

OPM technology

Laser melting combined with milling technology
for mass-production

日本金屬粉末3D列印技術 的最新發展與應用

台灣松井國際股份有限公司

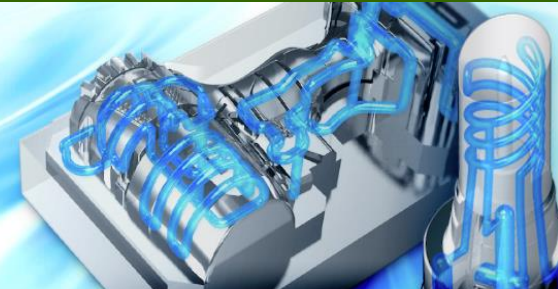
CAE technology

Prediction of molding condition
before and after completion



Conformal cooling design technology

The most efficient use heat exchange
and energy saving



Hands on practice as
software maker and developer

The most capable producers in the world

 **Greemolding**
Association of Solutions

 **RISE MOLD**
LASER TECHNOLOGY

 **OPM Lab**
OPM laboratory Co.,Ltd.

日本金屬3D列印複合加工技術的背景

这是一项由日本政府与产业界、学术界，作为国家战略而共同推进的高新技术。最初是由日本松下电工在单纯的金属3D列印技术的基础上，提出了复合加工的思路，并申请了基本专利。

但其能够真正成为一种具有实用价值的新型加工技术，主要还是依靠了日本OPM公司多年以来的锐意进取和不懈努力。OPM公司拥有该项技术的CAM软件专利，并在实用性和量化生产上作出了重大贡献，为此还获得了日本政府颁发的制造业大奖。

日本松井制作所（MATSUI）从2010年开始，就把这项技术介绍推广到包括台湾、香港和大陆在内的大中华地区。

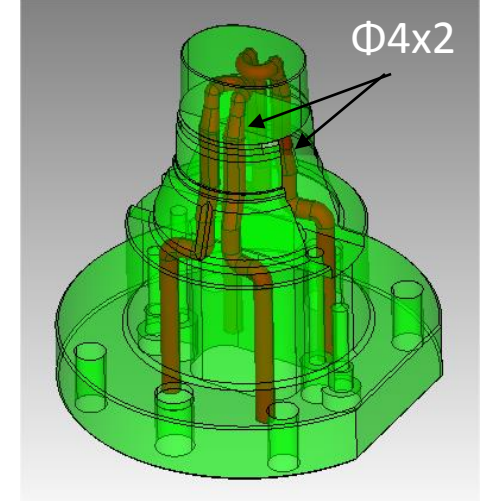
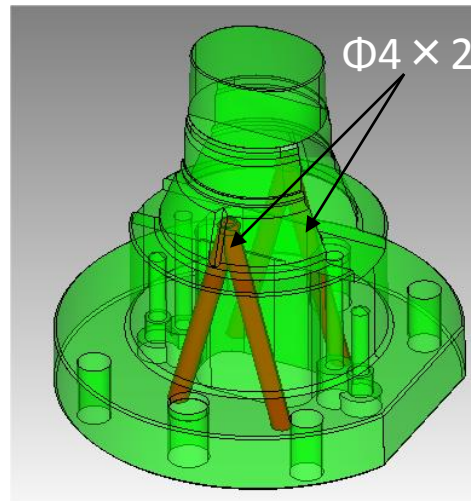
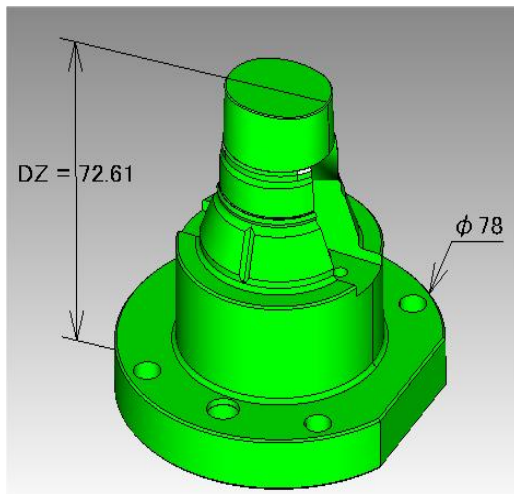
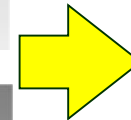
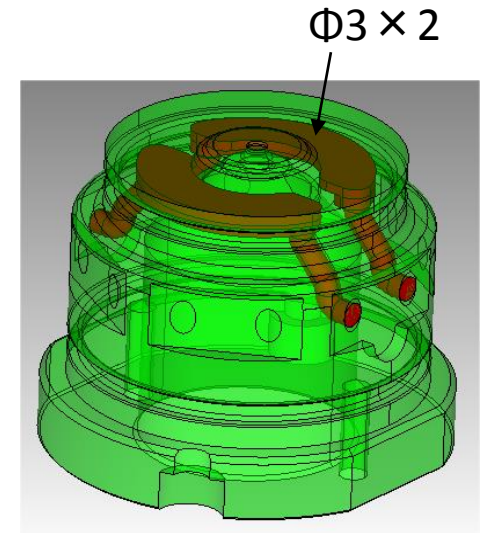
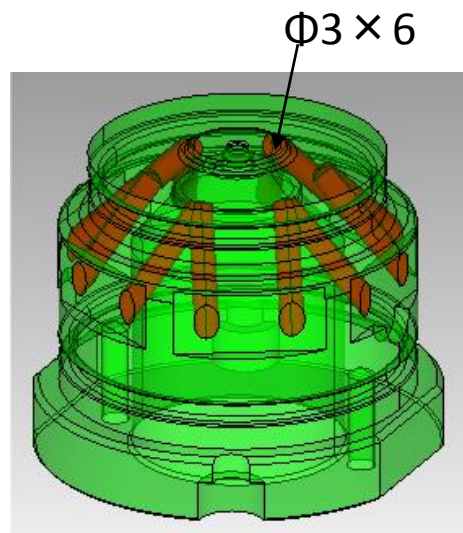
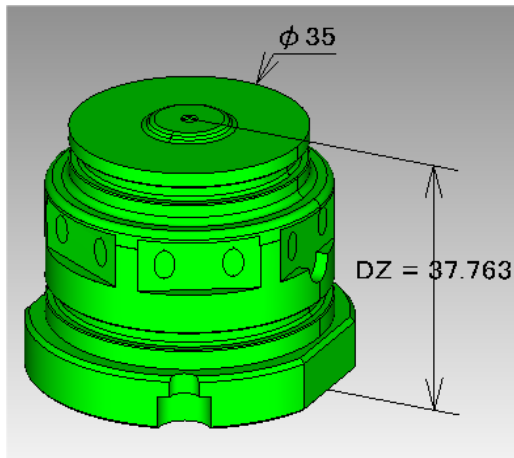
2014年10月，日本Sodick公司推出了OPM250L型号的金属3D列印复合加工机。台湾松井得到授权在大中华地区进行技术推广和机器销售，并且已经在台湾售出了机器。

金屬3D列印複合加工機 OPM250L

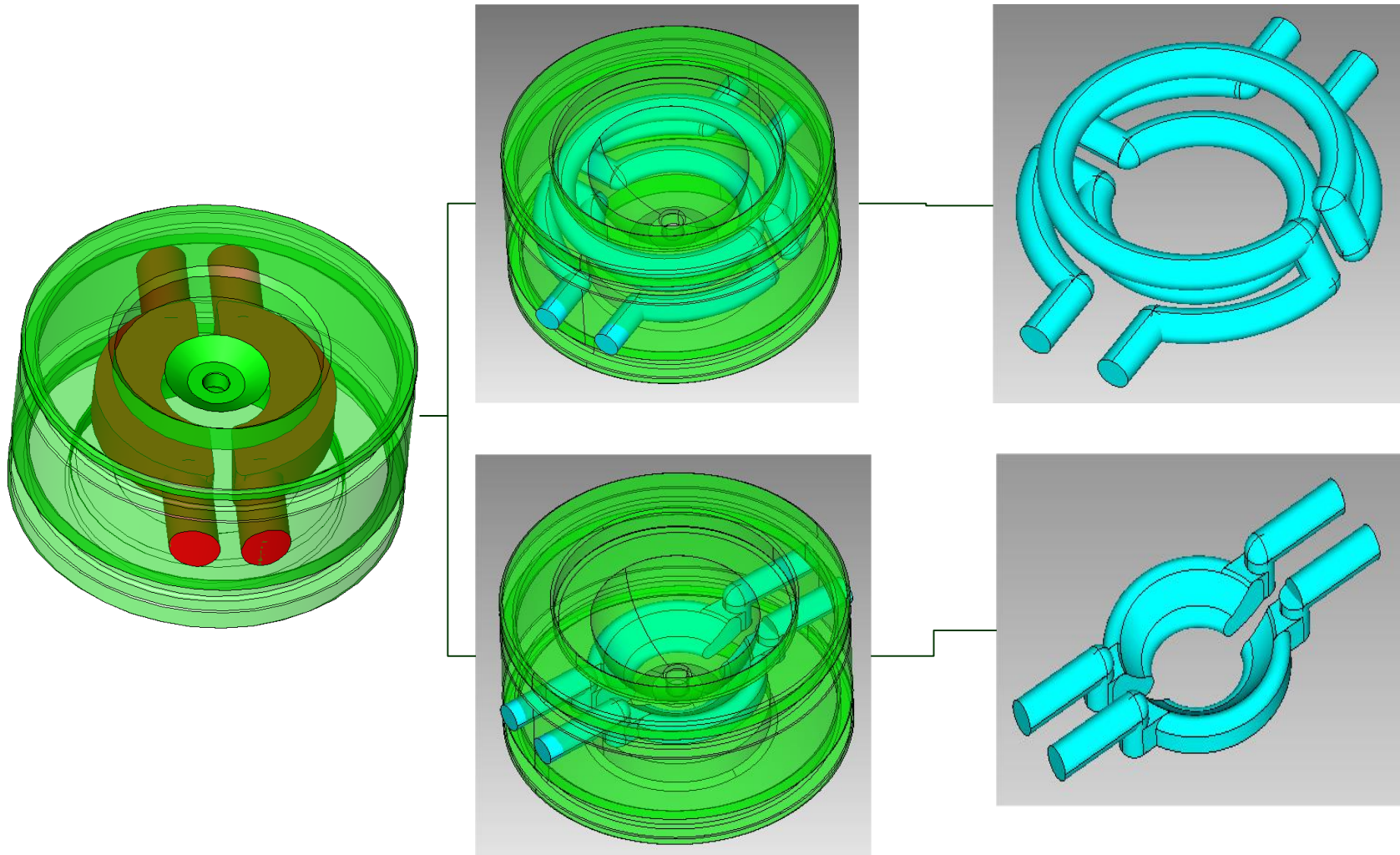


从应用案例开始

Conformal cooling channel

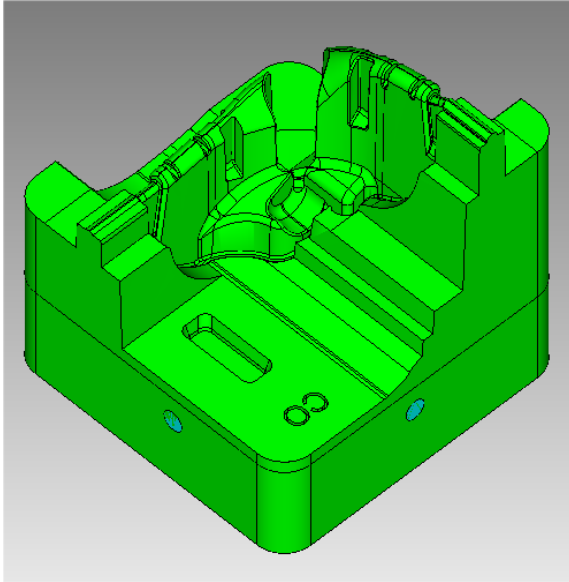


Conformal cooling channel

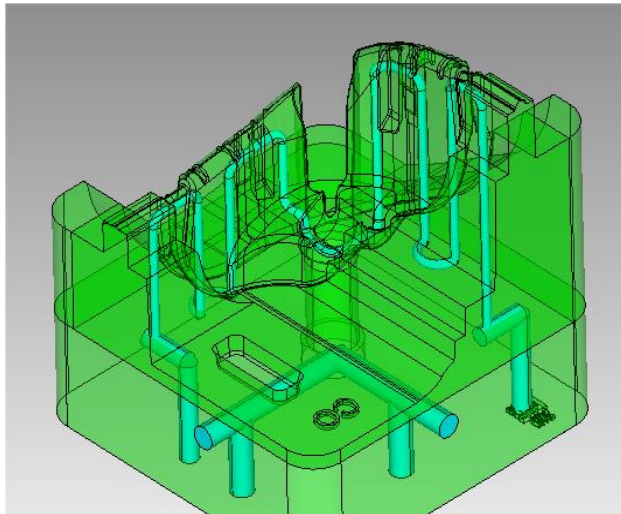
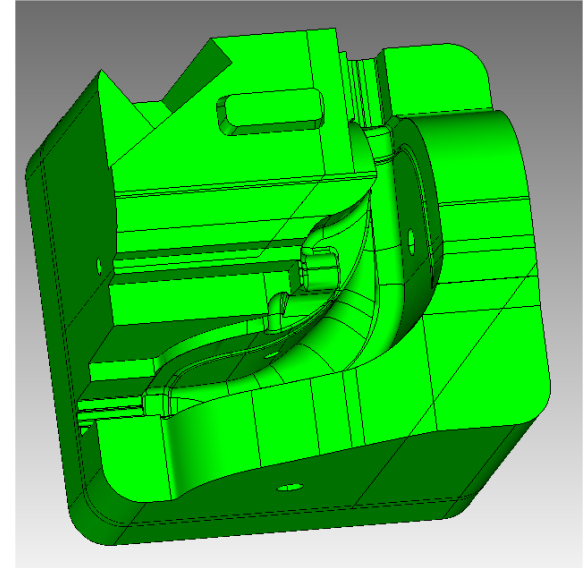


Conformal cooling channel

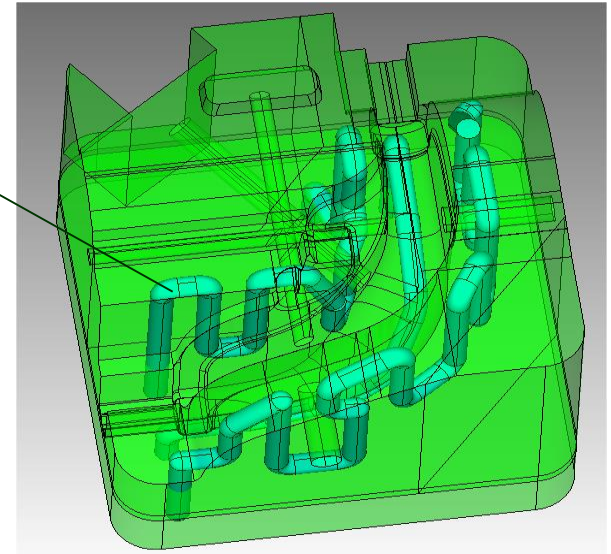
Core



Cavity



8ϕ



3D列印复合加工机简介

加工原理与特点

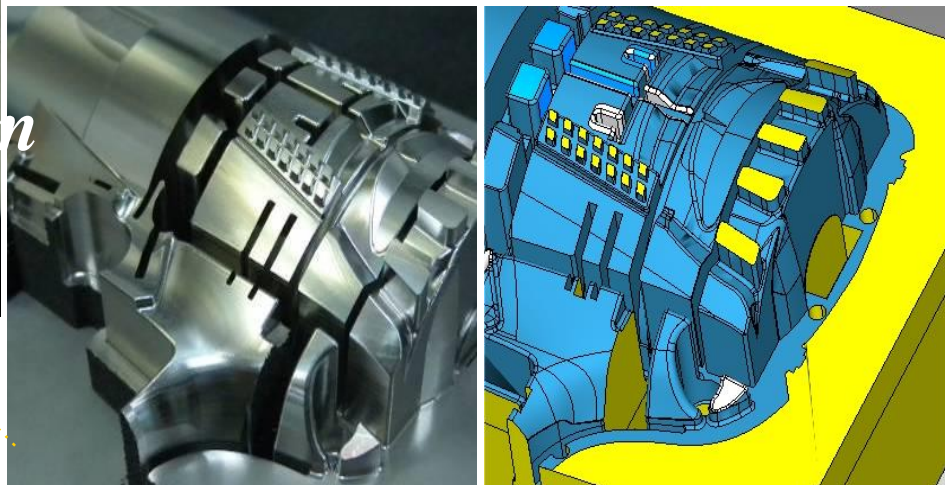
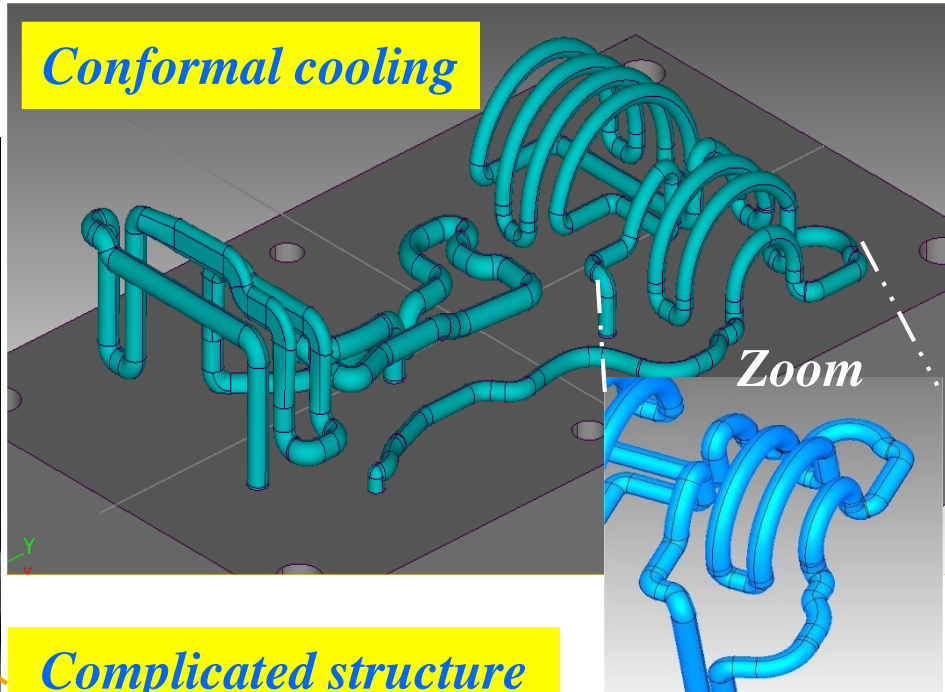
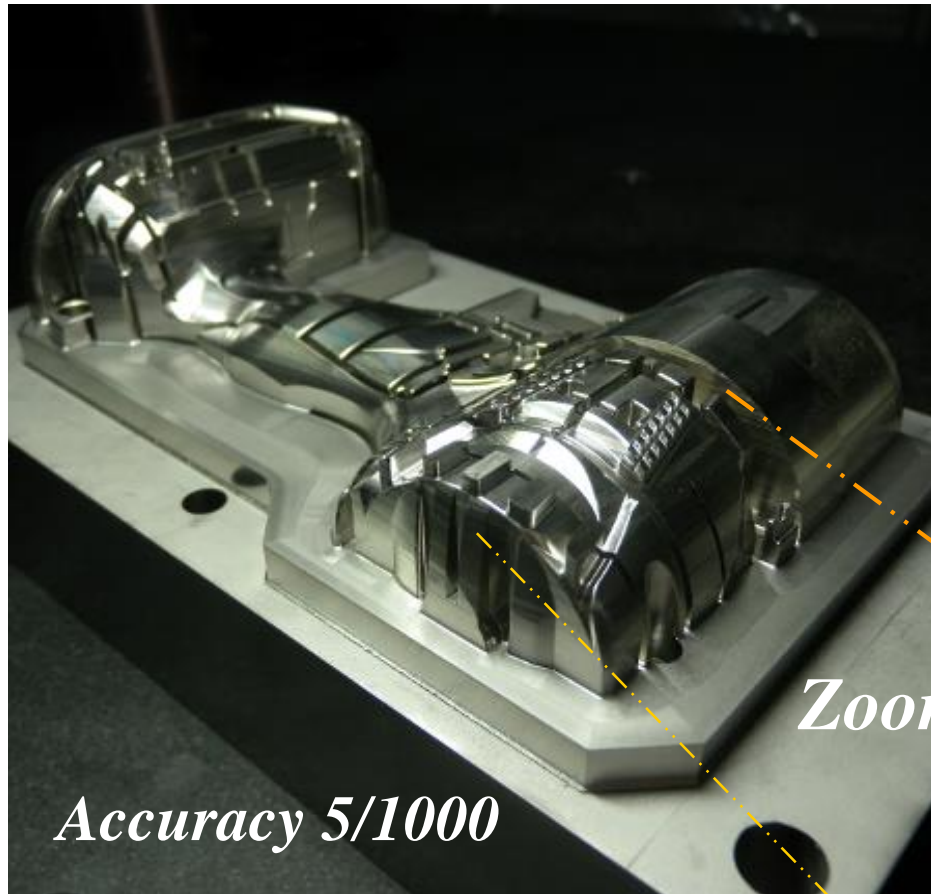
金属3D列印複合加工機 OPM250L

从金属粉末一步到位完成造型加工
而且含有内部水路和局部排气功能



金属粉末硬度：Hrc33
高强度热处理后：Hrc52以上

Core for impact driver
(material : YAG Hrc50)



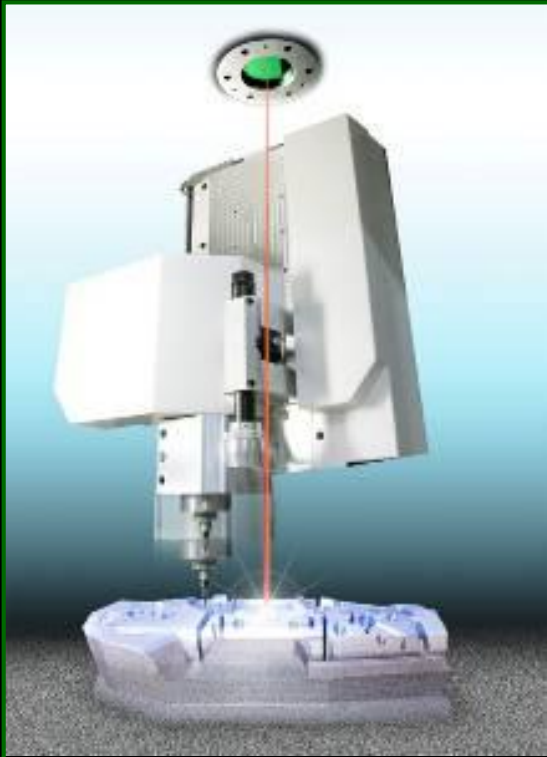
*The Cooling time can be
shortened by 50%.*

镭射熔融功率
500W

OPM250L加工机
基本构成

铣刀主轴转速
45,000min

金属粉末
镭射造形技术



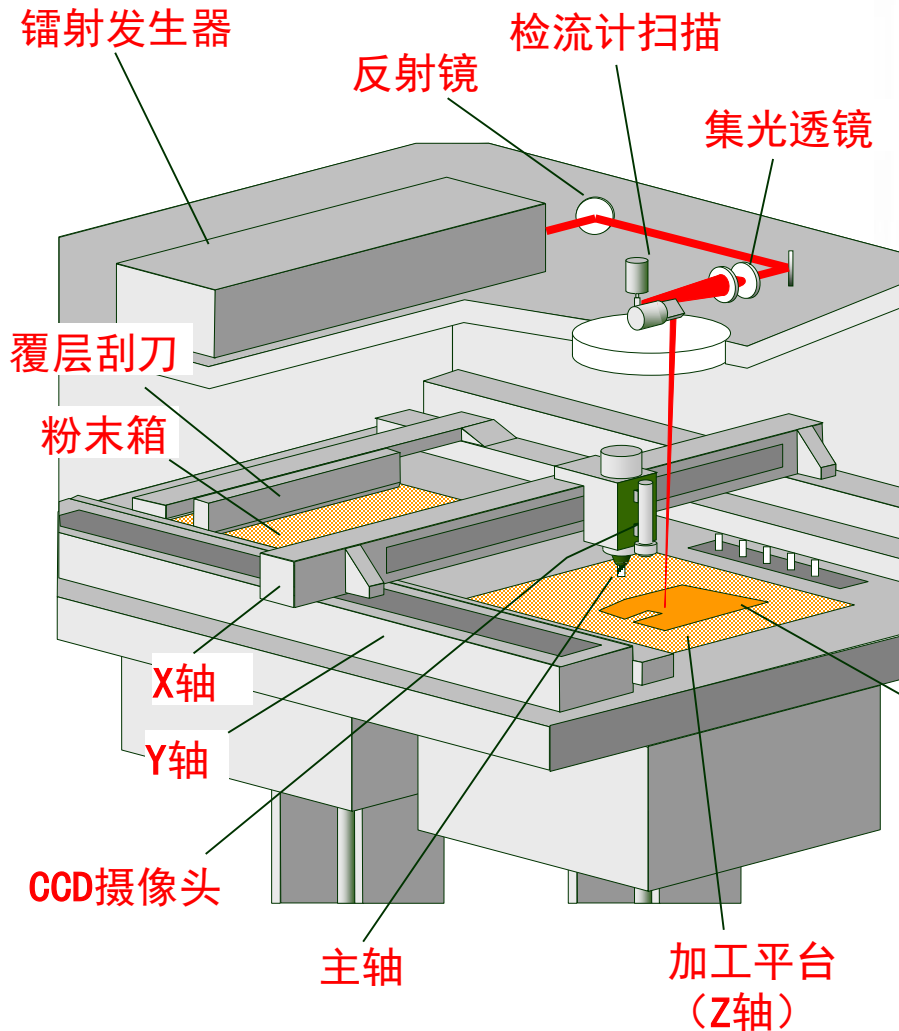
OPM250L



高速铣削
加工技术



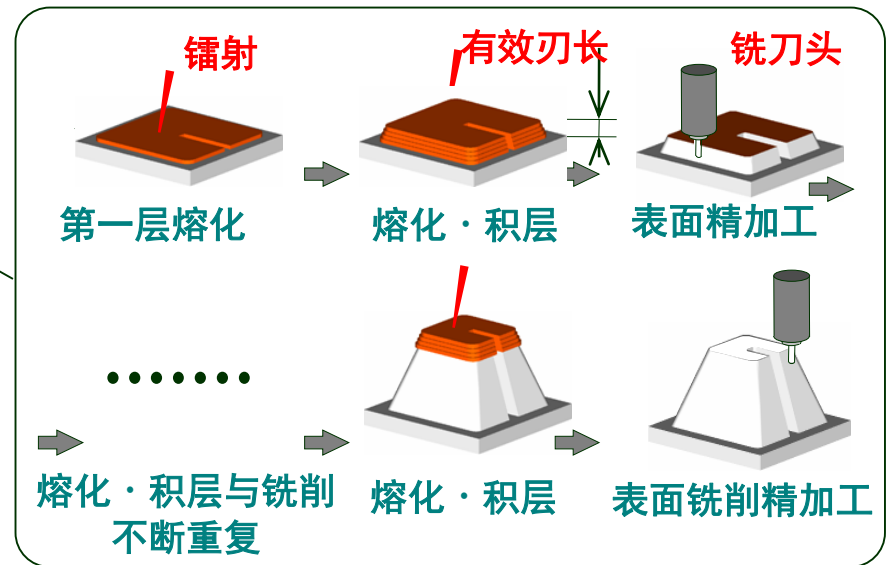
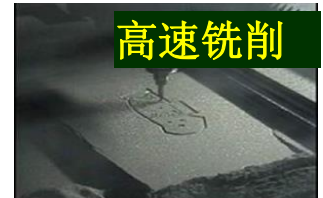
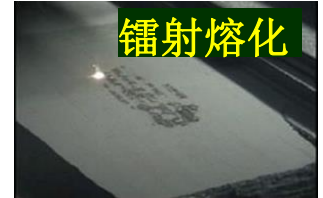
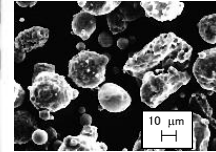
加工装置概要及加工过程



OPM250L



粉末材料



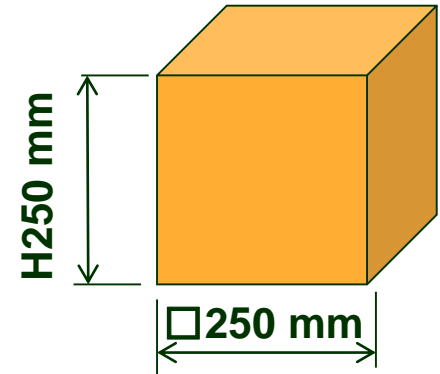
OPM250L 金属3D列印复合加工机概要

主轴

标准

转速: $45,000 \text{ min}^{-1}$

扭矩: 0.8 Nm



镭射输出功率

New !

功率: 500W

类型: Yb光纤镭射

最大工件尺寸

□250 x H250 mm



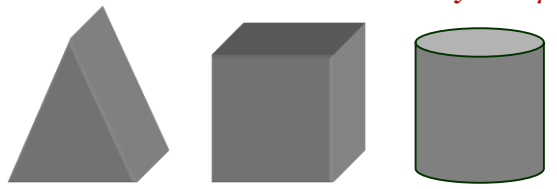




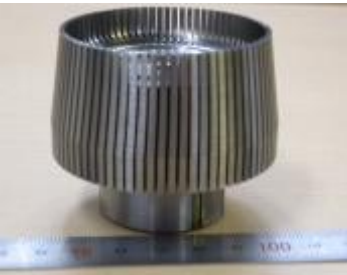

最大粉末供应量

90kg (马氏体时效钢)

ATC 刀具数量

16把 (热压配合式)

与单纯的金属3D列印方法之应用区别

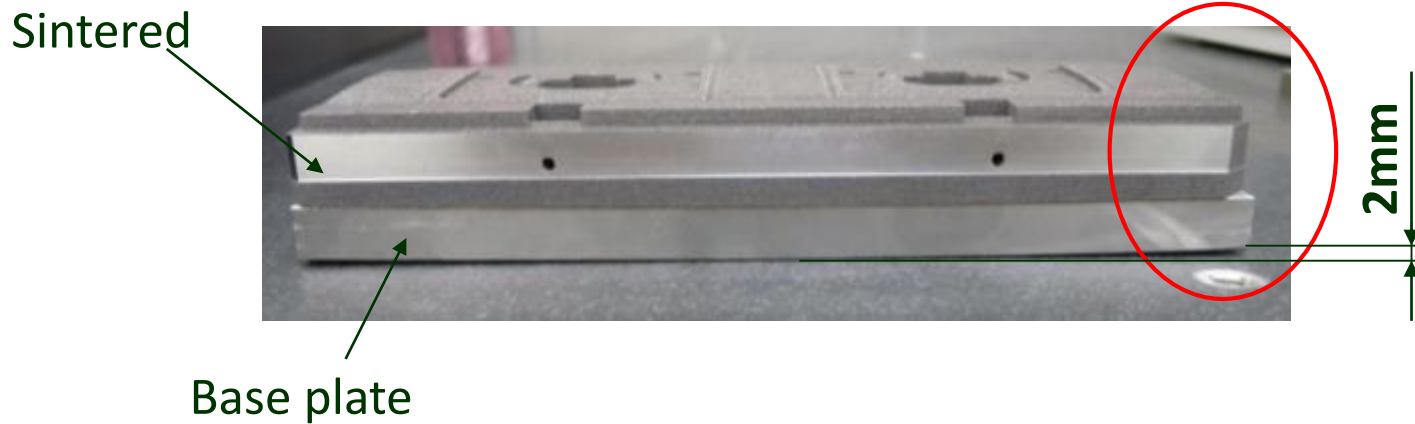
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Method</p>	<p><u><i>Laser sintering solo</i></u></p> <p>工法：增量加工</p>  <p>従来 金属光造形加工機</p>	<p><u><i>One Process Machining (OPM)</i></u></p> <p>工法：增量加工+除去加工</p> <p>Complicate structure (精度要求高, 外形复杂的模具零件)</p> 
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Representative sintered objects</p>	<p>Simple structure (只适宜于外形简单, 又可以实施后续加工的模具零件。)</p> <p>表面粗さ •Ry 50 μ</p>  	 <p>◎表面粗さ •Ry < 1~2 μ 以下</p>   <p>◎寸法精度 •$\pm 5/1000$</p>  

金属3D列印的技术难题

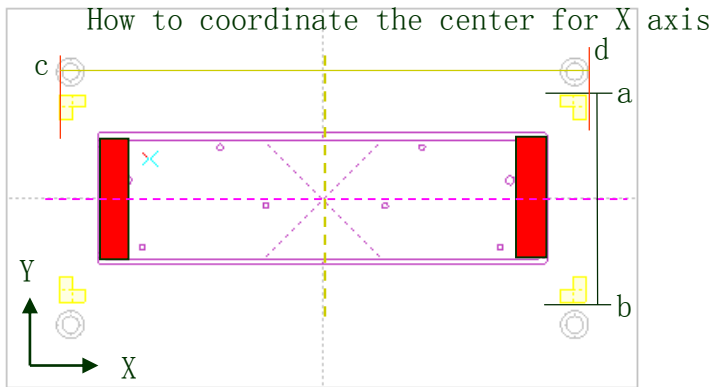
底板翘曲

Warping problem

Case example : Core for connector (210mm × 210mm)

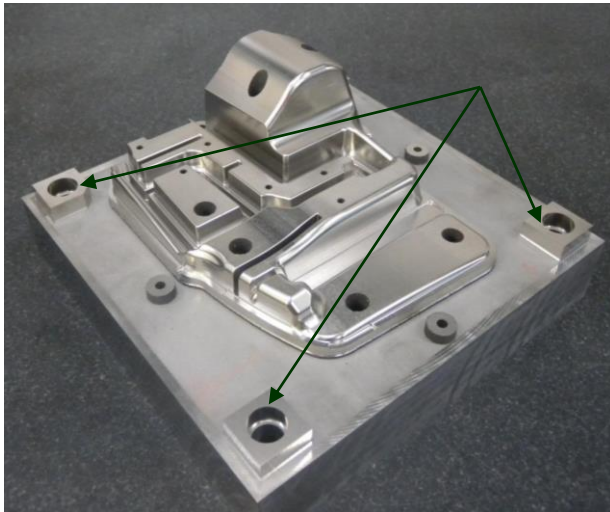


For secondary process



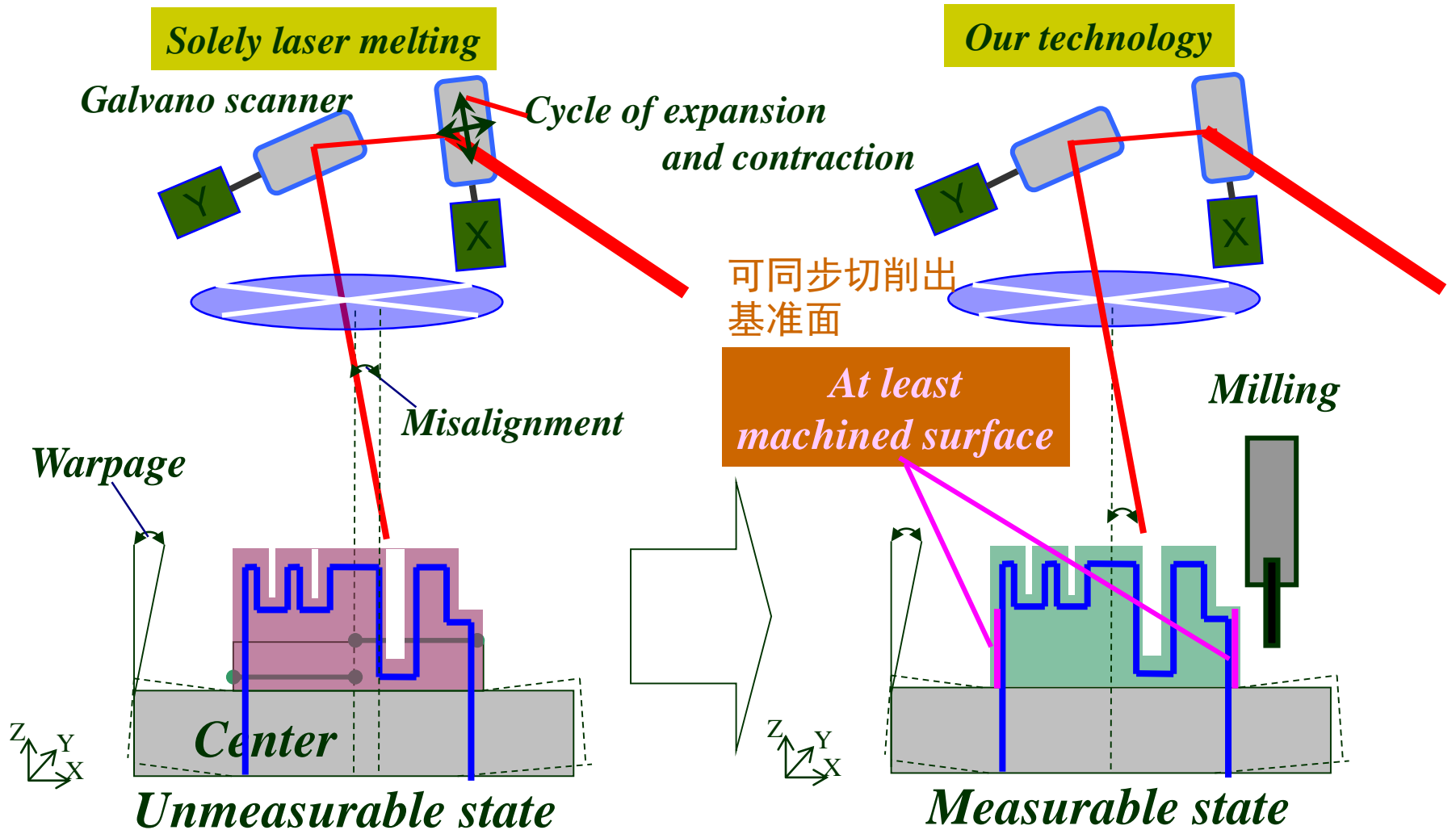
为保证部品精度，必须具有精准的基准面 (Datum)，可用于后续加工。

Method1: Reference block of milling surface



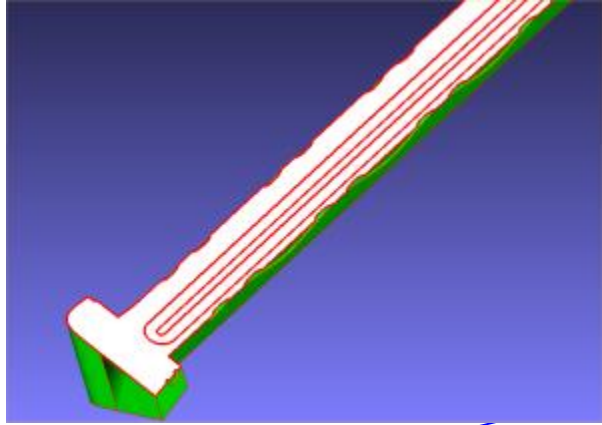
Method2: Reference milling surface of part



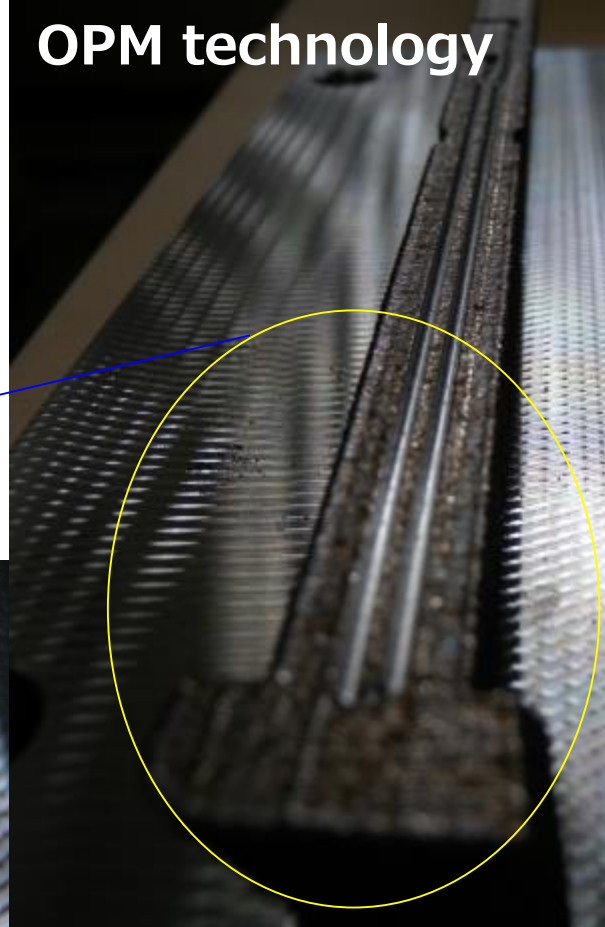


- ✓ Misalignment between cad data and sintered object on condition that is used galvano
- ✓ The base plate and sintered object are warped by inner stresses.
- ✓ It can't measure accurate dimensions from fiducial surfaces of the plate

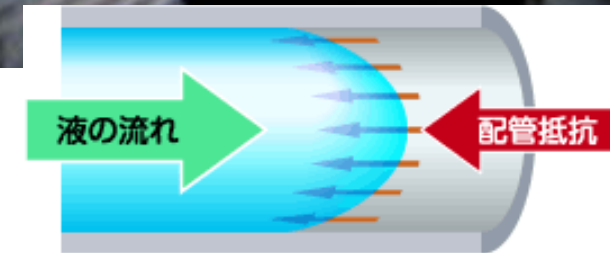
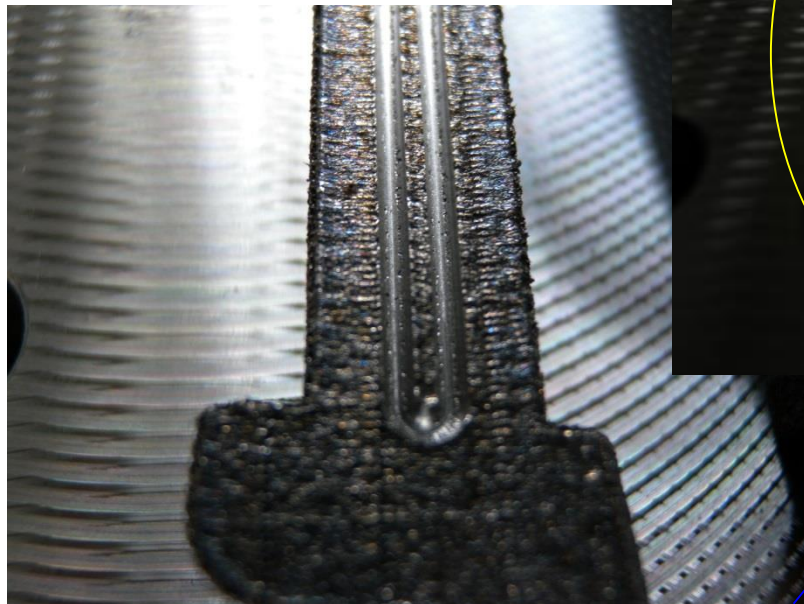
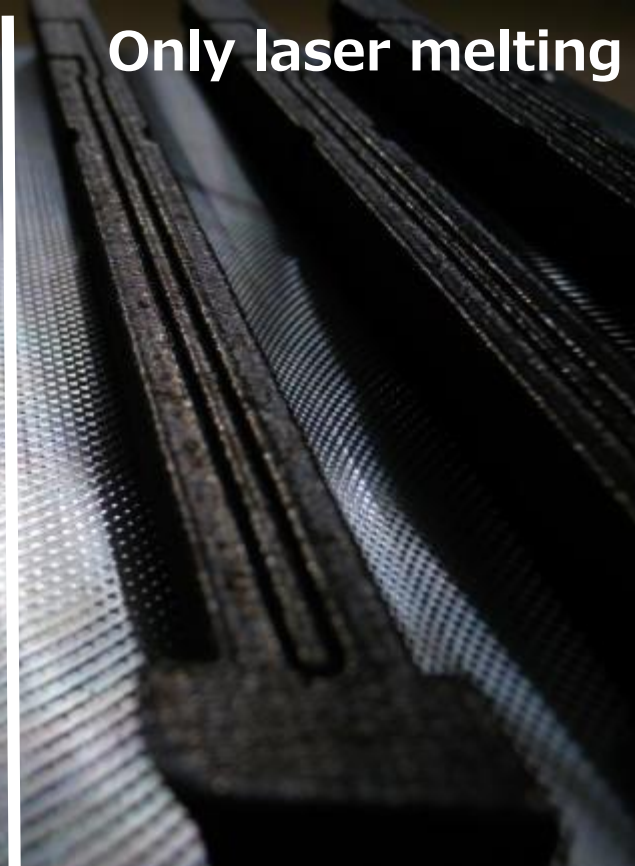
切削加工水路表面

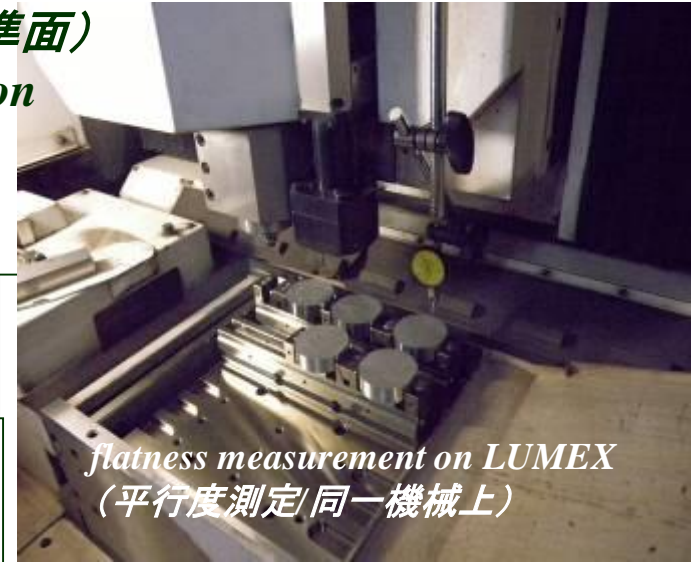
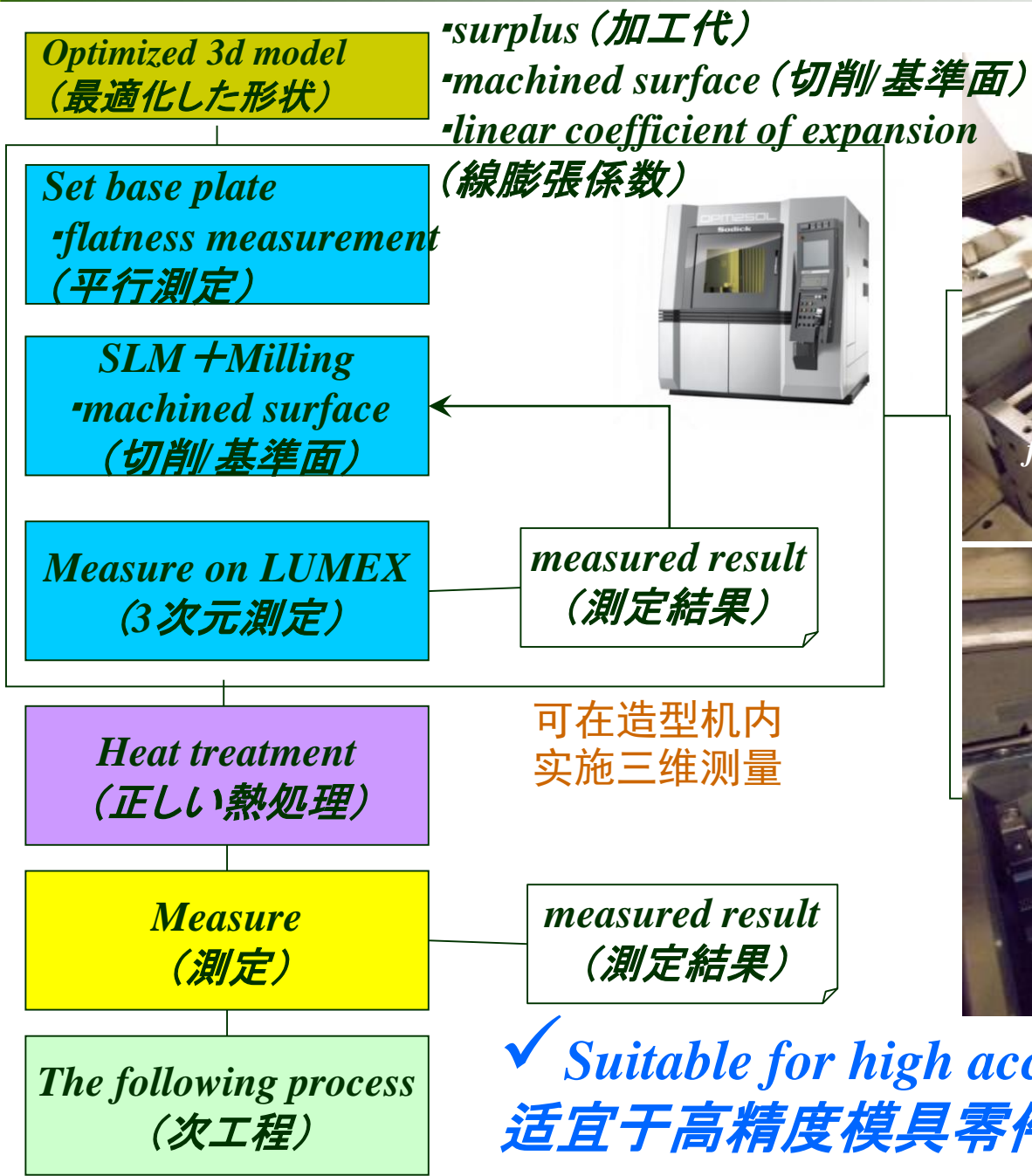


OPM technology



Only laser melting



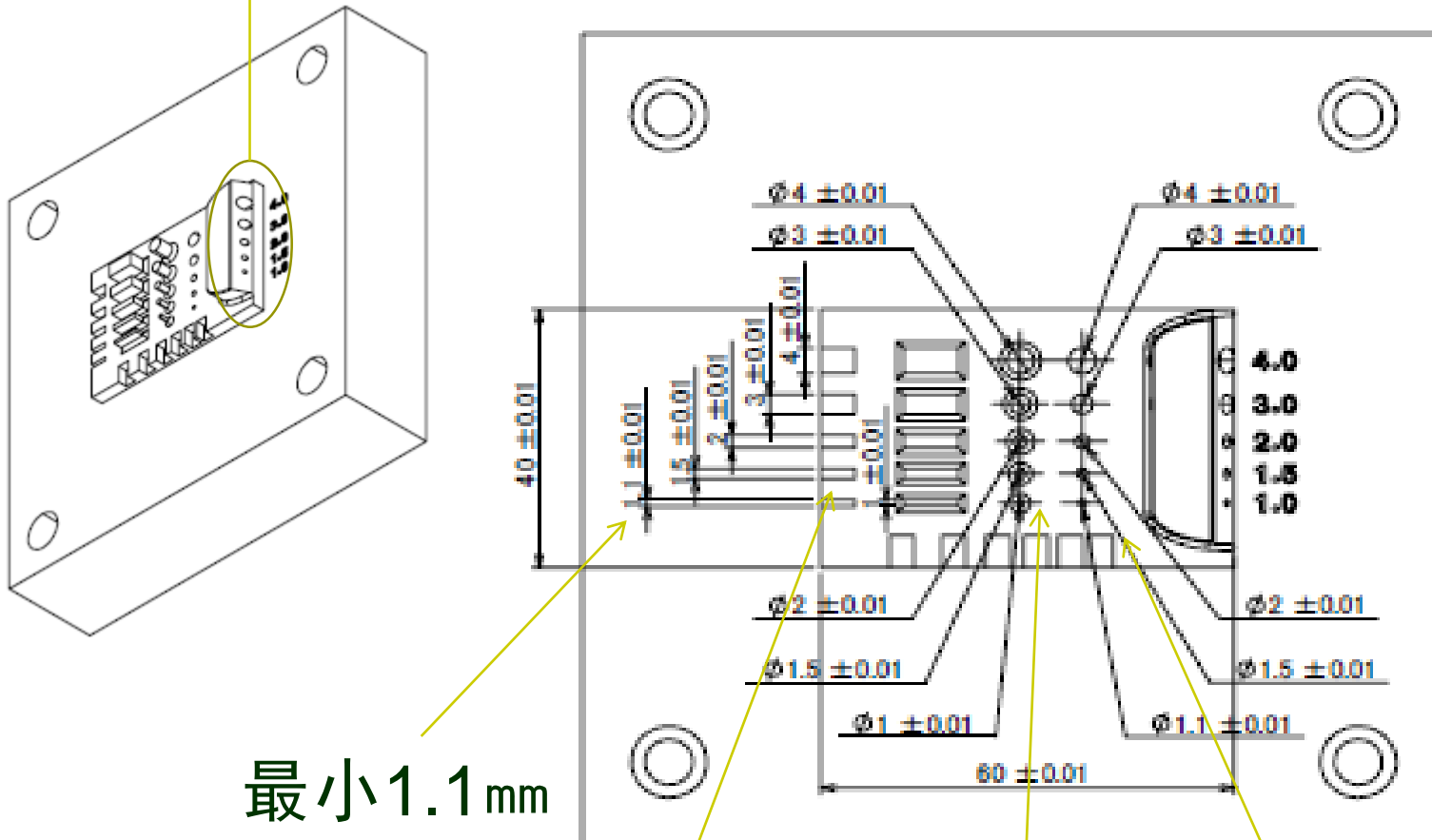


✓ **Suitable for high accuracy part**
适宜于高精度模具零件

切削加工精度

3D 水管 (1φ~4φ)

要求精度1/100以上



最小1.1mm

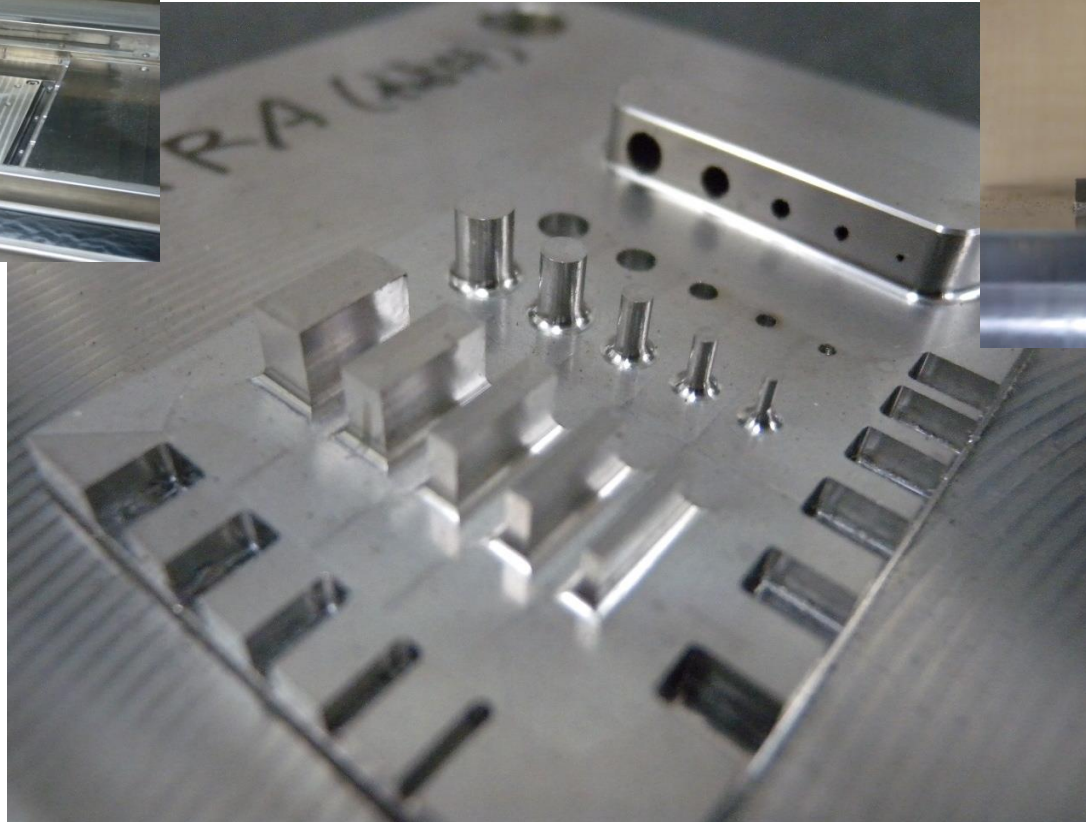
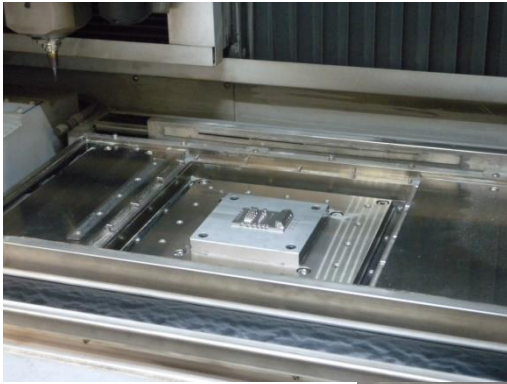
最小1mm板

φ1Pin

φ1.1穴

切削加工精度

样品形状完全符合要求



装置精度評価样品

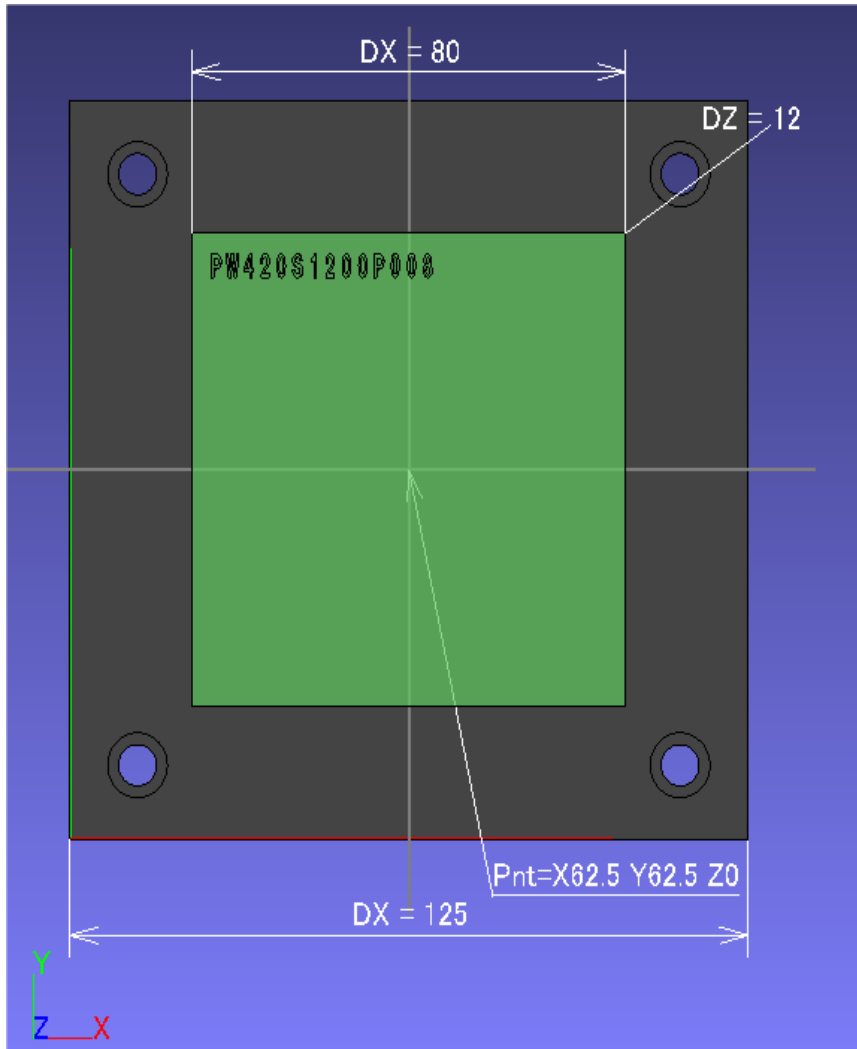
要求精度1/100以内

用于3D列印注塑模具的金属粉末材料

MATERIAL		TENSILE STRENGTH (MPa)	ELASTICITY (%)	0.2% YIELD STRESS (MPa)	YOUNGS MODULUS (GPa)	VICKERS HARDNESS HV	ROCKWELL HARDNESS (HRC)
OPM-SuperStar Correspond to STAVAX	Melted	Over1698	-	Over1410	182	-	55-57
OPM-YAG (Maraging)	Melted	811 (1967)	16(10)	598 (1810)	160	-	34(48-50)
OPM-Ultra1 (MAS-1) * Standard	Melted	990(1992)	20(15)	820(1930)	185	-	38(52-54)
OPM-Ultra2 (MAS-1) * Fine	Melted	measuring in progress					55
NAK55 (Ni-MARK)	<i>Now developing</i>						
SKD/SKH	<i>Now developing</i>						
Ti-6Al-7Nb Ti-6Al-4V	<i>Now developing</i>						
Aluminium	<i>Planning</i>						

Melting ratio of Ultra Maraging

We have achieved more than melting ratio of **99.99%** for Ultra maraging steel



Quality mode

No. 20150300-001
平成27年2月6日

成績書

株式会社OPMラボラトリー 様

京都市中小企業技術センター 所長

平成27年2月4日依頼の試料についての試験測定結果は下記のとおりです。

ロックウェル硬さ試験

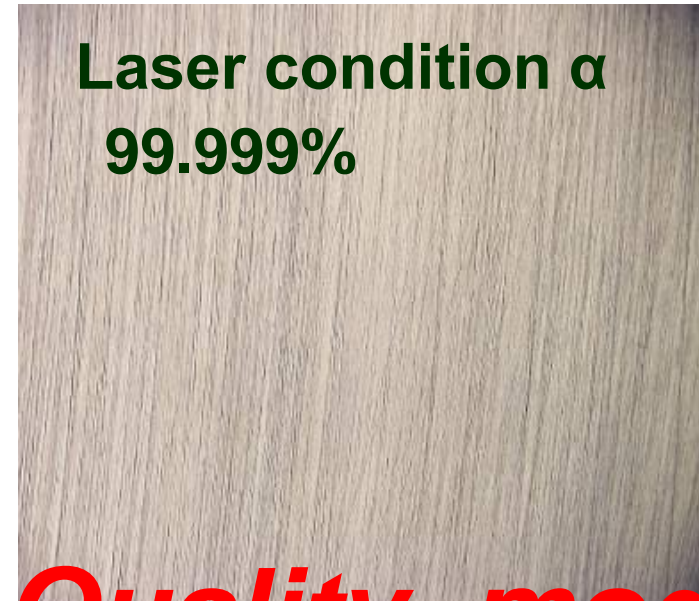
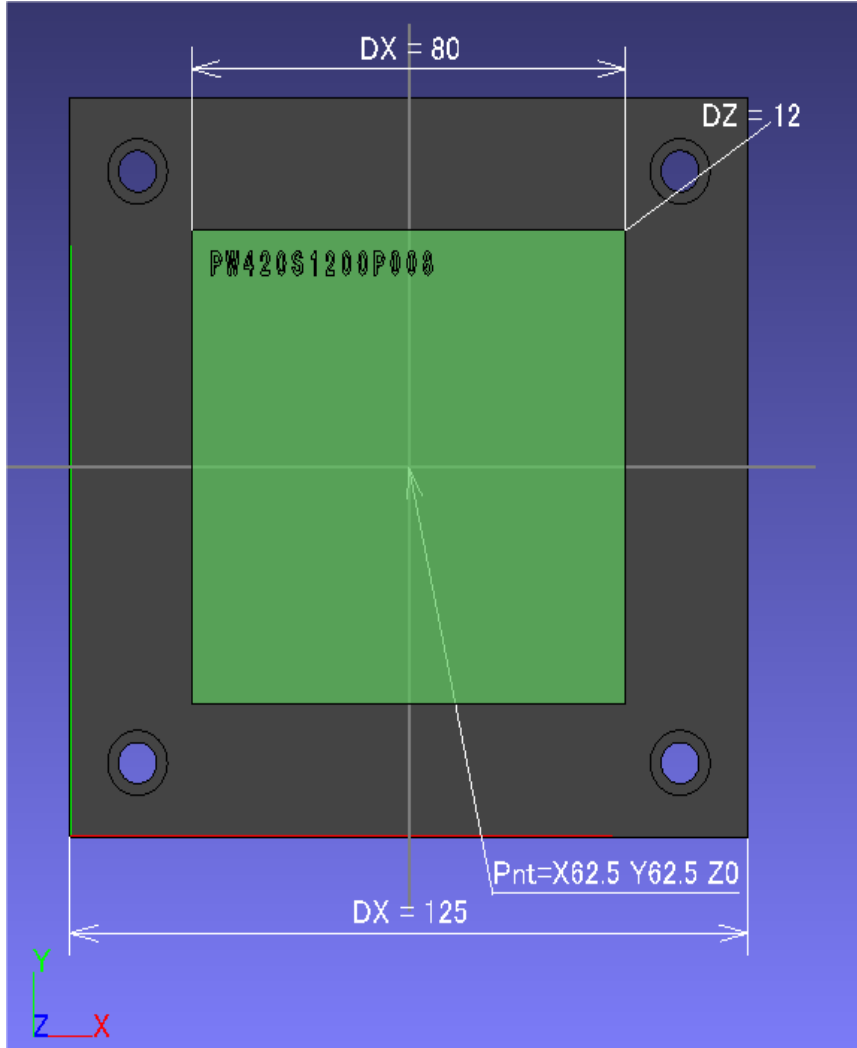
試験片名称	試験結果
OPM-ULTRA II	55.1 HRC

以下空白

55.1HRC

Melting ratio of Super Star SUS420J2

We have achieved more than melting ratio of **99.99%** for Super Star.




Quality mode

No. 20142591-001-2
平成 26 年 10 月 7 日

成 績 書

株式会社OPMラボラトリー 様

京都府中小企業技術センター 所長


平成26年10月7日依頼の試料についての試験測定結果は下記のとおりです。

ロックウェル硬さ試験

試験片名称	試験結果
OPM-Super Star (焼入後)	57 HRC

以下 余 白

57HRC

Revel of SPI finish numbers

We are here it's **SPI-A2**.

Diamond Mold Polishing & Finishing Specifications

Types of Finishes	Current SPI Finish Numbers	Description and Previous Finish Numbers	Roughness Comparison R.A.
Diamond	#3 Diamond Buff	A1 is comparable to	#1 0-1
	#6 Diamond Buff	A2 is slightly finer than	#2 1-2
	#15 Diamond Buff	A3 has more imperfections than	#3 2-3
Paper	600 Grit	B1 is finer than	2-3
	400 Grit	B2 is slightly finer than	#3 4-5
	320 Grit	B3 is comparable to	9-10
Stone	600 Stone	C1 is finer than	10-12
	400 Stone	C2 is slightly finer than	#4 25-28
	320 Stone	C3 is comparable to	38-42
Dry Blasted	#11 Glass Bead	D1 is finer than	10-12
	240 Aluminum Oxide Blast	D2 is comparable to	#5 26-32
	#24 Aluminum Oxide Blast	D3 is a little more coarse than	190-230

for Ultra maraging steel

SPI-B1: 外装品上級レベル仕上げ（SPI-C1に600番のグリットペーパー処理を付加、表面粗さRa = 0.05 - 0.08 Ra）

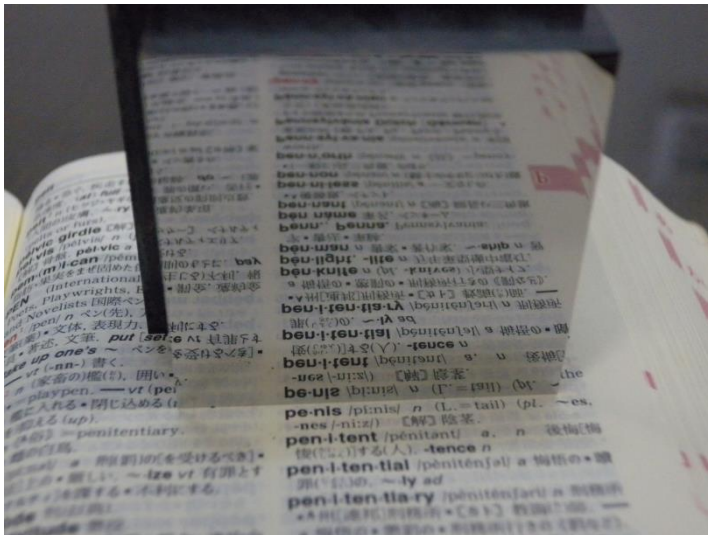
SPI-A2: 鏡面仕上げ（レンズや光沢面が必要な外装品用途向け最上級仕上げ。表面粗さRa = 0.03 - 0.05 Ra）

Revel of SPI finish numbers



Laser melting
plate

Ultra Maraging



More than **SPI-A2**

Dictionary

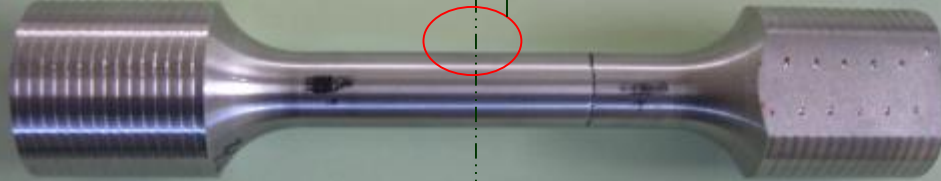
Quality mode

YAG Fatigue specimen of maraging steel

Fatigue test border line

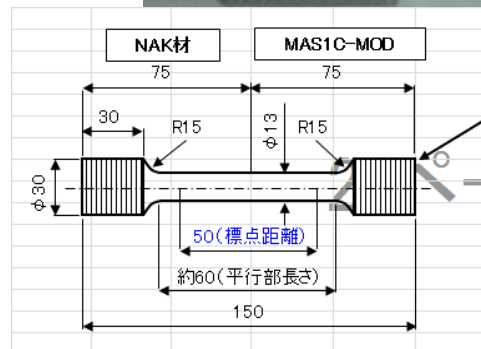
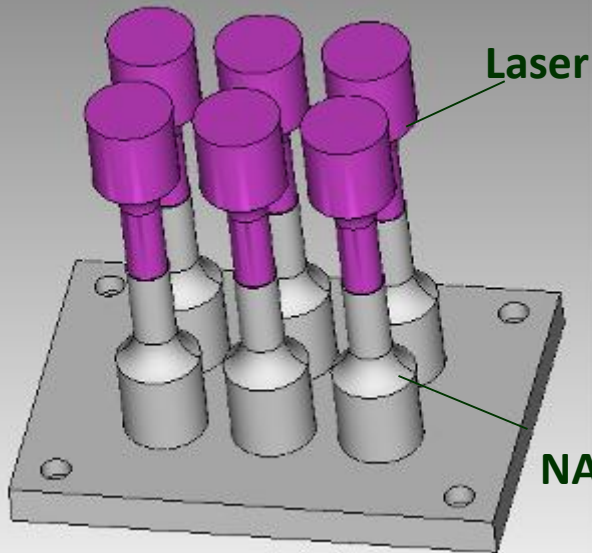
NAK

laser surface alloyed

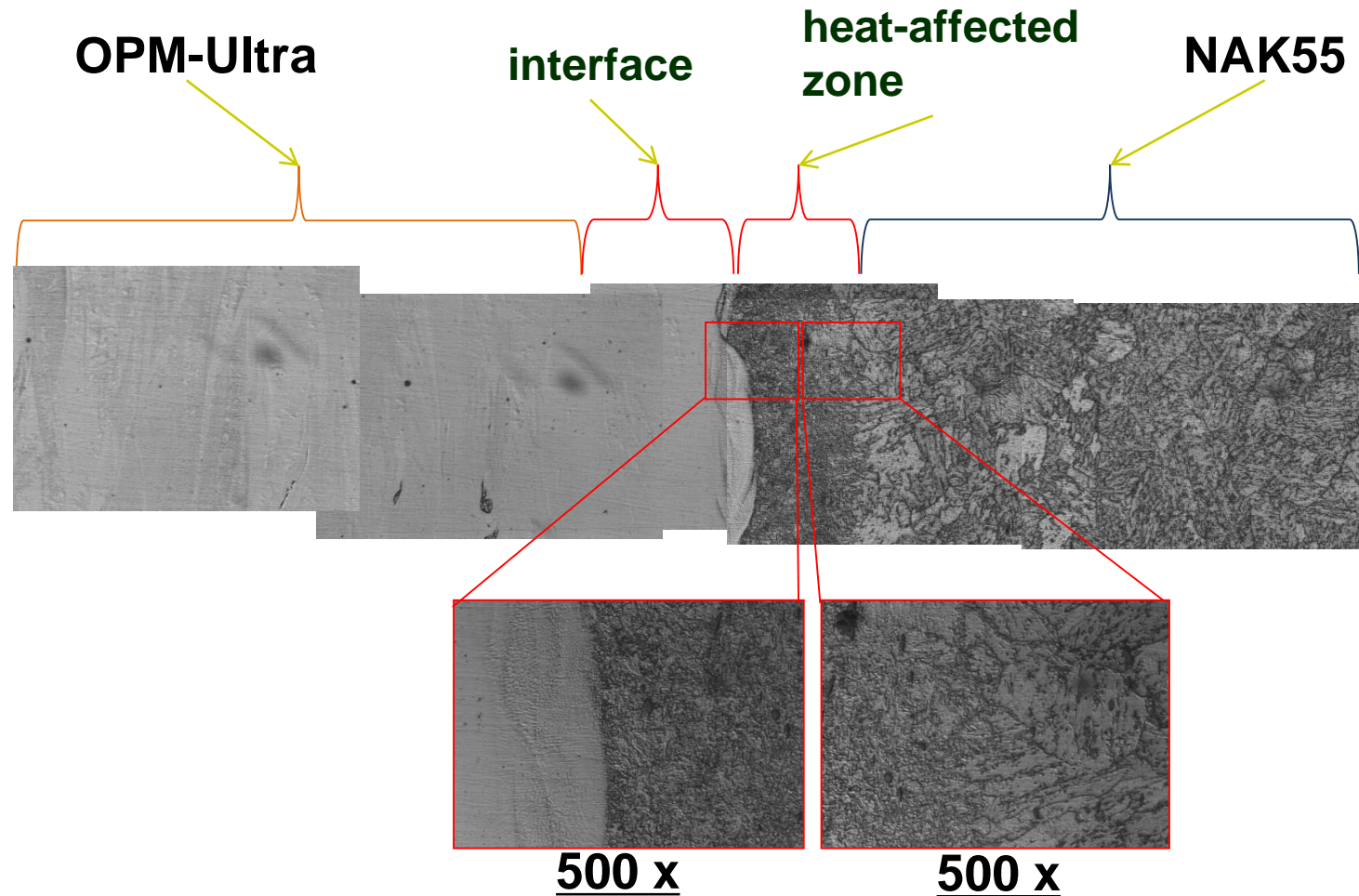


Maraging steel

toughness



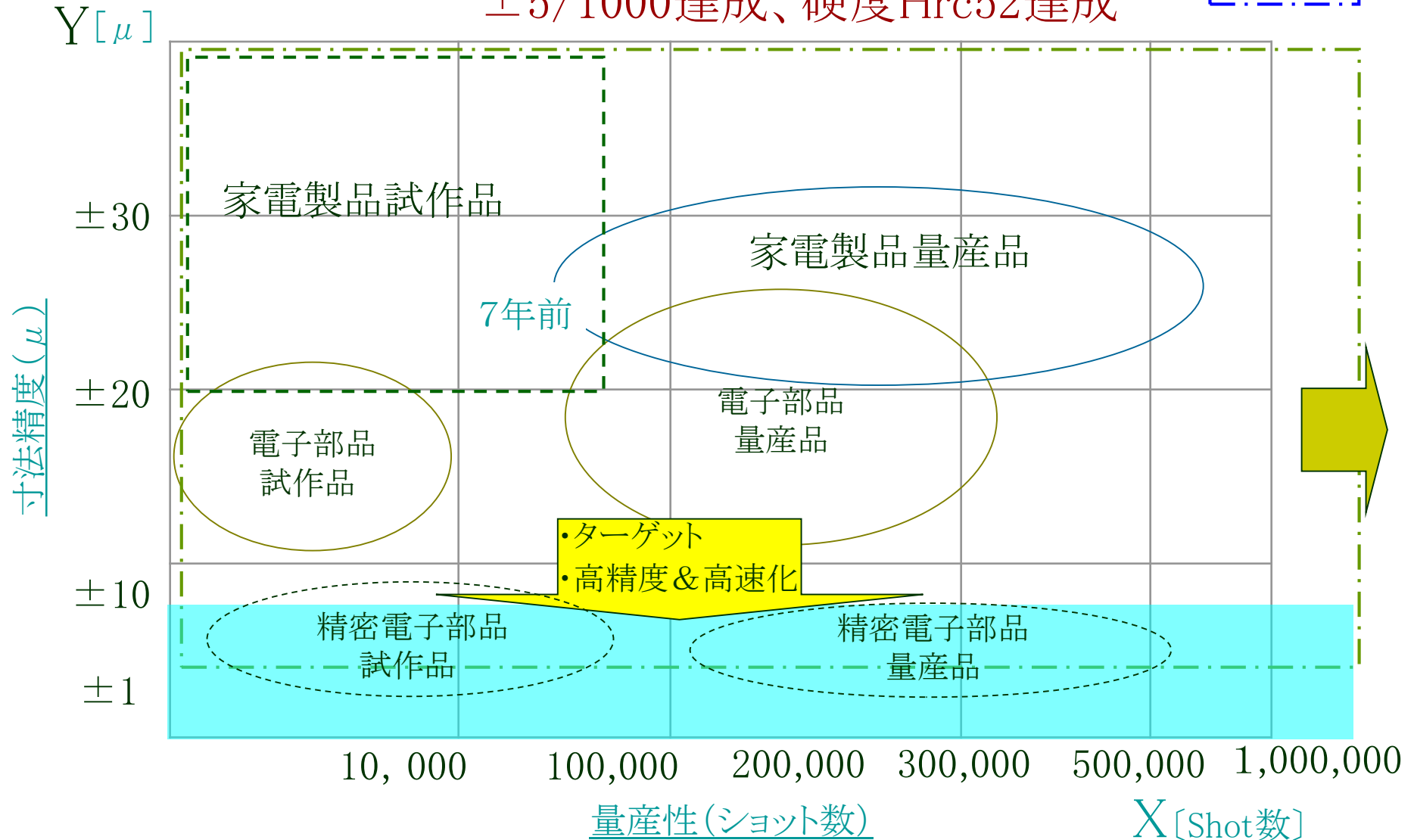
Dramatic evolution



金属粉末镭射造型复合加工法的模具加工适用范围

現状

±5/1000達成、硬度Hrc52達成

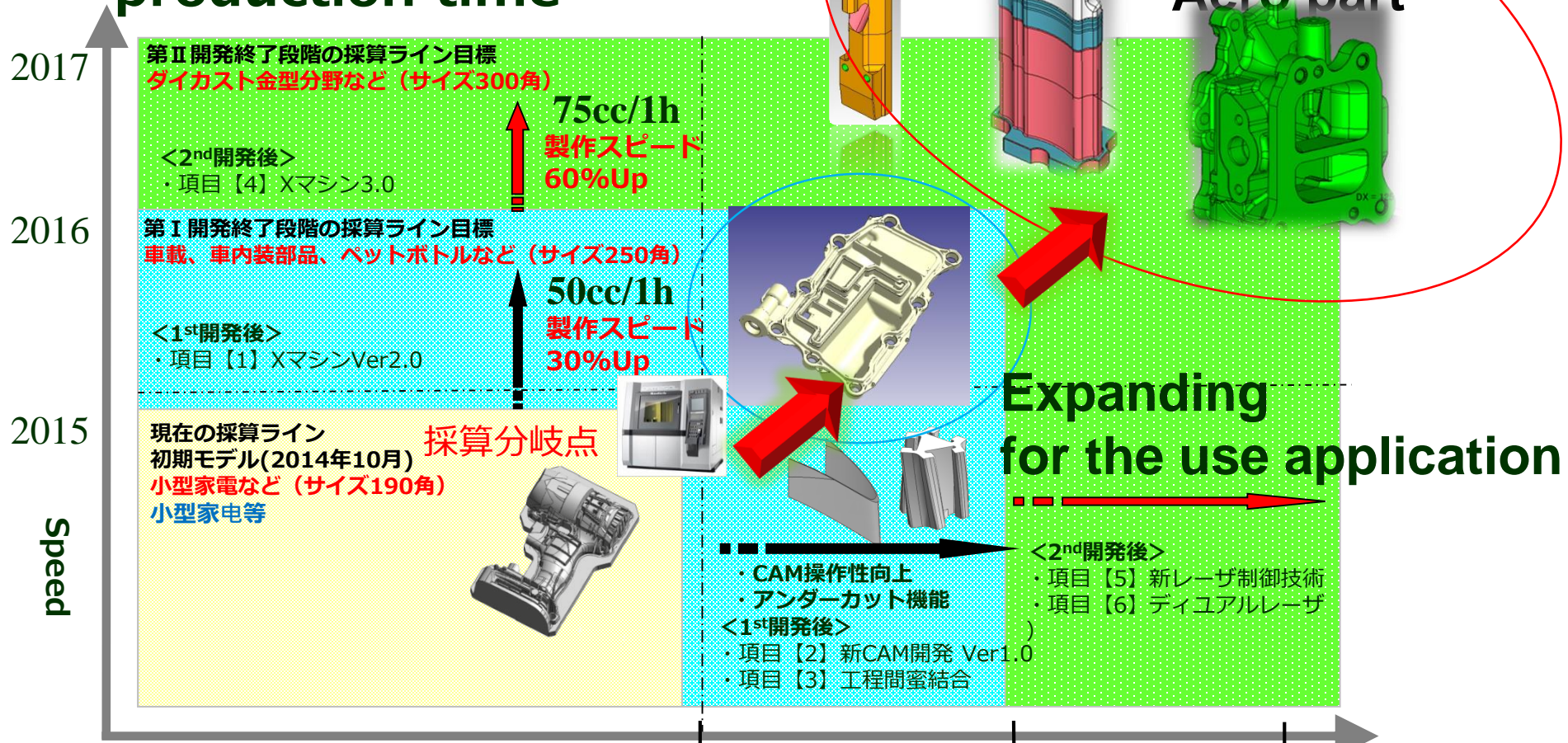


金属粉末镭射造型复合加工法的未来规划



Vision for OPM series

Reduction for production time



High accuracy · multiple function · stability

异型水路模具应用案例

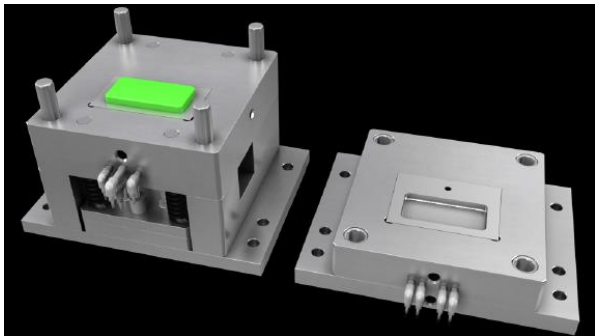
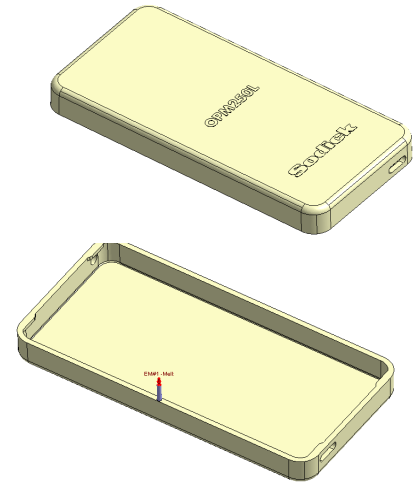
Case example “Molding for smart phone”

智能手机成形例

新!! 金属 3D打印机 OPM250L



智能手机外壳



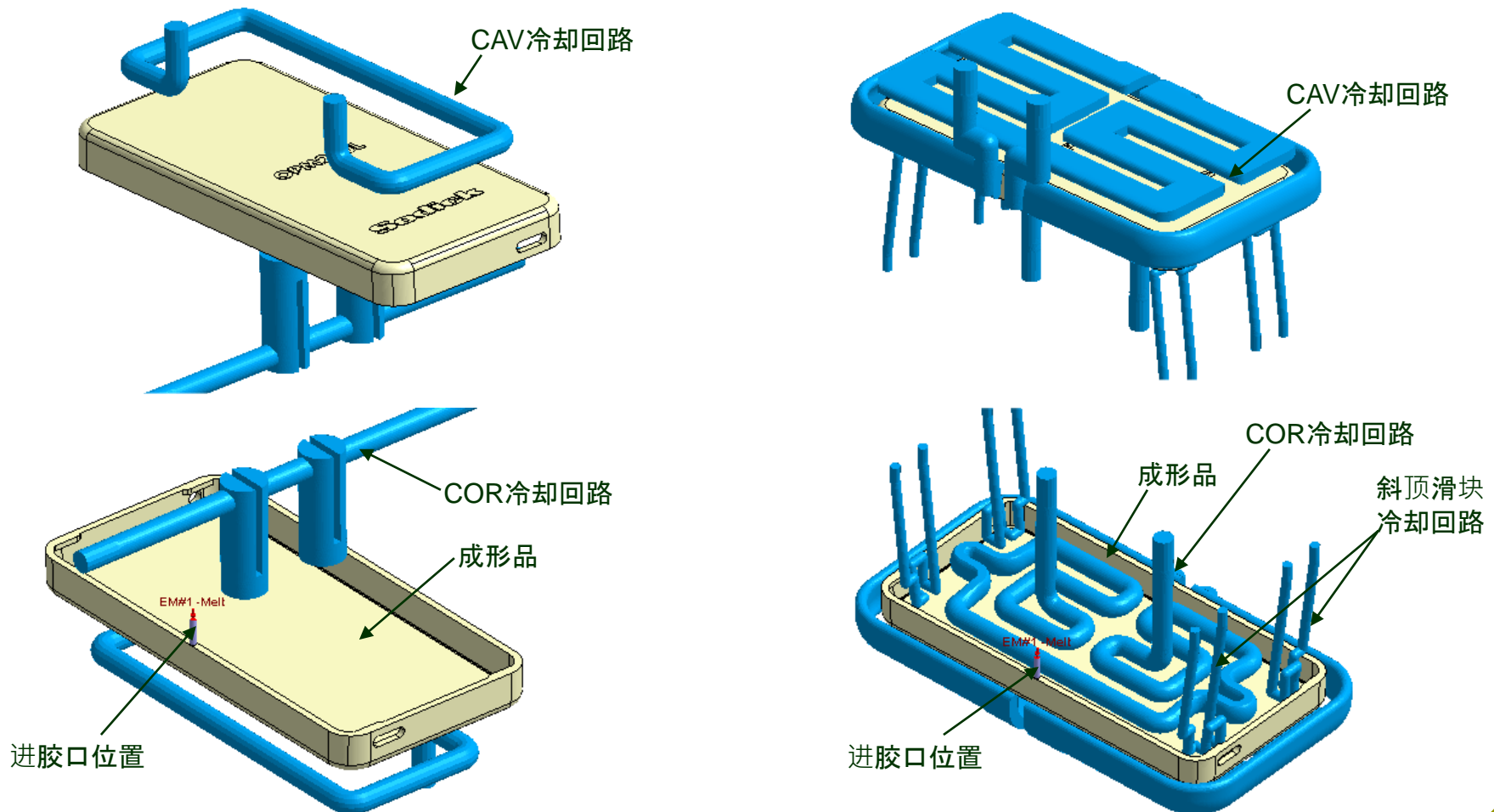
工具



注塑机(GL60)

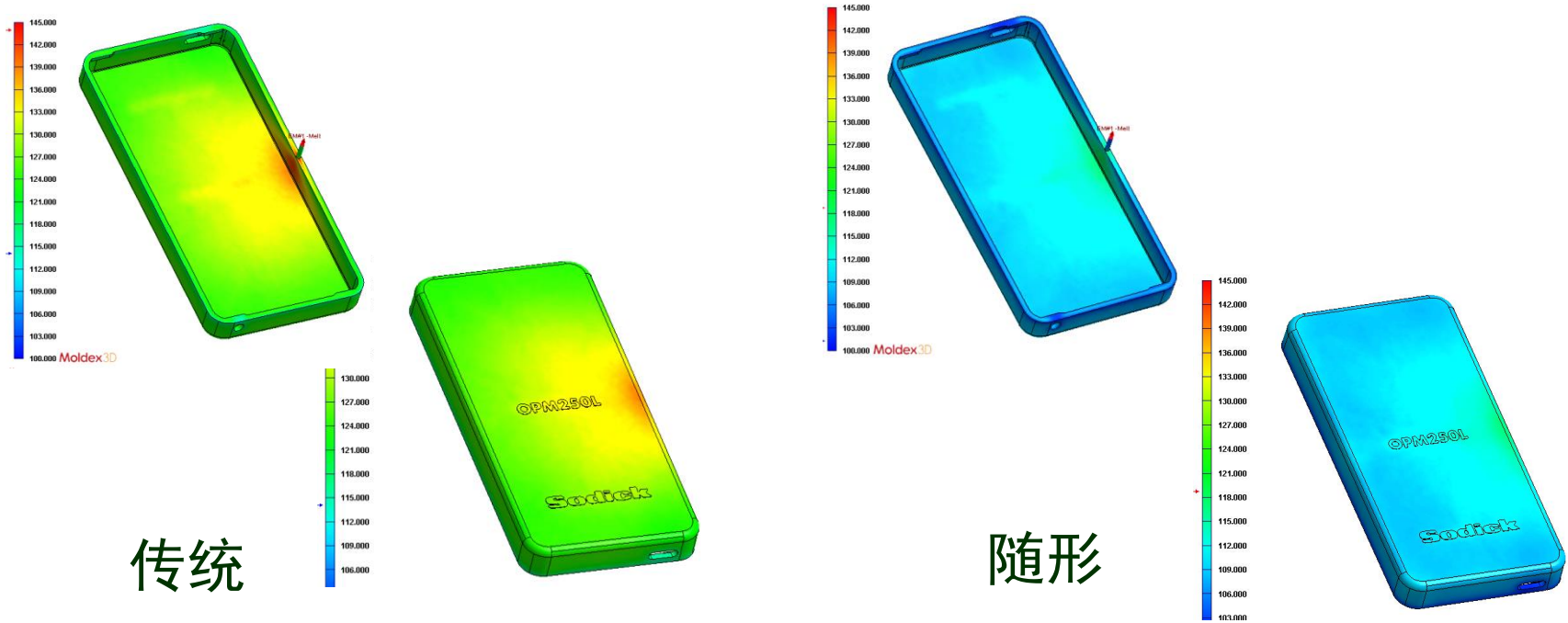
Compare normal cooling channel to conformal one

传统冷却水管和3D冷却水路的比较(产品部)



树脂温度结果(平均值)
 树脂固化平均温度(冷却时间结束时)

成形周期 23 sec
 冷却时间 8 sec



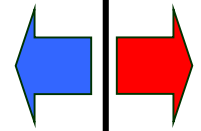
There is a difference 20 degree Celsius between normal and conformal at core and cavity side.

传统水路与3D水路之间树脂温度相差20°C

从变形的角度,冷却时间可以缩短60%以上。

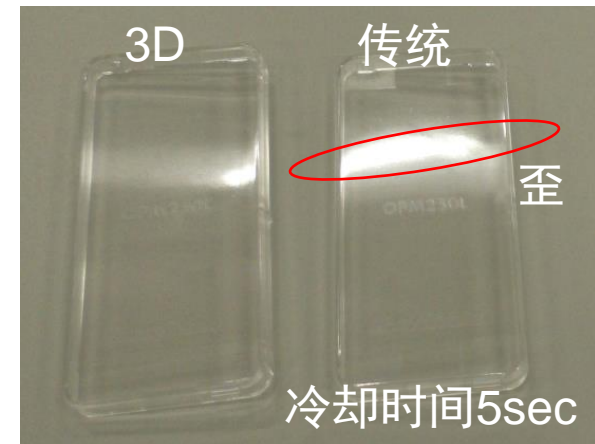
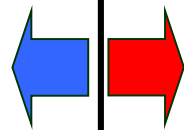
2.6倍的性能!!

3D水路产品
冷却时间:5 s
成形周期:22s



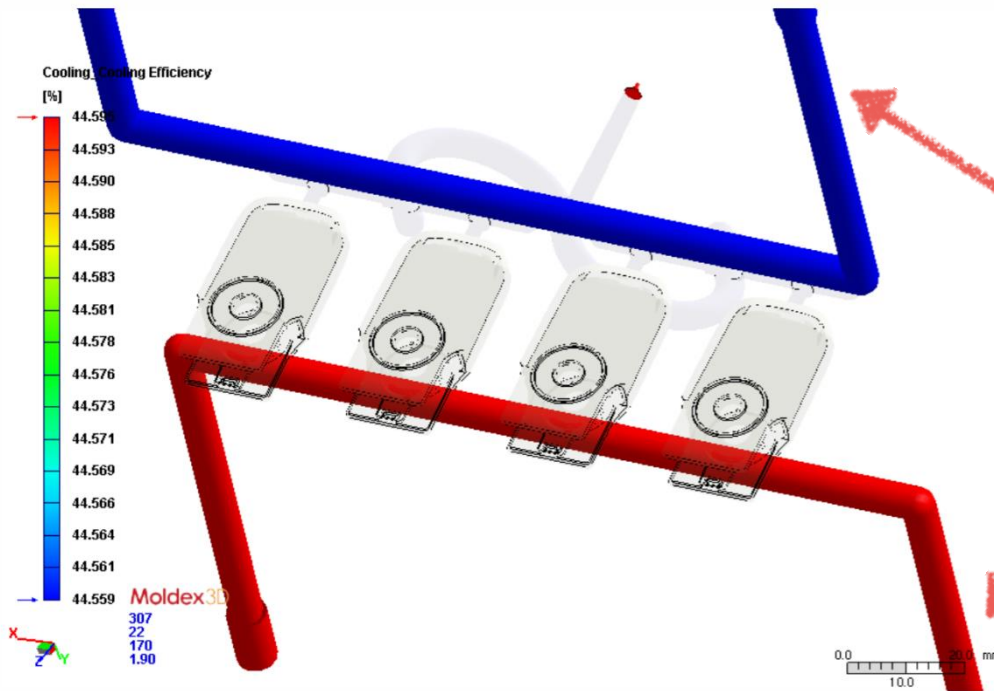
适用于连续成型

传统水路产品
冷却时间: 13sec
成形周期: 30 sec



USB模具

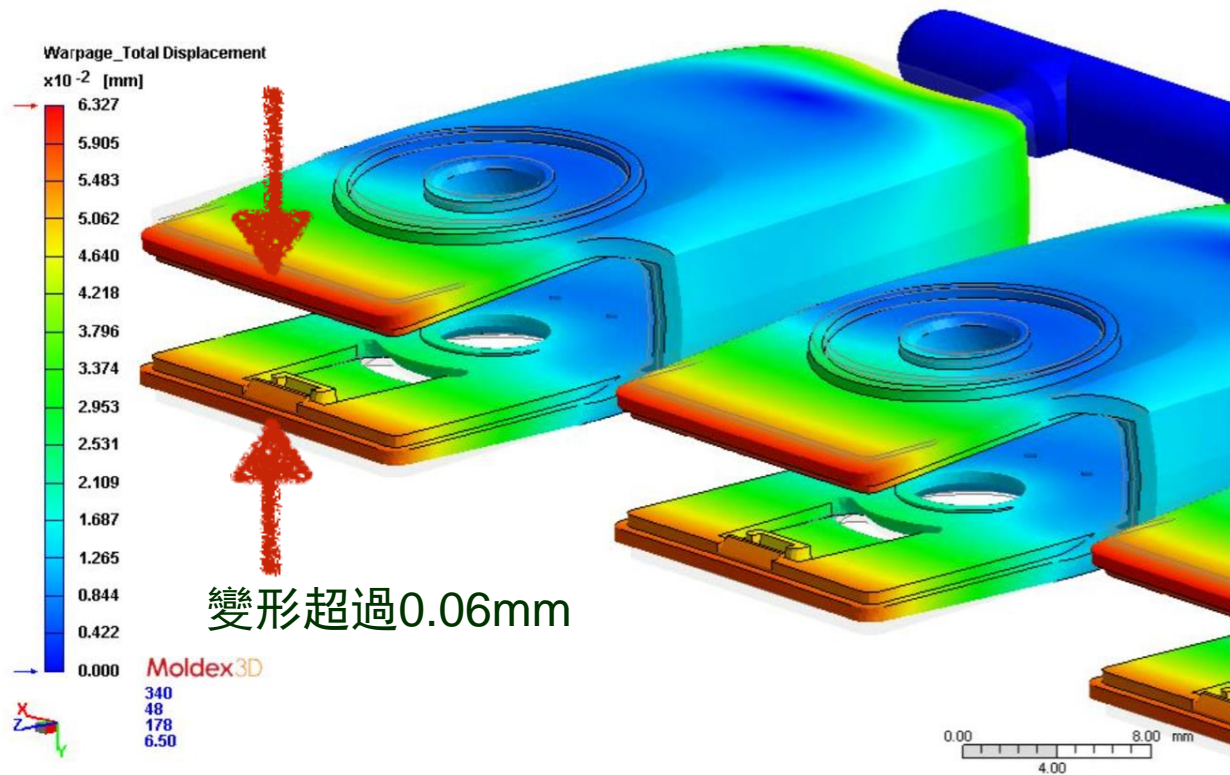
-傳統水路



只有母模水路，公模没有水路

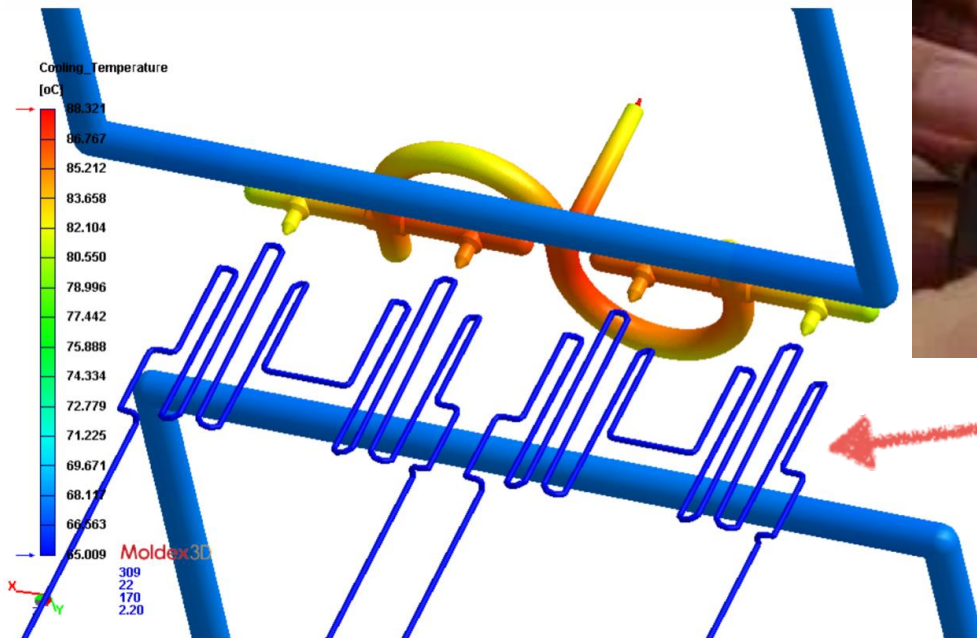
USB射出成型

-溫度不均 & 產品變形



USB模具

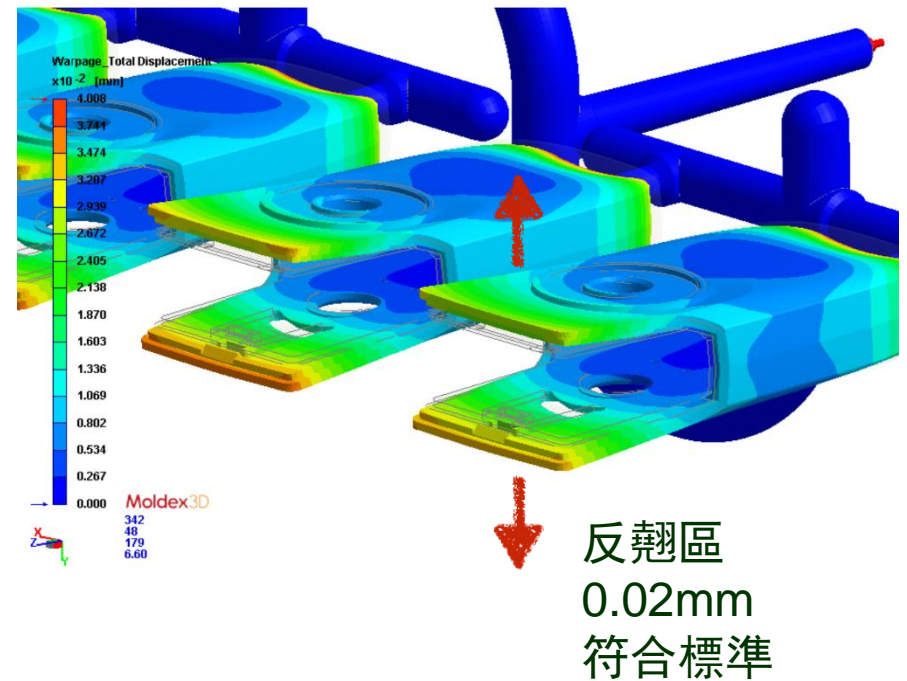
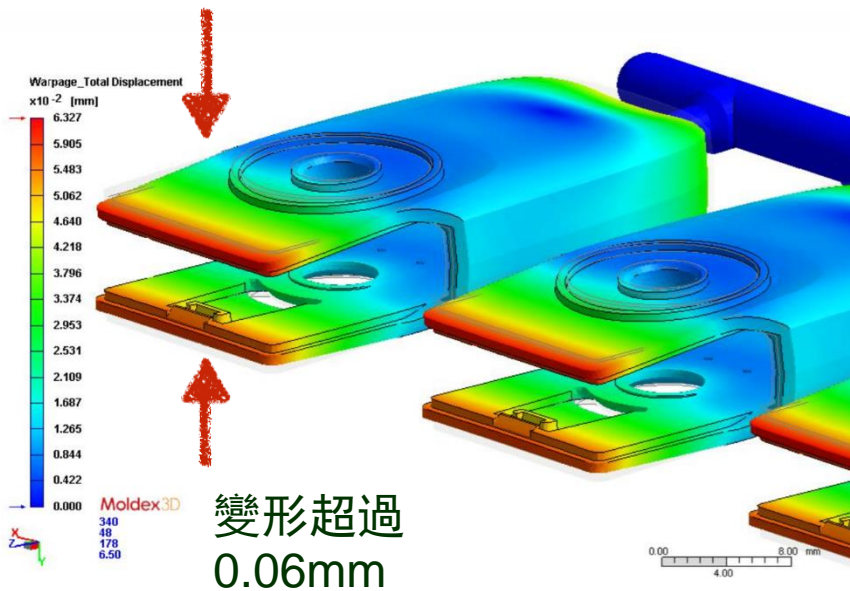
-導入異形水路



公模水路
 $\phi 0.89\text{mm}$
壁厚 $\phi 0.8\text{mm}$

USB射出成型

-導入異形水路前後



USB射出成型-冷卻效益

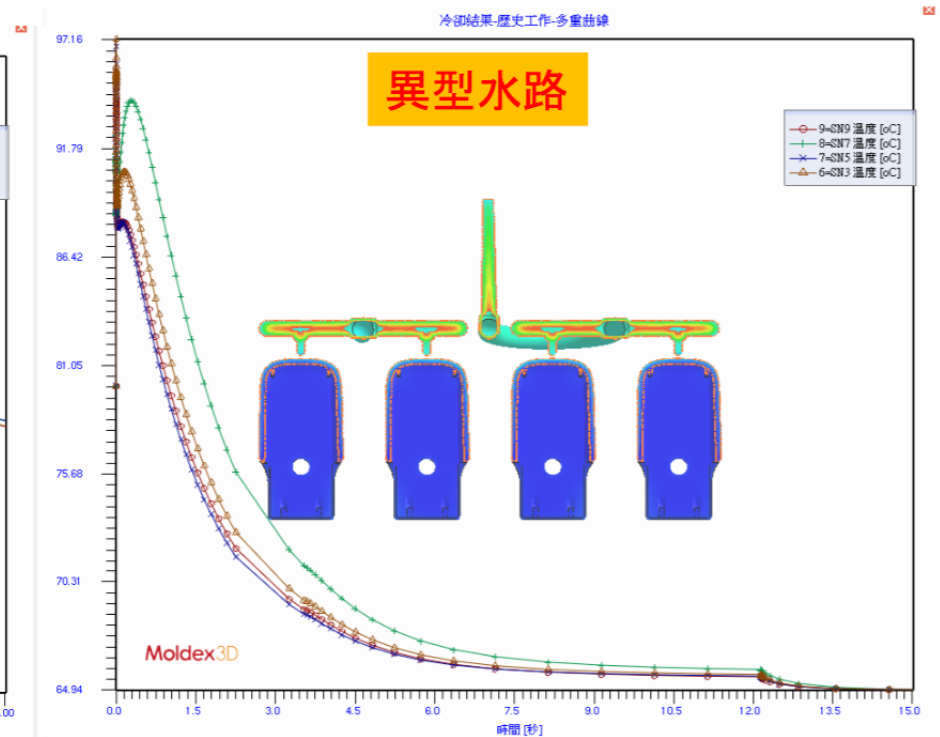
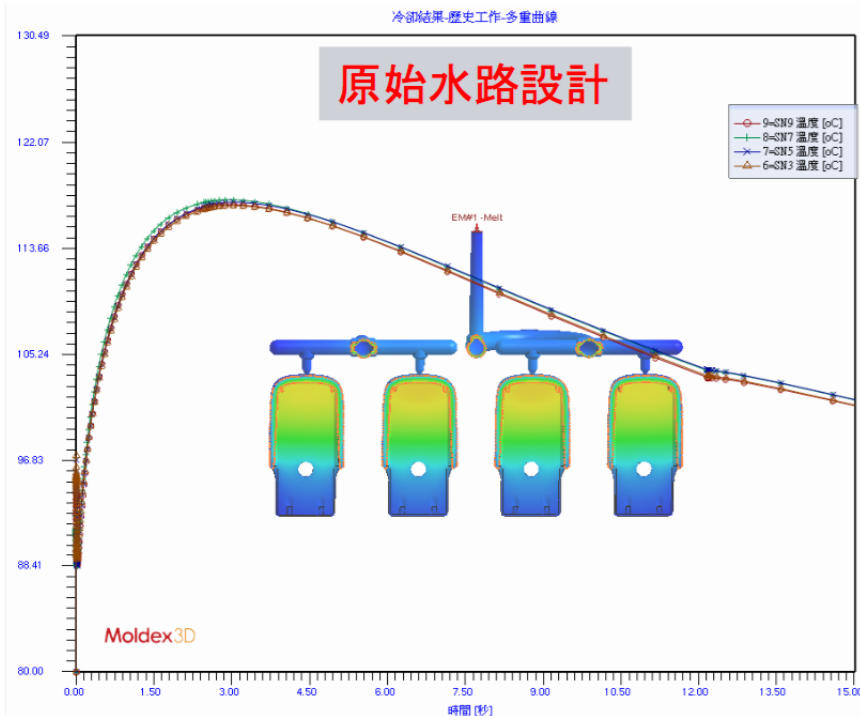
30秒

>>>>>>

20秒

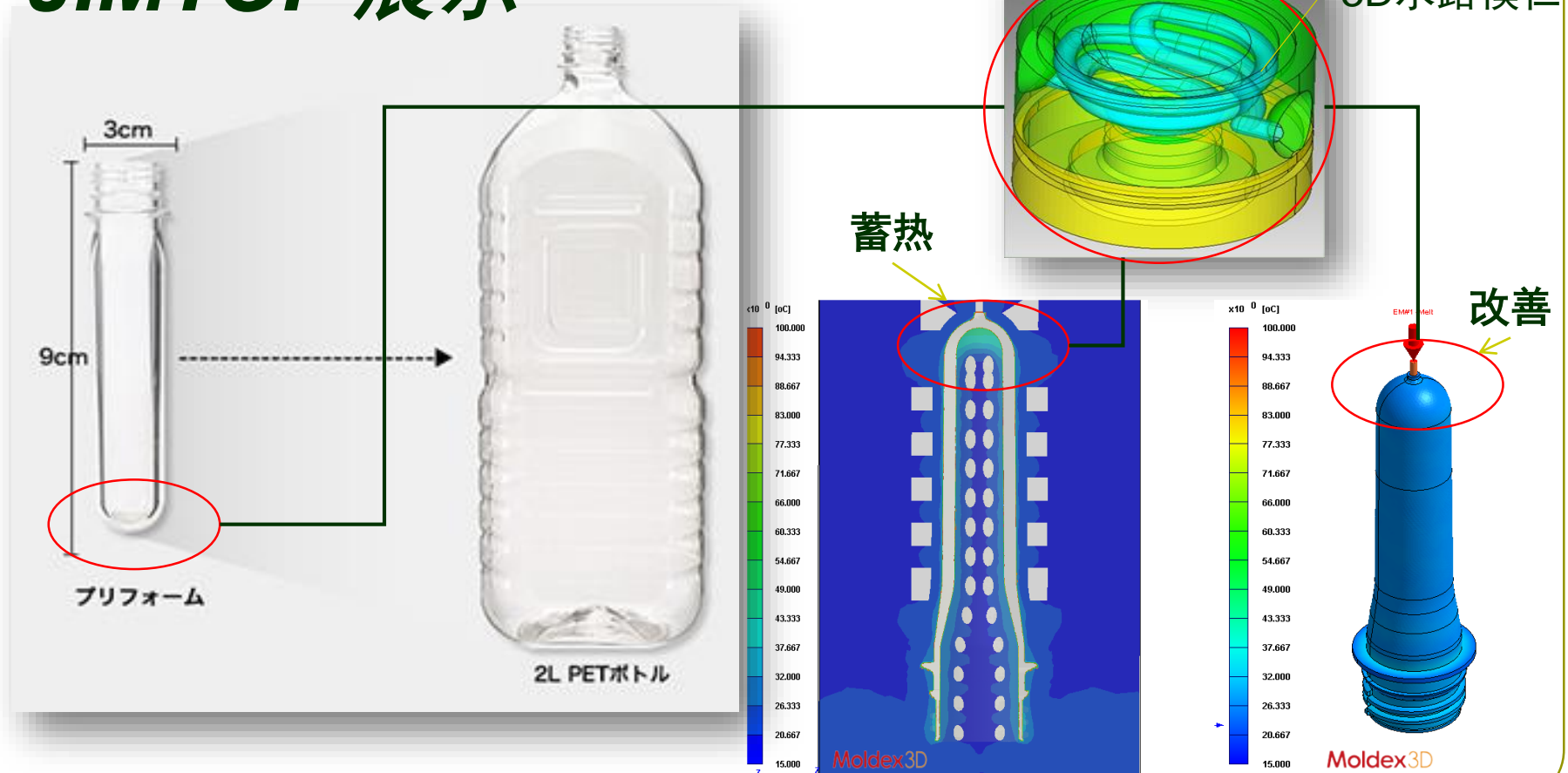
1小時省下20分鐘，大約省NTD 40元

投資 NTD100,000元 / 40元 = 1,500小時
 = 104天回本



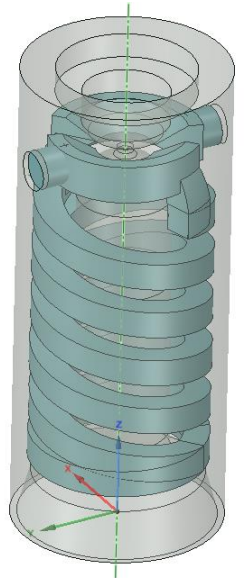
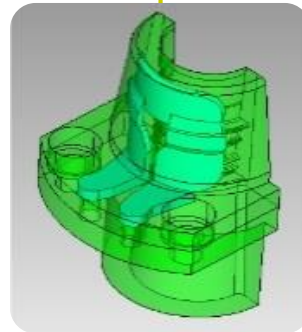
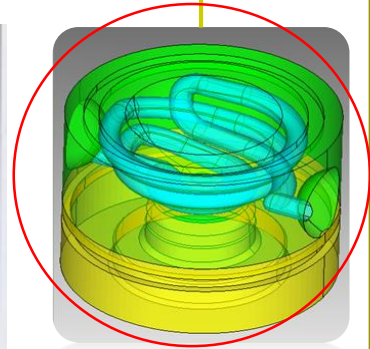
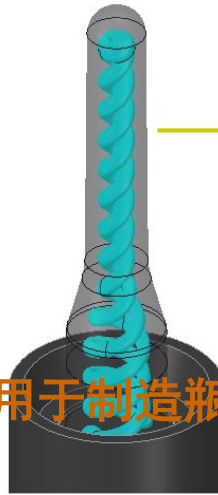
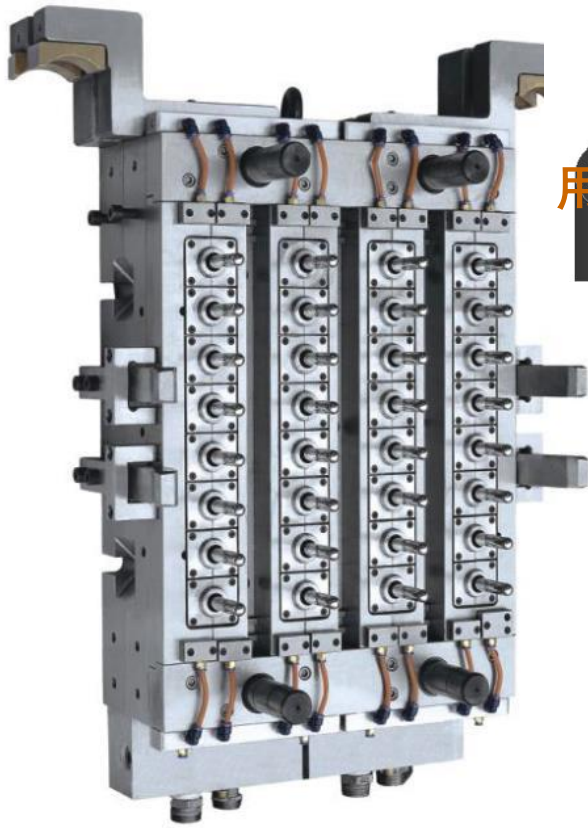
用于制造瓶胚模具 (3D水路)

JIMTOF 展示



用于制造瓶胚内芯 (3D水路)

用于制造瓶胚模具 (3D水路)

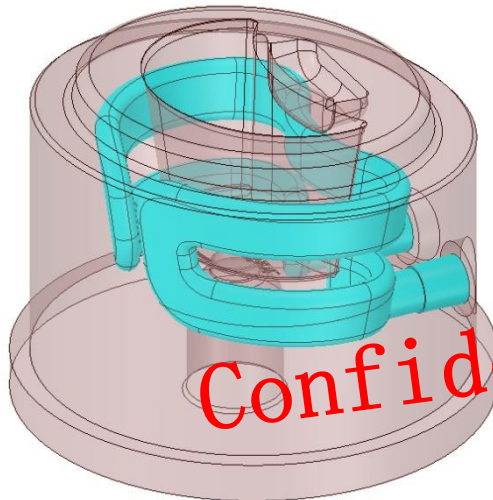
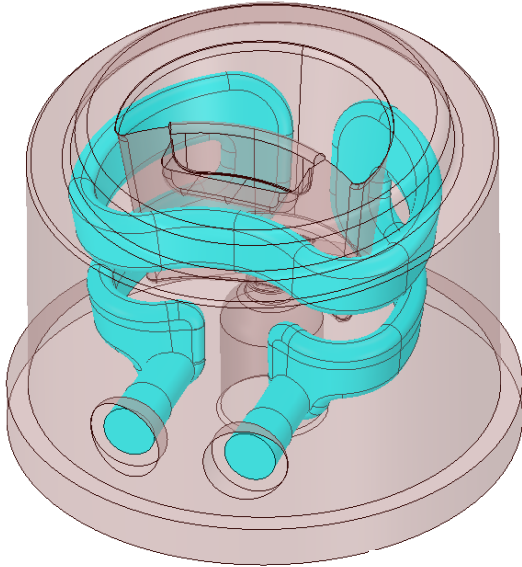


Case example of Home appliance

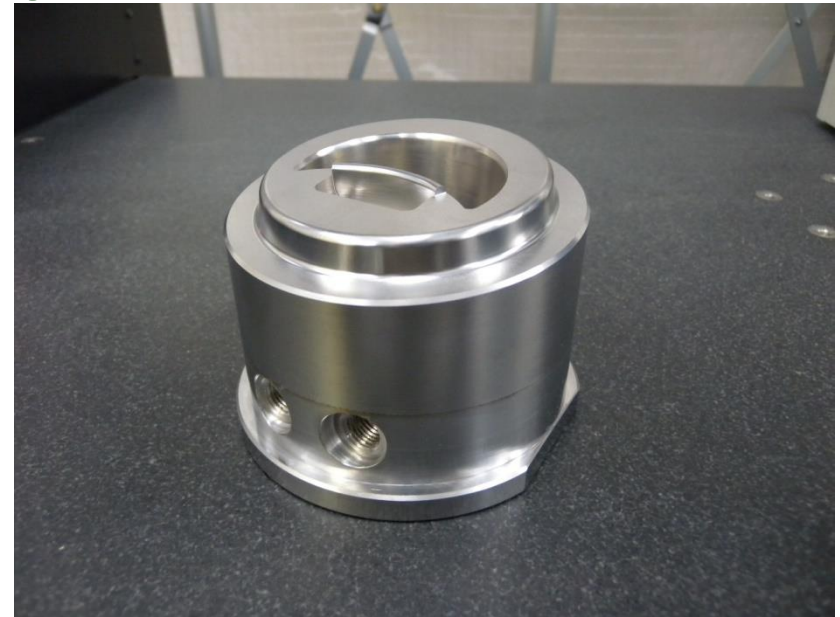
(material : Ultra Hrc52)

accuracy 1 / 1 0 0

P&G



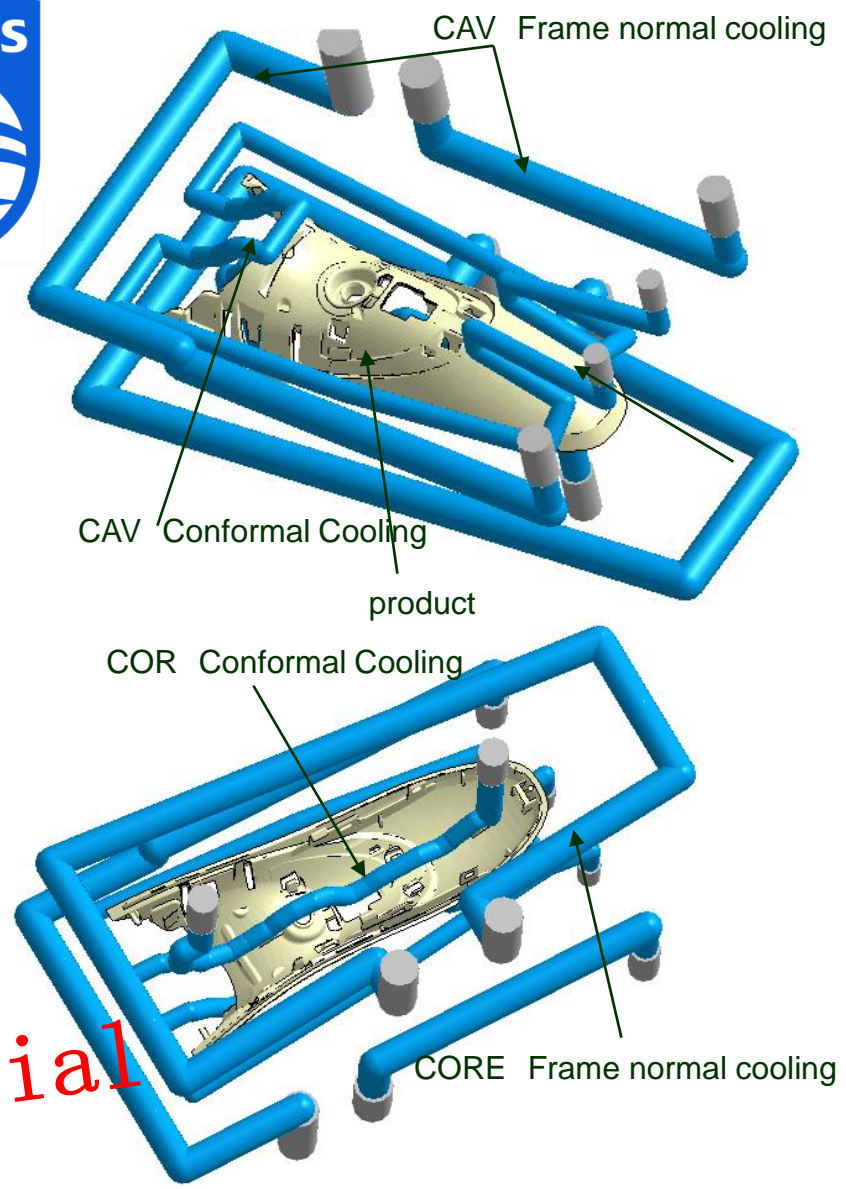
Confidential



Case example of shaver

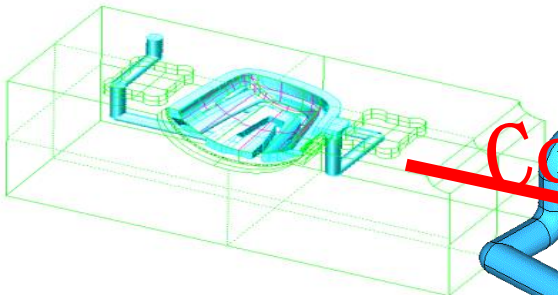
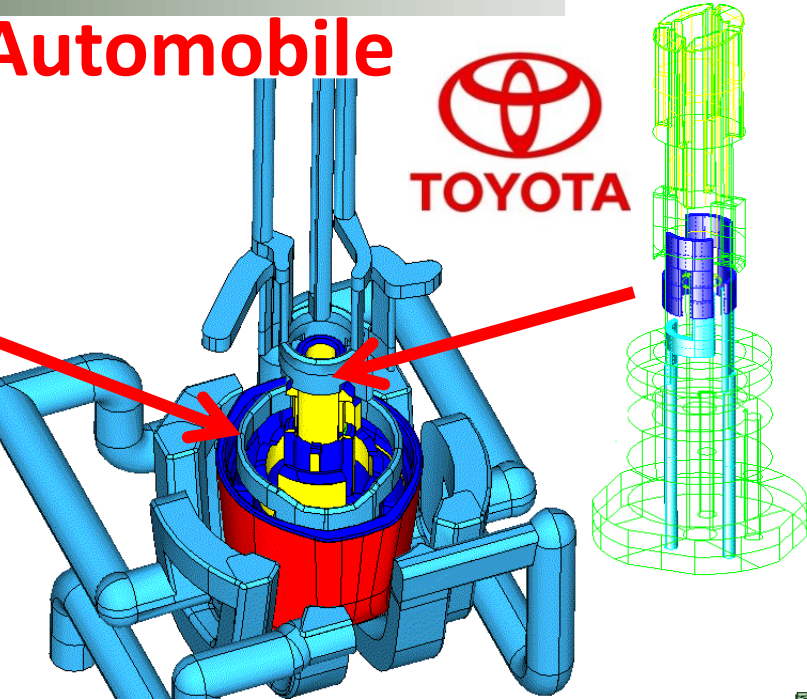
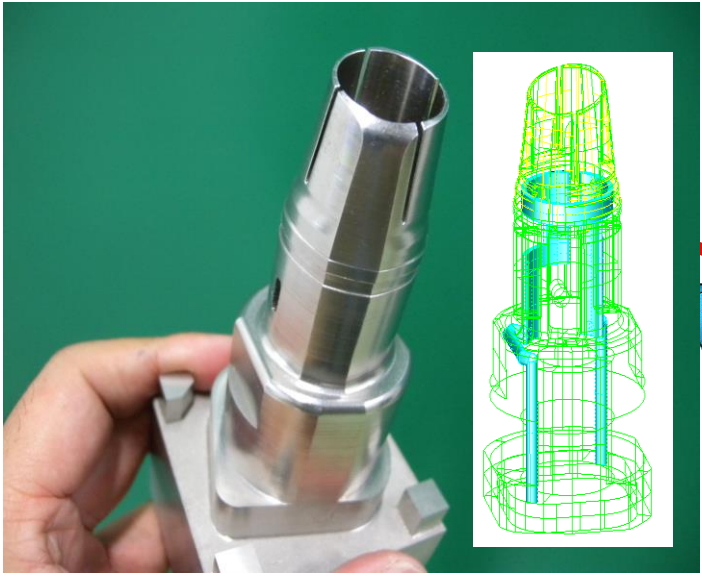
(material : Ultra Hrc52)

Accuracy 3 / 1 0 0 0

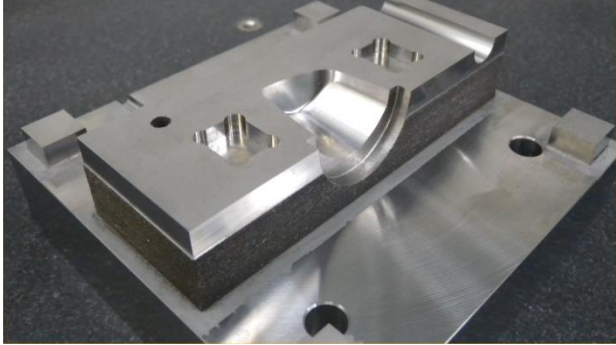
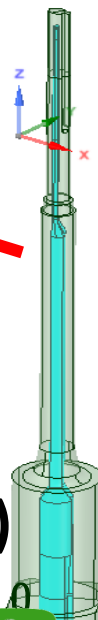
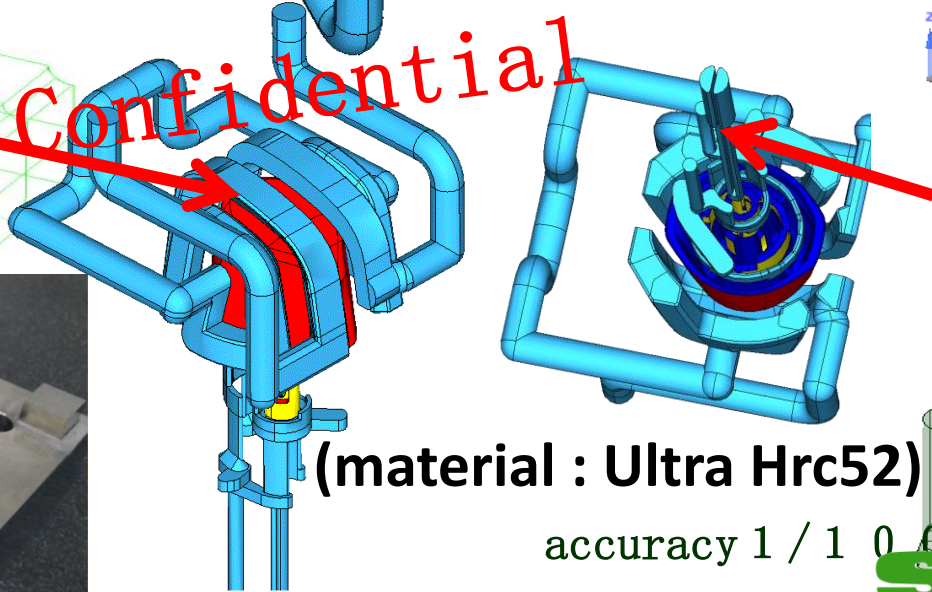


Confidential

Case example of Automobile



Confidential



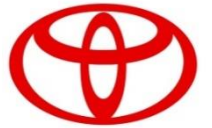
(material : Ultra Hrc52)

accuracy 1 / 1 0 0

Sodick

Case example of Automobile (material : Ultra Hrc52)

accuracy 1 / 1 0 0

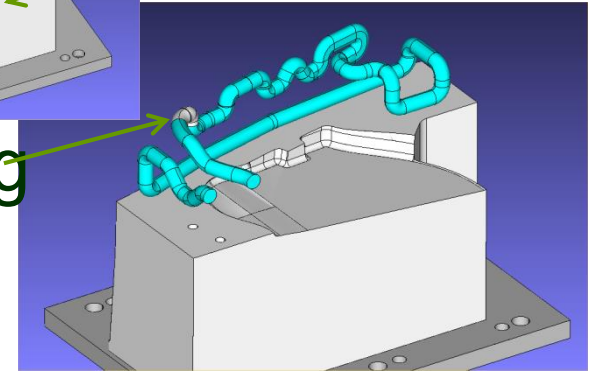
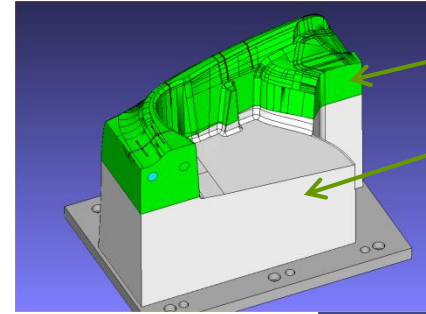
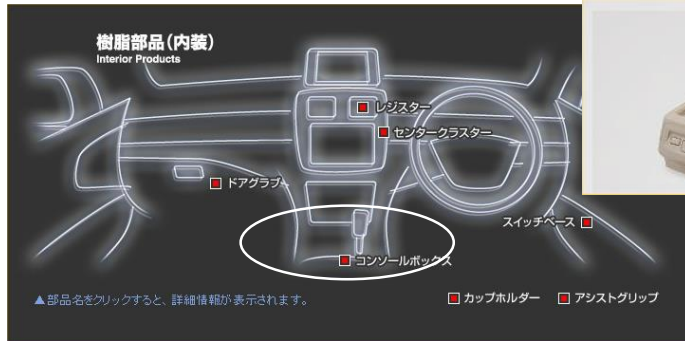


TOYOTA

DMLS

Plate

Conformal cooling

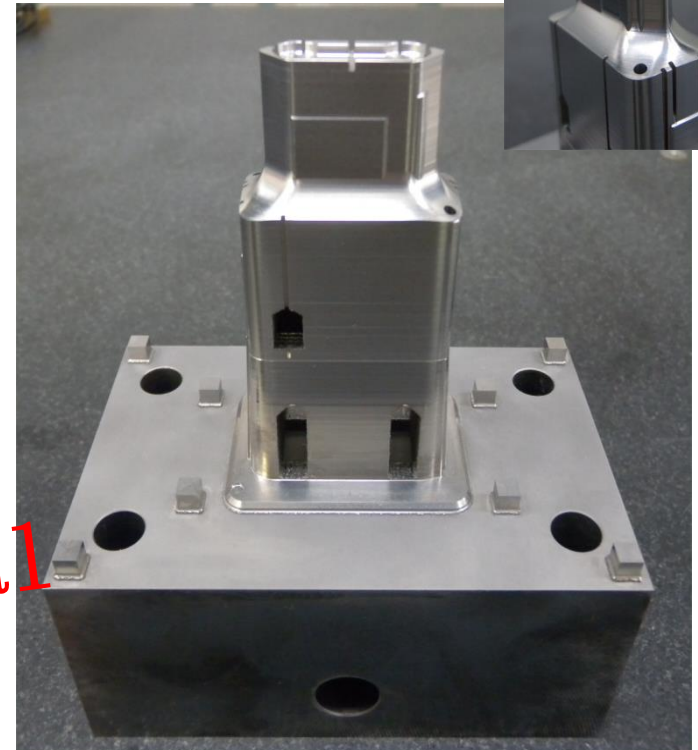
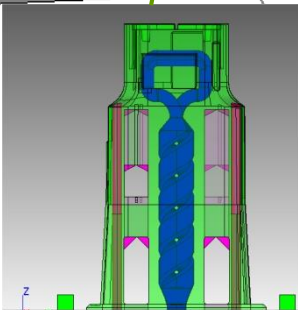
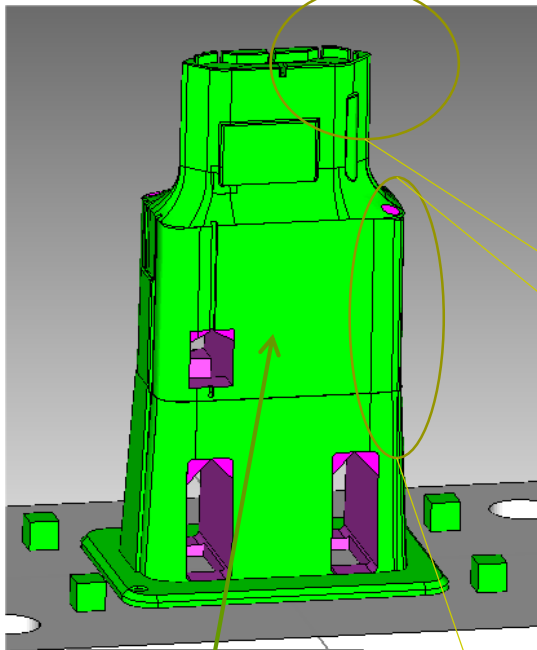
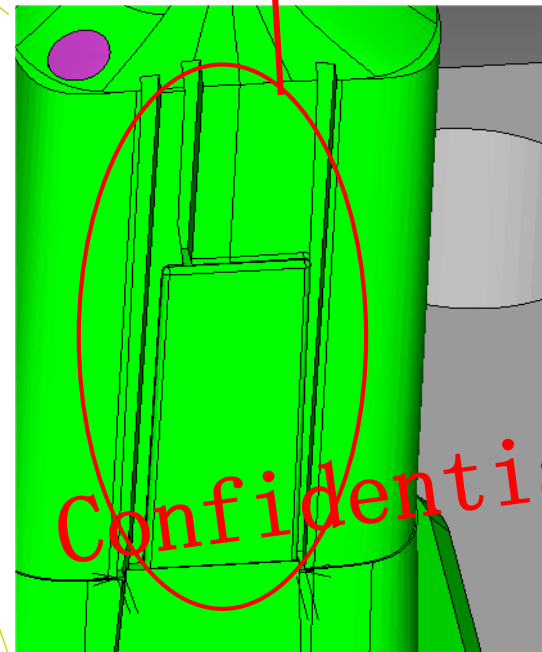
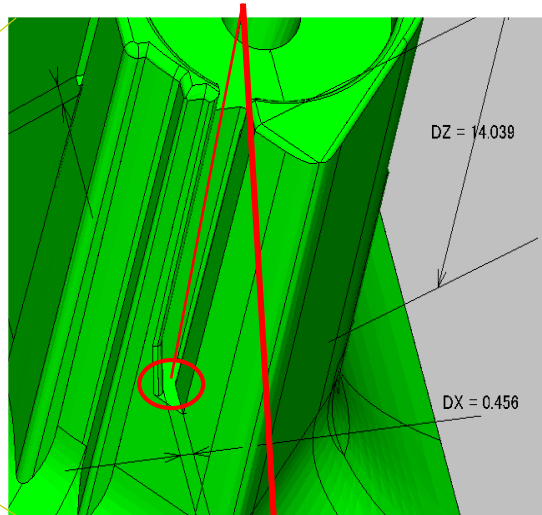


Confidential

Case example of plug (material : Ultra Hrc52)

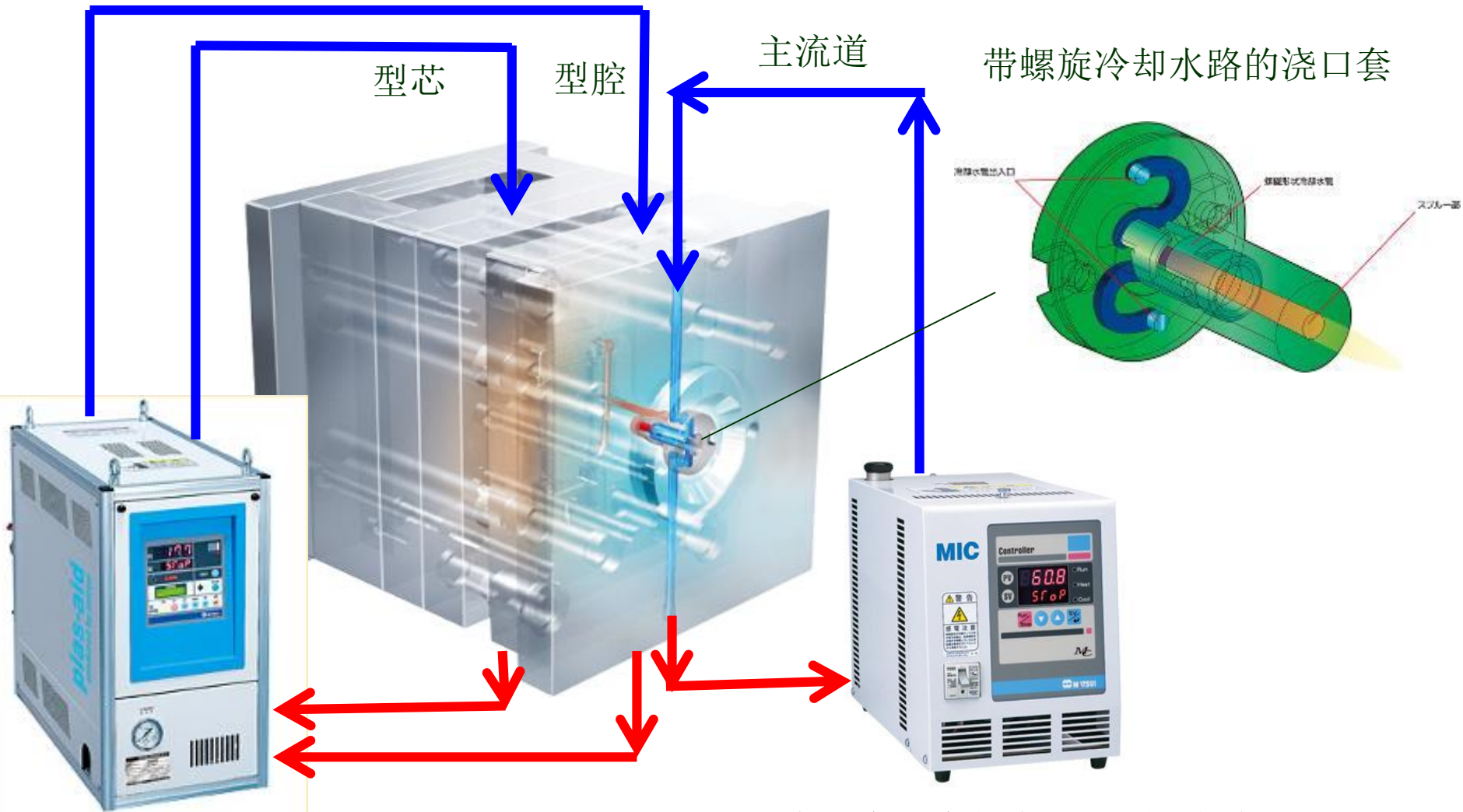
Accuracy 5 / 1 0 0 0

Salcomp



利用通水浇口套及其专用温控机对模具进行高度的温度管理

(可以针对主流道部位，设定与模具其他部位不同的控制温度)



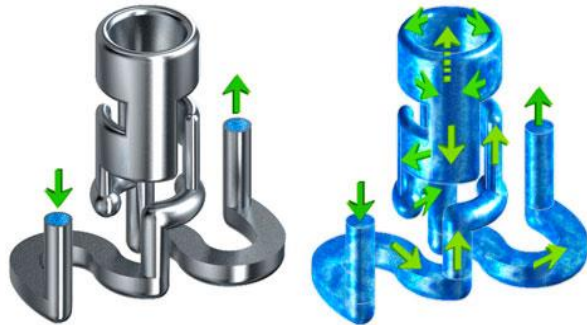
通常的模具温度控制机

与通水浇口套配套的专用小型温控装置

〈手机零件〉

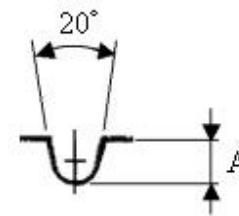
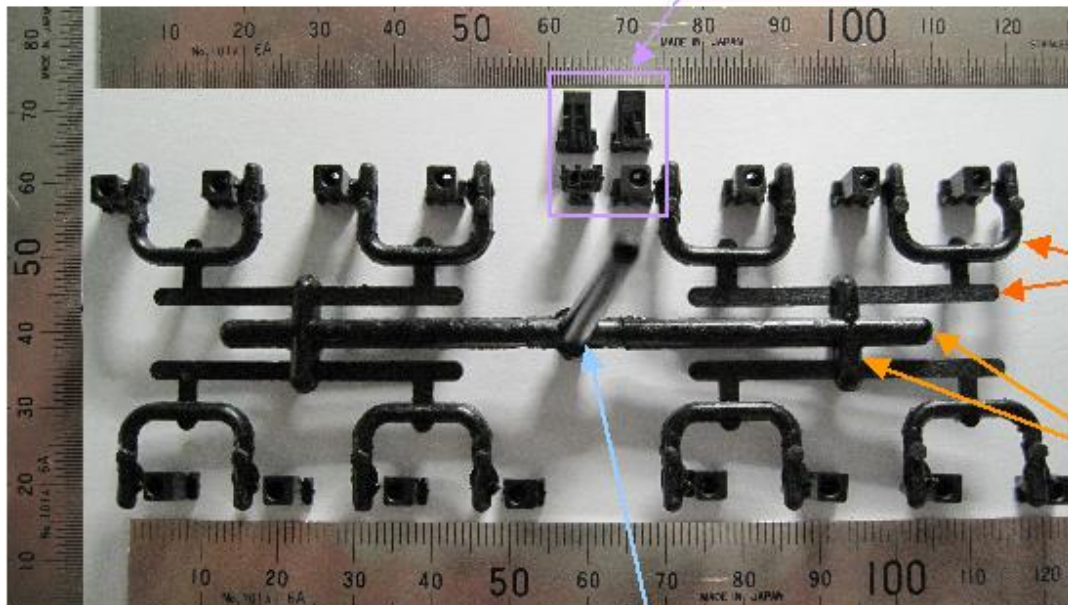
成型周期减少60%

- 1、冷却時間 使用前25sec⇒使用後5sec
- 2、成形周期 使用前37sec⇒使用後15sec



成品
最厚部：2.0
最薄部：0.2

- Mini DC Jack
携帯電話の電源(充電)プラグ受口。
- 成品の外寸は、 $3.5 \times 3.8 \times 7.5$
- 製品単体重量は、0.0813g
- 16CAVで1.3008g
- ランナー&スプルー重量2.56g
- PET材は新光製
- * ノンハロ材を用いたグリーン購買に関するもの



$A = \Phi 2.0$

$A = \Phi 3.0$

带内部螺旋状
水路浇口套的
冷却效果案例

Sprue L=38.0
 $\Phi 2.5 : 2^\circ$

<结论>

金属3D列印复合加工技术，是增量加工和去除加工的结合，既保留了柔性加工的优点，又发挥了高速切削加工精度好的特长，可一次性、一体化、高效率地加工完成具有内部异型水路和局部排气功能，但表面形状复杂、且难于实施后续加工的精密模具零件，为塑胶成型行业的广大客户提供了一种新型的模具零件加工技术。



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<http://www.matsui-mfg.net>