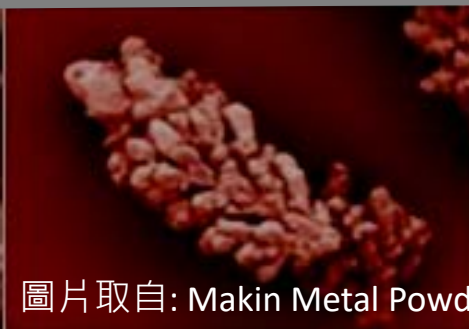
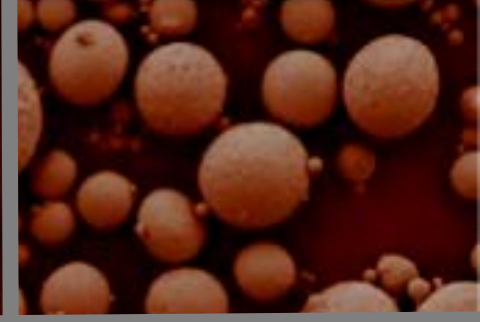
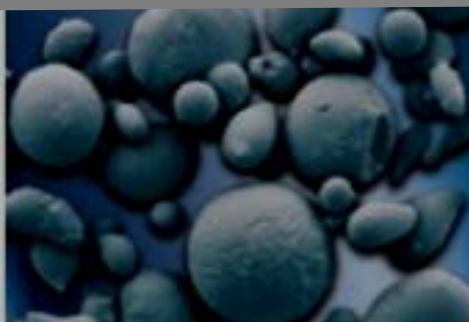
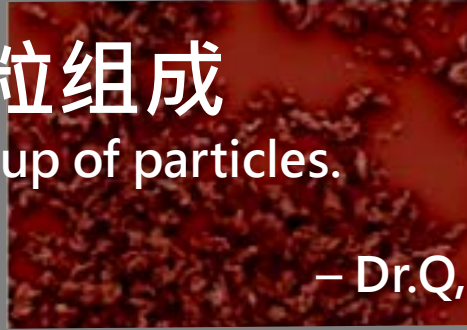


深邃美丽的世界是由颗粒组成

The deep and beautiful world is made up of particles.

– Dr.Q, 17th March, 2017



Expectation of PIMA-CN 2017

聚砂成塔的美丽新世界—粉末成形技术

Many a little makes the new beautiful world – Powder Forming Technology

邱耀弘博士 Dr. Q

PIMA-CN 中国粉末注射成形联盟 轮值主席

ACMT 粉末注射成形与材料科学技术委员会 主任委员

2017.3.17 中国·深圳 V1.9

你无法强握住粉末，但弄湿它后，便可塑出各种形状

You can not hold powder. But when you let it wet, you can shape it in thousands varieties. .

今日内容 Today content

- ✓ 为何选用粉末成形技术?

Why we need Powder Forming Technology

- ✓ 主流粉末成形技术介绍

Major PFT

- ✓ 主要应用

Major applications

- ✓ 展望未来

Looking ahead

为何要采用粉末成形技术？

Why we need powder forming technology ?

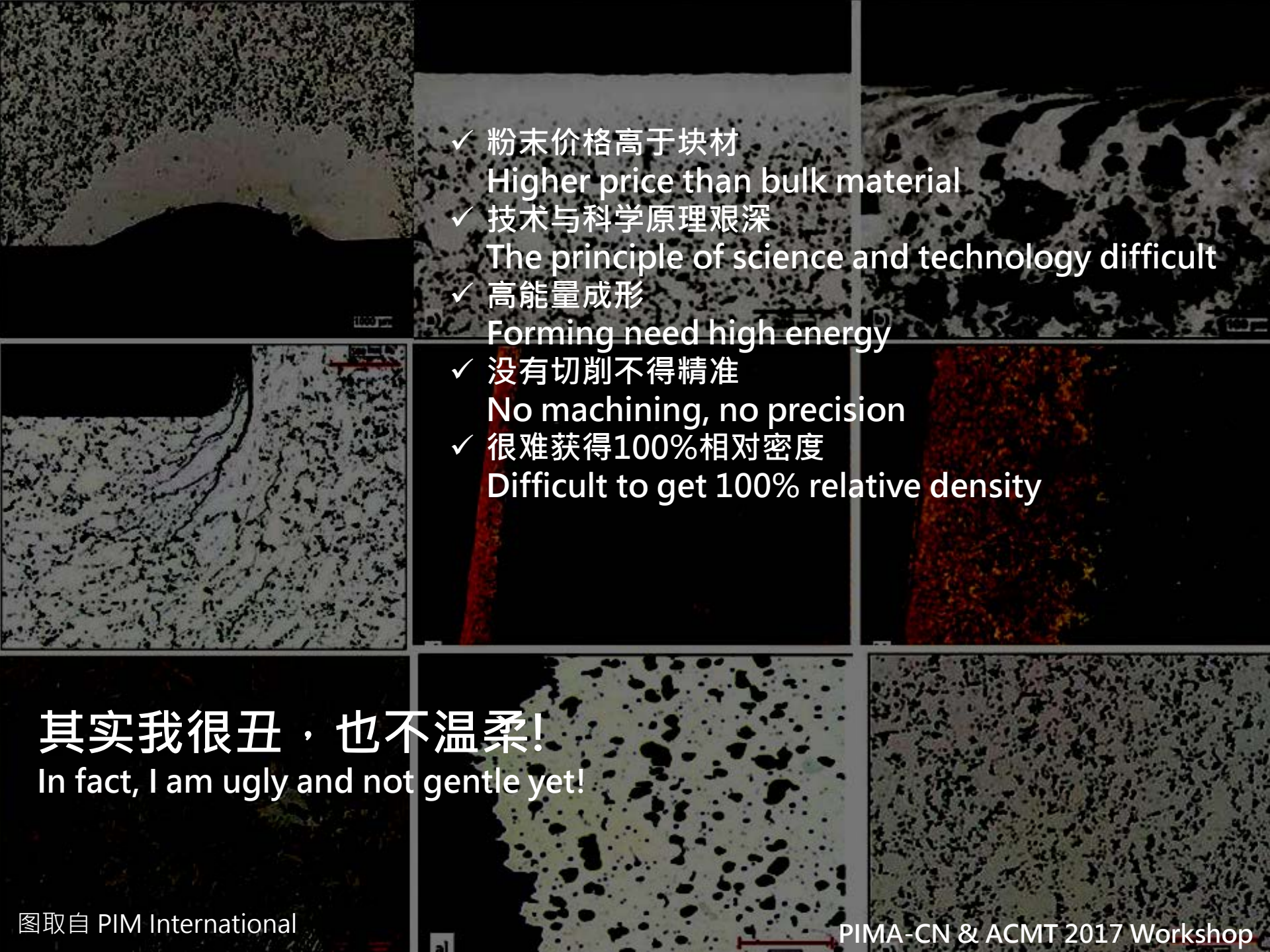
粉末成形技术

Powder forming technology

近流体成形技术

Near fluid forming technology

- ✓ 产品造型自由度高
High freedom of product modeling
- ✓ 材料选择与调配自由度高
High freedom of material selection and deployment
- ✓ 成形压力低，节能低耗
Low forming pressure, energy saving
- ✓ 减少残留应力的变形
Reduction of residual stress
- ✓ 材料利用率高
High material utilization

- 
- The background of the slide is a collage of six micrographs showing different stages and aspects of powder metallurgy. Top-left: A large, irregularly shaped powder particle. Top-right: A sintered surface with large, dark, irregular pores. Middle-left: A cross-section of a sintered part showing a porous interior. Middle-right: A sintered surface with a fine, granular texture. Bottom-left: A sintered surface with a fine, granular texture. Bottom-right: A sintered surface with a fine, granular texture.
- ✓ 粉末价格高于块材
Higher price than bulk material
 - ✓ 技术与科学原理艰深
The principle of science and technology difficult
 - ✓ 高能量成形
Forming need high energy
 - ✓ 没有切削不得精准
No machining, no precision
 - ✓ 很难获得100%相对密度
Difficult to get 100% relative density

其实我很丑，也不温柔！
In fact, I am ugly and not gentle yet!

为什么轻金属粉末不能轻易烧结？

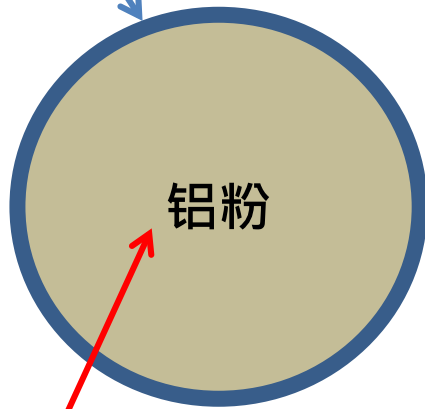
Why light metal powder can not be easily sintered?

举铝粉末为例

Use aluminum powder as an example

三氧化二铝
化学式：Al₂O₃
密度：3.5~3.7 g/c.c.
熔点：2054°C

加镁(Mg)抢氧



铝粉

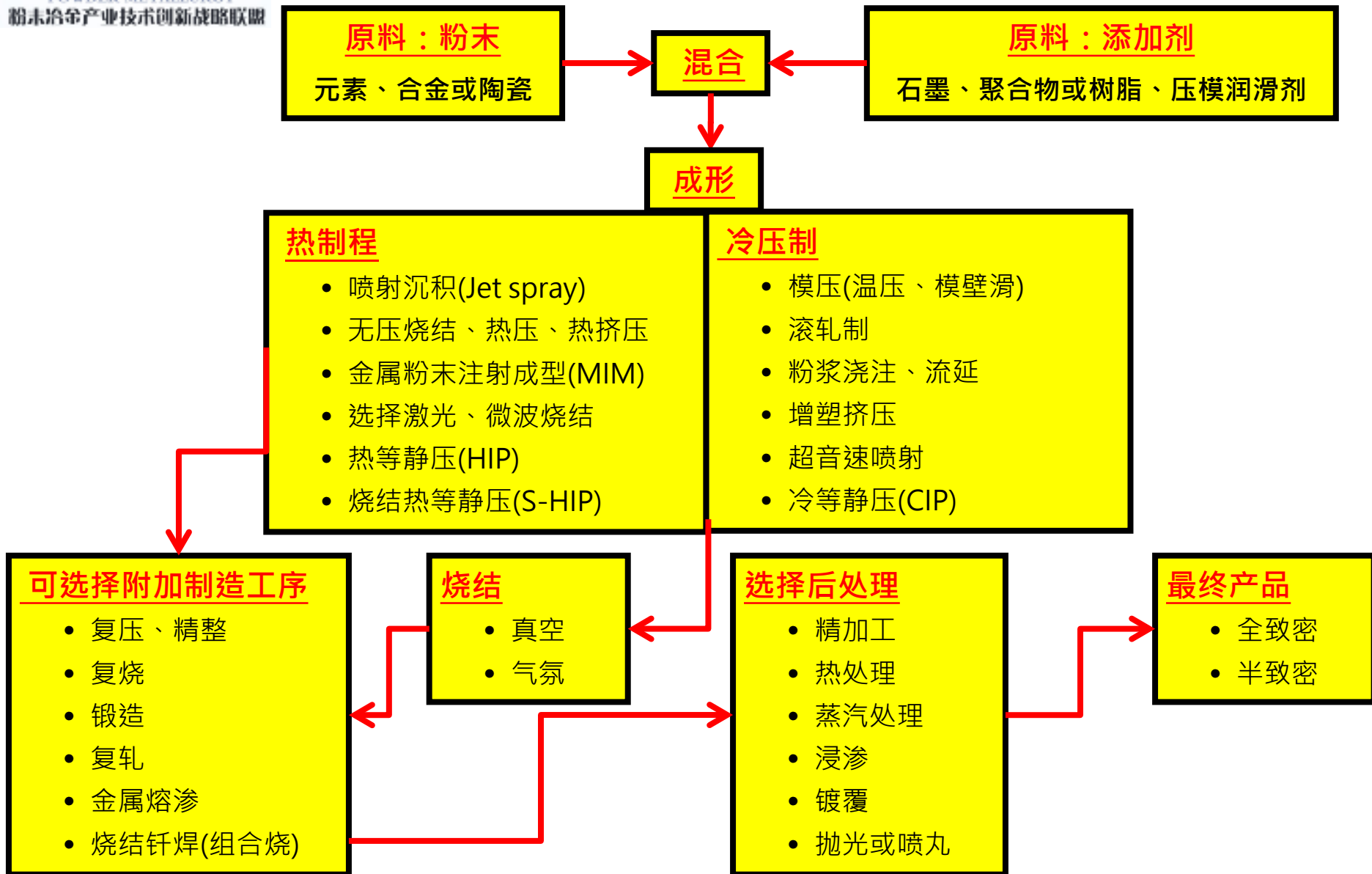
- ✓ 轻金属氧化物的熔点都很高
Light metal oxide with high melting point
- ✓ 金属粉末外面都有一层很厚的氧化层
Each metal powder with a thick layer of oxide
- ✓ 烧结的温度通常是在0.9熔点以下才能维持产品的形状
The sintering temperature is usually under 0.9 Tm in order to maintain the shape of the product
- ✓ 必须付出更多能量，如压力的改变
Pay more energy for sintering, ex. Pressure
- ✓ 添加剂可改善但不符合工业标准
Doping additive but can not fit industry standard

铝
化学式：Al
密度：2.7 g/c.c.
熔点：660°C

轻金属：有色金属密度低于4.5 g/c.c.
有色金属：实际上指的是非铁金属(Nonferrous Metals)，而不是颜色区分

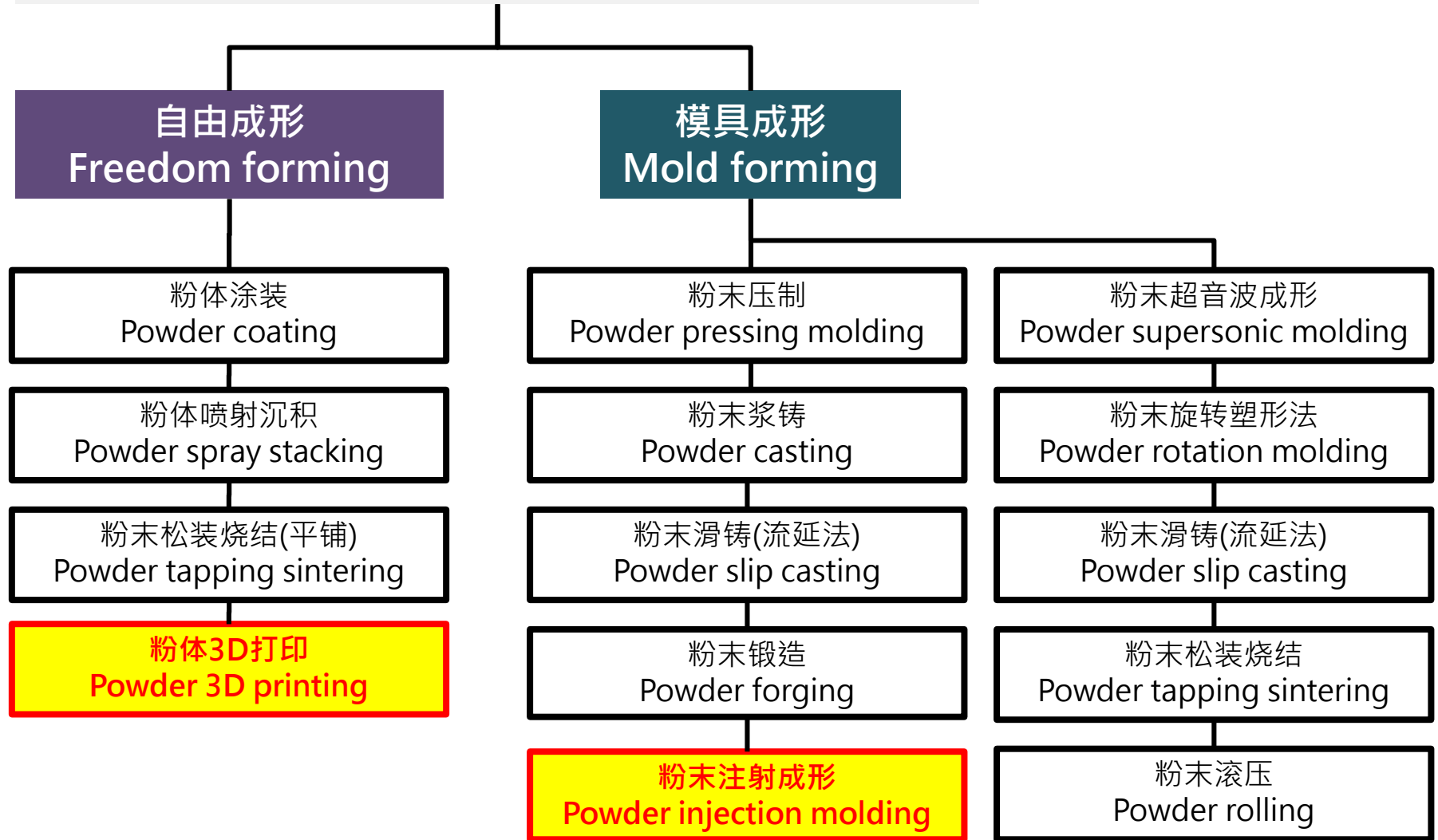
中国官方单位 对粉末成形技术的定义

Define powder forming technology by CPMA



粉末成形技术的主流

Major technology of Powder Forming Technology



目前主流技术: 尺寸的精确度/产出效率/形状设计自由度/ 材料自由度

粉体法占有3D打印技术的大部分

Powder stack is the core method of most 3D printing technology

分类Type	技术Technologies	材料Materials
挤出法 Extrusion	Fused deposition modeling (FDM) or Fused filament fabrication (FFF)	Thermoplastics, eutectic metals, edible materials, Rubbers, Modeling clay, Plasticine, Metal clay (including Precious Metal Clay)
	Robocasting or Direct Ink Writing (DIW)	Ceramic materials, Metal alloy, cermet, metal matrix composite, ceramic matrix composite
	Composite Filament Fabrication (CFF)	Nylon or Nylon with short carbon fiber + reinforcement in the form Carbon, Kevlar, Glass and Glass for high temperature fiber
光固化高分子 Light polymerized	Stereo lithography (SLA)	Photopolymer
	Digital Light Processing (DLP)	Photopolymer
连续液面生产 Continuous Liquid Interface Production (CLIP)	Photopolymer + thermally activated chemistry	
粉体床 Powder Bed	Powder bed and inkjet head 3D printing (3DP)	Almost any metal alloy, powdered polymers, Plaster
	Electron-beam melting (EBM)	Almost any metal alloy including Titanium alloys
	Selective laser melting (SLM)	Titanium alloys, Cobalt Chrome alloys, Stainless Steel, Aluminum
	Selective heat sintering (SHS)	Thermoplastic powder
	Selective laser sintering (SLS) + CNC machining	Thermoplastics, metal powders, ceramic powders
	Direct metal laser sintering (DMLS)	Almost any metal alloy
迭层法Laminated	Laminated object manufacturing (LOM)	Paper, metal foil, plastic film
粉末进给Powder feed	Directed Energy Deposition	Almost any metal alloy
线材进给Wire feed	Electron beam freeform fabrication (EBF ³)	Almost any metal alloy

影片分享: 3D打印的两大粉体床主流技术

Video share : Two major technology 3D printing by powder bed

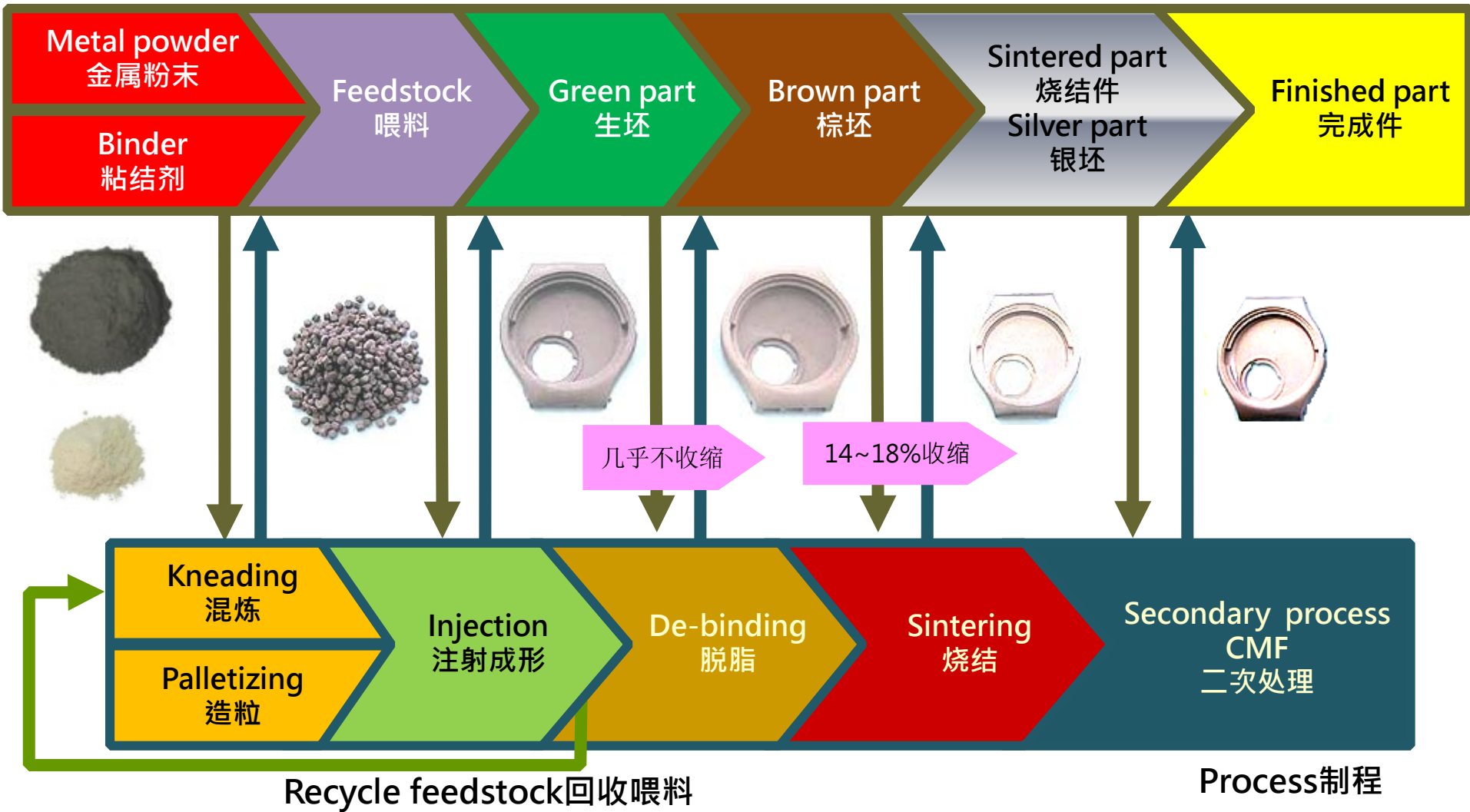
(1) ExOne

(2) SODICK

金属粉末注射成形制造流程

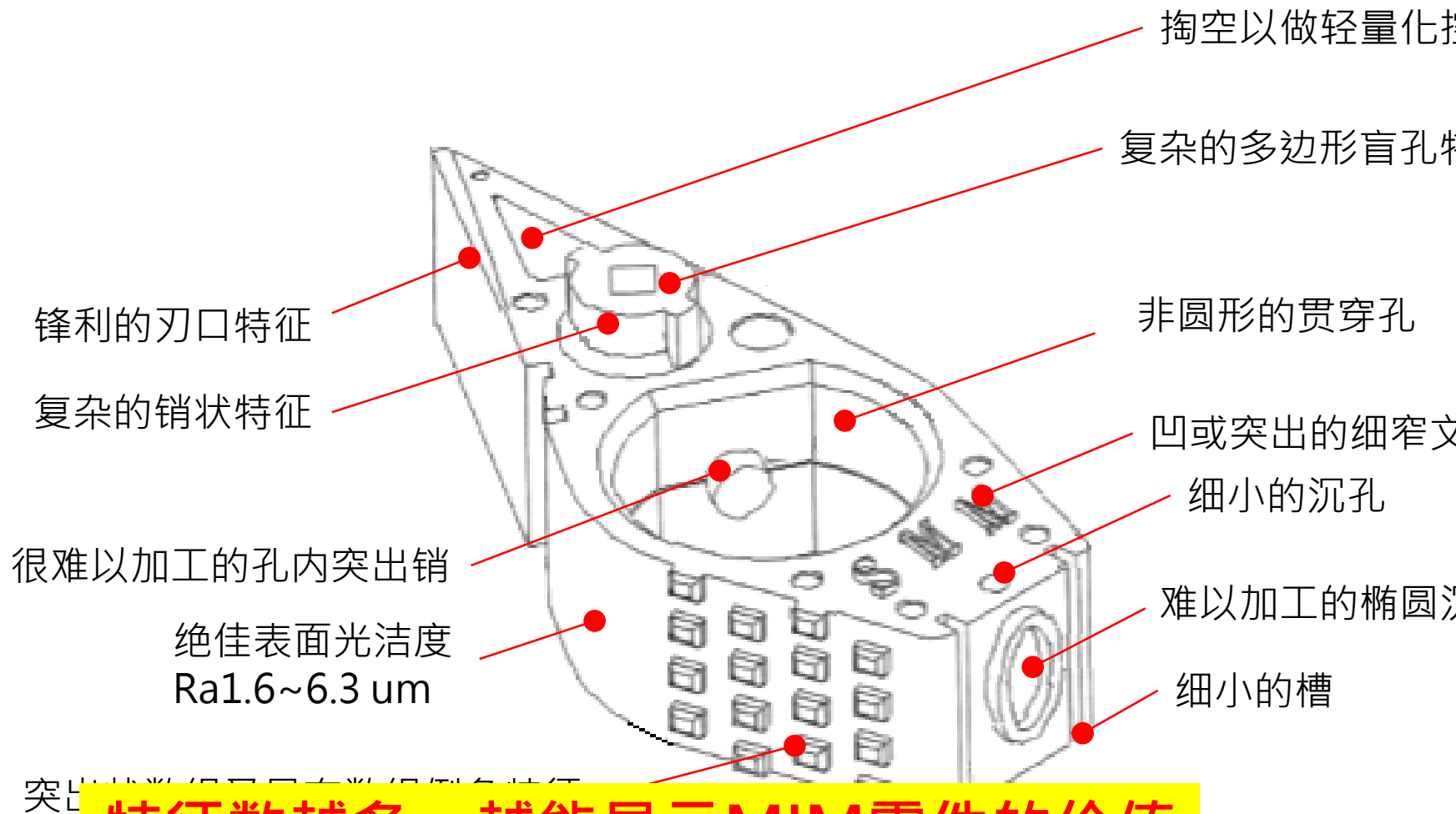
MIM process flow chart

Material forms材料形式



日本粉末冶金协会的MIM设计范例

Design sample of MIM from JPMA

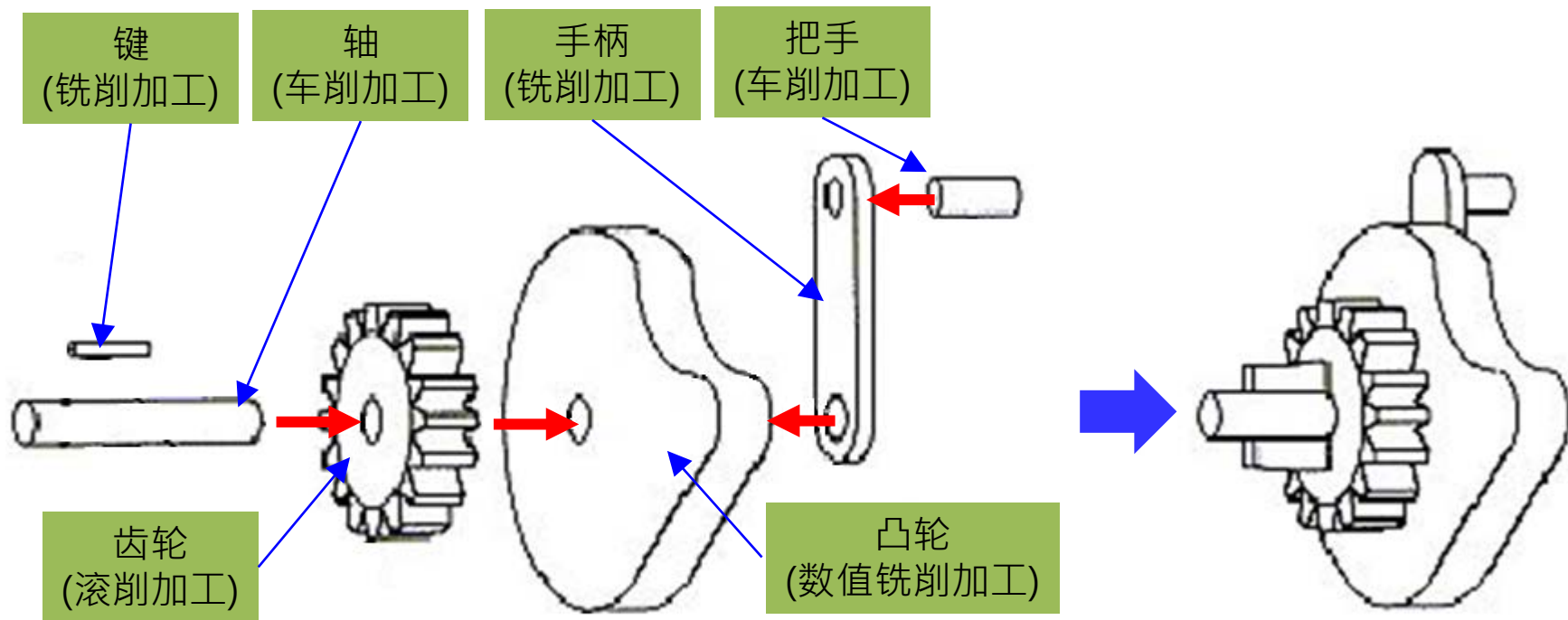


特征数越多，越能显示MIM零件的价值

可以实现多零部件一体化

Assembly parts into one piece design

由于加工技术或材料性能的原因，有些部件采用传统技术制造时，需要加工成几个零件来组装，有时几个零件的材质还不一样。采用MIM技术则可以直接制成一个整体的复合部件。

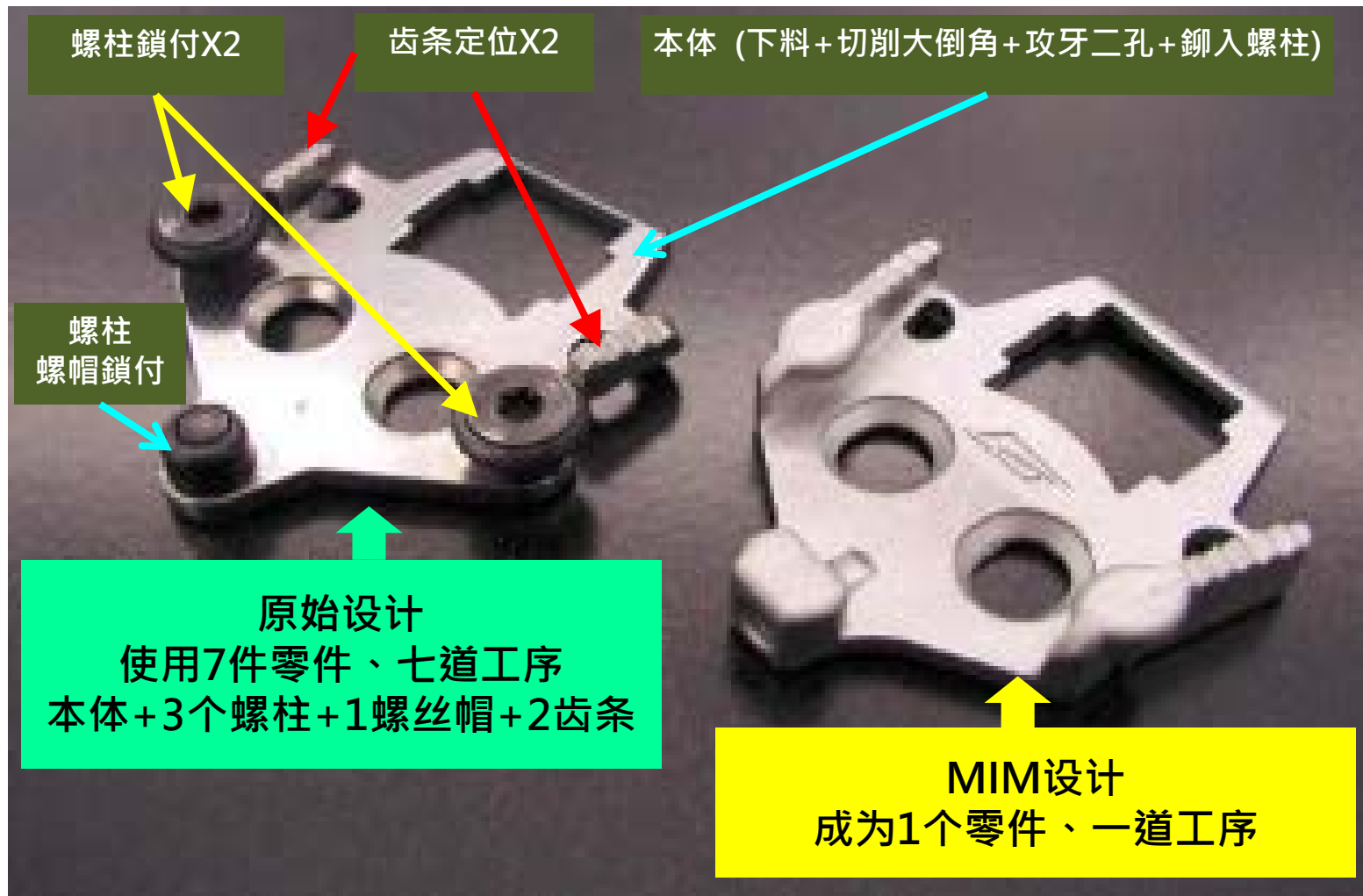


传统组装零件设计
零件数 = 6
必须注意组配公差以及相对位移可能

MIM一体零件设计
零件数 = 1
无定位和组配问题

MIM金属零件一体化设计范例

One piece design example of MIM process



工程材料中的硬派—陶瓷

Hard roles of engineering material - Ceramic

✓ 冷酷科技感，色彩丰富

Cool feeling with technology style, and multiple color

✓ 平滑、坚硬且耐蚀不易磨损

Smooth, hard, corrosion and wear resistant

✓ 耐高温防火

High temperature and fire resistant

✓ 丰富的电子特性功能，包含：电感、电容、电阻、介电

Rich electronic functions, include: Inductance, capacitance, resistance and dielectric properties

✓ 特别在于电子信号的发射与接收

Especially in the transmission and reception of electronic signals

陶瓷这么多的优点，苹果手机为何不采用陶瓷外壳？

Ceramic with many advantages, why i-phone does not applied it for housing?

✓硬且脆是罩门

Only one issue : brittle due to hardness of ceramic

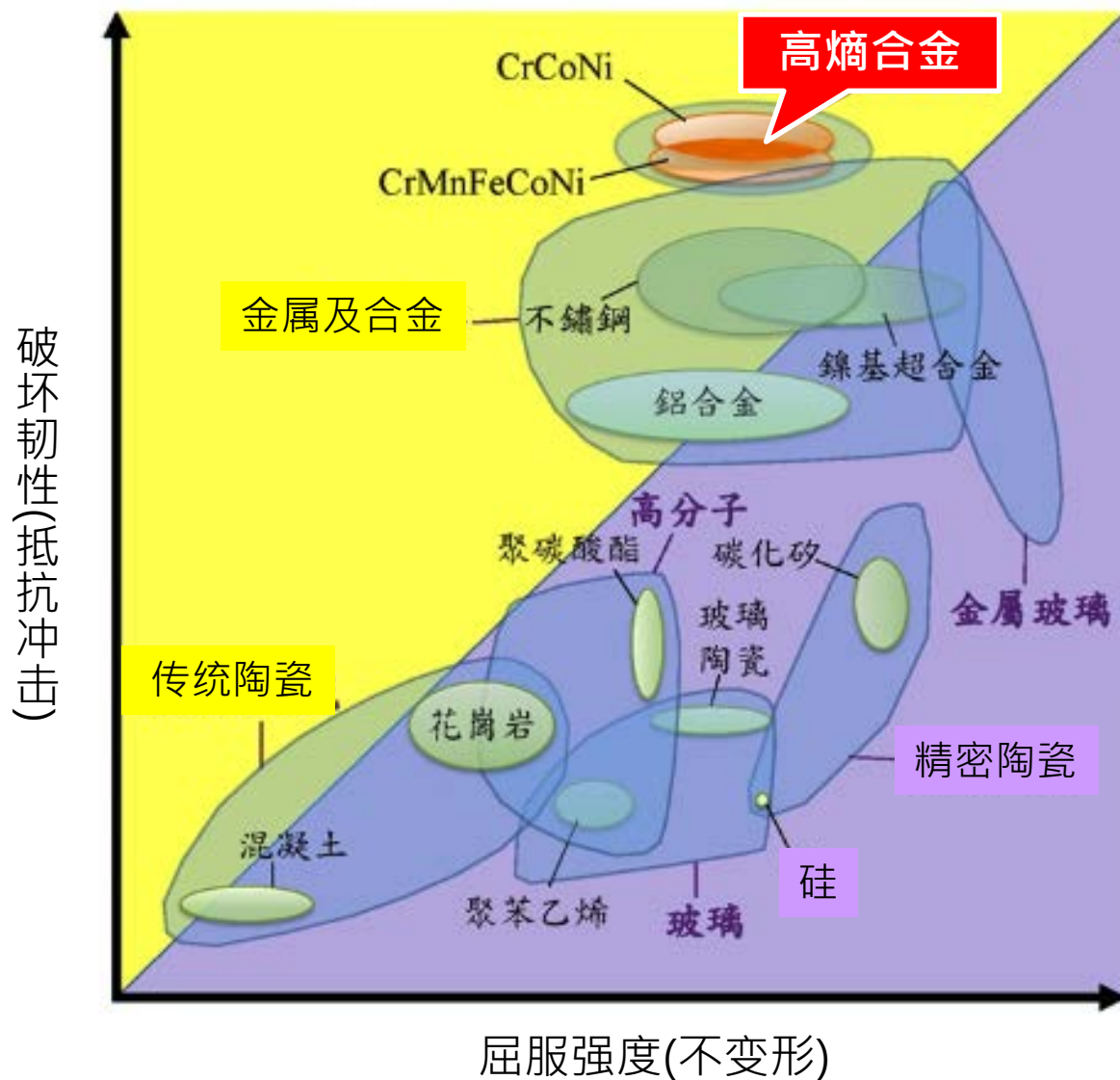
- 加工成本上扬Production cost higher
- 良率低Production yield lower
- 工时长Process time longer
- 放量风险高Scale up difficult

✓有没有办法突破？

Is there no way to break through?

高熵合金-粉末冶金制程方可轻易成形零件

High entropy alloy – it can easy forming by powder metallurgy process



- ✓ 高熵合金是以元素微小颗粒的组合，属奈米材料技术，可以经过计算机设计
- ✓ 根据环境条件，高熵合金可以突破材料学限制，例如在极为冰冷环境，高熵合金具有极高的韧性
- ✓ 高熵合金已经突破现代冶金的限制-不能以熔炼来成形，必须依赖粉末冶金技术来成形零件



谁拿走我們的利润？

Who took ours profit?

A photograph of a dirt path winding through a forest of birch trees. The path leads towards a stream in the distance, where the sun is setting, creating a bright, hazy glow. The trees are tall and thin, with their characteristic white bark and dark lenticels. The overall atmosphere is serene and natural.

需求没有变少，价格也还有空间。但质量呢？

Products demand has not changed and price so far so good.
But, where is your product quality level?

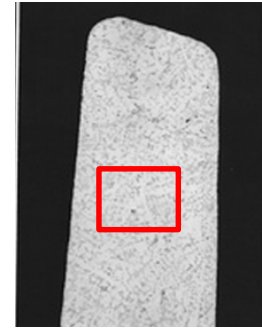
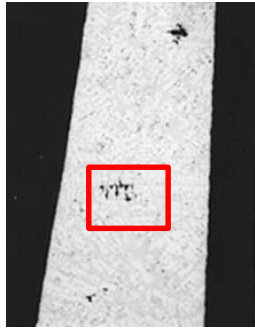
细节中住着魔鬼

The devil is in the details

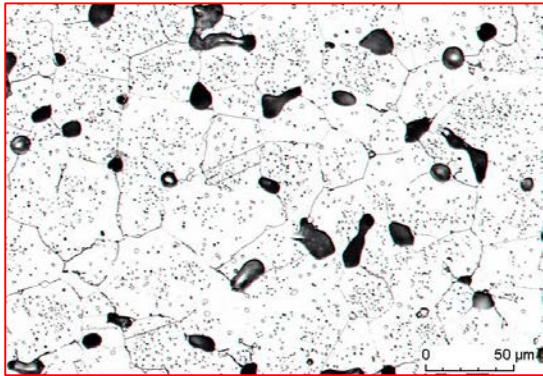
- ✓ 检视自己必须自己放下尊严
See oneself must put down their dignity
- ✓ 拿放大镜观察细节
Zoom in check by microscope
- ✓ **他山之石，可以攻玉**
From outside the box.

热等均压—粉末制程缺陷消除的利器

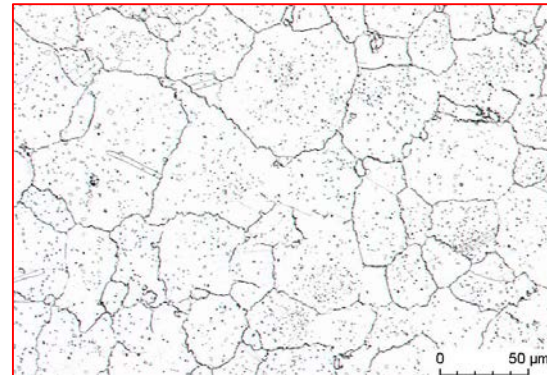
Hot Isostatic Pressing – the best elimination tool for powder process defect



HIP 大型設備



鑄造件或是PM/PIM件



消除孔隙/缺陷提高密度






我们需要这样的“魔术”

We need the **MAGIC**.

Many A Groups In China.



莫忘初衷，别忘了我们是从一无所有的开始
Don't forget the first stage, we all started like this – Nothing!

- 
- ✓微-微聚正面力量
 - ✓積-積累人類智慧
 - ✓分-分享知識快樂

Thank you!
謝謝您!

我們在同一條船上，我們一起加足馬力，困境突圍!!
Go ahead, we are a team! Let' s break through together!!

Dr. Q 邱耀弘博士

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