2016 International Forum Korea on
Advances in Mechanical Engineering

The R&D Prospects of Additive Manufacturing (AM) Technology at MIRDC

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August 18, 2016

Outline

1. What is MIRDC
2. AM Focus
3. MIRDC Strategy
4. Prospects

What is MIRDC…

Introduction

Profiles:

-Established in 1963.

-Employees: ~850 persons.

-Yearly industrial service: 700+ projects

-Yearly Training services: 17,000+ persons

-Verification & certification: 18,000+ cases

Core Technologies:

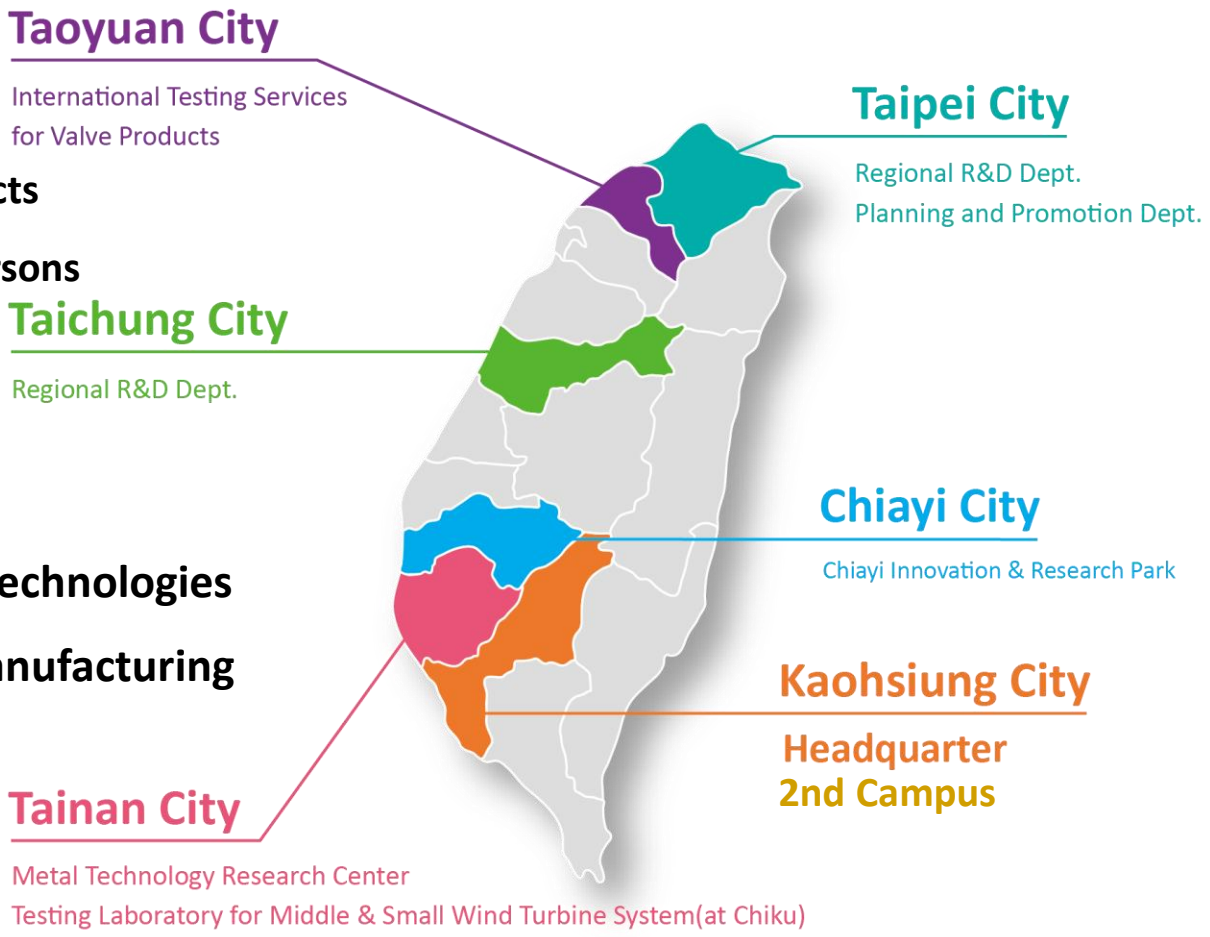
-Primary/Secondary processing technologies

-Rapid production/Intelligent Manufacturing

-Micro & Meso manufacturing

-Lightweight technologies

-...



Headquarter in Kaohsiung and 9 Branches in 6 Cities

Missions

Upgrading Competitiveness of Taiwan Metal Industry

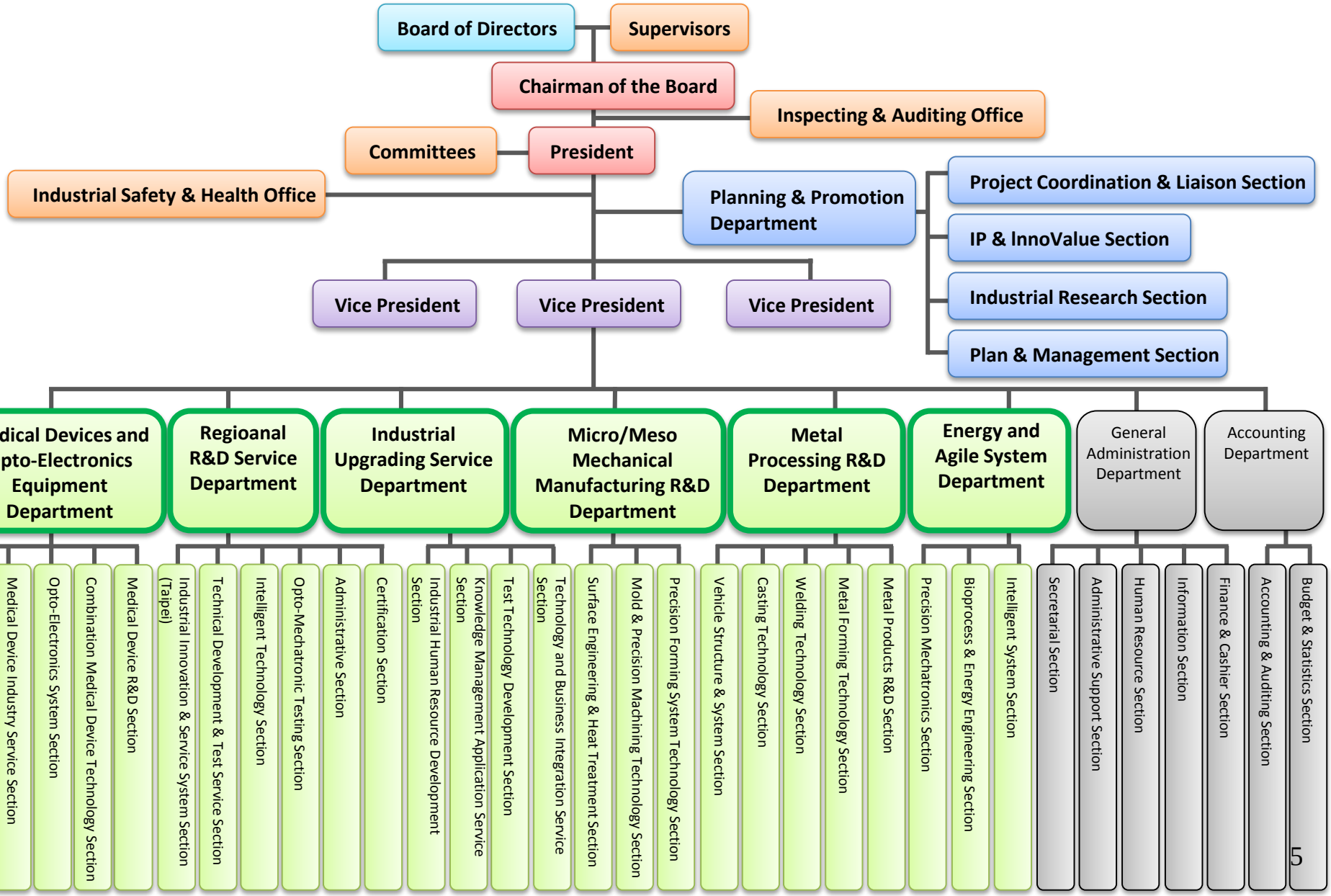
R&D Missions

- Advanced Technologies & Key Components / Modules
- Effective Process Design
- Establishing core laboratories

Industrial Strategy

- Collaborating with industrial, academic and research sectors
- International cooperation
- Industrial clusters
- Technologies transferring

Organization



6 R&D Fields

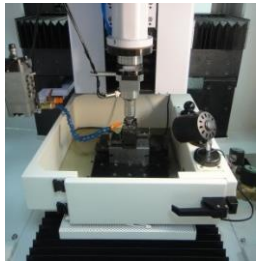
- ✓ Aesthetics of Technology
- ✓ Eco-friendly processing technology…

- ✓Alloy Design and Casting
- ✓Ingot, Rod, Wire, Powder…

Industrial Application Fields

- Metal-Based Products
- Mold & Die / Micro Machining
- Medical Devices & Care
- Automotive
- High Value-Added Equipment
- Integration Platform

- ✓ Precision molds and components
- ✓ Advanced micro processing technology...



Testing and certification of equipment for:

- ✓ Energy industry
- ✓ Optoelectronics industry…

- ✓ Dental and orthopedic implants
- ✓ Minimally invasive surgery system...

- ✓ Lightweight materials
- ✓ Chassis design and certification…

AM Focus…

Government Policies and Industrial Needs

Government Policies

- Executive Yuan
  Taiwan Productivity 4.0 Initiative
- Ministry of Economic Affairs
  Higher added-value of product

Industrial Needs

- Innovation for product
- Upgrading of industry
- Improve flexibility in manufacturing
- …

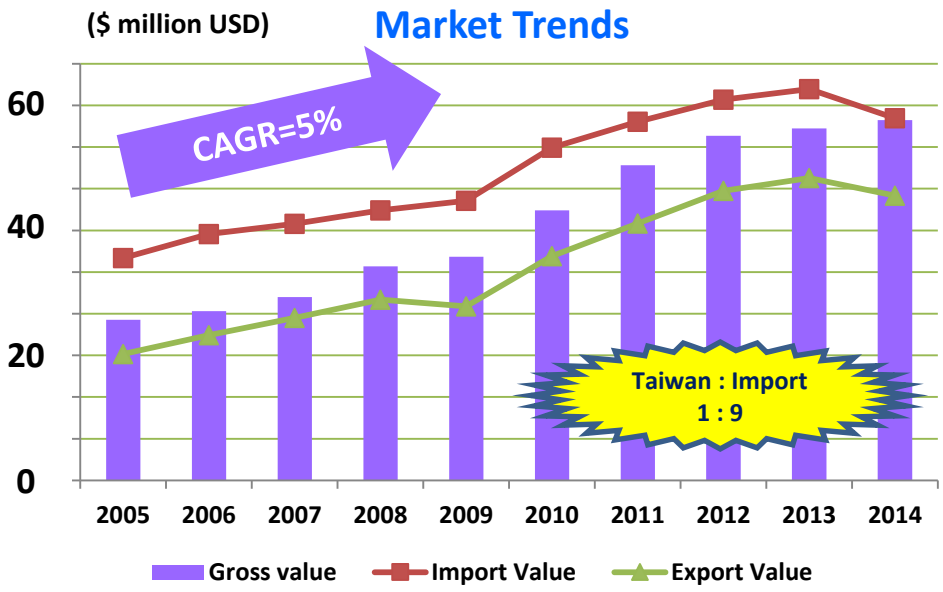
Opportunity

✓ Additive manufacturing
- Digital manufacturing
- Small amount of diversity
- Customization…

MIRDC

- The Only R&D center focuses on metal related technologies in Taiwan.
- R&D of metal AM technology is our responsibility and mission.

Needs: Medical Industry Case

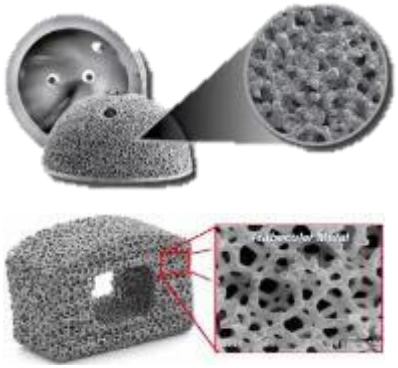


Objectives

- ✓ Increase export value
- ✓ Decrease import dependency

Examples

- ✓ Hip cup
- ✓ Cage
- ✓ Shoulder Joint
- ✓ …



Status

- ◆ High dependence to import
- ◆ Mainly focused on low-to-medium valued products
- ◆ Demand increased due to aging population
- ◆ A variety of medical devices

Opportunities

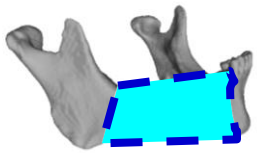
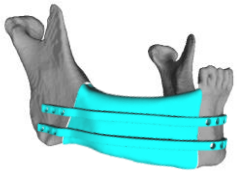
- ✓ High growth rate of markets
- ✓ Expectable value growth of AM medical devices
- ✓ Medical industry cluster booming
- ✓ Customized/complex structure devices by clusters jointed with hospitals/research institute

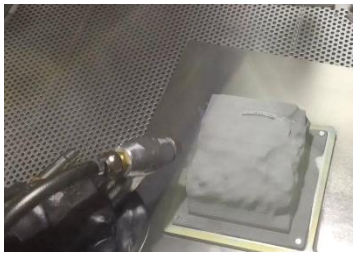
【Rapid Customization of Mandible Implant】

Quick response to the customized needs of the hospital

Current conditions and requirements

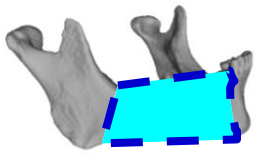
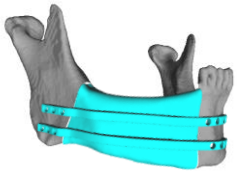
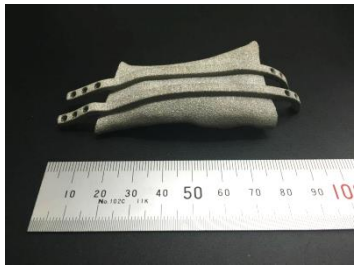
- ◆The **materials loss rate** of traditional manufacturing process is **very high** (~80%)
- ◆**Hard to machine** such kind of complex shape products (Ti64 alloys)
- ◆Traditional manufacturing process **takes long time** and **hard to fit the surgery schedule** of hospital (3.5-4 working days)

Traditional manufacturing process

Patient Information → Design → Raw Materials → 5 Axis Machining → Surface Roughening


Mandible Implant

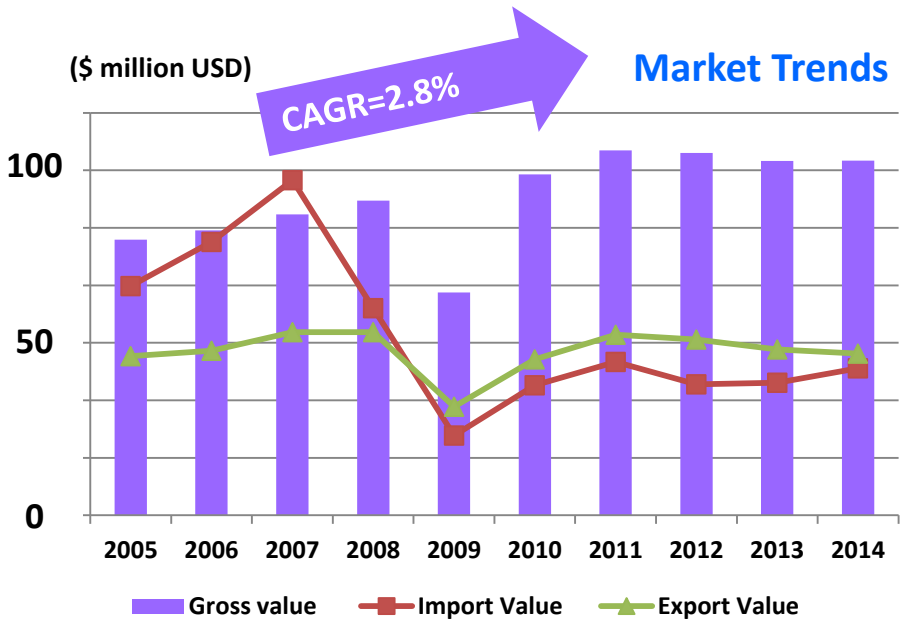
Implementation of Electron Beam Additive Manufacturing process

Patient Information → Design → EBAM

Integrated forming process for complex shape product

- ◆Improve materials **loss rate** (from ~80% to ~10%)
- ◆Lower **cost** (from 1500-2500 to 300-500 USD/pcs)
- ◆Shorten **delivery time** (from 3.5-4 to 1-1.5 working days)

Needs: Foundry Industry Case



- ✓Enhance productivity
- ✓Increase value of casting products
- ✓Incentive to work in Casting industry

Productivity 4.0
- Automation
- Intelligence
- AM

3K Casting
- Dangerous (危険/Kiken)
- Dirty (汚い/Kitanai)
- Difficult (きつい/Kitsui)

4C Casting
- Clean
- Career
- Competitive
- Creative

Status

- ◆Over 89% are small companies (No. of employees ≦70)
- ◆Shortage of experienced manpower
- ◆Needs of rapid response and flexibility in manufacturing

Opportunities

- ✓Urgent to industry upgrading
- ✓Complete supply chain from materials, processes, to end users, including surrounding supportive equipments, mold & die, and software.
- ✓Equipped with the rapid and flexibility production of SMEs.

【Maintenance and Replacement of Impeller】

Conformal Air Escape Molding Application (1st case in Taiwan)

Current conditions and requirements

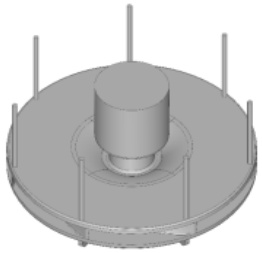
- The cost of “Lost wax precision casting" mold is high
- The 3 mm thin-wall curved blades of enclosed impeller will generate air back pressure under normal atmosphere and results in the defect of insufficient filling
- Traditional impellers and sand cores require combinative sand core molds, which are of high cost and poor combination precision

Traditional manufacturing process

Case Design
Air escape channels at the top of mold

Sand Core Molds
Multi-pieces combination

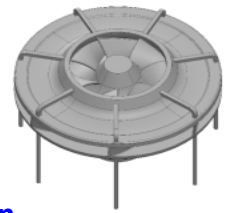
Trial molding
Air back pressure defects

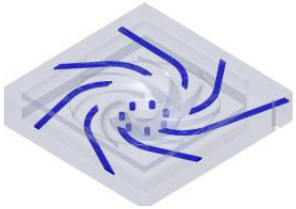


Design Change

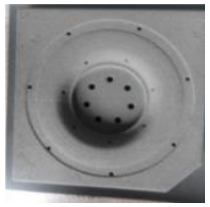
Low Yield Rate

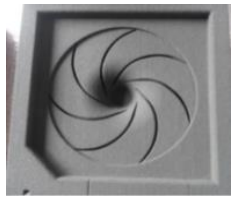
Implementation of 3D printing sand casting process



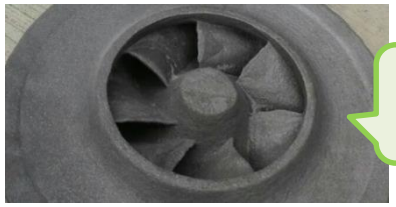


Conformal air escape channel and hollow sand core design





3D printing sand casts and cores



Impeller

Prototyping

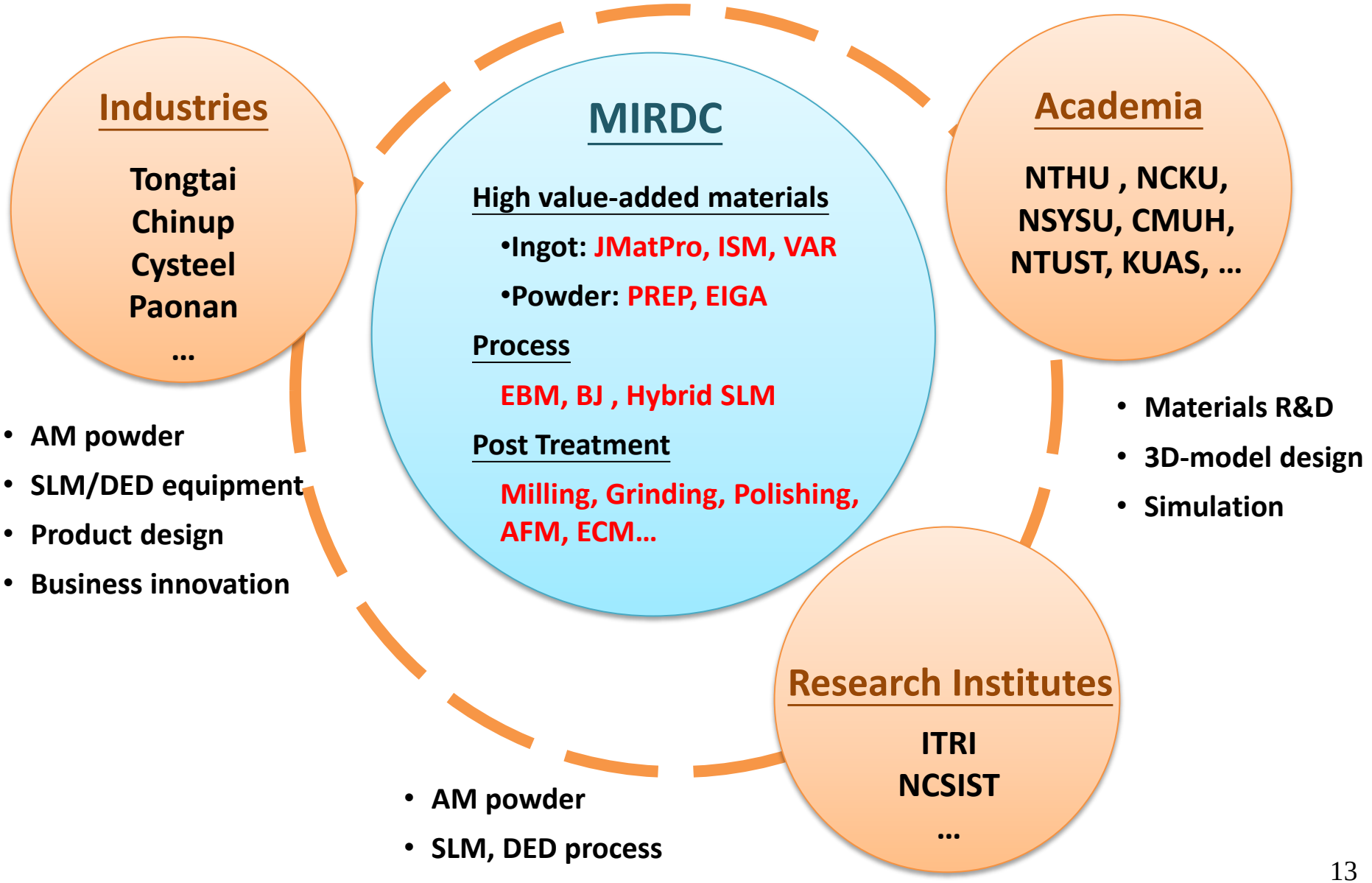
- Conformal air escape channel sand cast design.
- The integrally-formed hollow sand core design could reduce the vapor generation from the heating of resin in the sand core.

Benefit

(1)Reduce the cost by 20%

(2)Improve product yield rate by more than 10%.

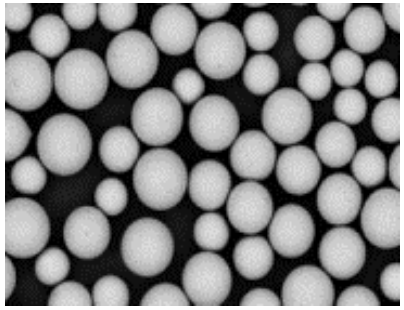
Fill the Gap of AM Supply Chain in Taiwan



Recently Results

Materials





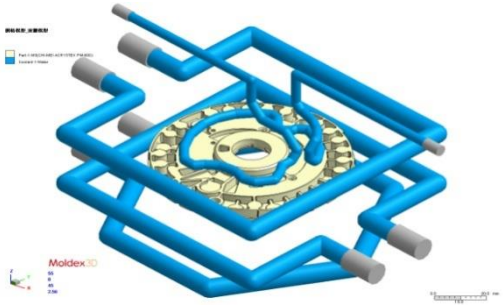
Niche alloy/rod/wire/powder (nitinol…) meet the ASTM biomaterials standards

AM Process

Medical
Industry

Hip Cup
EBM
(Ti64-ELI)

Mold & Die
Industry



Conformal Cooling Channel
Hybrid SLM
(SUS420J2)

Vehicle
Industry

Clutch Housing
BJ (casting mold)
(A356)

MIRDC's Strategy…

Facilities related to AM

AM Materials

(Powder, wire, …)

Phase Diagram Simulation (JMatPro)

Alloy Design & Melting

Prealloy & Wire

Powder Plasma Rotating Electrode Process (PREP)

Powder Electrode Induction Gas Atomization (EIGA)

Additive Manufacturing

(PBF, DED, BJ, …)

Electron Beam Melting (EBM)

Binder Jetting (BJ)

Hybrid Selective Laser Melting (Hybrid SLM)

Wire-Arc DED

Powder DED

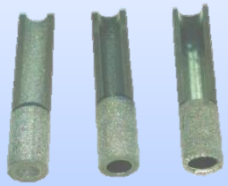
Direct Energy Deposition

Post Treatment & Certification

(Inner & outer surface, Materials analysis, …)

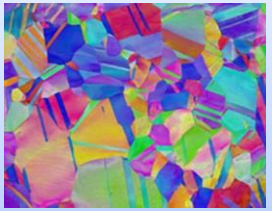
Ultra Sonic Machining

5-Axis Milling



Abrasive Fluid Machining (AFM)

Testing of Materials or Products



Microstructure Analysis

International R&D Cooperation

- Joint Laboratory
- Joint Project
- Exchange Researchers

Sweden
- Stockholm University
- Arcam AB
- AKERS

Germany
- Deisig Design
- Chemnitz University of Technology

England
- University of Strathclyde
- Heriot-Watt University

Unite State
- Georgia Tech
- Michigan University
- ITI
- ALTAIR
- COSMA
- ALLWAVE

Norway
- SINTEF

Finland
- VTT

Russia
- MSU Science Park
- Zelenograd SEZ

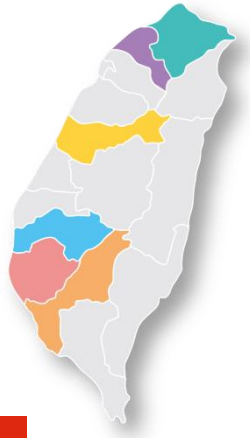
France
- ENISE

Slovakia
- Chirana

Holland
- TNO

Japan
- Tohoku University
- Sodick
- FEI
- TMDU
- NIMS
- JEOL
- ARPAK
- Sagamihara Industrial Creation Centre
- IKC
- DISCO
- BIPC
- ClassNK
- Hers
- JEF
- IHI

Taiwan



Hongkong
- HKPC
- STC

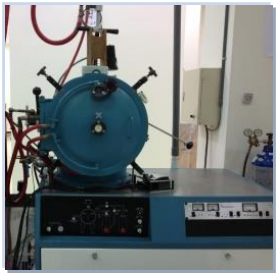
Cooperation Example

MIRDC

TOHOKU University/IMR

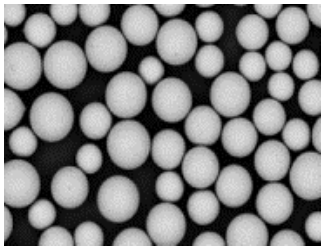
Joint Laboratory

Joint Project/ Exchange Researchers



Nitinol alloy design and melting

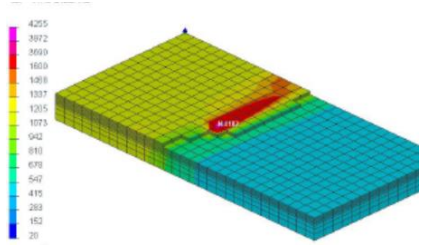
EBM Q10 (for medical device)



Rod/powder meet ASTM biomaterials standards

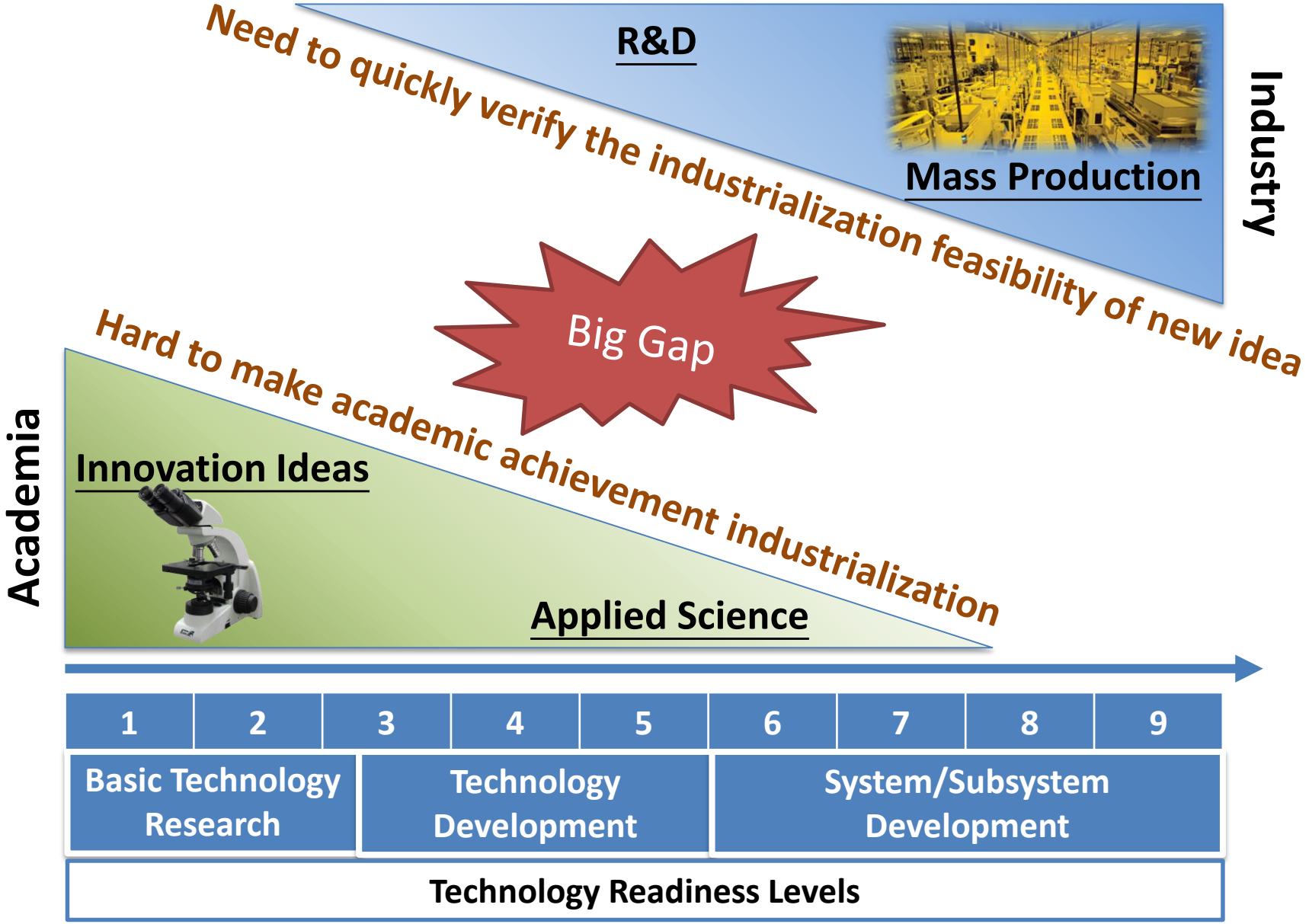
PREP

EBM A2X (for aerospace)

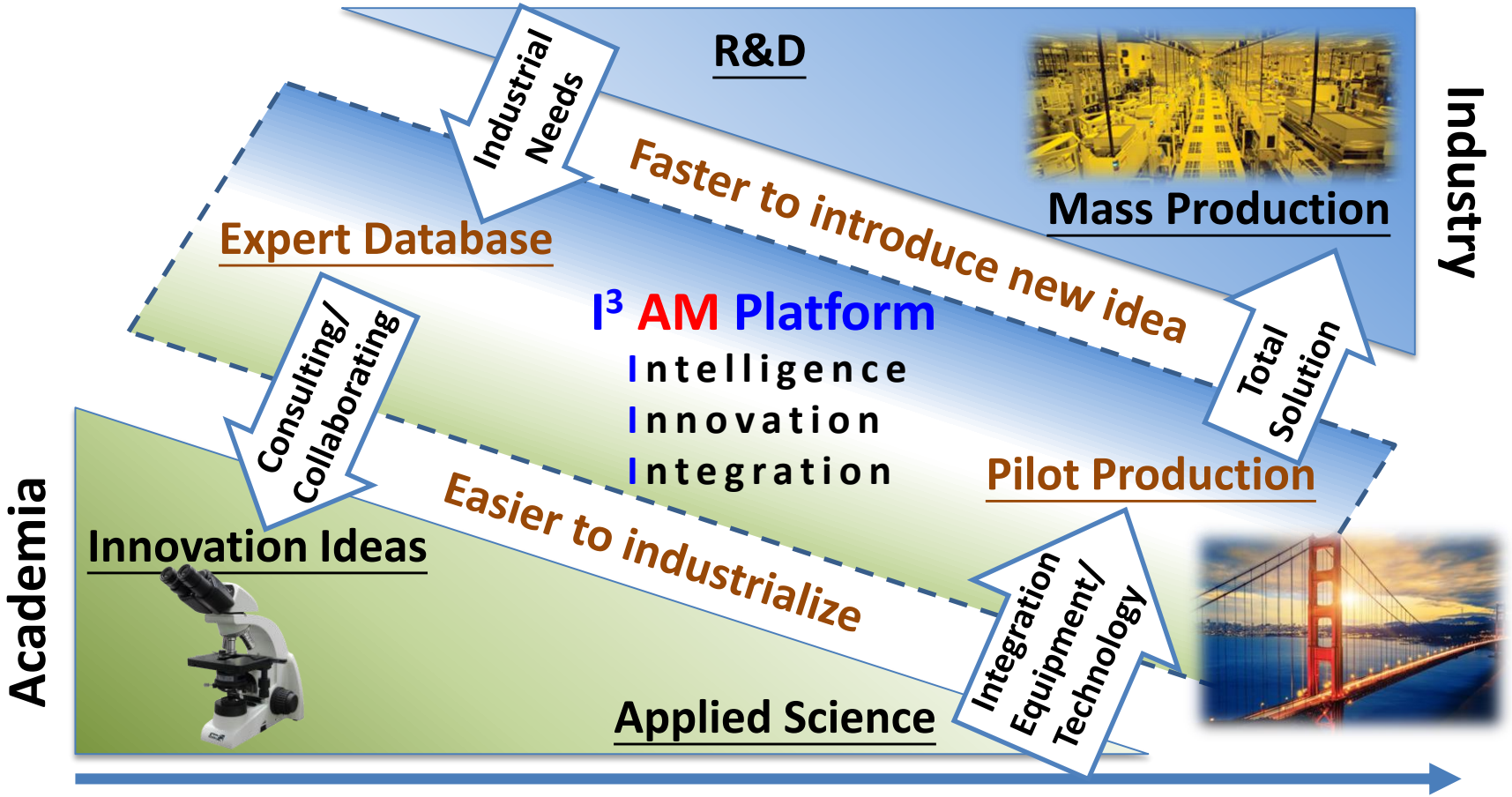


AM process simulation

I³ AM Platform

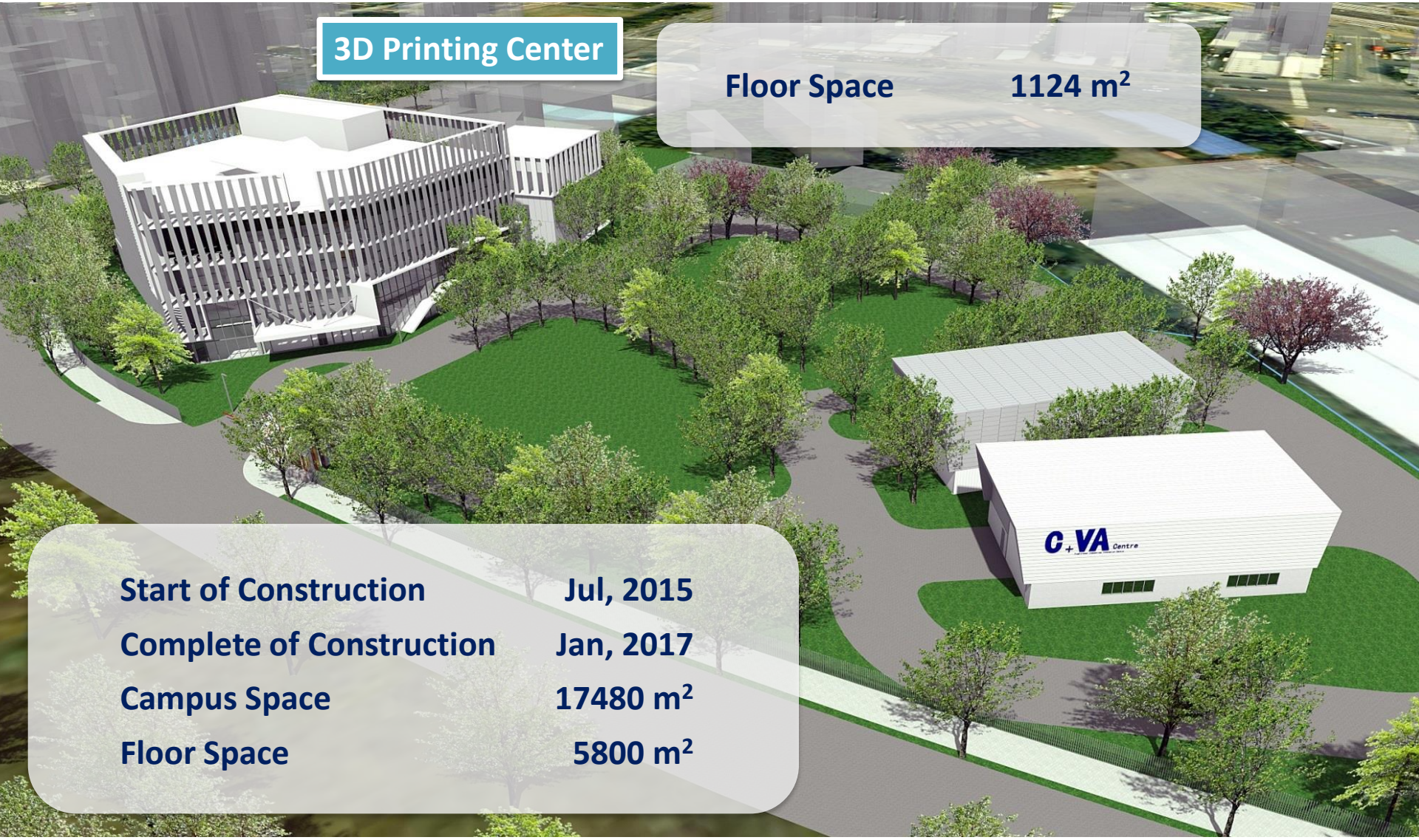


I³ AM Platform



Prospects…

Research Campus for AM (2017)



Prospects

- BECOME A KEY PLAYER OF AM TECHNOLOGY INNOVATION IN TAIWAN
- ORGANIZE "I^3 AM PLATFORM" AND ACHIEVE INTEGRATION SYNERGY

R&D

- ✓ Materials
- ✓ AM Process
- ✓ Post Treatment

R&Connection

- ✓ Connecting industry, academia, and research institute
- ✓ Industries upgrade

R&Solution

- ✓ Consulting
- ✓ Prototyping/ small batch production
- ✓ Education and training
- ✓ Incubation

Thank you for your attention!

金屬工業研究發展中心

Metal Industries Research & Development Center