
- Development technologies for various operating temperatures and cooling capacities

## Technology Readiness Level (TRL)



## Desired Partnership



# High-performance Compressor / Blower Technology

▶ Department of Energy Conversion Systems   ▶ Researcher: JeongMin Seo   ▶ Contact: +82-42-868-7541

Technology Overview

- Compressors and blowers are key elements that generate gas flow or pressure rise in gas turbine, industrial process and household applications.
- Compressor design (aerodynamic, structure, cooling, vibration, drawing) to satisfy the target performance under various operating conditions and testing technology
- Compressor performance assurance and performance estimation in design and off-design conditions

Customer / Market

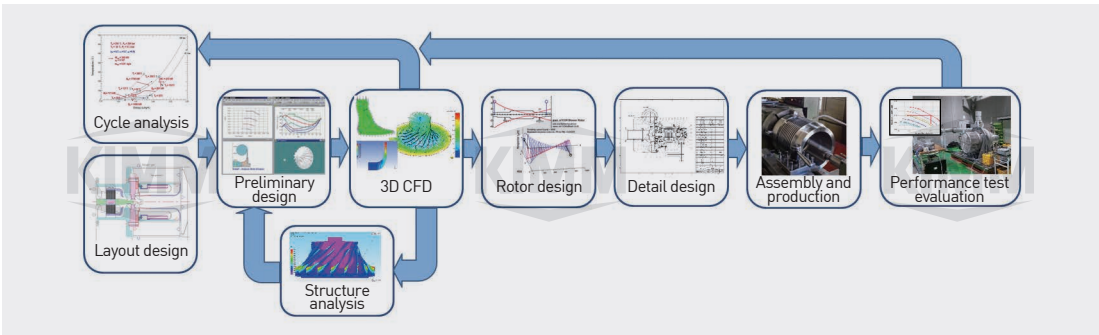
- Gas turbine manufacturer/user company
- Industrial process or general use compressor and blower manufacturer/user company

Problems of Existing Technology or Necessity of this Technology

- Multidisciplinary technology is required (design: aerodynamics, structure, vibration, heat transfer/manufacture: material, tolerance management, assembly/ performance test: apparatus, measurement standard, data measurement and analysis)
- Product development requires a lot of research experience, and it is difficult to introduce a new technology to this long-lasting area of study.
- There are many cases of multi-product small volume production that needs to be newly developed to meet the requirements of users. The impact of technological power on related industries is great, and there is a continuous demand for product development for new fields.

Technical Distinctiveness

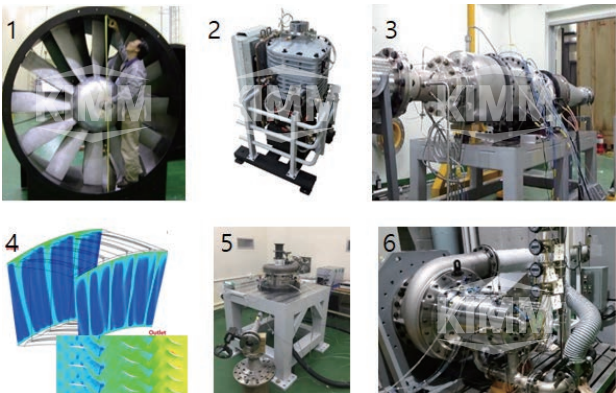
- Technology and process for entire cycle of compressor development except for manufacturing-cycle analysis, layout design, sizing, 3D CFD, 3D shape formation, production and assembly, and performance test, etc.-has been secured internally.
- Actions for each technology stage such as performance interpretation and analysis, optimal shape design, and product performance test are performed.



Excellence of Technology

- Equipped with 20 years of experience in developing high performance compressors and blowers for various purposes
- Equipped with various S/W for meanline design, 3D geometry formation, and 3D CFD analysis

No	Start	Target
1	2008	Reversible Axial Fan for ventilation system
2	2008	Turbo refrigerant compressor (magnetic bearings)
3	2012	Centrifugal compressor for 100kW class MGT
4	2014	Unsteady analysis of axial compressor for aero GT
5	2017	300HP 2 stage air compressor (magnetic bearings)
6	2017	Blower for ship EGR (exhaust gas recirculation)



Current Intellectual Property Right Status

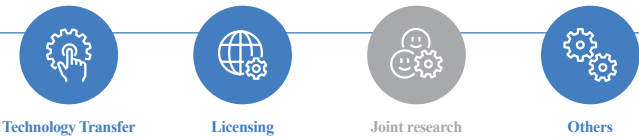
KNOW-HOW

- Compressor design technology and compressor performance securing/estimation at design/off-design points
- Various analysis techniques: Multistage performance analysis and unsteady simulation, shape optimization, RGP (real gas property, refrigerant, supercritical property) analysis, heat transfer analysis (cooling structure, motor heating), structural analysis (structure-aerodynamics interaction analysis)
- Detailed drawing and manufacturing assembly: Materials and tolerance management, drafting 2D/3D parts schematic drawing and assembly drawing
- Performance test: Performance test loop design, performance measurement complying with international standards
- Rotor design and manufacturing: Rotor-dynamic analysis, rotational shaft design, bearing and seal selection/design, precision balancing, rotational stability secured

Technology Readiness Level (TRL)



Desired Partnership



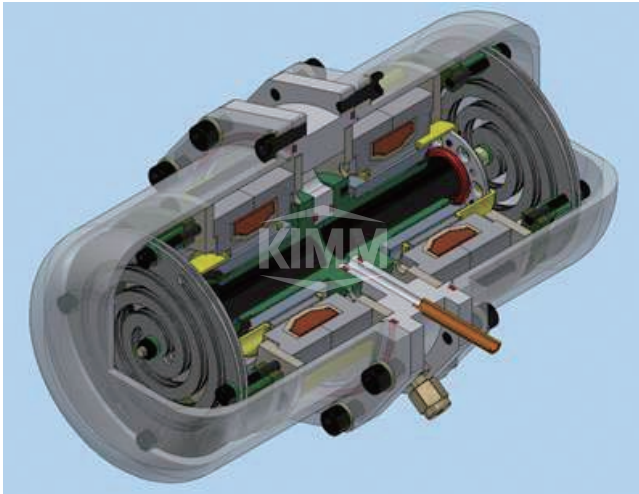


Pulse Tube Cryocooler

Department of Energy Conversion Systems    Researcher: Hankil Yeom    Contact: +82-42-868-7419

Technology Overview

- Pulse tube cryocooler technology to make and maintain thermal environment of extremely low temperature of 120 K (−153°C)



〈 Pulse Tube Cryocooler System 〉

Customer / Market

- Superconducting power devices, vacuum, medical, high-sensitivity sensors, infrared detectors, etc.

Problems of Existing Technology or Necessity of this Technology

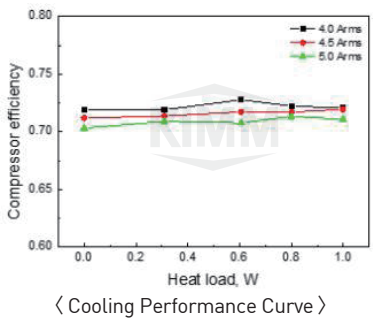
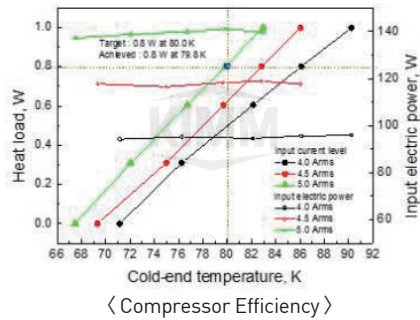
- For a focal plane array infrared detector used for precise thermal diagnosis and forward observation infrared system, cooling in extremely low temperature is crucial for clear imaging and high resolution.
- A high-performance compressor is needed to develop a small size pulse tube cryocooler with low vibration and high management reliability.
- In particular, development of linear compressor is required in advance, and system technologies such as optimal function combination of the compressor and the expander.

Technical Distinctiveness

- Thermal load issue following high density integration solved
- Contributed to low vibration and miniaturization
- Realized pulse tube cryocooler design and production technology to replace the Stirling cryocooler
- Overcame limitations regarding size and energy efficiency of cryocooler
- Completed the production of prototype of 100 W linear compressor (exterior size: 100 mm in diameter / 250 mm in length)
- Completed making of components like linear motor, cylinder/piston, gas flow line and prototype
- Verified the components making and assembly symmetry for reducing the vibration from the counter-direction moving piston
- Proposed the design to reduce the volume of the gas storage by putting the heat exchanger in the gas storage

Excellence of Technology

- Designed/Produced a coaxial pulse tube expander to replace the Stirling cryocooler
- Selected the design that separates the pulse tube and the regenerator to reduce the loss from temperature difference in the coaxial pulse tube expander, and made the outer pin on the high temperature part for effective heat transfer of the heat exchanger
- Miniaturized the low-temperature structure (pulse tube expander outer diameter 15 mm) to improve the cooling rate delay caused by excessive thermal mass of pulse tube expander (#2) and pulse tube expander (#1)



Current Intellectual Property Right Status

PATENT

- Pulse Tube Refrigerator Having Gas Storage Unit to Which Exchanger Is Attached (KR1421045)
- Heat Exchanger for Pulse Tube Refrigerator and Method of Manufacturing it (KR1517786)

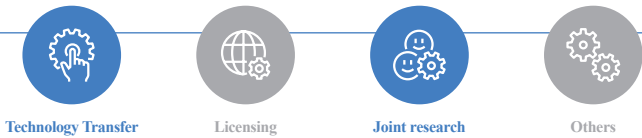
KNOW-HOW

- Liner compressor design technology
- Linear motor electromagnetic field analysis technology
- Flexure spring design/analysis technology
- Pulse tube cryocooler performance test technology

Technology Readiness Level (TRL)



Desired Partnership



Pump Development Technology

▶ Department of Energy Conversion Systems ▶ Researcher: Ilsu Yoo ▶ Contact: +82-42-868-7878

Technology Overview

- Full-cyclic pump development technology including design, production, and performance test
- High-efficiency/Low-NPSH pump design for energy saving and durability

Customer / Market

- Centrifugal/mixed flow/axial flow pump manufacturer
- Extreme environment (cryogenic/ultrahigh speed/high temperature) pump developer
- Plant/ocean/military/spacecraft pump manufacturer

Problems of Existing Technology or Necessity of this Technology

- Pumps are large energy consuming devices that account for over 15% of the total electric power production. For the improvement of energy consumption efficiency, high-efficiency design technology is required.
- To secure technical competitiveness and reliability, pump development technology or know-how for analysis and test as well as design is required.

Technical Distinctiveness

- Pump design technology accumulated over 20 years of R&D experience
- Full-cycle technology required for development from production to performance verification, not limited to design
- Reliable pump technology proven through successful commercialization
- Pump technology for special applications such as extreme environment (cryogenic/ultra-high speed/extra high temperature) pumps and plant (oil/gas/thermal power/nuclear power) pumps
- Holding pump technology  
APR 1400 reactor coolant pump / chemical development vertical barrel-type 10 stage pump / hydrocarbon extra high temperature pump / LNG carrier cargo pump / CO2 underground storage CO2 pump / supercritical CO2 power pump / high-speed pump / thruster for unmanned submarine / multi-phase flow pump / water jet pump for propulsion of vessel

Excellence of Technology

- This pump development technology has gone through the product design, production, performance verification process and can be applied for commercializing pumps for a variety of applications.

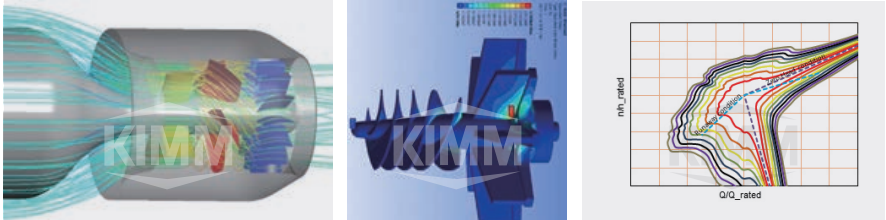


〈 10-stage vertical axis Pump 〉 〈 8-Stage Hydrocarbon (350℃) Pump 〉 〈 LNG Cryogenic Pump (-160℃) 〉



〈 Multiphase Hybrid Pump 〉 〈 Ultrahigh Speed Centrifugal Pump 〉 〈 Axial-Flow Thruster 〉

- This pump development technology includes the structural analysis/flow analysis technology and performance test.



〈 Flow Analysis 〉 〈 Structural Analysis 〉 〈 4 Quadrant Performance Test 〉

Current Intellectual Property Right Status

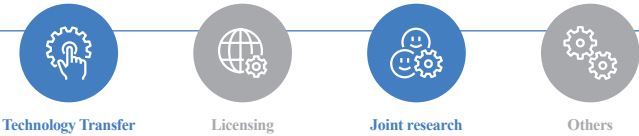
KNOW-HOW

- High-efficiency impeller/diffuser/volute design technology
- High-suction performance inducer/impeller design technology
- Pump composition design and manufacturing technology
- Rotor dynamics technology
- Structural analysis/flow analysis technology
- Performance test technology

Technology Readiness Level (TRL)



Desired Partnership



# High-efficiency Hydraulic Turbine Technology

▶ Department of Energy Conversion Systems   ▶ Researcher: Ilsu Yoo   ▶ Contact: +82-42-868-7878

**Technology Overview**

- Full-cyclic technology for Francis and Kaplan turbine development including hydraulic design, and design verification for improvement of power generating efficiency.

**Customer / Market**

- Hydraulic turbine design and development company
- Small hydropower generation company
- Public hydraulic turbine operation enterprise

**Problems of Existing Technology or Necessity of this Technology**

- Globally, the percentage of energy production by hydraulic turbine is increasing. (hydroelectric power accounting for 16% of world electric power generation)
- The demand for localized technology development for improving technology competitiveness of the domestic hydraulic turbine technology is increased.
- The independence of domestic hydraulic turbine design technology is needed to secure technical competitiveness and accomplish renewable energy independence ability.

**Technical Distinctiveness**

- Equipped with fluid machinery-related R&D experience accumulated over 20 years
- Equipped with full cyclic technology required for hydraulic development from design, production, to verification
- Equipped with fluid mechanics and structural mechanics-linked design technology and manpower

Excellence of Technology

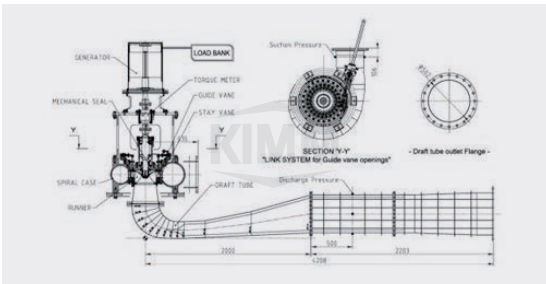
- Equipped with record of designing a high-efficiency 50 MW Francis runner



〈 Francis Runner Design 〉

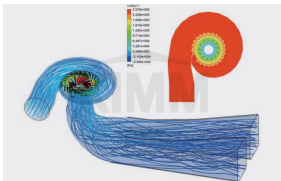


〈 Francis Runner Model 〉

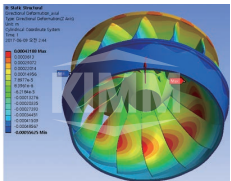


〈 Composition Design 〉

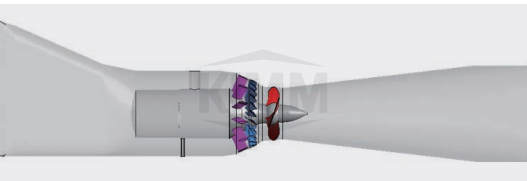
- The efficiency and reliability of hydraulic turbine increased to the level of advanced countries by applying the structural analysis/flow analysis and performance test technology



〈 Francis Turbine Flow Analysis 〉



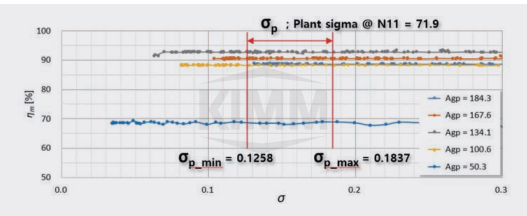
〈 Runner Structural Analysis 〉



〈 Kaplan Hydraulic Turbine Flow Analysis 〉



〈 Francis Hydraulic Turbine Test Facility 〉



〈 Caviatition Test 〉

Current Intellectual Property Right Status

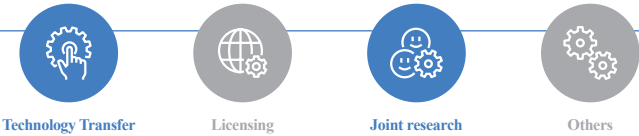
KNOW-HOW

- Francis runner design technology
  - Hydraulic turbine model composition design and manufacturing technology
- Rotor dynamics technology
  - Structural analysis/flow analysis technology
  - Performance test technology

Technology Readiness Level (TRL)



Desired Partnership





# Cryogenic Cooling System Design Technology

▶ Department of Energy Conversion Systems ▶ Researcher: Sehwan In ▶ Contact: +82-42-868-7061

Technology Overview

- Engineering technology to design and construct a cooling system using a cryocooler to create the cryogenic environment (below -150℃) required by the cooling target
- Cooling system divided into the cryogenic fluid cooling system using cryogenic fluid (liquid nitrogen, liquid helium, etc.) and the cryogenic conduction cooling system using a solid structure with good thermal conductivity.

Customer / Market

- Superconducting applications (superconducting power device, superconducting magnet, NMR, MRI, etc.), gas liquefaction/re-liquefaction

Problems of Existing Technology or Necessity of this Technology

- Various cooling system combination depending on the requirements of the cooling target (temperature, pressure, cooling load, etc.)
- Cooling system design to minimize the cooling load of a cryocooler while satisfying the requirements of the cooling target.
- Determination of suitable design margin for basic design of the cooling system and its components.

Technical Distinctiveness

- Cooling system design based on design and test experience of various cryogenic cooling systems (superconducting power cable, superconducting fault current limiter, SMES, NMR, etc.)
  - Cryogenic cooling system configuration to meet the requirements of the cooling target
  - Determination of design margin for the system and its components
  - Calculation of cooling load and selection of a cryocooler according to the system design
  - System basic design (cooling capacity, dimension)
  - Detailed design of a system cooling structure (conduction cooling system)

Excellence of Technology

- Track record of cryogenic fluid cooling system design and test
  - Superconducting power cable cooling system (single-phase 154 kV, 1000 MVA, 100 m)  
Liquid nitrogen circulation cooling (70 K, 5 bar), Stirling cryocooler: 2 kW @ 77 K
  - Superconducting fault current limiter cooling system (single-phase 154 kV, 2 kA)  
Liquid nitrogen circulation cooling (71 K, 5 bar), Stirling cryocooler: 4 kW @ 77 K
- Track record of cryogenic conduction cooling system design and test
  - SMES (Superconducting Magnetic Energy Storage)  
energy capacity: 600 kJ, operating temperature: 20 K, 2-stage GM cryocooler
  - NMR (Nuclear Magnetic Resonance)  
superconducting magnet: 9.4 T, operating temperature: 20 K, 2-stage pulse tube cryocooler



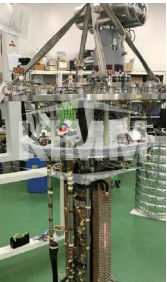
〈 Cooling System for Superconducting Power Cable 〉



〈 Cooling System for Superconducting Fault Current Limiter 〉



〈 Cooling System for SMES 〉



〈 Cooling System for NMR 〉

Current Intellectual Property Right Status

PATENT

- Pressurizing System for Cryogenic Pressure Vessel (KR1558840)
- System and Method for Superconducting Fault Current Limiter Recovery (KR1558839)
- Pressurization System using Floating Heater for Cryogenic Pressure Vessel (KR1569650)
- System and Method for Superconducting Fault Current Limiter Recovery (KR1601593)
- Recovery System for Superconducting Fault Current Limiter (KR1691983)
- Recovery System for Superconducting Fault Current Limiter (KR1691989)
- Recovery System for Superconducting Fault Current Limiter (KR1720752)

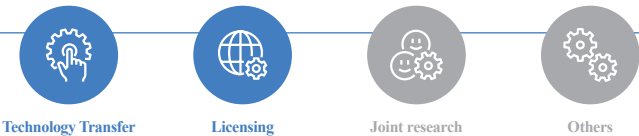
KNOW-HOW

- Cryogenic cooling system design technology

Technology Readiness Level (TRL)



Desired Partnership



# High-Performance Turbine Technology

▶ Department of Energy Conversion Systems   ▶ Researchers: Bumseog Choi, Hyungsoo Im   ▶ Contact: +82-42-868-7286

Technology Overview

- Turbine technology for power generation using unutilized energy (waste heat and renewable energy, etc.)
- Gas turbine (UMGT, MGT, GT) technology development

Customer / Market

- Power turbine manufacturers using waste heat and renewable energy
- Military and industrial aircraft turbine manufacturers
- Micro gas turbine manufactures

Problems of Existing Technology or Necessity of this Technology

- This technology requires multiple technologies from various fields and extensive research experiences to develop a product. (Design : aerodynamics, structure, rotordynamics, heat transfer/Manufacturing : material selection, manufacturing management, assembly/Test : performance test, analysis)
- There are continued demands for turbine development to utilize in new fields.
- The technologies derived from the turbine technology can be used to various applications in related industries.
- Turbine development technology of KIMM is at a level that can compete with the world's technology in the field of power generation using waste heat and renewable energy.

Technical Distinctiveness

- Possess turbine design (aerodynamics, structure, cooling, vibration, drawing) technology that can satisfy target performance under various operating conditions
- Possesses secondary flow management technology that maintains the flow inside the turbine stably under conditions of high temperature, high pressure, and high speed.
- Possess turbine operation technology at design point and off-design point
- It can be miniaturized depending on the field to be applied, and it is possible to create high-quality energy using energy that can be easily accessed from the surroundings. (e.g. ultra micro gas turbine, ocean thermal energy conversion turbine, etc.)



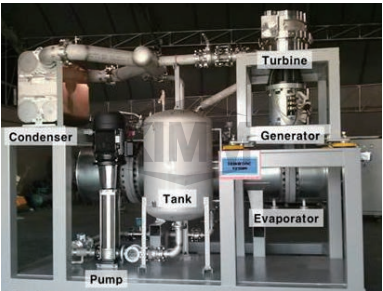
〈 Ultra-Micro Gas Turbine 〉



〈 OTEC Turbine 〉

Excellence of Technology

- ORC (Organic Rankine Cycle) turbine for waste heat recovery power generation: Development of turbine prototype for 200kW class ORC power generation system with domestic technology. Korea became the 4th country in the world having the midsize-class ORC technology. Field tests using actual waste heat were conducted at two domestic sites, and the performance test results showed thermal efficiency over 10%, which proved world's top-class technology.
- Ocean Thermal Energy Conversion (OTEC) turbine: The first 20 kW OTEC turbine in Korea was developed. The target performance was obtained in the verification test using deep sea water (Deep Ocena water Center, Goseong, Gangwon-do)
- Ultra-Micro Gas Turbine (UMGT): Experimental results of micro-turbine generators of 1kW or less are the level of the best in the world. UMGH technology of KIMM using liquid fuel is world-first and world-top level.
- Turbine for supercritical CO<sub>2</sub> generation: Developed a driving turbine for driving CO<sub>2</sub> pump and a power turbine for supercritical 200 kW CO<sub>2</sub> power generation for the first time in Korea.



〈 200kW ORC System for Waste Heat Recovery Power Generation 〉



〈 20kW OTEC System 〉

Current Intellectual Property Right Status

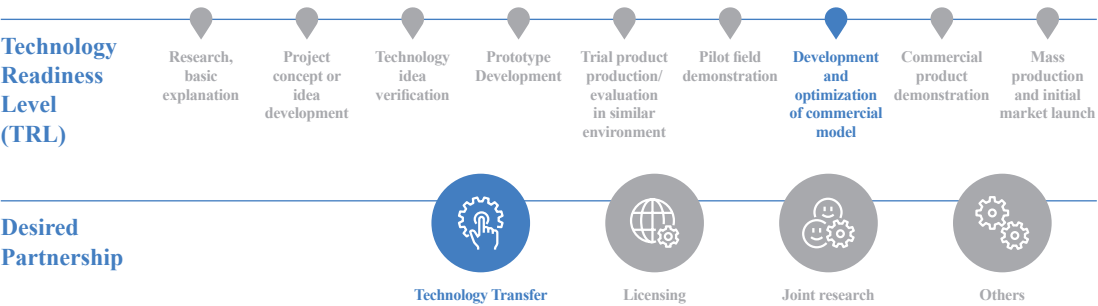
PATENT

- Gas Turbine Blade (KR2016-0061918)
- Self-driven Testing Apparatus (KR1501007)
- Turbine for Organic Ranking Cycle (KR1332632)
- Gas Turbine Testing Apparatus and Testing Method Using Thereof (KR1757986)
- Ultra Micro Gas Turbine with Thermal Stress Damage Prevention Design (KR1634876)
- Ultra Micro Gas Turbine with Bearing Cooling Part (KR1634875) and 14 other patents

KNOW-HOW

- Gas turbine (UMGT, MGT, GT) aerodynamic design, thermal stress analysis, and turbine stabilization technology
- Aerodynamic design and thermal stress analysis technology for waste heat recovery power generation turbine (ORC, SORC, OTEC, SCO<sub>2</sub>)
- High-performance turbine system drawing technology
- High-performance turbine component production, tolerance management, assembly technology
- High-performance turbine performance test and analysis technology

[Note] ORC: Organic Rankine Cycle / SORC: Super Critical Organic Rankine Cycle / OTEC: Ocean Thermal Energy Conversion / SCO<sub>2</sub>: Super Critical CO<sub>2</sub> / UMGH: Ultra Micro Gas Turbine / MGT: Micro Gas Turbine



# Joule–Thomson Cryocooler

▶ Department of Energy Conversion Systems   ▶ Researcher: Yongju Hong   ▶ Contact: +82-42-868-7366

Technology Overview

- Cooling technology to create and maintain thermal environment below extremely low temperature (120 K, -153℃)
- Technology using expansion of gas compressed with several hundred atmospheric pressure to cool down to an extremely low temperature within a few seconds

Customer / Market

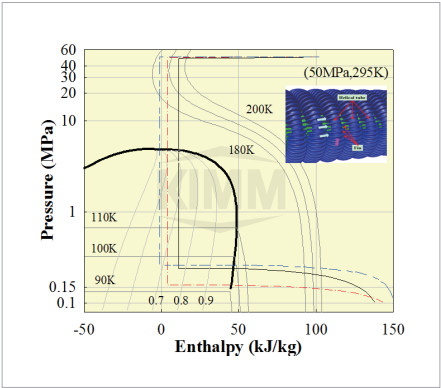
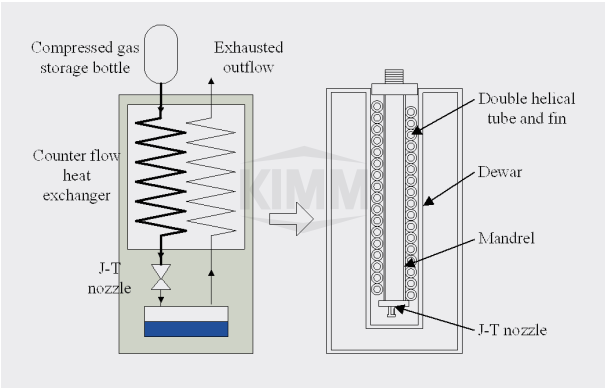
- Rapid cooling of infrared detector, small analytical instrument, cryosurgery, gas liquefaction

Problems of Existing Technology or Necessity of this Technology

- Cryogenic cooling is crucial for a cooling type detector to achieve high resolution and clear image.
- For cryosurgery using extremely low temperature require safe and temperature controlled cooling technology.
- Joule–Thomson cooling technology is a cooling technology that is smaller than other cryocoolers like Stirling cooler, pulse tube cooler, and GM cooler, can be operated under lower vibration level and enables rapid cooling.

Technical Distinctiveness

- Joule–Thomson cooling technology uses the cooling effect (Joule–Thomson effect) that occurs through sudden expansion of high–pressure gas that passes through a fine nozzle and amplifies the cooling effect through the high–efficiency heat exchanger to generate cryogen for cooling.
- In cooling of infrared detector, the Stirling or pulse tube cryocooler requires a few minute, but Joule–Thomson cooler uses a high flow rate of high pressure compressed gas to cool down to a cryogenic temperature in a few seconds. Its structure is relatively simpler and is easy to be miniaturized.

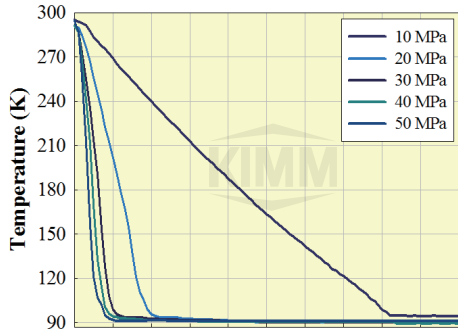


〈 Joule–Thomson Cooler Concept and Cooling Cycle Curve 〉

- A series of development process is needed for development of Joule–Thomson cooler including cooling cycle design, design and production technologies for components like heat exchanger, nozzle and flow control apparatus, and cooling function performance test.
- To secure sufficient cooling and long operating time while achieving rapid cooling, it is necessary to obtain optimal design technologies for small/high–efficiency heat exchanger, nozzle and flow control apparatus.
- For performance assessment of Joule–Thomson cooler, vacuum and cryogenic environment need to be established, and the thermal/structure design and operation technology of performance evaluation apparatus needs to be secured.

Excellence of Technology

- Equipped with technology for the entire development process for Joule–Thomson cooler–cooling cycle design, design of components (heat exchanger, nozzle, flow control apparatus), and cooling performance assessment (In-house design program for Joule–Thomson cooler design/cycle analysis/heat exchanger and nozzle design program)
- Performance analysis technologies for Joule–Thomson cooler in steady and transient state
- Thermodynamic cycle analysis technologies for single (nitrogen, argon) and mixed refrigerant
- Completed verification of the technology through rapid cooling Joule–Thomson cooler development and performance test



〈 Cool–down Characteristics of the Joule–Thomson Cooler 〉

Current Intellectual Property Right Status

PATENT

- Joule–Thomson Cooler Design (Program JTGUI: Registration No. 2011-01-123-005467, JTDESIGN2: Registration No. 2011-01-123-005453)
- Joule–Thomson Cooler Cycle Analysis (Program JTR-CD (Joule Thomson Refrigerator–Cool Down) : Registration No. 08-01-121-003011, JTC2ST : Registration No. 2010-01-121-004322) Registration No. 2010-01-121-004322)
- Nozzle, Flow Control Apparatus Design (Program NzFlow: Registration No. 2009-01-121-005649, TdBellows: Registration No. 2011-01-123-004743)
- Joule–Thompson Cooler Thermal Load Analysis (Program ColdFinger: Registration No. 2009-01-121-001780)

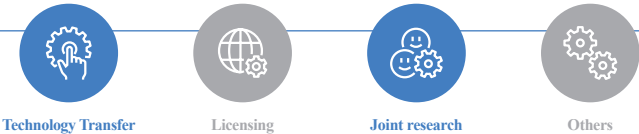
KNOW-HOW

- Joule–Thomson cooler’s cooling performance assessment technology

Technology Readiness Level (TRL)



Desired Partnership





# Low GWP Refrigerant Heat Pump Technology

Department of Thermal Systems | Researcher: Dong Ho Kim | Contact: +82-42-868-7281

**Technology Overview**

- Refrigeration system and heat exchanger design/evaluation technology related to Low GWP refrigerants that replace HFC/HCFC refrigerants to prevent global warming
- Detailed design and optimization technology for low GWP refrigerant refrigeration system
- Operation technology and evaluation technology for low GWP refrigerant application system (centrifugal chiller, etc.)

**Customer / Market**

- HVAC&R component and system business

**Problems of Existing Technology or Necessity of this Technology**

〈 Problem of Existing Technology 〉

- HFC/HCFC-based refrigerants are now being regulated. Hence HFO-based refrigerants and systems are being developed to replace them, but the related core technology is lacking in Korea.

〈 Necessity 〉

- In Korea, the use of refrigerants such as HFC/HCFC will be restricted from 2024 and will be reduced by 80% by 2045.
- For low GWP refrigerants and systems, thermophysical properties are different from those of existing refrigerants and systems, and therefore, a fundamental redesign is required.

**Technical Distinctiveness**

- Optimal low GWP refrigerant selection and cycle design technology in consideration of various applications (chillers, industrial/domestic heat pumps)
- Heat exchanger (shell-tube, plate type) design technology for refrigeration system
- Shell-tube evaporator (flood type, falling film type) performance evaluation technology

- Excellence of Technology**
- Performance evaluation of enhanced tube and design technology of for turbo chillers heat exchangers
  - Flooded and falling film evaporator design, manufacturing, and operation technology
  - Falling film-type evaporator design core technology to reduce refrigerant charge
  - Design/evaluation technology for flooded evaporator for 500 RT class R-1233zd (E)
  - Design/evaluation technology for falling film evaporator for 100 RT class R-1233zd (E)
  - Design/evaluation technology for vapor compression refrigeration system for 70 kW class R-1234ze (E)



〈 Heat Exchanger Performance Test Facility〉    〈 Heat Pipe Performance Evaluation 〉    〈 Heat Exchanger Design Technology 〉

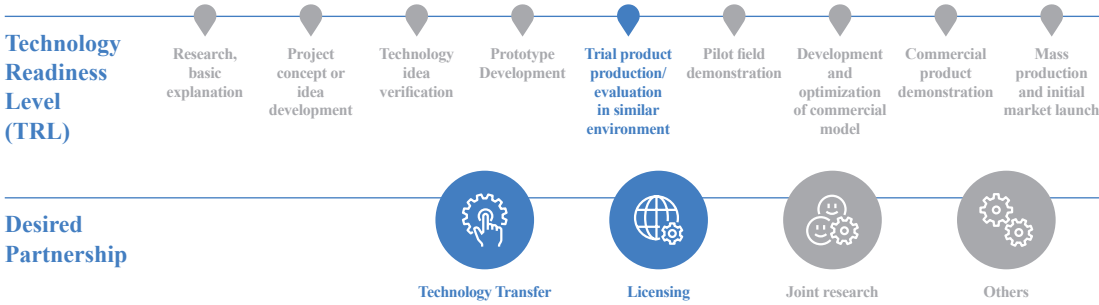
**Current Intellectual Property Right Status**

**PATENT**

- Industrial Shell & Tube Heat Exchanger Design Program (KR2017-011728)
- Falling Film Type Centrifugal Chiller (KR1930943)
- Falling Film Type Centrifugal Chiller (KR1932151)
- Distributor for evaporator of refrigerator and evaporator of refrigerator (KR2232211)

**KNOW-HOW**

- Heat exchanger performance test facility setup/operation
- Refrigerant thermodynamics cycle simulation



# Membrane Heat Pump Technology

Department of Thermal Systems | Researcher: Dong Ho Kim | Contact: +82-42-868-7281

**Technology Overview**

- An innovative cooling technology is in development to meet increased demand for chemical-refrigerant-free cooling device that resolves increased energy consumption issue for air conditioning. For this, eco-friendly dehumidification module design technology is developed using membrane that is operated under a vacuum condition.
- Technology to make high-temperature and humidity air to low temperature and humidity air using membrane module

**Customer / Market**

- Building air conditioning (cooling) device and system business

**Problems of Existing Technology or Necessity of this Technology**

- Technology that dramatically improves the efficiency of existing air-conditioning equipment is needed
- An innovative HVAC technology was demanded to resolve increased energy consumption for air conditioning following enhanced quality of life.
- A new concept of HVAC technology was needed to surpass the existing vapor compression cycle.
- Other than the vapor compression type cooling cycle that is considered an energy overconsuming device, the membrane heat pump technology for HVAC system operated with a vacuum pump without a compressor is required.

**Technical Distinctiveness**

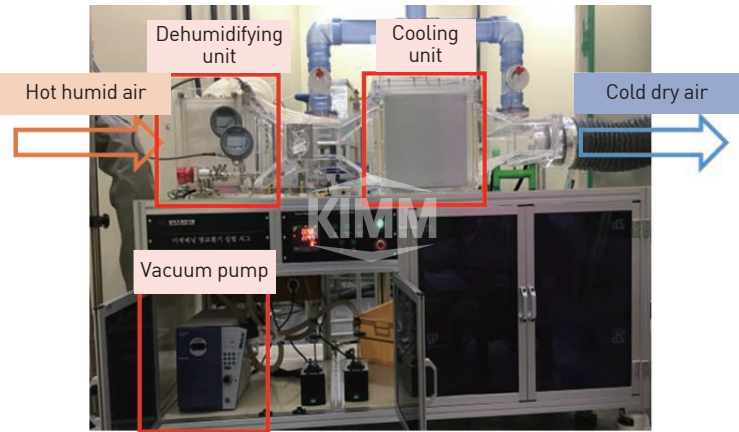
- Double the energy efficiency potential and eco-friendlessness compared to existing vapor compression HVAC
- Removes latent heat load in the air using the membrane and then performs cooling to improve the efficiency significantly
- Working fluid is simply "Water (H2O)" that has no impact on the environment.
- By removing latent heat load in the air, efficiency is improved by approximately twice compared to existing vapor compression type.
- With the dehumidification part and the cooling part, temperature and humidity can be controlled separately, and performance is excellent under the partial load condition.

	Existing Vapor Compression Type HVAC	Membrane Heat Pump
Functional aspect	<ul style="list-style-type: none"><li>• Average EER of 12 to 13 (COP 3.5 to 4)</li></ul>	<ul style="list-style-type: none"><li>• Average EER of 20 to 24 (COP 6 to 7) (twice the vapor compression type)</li></ul>
Applied field	<ul style="list-style-type: none"><li>• Requires condensate water drainage</li></ul>	<ul style="list-style-type: none"><li>• Can be used as dehumidification facility</li></ul>
Control	<ul style="list-style-type: none"><li>• Cannot control cooling / dehumidification independently</li></ul>	<ul style="list-style-type: none"><li>• Individual control of temperature/humidity possible</li><li>• Efficient handling of partial load</li></ul>
Refrigerant	<ul style="list-style-type: none"><li>• HCFC/HFC refrigerant (high GWP)</li><li>• high pressure system – leakage issue</li></ul>	<ul style="list-style-type: none"><li>• Working fluid: Water (no environmental impact)</li><li>• Low pressure system – reduced pipe cost</li></ul>

〈 Excellence of the Membrane Heat Pump Compared to the Existing Vapor Compression Cycle 〉

Excellence of Technology

- Acceptable reliability for dehumidification module and cooling module
- Secured mechanical/chemical performance properties for long hours in vacuum condition
- Confirmed similar/superior performance in the standard cooling condition compared to existing vapor compression cycle
  - System COP at KS C 9306 condition: Exceeds 4.5
  - (Reference) COP of vapor compression air conditioner: Below 3.5

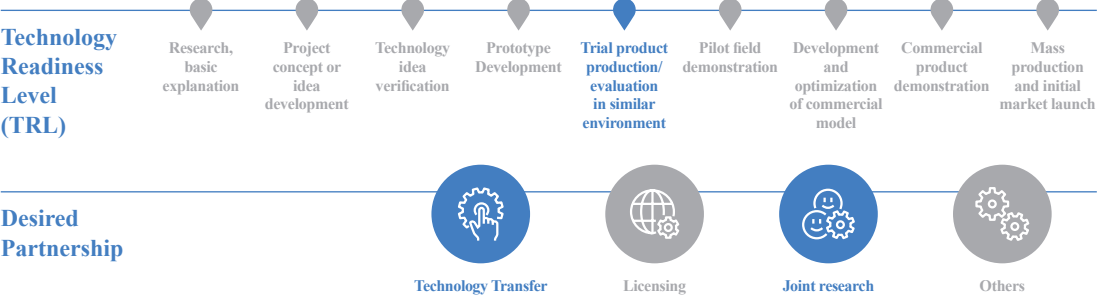


Lab Scale Membrane Heat Pump System Diagram

〈 Lab Scale Membrane Heat Pump System Diagram 〉

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Membrane Dehumidification Module and Dehumidification Apparatus Using the Module (KR2018-0001093)</li><li>• Indirect Evaporative Cooling Apparatus (KR1990591)</li><li>• Membrane Dehumidification Module and Heat Pump Using the Module (KR2016-0166637)</li></ul>	<ul style="list-style-type: none"><li>• Membrane dehumidification module analysis/design technology</li><li>• Membrane cooling module analysis/design technology</li><li>• Membrane heat pump cycle analysis/design technology</li></ul>

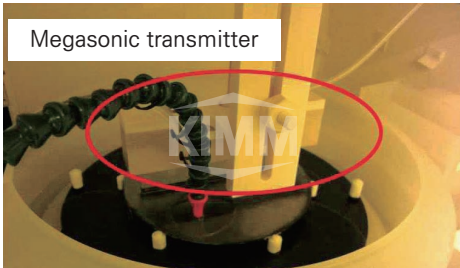


# Ultrasonic Generation and Cleaning Technology

▶ Department of Thermal Systems   ▶ Researcher: Hyunse Kim   ▶ Contact: +82-42-868-7967

Technology Overview

- Energy saving semiconductor wafer cleaning single wafer type megasonic that requires only 1/30 of power consumption and 1/10 cleaning fluid of existing batch type



Customer / Market

- Wafer cleaning, NEMS cleaning field, electronic component-HDD, etc.,-cleaning field

Problems of Existing Technology or Necessity of this Technology

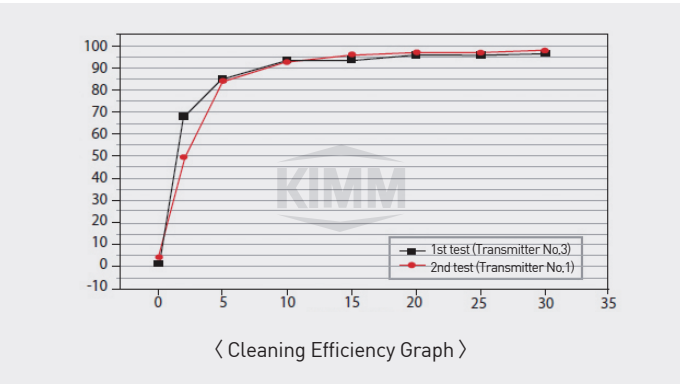
- Cleaning process is a major process that accounts for 30 to 40% of the entire semiconductor manufacturing process, a key industry in Korea, and an important process that determines the throughput, but the technology localization rate of cleaning device (spin type) is only 37.3%
- Megasonic is divided into the batch type that cleans multiple wafers at once and single wafer type that cleans one wafer at a time. Cleaning efficiency enhancement and cleaning time shortening are important for megasonic cleaning.
- Existing batch type megasonic technology over consumes electricity and cleaning fluid, and cleaning efficiency is declined due to low uniformity of sound pressure distribution, and the pattern damage occurs from the peak sound pressure.

Technical Distinctiveness

- Semiconductor production expansion effect from yield improvement (1.526 trillion won/year)
- Semiconductor manufacturing cost reduction effect from yield improvement (915.6 billion won/year)
- Semiconductor manufacturing energy reduction effect from yield improvement and physical technology (62.7 billion won/year)
- Related cost reduction effect from using physical cleaning technology (59.5 billion won/year)
- Work environment improvement effect from using physical cleaning technology
- Superfine cleaning technology applying highly uniform sound pressure distribution of ultrasonic for improved cleaning efficiency

Excellence of Technology

- Single wafer type 1 MHz megasonic transmitter performance test result is as follows:
  - Average sound pressure to maximum sound pressure 295%, standard deviation of 37%, cleaning efficiency of 96.5%
  - Resonant frequency generation error of  $\pm 0.9\%$ ; resonance design for transmitter using FEM and sound field analysis technology secured
  - DSS type oscillator that can fix frequency
  - Adopting fine output control circuit of 0.1W interval
  - Driving frequency fluctuation range error of  $\pm 1.3$  kHz



Current Intellectual Property Right Status

PATENT

- Large Area Ultrasonic Cleaning Apparatus (KR1827296) / Large Area Ultrasonic Fine Cleaning Apparatus (KR1599214) / Ultrasonic Cleaning Apparatus (KR1002706) / Ultrasonic Fine Cleaning Apparatus (KR1002706 JP5517227 US13/520838 CN201080061173.4) / Ultrasonic Cleaning Apparatus and Cleaning System Using Apparatus (KR1347068) / Cleaning Apparatus Using Ultrasonic Wave (KR852396) / Ultrasonic Fine Cleaning Apparatus (KR979568) / Ultrasonic Cleaning Method and Apparatus (KR523934) / Cleaning Ultrasonic Wave Apparatus and Ultrasonic Cleaning System (KR702596) / Cleaning Ultrasonic Wave Apparatus and Ultrasonic Cleaning System (KR827618) / Ultrasonic Cleaning Apparatus (KR784903) / Ultrasonic Cleaning System Using Cleaning Ultrasonic Wave Apparatus (KR817872) / Ultrasonic Cleaning System Using Cleaning Ultrasonic Wave Apparatus (KR748480) / Single Wafer Type Ultrasonic Cleaning Apparatus Using Multi-Frequency (KR951922)

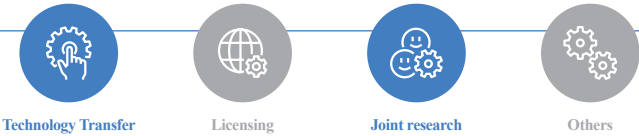
KNOW-HOW

- Precision design for ultrasonic transmitter using FEM analysis
- Fine cleaning technology using ultrasonic wave.

Technology Readiness Level (TRL)



Desired Partnership



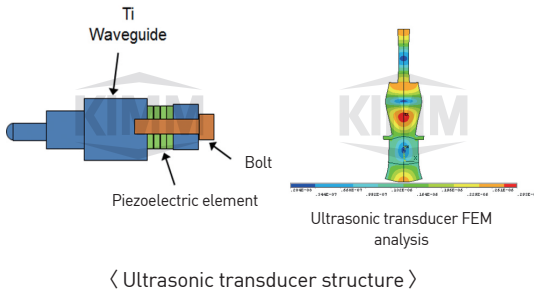


# Ultrasonic Machining System (for surface reformation and milling process)

▶ Department of Thermal Systems   ▶ Researcher: Hyunse Kim   ▶ Contact: +82-42-868-7967

Technology Overview

- Ultrasonic transducer technologies for nano surface reformation, and milling process for high quality and high precision machining
- Ultrasonic transducer technologies using piezoelectric actuators for increasing the surface hardness, reducing the coefficient of friction and performing milling.



Customer / Market

- Manufacturing system component supplier for displays, LEDs, and semiconductors
- Eco-friendly car and ship driving component manufacturer

Problems of Existing Technology or Necessity of this Technology

- Surface profiles using conventional milling tools are very smooth, so it had difficulty in generating surface texturing.
- When nano surface reformation technology using ultrasonic vibration is applied to various equipment and machinery driving components, the cost can be reduced as the life is extended with driving property enhancement from reduced coefficient of friction and improvement of surface hardness.
- To improve the surface improvement effect, the ultrasonic power needs to be raised compared to existing technology, and for this, precision design and production technology of ultrasonic transducer and the tuning technology with oscillator were developed.

Technical Distinctiveness

- Resonance design technology of the transducer and behavioral analysis technology are secured with behavioral analysis of the ultrasonic transducer using FEM.
- Ultrasonic transducer for nano surface improvement with bolt-clamped Langevin transducer (BLT) type was developed.
- Ultrasonic transducer for milling for high quality and high precision machining was developed.

Excellence of Technology

- Ultrasonic transducer for milling with surface texturing ability was developed.
- The surface hardness depth was 50 micro and the hardness value increased from 11.5 to 22.5.
- The coefficient of friction dropped from 0.02 to 0.017.
- Surface treatment depth was 85 micro—higher than 50 micro is considered a high value.



Main specifications

Subject	Value
Size of object	Φ1500mm x 1,000mm
Multi-head	2 Ultrasonic heads
	laser

〈 Transducer for Milling 〉

Current Intellectual Property Right Status

PATENT

- Ultrasonic Milling Machining Apparatus (KR1561531)
- Ultrasonic Milling Transducer (KR1632206)
- Machining Object Surface Treatment Apparatus Using Ultrasonic Transducer (KR1579943)

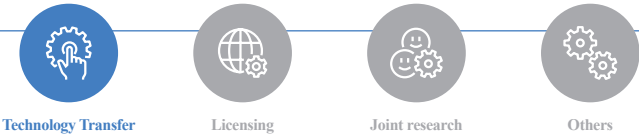
KNOW-HOW

- Ultrasonic transducer resonance property and sound field analysis technology using FEM
- Ultrasonic transducer design and fabrication technology

Technology Readiness Level (TRL)



Desired Partnership



# Thermal Storage Heating and Cooling System Technology

▶ Department of Thermal Systems   ▶ Researcher: Jinwoo Ryu   ▶ Contact: +82-42-868-7359

Technology Overview

- Technology that adds thermal storage tank to the heat pump system for cooling, heating, and water supply

Customer / Market

- Cooling, heating and hot water supply market in residential and industrial sectors

Problems of Existing Technology or Necessity of this Technology

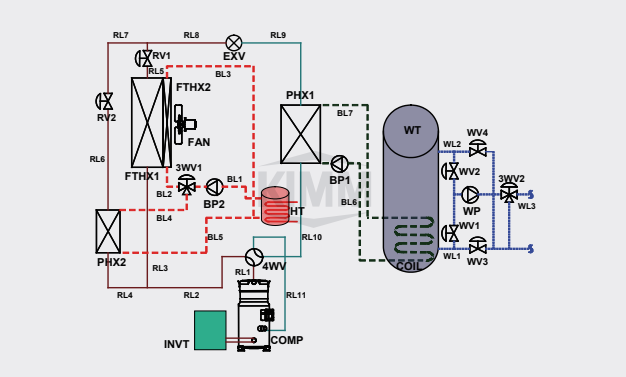
- Existing small sized ice and cold water storage facility is used for cooling only that annual operation efficiency is very low.
- To improve the annual operation efficiency, a heat pump with thermal storage tank that used for all 4 seasons is applied

Technical Distinctiveness

- Cooling and hot water supply operation using ice storage + hot water storage system during summer season and hot water thermal storage operation system during other seasons
- Heat pump cycle to generate medium-temperature water of 60℃ to 70℃ during heating

Excellence of Technology

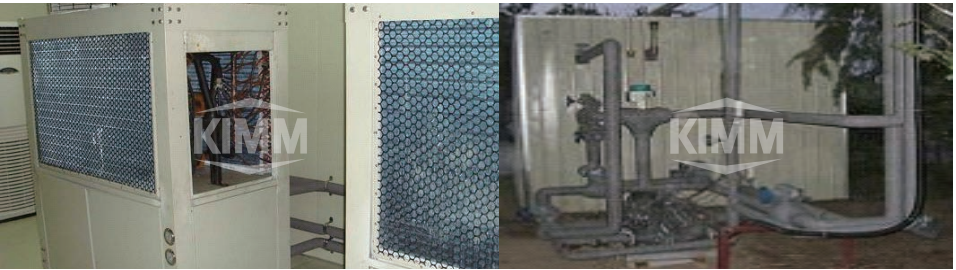
- Prototype production and performance realization through system design and cycle simulation
- Over 12% energy saving compared to conventional boilers (※ Boiler : 85% of efficiency for direct combustion type, electrical production/power transmission efficiency of 40%, 90%, respectively; assumption)



〈 System Design 〉



〈 Cycle Simulation 〉



〈 Installation of Prototype 〉

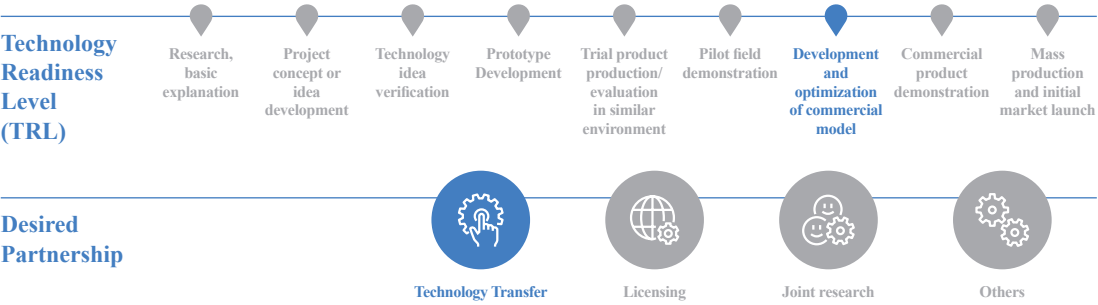
Current Intellectual Property Right Status

**PATENT**

- Heat Pump System Equipped with Heating and Control Method (KR0721420)
- Ice and cold(thermal) water Storage Type Heat Pump Design Program (06-01-121-002799 program registered)

**KNOW-HOW**

- Heat pump design technology generating medium temperature water
- Compressor selection, optimal capacity control technology
- Ice-on typed ice storage and hot water thermal storage tank design technology
- Year-round operation dynamic simulation, performance test

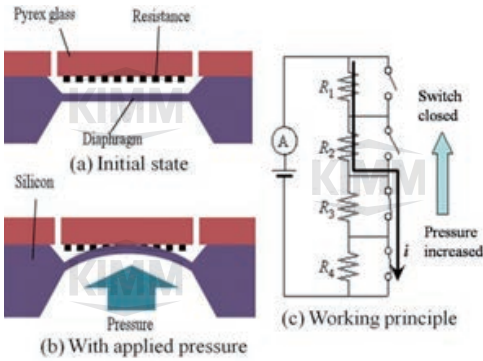


# Pressure Sensor Using Contact– resistance Change

Department of Thermal Systems    Researcher: Jungho Park    Contact: +82-42-868-7607

Technology Overview

- New type of sensor detecting pressure using the change in the electric resistance from physical contact of the elastically deformed diaphragm and pressure sensor array; original technology for circuit technology–free sensor chip for signal amplification/temperature compensation



Customer / Market

- IT industry: Pressure sensor, level sensor, load cell, touch sensor, tactile sensor
- Industrial field: Automation process, building air conditioning system, firefighting safety management and environment monitoring system

Problems of Existing Technology or Necessity of this Technology

- Existing semiconductor type pressure sensor has benefits of outstanding costeffectiveness, possibility of miniaturization, high–performance and mass production, but the pressure strength depending on applied pressure is weak and temperature drift effect is relatively big.
- Also, the signal is weak, which requires separate signal treatment technology and circuit technology for signal amplification and noise reduction.

Technical Distinctiveness

- Proposed pressure sensor is appropriate for pressure detection in stages and can be realized with the MEMS technology or general machining. By controlling the pressure switch array’s resistor interval or the curve of the resistor shape, the measured value by stage can be changed and linearized.
- The working pressure range can be adjusted with the diaphragm design, and as it does not require an electric signal amplifier and compensation circuit, its simple structure is superior to existing sensor in terms of technology and price competitiveness (30% lower than existing sensor)
- Original technology for low–cost, high durability sensor chip to replace existing semiconductor type pressure sensor (level, limit switch)

Excellence of Technology

- This technology is an original sensor chip technology using pressure/load detection method without a signal amplification circuit and designed with low–power driving circuit, which is completely different from existing domestic/international patented technology.
- Through minimization of electric circuit, durability and reliability are improved and the manufacturing cost is reduced to secure price competitiveness with the manufacturing cost 30% lower than for existing technology.

**Specifications**

- Sensor size : 6.8X 6.8 mm<sup>2</sup>
- Diaphragm thickness: 50 μm
- Diaphragm size : 4.2 X 4.2 mm<sup>2</sup>
- Electrode gap : 30 μm
- Cr/Au thickness : 0.21 μm

Pyrex glass

Si wafer

ITO

Cr/Au electrode

Sensor Chip

Amplifier

Communication

Power

〈 Sensor Prototype 〉

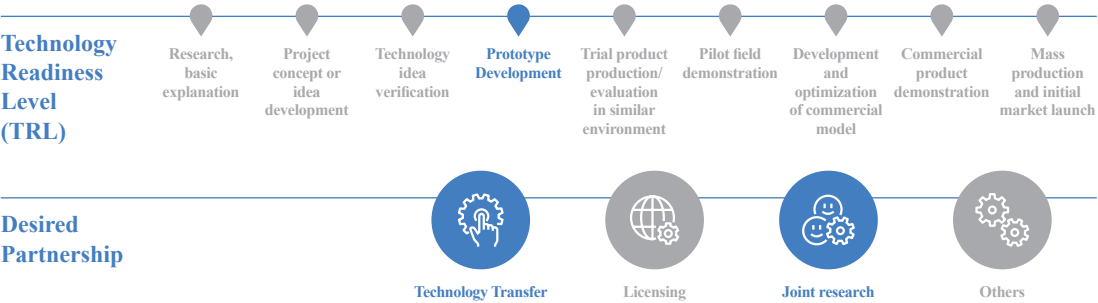
Current Intellectual Property Right Status

**PATENT**

- Micro Pressure Sensor (KR0773759)
- Linearity–compensated Micro Pressure Sensor (KR0828067)
- High Pressure Switch Using the Contact Resistance Changes (KR1518265)

**KNOW-HOW**

- Sensor chip linearization design following pressure measurement area
- Sensor durability test assessment technology
- Extra–high voltage limit switch allowing fine adjustment of set pressure error





# High Temperature Steam Heat Pump Technology

Department of Thermal Systems    Researcher: Chan Ho Song    Contact: +82-42-868-7071

**Technology Overview**

- Heat pump technology including the cycle design/analysis, heat exchanger design/manufacturing, and compressor performance assessment technology for heat pump system generating high temperature steam over 120°C

**Customer / Market**

- Existing boiler, heating market and industrial sectors that require high temperature steam, such as drying and food process

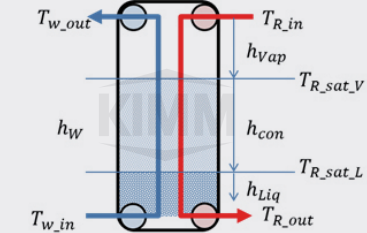
**Problems of Existing Technology or Necessity of this Technology**

- Generating steam using heat pump instead of conventional boiler to save energy and reduce greenhouse gas emission
- Technology that actively utilize renewable and waste heat of surroundings
- A technology recently commercialized in advanced countries; necessary to develop a very high level technology of world best through active investment and intensive R&D
- Heat energy network technology using high temperature thermal storage-steam heat pump system that resolves the heat energy supply and demand mismatching problem

**Technical Distinctiveness**


- Existing heat pump system could be operated to discharge water temperature of 80 to 90°C, but this technology includes design and related technology for generating steam of 120°C or higher

- Excellence of Technology**
- Design and manufacturing of heat exchanger using new refrigerant (R245fa)
    - Development of correlation between sensible and latent heat; design procedure establishment of actual scale heat exchanger
  - Development of oil-less refrigerant compressor performance test apparatus for high temperature steam heat pump
    - Apparatus for testing performance of oil-less refrigerant compressor such as isentropic efficiency measurement, that using a gas cycle modifying the evaporation and condensation section for reducing the size of equipment

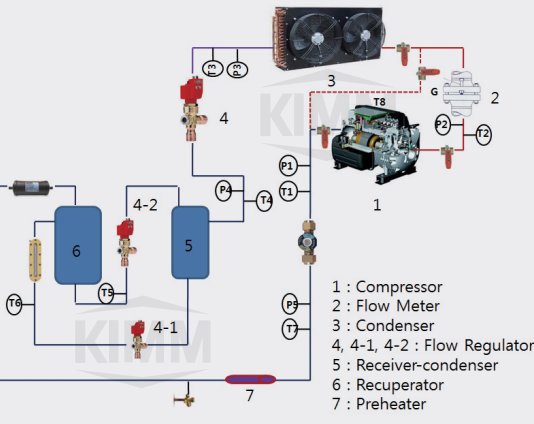


$T_{w,out}$ ,  $T_{w,in}$ ,  $T_{R,in}$ ,  $T_{R,out}$ ,  $h_{vap}$ ,  $h_{con}$ ,  $h_{LiQ}$ ,  $T_{R,sat,V}$ ,  $T_{R,sat,L}$

- R245fa Vapor heat transfer coefficient :  $Nu_{vap} = 0.09093 \cdot Re^{0.69496} \cdot Pr^{1/3}$   
- R245fa Condensation heat transfer coefficient :  $Nu_{con} = 3.38887 \cdot Re^{0.51161} \cdot Pr^{1/3}$   
- R245fa Liquid heat transfer coefficient :  $Nu_{liq} = 0.36492 \cdot Re^{0.59774} \cdot Pr^{1/3}$   
- Water liquid heat transfer coefficient :  $Nu_w = 0.33446 \cdot Re^{0.64778} \cdot Pr^{1/3}$   
- Water liquid Fanning Factor :  $f = -2.04361 \cdot Re^{0.02903} + 3.19576$



◁ R245fa-applied Heat Exchanger Design, Manufacturing ▷



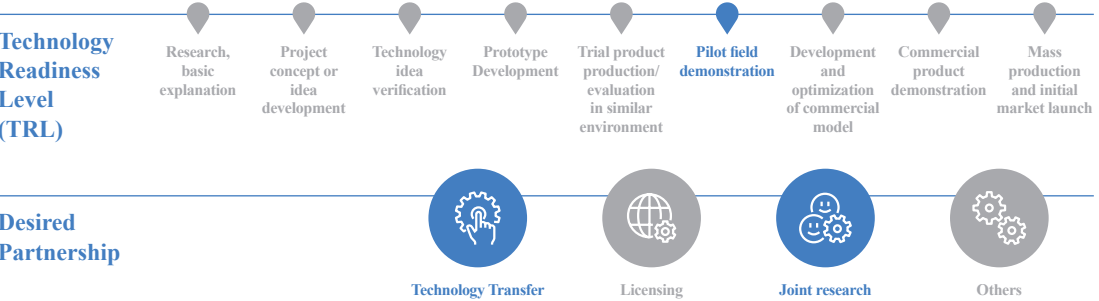
1 : Compressor  
2 : Flow Meter  
3 : Condenser  
4, 4-1, 4-2 : Flow Regulator  
5 : Receiver-condenser  
6 : Recuperator  
7 : Preheater

◁ Compressor Performance Test Apparatus ▷

Current Intellectual Property Right Status

KNOW-HOW

- Steam generation heat pump cycle design technology
- Compressor performance and reliability evaluation technology and testing method
- Technology of correlation equation development for design of heat exchanger



# Wet Electrostatic Precipitator Applied Heat Pump Technology

▶ Department of Thermal Systems   ▶ Researcher: Chan Ho Song   ▶ Contact: +82-42-868-7071

**Technology Overview**

- Technology on fine dust handling air conditioning system with wet electrostatic precipitator and heat pump
- Technology with the method of cleaning dust with water by ionizing dust in electric charging part and dust collector

**Customer / Market**

- Cooling, heating, HVAC market (duct type large air conditioning system)

**Problems of Existing Technology or Necessity of this Technology**

- Existing air conditioner removes fine particles through a filter that pressure loss is great with the filter, and the function of antimicrobial substances decline as time passes that regular filter replacement and quality control is needed.
- This technology removes particles with the wet electrostatic precipitator with barely any pressure loss. Ionized antimicrobial substance maintains high antimicrobial efficiency and does not require dust filter replacement.
- Also, natural humidification effect is occurred with the water film in collection plate.
- Fine dust filtering in the existing heating and cooling heat pump system uses a fine mesh (i.e., filter) to filter out dust. Thus, thicker filter means greater pressure loss, and the function of antimicrobial coating declines with time.
- The wet electrostatic precipitator filters fine dust and brings an antimicrobial effect with the antimicrobial substance. Without a mesh, pressure loss is small, and secondary pollution is prevented. There is also a natural humidification effect.

**Technical Distinctiveness**

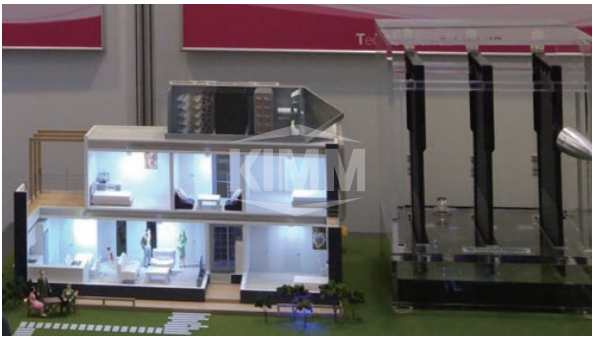
- This technology is special in a sense that a value was created by applying a wet electrostatic precipitator to the heat pump.
- Since there is a drainage hose for a air conditioner and heat pump, it naturally discharges polluted water that filter replacement or cleaning is not required.

**Excellence of Technology**

- It is the first domestic invention that combined heating, cooling, air conditioning device with wet electrostatic precipitator and antimicrobial function.
- Dust collection efficiency of 95% is realized.



〈 System Organization Model Diagram 〉



〈 Prototype Test 〉

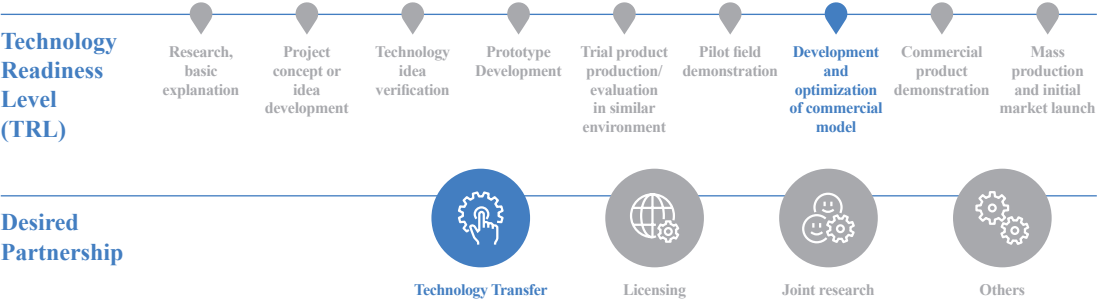
**Current Intellectual Property Right Status**

**PATENT**

- Air Conditioner with Humidity Control and Antimicrobial Function (KR1568103)
- Air Purification Apparatus with Antimicrobial Function Based on Photoelectric Effect (KR2016-0170553)

**KNOW-HOW**

- Wet electrostatic precipitator for heat pump design technology
- Heat pump system cycle design technology for wet electrostatic precipitator



# Polymer Heat Exchanger Technology

▶ Department of Thermal Systems   ▶ Researcher: Chan Ho Song   ▶ Contact: +82-42-868-7071

**Technology Overview**

- Design/production of corrosion resistance polymer heat exchanger and analysis/evaluation of thermophysical property

**Customer / Market**

- Market for low pressure heat exchanger for operating under exposure to corrosion environment (seawater heat exchanger substitution)

**Problems of Existing Technology or Necessity of this Technology**

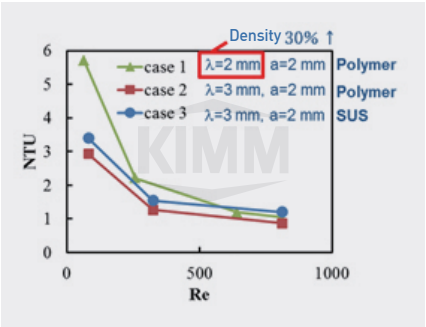
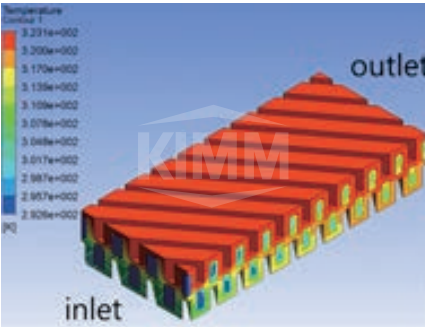
- Corrosion occurs for existing heat exchangers using seawater; existing titanium heat exchangers are expensive.
- Replacement with highly conductive polymer composite materials is expected to reduce the weight and production and maintenance cost significant.
- It is difficult to find a heat exchanger type heat sink.
- With the need for a non-metal heat exchanger for corrosion prevention, there is a need for development of heat exchanger made of polymer composite material.

**Technical Distinctiveness**

- Heat exchanger made of polymer composite is lighter and has higher design formability than existing heat exchanger.
- Technology for material selection, material mixing, and thermophysical properties assessment developed in the design process

Excellence of Technology

- Secured thermal conductivity of 2W/mK
- A heat exchanger for compactness improvement is designed and was confirmed to be able to replace a metal heat exchanger at a low Reynolds number.
- Plate type heat exchanger prototype made with an injection mold



〈 Polymer Heat Exchanger Plate Design 〉

〈 Prototype 〉

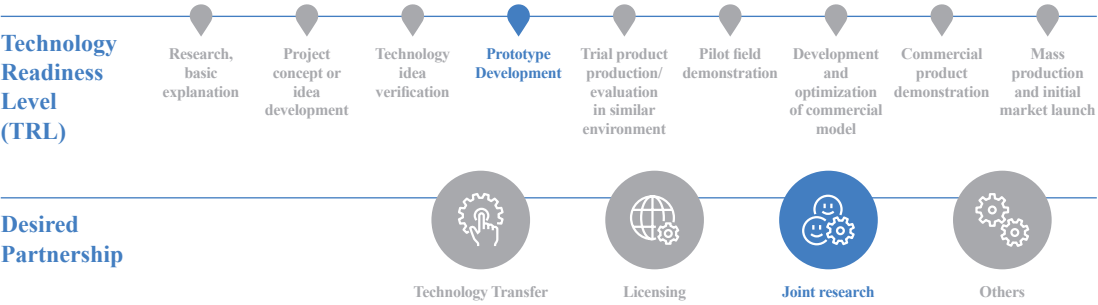
Current Intellectual Property Right Status

**PATENT**

- Primary Surface Heat Exchanger Thin Plate Manufacturing Method (KR1471182)
- Polymer Primary Surface Type Heat Exchanger (KR1529216)

**KNOW-HOW**

- Polymer heat exchanger design
- Thermophysical property evaluation in polymer heat exchanger manufacture





PCHE (Printed Circuit Heat Exchanger)  
Technology

▶ Department of Thermal Systems ▶ Researchers: Seok Ho Yoon, Joonseok Choi ▶ Contact: +82-42-868-7064, 7325

Technology  
Overview

- Technology of a micro channel heat exchanger with higher surface area density compared to existing heat exchangers
- Heat transfer plates chemically etched with micro channels are stacked to build one solid body core by diffusion bonding



Customer /  
Market

- Used for two- and single-phase heat exchange, and waste heat collection at power plants, steel mills, chemical plants, etc.
- Large plants or other places needing a large capacity heat exchanger

Problems  
of Existing  
Technology or  
Necessity  
of this  
Technology

- 〈 Problem of Existing Technology 〉
- Existing shell & tube heat exchangers have a low surface area density (100 m<sup>2</sup>/m<sup>3</sup>) that they are limited to be used when a high surface area density is required.
  - Currently, industries depend on the products of advanced foreign companies (e.g. Heatric of UK, VPE of the US, KOBLECO of Japan, etc.).

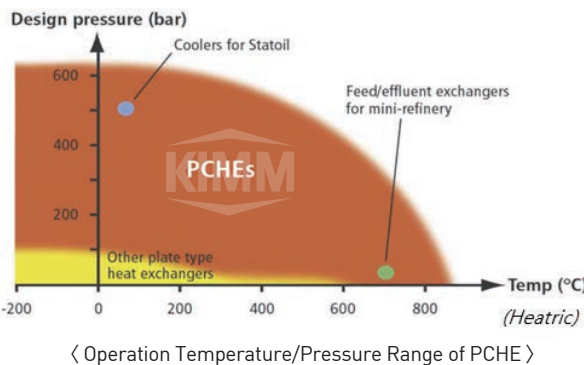
- 〈 Necessity of this Technology 〉
- Development of heat exchangers with a high surface area density to be used under a high temperature and pressure is needed.
  - Original technology is needed

Technical  
Distinctiveness

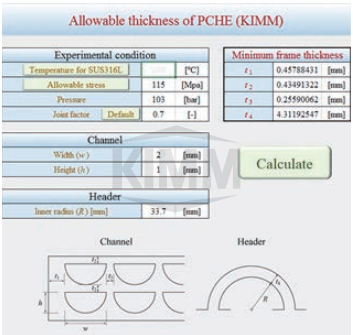
- Cost is high, but the volume can be reduced while operating under a high temperature and pressure.
- Can be used at high temperature (−250°C to 800°C) and high pressure (up to 50 MPa) with high surface area density
- Development of Domestic technology for a high value-added heat exchanger is needed.
  - Diffusion bonding
  - heat exchanger flow path and capacity design
- accumulated Know-hows through bonding experiments, flow channel design, and heat exchanger experiments

Excellence of  
Technology

- Can be used for a wide temperature range
- High operation pressure (up to 50 MPa)
- Diffusion bonding technology
  - bonding know-how and data base
  - Design of Vacuum Hot press
- Technology for PCHE design based on heat exchange capacity
  - Heat exchanger design know-how and data base
  - PCHE sizing according to the single- and two-phase heat transfer
- Developed a program caculating wall thickness of PCHE
  - Developed based on the ASME boiler & pressure vessel code
  - Calculate the minimum allowable wall thickness by comparing the stress and allowable stress of each channel wall according to the given pressure
  - Calculate wall thickness and header thickness



〈 Vacuum Hot Press for Diffusion Bonding 〉



〈 PCHE Wall Thickness Cacluation Program 〉

Current  
Intellectual  
Property  
Right Status

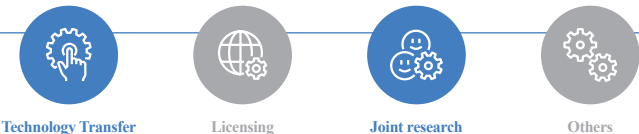
PATENT

- Micro Channel Heat Exchanger (KR0991113)
- Vacuum Hot Press for Diffusion Bonding (KR1034858)
- Vacuum Hot Press for Diffusion Bonding (KR1094961)
- Micro Channel Heat Exchanger (KR1080236)
- Micro Channel Heat Exchanger (KR1202773)
- Vacuum Hot Press for Diffusion Bonding (KR1167626)
- Vacuum Hot Press for Diffusion Bonding (KR1220300)

Technology  
Readiness  
Level  
(TRL)



Desired  
Partnership

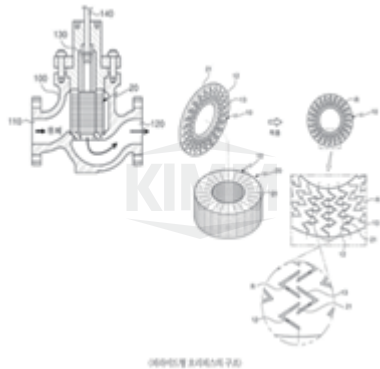


# Disc Shape Control Technology for High-differential Pressure Control Valve for Offshore Plant

Department of Thermal Systems    Researcher: Sonam Yoon    Contact: +82-42-868-7155

Technology Overview

- High-differential pressure control valve for offshore plant with a relatively simple design and easy processing achieving productivity improvement of differential pressure generator using multi-layer of discs and the fluid path furrow for creating pressure drop in discs to weaken cavitation and noise and reduce the pressure of large amount of fluid



Customer / Market

- Shipbuilding/Marine/Nuclear power

Problems of Existing Technology or Necessity of this Technology

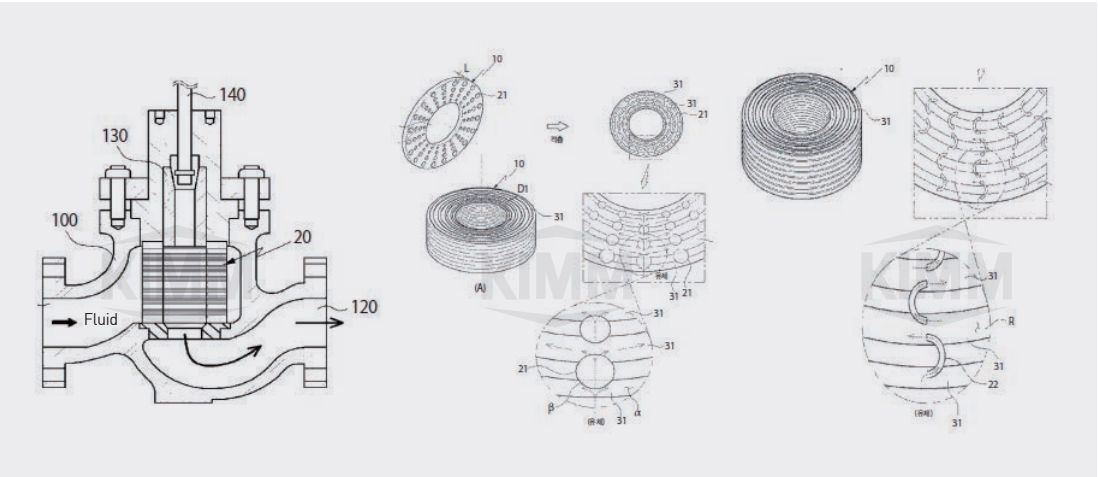
- Demand for pressure reducing technique by creating a longer fluid path within a designated space mechanically
- Difficulty in high-differential pressure generation drop due to 2D concept design and machining
- Mechanical high-differential pressure generation is needed for ease application at offshore plants

Technical Distinctiveness

- High pressure liquid from deep seafloor can be decompressed relatively easily.
- Valves for deep seafloor are difficult to use with the electrical control method and to easily generate high pressure drop, but this technology can solve this problem.
- Existing technology is made with the 2D concept design and production, but this technology is controlled with 3D concept that enables high pressure drop control and easy adjustment of pressure drop range.
- 3D concept design and production method is flexible depending on the pressure drop control range adjustment, and there is an economical effect as only one disc from a set of two discs is used for adjusting the pressure drop control range.

Excellence of Technology

- To generate a greater pressure drop within a given space, the velocity of flow needs to be accelerated (the speed of liquid going through the valve), and this requires a design strategy of making a long, narrow fluid path.
- There is a need for measure dealing with cavitation and noise reduction.
- The design is much more favorable than the existing 2D concept fluid path.
- It can be applied to offshore plant, gas and liquefaction line, and coolant control for nuclear power.
- Excellence of the technology was proven with the Structural Analysis on 2,500 Class High Pressure Drop Control Valve (KSMTE) and High Pressure Drop Valve Research Trend (PROCON)
- 25 years of experience in valve research



< Pyramid Orifice Structure >

Current Intellectual Property Right Status

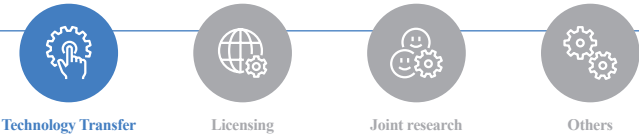
PATENT

- High Pressure Drop Control Valve for Offshore Plant (KR1376093)
- Disc Stacking High Pressure Drop Control Valve for Offshore Plant (KR1356123)

Technology Readiness Level (TRL)



Desired Partnership

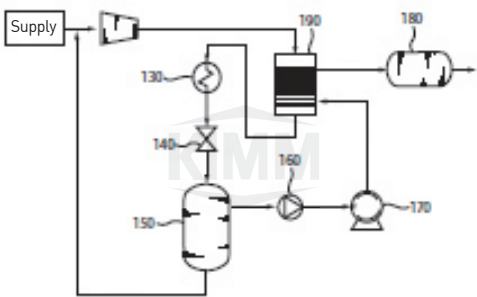


# Ground System for CO<sub>2</sub> Geological Sequestration

▶ Department of Thermal Systems ▶ Researchers: Konghoon Lee, Seok Ho Yoon ▶ Contact: +82-42-868-7291, 7064

Technology Overview

- Carbon dioxide liquefaction and underground injection apparatus



Customer / Market

- CO2 underground injection facility manufacturer, CO2 utilizing industry

Problems of Existing Technology or Necessity of this Technology

- Using the ocean storage, it is expected that CO<sub>2</sub> emitted on the earth be stored for 500 years by releasing CO<sub>2</sub> below 3,000 m-deep ocean floor. But due to safety issues including problems with ecosystems and ocean acidification, this technique has been prohibited by international laws. Surface storage method takes CO<sub>2</sub> to react to addible mineral such as magnesium or potassium for chemical reaction, but there are some issues related to the cost for chemical reaction and the treatment of resulting chemical products.
- CO<sub>2</sub> liquefaction requires a great energy consumption for cooling, and underground injection also requires extensive energy to heat CO<sub>2</sub> up to a high-pressure supercritical state. It is not proper to consume a lot of energy for liquefaction and storage of CO<sub>2</sub>, even though CO<sub>2</sub> sequestration is required for environment preservation.

Technical Distinctiveness

- Energy required for liquefaction is reduced by supplying only the gas CO<sub>2</sub> using a compressor after the vapor-liquid separator.
- CO<sub>2</sub> is more easily changed into supercritical state for underground injection as the injection pump and heater are used in the injection part.
- The injection part includes a high-pressure pump to prevent cavitation.
- Energy consumption for CO<sub>2</sub> liquefaction and storage is significantly reduced by using a heat exchanger between CO<sub>2</sub> from the injection pump and CO<sub>2</sub> from the compressor.
- Since the heat exchanger is installed between the injection pump and the heater, CO<sub>2</sub> is heated up in the heater after it is preheated in the heat exchanger to reduce energy consumption for CO<sub>2</sub> storage.
- It This facility is a CO<sub>2</sub> liquefaction and underground injection system that saves energy through heat exchange between CO<sub>2</sub> liquefied for transportation and CO<sub>2</sub> heated into the supercritical state for underground injection.

Excellence of Technology

- It The facility is composed of the vapor-liquid separator, injection part, and compressor. The feed of two-phase CO<sub>2</sub> is separated into the vapor and liquid in the separator. The liquid CO<sub>2</sub> is supplied to the pump and then changed into superical state. The vapor CO<sub>2</sub> is supplied into the compressor for recompression and liquefaction.



Current Intellectual Property Right Status

PATENT

- CO<sub>2</sub> Liquefaction and Underground Injection Apparatus (KR1399442)

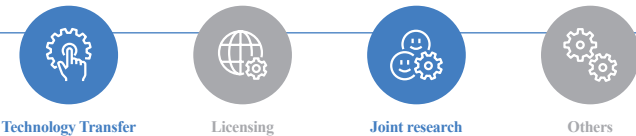
KNOW-HOW

- System design and engineering technology
- Flow mixing, heating apparatus design technology
- CO<sub>2</sub> heat exchanger design technology
- Turbo pump technology for injecting CO<sub>2</sub>

Technology Readiness Level (TRL)



Desired Partnership





# Plate Heat Exchanger Technology

▶ Department of Thermal Systems ▶ Researcher: Konghoon Lee ▶ Contact: +82-42-868-7291

Technology Overview

- High-efficiency plate heat exchanger technology with relatively higher heat exchanging performance compared to a similar volume



〈 Plate Heat Exchanger 〉

Customer / Market

- Oil refineries, chemical plants, energy plants, sCO2 power generation-related companies

Problems of Existing Technology or Necessity of this Technology

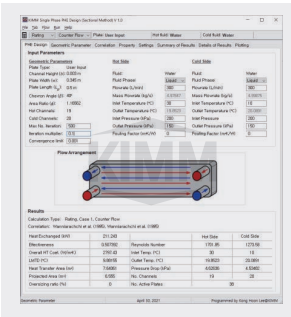
- Conventional shell & tube heat exchanger commonly uses multiple passes to improve the performance and it has large volume and size, which results in the requirement of a large foot print to be installed
- Shell & tube heat exchanger technology already has been matured and foreign companies are dominating the market.
- There are many demands of plate type heat exchangers which can be used under high temperature, high pressure, and corrosion environment.

Technical Distinctiveness

- Design ability for brazing type, gasket type, and welding type plate heat exchangers.
- Welding type plate heat exchanger is designed and manufactured to be used under higher temperature (up to 600℃) and higher pressure (up to 30 bar) compared to other types of plate heat exchangers.
- Energy saving in the industrial process, and cost saving in operation and maintenance.

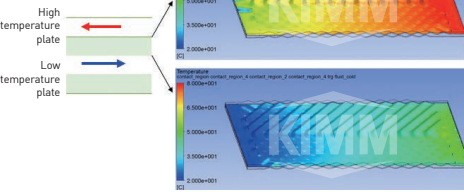
Excellence of Technology

- Ability to analyze heat exchanger performance based on inlet/outlet temperature, flow rates, etc.
- Ability to analyze the pressure drop issue with the flow analysis
- Flow distribution through flow visualization and fluid pass design for higher performance
- Testing facility for the verification of the design result
- Design program for the rating and sizing of plate heat exchangers in the specified conditions

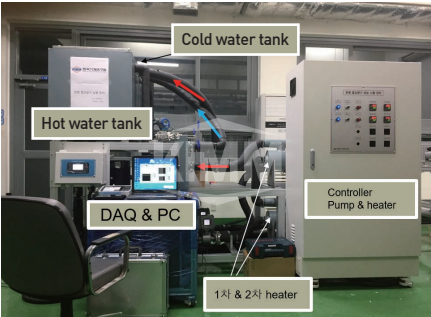


〈 Plate Heat Exchanger Design Program 〉

- Temperature distribution
- $U = 0.1\text{m/s}$

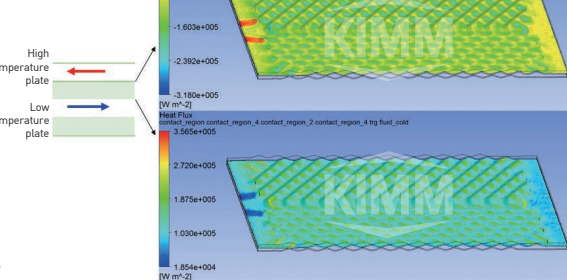


〈 Plate Heat Exchanger CFD Analysis 〉



〈 Plate Heat Exchanger Performance Test Equipment 〉

- Heat flux distribution
- $U = 0.1\text{m/s}$



Current Intellectual Property Right Status

PATENT

- Heat Exchange Plate for Plate Heat Exchanger (KR1768151)
- Heat Exchanger Plate and Plate Heat Exchanger Including the Same (KR2154815)

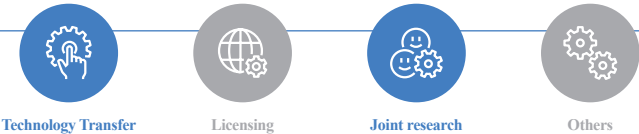
KNOW-HOW

- Plate heat exchanger design
- Plate heat exchanger analysis

Technology Readiness Level (TRL)



Desired Partnership

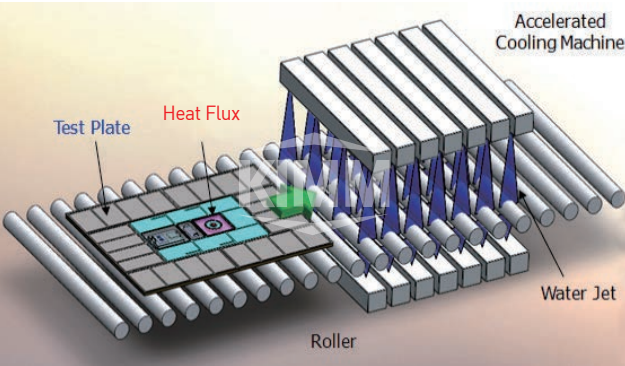


# 2D Heat Flux Gauge Block

▶ Department of Thermal Systems   ▶ Researcher: Konghoon Lee   ▶ Contact: +82-42-868-7291

Technology Overview

- Technology can be applied to measure the surface heat flux in the cooling/quenching processes for steelmaking



Customer / Market

- Extreme environment sensor, steelmaking company

Problems of Existing Technology or Necessity of this Technology

- In Thermo-Mechanical Controlled Process (TMCP) for steel production, it is very difficult to accurately measure the surface heat flux for steel cooling.
- Contact measurement is not possible in the steel cooling process where steam and droplets are mixed.
- The conventional sensor is limited to measure the internal temperature of hot steel block since it can be used only once.

Technical Distinctiveness

- The heat flux gauge with a cartridge heater can be used repeatedly more than 10 times.
- Applicable to the steel making processes where steam and droplets are mixed.
- Two-dimensional (thickness and radial) high temperature heat flux.
- High-temperature corrosion-resistant materials such as SUS316 and SUS310S are used.
- Uniform rapid heating using 16 0.5-inch high-temperature cartridge heaters (up to 1,000°C).
- Uniform depth of thermocouples adopting precision electric discharge machining (EDM) technology (1 mm from the surface)
- Minimizing cooling water flow disturbance by manufacturing Invar and refractory material upper cover

Excellence of Technology

- It consists of the first temperature measuring point having multiple different measurement points spaced apart along the thickness direction and the second temperature measuring point having multiple measurement points located at different depths from the side to the center direction. It is characterized by the second temperature measuring point for measuring directional heat flux.

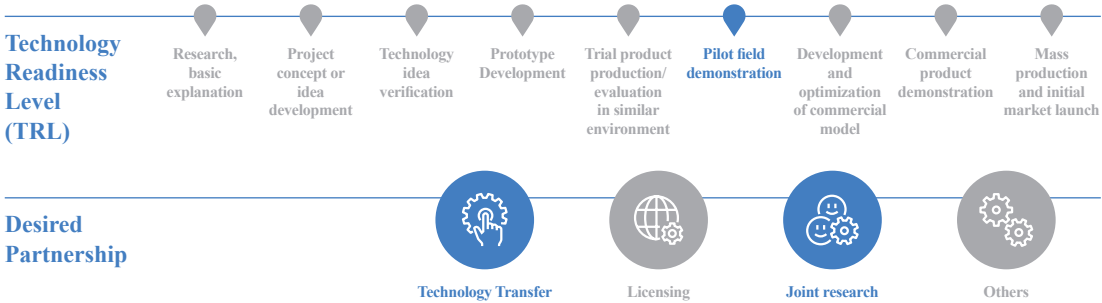


〈 2D Heat Flux Gauge Block : Heat Flux Measuring Apparatus 〉

Current Intellectual Property Right Status

PATENT

- Measuring Apparatus with Cooling Function (KR1168385, JP5550154)
- Guage for Measuring Heat Flux Having Double Row (KR1221972)
- 2D Heat Flux Measuring Gauge (KR1221966, PCT/KR2013/003254)
- Heat Flux Measuring Apparatus at Heat Cooling Process and Heat Flux Measurement Method Using the Apparatus (KR1013515)
- High Temperature Steel Plate Heat Flux Gauge for Cooling Process (KR0991107)
- Cooling Thermal Properties Measuring Apparatus for Thick Plate Rapid Cooling Process (KR0912240)
- Heat Flux Measuring Apparatus for Steel Manufacturing Process and Heat Flux Measuring Method Using the Apparatus (KR0955461)

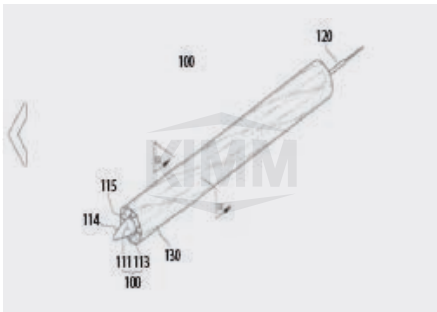


# Gas Hydrate Resistant Inline Heater

▶ Department of Thermal Systems   ▶ Researcher: Konghoon Lee   ▶ Contact: +82-42-868-7291

Technology  
Overview

- Inline heater technology to improve flow assurance in offshore plant pipelines



Customer /  
Market

- Oil & gas companies, offshore plant equipment and materials companies annual global market size of KRW 5 trillion

Problems  
of Existing  
Technology or  
Necessity  
of this  
Technology

- In the oil and gas industry, flow assurance means that resource materials are mined and transported stably and economically by controlling the temperature, flow and pressure of the flow in the pipe from the storage site to the consumption site.
- The factors that have the greatest influence on the flow stability of the deep-sea pipeline are the clogging of the pipe due to solid substances such as gas hydrate or wax, the damage of the pipe equipment due to the slugging phenomenon of multi-phase flow, the changes of flow rates due to the large pressure drop in the pipeline, viscosity heat loss, and so on.
- Recently, the oil and gas industry is investing billions of dollars a year for the design and technology development of deep-sea pipelines with flow assurance.
- In the case of oil fields to be developed in the decade or so, the frequency of pipe plugging has increased since they are located in the deep sea (up to 3,000 m in depth), the transport distance of resources is long, and the phase equilibrium condition of to generate the gas hydrate at the high pressure is satisfied.

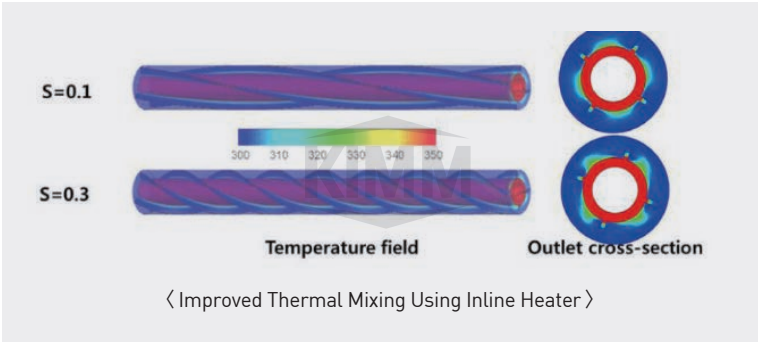
Technical  
Distinctiveness

- A cartridge-type in-line heater that can improve durability is provided and is inserted inside the heat transfer unit heating so that the working fluid is heated up by indirect contact.
- In addition, the temperature uniformity of the working fluid can be guaranteed by inducing agitation of the working fluid heated by the spiral swirl part on the outer surface of the heat transfer part.

- In addition, pressure loss can be reduced and the flow assurance of the working fluid can be improved by forming a flow pattern in the spiral swirl part..
- It can be applied as a technology that can respond very effectively to the improvement of pipeline flow assurance in offshore plants used for oil and gas production.
- Heated at a constant temperature regardless of the location inside the pipe
- Easy to control the working fluid temperature for each zone by using a cartridge-type inline heater
- Conventional technology suppresses gas hydrate formation by simply installing a heater on the outer wall of the pipeline, and the temperature difference between the outer wall and the center line of the pipeline occurs, which yields the deterioration of the thermal mixing characteristics in the radial direction of the pipeline.
- Whereas the suppression of gas hydrate generation is somewhat lower, this technology has excellent thermal mixing performance in the radial and pipeline flow directions. The suppression ability of gas hydrate generation in the pipeline is superior.

Excellence of  
Technology

- The inline heater is inserted into the pipe and can maintain the temperature inside the pipe uniformly.
- The heater can be manufactured in a swirl structure to increase the heat transfer area so that the fluid comes into direct contact with the heat surface to improve heat transfer.
- Compared to the conventional heating wire spooling method on the outer wall of the pipe, this technology has high heat transfer performance and excellent thermal mixing performance.
- According to the patent on cartridge-type inline heater owned by the KIMM, it is based on the experience of making a PIP prototype applied to a deep-sea plant, and is expected to make an entrance to the global market through a prototype and hydrate suppressing performance evaluation.



Current  
Intellectual  
Property  
Right Status

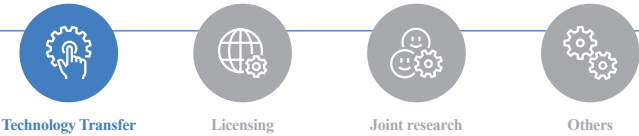
PATENT

- Cartridge-Type Inline Heater and System for Controlling Working Fluid Temperature Using the Same (KR1137528, PCT/KR2012/009761, US13/990871)
- Inline Heating Pipeline System for Preventing Gas Hydrate (KR1358235)

Technology  
Readiness  
Level  
(TRL)



Desired  
Partnership





# Thermal Storage Material and Thermal Storage System for High Temperature Heat Storage

▶ Department of Thermal Systems ▶ Researchers: Jun Seok Choi, Young Kim ▶ Contact: +82-42-868-7325, 7626

## Technology Overview

- Material and system for high temperature concentrated solar energy or industrial waste heat
- Can be stored at 300 to 700℃ for several hours
- Higher temperature heat can be stored at the lower costs and the smaller footprints than existing technology

## Customer / Market

- Industrial plant with high temperature waste heat
- Concentrated solar power generation system
- Other systems that require high temperature heat storage

## Problems of Existing Technology or Necessity of this Technology

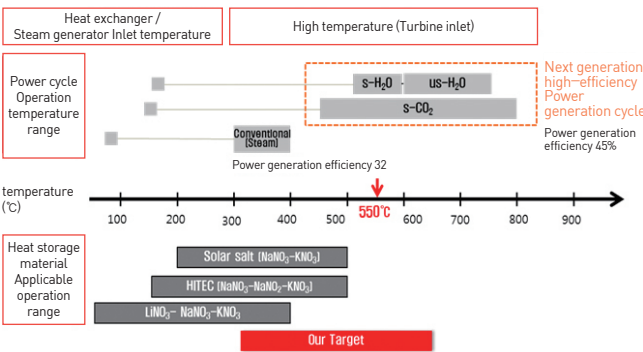
- The commercial molten salt (Solar Salt) used thus far starts to decompose at above 550℃ so that it cannot be used for higher temperature applications.
- Other candidate materials are unstable or can be melt at high temperature, above 400℃, which makes it difficult to use them in a large scale system.
- Existing heat storage systems use two storage tanks of hot and cold temperature resulting in the higher capital cost.
- Domestic institutes or companies have not experienced this kind of high temperature heat storage systems.

## Technical Distinctiveness

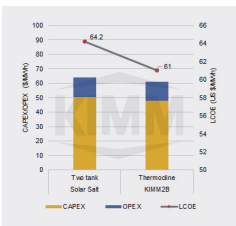
- Can transfer the heat at atmospheric pressure and store it at 300 to 700℃ for several hours
- Maintains the high temperature from the heat source so that the heat storage and conversion efficiency can be increased
- Using the thermocline single tank reduces the required system footprint thereby lowering the capital cost
- Cost of heat storage materials can be reduced

## Excellence of Technology

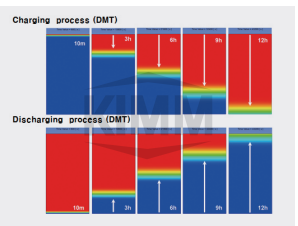
- Applicable Temperature for Developed Heat Storage Material



〈 High Temperature Heat Storage Pilot 〉



〈 Levelized Power Cost Reduction when applied this technology 〉



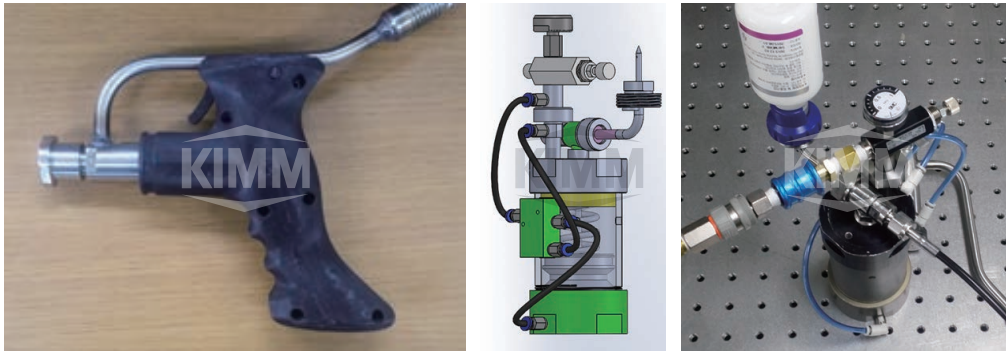


# Needle-free Injection Syringe Design Technology

▶ Department of Thermal Systems   ▶ Researcher: Young-Bog Ham   ▶ Contact: +82-42-868-7157

Technology  
Overview

- The needle-free injector design technology allows instant intradermal or intramuscular injection of accurate volumes without using needle through pressurization of drug in order to solve various problems caused by existing injection methods using a needle syringe.
- A Portable needle free injector is developed so that a single operator working in the field can vaccinate a large scale livestock farm.



〈 Handpiece 〉                      〈 Drugs supply and pressure transmitter 〉

Customer /  
Market

- Large scale livestock farms, public quarantine institutes, injecting drug (foot and mouth disease vaccine, etc.) manufacturers, and pet hospitals.

Problems  
of Existing  
Technology or  
Necessity  
of this  
Technology

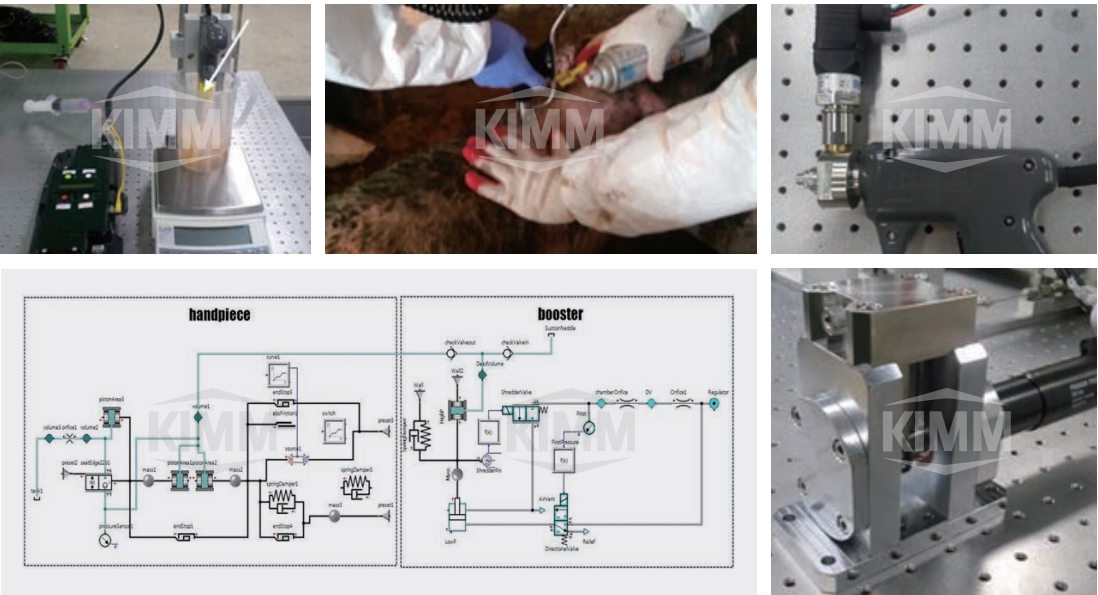
- Vaccines or drugs to livestock are usually delivered with a needle-syringe so there is a possibility of disease spread due to reuse of needles.
- Injection of accurate amount on the right spot is difficult using a syringe with a needle due to animal movement, and there are issues regarding increasing fatigue of the worker and possibility of safety accident.
- Pork quality may decline due to the needle mark and broken needle during injection and stress caused from injection.
- Imported needle-free injectors are expensive, heavy, or make noise during operation that is why their use is limited at livestock farms.

Technical  
Distinctiveness

- The use of compressed gas to amplify the pressure of drug makes less noise and does not require electric battery.
- The hand-piece is light-weight and causes less fatigue when using long hours, and the triple safety device keeps the worker safe.

Excellence of  
Technology

- Prevention of accidents and injuries which might occur with the existing needle syringe vaccination and reduction in vaccination time
- Reduced animal stress and prevention from needle stick injuries
- Adjustment of drug injection pressure and volume to inject fixed dose to required depth
- Reduced cost occurring from drug loss and purchasing expensive imported products



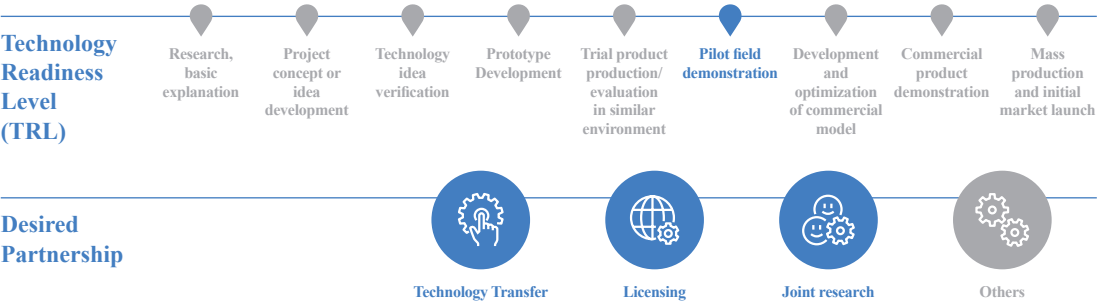
Current  
Intellectual  
Property  
Right Status

PATENT

- Needle-free Syringe (high pressure pump valve type) (KR1313632)
- Needle-free Syringe (elastic body impact type) (KR1313633)
- Pressure-controlled Needle-free Injector for Injection Volume Adjustment (KR1863355 – 0163067)

KNOW-HOW

- Axiomatic design technology for design parameter selection to achieve target injection volume and pressure
- Modeling and dynamic simulation technology using design blueprint before production
- Needle-free injector performance assessment technology
- Small high-pressure plunger pump and piezoelectric-driven high speed valve design technology
- Apparatus design technology for variable injection volume control





# High Viscosity Liquid Jet Dispensing Head Design Technology

▶ Department of Thermal Systems   ▶ Researcher: Young-Bog Ham   ▶ Contact: +82-42-868-7157

**Technology Overview**

- This technology involves the mechanism design of the piezoelectric-driven jet dispensing head that can generate 2D and 3D pattern at a high speed by dispensing viscous liquid at a fixed amount with ultra-fine precision.

**Customer / Market**

- Fields requiring precise, fixed-amount dispensing of high viscosity liquid
  - High viscosity epoxy precision dispensing: epoxy jet dispensing for semiconductor component bonding process
  - Functional paste precision dispensing: Paste jet dispensing for LED chip packaging process
  - Lubricant dispensing: Grease and jetting for high value-added components requiring continuous supply of the minimum amount of lubricant

**Problems of Existing Technology or Necessity of this Technology**

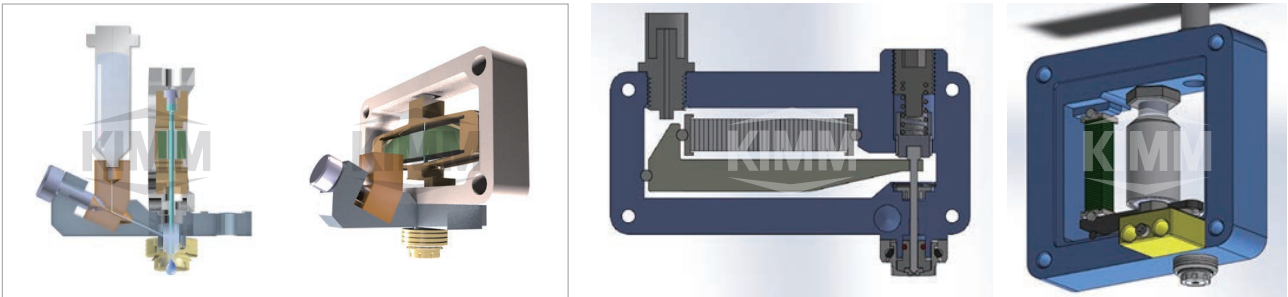
- Mostly, the pneumatic pressure-solenoid type dispenser is used, but precision industries like semiconductor packing use imported piezoelectric jet dispensers from advanced countries like Germany and the USA.
- Existing pneumatic pressure dispenser uses the pneumatic pressure as its power source but the pneumatic pressure supply causes instability due to the compressibility of air, which causes a decline in precision level, and results in difficulty to dispense high viscosity liquid
- The fluid path is opened with the solenoid valve, but a delay occurs due to its low response, which makes high-speed driving and droplet formation difficult and limits the droplet dispensing frequency

**Technical Distinctiveness**

- High-speed driving is possible using piezoelectric actuator with response dozen times higher compared to solenoid.
- Droplets are formed with the high force of piezoelectric actuator that high viscosity droplets can be dispensed.
- While ascending the tappet by extending displacement of piezoelectric actuator, the liquid is injected through the nozzle and the tappet descends at a high speed for instant high pressurization to dispense fine droplets.

**Excellence of Technology**

- The problems like limitations with viscosity, speed, and micro droplet formation of existing piezoelectric dispenser are overcome, and independent design of piezoelectric jet dispenser mechanism of the same level as foreign products became possible.



〈 Rhombus type 〉                      〈 Hinge-Lever Type I 〉                      〈 Hinge-Lever Type I 〉

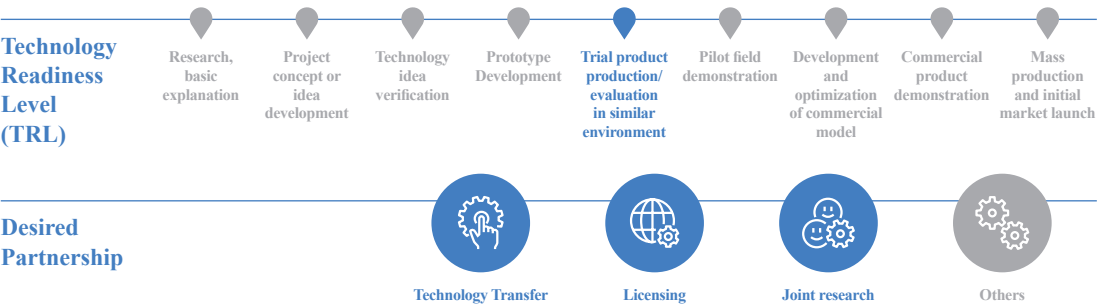
**Current Intellectual Property Right Status**

PATENT

- Jet Dispenser Using Hinge Lever Type Displacement Extension (KR1819077)
- Bimorph Piezoelectric Actuating Dispenser with Cutting Jet Type (KR1190080)
- Cutting Jet Type Dispenser Using Pressurized Area Amplified Displacement (KR1190119)
- Cutting Jet Type Dispenser Using Amplified Perpendicular Displacement (KR1190083)
- Cutting Jet Type Dispenser Using Hinge Lever (KR1059746)

KNOW-HOW

- Stacking type piezoelectric actuator mounting jig design technology
- Stacking type piezoelectric actuator initial compressibility setting design
- Nozzle & tappet end contact and sealing mechanism design technology
- Viscosity control technology for high viscosity liquid
- Stacking type piezoelectric actuator driving control technology for droplet formation



# Multidirectional Tennis Simulator Technology

Department of Thermal Systems    Researcher: Pil Woo Heo    Contact: +82-42-868-7331

Technology Overview

- A reduced model considering the characteristics of actual tennis courts
- Tennis simulator technology that realizes continuity and randomness at the same time

Customer / Market

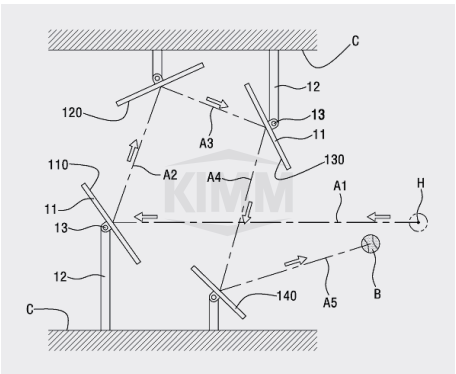
- Indoor sports market
- Tennis lesson market
- Indoor sports facilities of school/public/workplace

Problems of Existing Technology or Necessity of this Technology

- Tennis is a popular sport, but it is difficult to secure a tennis court and requires a long lesson period to improve skills. Therefore, an indoor tennis simulator is needed to remove the spatial restriction and provide efficient practice.
- The existing tennis practicing machines could be helpful for beginners because the ball returns to a certain position after it is hit, but it had limitations due to its monotonous characteristics.
- Screen tennis technology is structurally limited in its ability to mimic the continuous ball movement of a rally to and from each other on the court.

Technical Distinctiveness

- By reflecting the characteristics of real tennis courts, players can enjoy tennis indoors without getting bored and improve their skills.
- Multi-directional tennis simulator has multidirectional characteristics and can handle scores like a real tennis game.
- Through quantitative score management, a player can easily maintain concentration even by oneself, check on one's own condition, improve skill level, and adapt to the court.
- Because it has multi-directionality and multi-timing by continuity and randomness, it keeps the tension felt while rallying with opponents on the court and improves the ability to cope with random balls.
- It is possible to practice hitting in the effective area alone. The single-player game mode is a virtual tennis match against a machine, and the two-player game mode is a game played by two players.

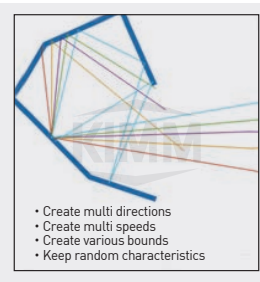


〈 Concept of Multidirectional Tennis Simulator 〉

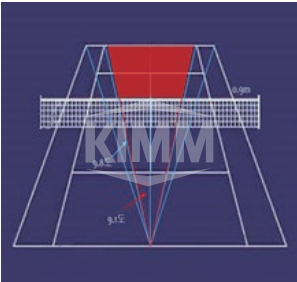
- Due to the nature of tennis games, if there is more or less difference in level of tennis skills with the opponent, it is difficult to play together on the court without interesting. Therefore, the multidirectional tennis simulator's two-player game mode can be useful even among family members and friends with different levels because players can complement each other.

Excellence of Technology

- A reduced model that simulates the characteristics of an actual tennis court
- An indoor tennis simulator considering multi-directional positions, multi speeds, various bound characteristics and random characteristics.
- A player can learn and master basic tennis skills by playing tennis by oneself in an interesting way.
- The ability to respond to the moment while maintaining concentration and tension is improved, effectively responding to the training of real-world adaptability to actually play tennis on the court.



- Create multi directions
- Create multi speeds
- Create various bounds
- Keep random characteristics



〈 Multidirectional Tennis Simulator Technology 〉

Current Intellectual Property Right Status

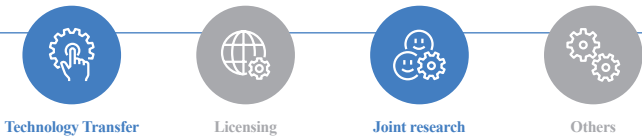
PATENT

- The real time tennis apparatus with low noise and multidirection (KR2066789)
- Multidirectional tennis training apparatus with recognition function of effective hitting (KR2235467)
- Apparatus for training tennis with in/out judgment part by sensing vibration (KR1766533)
- Tennis training apparatus having integrated multi-slopes (KR2066797)
- Low noise type tennis training apparatus with variable slope (KR2088578)
- Reduced interface area type of a tennis apparatus with multi tilt angle using none crossed area (KR2019-0176330)
- The transparent type of tennis apparatus with inclination angles (KR2319752)
- The plate type of realtime tennis apparatus with expanded effective area (KR2308862)

Technology Readiness Level (TRL)



Desired Partnership



# Underwater Breathing Apparatus Using Dissolved Oxygens

▶ Department of Thermal Systems   ▶ Researcher: Pil Woo Heo   ▶ Contact: +82-42-868-7331

Technology Overview

- Technology for an apparatus using dissolved oxygens for underwater breathing without an oxygen tank



Customer / Market

- Underwater disaster relief equipment, underwater exploration, scuba diving equipment
- Underwater scooter equipment, aquatic activity equipment manufacturer, underwater oxygen supply platform

Problems of Existing Technology or Necessity of this Technology

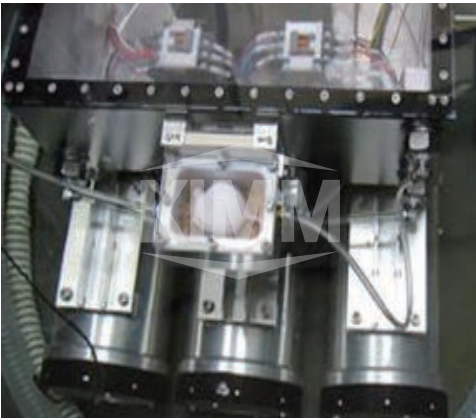
- When using an oxygen tank, underwater activities are allowed only within the time limited by the oxygen tank capacity.
- Long-hour underwater activities such as underwater rescue activities for an emergency marine disaster or underwater explorations require multiple oxygen tanks, which leads to make many limitations due to its volume and weight.

Technical Distinctiveness

- This technology does not require an oxygen tank, enables underwater breathing using dissolved oxygens in water
- When developed as a small portable design, it is expected to be utilized in various areas such as human rescue, transportation means, disaster prevention, aquanautics, leisure activities, and military activities in water.
- By minimizing the energy consumption, oxygens can be supplied from water for long hours.
- Underwater breathing apparatus technology using dissolved oxygen in water without an oxygen tank
- This technology reduces power consumption by increasing surface area
- Continuous treatment of gases emitted from breathing for reuse
- Improving dissolved oxygen separation rate using magnetic materials
- Underwater breathing with an oxygen tank limits underwater activity time due to its tank capacity; using dissolved oxygens in water enables long-hour underwater activities

Excellence of Technology

- Lab mice subjected to an experiment using 500 mL/min dissolved oxygen separation technology survived for 50 minutes underwater
- As an academic presentation, published on J. of Membrane Science, Sensors and Actuators A: Physical etc.
- Development of artificial gill technology for underwater breathing without an oxygen tank (Electronic Times, Dec. 2011, 2011) reported
- 2 principal researchers and 2 senior researchers were participated in the research.

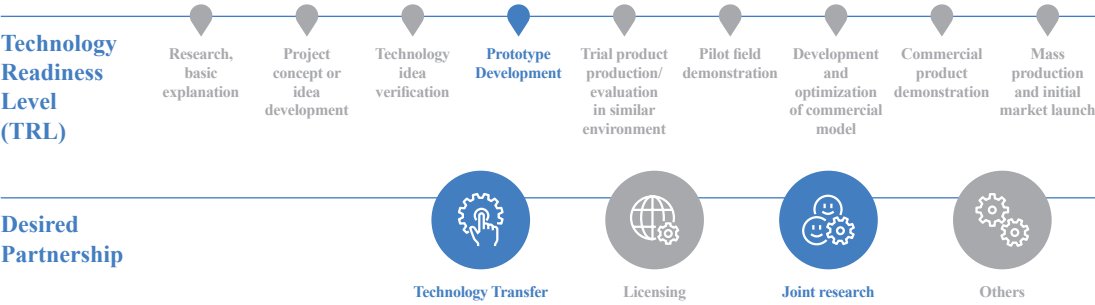


〈 Underwater Breathing Apparatus Using Dissolved Oxygens 〉

Current Intellectual Property Right Status

PATENT

- Air Separation Type of Respiration Submarine Mask (KR1144619, PCT/KR2010/008865)
- Apparatus for Breathing Using Hollow Fiber (KR1044390)
- Apparatus of Separating and Collecting Dissolved Gases (KR1055315)
- Device for Measuring Water Quality Using Hollow Fiber and Method Using the Same (KR1026991)
- Apparatus for Underwater Breathing Using Radially Positioned Hollow Fiber (KR1051020)
- Snorkel Using Hollow Fiber (KR1076701)
- Rebreather Using Hollow Fiber Membrane with Buffer (KR1078280)
- Dissolved Gas Distributing Type of Breathing Apparatus Using Hollow Fiber (KR1094939)
- Pressurizing Rebreather Using Hollow Fiber Membrane (KR1131195)
- Oxygen Controlling-type Breathing Apparatus Using Hollow Fiber (KR1408176)
- Underwater Propulsion Apparatus Using Hollow Fiber (KR1328615)
- Circulation Type of Respiratory Apparatus Using Hollow Fiber (KR1346757)
- Hollow Fiber Membrane Module (KR1387949)
- Respiratory Apparatus with Increased Separating Capacity Using Hollow Fiber (KR1692107)
- Rotary Type of Respiratory Apparatus Using Hollow Fiber (KR1635341)
- Two-way Injection Type of Hollow Fiber Membrane Module (KR1577908)
- Pressurizing Rebreather Using Hollow Fiber Membrane (KR1867371)



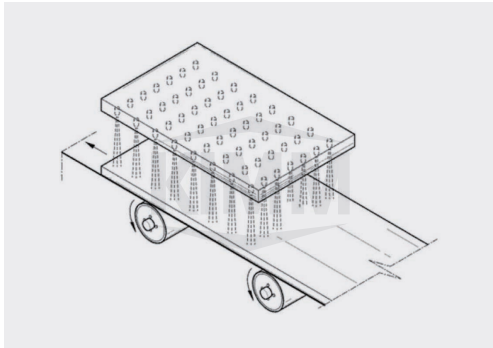


# Cooling System for Thick Plate or Steel Plate

▶ Department of Plant Technology ▶ Researcher: Kyuhyung Do ▶ Contact: +82-42-868-7929

Technology Overview

- Advanced high-efficiency non-leveling accelerated cooling technology for thick plate to improve energy efficiency in the thick plate processing



Customer / Market

- Major steel manufacturers/cooling facility manufacturing market

Problems of Existing Technology or Necessity of this Technology

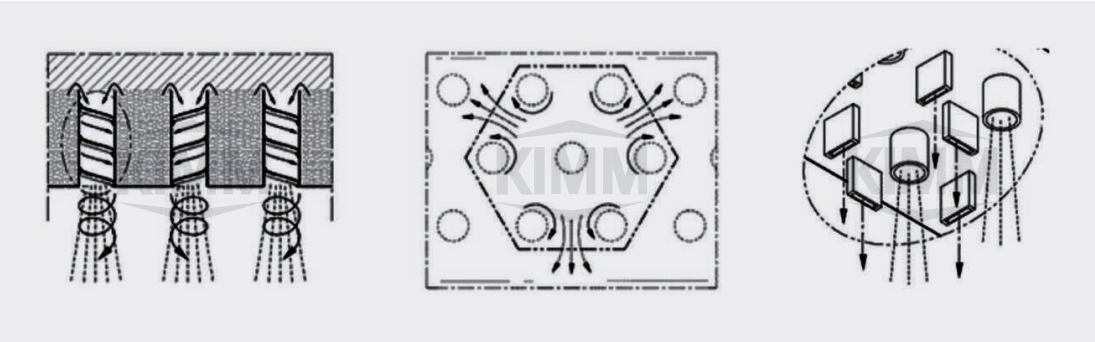
- There is a need for uniform cooling and residual water removal.
- Existing accelerated cooling control technology for thick plate or steel plate could not cool the plate uniformly that the plate deformation occurred, and most of the times, leveling process consumed a lot of energy and lowered the productivity.
- When accelerated cooling control was not done properly in the thick plate or steel plate manufacturing process, large deformations occurred from thermal stress caused by non-uniform cooling.
- Therefore, a uniform cooling method is needed to minimize plate deformation.

Technical Distinctiveness

- It is an innovative steel cooling process technology that uses accelerated cooling technology that could significantly reduce thick plate deformation and unnecessary energy consumption put into leveling in the post treatment. It can achieve revolutionary energy efficiency improvement.
- By eliminating the leveling process in the post treatment, the thick plate or steel plate production time can be shortened, that the productivity can be enhanced.
- The cooling apparatus has distinctive technology using multiple circular jet nozzles with swirl generator to cover unevenly cooled area between the nozzles and effectively discharging residual water by adjusting the swirl direction.

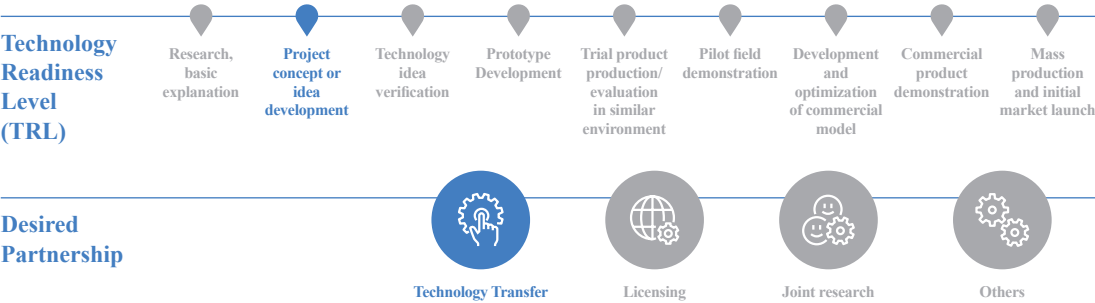
Excellence of Technology

- Multiple circular jet nozzle is one of the main cooling apparatus with high cooling ability and is widely used for thick plate cooling control.
- However, its drawback is uneven cooling between the nozzles, and to overcome such shortcomings, following cooling apparatus is proposed.
  - Using circular jet nozzles with swirl generator, areas with uneven cooling between the nozzles are covered, and the residual water is discharged effectively by adjusting the swirl direction.
  - It is a cooling apparatus using a dual-pipe multiple jet nozzle to increase the intensity of turbulence and improve the cooling ability while effectively discharging residual water.
- 2 principal researchers and 4 senior researchers are participating in the research for technology development.



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Cooling Ability Measuring Apparatus (KR1168385)</li><li>• Cooling System for Thick Plate or Steel Plate (KR1190609)</li><li>• Multiple Injection Type Cooling System for Thick Plate or Steel Plate (KR1167621)</li><li>• Cooling Ability Measuring Apparatus (JP147110/2012)</li><li>• Swirling Nozzle (KR1442647)</li><li>• Apparatus for Processing Nozzle and Method for Processing the Same (KR1334925)</li></ul>	<ul style="list-style-type: none"><li>• Multiple nozzle design technology applying swirl generator</li><li>• Swirl generating nozzle performance assessment technology</li></ul>



# Seawater Desalination System with Small and Medium Capacity Using Solar Energy

Department of Plant Technology    Researcher: Changdae Park    Contact: +82-42-868-7931

Technology Overview

- This technology uses solar energy to desalinate seawater without external energy supply. It can be composed of multi-effect evaporation and reverse osmosis, respectively.

Customer / Market

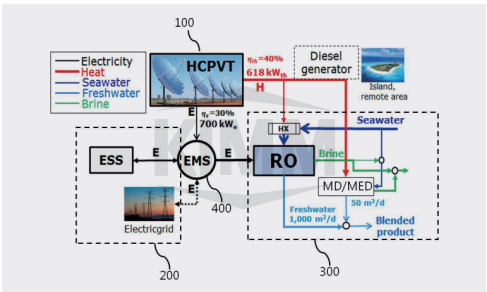
- Islands, the Middle East, Southeast Asia, Africa, etc. where water is scarce and electric power grids are not available.

Problems of Existing Technology or Necessity of this Technology

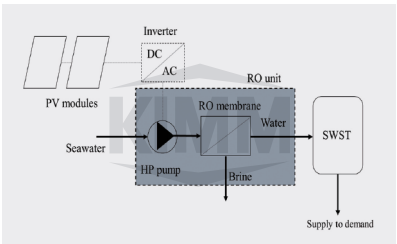
- Reverse osmosis, a general technology of seawater desalination, requires separate electrical energy, consumes a lot of energy, and is difficult to maintain/repair.
- Among distillation methods, large capacity multiple-effect distillation requires expensive initial construction cost and maintenance fee as well as complex maintenance technology, which is not appropriate to be applied in areas having difficulty with energy supply like island areas and underdeveloped areas.
- Existing seawater desalination device using solar heat is the solar still type or uses commercial solar thermal collector and heat exchanger, which accompanies indirect heat collection and heat exchange, resulting in low performance and efficiency.
- In areas with a power grid, it is possible to supply water by building a large-capacity RO plant, but in areas without power grid, it is difficult to build a large-capacity facility, and high construction and operation costs are required. In addition, RO plant has a problem that the water production cost increases significantly as the capacity becomes smaller.
- Therefore, an eco-friendly seawater desalination system is required, which has the lower water cost and better performance than existing desalination method using solar energy.

Technical Distinctiveness

- This invention can desalinate seawater using solar heat and various waste heats so that it generates fresh water when solar radiation is low.
- High freshwater production and thermal efficiency as the energy supplied once is repeatedly used in the next effect by applying multi-effect technology
- Therefore, compared to existing seawater desalination using commercial solar thermal collector, it can increase the fresh water production by 50 to 430% from the same area. The design does not require decompression so that maintenance is easy.
- The installation cost is low as it does not require heat exchanger, commercial solar thermal collector, and heat storage tank but the performance of the apparatus is  $18 \text{ L/m}^2 \cdot \text{d}$ , which is a world-class level.



- In the case of small- and medium-capacity seawater desalination facilities with a daily water requirement of 1 to 1,000 tons, photovoltaic seawater desalination technology (PV-RO) with a novel concept shows the world's best water cost (~1.5 \$/m3).
- Water production and supply are stable in response to year-round changes in insolation and water demand, and the water cost is comparable to that of a large-capacity RO plant using the power grid (1.5 \$/m3 based on 40,000 m3/d).
- Designed to be suitable for small- and medium-scale, it is easy to supply to underdeveloped (remote) regions with technical/economic difficulties.



Excellence of Technology

- Awarded the Excellent Paper Award from the Korean Society of Mechanical Engineers twice and the Solar Energy Society Award for Excellent Paper 5 times
  - Performance and Availability of Seawater Distiller with Heat Pipe Utilizing Low-Grade Waste Heat, 2012 Spring Conference of the Korean Society of Mechanical Engineers
  - Performance Experiment with Heat Flux for Multi-Effect Diffusion Solar Still, 2020 Korean Solar Energy Society Autumn Annual Fall Conference
- Published 16 research papers including 12 SCI papers in addition to the following academic papers:
  - Optimization of battery-less PV-RO system with seasonal water storage tank, Desalination, 2021
  - Model optimization and economic analysis of a multi-effect diffusion solar distiller, Desalination, 2020
  - Development of integrated effect plate for performance improvement of multi-effect diffusion solar still, Desalination and Water Treatment, 2020
  - Experimental study of effects of different heat sources on the performance of the hybrid multiple-effect diffusion solar still, SOLAR ENERGY, 2019
  - Numerical Analysis of the Performance of a Tiltable Multi-effect Solar Distiller, Desalination, 2018
- Parametric performance test of distiller utilizing solar and waste heat, Desalination and Water Treatment, 2014
- Experimental study of distiller with heat pipe utilizing waste heat from a portable electric generator, Desalination, 2012
- Experimental results of a seawater distiller utilizing waste heat of a portable electric generator, Desalination and Water Treatment, 2011
- Distillation utilizing waste heat from a portable electric generator, Desalination, 2010
- Media reports (a total of 34 reports on KBS, MBC, SBS, YTN news, etc.)
  - Development of solar-powered desalination facilities in remote areas, SBS News, (Feb. 26, 2014)/Production of desalinated water in islands and remote areas, Maeil Business Newspaper, (Feb. 27, 2014)/Simplified solar-powered seawater desalination plant construction process, Electronic Newspaper, (May 24, 2012)/Development of low-cost, easy-to-install solar-powered desalination technology, Seoul Economic Daily, (Oct. 18, 2012)/Documentary, Rising Future Industry-Go After Water, YTN Science, (Jan. 29, 2013).

Current Intellectual Property Right Status

PATENT

- Registered 5 overseas patents and 11 domestic patents including Ambient Pressure Type Multi Effect Distiller Using Solar Thermal Energy and Multiple Heat Source (US14/40837676)

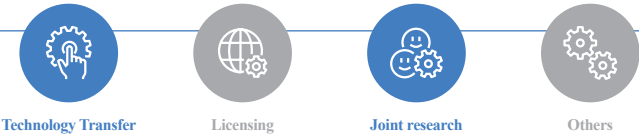
KNOW-HOW

- Design/production technology for seawater desalination using solar heat
- Design technology for solar heat seawater desalination with the lowest water production cost

Technology Readiness Level (TRL)



Desired Partnership



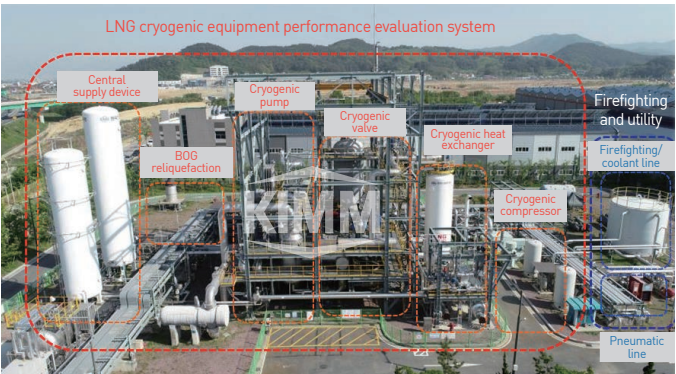


# Test Equipment to Evaluate the Performance and Durability of LNG Cryogenic Equipment and Related Systems

▶ LNG and Cryogenic Technology Center ▶ Researcher: Geuntae Lee ▶ Contact: +82-42-868-9036

## Technology Overview

- Test equipment to evaluate the performance and durability of LNG cryogenic equipment (pumps, valves, heat exchangers, compressors, BOG reliquefaction and cryogenic freezers) and related systems



## Customer / Market

- LNG cryogenic plant and ship companies and related equipment manufacturers

## Problems of Existing Technology or Necessity of this Technology

- LNG cryogenic equipment/systems are expensive parts and are mostly dependent on imports.
- Many domestic companies are developing LNG cryogenic equipment, but there are no test facilities, resulting in low success rate and low delivery performance.
- LNG cryogenic equipment/system is a component that requires reliability, and its soundness needs to be verified through testing.
- Some of the developed parts are being tested by overseas specialized agencies, taking a lot of time and high test costs. There is a very high risk that the core technology developed by domestic companies will be leaked abroad.
- KOLAS is required for the reliability of LNG cryogenic equipment/system test results.

## Technical Distinctiveness

- LNG cryogenic pump performance evaluation system is capable of large flow (3000 m3/h) tests according to ISO standards.
- LNG cryogenic valve performance evaluation system is capable of testing pressure resistance, air tightness and flow coefficient up to 14 inch valves according to ANSI standards.
- LNG cryogenic heat exchanger performance evaluation system has a flow rate of 5 ton/h or less and is capable of a high pressure (35 Mpa) test according to the ASME standard.
- LNG cryogenic compressor performance evaluation system has a flow rate of 6 ton/h or less and is capable of a high-pressure (35 Mpa) test according to standards such as API.
- Cryogenic freezer is capable of re-liquefaction of BOG and refrigerator capable of subcooling LNG and LN2
- Equipment, piping and instruments are configured to enable system performance tests related to LNG cryogenic temperature.

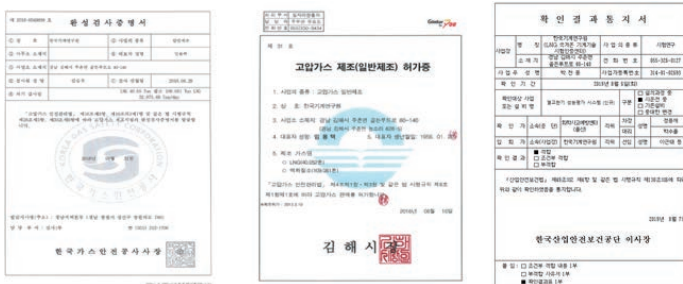
Standard : ISO-13709 second edition 2009 (Centrifugal pumps for petroleum, petrochemical and natural gas industries)	Standard : ANSI/ISA-75.02.01-2008 (Control Valve Capacity Test Procedures)	Standard : ASME PTC 12.5-2000 (Large Pressure Heat Exchangers)	Standard : API 617, VDI 2045, ISO 5389	Cryogenic Refrigerator Performance Test System
<b>Test Scope</b> <ul style="list-style-type: none"><li>• Flowrate : 0 ~ 3,000 m³/h</li><li>• Design Pressure : 2.0 Mpa.A</li><li>• Temperature : -163 °C</li><li>• Voltage : 6,600 V, 440&amp;380 V</li></ul>	<b>Test Scope</b> <ul style="list-style-type: none"><li>• Flowrate : 0 ~ 1,000 m³/h</li><li>• Valve Diameter : 1 ~ 14 inch</li><li>• Pressure : 3.0 Mpa.A</li><li>• Temperature : -196 °C</li></ul>	<b>Test Scope</b> <ul style="list-style-type: none"><li>• Test fluid : LNG, LN<sub>2</sub>, Ethylene-Glycol &amp; Water</li><li>• Flowrate : 0 ~ 6 Ton/h (LNG)</li><li>• Pressure : 35 MPa.A (High side), 3 MPa.A (Low side)</li><li>• Temperature : -196 °C</li></ul>	<b>Test Scope</b> <ul style="list-style-type: none"><li>• Test fluid : LNG, LN<sub>2</sub></li><li>• Flowrate : 0 ~ 6 Ton/h (LNG)</li><li>• Pressure : 35 MPa.A (High side), 3 MPa.A (Low side)</li><li>• Temperature : -196 °C</li></ul>	<b>Test Scope</b> <ul style="list-style-type: none"><li>• Standard : KS B 6270</li><li>• Test fluid : LNG, LN<sub>2</sub></li><li>• Flowrate : 0 ~ 3 Ton/h (LN<sub>2</sub>)</li><li>• Pressure : 3 MPa.A</li><li>• Temperature : -208 °C</li></ul>
<b>Test Item</b> <ul style="list-style-type: none"><li>• Flowrate, Head, NPSH, Efficiency, Vibration test, and etc.</li></ul>	<b>Test Item</b> <ul style="list-style-type: none"><li>• Flow Coefficient, Reliability Test, Pneumatic Pressure, Leakage, and etc.</li></ul>	<b>Test Item</b> <ul style="list-style-type: none"><li>• Heat Transfer, Heat Transfer Coefficient, Pressure Drop, Reliability Test, and etc.</li></ul>	<b>Test Item</b> <ul style="list-style-type: none"><li>• Flowrate, Pressure Ratio, Efficiency, Vibration test and etc.</li></ul>	<b>Test Item</b> <ul style="list-style-type: none"><li>• Flowrate, Capacity, COP, Vibration, Reliability Test and etc.</li></ul>



◁ Performance Evaluation System Specifications for LNG Cryogenic Pump, Valve, Heat Exchanger, Compressor and Refrigerator ▷

## Excellence of Technology

- As LNG is flammable and cryogenic (-163°C) and LN2 is cryogenic (-196°C), it is designed in consideration of domestic high pressure (Korea Gas Safety Corporation) and explosion-proof (KOSHA and PSM Report) regulations.



KGS approval

◁ Certificate of Completion Inspection by the Korea Gas Safety Corporation ▷

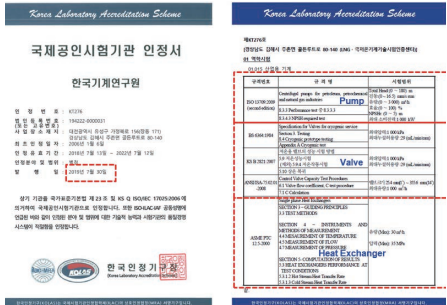
Gimhae city permit

◁ High-Pressure Gas Manufacturing License ▷

PSM result

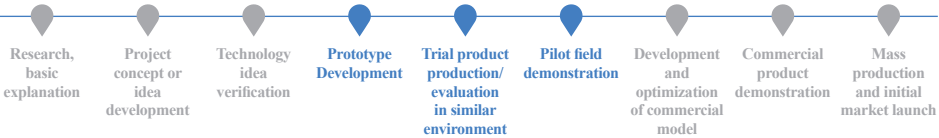
◁ Verification of PSM Report ▷

- All test facilities are designed to be variable to meet the test conditions, and all data are electronically measured to prevent human error.
- Professional researchers who have studied cryogenic temperatures for a long time designed the test equipment, and professional researchers performed accurate tests.
- In order to secure the reliability of test results, KOLAS has been obtained and a PSM report system is in operation for safe operation of test facilities.



◁ Accreditation by KOLAS ▷

## Technology Readiness Level (TRL)



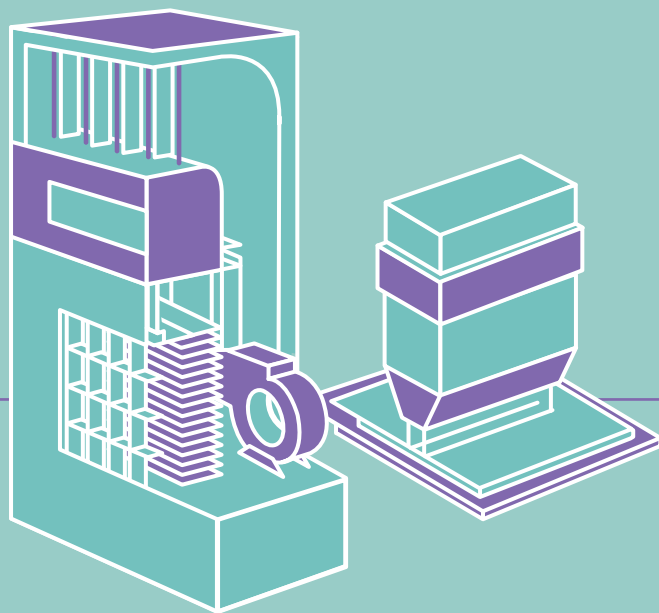
## Desired Partnership





# 4

## Environment System Research Division



FILTER-FREE INDOOR  
AIR PURIFICATION  
TECHNOLOGY /  
REMOTE PLASMA  
GENERATOR

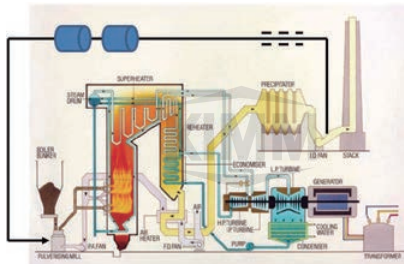
- 248 • Department of Environmental Machinery
- 268 • Department of Clean Fuel & Power Generation
- 280 • Department of Engine Research
- 294 • Department of Plasma Engineering

# Coal Combustion System Including Pulverizer

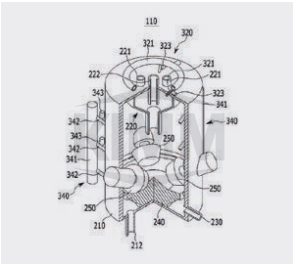
Department of Environmental Machinery    Researcher: Sangin Keel    Contact: +82-42-868-7336

Technology Overview

- Combustion technology for fire prevention of pulverized coal in supply equipment in coal-fired power plant



Fire Prevention Concept Map for Pulverizer



Basic Map for Pulverizer Fire Prevention-Related Patent

Customer / Market

- Power plants and energy facilities using pulverized coal and biomass as energy resource

Problems of Existing Technology or Necessity of this Technology

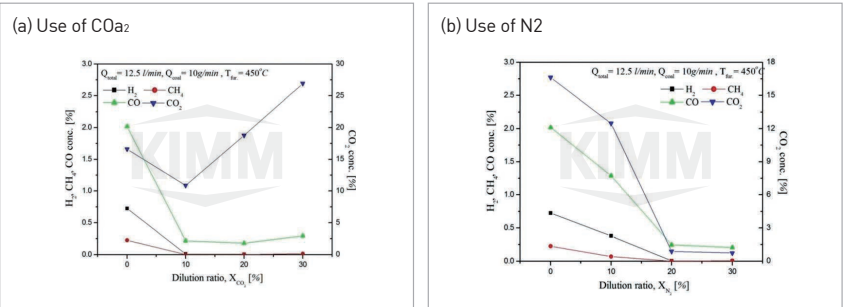
- The risk of fire is very high when pulverizing low-grade coal or biomass.
- There is no general method to prevent or control coal-pulverizer fire without large amount of steam or carbon dioxide injection.
- In case of occurrence of fire, some or all of power plants must be shut down for a long time, and the economic loss thereof is very large.

Technical Distinctiveness

- Secure the safety of plants facility operators from the coal-pulverizer fire
- Minimize economic loss caused by the stop of pulverized fuel supply and power generation facility shutdown
- Utilize various fuel types including low-grade coal and biomass as fuel for thermal power plants
- Reduct cost of supplementary facility and operation for pulverizer fire suppression
- Specify fire igitnion points in the pulverizer, and intensively control the area using inert or exhaust gas
- With continuous control of local oxygen concentration of fire ignition area in the coal pulverizer, suppress the ignition and explosion during coal-pulverizer operation.

Excellence of Technology

- Temperature change was measured inside the coal-pulverizer according to the concentration of inert gas.
- As a result of the experiment measuring for temperature and numerical simulation of the pulverizer, fire ignition area can be specified.
- Unexpected fire ignition and explosion can be prevented by the control of fire ignition area.



Effect of Inert Gas injection for fire suppression



Coal-pulverizer shape



Image of Fire ignition moment in Pulverizer

Image of Fire ignition in Pulverizer and Control with Inert Exhaust Gas

Current Intellectual Property Right Status

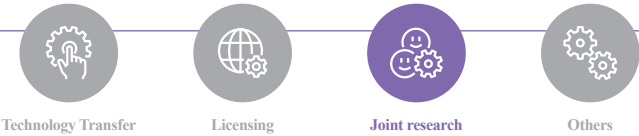
PATENT

- Pulverizer and Coal Burning System (KR1355691)
- Self Fire Controlled Pulverizer and Coal Burning System (KR1281062)

Technology Readiness Level (TRL)



Desired Partnership

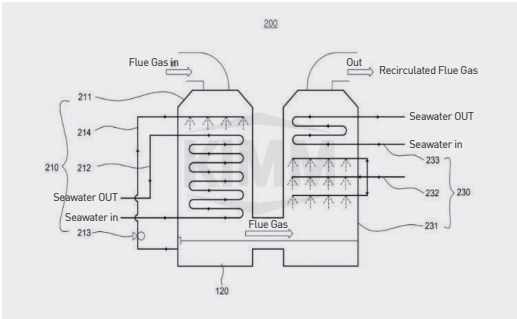


# Simultaneous Flue Gas Condensing and Sulfur Oxides Removal

▶ Department of Environmental Machinery ▶ Researcher: Sangin Keel ▶ Contact: +82-42-868-7336

Technology Overview

- Technology to remove moisture and sulfur oxides in flue gas simultaneously : condensing water from gas cooling and sulfur oxides removal using condensated water



Customer / Market

- Thermal power plant, electronic and chemical process facilities

Problems of Existing Technology or Necessity of this Technology

- By combining condensation and sulfur oxides removal as one process and using condensated water as process water, the additional waste water can be reduced.
- For conventional gas cleaning techniques, a large installation area and high equipment cost are required, and a generation of large amount wastewater are unavoidable.
- For the application of CCS (CO2 capture & storage) technology and FGR(flue gas recirculation), water condensing and sulfur oxides removal the facilities must be considered.

Technical Distinctiveness

- Compared to installing each individual facility, system area and its cost can be reduced by 1/2 or more by installing an integrated system with simultaneous removal technology.
- It can be applied to the existing plant without major process change.
- It is easily adatable to various coal properties and process changes introduced in Korea.
- Water and energy consumption can be reduced to less than 1/10 by using seawater.
- By using condensated water for removing a sulfur oxide, additional wastewater treatment process is not necessary.

Excellence of Technology

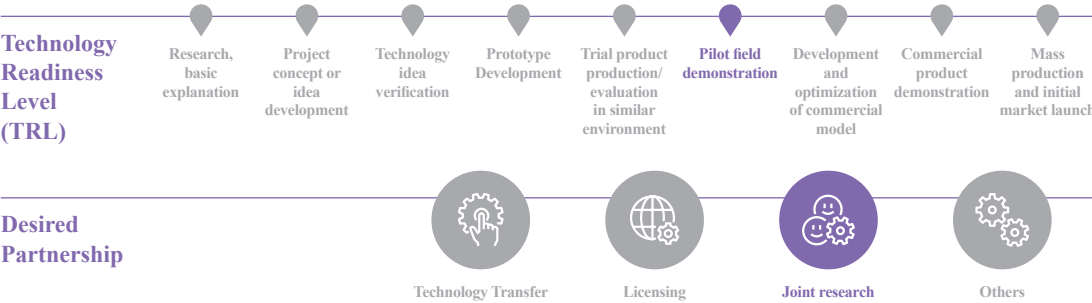
- This technology was adopted to pilot-scale Oxy-PC thermalelectric power plant.
- Moisture in flue gas was condensed using seawater, and pH of the condensed water is controlled and reused as spraying water to increase the effects of moisture condensation and sulfur oxides removal.
- The moisture content in the flue gas can be reduced from 25% to 4%. Its condensation effect can be maximized by using condensed water together with seawater.
- Operation with low sulfur and water contents of recirculating gases solves the problem of damage by corrosion and water related combustion efficiency.
- Applied to the 0.7 MW Oxy-PC pilot plant, function and efficiency of the technology were confirmed.



Current Intellectual Property Right Status

PATENT

- 2-path Fuel Gas Condenser for Sulfur Oxide Cleaning (KR1282918)



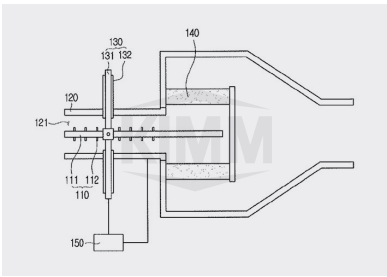


# Diesel Particulate Filter Using Metallic Filter Combined with Electrostatic Agglomerator

▶ Department of Environmental Machinery ▶ Researchers: Yongjin Kim, Hakjoon Kim ▶ Contact: +82-42-868-7475, 7775

Technology Overview

- Diesel particulate filter (DPF) using a metallic filter combined with an agglomerator in which ultrafine diesel particles are electrically charged by the corona discharge, collected in a grounded electrode and agglomerated until they are intermittently scattered by unexpected sparks and vibration.



Customer / Market

- DPF market for diesel vehicles, marines, diesel engines for power generation

Problems of Existing Technology or Necessity of this Technology

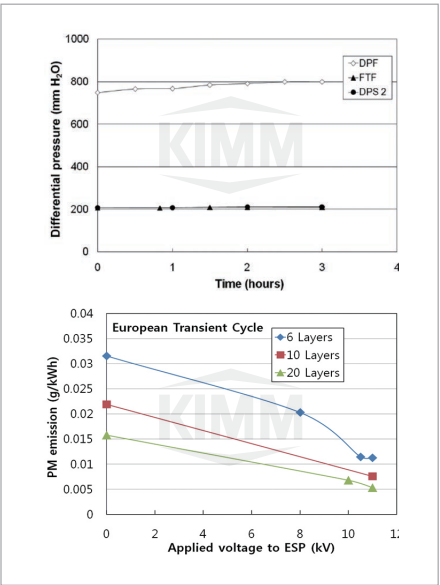
- It is necessary to develop an electrostatic filter with high thermal and mechanical durability and less pressure loss.
- A combination of a metallic filter with an electrostatic method with excellent ultrafile PM collection efficiency based on PM number concentration is necessary to increase low efficiency of the metal filter.
- Current ceramic filter type DPFs have a high pressure loss and low thermal and mechanical durability. A metallic filter has lower pressure loss and higher thermal and mechanical durability compared to a ceramic filter, but its PM collection efficiency is low less than 70%. In particular, it can not capture ultrafine particles with a size below 50 μm
- A low pressure drop filtration technology based on a metallic filter with high thermal and mechanical durability and higher ultrafine PM collection efficiency is necessary especially for high volumetric diesel engines.

Technical Distinctiveness

- Combination of a metallic filter with an electrostatic precipitation method can solve problems of the current ceramic and metallic filters. The electrostatic method charges nm-sized particles and agglomerates the small particles on the collection surfaces up to micro size. The metallic filter can remove the enlarged particles easily when they are escaped from the collection surface of the electrostatic agglomerator. This combination is very efficient against nm size particles with low pressure loss, high thermal and mechanical durability
- Existing DPFs using a metallic filter has a great durability, and it was considered as an alternative to a ceramic filter, but it could not collect nm-sized particles, therefore it could not meet the diesel PM emission regulation over Euro 6 standard and could not fulfill the regulation regarding number concentration standard at all.
- A combined metallic filter with the electrostatic agglomeration is a novel convergence technology that electrically collects ultrafine particles and agglomerate them into a size that could be treated by a metallic filter to make use of the benefits of the metallic filter as well as to meet particle number concentration regulation.

Excellence of Technology

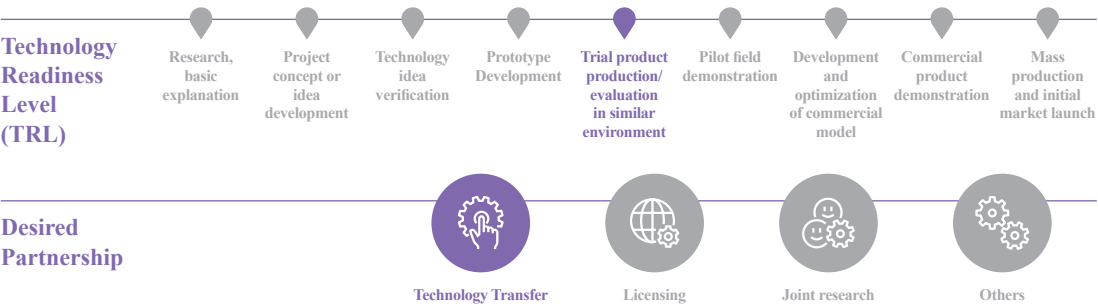
- An agglomerator with a corona charger and a collector is installed in front of the metallic filter to electrically collect ultrafine particles in the agglomerator. The particles collected in it continue to grow by the electrostatic cohesion, and once they are coarsened, they are scattered by electrical and physical shock into the downstream of the electrostatic agglomerator, and the larged particles are collected in a metallic filter installed in the downstream of the agglomerator.
  - The novel metallic filter shows a 1/4 of pressure loss compared to a ceramic filter, and is able to reduce the PM emission under the ETC mode operation for international standard, which is 1/3 of that of a metallic filter. And over 95% of the number concentration emission is removed.
- By publishing 3 SCI papers in 'IEEE Transactions on Industrial Applications' and 1 paper in Transactions of the Korean Society of Automotive Engineers, the excellence of the technology was proven.
- The researchers has over 20 years of research experience.
  - 10th Outstanding Environmental Technology Award (2012, Ministry of Environment)
  - 2012 KSME Technology Award
  - Director of Environment Systems Research Division in KIMM (2008 to 2011)
  - Vice-chairman of Korean Association for Particle and Aerosol Research (2008 to 2012)
  - Vice-chairman of KSME (2011 to present)



Current Intellectual Property Right Status

PATENT

- Metal Filter Particulate Matter Removal System Using Centrifugal and Electrostatic Forces (KR0865152) / Automatic Regeneration Electrostatic Automobile After-treatment System with Electrical Heater (KR0998445) / Electrostatic Precipitator with Structure for Insulating and Fixing Electrode Rod (KR1066018) /Apparatus for Purifying Exhaust Gas (KR1152337) / Oxidation Catalytic Apparatus for Purifying Exhaust Gas (KR1166688) / Exhaust Gas Reduction Apparatus Comprising Electric Heating Type Foam Filter (KR1218587) / Electric Charging Type Purifying Exhaust Gas (KR1339085) / Diesel Particulate System Using of Electrolytic Protection Type Diesel Particulate Filter (KR1383309) / Electrostatic Filtration Device with Foam Filter and Rod Type Electrode Combined with Wire (KR1453498)

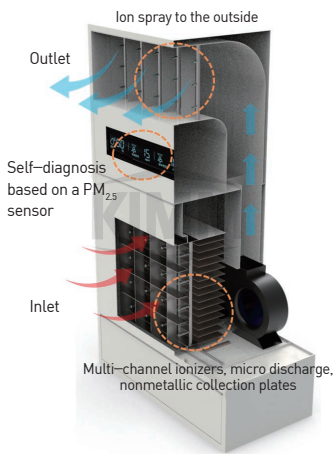


# Filter-Free Indoor Air Purification Technology

▶ Department of Environmental Machinery ▶ Researchers: Hakjoon Kim, Bangwoo Han ▶ Contact: +82-42-868-7775,7068

Technology Overview

- This air cleaner has been developed by two-stage electrostatic precipitation technology using non-metallic collection plates coated by carbon and plastic materials and fine discharge electrodes such as micrometer fiber bundles. This air cleaner generats almost zero ozone due to the micrometer sharpness and multiple electrodes. Also, this air cleaner is very useful especially to purify a large-area indoor very fast because of its extremely low pressure drop for high air flow rage. Finally, this informs an exact and scientific cleaning time by performing self-diagnosis with a PM2.5 sensor and a computing algorism.



Customer / Market

- HVAC systems for indoor air quality, Air cleaners and air conditioners for public sectors such as subways, daycare centers, and schools, Air cleaning facilities for commercial sectors such as restaurants, department stores, and supermarkets

Problems of Existing Technology or Necessity of this Technology

- A large scale indoors such as subway platforms and waiting rooms are almost open space to the outdoors because of frequent entry and exit by citizens, so the technology to purify the large open space is extremely difficult.
- HEPA (high efficiency parriculate air) filters and ESPs (electrostatic precipitators) are used to remove PM2.5 indoors. However, HEPA filters cost a lot because of frequent replacements by dust contamination on the filters causing high pressure drop. Also, typical metallic ESPs generate a large amount of ozone to increase the removal efficiency against ultrafine particles.

Technical Distinctiveness

- This technology reduces the cost of the device by using light materials such as non-metallic plastics and carbon. Also, almost no ozone less than 5 ppb is generated due to micro-fiber discharge and ion spray to indoor space.
- In addition, it has a filter-free structure for low back-pressure, so it is possible to clean a large amount of polluted air in a short time. Therefore its removal performance is better more than 1.5 times than that of the filter method.

- In particular, an intelligent computing device which calculates the exact cleaning time on collection plates is developed by using a low cost PM2.5 sensor and a computing algorism that its removal performance (Clean Air Delivery Rate) is periodically compared to its initial performance by PM concentration data from the PM sensor. Due to the algorism, the air cleaner alarms its cleaning time when the performance value falls below a certain limit.

Excellence of Technology

- The filter-free, high-capacity air purifier generates almost no ozone under the conditions of 2 m/s and -12 kV when the efficiency is over 95 %, and the electricity consumption is very low less than 10 W.
- In addition, the pressure loss is very small at 1/10 or less compared to the HEPA filter, and the filter qulity factor that is the filter efficiency divided by its pressure drop is 15 to 68 times better than those of filters.
- From performance test results with the first prototype, the air cleaning performance was improved by 20 % by adding ion spray to indoor space, and a maximum application area of 264.5 m2 was achieved. This improvement means that the number of air cleaners for an indoor room can be reduced by 1.7 times with the novel ESP air cleaner, compred to a typical air cleaner with a HEPA filter.



Current Intellectual Property Right Status

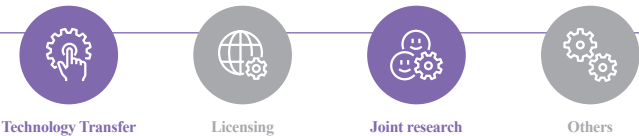
PATENT

- Air Purifier Using Carbon Fiber (KR937944)
- Particle charger using carbon fiber (KR849674)
- Air cleaner calculating information for its cleaning area (KR2171703)
- Electrostatic precipitator for compact air cleaner and compact air cleaner using thereof (KR2002127), etc.

Technology Readiness Level (TRL)



Desired Partnership

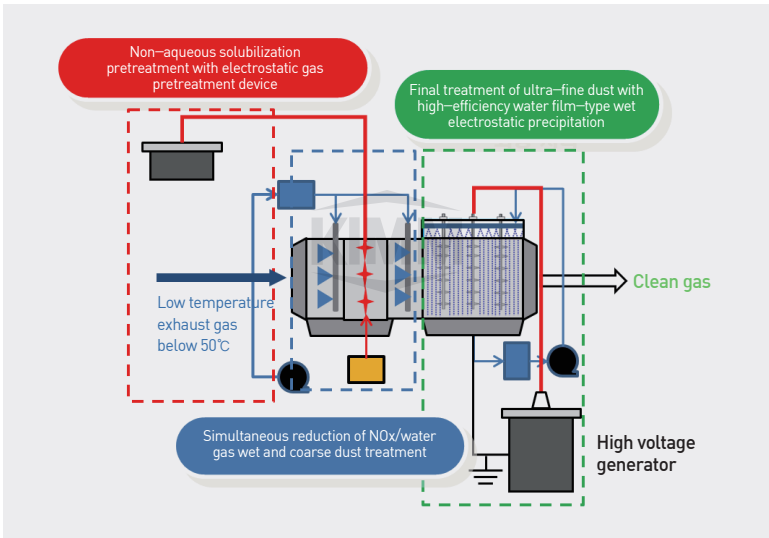


# Simultaneous Reduction of Harmful Gas and Ultrafine particulate matters

▶ Department of Environmental Machinery ▶ Researchers: Hakjoon Kim, Bangwoo Han ▶ Contact: +82-42-868-7775,7068

## Technology Overview

- Development of technologies for simultaneous reduction of gases and fine particulate matters using electrostatic
- Development of the world's first commercialization technology using electrostatic methods to simultaneously reduce gas and particulates generated from industrial factories and manufacturing processes



## Customer / Market

- Thermal power plants, general manufacturing industries and processes, IT manufacturing industries

## Problems of Existing Technology or Necessity of this Technology

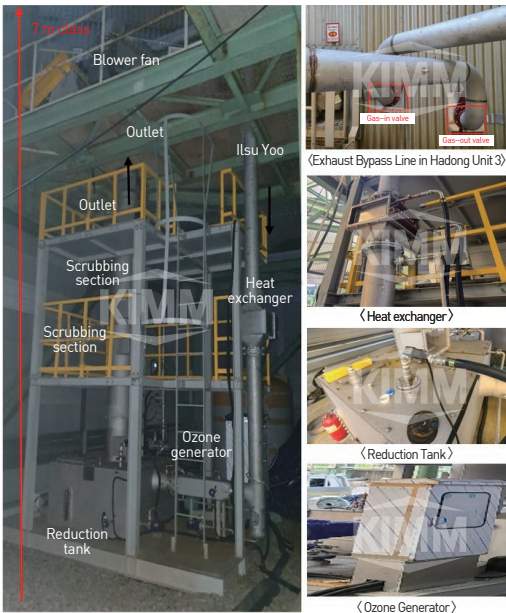
- Domestic particulate matter emissions account for the highest rate of over 40 % at worksites, and are continuously increasing.
- Current gas cleaning and fine particle removal technologies have disadvantages to cost a lot and to need large installation area because of usage of the separate devices against each pollutatns such as scrubber, SCR, electrostatic precipitator, and bag filter etc.
- In particular, the semiconductor industry is a representative industry that discharges various air pollutants such as SOx, NOx, HF, and PM2.5, and spends massive costs for exhauge gas cleaning facilities.

## Excellence of Technology

- The world's first technology to simultaneously reduce particulate and gaseous air pollutants such as NOx/SOx/HF/PM2.5 by using the combination method of electrostatic oxidation, wet reduction, and wet electrostatic precipitation has been commercialized for the semiconductor manufacturing industry. Also, demonstration research for thermal power plants has been performed using real exhaust gas.
- Development of technology for simultaneous reduction of pollutants such as SOx/NOx/HF/PM2.5 by using electrostatic radicals and novel additives to absorbe multiple gases in water
- Development of a water-film type wet electrostatic precipitator that removes the fine mist and particles as a final stage gas cleaning unit

## Technical Distinctiveness

- Confirmation of simultaneous reduction performance more than 95 % of SOx/NOx/PM2.5 with room temperature real exhaust
- Reinforcement of international competitiveness of domestic environmental technology by commercialization of high-efficiency reduction technology against NOx and fine particles even with room temperature exhaust with which current temperature-dependent catalytic method over 250°C or higher is not working
- Expected to dramatically improve the maintenance cost and to reduce installation area by the integrated system of removing multiple air pollutants
- Completion of demonstration research on a thermal power plant and commercialization for IT manufacturing processes



◁ Demonstration of Thermal Power Plant ▷

## Current Intellectual Property Right Status

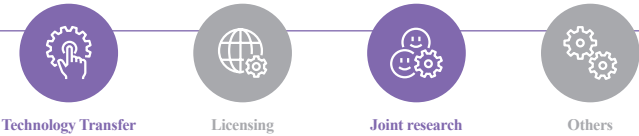
### PATENT

- Electrostatically Integrated System for Treating Pollution Gas (KR1448881)
- EApparatus for Treating Exhaust Gas of Semiconductor Manufacturing Facility (KR2145661)
- Cylinder Type Wet Electrostatic Precipitator (KR2080979), etc.

## Technology Readiness Level (TRL)



## Desired Partnership



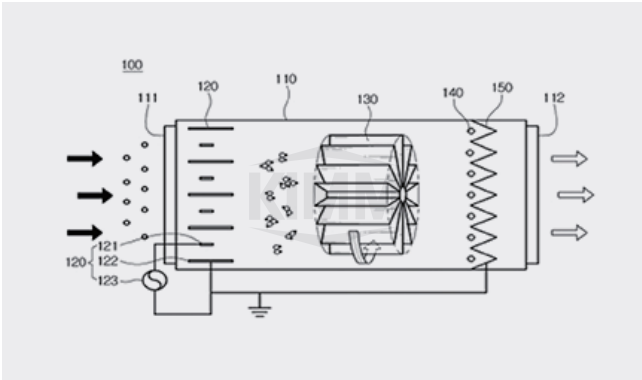


Oil Mist Eliminator

▶ Department of Environmental Machinery ▶ Researchers: Yongjin Kim, Hakjoon Kim ▶ Contact: +82-42-868-7475, 7775

Technology Overview

- An optimal oil mist eliminators against fine mists by combining unipolar charging, centrifugal and electrostatic collection methods



Customer / Market

- Machining industry using processes such as cutting, grinding, and cleaning, food disposal facility, odor control market

Problems of Existing Technology or Necessity of this Technology

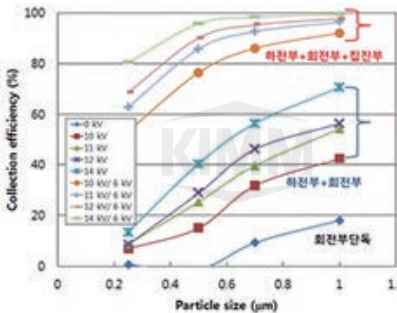
- Oil mist is very fine. So it is spread in the air fast, and the machine operator inhales the fine mists.
- Inhaling oil mist reduces the work efficiency, and if serious, it sticks to the body of the operator or the machine or products. Due to this issue, an oil mist collector is installed at the work area.
- A collection apparatus using filters collect the oil mist through the fibrous media to separate oil mist from the air.
- A collector using the filter is easy to install and inexpensive, but the filter needs to be replaced periodically, and due to frequent filter blocking, it is difficult to maintain a constant amount of air going through the filter. Also, the replaced filters are treated as industrial waste, and its treatment is also an issue.

Technical Distinctiveness

- The collected oil mist does not stick to the collection surface, so separate cleaning process is not necessary.
- Fine oil mists can be agglomerated in the charging stage.
- Due to the fine oil mist treatment in the charging stage, overall efficiency is enhanced and pressure loss is very low.
- Electrically charged oil mists are collected on the collection surface, the oil mists are agglomerated on the surface, and falled by their gravity as they became heavy.
- By electrically charging oil mists in the first stage and then mixing them with ions in rotating blades in the second stage, very small oil mists which are not removed by centrifugal force in the ratating zone but charged are removed by the third electrostatic precipitation stage to improve the oil mist removal efficiency.

Excellence of Technology

- Entrance: Polluted gas with oil mists enters
- High voltage generator: High voltage applied to the device
- Charger: Unipolar charges are attached to oil mists in the polluted air in the first charging stage. Some oil mists are collected.
- Rotor: Second stage after the charging stage. Mixing the polluted gas with multiple blades, so oil mists separated from the air due to inertial impact are collected on a wall, and uncollected fine oil mists and unipolar ions are mixed in the ratating zone to become charged mists.
- Collector: Electrically charged fine oil mist, which are not collected in the charger and the rotor, are collected by the final electrostatic force in the third stage.
- Exhaust Exhaust: Air separated from oil mist is discharged to outside



〈 Oil Mist SizeDistribution 〉

Current Intellectual Property Right Status

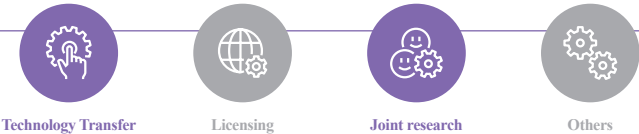
PATENT

- Apparatus for Collecting Oil Mist (KR0344758)
- Apparatus for Collecting Oil Mist Using Unipolar Charging, Centrifugal Method (KR1157822)
- Apparatus for Collecting Oil Mist (KR2013-0031869)
- Apparatus for Treatment of Oil Mist (KR1486887)
- Apparatus for Collecting Oil Mist (KR1471976)

Technology Readiness Level (TRL)



Desired Partnership



# Micro Bubble Generation Technology and Its Devices

▶ Department of Environmental Machinery ▶ Researchers: 홍원석, Taejin Min ▶ Contact: +82-42-868-7354, 7938

Technology Overview

- Micro bubble generator using pressurized dissolution and vortex method and an ozone micro bubble generation system

Customer / Market

- Water resources area to improve water quality (lake, reservoir, etc.)/Water treatment area including sewage and wastewater treatment/Disinfection and sterilization devices (connected to the ozone system or culture solution for plant factories, etc.)/Cleaning area for IT, industrial, and medical appliance sector



Problems of Existing Technology or Necessity of this Technology

- Micro bubble generation technology requires high concentration and size consistency with relatively low-pressure operational conditions.
- Traditional micro bubble generation technologies are insufficient of bubble concentration and operational condition. It is also recognized as inefficient devices due to excessive energy consumption.
- Due to the lack of a micro bubble measurement method and equipment, quantification of bubble size and concentration is insufficient. It has not been developed for large-scale micro bubble generation, making it difficult to apply in a various sectors.
- Various studies and researches of micro bubble generation are being conducted in the world and commercialized mainly in Japan in the aquaculture sector (seawater application), it is still needed to appropriate micro bubble generation technology for adopting various fields and sectors.

Technical Distinctiveness

- Developed the most advanced micro bubble generation technology developed various types of micro bubble generation technology and apparatus
- Optimal micro bubble generation system can be applied for each subject./Develop micro bubble systems for 1, 2, 5, 20 hp and a prototype is complete.
- A micro bubble measurement device provides accurate bubble size, size distribution, and bubble concentration. The economic feasibility of micro bubble generation technology is secured by using a low pressure operating condition.
- At a low-pressure operating condition, high gas-to-liquid ratio and high concentration micro bubble generation technology is realized./It can be generated stable and continuous micro bubbles with low pressure operational conditions by optimizing solubility as well as gas to liquid mixing.
- Low-cost, high-efficiency, energy-saving micro bubble generation system below 4 kgf/cm<sup>2</sup> pressure condition is realized./Realized the technology for generating over 100,000 ea/ml high concentration micro bubble./Micro bubble generating factor is quantified using accurate size measurement./Realized the technology to generate micro bubbles in different sizes for different application and the technology to operate various conditions with high gas to liquid ratio.

Excellence of Technology

- The study team's differentiated micro bubble generation system is as follows: A high-concentration solution is delivered from the nozzle by a high-efficiency gas-liquid mixing device or separator.
- Pressurized dissolving and vortex type nozzles produce a high concentration of micro bubbles.
- The technology's superiority was demonstrated by papers at associated societies.

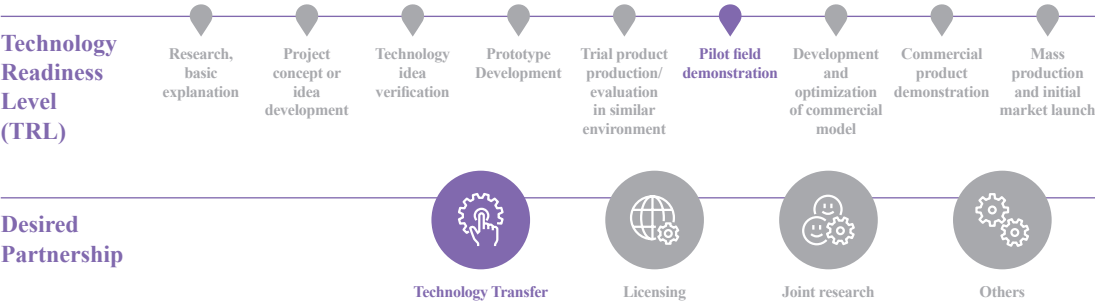


〈 Application of Ballast Water Sterilization Treatment System 〉

Current Intellectual Property Right Status

PATENT

- Device for Generating Bubble Using Dissolution Tank Capable of Controlling Water Level (KR1284267)
- Device for Generating Micro and/or Nano Bubble Based on Circulation Unit with High Solubility of Water (KR1284266)
- Device for Generating Micro Bubble Based on Circulation Unit (CN201180018438.7, JP2013-504845, US13/637730, IDW-00201204174)
- Apparatus for Cleaning Sterilization and Method Thereof (KR1225492)
- Mobile Type River Remediation Treating System Using Micro Bubbles (KR1136390)
- Membrane Filter System Having Function for Preventing Fouling (KR1270647)
- Cross-flow Filtration System Using Micro or Nano-sized Bubble (KR1157477)
- Apparatus for Treating Hybrid Non-biodegradable Wastewater Based on the Circulation of Ozone Water Comprising Ozone Bubbles (KR1144704)
- Device for Generating Micro Bubble and Pipe Using the Same (KR1178781)
- A Device for Generating Micro Bubbl (KR1178782)
- Ballast Water Treatment Apparatus Based on Plasma Discharging Using Micro Bubble (KR1191146)
- Ballast Water Treatment Apparatus Based on Electrolysis Using Micro Bubble (KR1191147)
- Ballast Water Treatment Apparatus Discharging Using Micro Bubble (KR1225491)
- Apparatus for Cleaning Sterilization Using Micro Bubble Generator (KR1238349)
- Apparatus for Generating Micro Bubble Using Flexible Ball (KR1176463)
- Micro and/or Nano Bubble Generating Device of Rotary Type (KR1340961)
- Device for Generating Micro and/or Nano Bubble Using Blade (KR1340962)

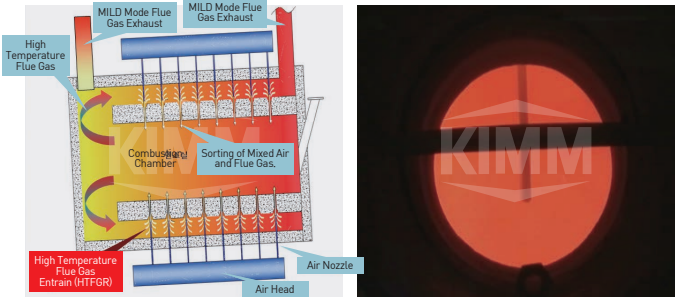


# Low Pollution Combustion Technology Using High Temperature FGR with a Nozzle with the Coanda Effect

▶ Department of Environmental Machinery ▶ Researcher: Sunghoon Shim ▶ Contact: +82-42-868-7349

Technology Overview

- Technology of mixing high-temperature flue gas with combustion air by nozzle of Coanda effect to lower the oxygen content while heating it to a higher temperature to make MILD combustion for superlow-NOx emission



Customer / Market

- Combustor/industrial furnace/incinerator/thermal power generation

Problems of Existing Technology or Necessity of this Technology

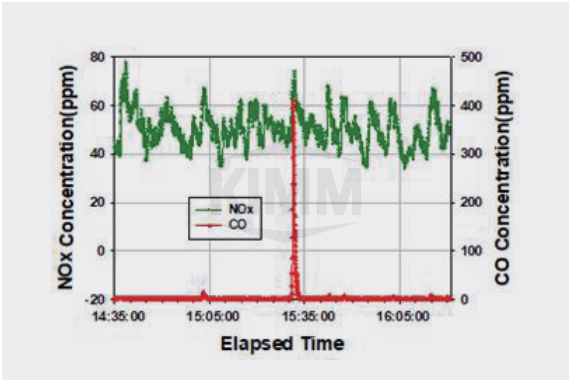
- An air nozzle combined with the Venturi type tube was used to mix high temperature combustion gas with air jet to reduce carbon monoxide (CO) and nitrogen oxides (NOx) simultaneously.
- However, for this method, the center of the air nozzle and the Venturi tube needs to be combined in a straight line, and the Venturi tube has to be of a certain length to generate negative pressure to induce high-temperature combustion gas, and because of this, the combustor wall has to be thicker.
- When the combustor wall becomes thicker, the width of the passage where hightemperature combustion gas flow and the width of the entire combustor increases, which means the area for installation has to be increased. And this leads to a higher cost.

Technical Distinctiveness

- By mixing high-temperature combustion gas with combustion airjet by a simple structure without increasing the wall thickness, reduction of NOx and CO becomes easier. With the NOx reduction effect of 80% for gas fuel and 40% for solid fuel, the installation and operation cost of the post treatment facility can be saved.
- No previous technology case of using a nozzle of Coanda effect for recirculation of high-temperature combustion gas was found.

Excellence of Technology

- The NOx and CO reduction effect in the combustion furnace with the air nozzle and Venturi tube has been proven, and the nozzle with Coanda effect was produced, and it was confirmed that the induction of combustion gas was effectively done.
- MILD combustion-applied incinerator and pellet heat technology transfer for commercialization is in the process.
- As a result of applying this technology to waste incineration, it is confirmed that NOx concentration can be maintained below 50 ppm (@12% O2) without using SNCR.
- Compared to conventional combustion, the excess air ratio can be reduced significantly to within 10% that it can reduce thermal loss and improve thermal use efficiency.
- By decreasing the peak temperature inside the combustor, ash melting and adherence is prevented to reduce damage of the incinerator wall and repair time.



Current Intellectual Property Right Status

PATENT

- Low Pollutant Emission Combustion Using High-temperature FGR (KR1133434)
- Low Pollutant Emission Combustion Using High-temperature FGR and Nozzle of Coanda Effect (KR1289411)
- Super Low-NOx Emission Combustion Apparatus Using Coanda Effect (KR1320406, PCT/KR2013/011796)
- Pellet Combustion Device and Method for Low-emission (KR1471636)
- Super-low NOx Emission Combustion Apparatus Using Coanda Effect (KR1453859)

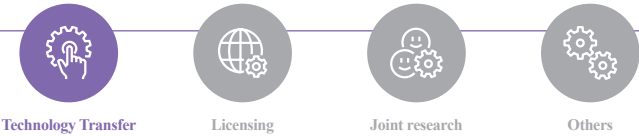
KNOW-HOW

- Optimal Coanda nozzle design technology to increase the FGR rate
- Optimal FGR Coanda nozzle arrangement technology to maximize NOx reduction effect
- Horizontal and vertical combustion furnace design technology for super-low NOx emission during combustion

Technology Readiness Level (TRL)



Desired Partnership



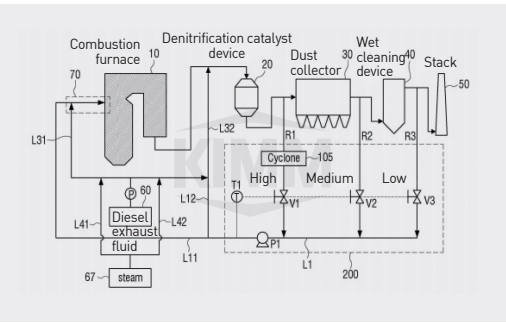


# Intelligent Nitrogen Oxide Control Technology Using Multi-Stage Combustion Gas Recirculation

▶ Department of Environmental Machinery ▶ Researchers: Sangin Keel, Jinhan Yoon ▶ Contact: +82-42-868-7336, 7528

Technology Overview

- Intelligent Nitrogen Oxide control system using multi-stage combustion and flue gas recirculation is a technology that can suppress the formation of air pollutants in thermal power plants and incinerator.
- Flue gas recirculation (FGR) is a technology that circulates the flue gases generated from the combustion furnace back into the furnace to control the concentration of oxidizer in the supply air in the furnace, ultimately lowering the concentration of NOx.
- By integrating FGR and multi-stage combustion technology, it can have the effect of preventing overheating of furnace temperature and dispersing the local high-temperature area, thus suppressing the total amount of NOx generated.
- An intelligent NOx control system has been developed by measuring supply air, furnace temperature, and flue gas concentration that affects the generation of NOx in real time and controlling operation conditions to minimize NOx concentration.



Customer / Market

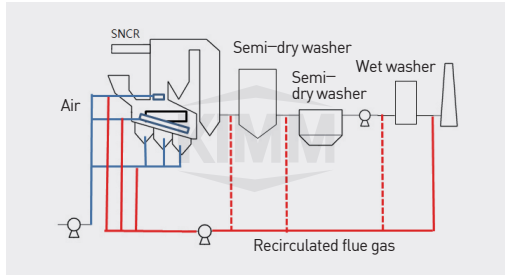
- Renewable energy facilities and power plant facilities
- Widely applicable to combustion fields such as steel mills and heat treatment facilities

Problems of Existing Technology or Necessity of this Technology

- Control NOx and SOx which can cause ultra-fine particle (PM 2.5)
- Increasing burden to control the concentration of NOx emission due to the strengthened environmental laws
- It is difficult to meet the strengthened NOx emission standards with the conventional selective non-catalytic reduction (SNCR) technology.
- Economic cost for the installation of selective catalytic reduction (SCR) facility

Technical Distinctiveness

- Minimize NOx emission concentration through furnace temperature control and FGR technology
- Distribute and control the amounts of primary and secondary supply air and recirculated flue gas
- Integrate the technology of optimal operation, multi-stage combustion, FGR, and SNCR

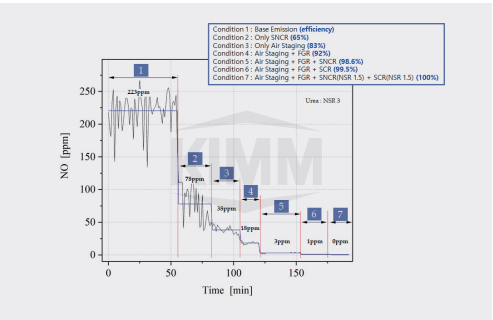


◁ Conceptual Diagram of Staged FGR Control Technology ▷

Excellence of Technology

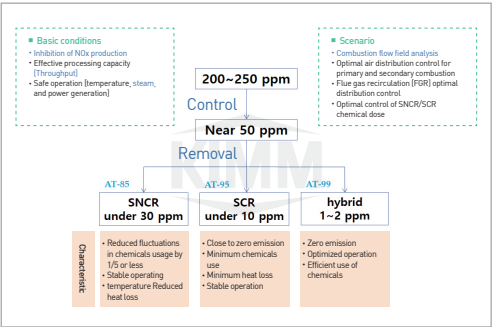
- Multi-stage combustion and FGR → NOx reduction by more than 90%
- Extension of operating time and suppression of clinker generation
- Prevention of high-temperature damage to equipment
- Lifespan extension of refractory materials
- Cost reduction by reducing urea/ammonia usage
- Reduction of the total amount of NOx emission and flue gas

◁ Results of Suppression of NOx Generation by Developing and Applying Intelligent NOx Control Technology ▷



- Stable production of steam
- Possible to reduce NO concentration below 30~10 ppm (data on the right)
- This technology has been applied to two facilities in Chungnam and Gyeongbuk provinces.

◁ Scenario of NOx Reduction Using This Technology and Its Characteristics ▷



Current Intellectual Property Right Status

PATENT

- System and method for the processing of exhaust gas by using multi-step exhaust gas circulation (KR1957450)
- System for processing NOx by using pyrolysis of reducing agent (KR2068334)
- System and method for simultaneous NOx and N2O removal process using reducing agent (KR0142034)
- Diesel exhaust fluid injection device and diesel exhaust fluid injection method using internal heat of incinerator (KR10-2020-0132158)
- Incinerator NOx control method and apparatus by suppressing combustion variability (KR 10-2020-132152)

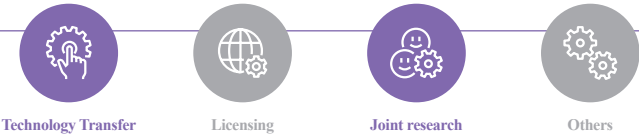
KNOW-HOW

- NOx control technology in a coal-fired reaction plant (fixed amount: KRW 55 million, 1 % of total sales)
- NOx control technology in combustion reactor (fixed amount: KRW 110 million, 1 % of total sales)

Technology Readiness Level (TRL)



Desired Partnership

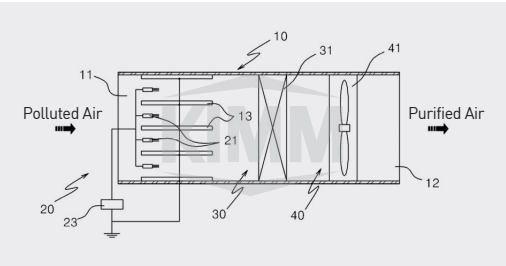


# Indoor Electrostatic Air Cleaning System Using Carbon Fiber Ionization Process

▶ Department of Plant Technology ▶ Researcher: Bangwoo Han ▶ Contact: +82-42-868-7068

Technology Overview

- Air cleaning system that uses micro carbon fiber discharge electrodes to electrically charge fine particles without generating ozone and collect fine particles with strong electrostatic force



Customer / Market

- Air purifier company, active ventilation system for public facility including subway station/parking lot/airport, dust collection facility manufacturer, environmental facility fields

Problems of Existing Technology or Necessity of this Technology

- Previous electric air purifiers have the ozone generation issue that it is not favorable to a closed indoor environment, and the mechanical filter type air purifiers have issues with the filter replacement management and the required power increase due to filter pressure drop increase as dusts are collected on the filter.
- The technology for dust collection is now going for a hybrid type that uses two or more principles, and existing method needs supplementation in its core technology to improve its performance.
- Existing filter type air purifier needs periodical filter replacements, and due to poor maintenance performed by the user, secondary pollutants may arise from filter contaminations. Electrostatic precipitator has the benefit of low pressure loss, but it requires high voltage to improve its fine particle collection efficiency. During strong corona discharges, the ozone level may exceed the recommended level for indoor environment, which limits its use.

Technical Distinctiveness

- Management is possible without filter replacements. The pressure loss is low and the energy efficiency is outstanding. Without generating harmful gases like ozone, it has great fine particle collection performance.
- The generation of harmful ozone can be suppressed to below a few ppbs because the micro carbon fiber discharge electrode of 5 to 10  $\mu\text{m}$  in diameter is applied that electric discharge can be done uniformly with a low applied voltage. This technique is environmentally friendly because it does not require filter replacements which results in filter waste. And the cost of filter replacement can be reduced.

- Fine particles can be collected with the electrical method with a low pressure loss and no ozone generation. With the dielectric coated collection plate, a high insulating property can be maintained that stable operations are possible under humid circumstances and with washing processes
- Ozone generation is below a few ppbs, which is lower than the eco-friendly certified standard (10 ppb). It can be maintained simply with water replacement without using a filter. In a viewpoint of energy consumption, this technique is outstanding because of low pressure drop.

Excellence of Technology

- A relatively low voltage is applied to the microcarbon fiber bundle to electrically charge the fine particles with high efficiency without generating ozone. And an electrostatic filter, metal collection plate or dielectric material-coated collection plate with a high-strength electric field collects the electrically charged particles. The ozone generation level is approximately 1 to 2 ppb, which is significantly lower than the local indoor environment standard level of 50 ppb. By applying voltage of 7 to 10 kV in the charger and over 10 kV in the collector, the technology can improve the particle collection efficiency to 95% or higher for fine particles of 0.3  $\mu\text{m}$  in diameter.



◁ Photo of Air Purifier ▷

Current Intellectual Property Right Status

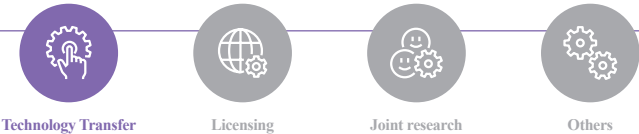
PATENT

- Aerosol Particle Charger Using Carbon Fiber (KR0849674) / Electric Dust Collector Using Carbon Fiber Woven Fabrics (KR1064488) / Air Purifier Using Carbon Fiber (KR0937944) / Air Purifier Using Carbon Fiber Woven Fabrics (KR1032612) / An Air Cleaning Device of Electric Dust Collection Type (KR1112441) / Electric Dust Collector Using Carbon Fiber Woven Fabrics (KR1064487) / Air Purifier Using Carbon Fiber Woven Fabrics (KR1064486) / The Hydrophile Property of Precipitation Plates (KR1178766) / Electrostatic Precipitator with Easily Replaceable Collection Plate (KR1331611) / An Electrostatic Precipitator Using Carbon Fibers Equipped with Edge-Coated Collection Plates (KR1453499) / Electric Dust Collecting Air Cleaning Device with Ion Generator in Outlet (KR859840) / Apparatus for Treating Harmful Gas (KR1190604) / Aerosol Electric Charge Equipment Using Carbon Fiber Woven Fabrics (KR1048416) / Electric Precipitator Using Activated Carbon Fiber Filter (KR1373720) / Electric Precipitator Using Activated Carbon Fiber Filter (KR1087055) / Solution Containing the Catalyst Particles Mist Recovery Device and Method (KR1334263) / Electrostatic Precipitator and System Using the Same (KR1221962)

Technology Readiness Level (TRL)



Desired Partnership



# Gas Turbine Combined Cycle Performance Analysis Technology

▶ Department of Clean Fuel & Power Generation ▶ Researcher: Dowon Gang ▶ Contact: +82-42-868-7655

Technology Overview

- Performance analysis technology of gas turbine combined cycle system composed of various components such as gas turbine (GT), heat recovery system generator (HRSG), and steam turbine (ST) using a physics-based model
- Physical model-based gas turbine combined cycle power generation performance analysis technology is a technology that can be used for performance design, acquisition performance evaluation, and performance diagnosis.
- In addition, this technology can be used to develop various applied power generation systems based on gas turbines (e.g. coal gasification combined cycle (IGCC), gas turbine-fuel cell hybrid system (GT-FC hybrid system))

Customer / Market

- Gas turbine manufacturers
- Engineering companies for energy systems
- Electric power companies with gas turbine combined cycle

Problems of Existing Technology or Necessity of this Technology

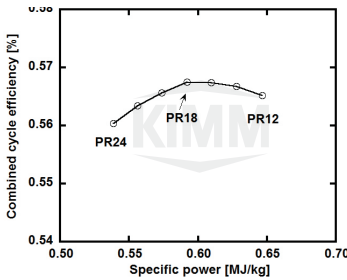
- Combined cycle gas turbine performance design aspect:  
: In the performance design of gas turbine for combined cycle, gas turbine performance design considered the performance characteristics of the bottoming cycle is required to maximize the efficiency of the combined cycle.
- Gas turbine combined cycle power plant performance acceptance test aspect:  
: In the performance acceptance test of gas turbine combined cycle power plant, correction curves of the combined cycle power plant derived by combining the design specifications of components is required, and the curves are utilized to examines whether the completed gas turbine combined cycle power plant is able to fulfill the performance in the contract.
- Diagnosis of gas turbine combined cycle power plant performance  
: Gas turbine combined cycle power plant performance diagnosis aspect: In the performance diagnosis of gas turbine combined cycle power plant, the analysis for the degree of degradation and the cause of deterioration were required to predict the appropriate maintenance schedule because the performance of gas turbine degrade with increase in operation time.

Technical Distinctiveness

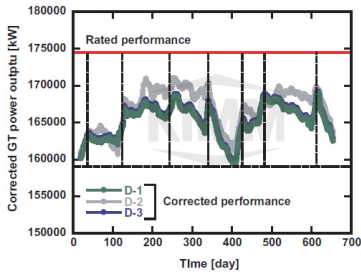
- Performance design of gas turbine for combined cycle
  - Estimation of realistic gas turbine performance specifications by utilizing the regression analysis model obtained through analyzing data from existing gas turbine, and physics-based model
  - Prediction of design performance specifications of gas turbine for combined cycle by simulation of gas turbine system with bottoming cycle using the physics-based model

- Performance acceptance test of correction curve for gas turbine combined cycle power plant
  - Accuracy improvement of correction curves of combined cycle by utilizing the modelbased simulation of overall combined cycle power plant as well as combination correction curves of each component provide by manufacturer's
  - Prediction of the correction curves of combined cycle power plant with inlet chiller and duct firing
- Diagnosis of gas turbine combined cycle power plant performance
  - More accurate quantitative analysis of performance degradation using physics-based model than that of using data analysis

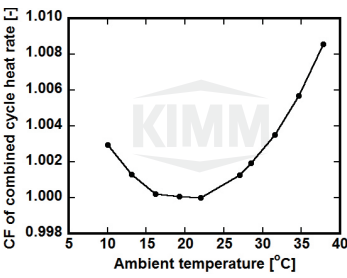
Excellence of Technology



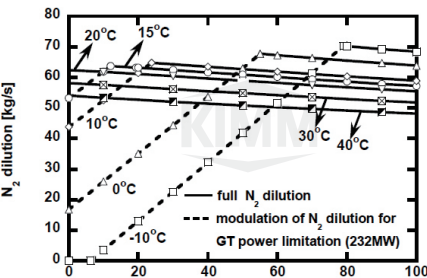
◁ Example of Optimal Pressure Ration Estimation for Combined Cycle Gas Turbine ▷



◁ Example of Performance Degradation analysis of Gas Turbine ▷



◁ Example of Correction Curve of Predicted Combined Cycle ▷



◁ Example of Performance Analysis of Integrated Gasification Combined Cycle ▷

Current Intellectual Property Right Status

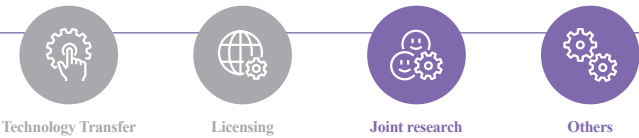
KNOW-HOW

- Performance design of gas turbine for combined cycle power plant
- The prediction of correction curves of combined cycle power plant
- The performance diagnosis of gas turbine
- Analysis of advance gas turbine-based energy system

Technology Readiness Level (TRL)



Desired Partnership





# Low-NOx Combustor Design by Using Laser Diagnostics Techniques

▶ Department of Clean Fuel & Power Generation   ▶ Researchers: Hanseok Kim, Minkuk Kim   ▶ Contact: +82-42-868-7368, 7276

Technology Overview

- Technology to obtain various information on velocity/concentration/mixedness /temperature/droplet distribution using non-intrusive laser-based measurement techniques in a high-temperature and high-pressure conditions
- Advanced combustor design for low emission of air pollutant through detailed analysis to combustion phenomena in complex flow field

Customer / Market

- Companies that need accurate measurement and analysis on combustion phenomena
- Companies that need to development a combustor for boiler/power plant/heating furnace / incinerator or to retrofit old combustor for better performances

Problems of Existing Technology or Necessity of this Technology

- Combustion phenomena should be accurately understood and controlled to satisfy various requirements for industrial combustor, such as high combustion efficiency, low pollutant emission, wide operation range and so on
- Accurate measurement of complex combustion phenomena in turbulent flow field is very difficult.
- For a gas turbine combustor which operates under high-temperature and highpressure conditions, there are concerns about accessibility and durability of a sensor.
- Therefore, non-intrusive sensing techniques (laser diagnostics) are required to measure quantitative data for various information including velocity/concentration/ mixedness/temperature/droplet distribution.

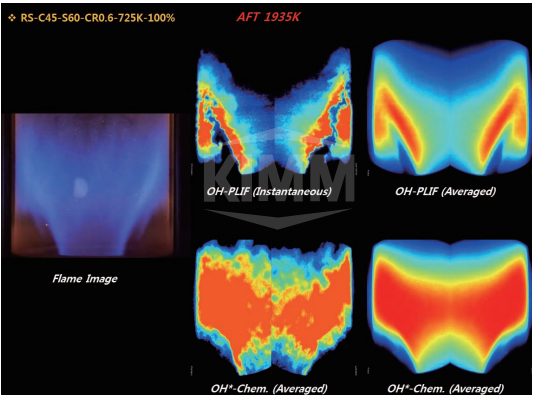
Technical Distinctiveness

- Laser diagnostics applies directly to real scaled combustor and it will be conducted under high-temperature and high-pressure condition such that the reliability of data could be maximized.
- Air flow rate 3.6 kg/s, 9.5 BarA, 900 K max./Fuel flow rate 180 kg/h (gas), 500 kg/h (liquid)
- Non-contact optical measurement is possible not only in high-temperature and high-pressure environments, but also in conditions where pollutants such as exhaust gas are generated through the special optical window design.

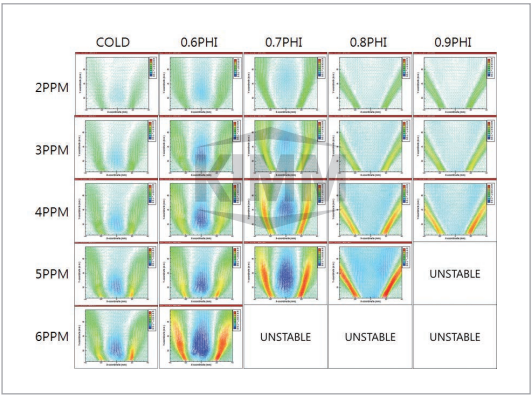
Excellence of Technology

- Knowledge for laser control, optical system organization, signal synchronization, signal correction, and data analysis required for accurate laser-applied measurement
- Correlation analysis between different measurement data is possible through simultaneous measurement of various laser applied measurement techniques.

List of Technologies for Simultaneous	
Stereoscopic PIV	Velocity flow field (2D3C)
OH-PLIF	Concentration field (OH radical)
Acetone-PLIF	Gas-fuel mixedness
Kerosene PLIF	distribution (mixture fraction)
High-speed Chemiluminescence	Reaction flow field
Spray Mie Scattering	Spray pattern
2D SMD(Fluorescence/Mie)	2D SMD distribution
PDPA	Velocity and droplet size



〈 OH-PLIF, High-speed OH Chemiluminescence Measurement 〉



〈 PIV Measurement and Flame Stability 〉

Current Intellectual Property Right Status

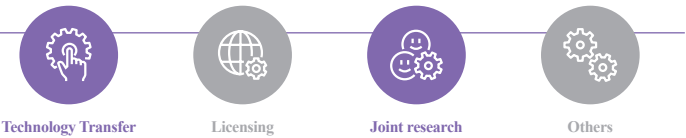
KNOW-HOW

- Combustion-flow field interrelation analysis technology using simultaneous measurement of OH-PLIF and stereo PIV
- Fuel mixedness quantification technology using acetone PLIF technique
- Liquid fuel atomization performance quantification technology using the PDPA technique
- Investigation of combustion instability by using high speed chemiluminescence and synchronized dynamics pressure measurement
- High-temperature, high-pressure flow chamber design and operation

Technology Readiness Level (TRL)



Desired Partnership

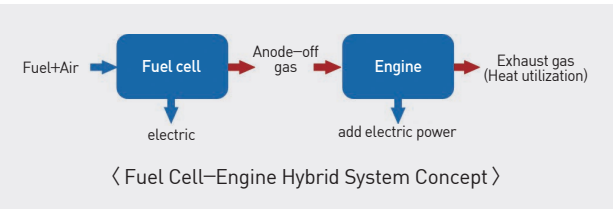


# High-Efficiency Hybrid Power Generation System Integrating Fuel Cell and Internal Combustion Engine

▶ Department of Clean Fuel & Power Generation ▶ Researcher: Kookyoung Ahn ▶ Contact: +82-42-868-7324

Technology Overview

- Developing high-efficiency distributed power generation technology by combining SOFC and HCCI type internal combustion engine
- In the proposed fuel cell-engine hybrid concept, unreacted fuel released from the fuel electrode (anode off-gas) is burnt in the HCCI engine, generating additional power.



Customer / Market

- Fuel cell system developer, energy suppliers for district, distributed power generation system developer/operator
- High-efficiency distributed power generation system (RPS market, Energy system for public buildings, Distributed power generation market)
- Expected supply expansion of distributed power generation system in future (for building/group energy, etc.)
- Power generation system for marine application (propulsion system and/or auxiliary power unit)-opening new application field using high-efficiency system for large ship (to cope with EEDI regulations)

Problems of Existing Technology or Necessity of this Technology

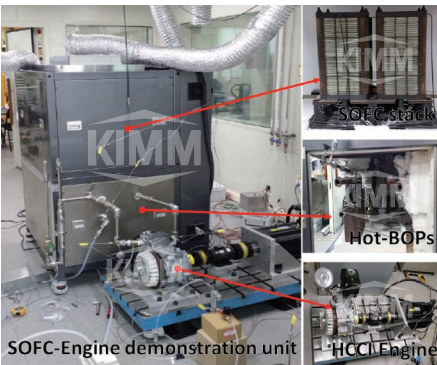
- As fuel cell technology is approaching to commercialization, much attention has been giving to the technology of efficiency improvement
- For improved system efficiency, efficiency improvement of fuel cell stack, system optimization, and BOP power consumption reduction are important, but considering the durability and technical limitations of fuel cell technology, developing a hybrid system is a realistically feasible approach. In the existing hybrid power generation, the method of combining fuel cells and gas turbines was mainly considered, but in distributed power generation of several hundred kW or less, it is advantageous in many ways to apply an engine rather than a gas turbine (in terms of performance, durability, manufacturing cost, etc.).
- By integrating atmospheric high-temperature fuel cell with the internal combustion engine engine, power generation efficiency can improve since the engine burns unreacted fuel components at the anode to obtain additional power. Reducing device costs and to improve the power generating efficiency, reduced fuel costs, CO<sub>2</sub> emission reduction achieved simultaneously. Power generation efficiency is improved by 5 to 7%p, and LCOE can be reduced by more than 10% due to reduced equipment cost and fuel cost reduction.
- The proportion of fuel components in the fuel cell anode off-gas is around 15%. In order to achieve complete combustion in the engine, the engine's design and operating conditions must be optimized. In system implementation, the interface design and control between the engine and fuel cell are the most important.
- Relevant design know-how is important

Technical Distinctiveness

- Fuel cell-engine hybrid system, which combines a fuel cell and an internal combustion engine, is a promising technology that dramatically improved the power generation efficiency of the existing fuel cell system. The research team has succeeded in developing and operating an empirical system for the first time in the world.
- Through demonstration system operation, it has been verified that the efficiency increases by 5.3 percentage point. (Efficiency improvement of 5% or higher in a small-scale system is a very challenging target and very promising result.

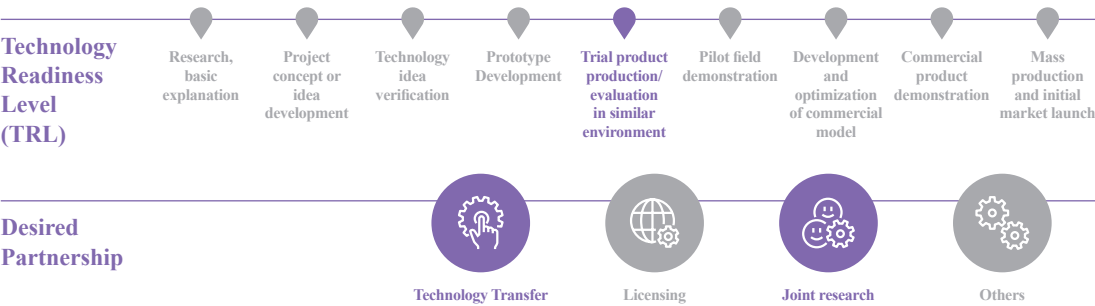
Excellence of Technology

- Securing Korea's highest system technology level in terms of capacity and efficiency. Planning on pursuing technology development/product development in connection with the development of a large-capacity SOFC commercial power generation system
- Various know-hows and technologies are secured for development of a large capacity generation system.
- Analysis/design technology for fuel cell-engine hybrid generation system, main component design technology, and system integration and operation control technology have been secured. World's first operation for concept demonstration has been successfully conducted.
- The fuel cell-engine hybrid system is a new concept system originally devised in Korea and is a very promising technology in all aspects of efficiency/economics/operating stability. Secured various applications such as power generation systems for buildings and hybrid systems for ships in the future.
- (System integration and operation control technology) The developed hybrid system consists of fuel cell, engine, and various parts of the reformer. System optimization and operation control technology were secured, and continuous operation for 200 hours was successful.
- (SOFC stack scale-up technology) SOFC stack scale-up technology for 5 kW with efficiency over 50% has been secured.
- (HCCI engine combustion technology) Fuel cell anode-off gas ultra-lean combustion technology has been secured. NO<sub>x</sub> emission is successfully controlled under 10 ppm.
- (Reformer and steam separation technology) Reformer heat transfer optimization technology and steam separation technology have been secured.
- (Modeling & Simulation) Modeling and simulation (M&S) technology that satisfies both accuracy and calculation speed has been secured
- Paper publication and academic conference presentations: 11 SCI(E) papers, 6 domestic papers in Korea, 20 international academic presentations, 62 domestic academic presentations



Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• High Efficiency Fuel Cell Hybrid System (KR1440191, KR1358095, US13/469142)</li><li>• Method of Warmin g-up in Fuel Cell-Engine Hybrid System (KR1653372)</li><li>• Fuel Cell-Engine Hybrid Power Generation System for Distributed Power Generation Which Has a Cooling Device (KR1735647)</li><li>• Fuel Cell-Engine Hybrid Generation System (KR1690634, KR1690635, KR1690636, KR1690637, KR1690638)</li></ul>	<ul style="list-style-type: none"><li>• Fuel cell power generation system analysis technology (process modeling, economic feasibility assessment, life cycle assessment)</li><li>• Fuel cell system simulation technology/Flow distribution technology for multiple fuel cell stack use</li><li>• Engine ultra-lean combustion technology for hybrid system application</li><li>• High temperature component design and hot box thermal design technology</li><li>• Fuel cell-engine hybrid system control technology</li></ul>

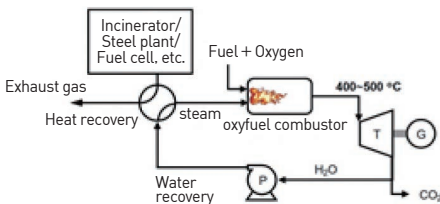


# Power Generation System that Minimizes the Decrease in Efficiency using Oxyfuel Combustion Technology

▶ Department of Clean Fuel & Power Generation ▶ Researcher: Kookyoung Ahn ▶ Contact: +82-42-868-7324

Technology Overview

- Power generation system using oxyfuel combustion technology that links waste heat or waste steam generated from large thermal facilities such as incinerators and steel plants to acquire the high electrical efficiency while also collecting CO2



Customer / Market

- Large capacity heat discharge facilities including heating furnace, incinerator, steel plant, fuel cell system

Problems of Existing Technology or Necessity of this Technology

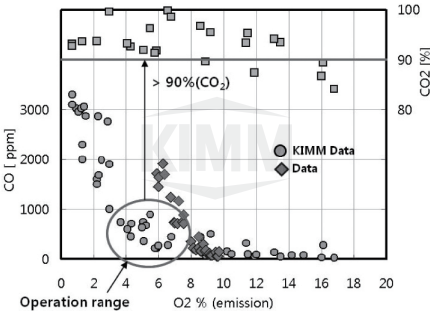
- The technology to reduce CO2 emission, the main cause of global warming and climate change, is a globally important technology. Various technologies such as efficiency improvement, waste heat recovery, combination with new and renewable energy, CO2 capture and storage (CCS) technology are being developed.
- Existing technologies that recover waste heat from facilities to generate power include organic Rankine cycle (ORC), thermoelectric generation system, but their efficiency is low, and the power output is low considering the initial investment that it is economically disadvantageous.
- CO2 capturing technology that can be applied for power generation system can be classified into pre-combustion, post-combustion, and oxyfuel combustion. There is an issue of the efficiency decreasing by about 10% due to oxygen producing electricity, and because of this issue, economic feasibility cannot be secured.
- A countermeasure is needed such as efficiency improvement of the components to overcome efficiency decrease and a new concept cycle, etc.
- Technologies such as Pure Oxygen (Oxyfuel) combustion, high-efficiency CO2 capturing generation system are needed.

Technical Distinctiveness

- To realize high-efficiency system, this "Waste heat recovery type oxyfuel combustion generation system technology" utilize energy from incinerators and steel plants that goes into waste to produce steam and combine the steam with oxyfuel combustion gas to supply to the turbine to generate power.
- By using waste heat or steam, the efficiency decrease issue of previous CO2 capture technology can be overcome.
- Entire CO2 contained in supplied fuel can be captured, and by applying unused steam in the oxyfuel combustion generation system, efficiency decrease from oxygen generation is minimized, and economic feasibility can be secured.
- For the same investment, greater power can be generated so its economic feasibility can be secured. Captured CO2 can be recycled (for greenhouse cultivation)
- A large-scale empirical study on CO2 capturing generation technology is being conducted internationally (Clean Energy System of the USA, etc.), but there is no study that considers efficiency decrease.
- Proposed system is a new concept cycle designed to minimize efficiency decrease.
- It is an original technology for an independent Pure Oxygen (Oxyfuel) combustor design using the lean burn technology of gas turbine.

Excellence of Technology

- The technology can be largely divided into "pure oxygen combustor technology" and "system integration and control technology".
- Key component is the "oxyfuel combustor" that supplies steam while stably maintaining the flame and realize perfect combustion. (CO emission concentration that represents imperfect combustion is very low.)
- Combustor emission property was outstanding compared to that of advanced companies.
- A 100 kW-level pilot plant was established in the experiment building at KIMM, and empirical operation was successfully done. (power generation of 80 kW, CO2 concentration of 93%)
- 18 SCI papers (system analysis/oxyfuel combustion/turbine development, etc.), 10 papers in Korean, and 40 domestic/international academic presentations
- Press coverage by YTN (Dec. 7, 2011), Yonhap News (Nov. 30, 2010), The Korea Economic Daily, The Korea Electric Power News, Daejeon Ilbo
- A project manager over 30 years of research experience (clean combustion technology) and 10 doctorate researchers participated in the study.



Current Intellectual Property Right Status

PATENT

- A Fuel Cell-Linked Power Generation Plant Using Pure Oxygen Combustion and a Control Method Thereof (KR1067509)
- Method and Combustion Apparatus (KR0395646, KR395647, KR397210)
- Oxyfuel Burner with Flue Gas Recirculation (KR0590845)
- Low NOx Oxyfuel Burner with High Speed Injection (KR0657864)
- Combustion System Including Exhaust Gas Recirculation Unit Using Ejector (KR0707520)
- Thermal Power Plant Having Pure Oxygen Combustor (KR0814940, PCT/kr2008/002600, CNZL 2008 8 0000374.6, EP08753396.4)
- Thermal Power Plant Having Pure Oxygen (Oxyfuel) Combustor and Using Waste Steam (KR0779609)
- Overheating Preventing Gas Turbine System (KR0862374)
- Gas Turbine System (KR0890823)
- Gas Turbine System for Low NOx emission (KR0890824)
- Fuel Cell-Linked Power Generation Plant Using Pure Oxygen (Oxyfuel) Combustion (KR0817898)
- Turbine Blade and Turbine Using It (KR0916354)

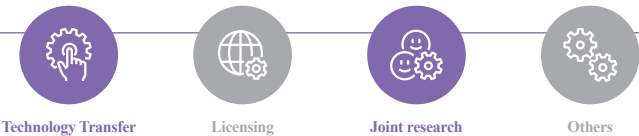
KNOW-HOW

- Pure Oxygen (Oxyfuel) combustion gas turbine generation system analysis technology (process modeling, economic feasibility assessment, eco-friendliness assessment technique)
- High pressure pure Oxygen (Oxyfuel) combustor design technology
- Pure Oxygen (Oxyfuel) combustion gas turbine generation system operation control technology

Technology Readiness Level (TRL)



Desired Partnership





# Gas Fuel-Based Integrated Greenhouse Energy System Technology (TRI-GEN System)

▶ Department of Clean Fuel & Power Generation ▶ Researcher: Sang Min Lee ▶ Contact: +82-42-868-7833

Technology Overview

- Tri-generation (Tri-Gen) system technology to produce and supply heat/CO<sub>2</sub>/electricity to horticultural greenhouse using gas fuels
- Integrated smart energy control technology for growing flowers and vegetables using Tri-Gen system

Customer / Market

- Gas engine heat pump (domestic market), gas engine generator (export market)

Problems of Existing Technology or Necessity of this Technology

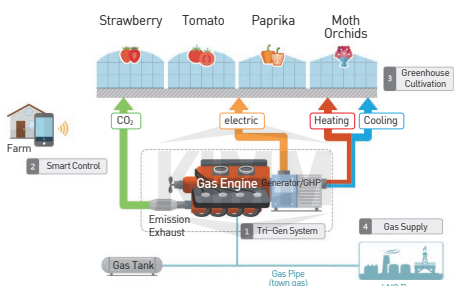
- Tax-free Diesel oil was mostly used for greenhouse heating, but with the abolishment of tax-free benefit for oil used for heating, the electric heating has been growing, which leads to national energy loss.
- Horticultural (greenhouse) area per person in Korea is No.1 in the world. Thus, the development of a new technology is expected to have a great ripple effect.
- Gas fuel price is expected to be stabilized in mid to long-term. Energy independence of future farms can be anticipated by decreasing electricity use and reducing CO<sub>2</sub> emission,

Technical Distinctiveness

- Heating cost can be reduced by replacing oil fuel with gas fuel.
- Possible to save on enrichment cost as it is unnecessary to install a liquefied carbon tank for carbon dioxide (CO<sub>2</sub>) enrichment.
- Crop production can be expanded by controlling temperature and humidity through additional cooling and dehumidification.

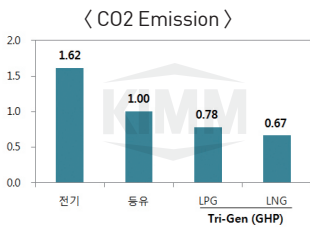
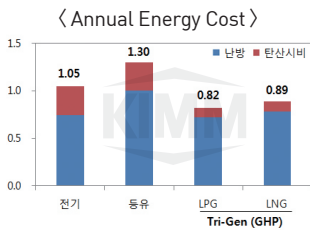
Excellence of Technology

- Tri-Gen (gas engine heat pump (GHP), gas engine generator)
  - Energy consumption is reduced through integrated management of greenhouse energy using a GHP. With the all-in-one system of GHP, investment cost can be saved by avoiding unnecessary installation.
  - GHP has 30% higher heating efficiency than a boiler (over 1.5 COP). Temperature and humidity can be controlled by providing cooling during summer in order to extend crop production; all day cooling for flowers and night-only cooling for vegetables. And photosynthesis is improved by supplying CO<sub>2</sub> in the exhaust gas. All these contribute to increasing farmer's income by significantly improving crop productivity.
  - Gas engine generator is not appropriate for domestic greenhouses, where electricity for agricultural purpose is cheap in Korea. However, it can be suitable for Central Asia and Middle East regions that are rich in resource with limited electricity infrastructure.

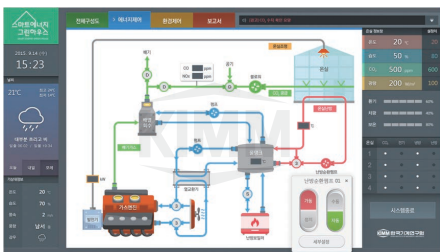


Mode1. Generator : CO<sub>2</sub>+Heating+Electricity(lightning)  
Mode2. GHP: CO<sub>2</sub>+Heating+Electricity

- Gas engine for horticultural energy source
  - An original gas engine with reduced emission was developed for carbon dioxide enrichment by supplying the exhaust gas from the engine.
  - With CO/NO<sub>x</sub> < 25 ppm, the gas engine development goal was achieved. No damage has been reported after the long-term tests from 5 demonstration sites.
- Comparison with existing method
  - Annual energy cost (heating cost + carbon dioxide enrichment cost) Possible to reduce by 30 to 40% (compared to kerosene heater)
  - Possible to reduce CO<sub>2</sub> emission by 50 to 60% (compared to electric heater)
  - Expected farmers' income (1 ha paprika greenhouse) 50 to 70 million won (payback period of 2 to 3 years)
  - Support measures such as installation aid, gas price benefit (tax free), CO<sub>2</sub> emission reduction certification
- Tri-Gen smart energy control system (remote/automatic control)
  - Measurement: Temperature/humidity/CO<sub>2</sub> concentration in the greenhouse, outdoor weather station (light intensity / wind speed), engine emission concentration
  - Control – Control: Heating and cooling/carbon dioxide enrichment/lighting/various thermo-fluidic devices



〈 Comparison of Tri-Gen(GHP) System with Existing Methods (Kerosene/Electric Heater + Liquefied Carbon Dioxide Enrichment) 〉



Current Intellectual Property Right Status

PATENT

- Independent Energy Supply Module for Horticultural Greenhouse Utilizing Trigenation Technology (KR1784878)
- Tri-gen System for Horticulture Utilizing Carbon Monoxide Sensor (KR1784896)
- Tri-gen System for Horticulture Utilizing Ultra Low Emission Gas Engine Skill with Low Pressure Fuel Condition (KR1769438)
- Tri-generation System Using Engine to Selectively Use Liquefied Petroleum Gas or Natural Gas, and Control Method Thereof (KR1712904)
- Tri-generation System Using High Lean Burn Operation and Control Method Thereof (KR1569677)

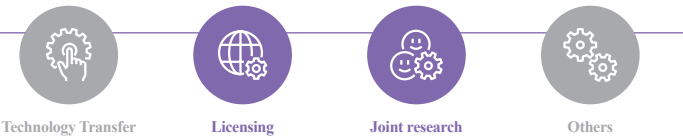
KNOW-HOW

- Integrated control technology of greenhouse environment, energy using Tri-Gen
- Greenhouse vegetable/flower growing technology using Tri-Gen

Technology Readiness Level (TRL)



Desired Partnership

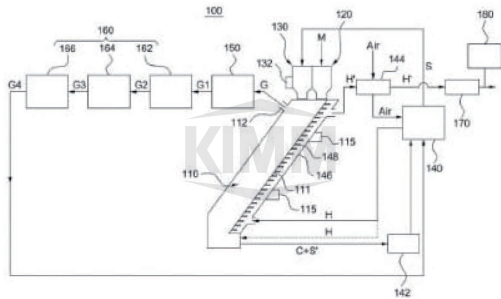


Biocrude-oil Production System

▶ Department of Clean Fuel & Power Generation ▶ Researcher: Yeonseok Choi ▶ Contact: +82-42-868-7344

Technology Overview

- A bio-crude oil production device, a bio-crude oil manufacturing system, and a bio-crude oil manufacturing method for effectively producing bio-crude oil from biomass using the fast pyrolysis method.



Customer / Market

- Bioenergy-related company

Problems of Existing Technology or Necessity of this Technology

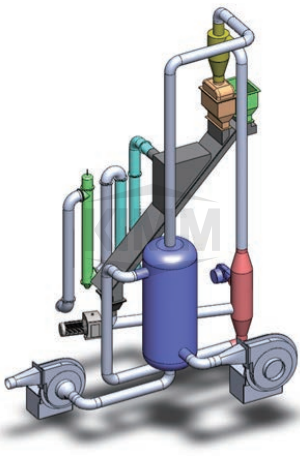
- Bubbling-fluidized-bed system for bio-crude oil production requires a large amount of fluidized gas for sand fluidization, so it needs large size of reactor and pipe with expensive installation cost. Moreover, a lot of undesirable charcoal remains in bio-crude oil because the pyrolysis vapor flows out with bio-char prior to the separation process.

Technical Distinctiveness

- Fast pyrolysis of biomass using this technology does not require the fluidized gas supply, so the facility size is reduced and the installation cost becomes cheaper.
- Fast pyrolysis of biomass using this technology can control heat and mass transfer optimally to maximize the bio-crude oil yield and to produce high quality bio-crude oil with less charcoal.
- Bio-crude oil can be combined to bio-refinery industry, and enable the active coping with certified CO2 emission reduction due to its carbon neutrality.
- This bio-crude oil production system has a simpler structure compared to existing bubbling fluidized bed, circulating fluidized bed reactors, therefore its size and construction cost can be reduced to 2/3 level.
- Pyrolysis-vapor and bio-charcoal are separated during the bio-crude oil production process, and this allows the production of bio-crude oil with high quality.
- It does not use carrier gas which affects the reactor operation condition, which enables an easy plant operation.

Excellence of Technology

- Over 10 papers on this technology were published in international journals, and related patents were registered in 7 countries.
- Several delegations from Philippines, Cambodia, Rwanda, and Ghana have visited this plant, and they showed high interests in the utilization of this technology in their countries.
- Performance test in pilot plant of 20 kg/hr showed the bio-crude oil yield of 65% that is comparable to advanced countries. Demonstration plant of 200 kg/ hr, largest in Korea, has been constructed.
- Patents for bio-crude oil manufacturing apparatus, bio-crude oil manufacturing system and method were registered in Korea and abroad (USA, Canada, China, Japan, Germany, Finland, Sweden).



〈 Photo of Demonstration Plant 〉



〈 Photo of Bio-crude Oil 〉

Current Intellectual Property Right Status

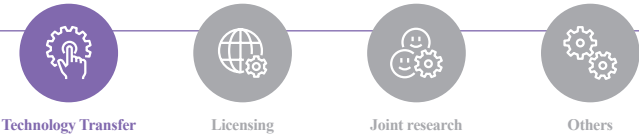
PATENT

- Device for Manufacturing Bio-oil, System for manufacturing Bio-oil and Method for Manufacturing Bio-oil Using the Same (KR0946714, US9005313, CA2762961, JP5633828, CN102449117, EP10780769.5)
- Fast Pyrolysis Reactor and Biocrude-oil Manufacturing System Using the Same (KR1068748)
- Apparatus for Manufacturing Bio-oil Using Fast Pyrolysis of Fluidized Bed (KR1285879)
- Apparatus for Collecting Bio-Steam and Apparatus for Manufacturing Bio-oil Having the Same (KR2012-0113240)
- Condensing Device (KR1175094)
- Biocrude-oil Manufacturing System with Improved Fluidization and Heat Exchange (KR2014-0026713)
- Biocrude-oil Manufacturing System with Multi-stage Condensation (KR2014- 0026716)

Technology Readiness Level (TRL)



Desired Partnership

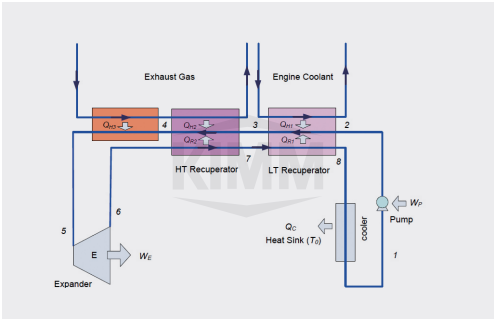


# Engine Waste Heat Recovery Generation System

▶ Department of Engine Research   ▶ Researcher: Youngmin Kim   ▶ Contact: +82-42-868-7377

Technology Overview

- Organic Rankine cycle generation system for fully recycling of engine coolant heat and exhaust heat



Customer / Market

- Waste heat power generation for automobile, ship, and power generation engine

Problems of Existing Technology or Necessity of this Technology

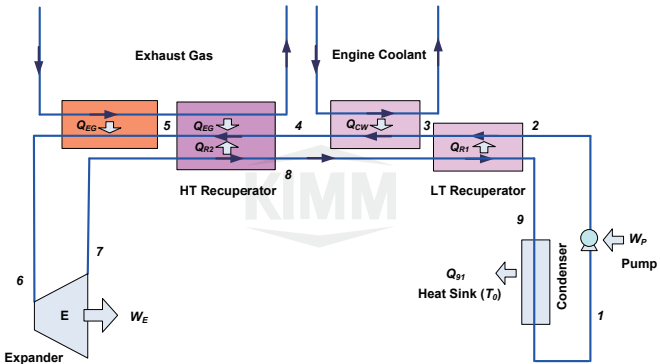
- Single-loop type ORC system suggested for engine waste heat recovery has a simpler equipment composition and is more economically feasible than the dual-loop method. However, it cannot effectively use 100% of the engine's coolant heat and exhaust heat at the same time, that the ORC output from the same engine waste heat is only about 70% compared to the dual-loop method.

Technical Distinctiveness

- Fully uses both coolant heat and exhaust heat from the engine.
- Achieves a cycle efficiency of 9.5%
- By making the refrigerant evaporation temperature of No.1 heat exchanger slightly lower than the engine coolant, the engine coolant heat of No. 1 heat exchanger can be used as evaporation heat 100% when the refrigerant is pre-heated in No. 1 regenerative heat exchanger.
- By using up to 100% of the engine coolant heat as evaporation heat, the engine waste heat recovery apparatus can reduce the temperature difference between the heat source and the working fluid in the process of the refrigerant evaporating in No. 1 heat exchanger, that the irreversible loss that occur from the temperature difference occurring in the existing process of evaporation by the heat from-engine exhaust gas can be reduced.
- With the novel heat exchange arrangement and ORC system optimization, the system performance (5.7 kW) is close or even exceeds that of existing dual-loop method under the same condition and assumptions while the system is as simple as the single-loop method.

Excellence of Technology

- The regenerative heat exchanger is composed of the high temperature (HT) recuperator and low temperature (LT) recuperator, and the liquid refrigerant heated with the LT recuperator evaporates with the engine coolant heat and then superheated through the HT recuperator, which is then heated to the maximum temperature with the engine exhaust heat and supplied to the expander.
- The evaporation temperature for liquid refrigerant can be set a bit lower than the engine coolant to use 100% of the engine coolant heat as the evaporation heat even when the liquid refrigerant is heated with the regenerative heat exchanger. Since the evaporation temperature is limited with the engine coolant temperature, there is a downside where the cycle efficiency cannot be increased, but since the temperature difference between the heat source and working fluid in the evaporation process is very small, there is a benefit of reducing the irreversible loss from the temperature difference in the existing evaporation process by engine exhaust heat.
- Presented papers at international scholastic society meetings("Highly efficient single-loop organic Rankine cycle for engine waste heat recovery" presented at Conference on Sustainable Development of Energy, Water and Environmental Systems (SDEWES 2014))
- Published SCI(E) papers("Highly efficient single-loop organic Rankine cycle for engine waste heat recovery"(Energies, 2014.10 submitted))



〈 Schematic Diagram for High-efficiency Engine Waste Heat Recovery ORC System 〉

Current Intellectual Property Right Status

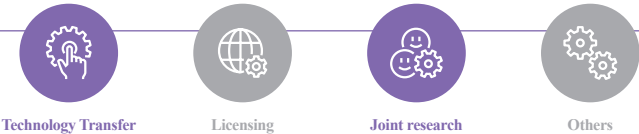
PATENT

- Engine Waste Heat Recovery Apparatus (KR2013-0040324)

Technology Readiness Level (TRL)



Desired Partnership



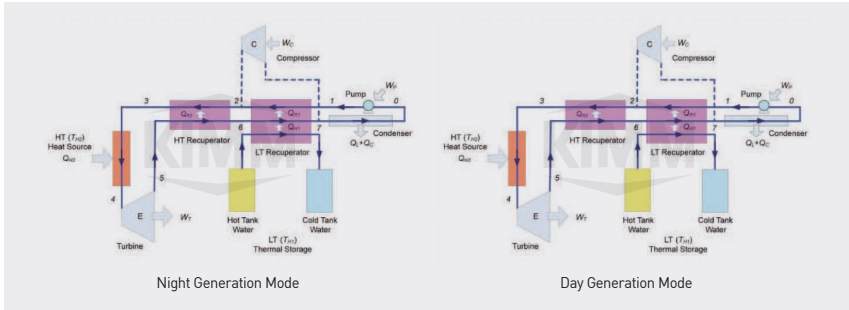


# System Configuration and Operation Method of Supercritical CO<sub>2</sub> Power Cycle with Improved Exergetic Efficiency Using Both High-Temperature Heat Source and Low-Temperature Heat Source

Department of Engine Research    Researcher: Youngmin Kim    Contact: +82-42-868-7377

Technology Overview

- System Configuration and operation method of a supercritical CO2 power cycle that effectively uses the low-temperature heat source to obtain higher output from the same high-temperature heat source



Customer / Market

- Coal-fired power plant, solar power plant, nuclear power plant

Problems of Existing Technology or Necessity of this Technology

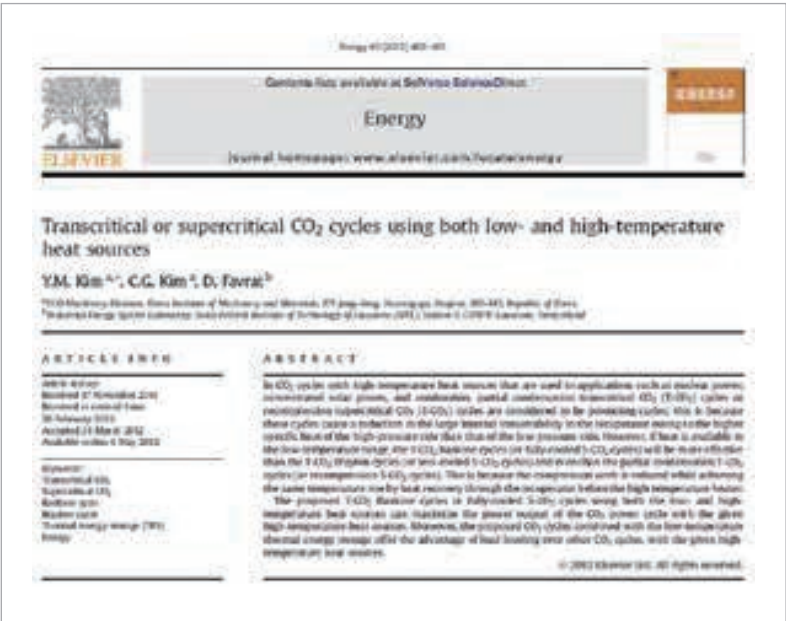
- Need to improve the efficiency and output and enable load control
- There is a limit to efficiency improvement as the high-pressure side has a higher specific heat than the low-pressure side in the regenerative heat exchange process of the supercritical CO2 power-cycle.
- A recompression cycle had been proposed, but the output was reduced due to increased compression work.
- There is increasing interest for supercritical CO2 power cycle system that could directly utilize different heat sources such as fossil fuel, biofuel, solar heat, nuclear power, and waste heat.
- There is a difficult with load control for coal-fired power plant or nuclear power plant, therefore, a supercritical CO2 power cycle system needs to be developed, which can improve efficiency from the same heat source and enables load control.

Technical Distinctiveness

- By utilizing low-temperature heat sources like low-temperature waste heat and geothermal heat, high-efficiency generation using high-temperature heat sources like coal-fired power generation, solar power generation, and nuclear power generation can be achieved.
- For thermal power plant and nuclear power plant, using the same hightemperature heat source, 20% efficiency improvement and 40% load control can be achieved compared to the existing method.
- The proposed supercritical CO2 power cycle utilizes low-temperature waste heat to obtain 20% higher output and efficiency improvement from the same hightemperature heat source.
- Compared to the thermal power plant and nuclear power plant that have a difficulty with load control, using the same high-temperature heat source, over 40% load control can be achieved.

Excellence of Technology

- During the night, the supercritical CO2 cycle operated for partial cooling and the low-temperature waste heat is stored.
- During the day, stored waste heat is used to run the proposed supercritical CO2 cycle.
- For example, for nuclear power, the generating output is 358 MWe and the thermal efficiency is 37.6%. During the day, the generating output is 500 MWe, and the thermal efficiency is 52.5%.
- Using the same heat source, over 40% load control can be achieved.
- Published a SCI paper: Transcritical or supercritical CO2 cycles using both lowand high-temperature heat sources (Energy 43 (2012), quoted 22 times (as of September 2014))
- Has several patents and papers on high-efficiency power cycle and energy storage.



Current Intellectual Property Right Status

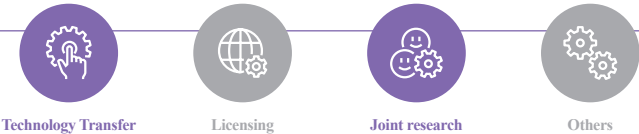
PATENT

- Heat Engine Based on Transcritical Rankine Cycle with Improved Exergy Efficiency and Method Thereof (KR1345106, PCT/KR2012/010664)

Technology Readiness Level (TRL)



Desired Partnership



# Solid Ammonium SCR System for NOx Reduction in Diesel Engine

Department of Engine Research    Researcher: Hongsuk Kim    Contact: +82-42-868-7367

Technology Overview

- A technology for thermal decomposition of solid ammonium to generate ammonia gas in order to use as a reducing agent for NOx emissions of diesel engines



Customer / Market

- Emission control system company for automobile car, marine, agricultural machine, construction machine, etc.

Problems of Existing Technology or Necessity of this Technology

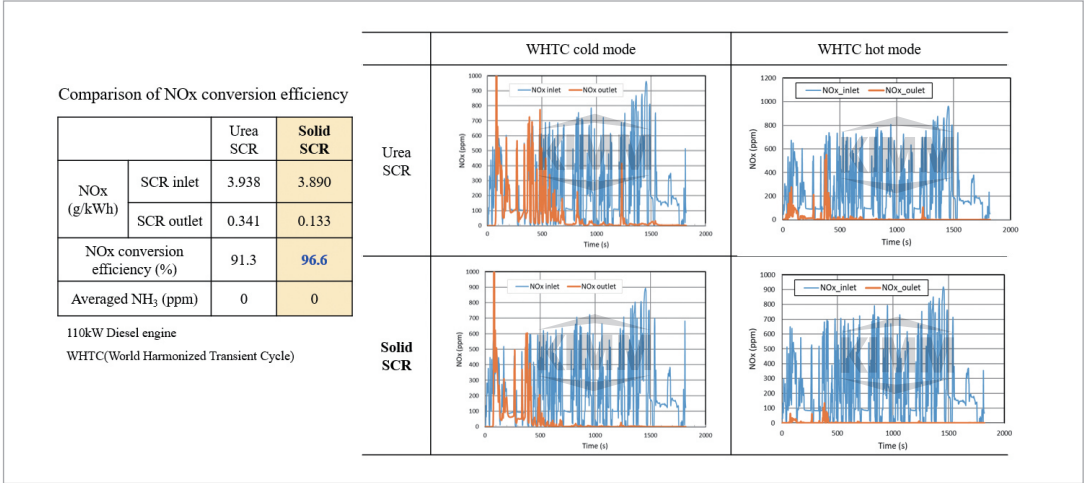
- Urea SCR technology, which uses a urea water solution (UWS) as the NH3 source, is a well-mature technology used these days.
- The UWS can give high NOx conversion efficiency for a wide range of catalyst temperatures. However, it has problems like poor NOx conversion at low exhaust gas temperature below 200°C and freezing issues below -11°C.
- Furthermore, the injection of UWS at low exhaust gas temperature and higher injection rate provokes the formation of deposits in the injector nozzle, exhaust pipe walls, and inside the SCR, which dramatically affects the performance of SCR.

Technical Distinctiveness

- Compared to liquid urea-water solution, theoretically, solid ammonium has three times greater ammonia storage capacity, so it can reduce storage volume by approximately two to three times.
- Since ammonia is supplied as a gas phase, it has excellent low-temperature NOx reduction performance. (Liquid urea cannot be used when the exhaust gas temperature is less than 200°C because of the problems of evaporation and decomposition.)
- It uses a low-cost reducing agent (ammonia carbonate or carbamate).
- Solid ammonium, a reducing agent, can be easily pyrolyzed using exhaust heat and electric heater.

Excellence of Technology

- We have a lot of engineering experience through many years of R&D on the characteristics of solid ammonium materials and various system configurations
- Our prototype for diesel engine showed excellent NOx reduction performance compared to urea water SCR

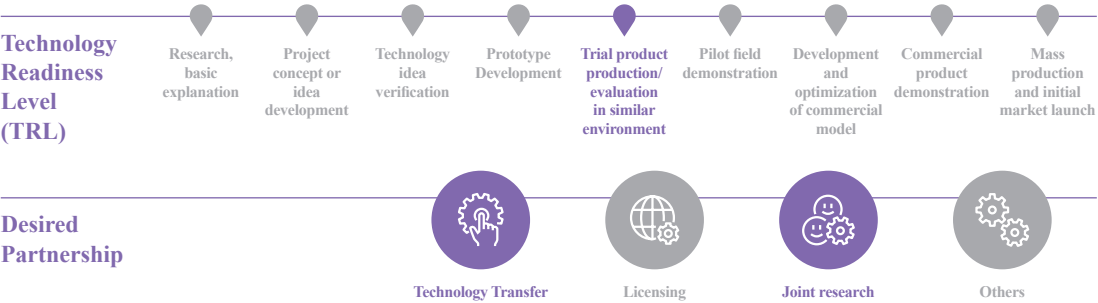


〈 NRTC (Non-Road Transient Cycle) NOx Reduction Property Test Result 〉

Current Intellectual Property Right Status

PATENT

- A Reactor for Solid Ammonium Salt and Control Method Thereof and NOx Emission Purification System Which Using Solid Ammonium Salt and Selective Catalytic Reduction Catalyst (KR1436936, PCT/KR2013/011542, US14/382614, EP13863670.9)
- NOx Emission Purification System using Solid Ammonium Salt and Selective Catalytic Reduction Catalyst (KR1185413)
- Emission Purification System Using Solid Urea and Selective Catalytic Reduction Catalyst (KR924591)
- Solid Urea Reactor and NOx Purification System Using Solid Urea and Selective Catalytic Reduction Catalyst (KR999571)
- Exhaust Gas Purification System (KR1476757, US13/855113)
- Exhaust Gas Purification System (KR2012-0145181)
- Catalyst System for Exhaust Gas Purification (KR2013-0136264)
- An Ammonia Gas Generator by Using Solid Ammonium Salt (KR2013-0122062)
- Cartridge of Solid Ammonium Salt and Its Production Method (KR2013-0122177)
- After Treatment System with Solid Ammonium for Selective Catalyst Reduction (KR2014-0051606)



# Urea SCR System Technology for Diesel Engine NOx Reduction

Department of Engine Research    Researcher: Hongsuk Kim    Contact: +82-42-868-7367

**Technology Overview**

- “Urea SCR technology” purifies NOx emissions from diesel engines.
- In the urea SCR technology, more fast evaporation and decomposition of injected urea–water–solution is required for high NOx removal efficiency.

**Customer / Market**

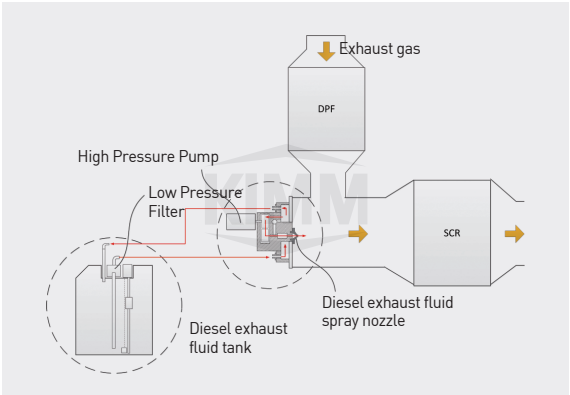
- Manufacturers of exhaust emissions control system for automobiles, construction machinery, agricultural machinery (tractors, etc.), small ships, etc.

**Problems of Existing Technology or Necessity of this Technology**

- When the conventional diesel exhaust fluid injection technology is applied at low temperatures(below approximately 200℃), deposit of solid ammonium can be formed in an exhaust pipe because of incomplete evaporation and decomposition characteristics of urea. More improvement of atomization of urea spray can solve this problem.

**Technical Distinctiveness**

- KIMM has a technology that can improve the NOx removal performance of urea SCR system by increasing pressure of urea injection with a dual urea pump.
- When diesel exhaust fluid is injected with high pressure using a dual pump, atomization characteristics are improved, so evaporation and thermal decomposition characteristics of diesel exhaust fluid are improved.

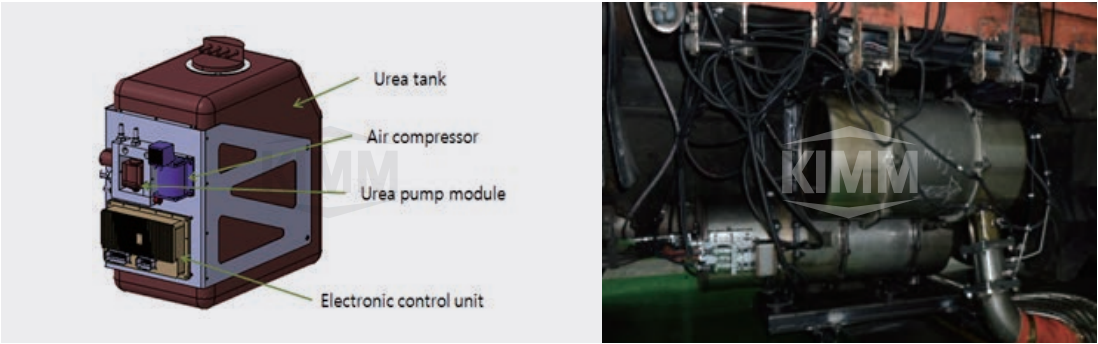


〈 High Pressure Injection System of Diesel Exhaust Fluid Using Dual Urea Pump 〉

**Excellence of Technology**

- Our technology was proven with a heavy–duty diesel truck . NOx purification performance of 92% has been confirmed using KC1–8 mode test protocol.

〈 Prototype for Diesel Exhaust Fluid Supply System and Installation on the Bottom of a Large Truck 〉



〈 Test Result Confirming the Reduction Rate (KC1–8 mode, 2 times on average) 〉

	THC*(g/kWh)	CO(g/kWh)	NOx(g/kWh)	PM*(g/kWh)	BSFC*
Before installing the device	0.095	0.775	6.739	0.047	160.9
After installing the device	0.013	0.010	00.531	0.008	159.4
Reduction rate (%)	86.3	98.7	92.1	83.0	0.9

\*THC: Total HydroCarbon, PM: Particulate Matters, BSFC: Brake Specific Fuel Consumption

**Current Intellectual Property Right Status**

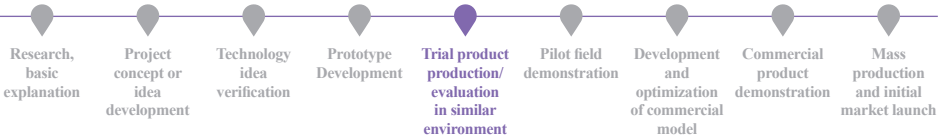
**PATENT**

- Urea Supply System for Exhaust Post–Treatment System and the Method of the Same (KR1896554)
- Urea Aqueous Solution Supply Device for Exhaust Purification (KR1965853)
- Program: Diesel engine urea SCR system control program (Registration No.: C–2016–021518)

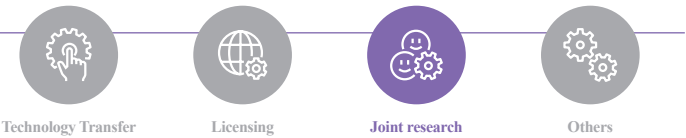
**KNOW-HOW**

- Design drawings, component specifications, controller circuit diagrams and programs
- Technology to overcome urea nozzle clogging at high temperature
- System design technology for even distribution of urea inside SCR catalyst
- System design and technology to improve NOx purification rate

**Technology Readiness Level (TRL)**



**Desired Partnership**



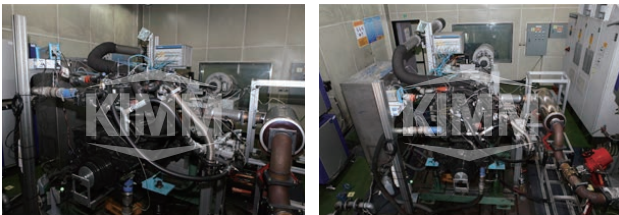


# Hydrogen-Natural Gas Blending Fuel(HCNG) Engine for City Bus Complying with Post EURO-6

▶ Department of Engine Research ▶ Researcher: Cheolhoon Park ▶ Contact: +82-42-868-7928

Technology Overview

- This technology is an engine technology using hydrogen-natural gas mixed fuel (HCNG) that can effectively lead the hydrogen era as next-generation energy.
- HCNG is a term that combines the first letters of 'hydrogen' and 'compressed natural gas' and represents a blended fuel of hydrogen and compressed natural gas, which has better cleanliness and combustion capability than CNG.
- This technology is a HCNG engine technology that can satisfy the post EURO-6 exhaust emission regulation.



〈 HCNG Engine and Components 〉

Customer / Market

- Manufacturer/supplier/demander of engines for power generation, car, and ship

Problems of Existing Technology or Necessity of this Technology

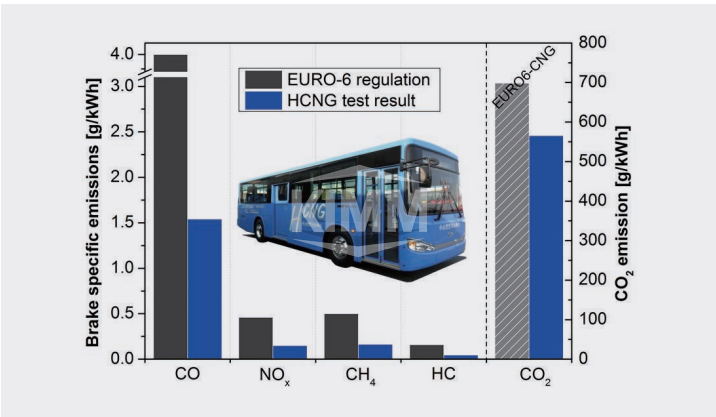
- EU's exhaust emission regulation EURO-6 has come into effect since 2014, and post EURO-6, that is, EURO-7, which is stricter than EURO-6, is expected to come into effect starting 2020.
- Domestic exhaust regulation for large vehicles including bus abides by the EU standard that vehicles that are currently in development must be equipped with a technology that satisfies EURO-7 to be commercialized.

Technical Distinctiveness

- With the equivalent power output capacity, the HCNG engine emits 18% less CO2 and shows 8% improvement in specific fuel consumption compared to existing city buses using CNG.
- Particularly, it reduces all harmful exhaust substances to below 1/3 of the EURO-6 regulation that it will easily fulfill the EURO-7 regulations that will come into effect starting 2020.
- High EGR technology-particularly suitable for HCNG engine, fuel supply and control technology, and exhaust post treatment technology are applied to all operation conditions for optimization and to improve durability and specific fuel consumption.

Excellence of Technology

- It is the world's first HCNG engine. (Advanced countries are also working on a HCNG engine to cope with the future era of hydrogen energy but have not developed an engine that satisfy the EURO-6 regulations.)
- To secure more commercialized technologies, a HCNG engine has been installed in 2 city buses that operate in Ulsan and Incheon each.
- The research team has published 27 papers including 13 HCNG engine-related SCI papers.



〈 Certified Mode Test Result of HCNG Engine and HCNG Bus with the Same Engine Installed 〉

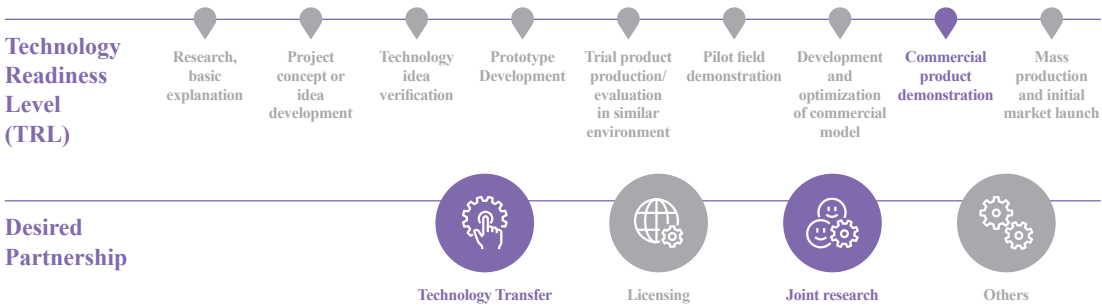
Current Intellectual Property Right Status

PATENT

- Method for Controlling Combustion Processes of the Hydrogen Engine (KR1290775)
- Advance Method of Startability for Natural Gas and Hydrogen blended fuel engine (KR1550813)
- Method for Improving Engine Idle Starting Ability and Catalyst Effect (KR1544388)
- Control Apparatus of Engine Using Reformed Gas and Natural Gas (KR1203161)

KNOW-HOW

- HCNG fuel supply system, turbo charger and ECU matching technology
- Control variable optimization by operating condition for HCNG engine
- HCNG engine's excess air ratio, EGR rate and exhaust gas optimized mapping technology
- Post treatment apparatus optimized mapping technology for HCNG engine's fuel and transient operating condition
- HCNG engine's combustion chamber optimization and key operating conditions' combustion performance assessment technology



# High-efficiency Direct Injection Type Ultra Lean LPG Engine

▶ Department of Engine Research ▶ Researcher: Cheolhoon Park ▶ Contact: +82-42-868-7928

Technology Overview

- High-efficiency direct injection type ultra-lean LPG engine using spray-guided type combustion system
- By locating the fuel injector in the center of the combustion chamber like a diesel engine and locating the discharge electrode of the spark plug in the recirculation zone of the spray to create a stable stratified lean mixture regardless of the operating condition of the engine to enable stable lean combustion through optimization of fuel injection strategy and ignition strategy. With this, highly efficient combustion is possible even under a very lean mixture condition, therefore, this next-generation engine technology can achieve fuel consumption reduction and high power output at the same time.

Customer / Market

- Gas fuel (LPG, CNG) engine manufacturer

Problems of Existing Technology or Necessity of this Technology

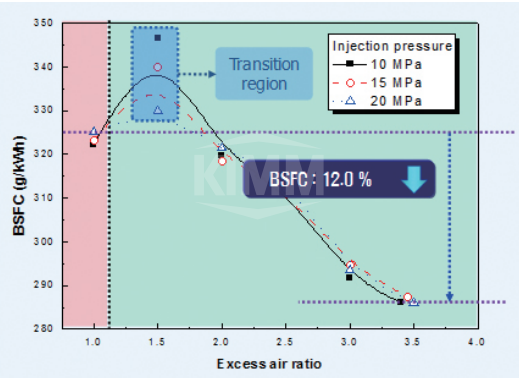
- Gaseous fuel like LPG and CNG is responsible for a large part of domestic transportation fuel, and with price relatively cheaper than gasoline and diesel, the number of registered vehicles using it exceeded 2 million in the late-2000s, and the number is still on the rise.
- Also, if the government adjusts the price of low-carbon gas fuel, which has relatively clean fuel image, to 50% of the existing gasoline and diesel fuel in consideration of the diversification of domestic energy sources and the social cost from environmental pollutants, the supply of natural gas vehicles is expected to increase.
- Low-carbon gaseous fuel such as LPG and CNG is beneficial as vehicle fuel seen from the aspect of easy fuel supply, improvement effect compared to the existing system, possibility of commercialization, and relative difficulty of technology development. However, until today, mainly the intake port injection method is being applied, therefore the limitations of premixed fuel combustion, that is, the limitation of pumping loss and ultra-lean combustion and the engine output and exhaust performance improvement effects due to the evaporation heat of fuel still need improvement. It is still insufficient to be used as an alternative in the future considering the CO2 emission regulations and energy efficiency aspects.
- In order to solve the problems of the premixed fuel combustion, direct injection technology in which the gaseous fuel is directly injected into the combustion chamber is considered to be one of the most important technologies for satisfying the emission regulations and CO2 regulations in the future.

Technical Distinctiveness

- The direct injection gas engine directly injects the gaseous fuel into the cylinder in the engine, which improves the accuracy of fuel control and lean combustion can be realized to maximize the combustion efficiency.
- In addition, due to the evaporating property of gaseous fuel, the temperature of the air is cooled, thereby suppressing abnormal combustion such as knocking, improving thermal efficiency by increasing compression ratio, and achieving high volumetric efficiency from direct injection to the cylinder. It has the advantage of reducing emission of harmful gas and maximizing energy efficiency, the key to CO2 emission, through enhancement of output and fuel economy.

Excellence of Technology

- 10% improvement in specific fuel consumption through development of core technology for ultra-lean direct injection gas engine
- Expansion of lean combustion operation through optimization of fuel injection control
- Performance and exhaust improvement through application of boosting system and EGR control system



Current Intellectual Property Right Status

PATENT

- Inter-injection Spark Ignition Control Method for Direct Injection Gas Engine (KR1615698)
- Direct Injection Gas Engine (KR1599473)
- Valve Operation Control Method for Preventing the Carbon Deposition of Spark Plug in a Direct Injection Gasoline Engine (KR1226058)
- Temperature Stratification Method for Anti-knocking in a Direct Injection Gasoline Engine (KR1299688)

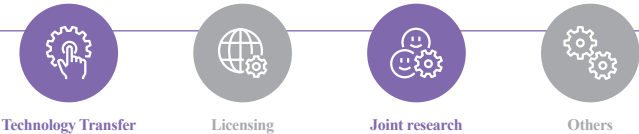
KNOW-HOW

- Gaseous fuel high-pressure fuel supply and ignition control technology
- Ultra-lean mixture engine's combustion stability control technology
- Direct injection fuel injection time and injection fraction optimization technology
- Engine optimized control by operating condition and EGR/boost control technology

Technology Readiness Level (TRL)



Desired Partnership

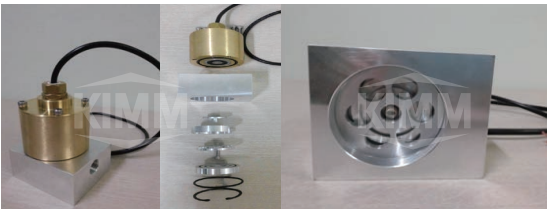


# High Flow Rate Methane-based Gas Fuel Injection Valve

▶ Department of Engine Research ▶ Researcher: : Young Choi ▶ Contact: +82-42-868-7962

Technology Overview

• High flow rate injection valve is a core device of the fuel supply system required for the application of MW-class internal combustion engines fueled with methane-based gas fuel, where methane is the main component. It is a methane-based gas fuel injector technology characterized by the opening that is opened by the electromagnetic force generated from the solenoid and closed by the pressure difference and spring force, and a flow path of a specific shape.



Customer / Market

- MW-class gas engine production company (for ship and power generation)
- Retrofit company from large diesel engine to large gas engine (including a retrofit kit manufacturer and seller)
- Repair and maintenance company of gas engines for medium/large ships and power generation

Problems of Existing Technology or Necessity of this Technology

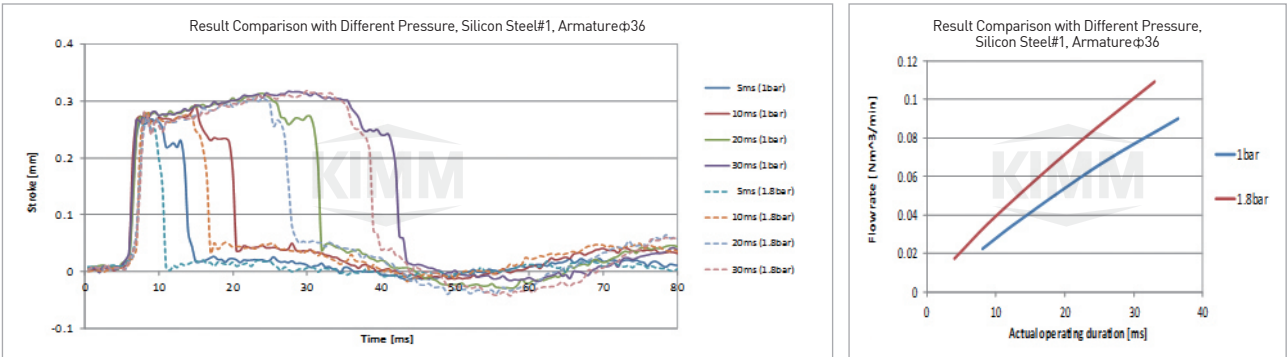
- Existing injector has a confined area for flow channel and there is a limit for sufficient fuel supply.
- Because the leakage rate of existing high flow rate injector (4.8 L/min or less at the pressure difference of 0.7 bar) is large, an injector with a smaller leakage rate is needed.
- Expensive ferromagnetic material is used in the core and armature. Therefore, there is a need for an economically feasible material with great formability and durability that could fulfill required response time and flow rate.
- Injector capability that could guarantee stable stroke and flow rate with the same control signal is required.

Technical Distinctiveness

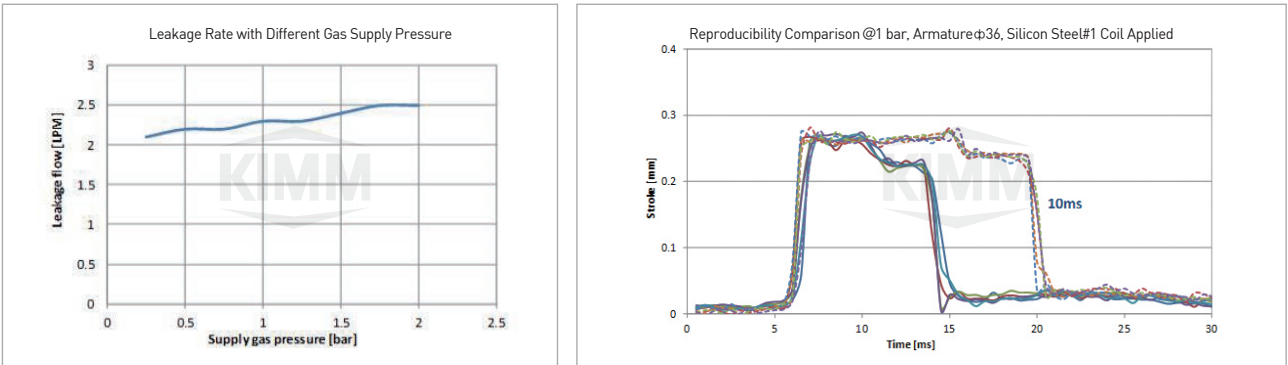
- Solenoid structure with maximized magnetic force by electromagnetic analysis and experiment
- Armature structure with minimal resistance and optimized stroke to secure quick responsiveness and sufficient flow rate
- Differentiation of injection valve driving characteristics according to the change in material of the solenoid core and armature (Silicon steel with strong magnetic force is appropriate for a case of high pressure difference)
- A specific shape of internal flow channel designed to guarantee high flow rate
- Consistent valve opening and closing responsiveness matching with stroke regardless of repetitive injection valve operation
- Minimized valve leakage through improvement of lower outlet design by replacement of O-ring
- Monitoring and control function for the high flow methane-oriented gaseous fuel injector
- Measurement of stopper abrasion and spring elasticity change using shock and oscillation detection in the acceleration sensor for injector maintenance and selfdiagnosis of error

Excellence of Technology

- Valve response accuracy, reproducibility and flow rate linearity following the control duty ratio
- Injection valve opening and closing responsiveness within 2 ms
- Ultra-low leak injection valve with the leakage of 2 to 3 L/min under the pressure difference of 0.2 to 2 bar



◁ Valve Opening/Closing Response Characteristics with Different Driving Time ▷ ◁ Flow Linearity According to Working Time ▷



◁ Change in Leakage Rate According to Gas Supply Pressure ▷ ◁ Accuracy of Displacement and Opening/Closing Time Reoccurrence During Repeated Valve Opening and Closing ▷

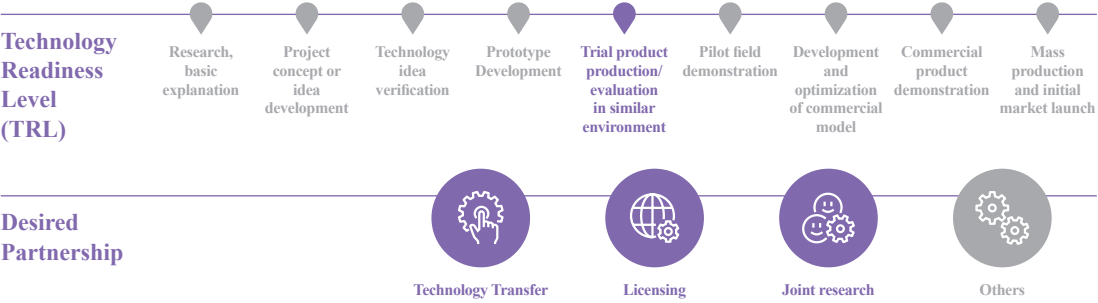
Current Intellectual Property Right Status

PATENT

- An Injection Valve for the Methane-Oriented Gaseous Fuel (KR1570492)
- A Monitoring and Control Method of Injection Valve for the Methane-Oriented Gaseous Fuel (KR1674994)

KNOW-HOW

- High flow methane-oriented gaseous fuel injection valve design technology
- High flow methane-oriented gaseous fuel injection valve control technology
- Methane-oriented gaseous fuel injection valve breakdown diagnosis technology





## Remote Plasma Generator

▶ Department of Plasma Engineering

▶ Researcher: Wooseok Kang

► Contact: +82-42-868-7435

## Technology Overview

- Plasma generator that enables effective processing by reducing damages on a material in a wide range of pressure variations



## Customer / Market

- Semiconductor/display equipment company
- Material/bio/agriculture/environmental application equipment manufacturer using plasma processing

## Problems of Existing Technology or Necessity of this Technology

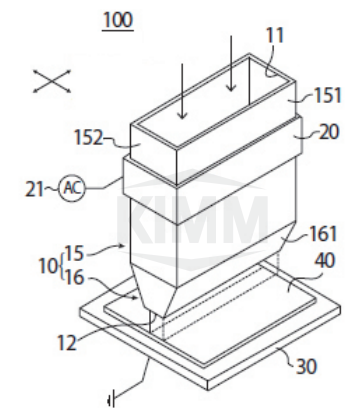
- Existing remote plasma generators rely on the radio frequency (RF) or microwave (MW) power supplies that require matching technology between the plasma reactor and the power. Matching is venerable to load change, and is difficult to operate under high pressure.
- In particular, matching technology may limit high-power ICP for large capacity/area treatments.

## Technical Distinctiveness

- Enables process that minimizes material damage
- Can be applied extensively as a new applied technology in flexible device/display and bio fields
- Can be applied for various operating areas
- Effective process by controlling the plasma characteristics
- Neutral particle and low energy ion treatment: Effective plasma chemical process/ minimal damage to the vulnerable objects
- Can be operated under a broad pressure range due to the capacitively coupled effect of the dielectric substance
- Wide operation ranges—less dependent to the operation pressure change
- Easy flow velocity/reaction effect/uniformity control with the nozzle type design
- Can be operated under high power conditions/large—volume (or surface) treatment

## Excellence of Technology

- The capacitively coupled type does not require a special matching technology, and depending on the size of dielectric substance support, large capacity and large area plasma treatment can be conducted easily.
- The operating range is wide from few mTorr to few Torr, and depending on the slope angle of the slope on the nozzle part, the electric field and flow velocity change rate can be adjusted to easily control the process parameters.

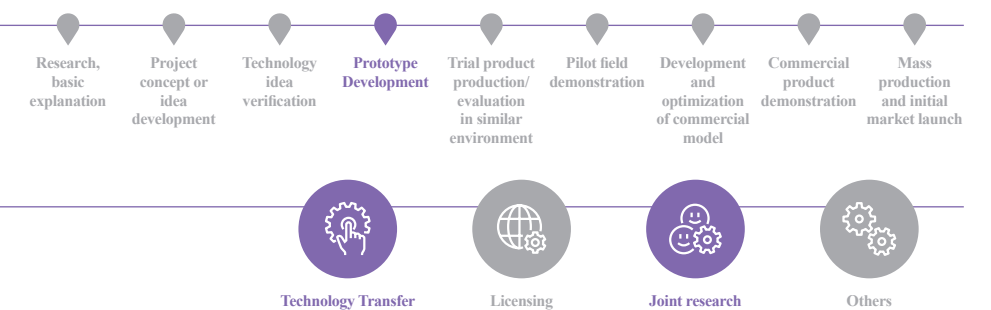


### 〈 Capacitively Coupled Remote Plasma 〉

### Current Intellectual Property Right Status

## PATENT

- Apparatus for Generating Remote Plasma (KR2013-0073901, EP14153996.5)
- Apparatus for Generating Capacitively Coupled Plasma (KR1512159)

Technology  
Readiness  
Level  
(TRL)

# Regeneration Technique of Diesel Particulate Filter Using Plasma Burner

▶ Department of Plasma Engineering ▶ Researcher: Young-Hoon Song ▶ Contact: +82-42-868-7302

Technology Overview

- Plasma burner and diesel particulate filter. Here, the particulate filter is automatically regenerated by oxidizing the particulate matters collected in the diesel particulate filter.



Customer / Market

- Automobile component and automobile companies

Problems of Existing Technology or Necessity of this Technology

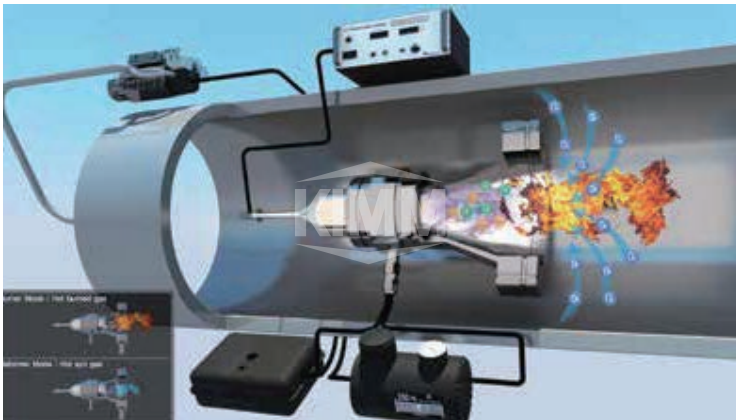
- Currently, some car models use an exhaust gas filter coated with a noble metal catalyst that burns exhaust gas, but the performance of the noble metal catalyst that burns exhaust gas deteriorates rapidly due to the sulfur component of the fuel, and diesel cars running in large cities have an exhaust temperature lower than the catalyst's active temperature. So there are many cases where the catalyst of the exhaust gas filter does not work.

Technical Distinctiveness

- When a plasma burner is used to burn the exhaust gas collected in the exhaust gas filter, 1) there is no need to use an expensive noble metal catalyst, 2) the performance is not affected by the sulfur content of the fuel, and 3) the diesel vehicle's exhaust gas can be reduced by more than 95% regardless of the diesel exhaust gas temperature.
- When a plasma burner is used to burn the exhaust gas collected in the exhaust gas filter, 1) there is no need to use an expensive noble metal catalyst, 2) the performance is not affected by the sulfur content of the fuel, and 3) the diesel vehicle's exhaust gas can be reduced by more than 95% regardless of the diesel exhaust gas temperature.
- There is no risk of miss-firing for a plasma burner, therefore, it is safe technology to be applied for cars.

Excellence of Technology

- Plasma DPF system has been successfully operated for more than 3 years in military special vehicles, and will be applied to special vehicles and construction machines where it is difficult to apply general combustion gas reduction devices.
- The KIMM's plasma burner technology was transferred to HK-MnS, the exhaust emission reduction apparatus company spin off by Hyundai Kia Motors, and the company has been operating a diesel engine locomotive for subway rail management with the PM filter using a plasma burner since 2009.
- The technology was awarded the Invention Award from the Korea Intellectual Property Office, and the Technology Award from the Ministry of Commerce, Industry and Energy, and based on these, the head researcher received the Prime Minister Citation and Industrial Technology Award from the Korean Society of Combustion.



〈 Operating Principle of Plasma Burner 〉

Current Intellectual Property Right Status

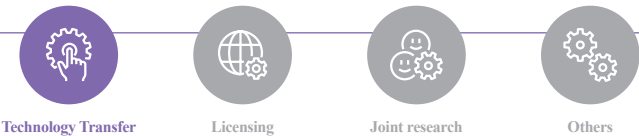
PATENT

- Plasma Reactor and Plasma Reaction Method Using the Same, and Plasma Reaction Method of Persistent Gas and NOx Reducing Device of Occluding Catalyst System (PCT/KR2006/004043, KR0619237, KR0679868, KR0586880, KR0561199, IN252034, IN2744/KOLNP/2011, US8568662, US8524162, CNZL 2006 8 0037559.5, CNZL201010284991.2, CNZL201010284993.1, EP 1933975, EP2343114, EP2233203, EP2233196, EP1933975, JP4834736, JP5339220)
- Plasma Reactor and Reduction Equipment for PM in Exhaust Gas Using the Same (pct/kr2007/003394, KR0692948, KR0679869, KR0699495, CNZL 2007 8 0001193.0, US8,272,206, EP4659097, HK09101433.4)
- Plasma Burner and PM Filter (KR0866327, KR0866330, KR0866328, KR0913606, CNZL 2008 1 0129999.4, US8,257,455, JP5086199, JP5473023, EP08356112.6, EP11181993.4)

Technology Readiness Level (TRL)



Desired Partnership



# Flow Controller with Enhanced Flow Control Property

▶ Department of Plasma Engineering ▶ Researcher: Dae Hoon Lee ▶ Contact: +82-42-868-7406

Technology Overview

- Ringer’s solution control device with linear and precise flow rate control



Customer / Market

- Hospital and clinic requiring precise flow rate control (fields requiring precise injection of ringer’s solution e.g. anticancer drug injection, etc.)

Problems of Existing Technology or Necessity of this Technology

- When injecting the ringer’s solution, a cheap disposable precise flow rate controller is provided for linear flow rate control.
- Existing flow controller cannot control the flow rate precisely resulting in parabolic flow pattern with control wheel operation and accurate flow rate estimation and control was impossible. Therefore, an expensive infusion pump was used for treatment that requires precise injection such as cancer treatment. However, precise flow rate control is also difficult with this device, and due to its expensive price, it could not be popularized.
- The device enables cheap and disposable tool for precise linear flow rate control to overcome the problems in cost and controllability of existing fluid treatment.

Technical Distinctiveness

- Realized a cheap, disposable flow rate controller with accurate linearity control
- Contributed to expansion of treatment of symptoms that can be treated with fluid treatment and improvement of treatment effect
- Realized the concept of flow rate controller with satisfactory price and performance
- Existing method of controlling the flow rate with the rotary controller uses a circular flow channel and linear flow rate control is fundamentally impossible. Therefore, for each treatment and for every flow rate adjustment, the flow rate change has to be checked every time.
- Linear flow rate control is a function that is not even guaranteed in an expensive infusion pump.
- This invention adopts a linear movement structure for the flow rate controller to enable precise linear flow rate control, and since it is disposable, the pricecompetitiveness has been secured

Excellence of Technology

- Unlike existing apparatus that uses a rotary controller for the ringer’s solution pass through, by using a worm gear that enables linear movement in the flow rate controller, the nonlinearity and possibility of error in the process of the rotary movement are fundamentally eliminated.
- In the invented flow rate controller, the flow rate controller that moves linearly by the rotor moves to show the travel range of the ringer’s solution and how the flow path area changes.
- Linearly changing flow path area and travel route enables linear flow rate control.
- Has worked for KIMM from 2004 to present, and invented 9 technologies (1,780 million won as fixed payment + running royalty) during the period
- During the same period, 136 patents were applied and 93 were registered.
- Received the 2007 Korea Intellectual Property Office’s Patent Award (The Most Excellent Researcher Award)

Current Intellectual Property Right Status

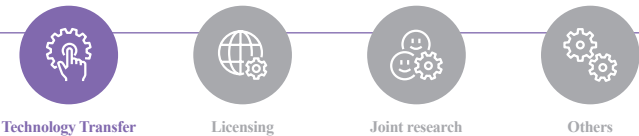
PATENT

- Regulator of Amount of Flowing Ringer’s Solution (KR1409482, PCT/KR2013/003405)

Technology Readiness Level (TRL)



Desired Partnership





# Plasma Combustor with Low-NOx Generation

▶ Department of Plasma Engineering ▶ Researcher: Dae Hoon Lee ▶ Contact: +82-42-868-7406

Technology Overview

- A combustor that stabilizes lifted flame and enables ultra-low NOx generation by supplying reformed gas containing hydrogen with the plasma reactor inside the combustor



Customer / Market

- Burner, combustor manufacturer or a company with production facilities that use boilers or industrial burners that are subject to total NOx emission regulation

Problems of Existing Technology or Necessity of this Technology

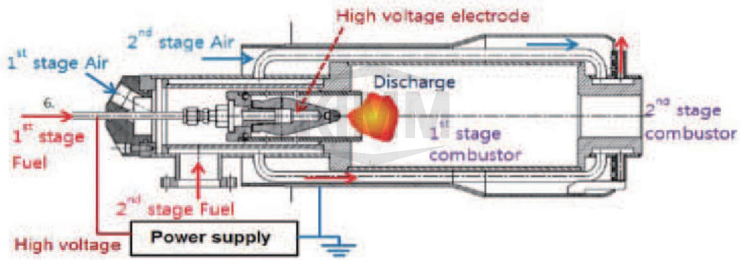
- To develop combustion technology that minimizes emission of NOx that inevitably occurs from a burner or combustor
- Existing low-NOx burner requires additional facilities such as staged combustor and excessive EGR.
- A new technology is required to reduce NOx without excessive change in the combustor or additional facilities.
- If the regulations such as total NOx emission regulation that grow stricter cannot be fulfilled, facility extension is limited in the whole industry, and ultra-low NOx emission realized through combustion technology without an after treatment requiring excessive cost and facility is an economic and effective countermeasure.

Technical Distinctiveness

- Without additional facility installation or an after treatment facility other than existing burner facility, the new technology can be applied within the existing burner and combustor installation condition.
- Compared to existing low-NOx emission burner, it is a new concept combustion technology that enables single digit ppm NOx emission without EGR.
- Additional cost for realization of ultra-low NOx emission is within the range that does not greatly affect existing price of burner.
- Plasma burner technology for ultra-low NOx emission maintains the appearance of existing burner while achieving improvements.
- The simple structure and form of plasma burner has benefits in terms of durability and reliability.
- It can realize stabilization of lifted flame, which cannot be done with existing burner.

Excellence of Technology

- Plasma reactor installed inside the burner head reforms the fuel to supply gas rich in hydrogen to the combustor.
- Reformed gas containing hydrogen stabilizes flame while the main flame is lifted through rapid flame stabilization.
- Lifted flame quickly improves the characteristics in mixing of air and fuel, and removes high temperature condition in flame root, also, the synthetic gas provided by the plasma reactor inside the burner itself acts as a reducer.
- Published the paper, NOx Reduction Strategy by Staged Combustion with Plasma- Assisted Flame Stabilization (Energy & Fuels 2012; 26; 7; 4284-4290)
- Received the 2007 Patented Technology Award (The Most Excellent Researcher Award)



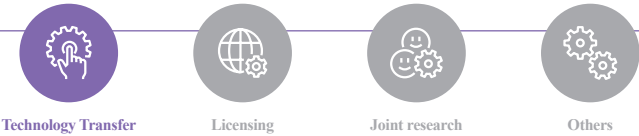
Current Intellectual Property Right Status

PATENT	
• Plasma Burner (KR1525140)	• Plasma Torch (KR2013-013652)
• Plasma Burner (KR1527960)	• Plasma Burner (KR1174094)

Technology Readiness Level (TRL)



Desired Partnership



# VOC and Low-concentration Contaminants Removal Technology

▶ Department of Plasma Engineering   ▶ Researcher: Dae Hoon Lee   ▶ Contact: +82-42-868-7406

**Technology Overview**

- Apparatus for effective removal of volatile organic compounds (VOCs) generated by evaporation of organic solvents or hydrocarbon fuels. Plasma-catalysis can remove VOCs without additional use of fuel

**Customer / Market**

- Paint factory, petroleum-based fuel storage facility
- Businesses and manufacturing sites using organic solvent

**Problems of Existing Technology or Necessity of this Technology**

- Low concentration VOC has a low calorific power, so it was removed through simple adsorption or incineration using a separate fuel.
- Simple adsorption method requires replacement of absorbent and regeneration process, and there is a risk of fire in the process of adsorption.
- Incineration method requires a separate fuel supply facility and emits secondary pollutants such as NOx.

**Technical Distinctiveness**

- This technology uses catalytic reaction assisted by plasma for oxidative removal in VOC without using separate fuel.
- The catalytic oxidation method does not discharge secondary by-products like NOx.

**Excellence of Technology**

- The capability to eliminate organic substances like benzene and toluene was verified.
- Can treat complex pollution with VOCs
- Using plasma reaction and catalytic oxidation, low temperature activation of catalyst can be induced.
- Can eliminate non-alkane hydrocarbon under 300 degrees Celsius
- Published the paper, Low temperature activation of CO removal by O3 assisted catalysis (Environmental Science & Technology 2014; 48 (24), 14543-14548

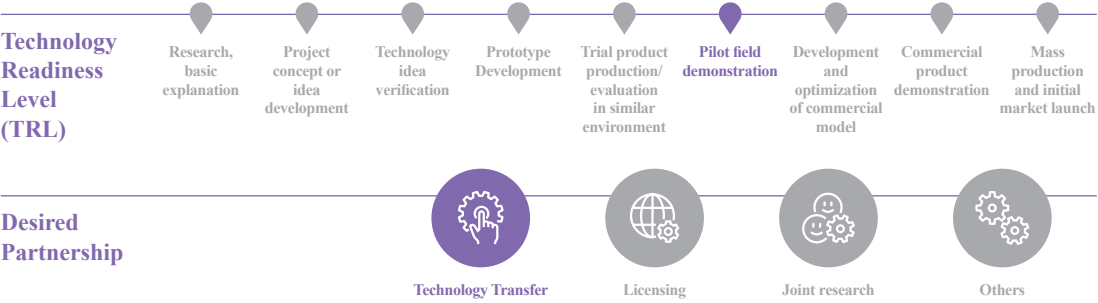


〈 Pilot VOC Treatment Apparatus 〉

**Current Intellectual Property Right Status**

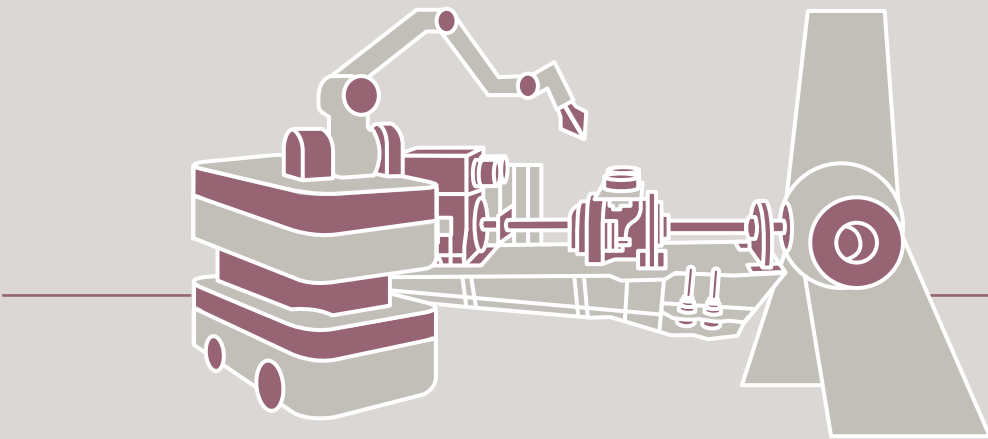
PATENT

- Air Cleaning Device (KR1544387)
- Air Cleaning Device (KR1661678)
- Air Cleaning Device and Driving Method of the Same (KR1767159)
- Air Cleaning Device (KR1607645)



5

Mechanical Systems Safety  
Research Division



MOBILE  
AUTONOMOUS  
OPERATING  
MACHINERY

MECHANICAL SYSTEM  
STATUS MONITORING  
AND FAILURE  
DIAGNOSIS  
TECHNOLOGY

- 306 • Department of System Dynamics
- 318 • Department of Smart Industrial Machine Technologies
- 334 • Department of AI Machinery
- 344 • Department of Reliability Assessment

KOREA  
INSTITUTE OF  
MACHINERY &  
MATERIALS



# Ship Noise/Vibration/Shock and Survivability Improvement Design Technology

▶ Department of System Dynamics   ▶ Researcher: SangRyul Kim   ▶ Contact: +82-42-868-7466

Technology Overview

- Analysis and noise control technology of ship noise/underwater radiated noise using statistical energy analysis method
- Vibration analysis and vibration-proof design technology for ships based on finite element analysis
- Shock-resistant design, damage analysis and evaluation technology for ship hull structure against underwater threats
- Analytical evaluation technology of ship survivability level considering damage, vulnerability, and resilience

Customer / Market

- Defense shipyard
- Manufacturers of equipments requiring low noise, low vibration, and shock resistance performance

Problems of Existing Technology or Necessity of this Technology

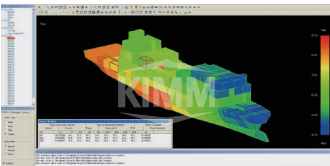
- Cabin noise control technology contributes to the improvement of combat power by improving the working environment of crew members and is necessary to prevent hearing loss caused by exposure to noise. Underwater radiated noise reduction technology is necessary to improve the survivability by reducing the detection probability.
- Ships are always exposed to vibrations from propulsion systems such as engines, which not only affect the performance and lifespan of the ship, but also greatly affect the fatigue of the crew. When designing a ship, a design that can minimize vibration is required, and after shipbuilding, it is necessary to evaluate the vibration response through vibration measurement during trial operation of a ship.
- There is no technology to systematically analyze and evaluate integrated survivability in domestic ship design. Based on the results of localization and advancement of survivability improvement technology, it is possible to design and build ships with a level of survivability suitable for the operational characteristics of ships with domestic defense shipyards.

Technical Distinctiveness

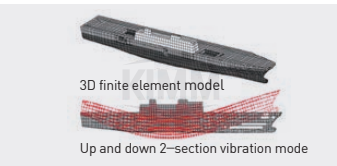
- Possibility of accurate ship noise/underwater radiated noise analysis and low-noise design at the design stage through the application of noise control technology and database of various ships/equipment
- Possibility of calculating the vibratory force for various propulsion systems such as water jet propeller, air propeller, and Voith-Schneider propeller, performing customized vibration analysis and vibration protection design at the ship design stage, and analyzing the effect of vibration to fatigue failure and establishing measures to prevent recurrence
- A technology for analyzing shock response to the initial shock wave of an underwater explosion, the shipping response to the gas sphere pressure wave, and ship shock test simulation technology for the performance review of shock resistance design requirements of the Korean Navy based on the Republic of Korea ship design and shipbuilding standards/procedures and available database

Excellence of Technology

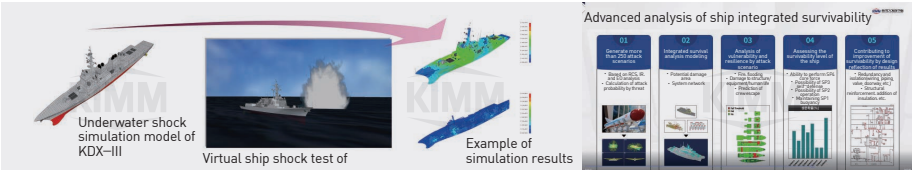
- High-accuracy noise reduction design can be realized using air conditioning noise prediction technology, elastic mount/equipment base/floating floor/acoustic enclosure performance prediction technology, etc.
- Developed submarine noise analysis and low control technology (such as transmission path and contribution of major noise sources in the water, acoustic radiation efficiency, and performance of acoustic coating materials) contributed to the design of Korea's first submarine "Dosan Ahn Changho"
- Possess experience in vibration analysis, control measures, and real ship measurement/evaluation for more than 20 various ships by development stage, such as mine sweeper hunter (MSH), large transport ship (LPX), and fast craft (PKX).
- Experience in review/suggestion of adequacy of vibration standards, analysis of vibration characteristics for various propellers (spiral, waterjet, air propeller), vibration analysis/evaluation, vibration measurement/evaluation, trouble shooting related to structural vibration, and vibration-proof design
- Experience in supporting successful strategical development through various consigned studies related to shock resistance performance evaluation and design criteria of the ROK Navy's new ships and participation in a joint investigation team to determine the cause of the sinking of the Cheonan



〈 Ship Noise Analysis and Evaluation Technology 〉



〈 Ship Vibration Analysis and Evaluation Technology 〉



〈 Ship Shock-Resistance Analysis and Evaluation Technology 〉

〈 Vessel Survivability Improvement Design Technology 〉

Current Intellectual Property Right Status

PATENT

- Air transparent soundproofing device (KR1897468)
- Apparatus for underwater radiated noise measurement and Method Thereof (KR1801218)
- Low Noise Room Unit (KR1556501)
- Silencer (KR1289312)
- Structural damage detection method using acceleration and strain signals (KR1055314)
- Smart-elastic mounts for ships based on the internet of thing (KR1805530)
- Impact machine device using restoring force (KR1301761)

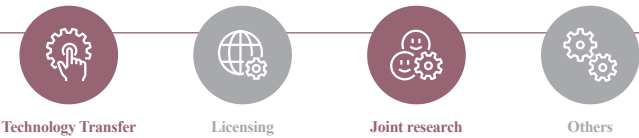
KNOW-HOW

- Ship noise and vibration analysis using SEA and low-noise design
- Underwater radiated noise analysis and low-noise design
- Noise analysis and noise control know-how for HVAC (Heating, Ventilation and AirConditioning)
- Structural analysis modeling know-how necessary to secure the reliability of the vibration analysis results of ships

Technology Readiness Level (TRL)



Desired Partnership



# AI-based Predictive Diagnosis and Damage Management Techonoly

▶ Department of System Dynamics ▶ Researcher: SangRyul Kim ▶ Contact: +82-42-868-7466

**Technology Overview**

- Diagnosis and prognosis technology in mechanical systems using airtificial intelligenece
- Damage detection and autonomous damage restoration technology in pipeline systems using airtificial intelligenece

**Customer / Market**

- Onshore/offshore plant industry (power plant, chemical process plant, shipbuilder, etc.)
- General manufacturing industrial complexes

**Problems of Existing Technology or Necessity of this Technology**

- While the convergence of digital/AI technology in the traditional machinery industry according to the 4th industrial revolution is accelerating, manufacturing industries experiencing production disruptions due to COVID-19 are expected to expand the introduction of automation and unmanned systems.
- When an automated/unmanned system is introduced in the manufacturing industry, it must be accompanied by a technology that can accurately diagnose the condition of the system in order to guarantee the quality of the product and reduce accidents caused by equipment failure. The demand for technology that can predict the current operating status from massive data acquired during operation, simplify the production process and reduce downtime from unexpected failure by improving the interaction between people and machines is increasing. And the AI technology market forecast in the manufacturing sector is expected to grow from USD 1.1 billion in 2020 to USD 16.7 billion in 2026, with an annual growth rate of 57.2 %.
- Major accidents (Binggrae factory accident in 2014, Hanwha Chemical accident in 2015, Hyosung Yongyeon factory accident in 2016, Samsung Electronics CO2 leak accident in 2018, Lotte Chemical Daesan plant explosion accident in 2020, US warship explosion in 2020 Accidents, etc.) occurred continuously due to mechanical system failure, and regulations to prevent them were strengthened and the demand for machine system status diagnosis technology increased.
- In the case of large-scale plant piping systems, when an accident occurs due to deterioration of equipment or various unexpected external causes, major human and material losses occur, and thus, it is necessary to respond promptly in the early stage of the accident. In addition, automation/unmanned accident response technology is required to prevent secondary accident of the manpower involved in dangerous situation.

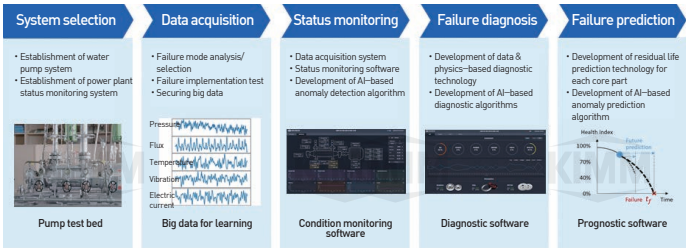
**Technical Distinctiveness**

- (Predictive diagnosis) Possibility of expanding to general rotating mechanical systems with AI-based diagnosis technology using big data targeting mechanical systems (pumps, etc.)
- (Predictive diagnosis) Establishing a framework that can apply the existing machine learning techniques and the latest AI techniques
- (Damage management) Development of pipeline damage detection and restoration technology using smart valves
- (Damage management) Rapid damage detection and restoration in the pipeline using data communication method among smart valves (sensors) and independently embedded damage detection method in a smart valve



**Excellence of Technology**

- (Predictive diagnosis) Developed a diagnostic technology for power plant pumps and verified the diagnostic success rate of more than 95 %
- (Predictive diagnosis) Scalability by combining the latest AI technologies such as transfer learning as well as existing machine learning techniques
- (Predictive diagnosis) The cause of the increase in O&M cost of mechanical systems is the occurrence of unplanned failures and frequent preventive maintenance to prevent them. O&M cost reduction by estimating the remaining useful life through predictive diagnosis.



- (Damage management) Development of the smart valve with embedded sensing and control algorithms and completion of performance evaluation of the algorithm in the testbed
- (Damage management) Confirmation of the world-class damage restoration time (less than 90 seconds in the firemain piping system of a naval ship)
- More than 20 years of research experience in the field of dynamics-based mechanical system analysis and diagnosis

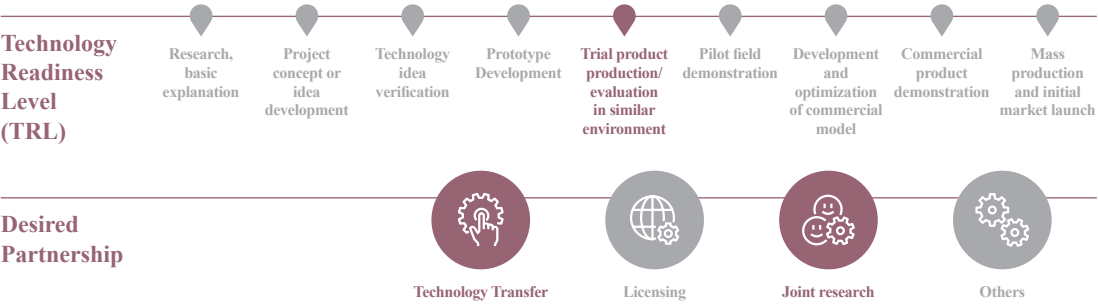
**Current Intellectual Property Right Status**

**PATENT**

- Band-type pipe leakage detecting apparatus and pipe leakage detecting method using the same (KR2106823)
- Integrated control system for inner and outer sections of a vessel and method for integrated control system using the same (KR2019-0057831)
- Piping system damage determination system and piping system damage determination method using the same (KR2019-0131571)
- Machine diagnosis system through image learning and machine diagnosis method using the same (KR2019-0047303)

**KNOW-HOW**

- Condition monitoring, diagnosis and prognosis software for various mechanical systems
- Boiler feed water pump PHM (Prognostics and Health Management software)

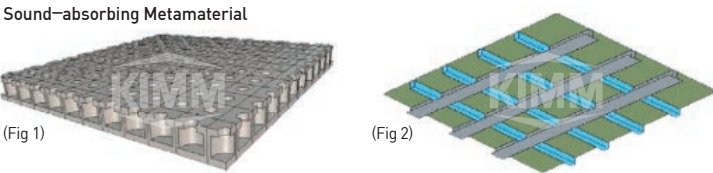


Sound-absorbing and Insulation Metamaterials

▶ Department of System Dynamics ▶ Researcher: Hyunse Kim ▶ Contact: +82-42-868-7461

Technology Overview

- Low-frequency sound-absorbing structure using metamaterials



Customer / Market

- Soundproof design for transportation systems (automobile, ship, aircraft, etc.)
- Noise barrier for roads, substations, etc.
- Sound absorption/insulation materials for buildings

Problems of Existing Technology or Necessity of this Technology

- Among noise from wind power blade noise, floor impact noise, HVAC noise, transformer noise, and exhaust noise from cars and ships, low frequency noise between 10 to 200Hz not only annoys people, but also may intimidate structural stability, and there is a need for soundproof measure for such noise.
- Conventional low-frequency noise-reduction method is increase of the thickness of the sound-absorbing materials.
- However, an effective low-frequency noise controlling technology is needed.

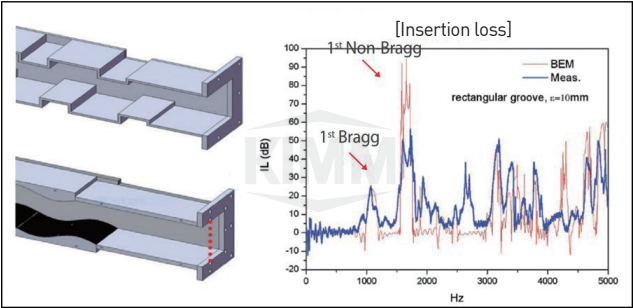
Technical Distinctiveness

- Metamaterial sound-absorbing structures could be built with low-price plastics, so that they could be price-competitive compared to the conventional materials.
- Conventional sound-absorbing materials such as sponges wear out over time, but plastics can be used stably for a long time.
- Unlike conventional sound-absorbing materials, metamaterial can be designed to be effective for a specific frequency range, and their weight and size can be reduced while boasting excellent performance.

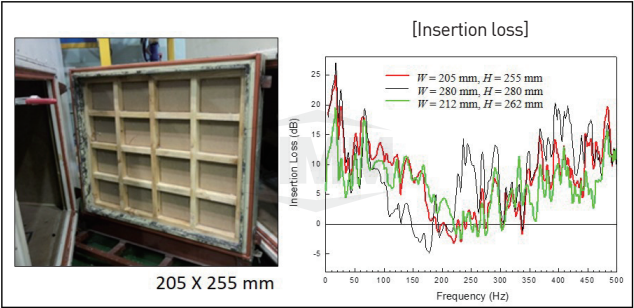
Excellence of Technology

- Low-frequency sound-absorbing structure
- Provides light-weight sound-absorbing/insulating material

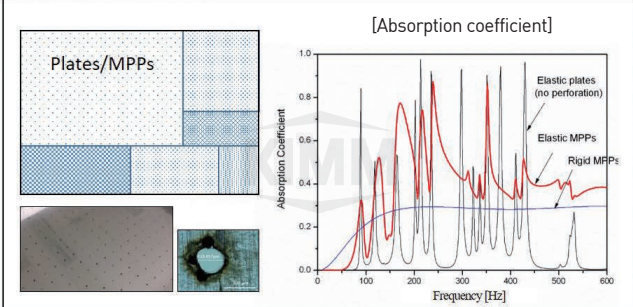
[Silencer for Low-frequency Noise]



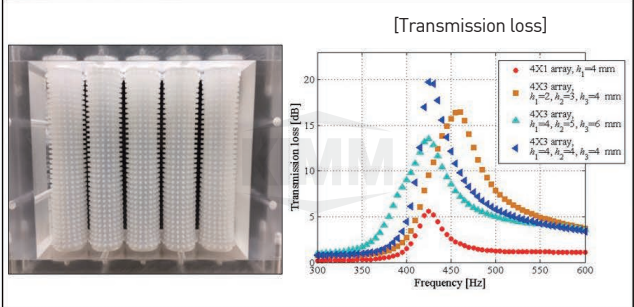
[Floor Impact Noise Reduction]



[Silencer for Low-frequency Noise]



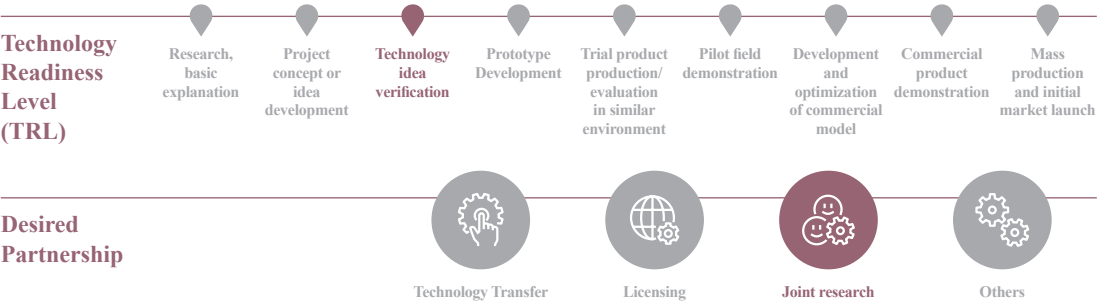
[Floor Impact Noise Reduction]



Current Intellectual Property Right Status

PATENT

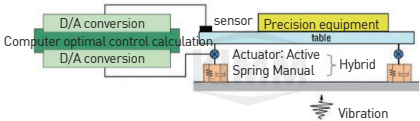
- Low Noise Room Unit (KR1556501)
- Duct Silencer with Periodic Wrinkled Surfaces for Reducing Noise Having Variable Frequency (KR1228403)
- Sound Absorption Type Soundproofing Panel (KR0400886)
- Sound Absorbing Device of Round Soundproof Wall (KR0189328)
- The Composite Panel for Improving Sound Insulation Performance (KR1158108)
- Low Noise Ceiling System for the Impact Noise (KR1244461)
- Sound Absorbing Cell and Sound Absorbing Structure Containing the Same





# Hybrid Mount System Technology for Improvement of Vibration Reduction Performance

▶ Department of System Dynamics   ▶ Researcher: Seok Jun Moon   ▶ Contact: +82-42-868-7428

Technology Overview	<ul style="list-style-type: none"><li>Technology to design and fabricate a novel mount system by integrating a controllable actuator to enhance the performance of the mount installed under an apparatus for vibration reduction</li></ul> 
Customer / Market	<ul style="list-style-type: none"><li>Vibration proof mount manufacturer, manufacturer of device requiring low noise and low vibration, defense industry, precision machinery industry, aerospace industry, etc.</li></ul>
Problems of Existing Technology or Necessity of this Technology	<ul style="list-style-type: none"><li>Passive mount that is currently in use has satisfactory vibration reducing performance, but a special industries demand development of a new mount with vibration reduction performance improved by 10 dB or higher.</li><li>A newly developed technology needs to reflect dynamic properties of active elements that could improve the vibration reduction capability by 10 dB or higher compared to existing mount while combining with passive elements.</li><li>To develop a new mount demanded by the market, a technology to integrate existing passive mount with an actuator that allows various controls is needed. However, the passive mount and the actuator have their own dynamic properties that the design and fabrication technology to be developed needs to accurately grasp them and create a mount that could realize the characteristics the market demands.</li></ul>
Technical Distinctiveness	<ul style="list-style-type: none"><li>A low-noise, low-vibration high-value added apparatus can be developed, and a product for the defense market that demands special functions can also be developed.</li><li>A new product that can fulfill the vibration limit condition of micro/nano-devices can be developed.</li><li>This technology is appropriate for customized products rather than ready-made products, and added-value can be increased with it.</li><li>Equipped with technology to develop optimized products that could fulfill various requirements.</li><li>Compared to competing technologies, it is considered superior in terms of cost.</li></ul>
Excellence of Technology	<ul style="list-style-type: none"><li>A mount installed under an equipment supports the dead load of the equipment and protects the equipment from external vibration to support the equipment to perform its original function.</li><li>Along with advancement of industries, development of a mount with better vibration proof or shock resistant performance is required, and there is an increasing demand for a hybrid mount that combines the passive mount and the active actuator.</li><li>A hybrid mount that combines the passive air spring with a piezoelectric actuator, an electromagnetic actuator or a pneumatic control actuator has been attempted.</li><li>In the automobile industry, a hybrid mount that combines a passive rubber mount with an electromagnetic actuator or MR/ER-compatible fluidic actuator is being developed.</li></ul>

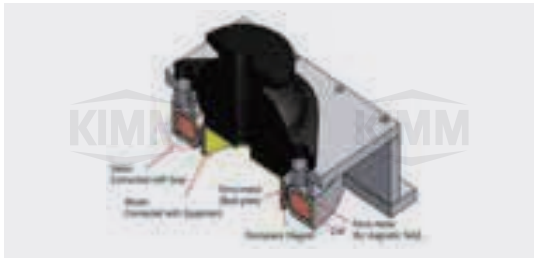
- For the field to be applied, different types of hybrid mount need to be developed, and a hybrid mount development technology that considers the characteristics of a passive mount and an active actuator from the design stage is demanded.



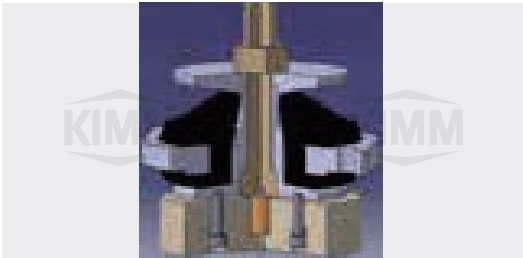
Hybrid Mount for 100 kg Class  
(serial, rubber mount + piezoelectric actuator)  
A study on the hybrid mount against vibration and shock for naval ships, J. Shock and Vibration, 2010



Feasibility study on a hybrid mount system with air springs and piezostack actuators for microvibration control, J. of Intelligent Material System and Structures, 2012



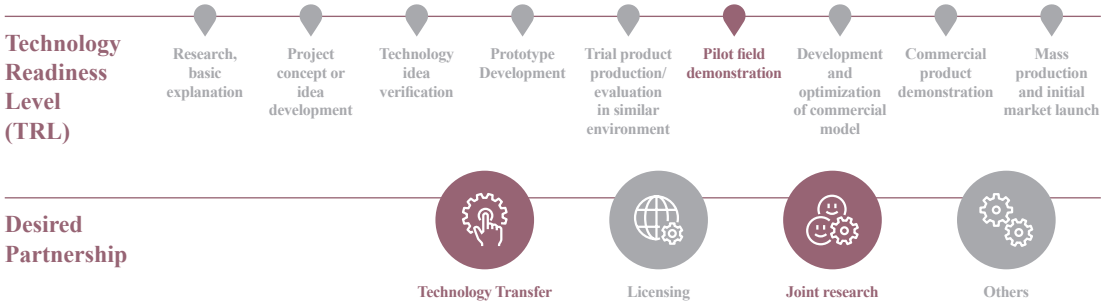
Hybrid Mount for 250 kg Class  
(parallel, rubber mount + electromagnetic actuator)  
A new mount with moving-magnet type electromagnetic actuator for naval shipboard equipment, Int. J. of Nav. Archit. and Ocean Eng., 2015



Hybrid Mount for 400 kg Class  
(inertial mass, rubber mount + piezoelectric actuator)  
A inertia-type hybrid mount combining a rubber mount and a piezostack actuator for navel shipboard equipment, Int. J. of Nav. Archit. and Ocean Eng., 2013

Current Intellectual Property Right Status

PATENT	
<ul style="list-style-type: none"><li>Vibration Absorbing Device in Type of Active Control (KR1373843, FR12/59138, GB1217352.2, US13/628211)</li><li>Active Control Type Vibration Absorbing Device Having Structure of Magnetic Flux Leakage Reduction (KR1378034)</li><li>Inertia Type Hybrid Mount for Vibration and Shock Suppression (KR1103059)</li><li>Hybrid Electromagnetic Actuator Against Microvibration (KR1084987)</li><li>Vibration Damping Device and Mount System Having the Same (KR1263259)</li></ul>	
KNOW-HOW	
<ul style="list-style-type: none"><li>Military suitability performance evaluation method for mounts based on MIL-M-17185A and MIL-PRF-32407A</li></ul>	



# Wind Turbine Drive Train Condition Monitoring and Fault Diagnosis / Prognosis Technologies

▶ Department of System Dynamics ▶ Researcher: SangRyul Kim ▶ Contact: +82-42-868-7466

Technology Overview

- Algorithm that analyzes the signal measured from main components of the wind turbine to evaluate/assess their health in real-time and provides information required for operation and maintenance (O&M).
- It is based on the condition monitoring system (CMS) for real-time diagnosis of the wind turbine system. While conventional CMSs only detect existences of the fault, this technology provides the fault diagnosis of main components and also predicts the remaining useful life (RUL) of the components.
- For the fault diagnosis and prediction of RUL in this technology, big data processing and AI/machine learning techniques (neural network, extended hidden Markov model) are applied to improve the accuracy of fault diagnosis to 99%, and with the statistical inferences including the Bayesian method and Monte Carlo simulation, the error in estimated RUL was reduced to 10% or lower.
- The fault diagnosis and RUL prediction for main components can be effectively applied in the case of varying load condition due to the wind.

Customer / Market

- Wind turbine, power plant, chemical plant, aircraft and railroad vehicle using power train system

Problems of Existing Technology or Necessity of this Technology

- To consider economic aspects, a large capacity wind power generation system has huge blades to support enormous aerodynamic force in order to transform wind energy in wide area, which increases the risk of wind power generation system damage. Therefore, development to monitor, diagnose and predict the conditions of main components including blades, gearbox, and the generator to reduce breakdown time and increase availability is critical to guarantee profitability of the wind farm.
- Over the past 20 years, it is known that more than 40% of the failures of wind turbines installed in Europe were due to equipment and parts failure. Many of the wind power generators used in Korea are going through difficulties in O&M due to contractual or technical issues, which is caused by inexperience in operating wind power generators and lack of technology for condition monitoring and fault diagnosis.
- Conventional CMS only detects whether the measured signal exceeds the normal value or whether a fault has occurred. Therefore, detailed diagnosis and prediction technology for faults is necessary to enable active risk management of the target system.

Technical Distinctiveness

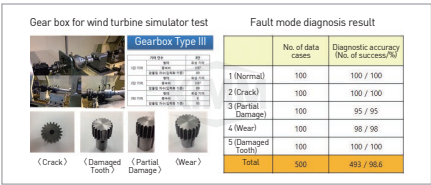
- Application of machine learning (AI) technique to diagnose abnormalities and detailed failure mode diagnosis techniques
- Apply Algorithm and signal system that fulfills international standards (DNV · GL, IEC 61400-25)
- From the long-term aspect, diagnosis and condition-based maintenance (CBM) technology is needed to guarantee the system health and reliability.

Excellence of Technology

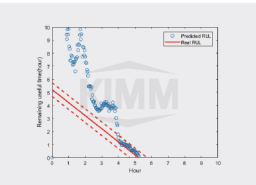
- Fault diagnosis and prognosis algorithms verified by using the wind turbine simulator
- Accuracy of fault diagnosis over 99%, RUL prediction error below 10%
- The fault diagnosis and RUL prediction for main components can be effectively effectively applied in the case of varying load condition due to the wind (characteristics of wind turbine operation), and the applicability and performance of this technology has been confirmed with the actual operation data of wind turbines.
- Acquirement of condition monitoring system (CMS) and monitoring body certifications from KR and DNV/GL.
- CMS installed and operated by 17 units in Complex 1 and 2 at Yeongheung wind power plant of Korea South-East Power Co., Ltd.
- Installed and operated CMS in 20 units of Korea Offshore Wind Power's southwest offshore wind power demonstration complex



〈 KIMM Wind Turbine Simulator 〉



〈 Gear Box and Test Results of Fault Mode Diagnosis Result 〉



〈 Example for RUL Prediction 〉



〈 KIMM Bearing Simulator 〉



〈 GL certificate on the Condition Monitoring System 〉



〈 GL Certificate on the Monitoring Body 〉



〈 KR certificate on the Monitoring Body 〉



〈 Yeongheung Wind Farm and Condition Monitoring Control Room 〉

Current Intellectual Property Right Status

PATENT

- Condition Monitoring Apparatus and its Method for Machinery System (KR1166871)
- Fault Diagnosis of Wind Turbine Using Active Bins (KR1420846)
- Alarm Levels Setting Method for Condition Monitoring and Fault Diagnosis of Wind Turbine Generator (KR1599210)
- Structure Health Monitoring System of Offshore Wind Turbines and its Method (KR1740896)
- Prognosis Method for Wind Turbine Generators (KR2068643)

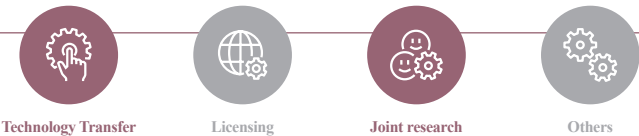
KNOW-HOW

- Intelligent monitoring technology considering wind turbine operation pattern
- Monitoring, diagnosis, and prognosis technology based on actual operation data of domestic wind turbines

Technology Readiness Level (TRL)



Desired Partnership

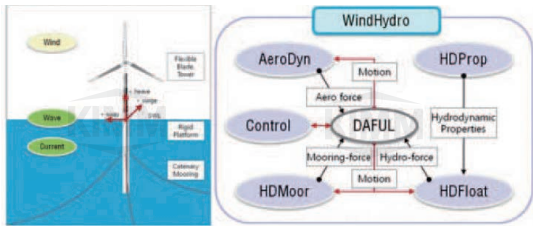


# Floating Offshore Wind Turbine Dynamic Analysis Program–WindHydro

▶ Department of System Dynamics   ▶ Researcher: Jinseop Song   ▶ Contact: +82-42-868-7442

Technology Overview

- Coupled aero–hydro–structural–servo–dynamic analysis software for floating offshore wind turbine



Customer / Market

- Research, design, manufacturing company of large wind turbines.

Problems of Existing Technology or Necessity of this Technology

- Reliable dynamics analysis is essential for research and design of large wind power generation systems, and it is important to secure an analysis program that can support it in order to secure efficient and leading design technology.
- There are considerable number of programs that could individually perform dynamics analysis for onshore or offshore wind turbine or hydro–kinetic analysis for floating marine construction, but for an offshore floating wind turbine, there are not many programs that could perform coupled aero–hydro–structural–servo–dynamic analysis.
- Therefore, a program needs to be developed to reflect the demands of analysis from the research and design in the floating wind turbine field.

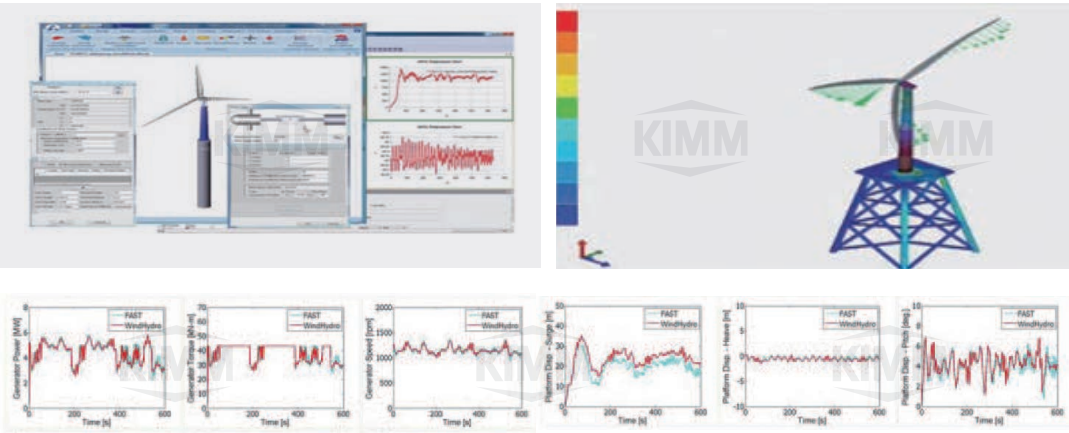
Technical Distinctiveness

- The cost and time for test and demonstration can be minimized for various conditions to be considered in the design stage, and the optimal design of the system can be achieved.
- For floating wind turbines, the system reliability can be enhanced by pre–checking various environments such as wind, wave, tidal current, and earthquake and possible accidents like system breakdown and collision through simulation and reflecting them in the design.
- WindHydro was developed to provide coupled aero–hydro–structural–servodynamic analysis specialized for wind turbine and ocean engineering–based floating body movement analysis program.
- By organizing the structure modeling not based on modal model but nodal model, the effect on increase in nonlinearity from enlargement of wind turbine can be obtained.
- As WindHydro supports the graphical user interface (GUI), a beginner can easily be accustomed to the analysis sw.

- As WindHydro was developed based on a commercial multibody dynamics program, if necessary, an analysis including a flexible model based on finite element model can be performed.
- As it is developed and maintained with domestic technology, addition of analytical function desired by domestic research and industrial fields and technical support are easy.

Excellence of Technology

- Dynamic analysis technology for floating wind turbines is being developed and verified by top global institutions. FAST developed by NREL, is the global leader in related technology. WindHydro was compared with FAST under various conditions to prove its reliability.



Current Intellectual Property Right Status

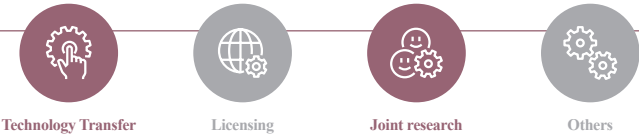
PATENT

- Calculation program for the wave force acting on offshore wind power generation system Ver.2.0(C-2012-020195)
- RAO calculation program in the time domain for regular wave of offshore wind turbine Ver.1.0(C-2012-009716)
- RAO calculation program in the frequency domain for regular wave of offshore wind turbine Ver.1.0(C-2012-009715)
- Calculation program for force and moment from mooring of floating offshore wind turbine Ver.1.0(C-2012-009714)
- Calculation program for the tidal current force acting on offshore wind turbine Ver.1.0(C-2012-009713)
- Calculation program for the wave force acting on offshore wind power generation system Ver.1.0 (C-2012-009712)
- Analysis program for Rotor blade characteristic of wind turbines Ver.1.0 (C-2012-00711)
- Controlling software module of wind turbines Ver.1.0 (2011-01-123-005591)

Technology Readiness Level (TRL)



Desired Partnership





# Unmanned Vehicle Control Technology for Land-Air Cooperation

▶ Department of Smart Industrial Machine Technologies ▶ Researchers: Geunho Lee, Seungjin Yoo, Jichul Kim, Mingueuk Kim ▶ Contact: +82-42-868-7725

Technology Overview

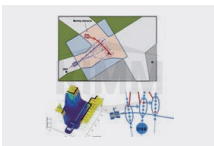
- Autonomous driving technology, which is the core technology of unmanned driving systems, cooperation with aerial drones, and simultaneous control of multiple vehicles



〈Autonomous Driving System Capable of Cooperating With Drones〉



〈Autonomously Drivable Electric Vehicle〉



〈Rough Terrain Autonomous Driving〉



〈Vehicle System Control〉



〈Steering/Pedal Controlling Module〉



〈Takeoff and Landing Pad Module〉

Customer / Market

- Construction machine/agricultural machine manufacturer
- Nuclear power plant/disaster response-related institution
- Multi-purpose unmanned vehicle utilization company

Problems of Existing Technology or Necessity of this Technology

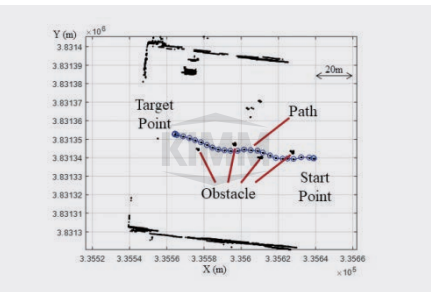
- Existing autonomous driving technology is focused on driving on roads with infrastructures.
- Existing autonomous off-road driving lacks consideration of the ground shape.
- A multi-purpose unmanned driving system platform technology is needed.
- There is no unmanned vehicle that can be used together with a landing pad for cooperation with the drone

Technical Distinctiveness

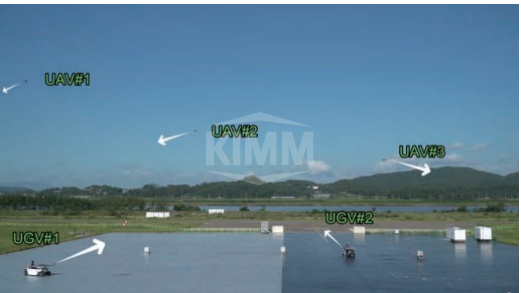
- Provides a technology for integrated platform of multi-purpose autonomous working and autonomous driving
- Create a path considering the ground geometry and obstacle avoidance
- Possible to utilize drone takeoff and landing pad

Excellence of Technology

- Enables precision control of path following using an inexpensive, high-precision GPS
- Follows the route on a tough road
- Modification of existing systems to enable autonomous driving



〈Obstacle Avoidance Driving〉



〈Simultaneous Use of Multiple Drones and Vehicles〉

Current Intellectual Property Right Status

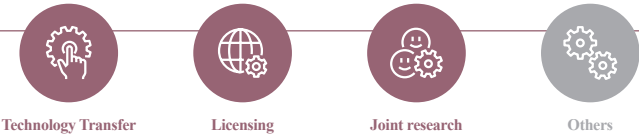
KNOW-HOW

- Electronically controlled vehicle modification technology
- Obstacle avoidance route planning skills
- Cheap high-precision GPS utilization technology
- Vehicle system integrated control technology

Technology Readiness Level (TRL)



Desired Partnership

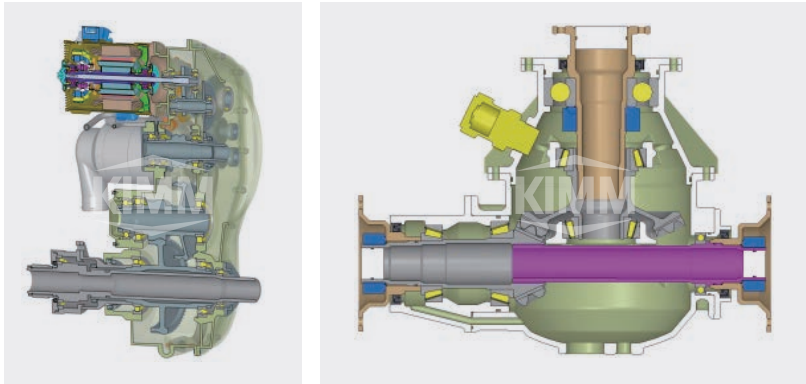


# High-Speed and Lightweight Power Train Design and Testing/Evaluating Technology

▶ Department of Smart Industrial Machine Technologies   ▶ Researchers: Geunho Lee, Socheol Kim, Jonghyeon Son, Mingun Kim   ▶ Contact: +82-42-868-7918

Technology Overview

- Design, analysis, test/evaluation technology of gearbox, coupling and shaft system required to transmit engine power to propeller in rotocraft
- Actuator gearbox design, analysis, test/evaluation technology used in aircraft canopy switchgear, high-lift system, etc.
- Lightweight technology for gears, shafts and housings of aircraft gearboxes



〈 Light-Weight Aircraft Gearbox 3D Model 〉

Customer / Market

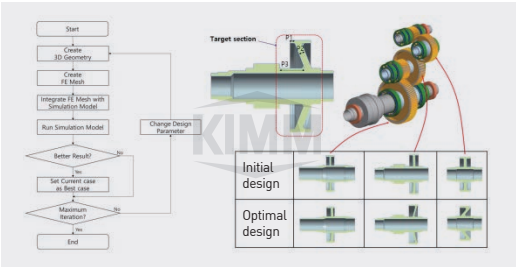
- Manned/unmanned military/civil aircraft (fixed wing, rotary wing)
- UAM (urban air mobility), eVTOL, electric vehicle

Problems of Existing Technology or Necessity of this Technology

- Aircraft gear rotating at high speed is greatly affected by dynamic factors and its speed sometimes exceeds the range supported by evaluation standards such as ISO/DIN. It is necessary to understand the meanings of the formulas of the standard and modify them for use.
- Since the powertrain accounts for about 10 % to 15 % of the total net weight of the aircraft, it is necessary to extremely lighten its components.
- Domestic manufacturers of gears, housings, shafts, etc. have very little experience in developing or manufacturing products that are lightweight enough for aircraft.

Technical Distinctiveness

- Establishes lightweight integrated design and analysis process
- Possesses design, analysis, test/evaluation technology for high-speed gearbox of 20,000 rpm or more
- Possesses lubrication/cooling device design, analysis, test/evaluation technology essential for high-speed/light-weight gearboxes
- Establishes integrated management process such as high-precision bevel gear machining, housing measurement, and contact pattern analysis/adjustment



〈 Optimal Design of Gear Web Shape Using NSGA-II Algorithm 〉



〈 High-Speed and Lightweight Gearbox and Lubrication/Cooling Test Equipment 〉



〈 Vertical Shaft Lightweight Gearbox Testing Device 〉

Excellence of Technology

- Contributing to the success of mass production product development through design and test evaluation of gearbox for power generation by participating in military unmanned aerial vehicle (MUAV) system development
- Transferred technology for canopy actuator gear design and optimization program for aviation
- Achieved more than 98% of gearbox power efficiency

Current Intellectual Property Right Status

PATENT

- Gearbox Tester Having Variable Torque Function and Variable Torque Applied Method (KR1109540)
- Backlash Adjuster and Test Apparatus for Gearbox Having the Same (KR1157476)
- Torque Loading Device and Torque Control System (KR1255679)
- Method and apparatus for inspecting workpiece (KR2177726)

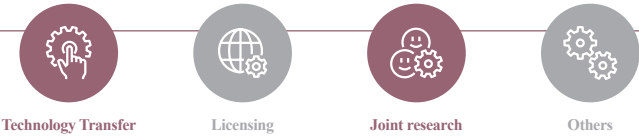
KNOW-HOW

- Gear design and optimization program
- Plate Heat Exchanger Design Program

Technology Readiness Level (TRL)



Desired Partnership

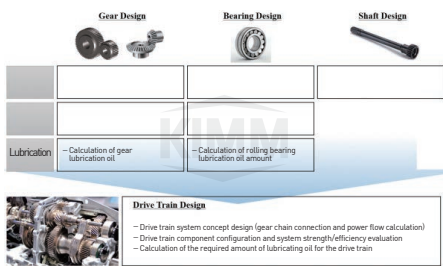


# Gear Train and Bolt Design Optimization Technology

▶ Department of Smart Industrial Machine Technologies ▶ Researchers: Geunho Lee, Soochool Kim, Jonghyeon Son, Mingyun Kim ▶ Contact: +82-42-868-7918

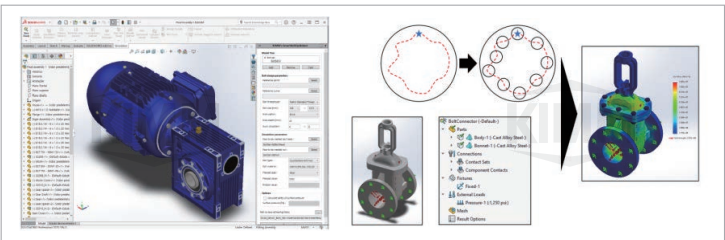
## Technology Overview

- Software technology for strength evaluation/tooth contact analysis and optimal design of gearbox



〈 Gear Train Design Software Technology 〉

- Bolt design automation and optimization technology



〈 Bolt Design Automation and Optimization Software 〉

## Customer / Market

- Geartrains for automobiles, heavy equipment and agricultural machinery, lightweight/high-speed gearboxes for aircraft, etc.
- Industrial machine powertrain
- Applied to various mechanical parts such as pressure vessels

## Problems of Existing Technology or Necessity of this Technology

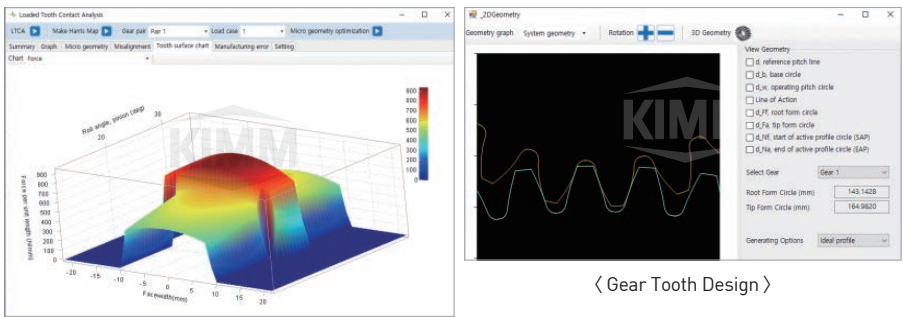
- Existing design software uses the try-and-error method to select design specifications, so it takes a lot of time to select design specifications.
- Especially in the case of overseas software, due to the complicated and difficult UI and high price, the utilization of domestic users is low, and the upgrades are not continuously performed to meet domestic situation.

## Technical Distinctiveness

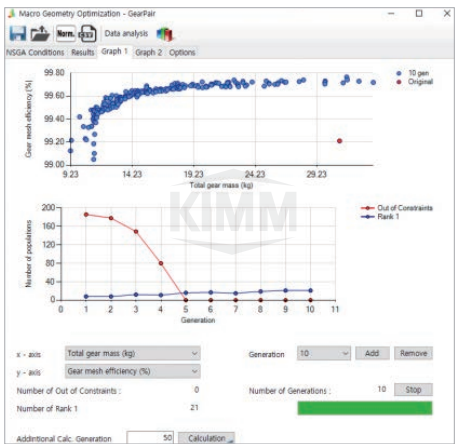
- Design specifications can be quickly derived by applying an optimization algorithm
- Fast results can be obtained by performing gear tooth contact analysis based on the analytical method
- It can be supplied to companies at a lower price than overseas software, and it is continuously upgraded to meet the domestic situation.

## Excellence of Technology

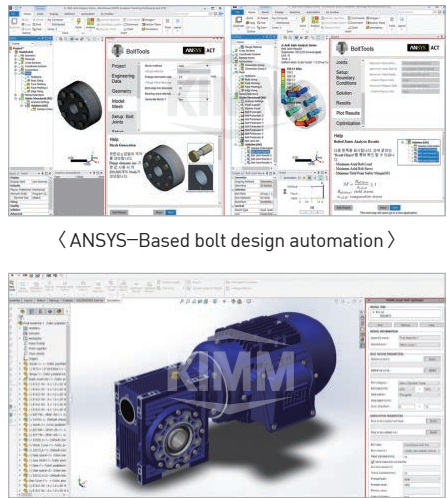
- Possible to design a fast geartrain system using an optimization algorithm in the concept design stage
- Various design functions for geartrain and fastening related element parts are provided, enabling users to easily design element parts
- Currently, various companies such as SMEs and large companies are using the program, and technology related to gear strength evaluation and tooth shape generation has been transferred to other analysis software.



〈 Gear Tooth Contact Analysis 〉



〈 Optimal Design for Gear Train 〉



〈 Solidworks-Based Bolt Design Automation 〉

## Current Intellectual Property Right Status

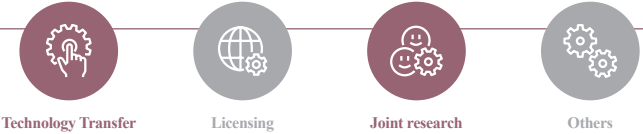
### KNOW-HOW

- Wet multiple disk clutch design software
- Plate Heat Exchanger Design Program
- Gear design and optimization program
- Single bolt and multi bolt basic design program

## Technology Readiness Level (TRL)



## Desired Partnership





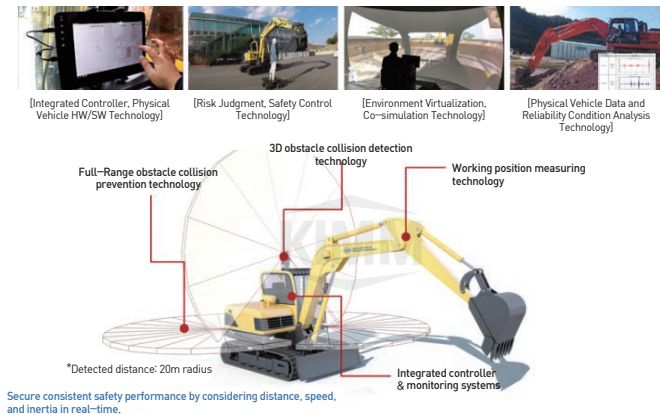
# Machine’s Environment Recognition and Collision Prevention Safety Control Technology

▶ Department of Smart Industrial Machine Technologies ▶ Researcher: Jichul Kim, Hanmin Lee, Seungjin Yoo, Dongwook Lee, Youngjae Kim ▶ Contact: +82-42-868-7473

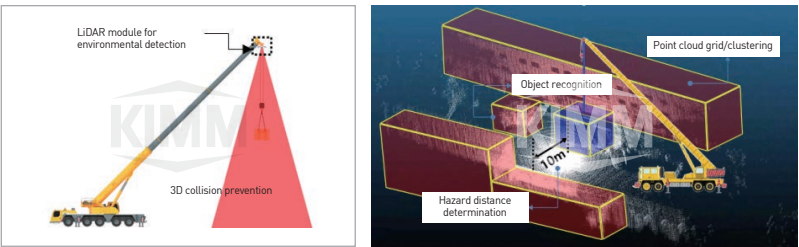
Technology Overview

- Human-centric machine system safety technology for monitoring surroundings of working machines such as excavator and collision prevention

LiDAR-based excavator collision prevention safety control technology



LiDAR-based crane collision prevention safety control technology



Customer / Market

- Construction machinery (excavator, forklift, etc.) manufacturer, operator
- Construction/civil engineering business companies, government-run local governments, etc.

Problems of Existing Technology or Necessity of this Technology

- An ultrasonic, image sensor cannot predict dynamic behaviors.
- Need to determine the safe time for braking considering dynamic properties of the moving object.
- Active control of emergency stop required, more than a simple alarm
- Can reduce fatal accidents from construction site-high risk group within top 15% of industrial accident
- Crucial core technology for the future considering the trend for machine safety regulation and the speed of unmanned technology advancement

Technical Distinctiveness

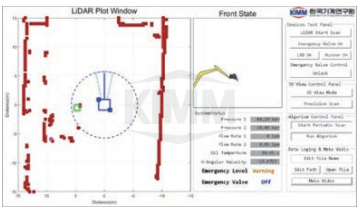
- Developed a LiDAR-based technology with high resolution and precision with existing image and ultrasonic sensor
- Developed a risk judgment algorithm enhanced from the simple distance-based to consider time
- Secured consistent safe distance considering the inertia of excavator’s turning movement
- First application of crane 3D collision prevention

Excellence of Technology

- Full-Range (360 degree) obstacle monitoring technology
- Simultaneous recognition of multiple objects and algorithm computation within 100ms
- 3D obstacle collision monitoring technology
- Distance-based and time-based collision risk judgment algorithm technology



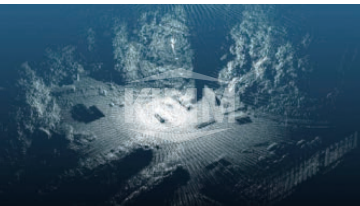
〈 Safety Control Experiment Using a Mannequin for Collision During Turning 〉



〈 Driver-provided Environment Monitoring System 〉



〈 3D Crane Collision Safety Control Experiment 〉



〈 Environmental Recognition Result 〉

Current Intellectual Property Right Status

PATENT

- Apparatus of Separating and Collecting Dissolved Gases (KR2109155)
- Displacement measuring device and hydraulic cylinder including the same (KR2165284)

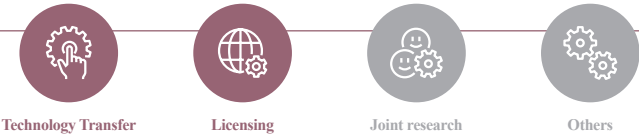
KNOW-HOW

- LiDAR data post processing (filtering, clustering, etc.) technology
- Object dynamic movement (speed) prediction technology
- Distance and time-based collision risk assessment
- Technology for mounting/modifying safety control function to prevent collision of excavators and cranes

Technology Readiness Level (TRL)



Desired Partnership

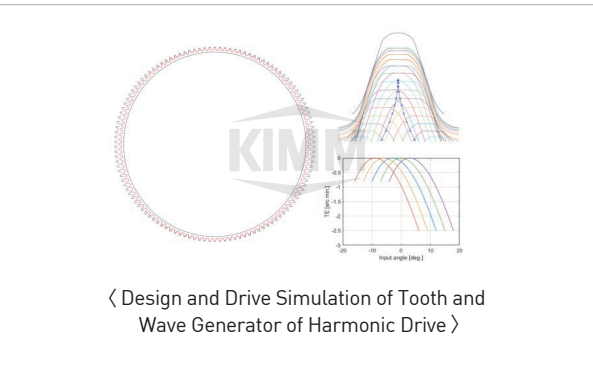
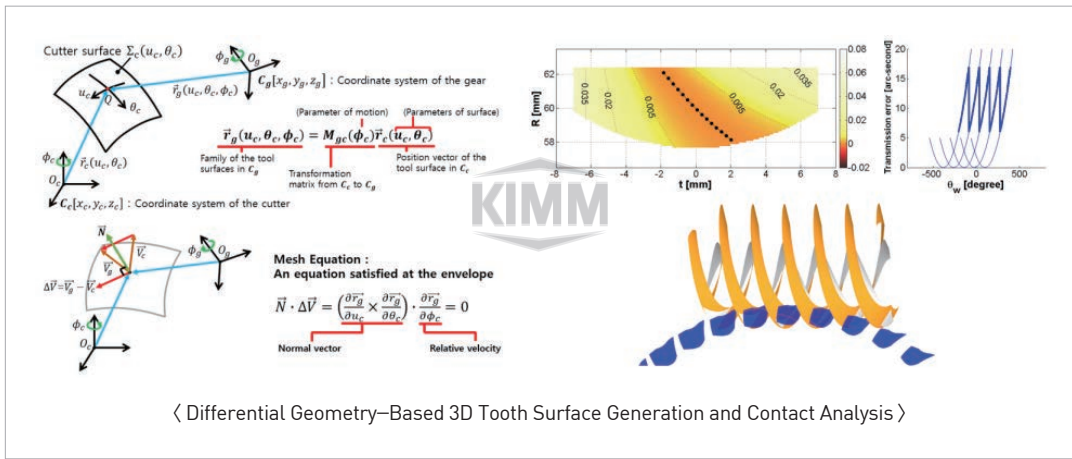


# Gear Geometry Design and Analysis Technology

▶ Department of Smart Industrial Machine Technologies   ▶ Researcher: Jonghyeon Sohn   ▶ Contact: +82-42-868-7994

## Technology Overview

- Technology to generate a precise three-dimensional tooth surface of a gear from a cutting tool profile and processing method
- Tooth Contact Analysis (TCA) technology to calculate contact patterns and transmission errors.
- Single and double enveloping worm gear design and analysis technology
- Design and drive simulation technology of harmonic drive (or strain wave gear) tooth and wave generator



## Customer / Market

- Worm gear reducer for electric power steering of automobile
- Precision reducer for power transmission and control of aircraft/industrial machines/robots, etc.

## Problems of Existing Technology or Necessity of this Technology

- Special gears that do not belong to general parallel shaft involute gears have the tooth surfaces that are mostly not standardized, and it is difficult to express the tooth surfaces with a simple formula, and thus, it is difficult to modify the tooth surfaces or reverse design and find the cause in case of a problem such as a noise and vibration.
- The tooth profile used for the harmonic drive is not standardized, and the inner flex spline is transformed into an ellipse during operation, causing the general gear design or analysis technique to be difficult to be applied.
- The tooth profile design and analysis technology based on differential geometry precisely calculates the machined tooth surface from the cutting tool profile and processing method, making it possible to obtain a 3D tooth surface of a special gear that is not supported by commercial software, and it can be used for finite element analysis.
- In addition, it is possible to calculate how changes in the cutting tool profile or processing method affect the machined tooth surface and its driving characteristics (contact pattern, transmission error, etc.), making it possible to correct the tooth surface or reverse design and easy to solve problems such as a noise and vibration.

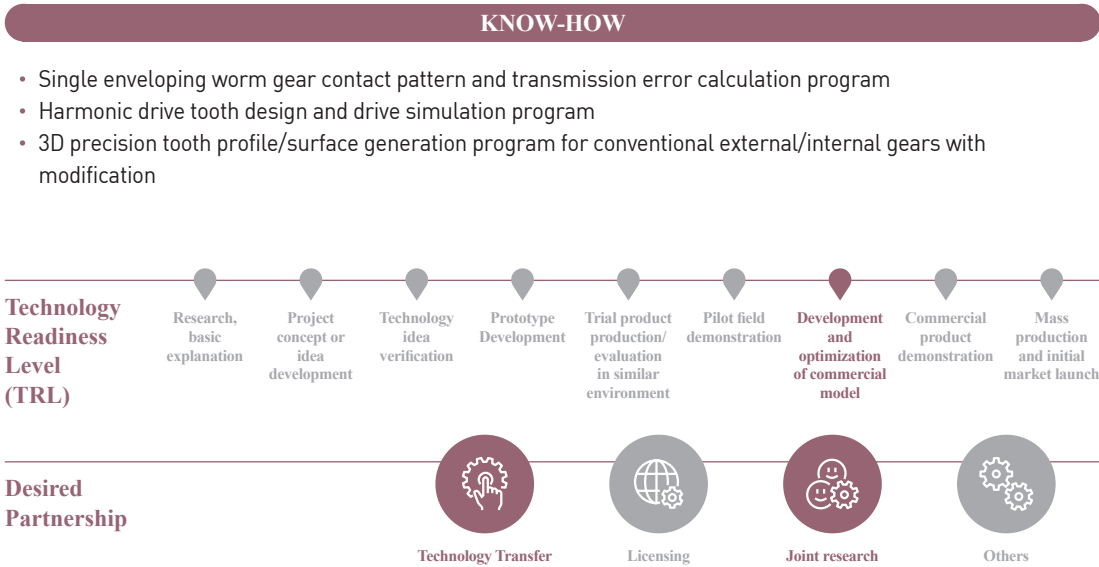
## Technical Distinctiveness

- It can accurately calculate the three-dimensional tooth surface, contact pattern and transmission error of single and double enveloping worm gears that are not fully supported by commercial gear design software.
- In the case of harmonic drive, design variables such as reduction ratio and eccentricity of the elliptical wave generator as well as the tool profile for processing an internal gear (circular spline) and an external gear (flex spline) are reflected in the design. It can simulate the driving and calculate the transmission error.
- For any other type of gear, given the profile of cutting tool and the machining method (relative motion between the cutting tool and the workpiece), the three-dimensional tooth surface of the machined gear can be accurately calculated, and the contact pattern and transmission error can also be calculated.

## Excellence of Technology

- The novelty and validity of the technology have been proven by publishing a new worm gear contact pattern calculation method in the SCI top journal—Mechanism and Machine Theory—in the field of gear tooth design and analysis (lead author and corresponding author).
- Transferred 3D gear tooth generation technology to another gear analysis software company

## Current Intellectual Property Right Status



# Virtual Operation Technology for Autonomous Driving of Agricultural Tractors

▶ Department of Smart Industrial Machine Technologies ▶ Researchers: Moohyeon Cha, Hanmin Lee, Minyoung Lee, Chanseok Park, Mingeuk Kim, Jichul Kim, Seungjin Yoo ▶ Contact: +82-42-868-7927

Technology Overview

- This technology is a virtual test and integrated operation technology that can effectively reduce the time and cost required for developing autonomous driving product for agricultural work machines. It is capable of performing a virtual test for autonomous driving of agricultural machines, and during real vehicle operation, more effective multi-tasking machine control is achieved with remote operation technology.



Customer / Market

- Smart farm service/solution company
- Autonomous driving agricultural machinery manufacturing/solution company
- Unmanned processing machine manufacturing/solution company
- Car (including autonomous driving) simulator manufacturer

Problems of Existing Technology or Necessity of this Technology

- Industrial work machines that mainly perform tasks in harsh environments have very diverse operating scenarios and have many restrictions in terms of safety and cost in field tests, which have impeded the commercial development of unmanned processing machines.
- For unmanned agricultural tractors and similar precision driving-based industrial processing machines, it is essential to secure on-site response capabilities of precision driving algorithms for various driving scenarios by virtually testing them along with precision position/direction tracking technology using low-cost sensors.

Technical Distinctiveness

- This technology enables pre-simulation tests for various working environments before on-site tests for agricultural tractors and implements long-distance remote control. Unmanned operation simulation can be realized in a 3D-based virtual working environment when the user designates work path in the satellite map. In addition, it can replace or supplement the actual field test because it can virtually test unmanned core performance such as environment recognition and path control.
- In addition, in conjunction with the unmanned processing machines in operation, remote operation using long-distance camera images, monitoring of 3D-based work results, and vehicle control are possible, which can also be used for centralized operation and control of clustered unmanned processing machines such as smart farms or smart construction.
- This technology can effectively reduce the time and cost required for unmanned product development and testing of agricultural work machines. It was developed with 100 % domestic technology using open source and is expected to contribute to developing various unmanned industrial processing machines and integrated operation systems in addition to agricultural tractors.

Excellence of Technology

- Ultra-low-cost precision position/direction recognition technology with cm-level precision
- Precision path tracking algorithm technology within 0.1 m error that can respond to delays in the hydraulic control system
- Pre-optimization test technology that can easily adjust various autonomous driving parameters
- HILS test system technology that enables driving tests in conjunction with working machine hardware
- Online map-based work path automatic planning and soil work path visualization technology
- 3D-based multi-tractor remote control and low-latency WiFi-based video transmission/reception technology
- Portable terminal-based remote control technology for processing machines



〈Agricultural Tractor Virtual Test and Remote Operation Concept〉



〈Real Vehicle-Based Virtual Driving Test, Mobile Terminal and WiFi-Based Remote Control Technology〉



〈3D-Based Tractor Unmanned Operation Virtual Test and Work Path Visualization Technology〉

Current Intellectual Property Right Status

PATENT

- Test system for autonomous operating apparatus and controlling method thereof (KR1967216)
- Autonomous operating system using mixed reality and controlling method thereof (KR2000110)
- Apparatus for providing driving environment for testing autonomous traveling machine and method of controlling the same (KR2009779)

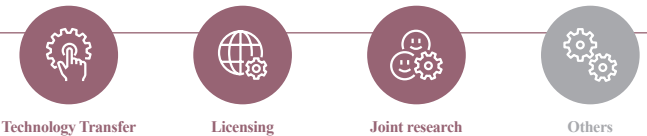
KNOW-HOW

- GPS-based location and direction precision recognition program
- 3D-based driving simulator for virtual test of unmanned tractor
- Sensor fusion technology for precise positioning
- Higher/lower control program for autonomous driving of freight vehicles

Technology Readiness Level (TRL)



Desired Partnership





# Omnidirectional Ground Motion Generating Simulator Technology

▶ Department of Smart Industrial Machine Technologies ▶ Researchers: Moohyeon Cha, Hanmin Lee, Minyoung Lee, Chanseok Park ▶ Contact: +82-42-868-7927

Technology Overview

- Interfaces that helps with mutual interaction of human or autonomous machine system in the virtual, augmented, remote working environment and the simulator technology that applies it: The Technology includes the treadmill platform that provides virtual walking or driving environment and the motion platform where the intention of the user is easily input



Customer / Market

- Virtual reality and simulation production/solution company
- Health and rehabilitation device manufacturer/solution company
- Sports and entertainment production/solution company
- Car (including autonomous driving) simulator manufacturer
- National defense/public training simulator manufacturer

Problems of Existing Technology or Necessity of this Technology

- Existing simulator uses an unintuitive interface like a joystick to realize the movement of the trainee or the driving motion, which feels less engaged with the virtual reality.
- To verify the operability of increasing autonomy machine system, a virtual reality technology, that could precisely simulate working scenarios of a system to verify the mutual interaction with human, needs to be developed.
- In particular, an omnidirectional treadmill mechanism has never been commercialized. A new affordable mechanism having driving and noise performance at the same time needs to be developed.

Technical Distinctiveness

- This technology includes the treadmill and motion plate technology that recognizes the movement speed intended by the trainee or the driving device to move or control the virtual reality environment.
- With this technology, a virtual training system can be utilized for operation training for machines for special works or large machines such as construction machinery to prevent accidents.
- It is expected to be utilized for various fields in the future including combat training for national defense, medical rehabilitation treatment, and sports ability enhancement.
- It uses a low-noise, high-efficiency power transfer driving system for 360-degree omnidirectional ground motion generation and applies the independent power-train mechanism for ground without limitations regarding ground shape and material.
- The moving body (trainee) speed prediction-based feed forward control technology for ground speed control has been verified.
- A low-cost high-precision virtual reality contents control technology using lower body movement and posture is secured to simplify the system.

Excellence of Technology

- An omnidirectional driving mechanism for highspeed, low-noise ground movement is under development.
- The feed forward control algorithm based on foot pressure distribution change rate or movement of center of gravity has been developed.
- A human interface prototype specialized for immersive large-scale virtual reality environment has been developed.



〈 Human Interface Prototype 〉

- Simulator technology for fire training and large machine equipment safety has been developed.
- Detection and control simulation technology for prior verification of unmanned/ autonomous special working machine for industrial use has been developed.
- Technology for virtual movement simulator for manned/unmanned driving vehicles has been developed.

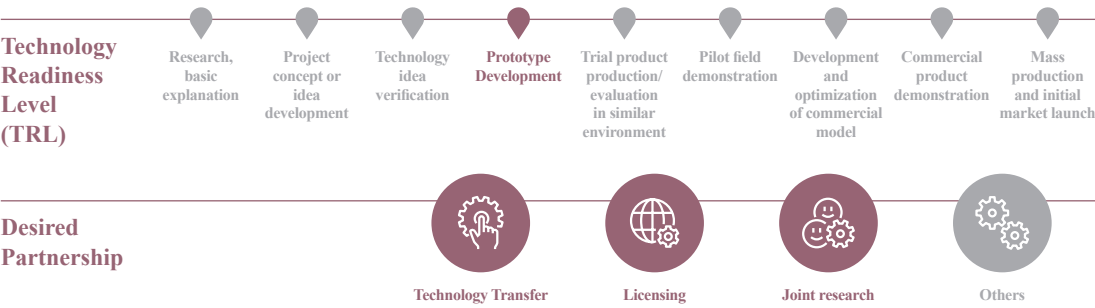


〈 Virtual Movement Support Simulator Technology 〉

- A virtual reality prototype for unmanned vehicle system is under development for prior operability verification.

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Omnidirectional Ground Movement Treadmill Mechanism (KR0061073, KR1740945, KR1672705, KR1672702, KR1679223, KR1740921)</li><li>• Omnidirectional Ground Movement Simulator Application Technology (KR0052297, KR0057892, KR0052293)</li><li>• Ground Movement Simulation Control Technology (KR1650763, KR0052302)</li><li>• Simulator for Driving Performance Assessment of Mobility (KR0011568)</li></ul>	<ul style="list-style-type: none"><li>• Driving body-measured data-based virtual reality simulator design technology</li><li>• Engineering analysis data-based virtual reality simulator design technology</li><li>• Working and driving test system for autonomous machine and its control method</li><li>• Autonomous machine system using mixed reality and its control method</li></ul>



# Structural Stability Assessment Technology

▶ Department of Smart Industrial Machine Technologies ▶ Researchers: Jeongwoo Han, Heungseop Kim, Mingeun Kim ▶ Contact: +82-42-868-7432

**Technology Overview**

- Structural analysis/design
- Fatigue analysis and life assessment
- Structural Safety test and assessment technology (Static/dynamic load test, fatigue and test)

**Customer / Market**


- Railroad
  - Defense (armored car, tank etc.)
- Construction machine /agricultural machine
  - Aircraft fuselage

**Problems of Existing Technology or Necessity of this Technology**

- Safety, reliability, and weight reduction of the structure through the structural test and assessment

**Technical Distinctiveness**

- Static load, dynamic load, fatigue load test for large full-scale structure
- 50 ton, 100 ton UTM
- Reaction test bed: 25 m(L)×12 m(W)×1 m(T)
- Reaction test wall: 25 m(L)×8 m(H)×1 m(T)
- Structural bearing capacity : 1,000 ton (distributed), 100 ton (point)
- Hydraulic actuator : 5 ~ 100 ton(39 sets)
- Digital controller (FlexTest 200, 2 sets)
  - Simultaneous control of 20 actuators each station (8 stations)
- Hydraulic power supply units



Large Scale Structure Test Facility and Equipment

Excellence of Technology

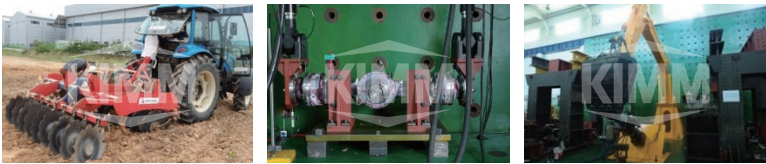
- (Railroad) Railroad bogie frame/car body structure**

  - Research objective: Fatigue test of bogie frame structure for railroad
  - Research content: Static load test, fatigue load test
  - Fatigue test conditions (UIC615-4)
    - Stage 1: 100% (vertical load + lateral load + twist load) 6,000,000 cycles
    - Stage 2: 120% (vertical load + lateral load + twist load) 2,000,000 cycles
    - Stage 3: 140% (vertical load + lateral load + twist load) 2,000,000 cycles
  - Measured data: Strain gauges, LVDT (over 80 chs)
  - Crack inspection: Magnetic particle test (MT)
  - Domestic/Exporting railroad (KTX, Honam Line, maglev train, light rail etc.)



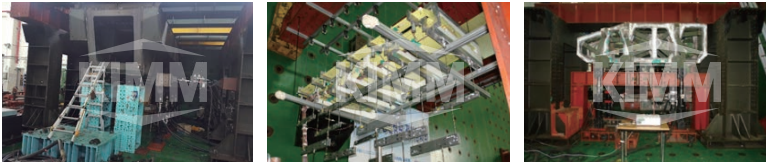
- (Construction machine/agricultural machine) Construction machine/agricultural machine structure**

  - Research objective: Durability test for wheel loader front/axle, agricultural machinery/harvesting machine structure
  - Research content: Static load test, fatigue load test
  - Fatigue test conditions
    - Field test/working load analysis
    - Durability condition, loading freq.



- (Defense/Aircraft fuselage) Defense vehicles and aircraft structures**

  - Durability test of wheeled armored vehicle frame structure
  - Design and development test for T-50 fuselage design and development test and Surion fuselage



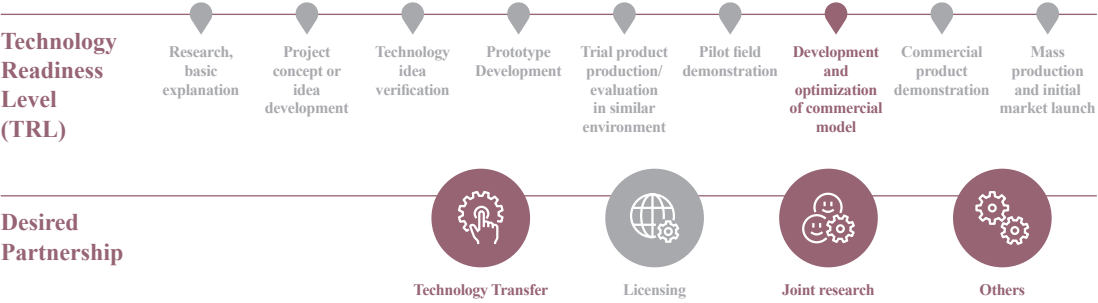
Current Intellectual Property Right Status

**PATENT**

- A Load-testing Apparatus for a Train Bogie Frame (KR0896952)

**KNOW-HOW**

- Design technology for test apparatus for 4-score suspending realizing vertical ground reaction force

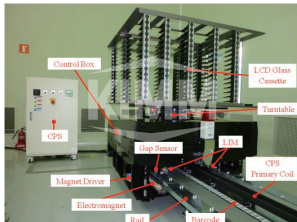


# Magnetic Levitation Conveyance Device

▶ Department of AI Machinery ▶ Chang-Hyun Kim, Jaewon Lim, Chang-Wan Ha, Doh Young Park, Jong-Min Lee, Hyung-Suk Han ▶ Contact: +82-42-868-7279

## Technology Overview

- High precision magnetic levitation system technology that can precisely transport a large product without generating dust in a vacuum environment such as semiconductor and display manufacturing site. The system can be applied for both horizontal and vertical configurations and can be mounted on both ceiling, and floor.



〈 Prototype of Active Magnetic Levitation Conveyance Device 〉



〈 Prototype of Passive Magnetic Levitation Conveyance Device 〉

## Customer / Market

- Transport and process equipment for ultra clean, such as zero-particle, environment
- Transport and process equipment in the semiconductor, display, solar cell, food and drug manufacturing industry

## Problems of Existing Technology or Necessity of this Technology

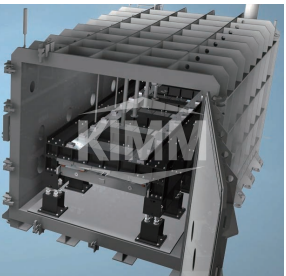
- Existing automated transport system, conveyor system, relies on friction and creates dust, vibration and noise. Because of this, the components break down and faulty products occur from scratch or damage. A technology to overcome this issue is in need.
- The research team has secured both the active magnetic levitation technology where the power device is mounted on the levitating body (carrier) and the passive magnetic levitation technology where the power device is installed on an external fixture installed on the ground.
- The active magnetic levitation conveyance device has the levitating device mounted on the carrier and is appropriate for atmospheric environment with a long conveyance distance. The passive magnetic levitation conveyance device has the levitating device on the ground and has a carrier with a simple structure, therefore, it is suitable for application where multiple carrier movements for a relatively shorter distance is are needed. It can be used in vacuum environment as it does not require power supply for the carrier.

## Technical Distinctiveness

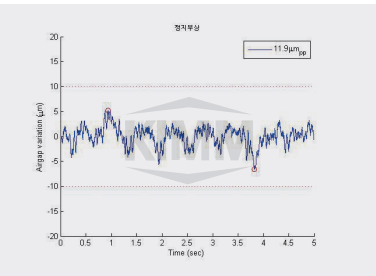
- Magnetic levitation non-powered conveyance system can be used in vacuum condition, and without dust generated from friction, a clean, zero-particle system is realized.
- Active magnetic levitation conveyance device
  - Nnon-contact movement with application of a non-contact power supply device
  - Minimal power consumption with the hybrid type that uses a permanent magnet and an electromagnet
- Passive magnetic levitation conveyance device
  - Simple levitated body that does not require power supply or electric device
  - Non-powered (passive) magnetic levitation technology applicable for vacuum environment
- Can overcome a section without electromagnet installation that exists in the conveyance path between vacuum chambers

## Excellence of Technology

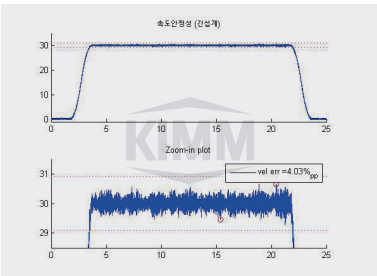
- Active magnetic levitation type
  - Completed the development of a prototype of magnetic levitation conveyance device for LCD glass
  - Can transport an object of 100 kg to 350 kg; the gap between the rail is maintained at 3 mm with fluctuation within  $\pm 1$  mm; and maximum speed of 4 m/s
- Passive magnetic levitation type
  - Completed the development of a prototype of magnetic levitation conveyance device for OLED process
  - Completed the performance test in the vacuum chamber of 10-3 Torr
  - Can transport from 5th generation 400 kg carrier to 8.5th generation 800 kg carrier; 1 mm gap is maintained; with maximum speed of 0.5 m/s
  - Has Ultra-precise control of the gap fluctuation – within  $\pm 7 \mu\text{m}$  while the carrier is being levitated at a still position, within  $\pm 140 \mu\text{m}$  while the carrier is moving at 0.5 m/s
  - The fluctuation rate is  $\pm 3\%$  when the carrier is moving at the regular speed of 0.03 m/s. It can be used for a process that requires uniform processing during conveyance.



〈 Set up in Vacuum Chamber 〉



〈 Precise Levitation Control of Passive Magnetic Levitation Conveyance Device 〉



〈 Speed Control Performance of Passive Magnetic Levitation Conveyance Device 〉

## Current Intellectual Property Right Status

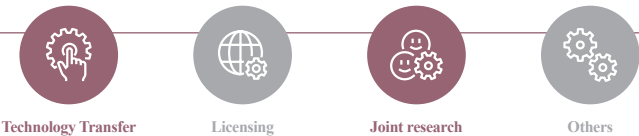
### PATENT

- Magnetic Levitation Conveyance Device Having Tray Without Power (KR1335643)/
- Magnetic Levitation Conveyance Device Having Steering Ability (KR2012-0158333, PCT/KR2013/011145)/
- Magnetic Levitation Conveyance Device (KR1101917)/Magnetic Levitation Conveyance System Having Spring (KR1182354)/
- Magnetic Levitation Conveyance Device During Linear Induction Motor (KR1049221)/
- Magnetic Levitation Conveyance Device Using Vertical Linear Motor (KR1049222)/
- Carriage Structure of Magnetic Levitation Conveyance System with Spring/Linear Guide Electromagnetic Module (KR1203163)

## Technology Readiness Level (TRL)



## Desired Partnership





# Repulsive Maglev Technology

▶ Department of AI Machinery   ▶ Researcher: Chang-Hyun Kim   ▶ Contact: +82-42-868-7279

## Technology Overview

- Technology to levitate an object using repulsive force of a permanent magnet/electromagnet and moves and rotates the levitating object as desired within a designed operational range



## Customer / Market

- Toy, electronics, entertainment, interior design using magnetic levitation
  - Maglev character miniature, maglev Bluetooth speaker, maglev light bulb, maglev flower pot, etc.
- VR, robot using user interface such as maglev joystick or mouse
- General store, exhibition hall, promotion hall that can boost the display effect using maglev technology

## Problems of Existing Technology or Necessity of this Technology

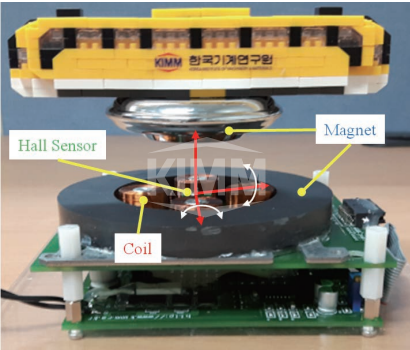
- Existing products have limits regarding the size and weight of the object that can be levitated. The levitation position of the object is fixed, and the stable levitation range is narrow, so it is difficult to balance the levitating object.
- A new human-machine interface to replace existing joystick or mouse is needed to eliminate mechanical constraint and friction, recognizes the movement to be used as user input, and enable natural force feedback.
- Technology uses a simple actuator to rotate or row according to the motion program, and with the inductive power supply device, power is transferred to the levitating body wirelessly, which can be applied for various unique electronics such as speaker or light bulb.

## Technical Distinctiveness

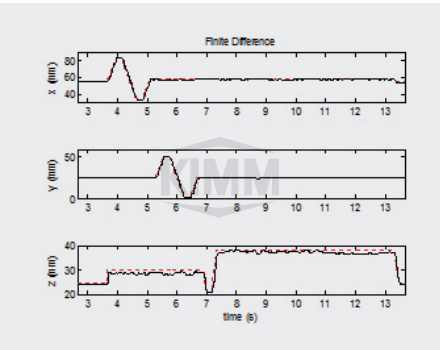
- Desired motion can be performed within the designed operational range with the non-contact movement
- By changing the design based on the original levitation technology, various sizes and weights can be handled.
- It is based on the repulsive force of a permanent magnet/electromagnet, but for a base where a coil is installed, it can be installed on the ground or wall, and with extended installation of the coil, movements can be performed in a larger space.
- Motion control precision can be enhanced by applying a precise position detection sensor while maintaining the position of the levitating body with a cheap hall sensor.

## Excellence of Technology

- A prototype of magnetic levitation plate achieved levitation over 20 mm for a 500 g levitating body.
- Levitation is maintained with a balance using the magnetic force of a permanent magnet, so there is barely any thermal or electric power consumption.
- By using multiple extension coils, a technology realizing 6 degree-of-freedom motion was secured for a space with width and length of 100 mm and height of 50 mm.



〈 Prototype of Repulsive Magnetic Levitation Device 〉



〈 Result of Realization of 6 Degree-of-Freedom Motion Using Multiple Extension Coils 〉

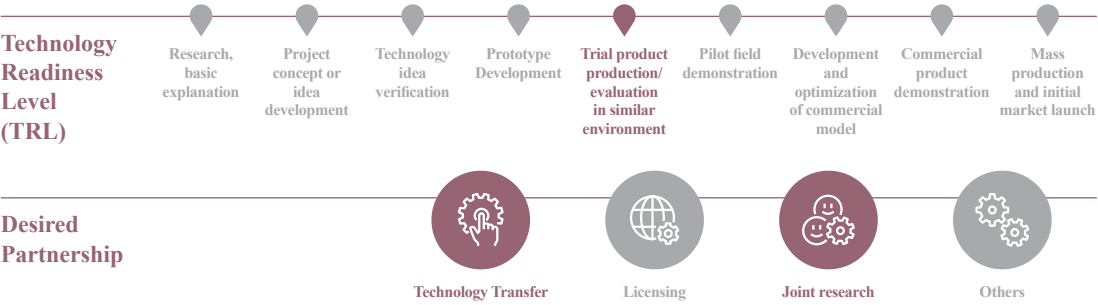
## Current Intellectual Property Right Status

### PATENT

- Haptic Device Using Magnetic Force (KR1721204)
- Gripper Using Magnetic Levitation (KR1729684)

### KNOW-HOW

- Design and analysis technology for permanent magnet/electromagnet for levitation of various size and weight
- Levitating object recognition technology using hall sensor
- Control technology for levitating object posture maintenance and motion generation

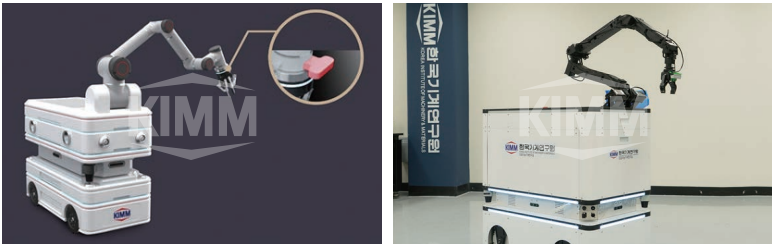


# Mobile Manipulator Technology

▶ Department of AI Machinery ▶ Researcher: Chang-Hyun Kim, Jeong-Jung Kim, Doo-Yeol Ko, Jinseong Park, Byuongtae Ahn, Young-Sik Shin, Sanghyun Kim ▶ Contact: +82-42-868-7279

Technology Overview

- A robot capable of autonomous driving and autonomous operation based on a modular mobile manipulator platform and AI that can perform various material handling and logistics tasks within a non-structured manufacturing environment



〈 Overview and Prototype of Mobile Autonomous Robot 〉

Customer / Market

- Logistics transfer and monitoring task in manufacturing industries such as automobiles, semiconductors, displays, food, and pharmaceuticals
- Other areas that require recognizing, picking up, positioning, or manipulating target items

Problems of Existing Technology or Necessity of this Technology

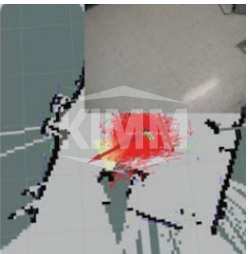
- It is difficult to introduce an automation system in a manufacturing site where various operations are performed in a non-structured, narrow, and unorganized environment with obstacles. To work in this environment, a system capable of responding to various tasks and environmental changes with the minimal system is required.
- It is possible to perform various tasks in a non-structured environment by securing core and integrated technologies for configuring a mobile autonomous robot system that can move to a desired location and perform various tasks.
- Previous robots are difficult to scale up and the manufacturing cost is too high so the applicability of robots has been limited in the industries. In order to avoid these issues, the system should have modular architecture in both HW and SW platforms.

Technical Distinctiveness

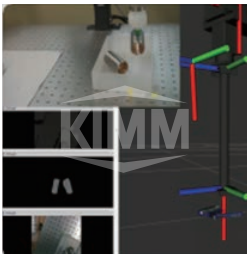
- AI-based autonomous driving
  - Autonomous driving is possible in narrow environments through an omnidirectional platform and driving algorithm.
  - Alignment within a target position can be realized through sensor fusion and control.
- AI-based autonomous operation
  - It is possible to recognize the type and posture of the target object from the image obtained by a camera at a work site with randomly placed objects.
  - It is possible to pick up the recognized object and place it in the desired position or manipulate it.
- Modular mobile manipulator platform
  - By proposing a modular stacked structure, the platform can be configured and modified according to various types of work.

Excellence of Technology

- Technology for autonomous driving and achieved driving accuracy of  $\pm 2$  cm
- Technology for autonomous work and achieved work-piece recognition accuracy of  $\pm 5$  mm
- Completed prototyping of driving module, 3D LiDAR module, sensor and control module, HRI module, and manipulator module capable of payload of 100 kg and maximum speed of 1 m/s
- Completed work tests in lab environment that simulates a real manufacturing site



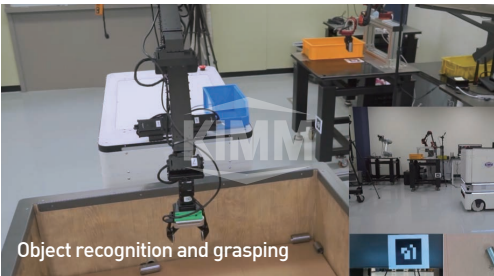
〈 Autonomous Driving in an Indoor Environment 〉



〈 Recognizing and Processing Randomly Placed Workpiece 〉



〈 Developed Module Prototype 〉



〈 Work in manufacturing site work 〉

Current Intellectual Property Right Status

PATENT

- Unmanned Transport System Using Autonomous Delivery Robot and Method of Transport Using Unmanned Transport System (KR2088415)
- Mobile Robot (KR0019061)
- Module Type Platform for Transportation (KR0092042)
- Stack-Type Module Robot (PCT/KR2020/005779)
- Method for Picking and Place Object (KR0092043)
- Lifting Module and Stack-Type Module Robot (KR0050879)

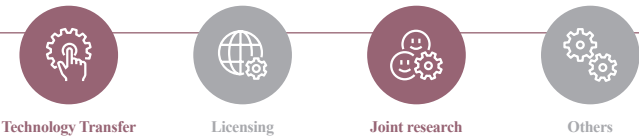
KNOW-HOW

- Mobile manipulator system HW design and firmware development technology
- Recognition of work objects and manipulation technology for autonomous work
- Position estimation/path planning/collision avoidance of mobile robot for autonomous driving

Technology Readiness Level (TRL)



Desired Partnership

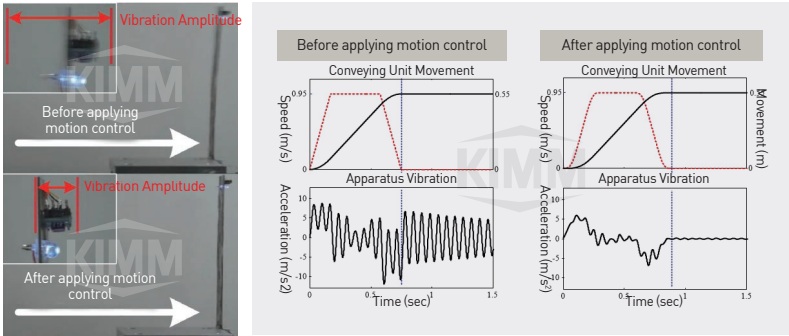


# Motion Control Technology for Fast Movement with Less vibration by using Input Shaping Technique

▶ Department of AI Machinery ▶ Researcher: Chang-Wan Ha ▶ Contact: +82-42-868-7203

Technology Overview

- Technology to eliminate undesired vibration by shaping the movement of the conveying unit with the motion control technology that reduces the vibration in the apparatus that occur during highspeed driving



Customer / Market

- Semiconductor/display assembly/transfer equipment manufacturer
- Precision crane manufacturer
- High value-added industry requiring high-speed driving and low-vibration motion

Problems of Existing Technology or Necessity of this Technology

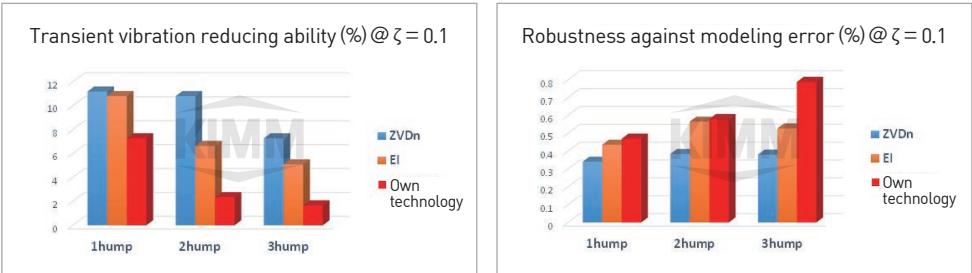
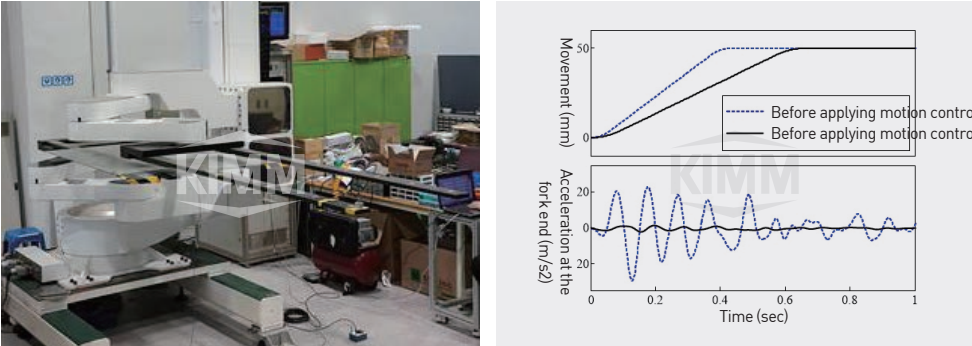
- Cheap conveyance equipment like a ladder truck moves slower to reduce vibration of the apparatus or enhances the hardness of the apparatus.
- To raise the value of the equipment, a technology to reduce the weight of the system and allows 'smart' movement is needed, and motion control technology is crucial.
- For some semiconductor assembly process (LCD driver IC assembly apparatus), the idle time among the entire process time waiting for natural decrement of the vibration accounts for approximately 20 to 40%, which means 9 hours out of 24-hour full-time work are spent to reduce vibration.
- For some display conveyance process (display panel conveyance apparatus), excessive vibration sometimes leads to work failure as it damages the display panel. This motion technology is a very important core technology that increases productivity and secures stability.

Technical Distinctiveness

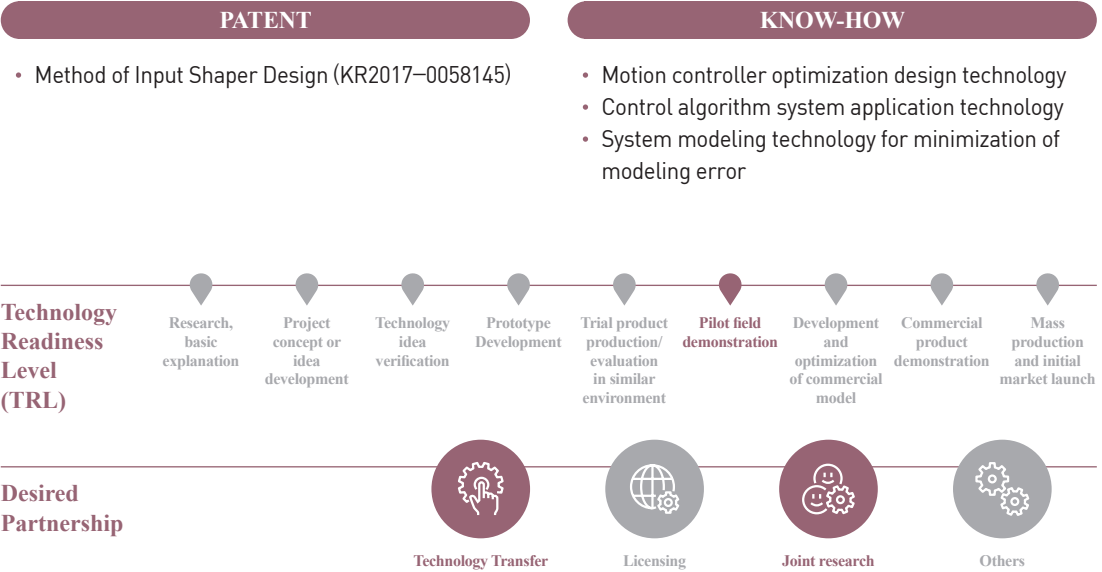
- The vibration reduction effect can be achieved with software adjustment (algorithm), not a hardware change.
- As it does not use feedback control, an additional sensor is unnecessary-high control performance for a low investment cost.
- The algorithm application can be set as an option for the user to make the decision as desired.

Excellence of Technology

- The core performance index for this technology is the tenacity for modeling error and excessive vibration reduction ability.
- The vibration reducing performance is maintained even when there is an error in the system information that was made aware previously. And the excessive vibration reduction performed during moving is also important.
- Therefore, the research team proved that the tenacity efficiency was 39.4% higher compared to existing motion control technology (input shaper), and the excessive vibration reduction ability was 32.7% higher.
- Verification for the performance was completed by applying for various equipment (crane, semiconductor assembly equipment, display panel conveyance equipment, etc.)



Current Intellectual Property Right Status



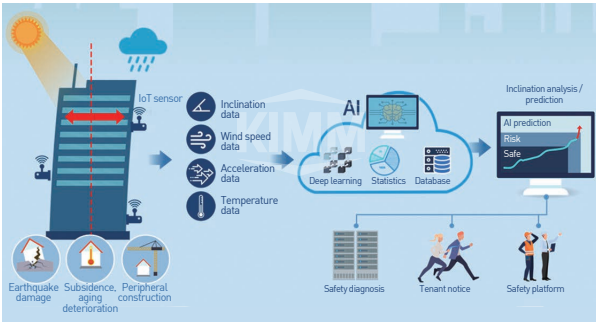


# Facility Disaster Safety Management System Using AI and IoT Sensors

▶ Department of AI Machinery ▶ Researchers: Hyungsuk Han, Changwan Ha, Jinseong Park, Byungtae Ahn, Youngsik Shin, Jaegyong Lee ▶ Contact: +82-42-868-7814

Technology Overview

- An intelligent facility disaster safety management system that monitors, predicts, evaluates, and responds to the stable state of facilities such as collapse and overturning of buildings using complex IoT sensors, big data, and AI technology
- Real-time monitoring of changes in the inclination and vibration of buildings caused by climate/wind speed affecting the safety of facilities, surrounding influences such as construction/subway operation, and ground subsidence due to groundwater/soil movement through IoT sensors
- Prediction of building risks using statistical analysis methods such as ARIMA and AI based methods such as LSTM using time series data



Customer / Market

- Safety management of earthquake-damaged buildings
- Safety management of old buildings
- Safety management of buildings under construction
- Safety management of buildings above subway lines

Problems of Existing Technology or Necessity of this Technology

- In accordance with the Special Act on Management of Disasters in Super High-Rise Buildings and Complex Buildings With Underground Connections, precision sensors and related systems are installed for long-distance bridges and high-rise complex buildings to monitor the displacement status of the facilities in real time. However, monitoring of changes in facilities of general buildings nationwide is not carried out due to realistic restrictions.
- A disaster safety management system is needed that can monitor and predict safety in real-time by constantly installing relatively inexpensive IoT sensors in facilities instead of expensive precision sensors used in high-rise buildings.
- Through the developed system, it is possible to prevent large-scale losses that occur after disasters in advance, and it is possible to use the management manpower productively through constant monitoring using AI. In addition, by preventing facility crises and disasters and increasing their utility, they can secure public safety and contribute to the promotion of public welfare, thereby alleviating the neighborhood's concerns (resolving civil complaints) about safety through scientific management.

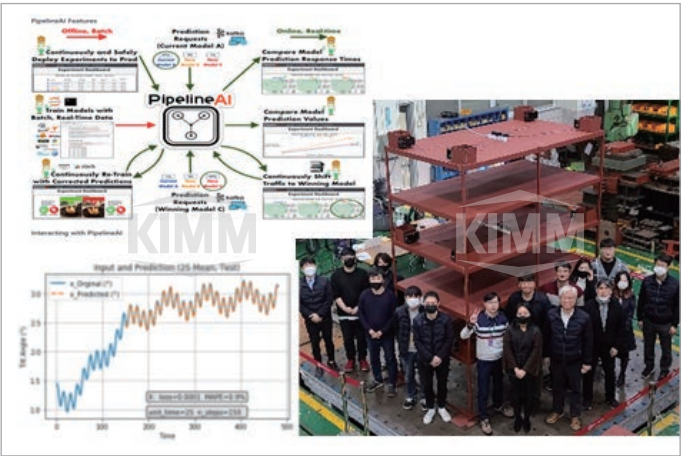
Technical Distinctiveness

- Monitoring and prediction using inexpensive MEMS-type tilt, acceleration, and geomagnetic sensors instead of expensive GNSS sensor equipment used in high-rise buildings
- A system capable of simultaneously managing/operating disaster safety management of multiple buildings and making comprehensive judgments through the central management server

- This method of predicting the slope of a building predicts the slope of natural subsidence that may occur during construction using the ARIMA method, which is a statistical prediction method, and the RNN-LSTM-based AI method with the use of the sequential data from slope sensor. It detects sudden changes in trends, such as a stable period where the gradient does not change significantly, and an aging period where the gradient may gradually increase in one direction. Also, it predicts the future slope of the building for each situation. If necessary, the prediction algorithm will be updated by learning from the point where the trend has changed.
- Multiple sensors are installed for each floor of a building to monitor and predict the slope that changes differently for each floor, "inter-floor displacement."

Excellence of Technology

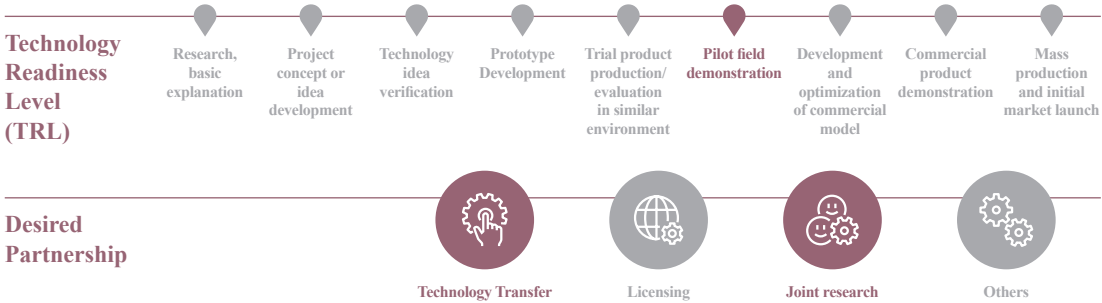
- Verification of facility disaster safety management system through empirical model: Acquired test certification from KTL for IoT sensor performance, local management system processing capability, and AI algorithm accuracy
- Media coverage in 23 newspapers by distributing press releases on the development of AI-based facility disaster safety management system
- Registered a number of related patents and programs
- Media reports on AI-based facility disaster safety management system



◀ Pipeline and Empirical Model of AI Prediction System ▶

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Building disaster safety management system and method thereof (KR2020-0163280)</li><li>• Local management system (Edge) operating program Ver. 1.0 (C-2020-039391)</li><li>• ARIMA (autoregressive integrated moving average) technique-based inclination prediction program for facility disaster safety management system (C-2020-045832)</li><li>• Artificial intelligence-based inclination prediction program for facility disaster safety management system Ver. 1.0 (C-2020-045833)</li></ul>	<ul style="list-style-type: none"><li>• IoT sensor reliability analysis and data preprocessing</li><li>• Prediction techniques that respond to data omissions, aperiodic acquisitions, and splash phenomena</li><li>• 3D building deformation visualization technology using multiple data</li></ul>



# Vibration Data SRS/FDS Analysis App

▶ Department of Reliability Assessment   ▶ Researcher: Jongwon Park   ▶ Contact: +82-42-868-7107

**Technology Overview**

- Shock response spectrum (SRS) for maximum response analysis of vibration data and fatigue damage spectrum (FDS) calculation app for fatigue damage analysis

**Customer / Market**

- Test design and execution company that analyzes vibration data and applies it to the test
- Defense company that designs and performs vibration tests according to MIL-STD-810

**Problems of Existing Technology or Necessity of this Technology**

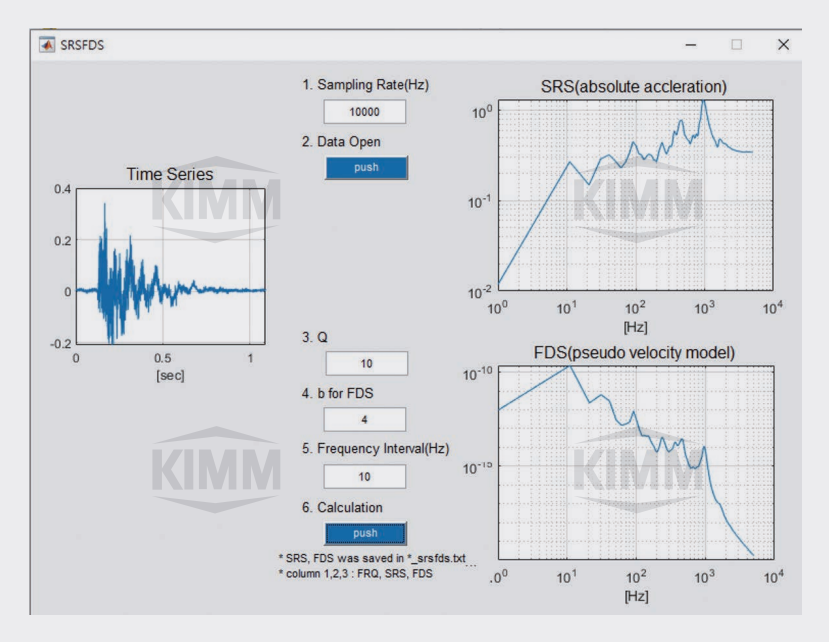
- Commercial analysis programs have a high entry barrier due to high initial costs and warranty costs, which widens the technological gap with large companies.
- Since commercial programs must have various functions, it is not allowed to purchase only the desired function separately, and there is a problem of lack of intuitiveness due to the complexity of parameter selection and generalized operation due to using it together with other functions.

**Technical Distinctiveness**

- Since the program was created with simplified codes using verified library based on SRS/FDS, users can intuitively and easily change the formulas.
- As UI configuration was independently created, UI can be configured according to user needs.

**Excellence of Technology**

- SRS/FDS calculation for given vibration data
- Setting off the output of calculated SRS/FDS text file
- Able to change major parameters such as amplification factor Q and Basquin coefficient b
- Able to change analysis frequency interval



〈 Vibration Data SRS/FDS Analysis App 〉

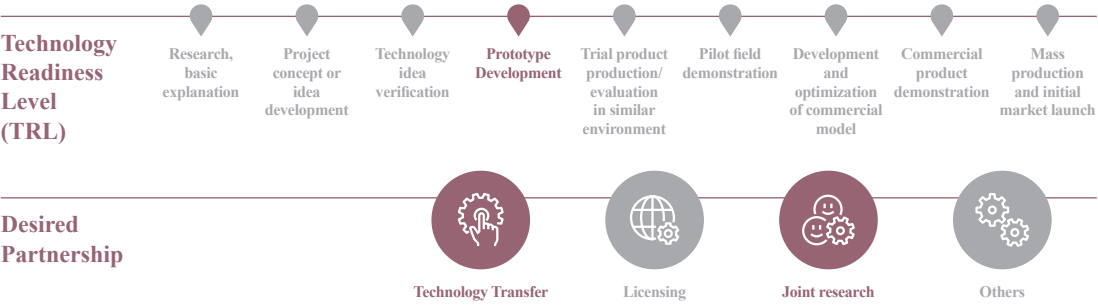
**Current Intellectual Property Right Status**

**PATENT**

- SRS/FDS analysis app for vibration data (C-2020-022820)

**KNOW-HOW**

- A program created with a combination of libraries verified on the theoretical basis of SRS/FDS
- Creation of an application with GUI applied for user convenience





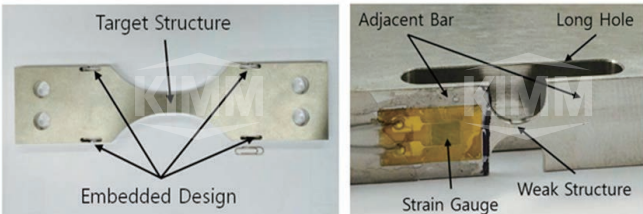


# Prognostics and Health Management Technology of Mechanical Structure Under Fatigue Load

▶ Department of Reliability Assessment   ▶ Researcher: Dongcheon Baek   ▶ Contact: +82-42-868-7189

Technology Overview

- Embedded structural design and sensing technology to predict in advance the point of fatigue failure caused by the propagation of cracks in mechanical structures subjected to random repetitive loads



Customer / Market

- National Infrastructure (bridge, tunnel, dam) monitoring and safety diagnosis company
- Machinery asset monitoring at cargo handling machine and heavy construction equipment rental company
- Machine structure with unpredictable model-based fatigue limit due to corrosion environment
- Improvement of machine structure with over-applied safety coefficient due to uncertainty and deviation of future loads

Problems of Existing Technology or Necessity of this Technology

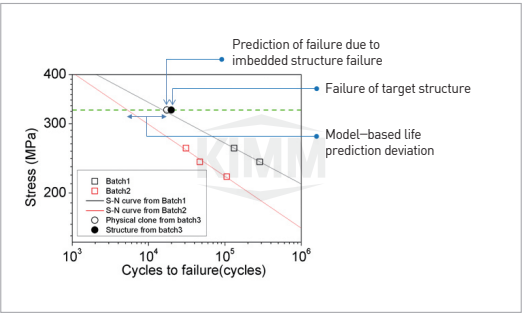
- The existing model-based prediction method for predicting the fatigue life of mechanical structures essentially involves the following three error sources uncertainty of materials properties, unknown future loading condition and the modeling error itself by simplification.
- Model-based life prediction using the fatigue property is difficult when the structure is affected by corrosive environment and variable random loading.
- Prediction of remaining useful life is difficult for a used machine structure with unclear use history or loads exceeding the permitted weight.
- It is useful for a machine structure that switched from preventive maintenance to condition-based maintenance to reduce the operational expenses.
- With this technology, second damage in the system can be prevented and the golden time can be secured in case of a big disaster.

Technical Distinctiveness

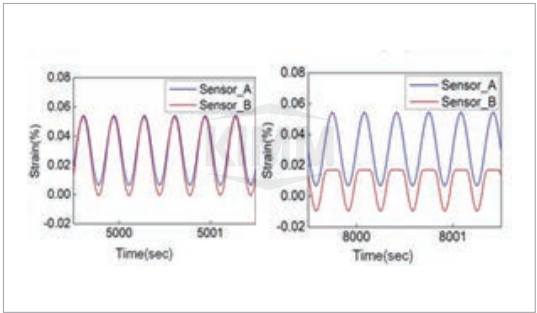
- It is a fatigue limit prediction technology with additional processing or attachment of an embedded structure that interlocks the target structure mechanically. It can be called as a mechanical fuse for fatigue damage accumulation.
- It is a new concept fatigue failure prediction device that can be used in random loading and corrosive environment.
- A non-model-based sensor that monitors the health of the structure was developed.

Excellence of Technology

- To prove the superiority to existing model-based life prediction technique, an experiment with a 316 L stainless steel structure with a constant amplitude fatigue loading was conducted, and the failure was predicted at 86% point of the entire life. (with existing model-based prediction, there is a 25 to 280% error)
- It can be applied also for random fatigue loading.
- It can be applied regardless of material property deviation and corrosive environment.



〈 Comparison with Existing Model-Based Prediction Method 〉

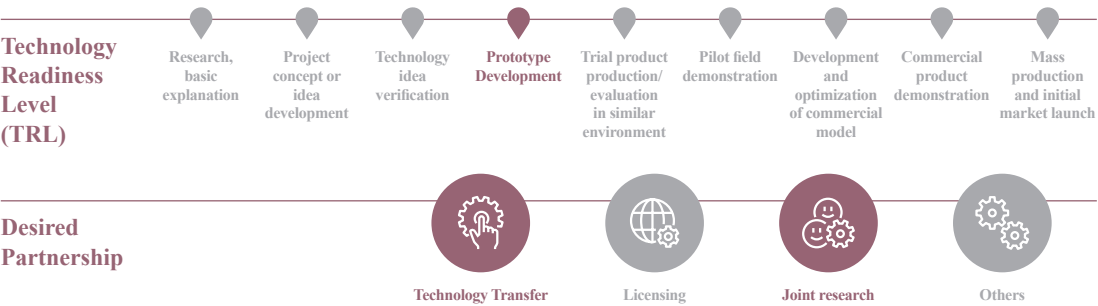


〈 Signal Change of Strain Sensor before and after failure of Embedded Structure for failure prediction 〉

Prediction method (Batch #)	Fatigue Life Prediction (In reality, failure after 19,800 cycles)	Life prediction error
Model-based life prediction (Batch 1)	15,900 cycles	4,900 cycles(19.7%)
Model-based life prediction (Batch 2)	5,240 cycles	14,600 cycles(73.5%)
Failure predicting embedded-structurebased prediction	17,400 cycles	2,400 cycles(12.1%)

Current Intellectual Property Right Status

PATENT	KNOW-HOW
<ul style="list-style-type: none"><li>• Fatigue Failure Prediction Apparatus of Mechanical Structures (KR1718131)</li></ul>	<ul style="list-style-type: none"><li>• Fatigue load-linked structure design technology considering machinability</li><li>• Failure prediction structure sensing and signal processing technology</li><li>• Failure prediction timing control technology</li></ul>



# Oil Reservoir for Hydraulic System Equipped with Return Line with Easy Gas Separation

▶ Department of Reliability Assessment   ▶ Researcher: Yongbum Lee   ▶ Contact: +82-42-868-7151

Technology Overview

- Technology for easy discharge of air and gas in oil by installing a tilted return line that enables easy gas separation in the oil reservoir attached to the construction machine



Customer / Market

- Construction machine (excavator, crane, etc.) manufacturer, hydraulic power unit and test apparatus manufacturer

Problems of Existing Technology or Necessity of this Technology

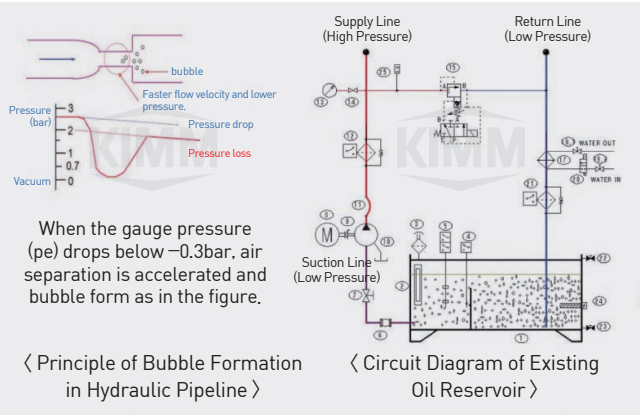
- Oil in the hydraulic system contains about 9% of air dissolved in pressured air. This air could have entered through the throttling part and the hydraulic pump or have occurred because the return line is incorrectly connected to the reservoir, the oil has stayed in the reservoir for too shortly, or the air and hydraulic oil have not been sufficiently separated.
- When air content in oil is high, cavitation happens in the pump, which is a phenomenon where very fine particles are separated from the surface of a substance. This usually occurs at the control edge of the hydraulic pump or valve. This becomes the cause of loud noise (max. 110 dBA at 420 bar) and erodes the product. Such phenomenon is caused by local peak pressure and a high temperature.
- This technology allows for easy gas separation, a simple structure and reliability.

Technical Distinctiveness

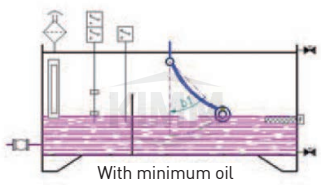
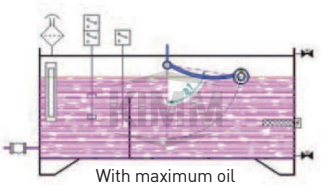
- Realizes low noise and high efficiency
- Can reduce the noise from cavitation by 15% or higher as it allows for easy gas separation
- Minimizes the gas content in oil and improves the volumetric efficiency by 50%
- Existing oil reservoir has the return line fixed on the bottom, so it takes time for the gas to travel to the top, and gas is contained in the flow in the pump and makes noise. With a new oil reservoir structure design, the return line is tilted to stay most closely to the surface of the oil to realize easy air and gas discharge.
- Achieved low noise and high efficiency with a simple structural change of adding a tilted return line joint to existing oil reservoir

Excellence of Technology

- An oil reservoir with a tilted return line for easy gas separation was produced for testing and is in the testing. (The noise was reduced by 7.4 dBA from 86.4 dBA to 77.6 dBA.)
- Paper: Modeling & Simulation of the Hydraulic Servo Actuator Cushion for Power Plant (Korean Tribology Society Fall Symposium)



◁ Image of Prototype of Oil Reservoir with Tilted Return Line ▷



◁ Circuit Diagram of Oil Reservoir with Tilted Return Line for Easy Gas Separation ▷

Current Intellectual Property Right Status

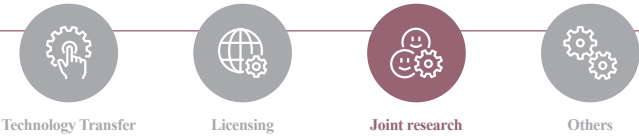
PATENT

- Oil Reservoir for Hydraulic System using Return Line for Gas or Air Separation (KR1422809, PCT/KR2013/003740, JP2014-529628)

Technology Readiness Level (TRL)



Desired Partnership

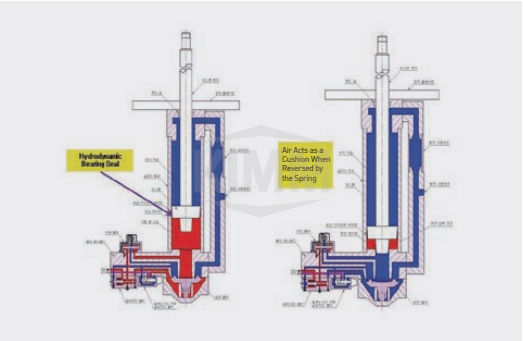


# Hydraulic Servo Actuator Using Hydrodynamic Bearing for Turbine Control at Nuclear and Thermal Power Plants

▶ Department of Reliability Assessment ▶ Researcher: Yongbum Lee ▶ Contact: +82-42-868-7151

Technology Overview

- Realizing high performance and extended life by adopting a hydrodynamic bearing for the hydraulic servo actuator of the turbine control steam valve at nuclear and thermal power plants



Customer / Market

- Power plant maintenance company, Hydraulic servo actuator manufacturing company

Problems of Existing Technology or Necessity of this Technology

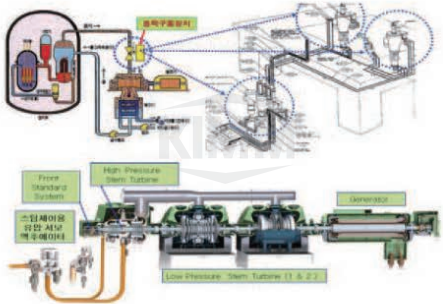
- Aims to develop a leading product with “development of a high performance, high-efficiency steam control hydraulic servo actuator” by including a hydrodynamic bearing that minimizes seal friction and a smart check valve in the hydraulic servo actuator used for steam control at a nuclear/thermal power plant
- Existing technology is the technology from 30 to 40 years ago when plants were first introduced and lag behind. Power plants demand technical supplementation.
- A localization is needed as the entire amount depending on the import
- Includes a new technology that makes up for problems in existing technology
- Secured industrial property rights to pioneer into overseas markets

Technical Distinctiveness

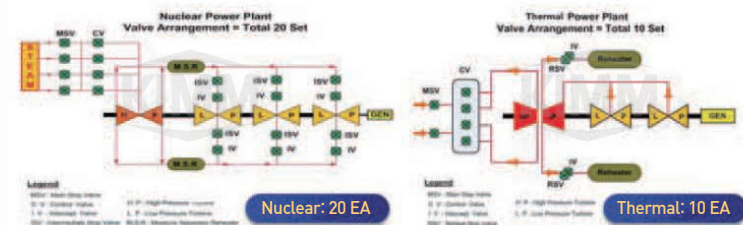
- Possible to secure a new market
- Supplied consumables for periodic repair at local/overseas nuclear/thermal power plants and new plant constructions
- Effective supplementation of existing problems and application of new technology/ planning to apply for the output enhancement project at local obsolete generating units
- Effect of replacing imports (applying 20%): 1.6 billion won for 20 units at nuclear power plants, 1.6 billion won for 40 units at standard thermal power plants
- Contributed to performance and function enhancement/Realized low-friction by designing the piston ring, a metal seal, as a non-contact dynamic bearing
- Realized functional enhancement by designing a smart check valve that prevents the oil leak issue that frequently occurs through an orifice leading to a breakdown with the operating pressure/achieved high performance (responsiveness increased by over 150%) and high efficiency (friction force improved by over 500%)

Excellence of Technology

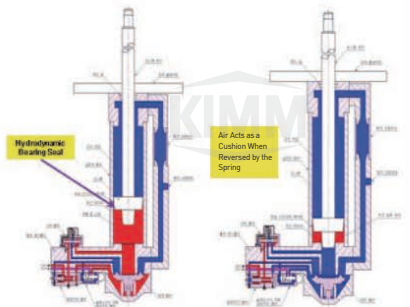
- Papers: Modeling & Simulation of a Hydraulic Servo Actuator Cushion for Power Plants, Modeling and Analysis of Mechanical Fluid and Electrical Integrated System, A Study on the Air Vent Valve of the Hydraulic Servo Actuator for Steam Control of Power Plants



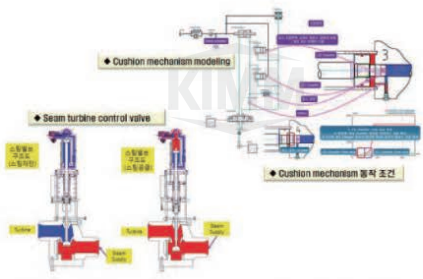
〈 Schematic Diagram of Power Plant and Block Diagram of Generation System 〉



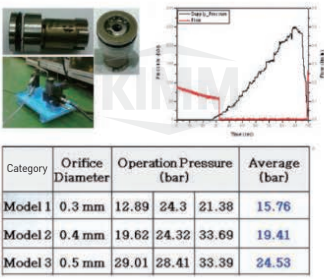
〈 Block Diagram of Steam Control Hydraulic Servo Actuator of Nuclear/Thermal Power Plant 〉



〈 Hydraulic Servo Actuator 〉



〈 Modeling & Simulation 〉



〈 Smart Check Valve Test Result 〉

Current Intellectual Property Right Status

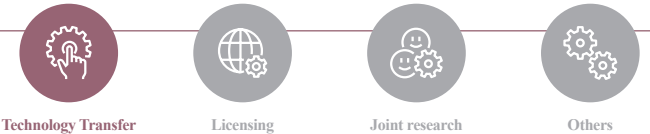
PATENT

- Hydraulic Apparatus for Sluice Gate Using Air Elimination Valve (KR120315)
- Hydraulic Servo Actuator for Turbine Control Steam Valve of Nuclear and Thermal Power Plants using Hydrodynamic Bearing (KR0046770)
- Turbine Valve Control Actuator Using Internal Check Valve for Nuclear and Fossil Power Plants (KR1166689)
- A Cylinder Measurable the Position of Piston Rod (KR717338)
- Redundancy system of hydraulic servo valve for safety control of turbine control actuator for power plant and operation method of the same (10-2020-0120794)

Technology Readiness Level (TRL)



Desired Partnership



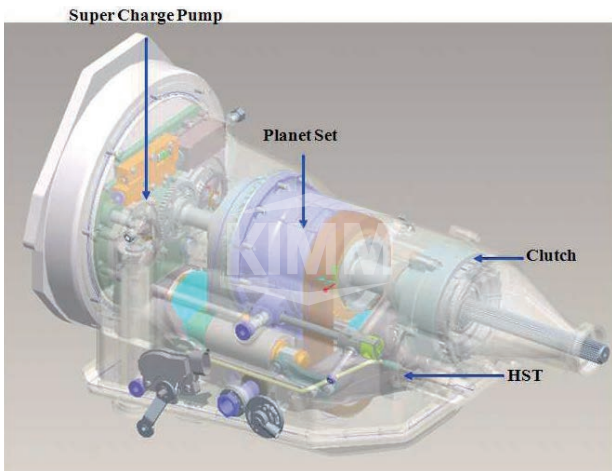


# High Power Hydrostatic Transmission

▶ Department of Reliability Assessment   ▶ Researcher: Dong Soo Jung   ▶ Contact: +82-42-868-7154

Technology Overview

- High power hydrostatic transmission for luxury car, bus and truck



Customer / Market

- City bus, SUV, mid-large commercial vehicle and agricultural machinery

Problems of Existing Technology or Necessity of this Technology

- Comparison of hydrostatic transmission by type

Performance/Transmission	Hydraulic	Toroidal	Belt	Chain
Torque	Hige	Hige	Low	Hige
Complexity	Hige	Moderate	Moderate	Moderate
Weight	Hige	Medium	Medium	Medium
Efficiency	Hige	Hige	Hige	Hige

Excellence of Technology

- Improve convenience of driver of agriculture machines and mid, large-sized vehicles with poor driving condition
- Developed a continuously variable transmission for bus and truck
- Maximum power: 380 horsepower
- Maximum torque: 140 kgf · m
- Maximum speed: 2,700 rpm
- Power efficiency: Over 80% in the key performance section
- Noise: Below 90 dB
- Target durability: 200,000km
- Maximum speed: 160 km/h
- Weight: 130kg
- A fuel saving approximately by 10 to 25%; outstanding mobility at a low speed, barely any transmission shock; achieves enhanced fuel efficiency and reduced exhaust gas by linking the driving condition with the optimal fuel range of the engine

Technical Distinctiveness

- Equipped with a hydrostatic device technology
- Variable displacement hydraulic pump technology
- Regulator technology for a variable displacement hydraulic pump
- Fixed displacement hydraulic motor technology
- Hydraulic pressure control valve technology



Current Intellectual Property Right Status

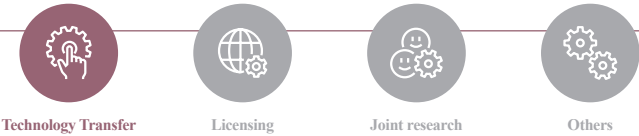
PATENT

- Bent Axis Type Hydrostatic Transmission (KR1289308)
- Axial Piston Pump (KR1388001)

Technology Readiness Level (TRL)

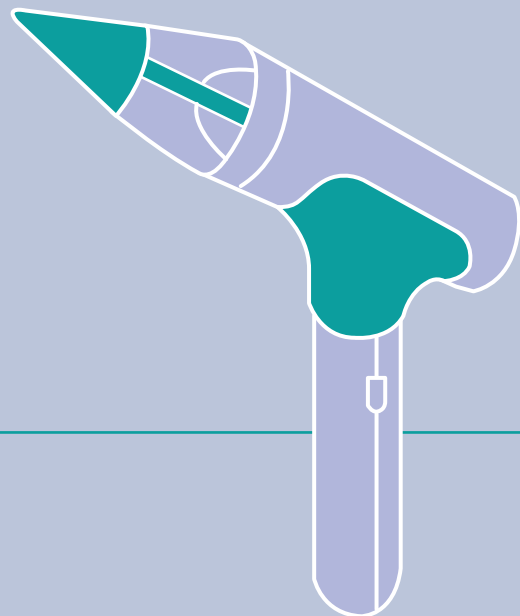


Desired Partnership



6

Daegu Research Center for  
Medical Devices and  
Green Energy



Complex Health Management System  
Technology for Early Diagnosis/  
Treatment/Rehabilitation of Chronic  
Respiratory Disease

358 • Department of Medical Device  
368 • Department of Medical Assistant Robot

KOREA  
INSTITUTE OF  
MACHINERY &  
MATERIALS

# Fully-automated Molecular Diagnostics System with All-in-One cartridge for Point-of-Care testing

▶ Department of Medical Device   ▶ Researcher: Ohwon Kwon   ▶ Contact: +82-53-670-9001

Technology Overview

- All-in-one molecular diagnosis cartridges and analysis equipment technology allowing for quick on-site (Point-of-Care) diagnosis of infectious disease (COVID, flu, STD) by a semi-professional



Customer / Market

- In Vitro diagnostics, molecular diagnosis market

Problems of Existing Technology or Necessity of this Technology

- The occasions calling for quick diagnosis due to the emergence of new virus diseases are increasing, and the demand for the DNA test for disease prevention has increased.
- The DNA test for detecting virus mostly uses the PCR method or isothermal amplification, so the test is conducted with an electrophoresis tool or a real-time PCR machine. However, out of the necessity at the field, a simpler, automated DNA test is demanded.
- A lot of time is consumed for pre-treatment of a specimen, mixing of a specimen and a reagent, and the residue treatment. And the existing specimen pre-treatment device has a complex structure with high production cost and consumable expenses. While treating a large amount of specimens at once, the specimen could possibly be contaminated.

Technical Distinctiveness

- It is mechanically simple and effectively handles the specimen pre-treatment.
- It automatizes the entire process – nucleic acid extraction, amplification and detection (turnaround time <60 min)
- It includes the chambers that store reagents to be mixed with the specimen, and the reagents are connected to the specimen pre-treatment device, where specimens are discharged from each chamber in order according to the pre-treatment process order. This simplifies the pre-treatment device and integrates the nucleic acid amplification and detection device, which the nucleic acids extracted from the specimen flow in.
- By completing the additional design of cartridges for emergency sites, the selection configuration of analysis equipment/cartridges for each on-site situation has been diversified (desktop, hand-held)

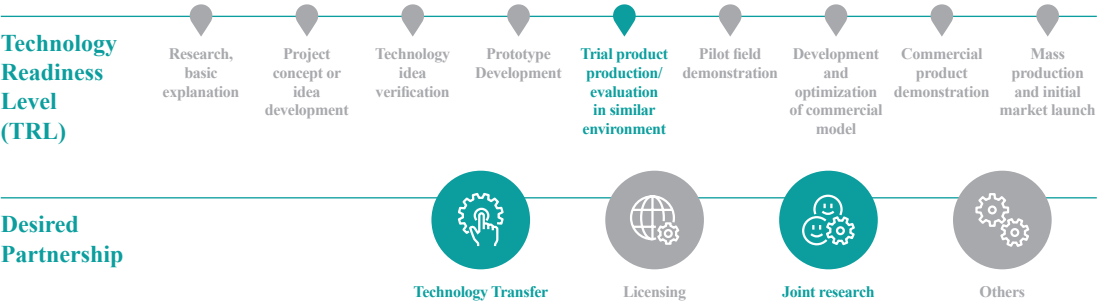
Excellence of Technology

- Prototype process chart
- | Process Order              | Component/Process   | Additional Explanation  |
|----------------------------|---|---|
| Nucleic acid extraction    | Modify disposable cartridge and joint design<br>Optimize cartridge driving module                               | Nucleic acid extraction time < 15 min.<br>*May differ depending on the test subject and item              |
| Nucleic acid amplification | Precise temperature control (heating/cooling) module  | Nucleic acid amplification, detection time < 45 min<br>*May differ depending on the test subject and item |
| Nucleic acid detection     | Prototype modification  |   |
| Diagnosis                  | Integrated system for nucleic acid extraction, amplification, and detection and control and analysis assessment | Target test time < 40 to 60 min   |
- Completed performance verification of integrated cartridge and detection prototype (nucleic acid amplification unit, fluorescence analysis unit) through institutional research project and government entrusted project (verified by accredited certification body)
  - The basic system for multiplexing PCR through multichannel optical modules was completed.

Current Intellectual Property Right Status

PATENT

- Sample Preparation Device (KR1244467)
- Nucleic Acid Automatic Analysis Device (KR1481054, US8759079, CN201110428842.3)
- Device for Automatically Analyzing Nucleic Acid and Opening and Closing Device Thereof (KR1487537)
- A Cartridge for Automatically Analyzing a Nucleic Acid (KR1512161)
- Cartridge for Sample Preparation (KR1630784)
- Cartridge for Sample Preparation and Collected Acid Analysis (KR1703992)
- Integrated Molecular Diagnosis Cartridge (KR2182376)



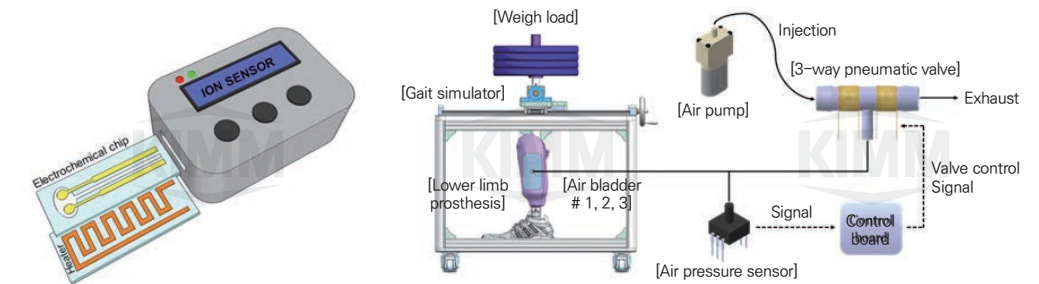


# Biosignal Detection Sensor and Control Technology

▶ Department of Medical Device   ▶ Researcher: Kang-Ho Lee   ▶ Contact: +82-53-670-9027

Technology Overview

- Development of electromechanical sensors and control technology that can diagnose diseases and monitor health by detecting bio reactions (DNA, protein, cell, etc.) and patient biosignals



Customer / Market

- Sensor and measurement device-related company in the medical, bio field
- Wearable device related market
- Senior and patient care product company
- Medical health assistive device-related company

Problems of Existing Technology or Necessity of this Technology

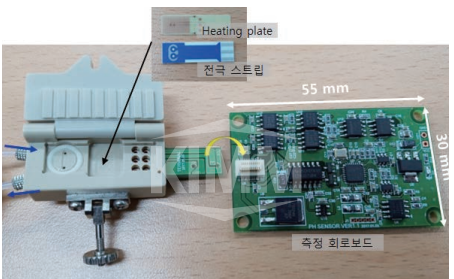
- When ion concentration is being measured, the detection and dynamic range are limited due to the offset phenomenon that occurs in the process of acquiring the electrochemical reaction voltage.
- Existing wearable devices have the inconvenience of wearing and taking off and are not easy to wash.
- Body assistive devices that come in contact with the skin may develop skin diseases due to pressure when the pressure is not properly distributed.

Technical Distinctiveness

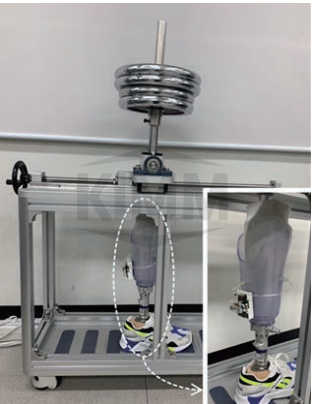
- A disposable platform capable of measuring ion concentration by separating the reaction part and the conversion/reading part
- Enhancement accuracy and expansion the dynamic range by automatic offset compensation while detecting the differential signal to enhance accuracy and expand the dynamic range.
- Improvement of washing durability by manufacturing button-type sensor structure when acquiring biosignals
- After monitoring body pressure in real-time, posture correction and pressure distribution through air actuating control

Excellence of Technology

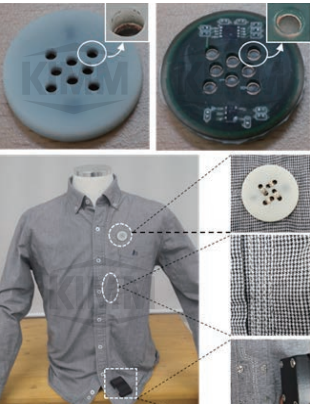
- Improved detectable dynamic range using a feedback structure that automatically compensates for offsets
- The first small module to achieve detection by concentration in the DNA PCR (polymerase chain reaction) experiment
- Body pressure sensing technology is applied to the prosthetic socket for ankle amputation patients to distribute pressure and relieve pain during ambulation.
- The pressure data sensed in real-time is transmitted wirelessly and visualized with a smartphone app.



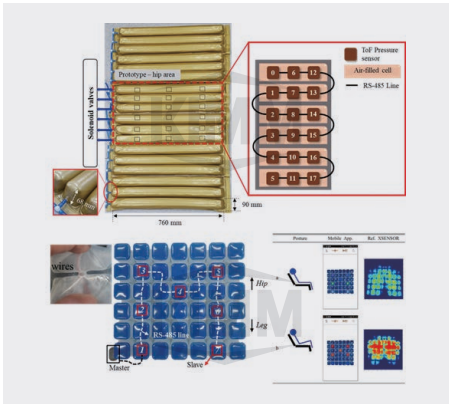
〈 Ion Concentration Measurement Module Prototype〉



〈 Ankle Prosthetic Active Custom Socket〉



〈 Smart Textile Button-Type Sensor〉



〈 Real-Time Body Pressure Detection and Posture Correction Mattress/Cushion〉

Current Intellectual Property Right Status

PATENT

- Method and Apparatus for Detecting Ion Concentration (KR10-1729685, US10/959, 001)
- Differential Amplifier with Offset Correction Ability and Driving Method of the Same (KR2018-0018123)
- Electronic Textile Device Having a Button-Shaped Sensor (KR10-1864244)
- Module-Type Button for Electronic Textile (KR10-1864246)
- Finger Apparatus and Robot Hand Having the Finger Apparatus(KR10-2097417)

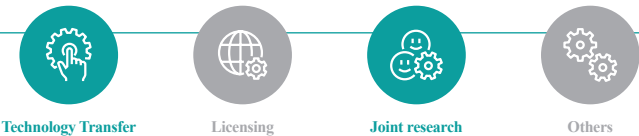
KNOW-HOW

- Analog circuit design and hardware module manufacturing technology
- Real-time feedback control technology
- Small device fabrication technology for point-of-care
- Smartphone app technology for real-time health and biometric information delivery

Technology Readiness Level (TRL)



Desired Partnership



# Complex Health Management System Technology for Early Diagnosis / Treatment / Rehabilitation of Chronic Respiratory Disease

▶ Department of Medical Device   ▶ Researcher: Dongkyu Lee   ▶ Contact: +82-53-670-9011

Technology Overview

- A complex multi-functional health management system technology that can diagnose/treat/rehabilitate chronic respiratory diseases such as small medical device technology for smart pulmonary function test, phototherapy, nebulizer, vacuum inhalation module treatment, and breathing training
- A single breath analysis technology to analyze the maximum peak flow and the concentration of gas biomarkers in the breath at the same time to observe the physical, chemical respiratory conditions for monitoring of asthma and COPD patients



Customer / Market

- Bio diagnostic device/in-vitro diagnostic device company
- Medical device manufacturer/seller
- Sensor manufacturer
- Environment monitoring, bio-applied company

Problems of Existing Technology or Necessity of this Technology

- Recently, there is high demand for a multi-purpose complex medical devices for diagnosis/treatment/rehabilitation, for health management of chronic diseases.
- In the case of diagnostic devices, it is difficult to implement an accurate smart pulmonary function test device through a pressure sensor due to the difference in sensitivity and measurement range. As expiratory gas analysis is affected by complex environmental factors such as temperature, humidity, and expiratory rate, it is difficult to accurately analyze and requires a calibration algorithm. Since it is difficult to analyze gas at fast flow of the maximum expiration rate and the presence or absence of disease with existing single gas analysis, multiple sensors that can analyze the detected gas even in a high-velocity environment are required.
- There are various treatment methods in the case of treatment devices, but they are expensive and there is only a single independent treatment device for each, and thus, a treatment device that can improve treatment efficiency and implement various treatment methods is required. As for rehabilitation device, there is a problem of difficulty in adjusting the pressure load to suit the necessary pressure load of each patient.
- Since all devices exist independently, collection and management of data for medical acts are not centralized. An integrated configuration of a diagnostic device for analyzing the treatment and rehabilitation effect after using treatment and rehabilitation device is required.

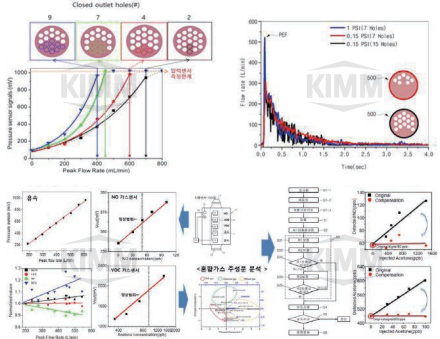
Technical Distinctiveness

- It can be configured as a multi-purpose complex system such as diagnosis/treatment/rehabilitation for health management of chronic diseases
- In the case of a diagnostic device, an accurate smart lung function test device is implemented through a single or two pressure sensors.
- It is a structure that allows simultaneous analysis of maximum expiratory speed and expiratory gas with a single

- respiration. A low-cost on-site gas analysis system for chronic respiratory disease has been implemented by applying a structure capable of analyzing maximum speed, respiration volume and expiratory gas without additional parts, and a low-cost environmental sensor to a medical device.
- Applies a complex correction algorithm that uses a multi sensor to correct the environmental factor and the mixed gas factor
  - The treatment device can be implemented as a modular or integrated type to efficiently apply various treatment methods, and the rehabilitation treatment device can be modularized and made into integrated system to automatically control the pressure load.
  - It can be combined with various small medical devices such as complex multi-purpose structure and modular type, and developed as a portable and home medical device.

Excellence of Technology

- Respiratory diagnostic device
  - Can conduct the maximum peak flow and expired gas analysis with a single breath
  - Can analyze the maximum peak flow and the gas biomarkers in it (Maximum peak flow rate between 150 and 700 L/min, FENO 20 ppb speed, VOC (acetone) 400 ppb speed, injection within 20 sec/measurement within 5 min)
  - Optimized detection using a multi sensor and a complex correction algorithm
  - Developed as a simple, cheap small point-of-care medical device that does not require sample injection pump or a humidity filter
  - Development of an accurate smart lung function test device through one or two pressure sensors
- Respiratory therapy/rehabilitation device
  - A modular respiratory treatment device structure for phototherapy/nebulizer/vacuum/spray therapy
  - Development of rehabilitation device capable of automatic load control for internal pressure
- Configurable as a multi-purpose device for respiratory diagnosis/treatment/rehabilitation



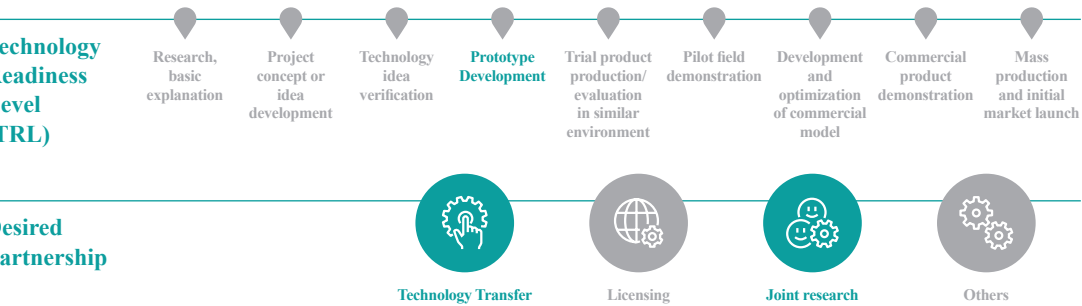
Current Intellectual Property Right Status

PATENT

- Apparatus and Method for analyzing Breath Gases Using Multi-sensor (KR1817752)
- Analysis Method of Single Breath and Analysis Device of Single Breath (KR2016- 0159996)
- Analysis Method of Single Breath and Analysis Device of Single Breath (PCT/KR2017/012950)
- Patient-Customized Peak Flow Meter (KR2019-0144523)
- A user-customized lung function test apparatus, a method for configuring the test apparatus, and a lung function test method using the test apparatus (KR2021-0017598)

KNOW-HOW

- Multi gas sensor fabrication, signal measurement technology
- Gas collection, concentration, separation technology
- Multi sensor signal analysis and measurement algorithm technology
- Design and manufacture of multi-purpose diagnostic/treatment/rehabilitation device



Active Knee Prosthesis

▶ Department of Medical Device ▶ Researcher: Jiuk Jung ▶ Contact: +82-53-670-9017

Technology Overview

- An integrated drive module that is applied to expensive robots was independently developed with excellent performance and applied to active prosthetic knee that supports ambulation activities (walking on level-ground, slopes and stairs) of people with lower extremity disability in their daily life



Customer / Market

- Lower-limb amputees due to traffic accidents and industrial accidents/prosthetic orthopedic device

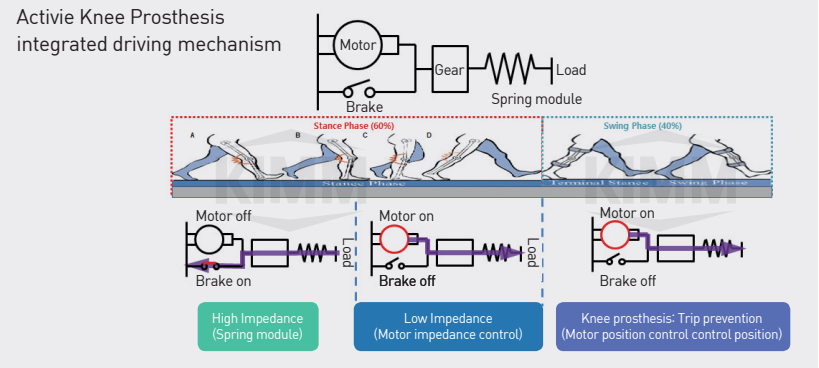
Problems of Existing Technology or Necessity of this Technology

- Existing commercial passive prostheses were developed for the purpose of functionally/esthetically replacing the amputated body part, making it impossible to walk naturally and causing excessive metabolic energy consumption in the user, resulting in imbalance in the user's physical aspect.
- In addition, people with disabilities wearing passive prostheses had difficulty walking on slopes and stairs and had to go back a long way.
- Through the previous project, an active ankle-foot prosthesis for lower extremity amputation patients was developed, and clinical research and commercialization research for various ankle amputation patients (elderly people, both feet amputees, etc.) is being conducted. There is a need to develop robotic prosthesis that focuses both on the ankle and the knee.
- The prosthetic leg products commercialized in Korea do not reach the technological level of developed countries and is not favored by domestic users. Foreign products occupy most of the domestic market share. In addition, bionic technology, which combines human motion imitating robot technology and bio-interface technology, has a technological gap of more than 10 years compared to advanced countries that are undergoing clinical trials. Therefore, technology development should be urgently carried out in terms of narrowing the technological gap with advanced countries and localizing prosthetic legs.

Technical Distinctiveness

- Design and development of integrated drive module including spring module
- It enables natural walking through the implementation of a human body motion imitating mechanism, and it is possible to walk uphill/downhill on slopes and stairs as well as walk all day on a single charge with extremely low energy consumption.

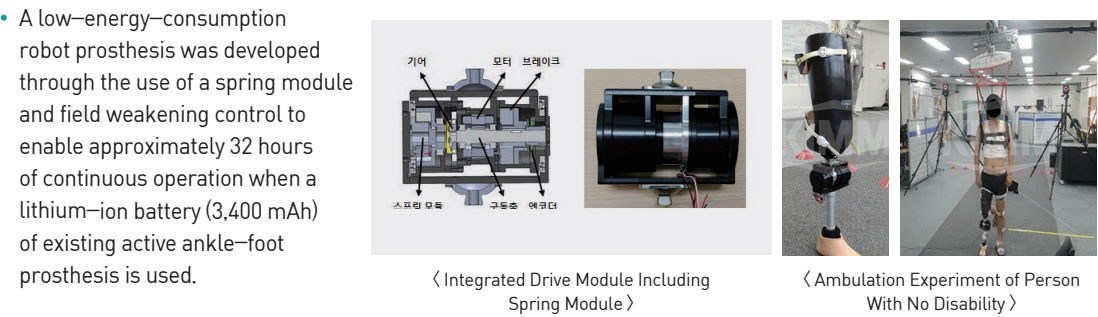
Integrated drive module mechanism for active knee prosthesis including spring module



Excellence of Technology

- It enables natural ambulation on level-ground, slopes and stairs by using an integrated drive module equipped with human motion imitating mechanism.
- A spring module is used where strong rigidity is required to prevent the risk of overturns by maintaining the rigidity of the knee joint even when the power of the robot prosthesis is switched off.
- The health-side movements of the non-disabled during level-ground ambulation showed 89.6 % ambulation similarity with wearing an active knee prosthesis.

Experiment of Flat Ground Ambulation With the Active Knee Prosthesis and Person With No Disability



Current Intellectual Property Right Status

PATENT

- Integrated drive module having compliance module and integrated drive method using the same (KR2020-0121721)
- Integrated drive apparatus and knee-type robot artificial leg (10-2073621-0000)

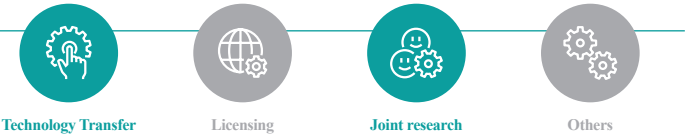
KNOW-HOW

- Bio-interface sensor-based gait cycle identification and gait pattern generation technology

Technology Readiness Level (TRL)



Desired Partnership



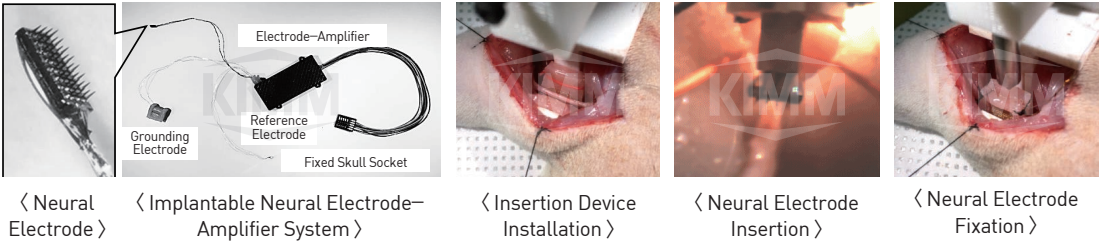


# Peripheral Nerve Signal Processing Technology

▶ Department of Medical Device   ▶ Researcher: Jun-Uk Chu   ▶ Contact: +82-53-670-9105

Technology Overview

- Peripheral nerve signal processing technology that selectively measures and stimulates peripheral nerves to restore the motor and sensory functions of amputees and paralyzed patients



Customer / Market

- Implantable electronic medical device
- Prosthetic hand and leg for amputee
- Electrical stimulator for paralyzed patient
- Degenerative nerve disease treatment device

Problems of Existing Technology or Necessity of this Technology

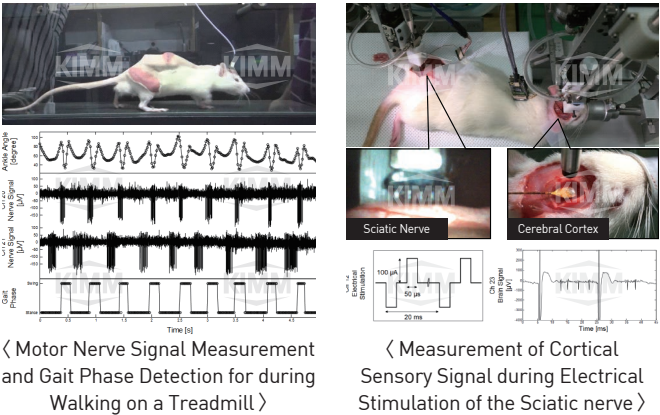
- Conventional peripheral nerve electrode system has difficulty in measuring and stimulating in a nerve fiber unit.
- Motor nerves are less distributed than the sensory nerves and are difficult to be measured due to the interference of muscle signals and motion artifacts.
- Need a surgical technique of stably inserting a multi-channel neural electrode in the peripheral nerve to measure and stimulate in the nerve fiber unit
- Need a measurement technology that guarantees a high signal to noise ratio and a technology to discriminate a motor nerve fiber from a peripheral nerve bundle

Technical Distinctiveness

- A neural electrode implantation technology that inserts a multi-channel neural electrode at a precise location and depth in the peripheral nerve bundle and minimizes the damage in the neural electrode and nerve tissue
- By absorbing the multi-channel neural electrode with vacuum, transfer and implantation are stable. By implanting the multi-channel neural electrode with the shock impulse, implantation can be done easily regardless of the surface tension of the peripheral nerve bundle.
- Peripheral motor nerve signal measurement technology to minimize the contamination of nerve signals from muscle signals and motion artifacts and discriminate motor nerve signals among all nerve signals detected
- By locating the neural electrode inside the closure wrapped with a metal gauze, it can be shielded from muscle signals and motion artifacts, and by applying electrical stimulation to all channels of the neural electrode to check the availability of muscular motion, the motor nerve fibers can be distinguished.

Excellence of Technology

- Provide motion commands to the prosthetic arm controller by analyzing the efferent motor nerve signals and recognizing the motion intention
- Developed the multi-channel action potential detection and classification technology
- Verified the possibility of motion intention recognition based on analysis of movement of an animal model
- Developed a vision system for synchronization of motor nerve signals and motion analysis data
- Developed a gait phase detection algorithm that can discriminate stance phase and swing phase while walking on a treadmill
- Delivers the tactile sensory information by applying electrical stimulation to afferent sensory nerves based on the prosthetic arm sensor
- Developed the technology for multi-channel stimulation pattern generation and interleaved stimulation
- Verified the possibility of tactile sensory information delivery by measuring the cortical sensory signal of an animal model
- Generated an electrical stimulation pattern according to cutaneous sensation area that can evoke a cortical sensory nerve signal
- Confirmed the similarity of the mechanical stimulation on skin and electrical stimulation of peripheral nerve to the evoked cortical sensory signal



Current Intellectual Property Right Status

PATENT

- Nerve Electrode Insertion Device (KR1808254)
- Recording System of Peripheral Motor Nerve Activity and Method for Discriminating Peripheral Motor Nerve Activity (KR2017-0172501)

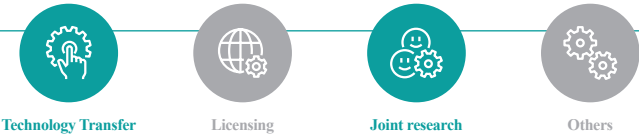
KNOW-HOW

- Neural electrode implantation in peripheral nerve and cerebrum
- Nerve signal amplifier and electrical stimulator design technology
- Multi-channel action potential detection and classification technology
- Multi-channel stimulation pattern generation and interleaved stimulation technology
- Motor nerve signal measurement-based motion intention recognition technology
- Sensory nerve electrical stimulation-based tactile sensory information delivery technology

Technology Readiness Level (TRL)



Desired Partnership



# Non-Face-to-Face Medical Examination Robot System

▶ Department of Medical Assistant Robot ▶ Researcher: Joonho Seo ▶ Contact: +82-53-670-9103

Technology Overview

- A medical robot system development technology that enables non-face-to-face remote examination by convergence of robot technology and ICT.
- As medical examinations can be performed without the subject and the medical expert meeting face-to-face, it is possible to provide non-face-to-face medical services in cases where it is inconvenient to move patients, such as in islands or remote military bases, or in places where there is a risk of infection by medical staff during the examination.
- The system consists of a "slave robot" to be used for remote subjects, a "master device" to be remotely controlled by a medical specialist, and a "communication platform" to connect the two medical sites through a network.
- Representative systems to which this technology is applied include a robotic system capable of remote ultrasound imaging and a robotic system capable of non-face-to-face sample collection.



〈 Non-Face-to-Face Remote Ultrasound Imaging Diagnostic Robot System〉



〈 Non-Face-to-Face Remote Specimen Collecting Robot System〉

Customer / Market

- Non-face-to-face remote ultrasound imaging robot system
  - Ultrasound imaging service can be provided for residents of medically vulnerable areas, such as islands, military bases, and deep-sea fishing boats, and elderly patients who cannot travel long distances.
- Non-face-to-face remote specimen collecting robot system
  - Clinical sites for the specimen collection of infectious disease where there is a risk of secondary infection from the examinee, infection sites with high patient density such as passenger ships and high contamination level, which makes it difficult to access medical staff, or medical sites where there is a demand for sample collection due to a new infectious disease

Problems of Existing Technology or Necessity of this Technology

- Non-face-to-face remote ultrasound imaging robot system
  - Currently, a telemedicine system for patients in medically vulnerable areas is being operated, but there is a limit to the application of telemedicine service as only a medical examination is possible mainly through video communication.
- Non-face-to-face remote specimen collecting robot system
  - Methods such as "walk-through" and "driving-through" systems are being introduced to minimize contact with infected patients, but there is still the need to wear protective clothing, and there are problems such as seasonal inconvenience and medical staff fatigue.
- Non-face-to-face specimen collecting robot technology is not only dangerous to patients because it is based on multiple degree of freedom robot arms that are mostly used for industrial purposes, but it may not be easy to obtain approval as a medical device, and the unit price is very expensive.

Technical Distinctiveness

- The non-face-to-face remote ultrasound imaging robot system introduced and commercialized abroad is heavier (3 kg) and bulkier than the system developed herein. It supports remote control of an ultrasonic probe with a low degree of freedom (4 DOF).
- Ultrasound specialists can provide advanced medical services such as ultrasound imaging without having to travel long distances.
- There is no risk of infection as the medical staff wears normal clothes and can collect samples non-face-to-face with the patient during the examination.
- The non-face-to-face specimen collection robot in this technology is optimized for sampling in the face area, making it safe for patients and possible to produce multiple units at a low cost.

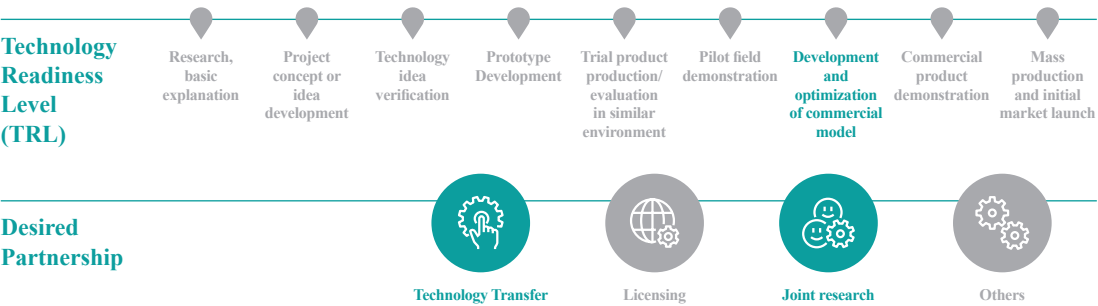
Excellence of Technology

- Non-face-to-face remote ultrasound imaging robot system
  - The robot is designed to be light and compact (1.5 kg) and provide free remote probe movement operation (6 DOF), making it easy to combine with existing ultrasound imaging equipment and move to remote areas.
  - The maximum contact force is 5 kgf, and the movement speed required for ultrasound diagnosis is 1 Hz.
  - It can be connected in a wireless LTE environment or general Internet environment, and can be used for remote ultrasound imaging not only in Korea but also in medically vulnerable areas abroad.
- Non-face-to-face remote specimen collecting robot system
  - A robotic structure optimized for specimen collection from the patient's facial area; the components to be inserted into the nasal cavity or the oral cavity of the subject are designed safely for the patients to include only the specimen-collecting cotton swab
  - It can be easily connected to general disposable specimen collecting tools, and enables simple movements of the patient such as installing a specimen-collecting cotton swab or moving the collection bin, minimizing the demand for on-site medical staff.
  - Safe and accurate non-face-to-face specimen collection can be realized as the cotton swab reaches the examination area and measures the resistance that occurs during smear collection and displays it to remote examination and medical staff.

Current Intellectual Property Right Status

PATENT	
• Remote ultrasound diagnostic system (KR2017-0106527, US14/966,823)	• Swap module capable of remote examination and remote examination device including the same (KR2020-0128400)
• Remote ultrasound diagnostic device (KR1634588)	• Testing device capable of installing and collecting swabs and a specimen collection method using the same (KR2020-0130537)
• Remote respiratory sample collecting apparatus driven with multiple degree of freedom (KR2020-0047976)	• Hand-held specimen collection device (KR2020-0116660)

KNOW-HOW	
• Parallel robot design and manufacturing technology for multiple	• Remote force sensing and patient monitoring technology
• Real-time remote control technology of robot	• CODEC technology for remote robot control in web/mobile environment



# Robotic Ankle-Foot Prosthesis for Lower-limb Amputees

▶ Department of Medical Assistant Robot ▶ Researcher: Hyun Soo Woo ▶ Contact: +82-53-670-9019

Technology Overview

- This technology is the world's first robotic ankle-foot prosthesis that satisfies 1.4 kg for weight, 150Nm for ankle joint torque, and 30 degrees for ankle joint angle while costing only 1/3 of existing robotic ankle-foot prosthesis, which allows for securing high product competitiveness

Customer / Market

- Hospital/rehabilitation institute/medical device manufacturer

Problems of Existing Technology or Necessity of this Technology

- Early commercial prosthetic legs were developed from the aesthetic purposes to replace the amputated part. Now, prosthetic legs that play a core role from functional aspects—allowing for natural gait, while avoiding excessive metabolism to use—are being developed and supplied.
- However, for natural gait, sufficient torque for push-off needs to be generated. Yet existing prosthetic leg was light but could not generate a great torque or generates sufficient torque but heavy in weight and has a long length that it could only be used by a patient who could fit it.
- Therefore, to allow more amputees to use the leg, a lighter, shorter robotic ankle-foot prosthesis that generates sufficient torques for natural gait needs to be developed.

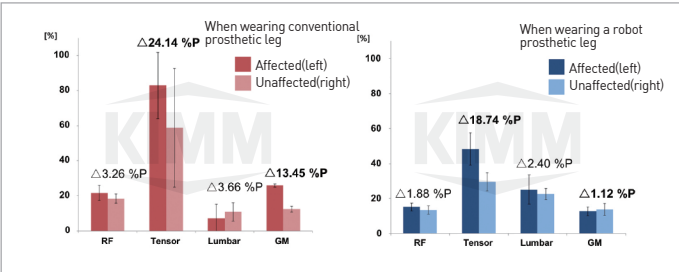
Technical Distinctiveness

- Successful development of a robotic ankle-foot prosthesis that fulfills the world's top level of weight and ankle movement (1.4 kg, 150 Nm, 30°)
- The weight of adult foot is about 2 kg, but a robotic ankle-foot prosthesis has heavy components around the ankle due to its structural characteristics, and the user may feel unnatural, so the main goal was to achieve 1.4 kg for the weight. Advanced global institutions have failed to meet both the weight and ankle movement requirements. Even the world's leading organizations are not satisfied with the weight and ankle movement function at the same time.
- Proprio from Össur is light weighted (1.4 kg) but only has ankle angle control function. BioM from BionX generates enough push-off torque when it kicks the ground, but the weight is heavier due to additional mechanism (1.8 kg).

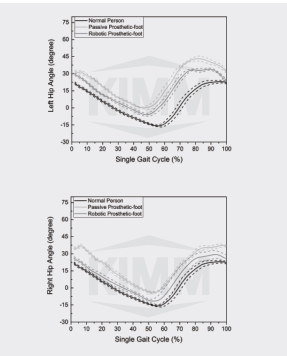
Excellence of Technology

- The world's top-level gait cycle detection rate (90%) was achieved by establishing a gait analysis device for generating a customized gait model and securing the gait model generation technology
- Cooperating with a medical institution, an empirical test was conducted with actual patients, and it was quantitatively verified that the patients were able to walk more naturally with the newly developed robotic ankle-foot prosthesis.
  - It was verified that muscular activity from all measured muscles except for lumbar was reduced while using the robotic ankle-foot prosthesis.
  - It seems the active movement of the robotic ankle-foot prosthesis has assisted movement of affected muscles.
  - The difference in the left and right muscular activity in all observed muscles decreased (5% in average)

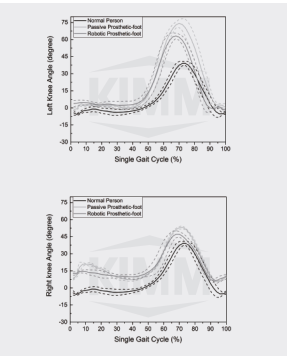
Comparison of Left and Right Muscular Activity for Wearing the Existing Prosthetic Foot and the Robotic Ankle-foot Prosthesis



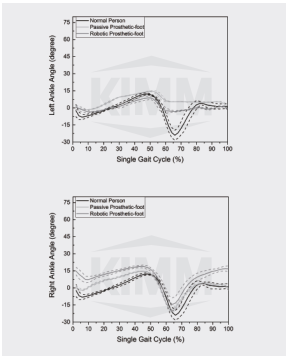
- Comparison of joint angle movement between normal person vs. passive prosthetic foot vs. robotic ankle-foot prosthesis
  - Comparison of the change in the angle of coxa, knee and ankle for one step
  - The graphs show the joint movement of affected leg (left) and normal leg (right).
  - All joints' movement became closer to the movement of normal person's leg when using a robotic ankle-foot prosthesis.
  - For the normal leg, the joint movement became closer to that of a normal person when a robotic ankle-foot prosthesis was worn on the affected leg.



〈 Comparison of Coxa Movement between Normal Person, Passive Prosthetic Foot, and Robotic Ankle-foot Prosthesis 〉



〈 Comparison of Knee Joint Movements between Normal Person, Passive Prosthetic Foot, and Robotic Ankle-foot Prosthesis 〉



〈 Comparison of Ankle Joint Movements between Normal Person, Passive Prosthetic Foot, and Robotic Ankle-foot Prosthesis 〉

- (July 2018) Hugo Dynamics was established as a research institute for commercialization of robot prostheses.
- (December 2020) Ministry of Patriots and Veterans Affairs conducted a pilot project for distributing robot prostheses for people with national merit.

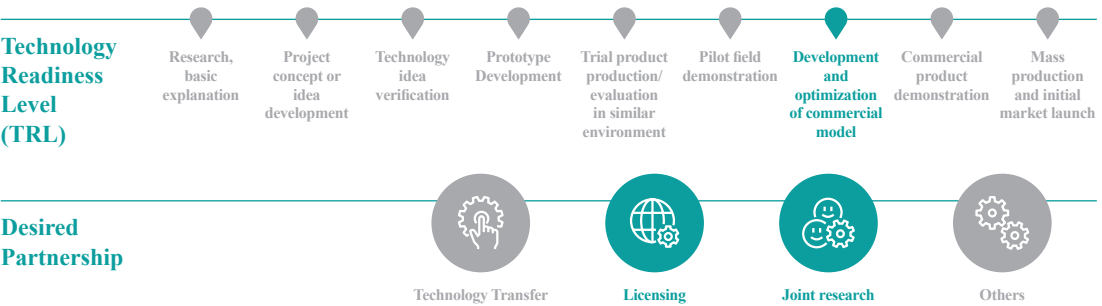
Current Intellectual Property Right Status

PATENT

- Joint Driving Module and Compliant Type Robot Artificial Ankle (KR1793141)

KNOW-HOW

- Gait analysis technology using 3D motion capture system
- Gait model generation technology
- Precision motor control technology for gait model realization
- Embedded controller/driver design technology





# Smart Workout Equipment and Exercise Managing Platforms for Home Gym & Fitness Centers

▶ Department of Medical Assistant Robot   ▶ Researcher: Yongkoo Lee   ▶ Contact: +82-53-670-9021

Technology Overview

- Machine ICT convergence smart workout equipment and customized exercise management platform technology



Customer / Market

- General public, rehabilitation patients, sports equipment companies, neighborhood sports facilities, schools, hospitals, sanatoriums, etc.

Problems of Existing Technology or Necessity of this Technology

- With the transition to a non-face-to-face era due to the prolonged COVID-19 pandemic, the possibility of continuous outbreaks of new diseases, and the intensification of environmental pollution, activities such as outdoor or indoor sports facilities have decreased, and there is growing demand for home exercises and minimal or non-face-to-face coaching.
- When working out in gyms or rehabilitation facilities, a trainer or an instructor may instruct and manually record their exercise, but in most cases, individuals have difficulty systematically managing their work out as they arbitrarily select the type and amount of exercise without planning out.
- It is difficult to record how and how much a patient with an exercise prescription exercised properly.
- High-priced automatic exercise equipment with a kinesimeter are being released, but due to inconvenient use and a high price, they are not supplied to general sports facilities.
- Work out devices linked with video games can motivate people to continuously work out; such devices are mostly imported, and there is an urgent need to localize.

Technical Distinctiveness

- At a low cost, a systematic and precise exercise management is possible.
- The public and professional athletes and patients needing remedial exercise can exercise with a systematic exercise prescription and treatment at a community sports facility.
- The records of exercise can be used as motivation.
- This device can be attached to an existing sports equipment when needed.

- By linking with the member management system, the members can check their exercise history online on their own and receive additional coaching.
- Can be provided with a customized exercise coaching program from professionals all over the world
- Professionals, as supplier of exercise coaching programs, can establish reputation and promote their business and related products.
- Extensive data on exercise programs by race, age, stamina, body type, medical history and sports and the actual result of exercise performance can be used for academic, commercial purposes.
- Most of existing automatic kinesimeters are built inside the sports equipment, but this technology allows the device to be attached on various equipment to utilize existing infrastructure.
- There are many kinesimeters for aerobic exercises using u-health technology, but there are barely any kinesimeters for machine exercises.

Excellence of Technology

- We have developed a sensor module and a wireless transmission module that can be applied to both autonomous weight exercise equipment and machine exercise equipment such as exercise mats, iron bars, and dumbbells that detect various movements, as well as a smartphone app and a customized exercise management platform that can operate them.
- Verified the accuracy of the sensor module using the precision measurement equipment, and through the demonstration, successfully conducted an experiment of checking the prescription and execution of exercise real-time



< Dip Bar Exercise (Example) >   < Tension Meter for Indoor Swimming (Example) >   < Real-time Monitoring with Application >

Current Intellectual Property Right Status

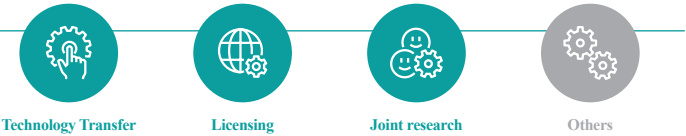
PATENT

- Rehabilitation Exercise Managing System and Managing Method Using the Same (KR1510088)
- Online Information System for Therapeutic Exercise (KR1570984)
- Barbell Exercise Measuring Device (KR1551343)
- Barbell for Managing Quantity of Exercise and Exercise Managing System Having the Same (KR1629723)
- Tension Measuring Apparatus (KR1673146)
- Tension Measuring Apparatus (KR1719573)
- Device for Discriminating Dumbbell Exercise and a Method by Using the Same (KR1719572)
- Lower body exercise apparatus (K1768999)
- Apparatus for exercising lower body (K1817790)
- Swimming training device (1864245)
- Multi-exercising apparatus for a lower body (K2003720)
- Apparatus for measuring movement angle of joint (K1913618)
- Elastic device capable of controlling stiffness (K1967160)

Technology Readiness Level (TRL)

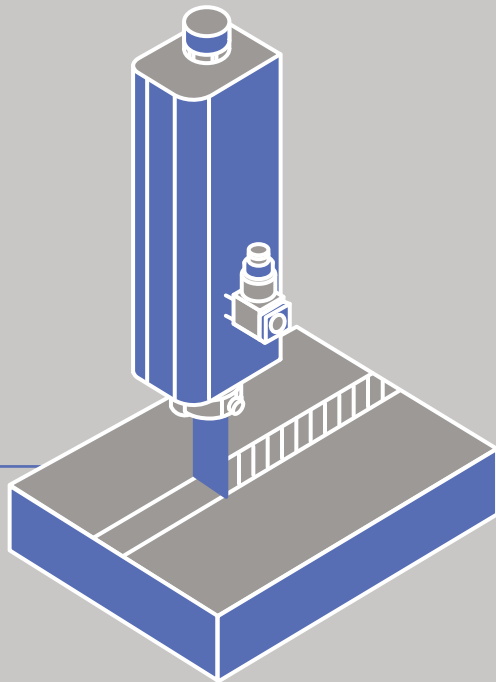


Desired Partnership



7

Busan Machinery  
Research Center



SURFACE HARDENING  
AND HOMOGENIZATION  
TECHNOLOGY FOR  
METALLIC MATERIALS USING  
HIGH-POWER DIODE LASERS

376 • Laser Industrial Technology Research Group

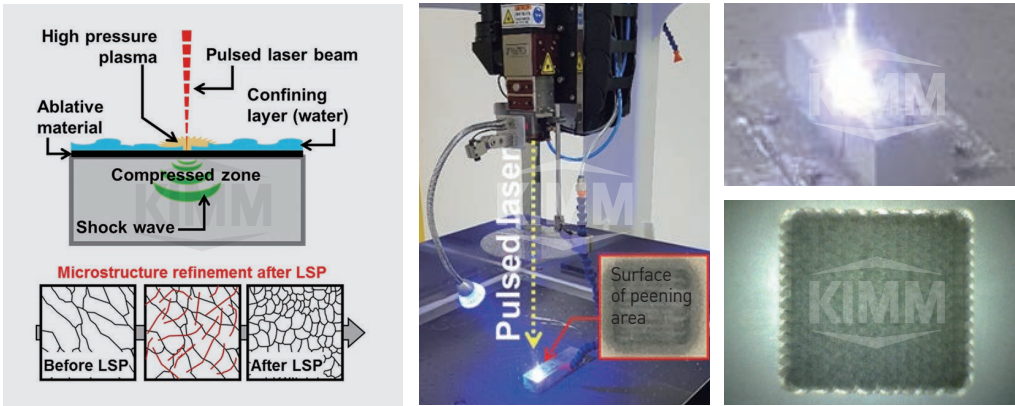
KOREA  
INSTITUTE OF  
MACHINERY &  
MATERIALS

# Laser Shock Peening Technology for Surface Hardening and Residual Stress Control for Metallic Materials

▶ Laser Industrial Technology Research Group   ▶ Researchers: Ryoochan Kim, Sujin Lee   ▶ Contact: +82-51-310-8133

Technology Overview

- Laser shock peening technology: A technology that irradiates pulse laser to form a compressive residual stress and a hardened layer several millimeters deep on the surface of a metallic material
- Laser shock peening improves fatigue performance, abrasion resistance and corrosion resistance of high-precision component used in shipbuilding/offshore, automobile, and plants  
→ Improve durability and service life of corresponding component



〈Principle and Process of Laser Shock Peening〉

Customer / Market

- High durability and high precision metal machine parts in defense, automobile and plant industries
- In the case of the U.S. Air Force, the application of laser shock peening technology reduces annual replacement cost of fighter parts by KRW 70 billion.

Problems of Existing Technology or Necessity of this Technology

- The center's laser shock peening technology is a local plastic processing technology that can also control residual
- It can replace the shot peening technology and at the same time achieve the best effect among the peening technologies developed so far.
- As a promising technology that can be applied to the maintenance of nuclear reactors in extreme environments, it is necessary for long-term safe operation of nuclear power plants
- It is possible to reduce operating costs by improving the lifespan of high value-added products and parts.

Technical Distinctiveness

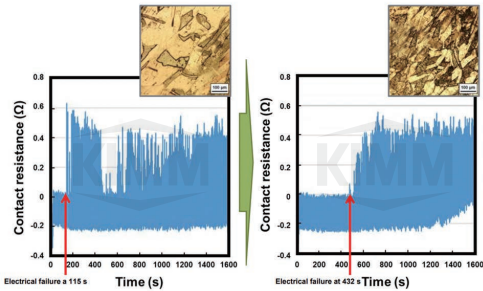
- KIMM BUSAN MACHINERY RESEARCH CENTER has the laser shock peening technology and its system that can be connected with the robot and stage modes.
- Possible to cover from basic research for the application of laser shock peening technology to production and development of mid- to large-scale prototypes
- Possible to provide preliminary test for surface reformation and evaluate the applicability of actual parts before mass production using the center's laser shock peening device.
- The only one in Korea that can perform laser shock peening process with maximum output energy of 7 J



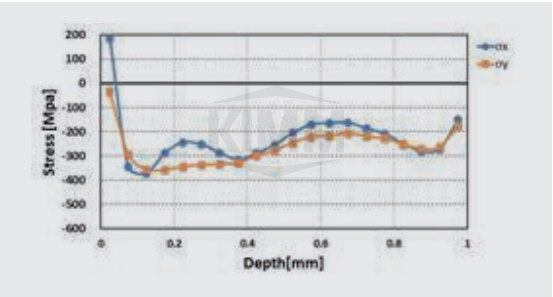
〈Laser Shock Peening System of KIMM〉

Excellence of Technology

- As a result of a laser shock peening test on copper alloy and stainless steel, 150 to 200% of metal structure refinement and wear resistance improvement can be achieved
- Almost no deformation of the material surface compared to the conventional shot peening technology



〈Example of Improvement in Abrasion Resistance for Copper Alloy by Laser Shock Peening〉



〈Residual Stress Distribution According to Depth for SS304 Material〉

Current Intellectual Property Right Status

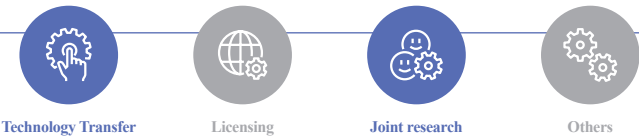
KNOW-HOW

- Core technology of laser shock peening system development
- Laser shock peening element technology for each applied material
- Peening section analysis and evaluation technology

Technology Readiness Level (TRL)



Desired Partnership



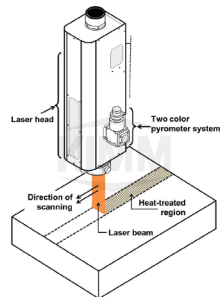


# Surface Hardening and Homogenization Technology for Metallic Materials Using High-power Diode Lasers

▶ Laser Industrial Technology Research Group   ▶ Researchers: Ryoohan Kim, Sujin Lee   ▶ Contact: +82-51-310-8133

Technology Overview

- A technology that irradiates a large-area diode laser of 20 to 2,500 mm2 to form selective hardening and homogenization layer several millimeters deep on the surface of a metallic material.
- Real-time laser power control technology of the optimum temperature and selective surface treatment technology for material laser heat treatment.



◁ Example of Heat Treatment Technology of Metallic Material Using Large-area Diode Laser for Mold Steel Application ▷

Customer / Market

- Inderstries related to the infrastructure of manufacturing businesses, such as casting and molding.
- Root industries of mold and injection molding

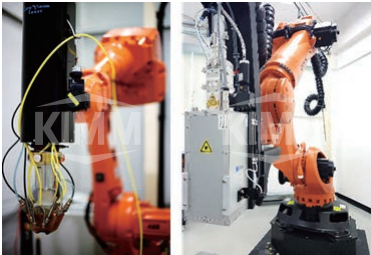
Problems of Existing Technology or Necessity of this Technology

- Unlike existing technology that performs heat treatment on the entire product, this technology can set the temperature section for customized heat treatment of the product, enabling selective hardening and homogenization of molds and injection molding.
- It is possible to maximize the mold's durability and economic feasibility by increasing the life (e.g. casting mold, automobile exterior plate mold)

Technical Distinctiveness

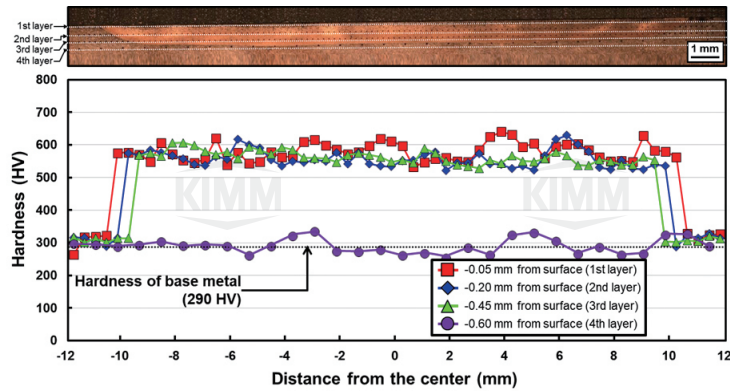
- KIMM Busan Machinery Research Center has a high-power (4, 8 kW) diode laser system together with key processing technologies of laser surface hardening and homogenization
- Possible to cover from basic research for the application of diode laser heat treatment technology to production and development of mid- to large-scale prototypes

◁ High-Power Diode Laser System of KIMM ▷



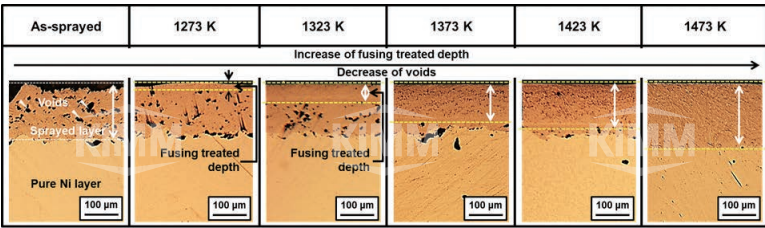
Excellence of Technology

- As a result of diode laser heat treatment test on mold steel, a 200% improvement in hardness can be achieved.



◁ Surface Hardening of Mold Steel by Diode Laser Heat Treatment Technology ▷

- In laser homogenization treatment for HVOF sprayed coating, it is confirmed that inherent defects (pore, macrosegregation) are removed as compared with the assprayed



◁ Defect Control of HVOF Sprayed Coating with Diode Laser Homogenization Technology ▷

Current Intellectual Property Right Status

PATENT

- Continuous Casting Mold, Method for Manufacturing of Continuous Casting Mold by Laser Assisted Heat Treatment, and Method for Coating Thermal Sprayed Layer by Laser Assisted Heat Treatment (KR2107127)

KNOW-HOW

- Technology to establish large-area (20 to 2,500 mm2) diode laser system
- Laser heat treatment core technology for each applied material
- Heat-treated part analysis and evaluation technology

