Plastic Laser Sintering
–Challenges to Real Manufacturing–

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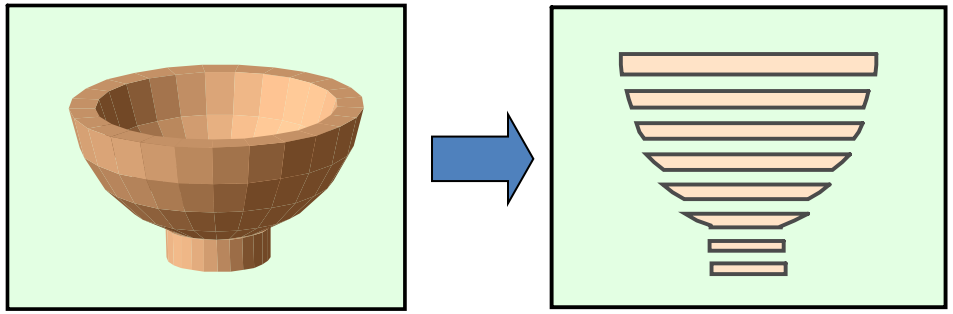
Outline

- Additive Manufacturing
- Research activity at IIS UT
- Preheat free laser sintering
- Conclusions

Additive Manufacturing

- "process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies, such as traditional machining." -ASTM F42 Terminology

Computer

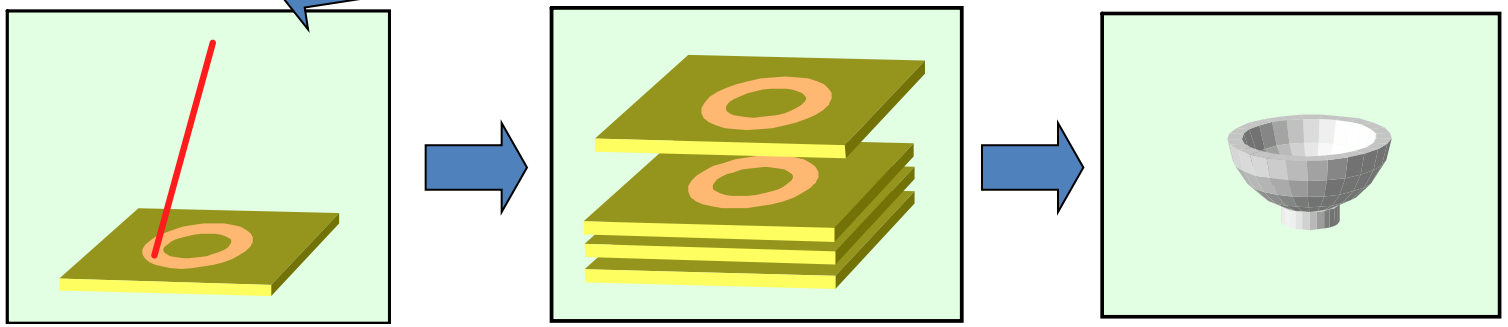


3D CAD Data

2D slice data

- This process runs automatically once it is started by single click.
- Variety of sheet fabrication and lamination methods.
  SLA, SLS(M), Inkjet, etc, etc…

Real world



Sheet fabrication

Sheet lamination

Real 3D object

Rapid Prototyping, Manufacturing and Tooling

- Rapid Prototyping (RP)

  Why “rapid”?

  Because of short lead time and low initial cost.

  Why “prototyping” ?

  Because we cannot or could not use that technology for mass production due to its low productivity, high cost per part and low qualities such as mechanical strength and precision.

- Rapid Manufacturing (RM) and Rapid Tooling (RT)

  •Fast establishment and flexibility of production

  •Lower cost in low volume production and tool fabrication

  •Low but acceptable quality for specific application.

- Rapid Technologies/*RX* Technologies

  AM applications that are utilizing rapid features of additive manufacturing.

Non-Rapid Applications

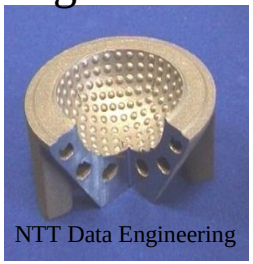
- Does AM application always force us to be tolerant about its low quality? Is there any advantageous quality with AM other than rapidity?
- Additive manufacturing provides us with…

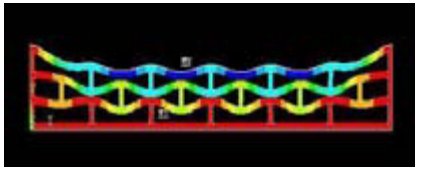
  Great freedom of part topology; design freedom

  Pluralism of material in a single part (functionally graded material)
- Non-rapid AM application

  Applications that is supported by AM advantages other than rapid relating features. Lattice structure, cooling channel, functionally graded, mesostructure
- Finding adequate applications of immature manufacturing technology is a big challenge but rewarding. Price competition using conventional manufacturing is exhausting and everlasting.

ARCAM


NTT Data Engineering


University of TEXAS

Challenges Toward Non-Rapid Application

- Smart application and business model

  The part in nonrapid application can be realized only by additive manufacturing.

  Mechanical design that can be fabricated only by AM is not accepted by the most bosses in industries.

  We need smart applications that are worth to use AM.

  High flexibility of AM is advantageous for mass customization. Many business model combining AM and internet have been proposed.

  >> Industries

- Much more technological progress as fabrication methods

  Physical and chemical property, precision, productivity, repeatability, cost and sustainability

  >> Academe

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- Additive Manufacturing
- Research Activity at IIS UT
  1. Plastic Laser sintering
  2. Photonic device
  3. Tissue engineering scaffold
- Preheat Free Laser Sintering
- Conclusions

Research Activity at IIS, the University of Tokyo

- Process

  Plastic Laser Sintering

- Research topics

  Non-rapid application of plastic laser sintering

  Biomedical, Material Science

  Process development / improvement

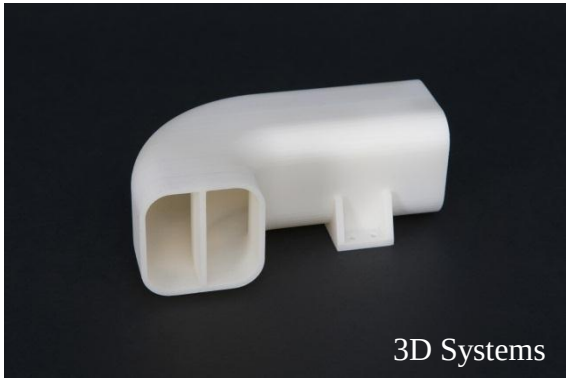
Application of Plastic Laser Sintering

- Thermoplastic (mainly semi-crystalline)

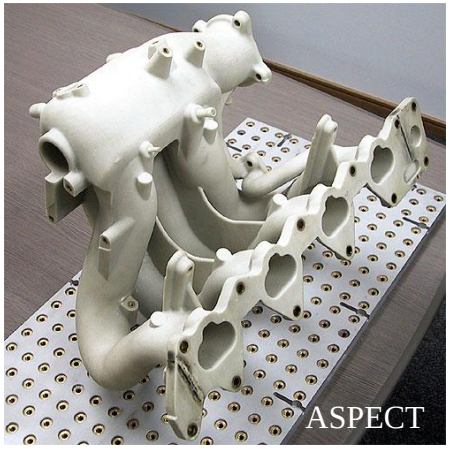
  PA12, PA11, PP, PEEK, PS(for casting)
- Relatively good material property

  Impact, durability, heat resistance
- Relatively easy material development

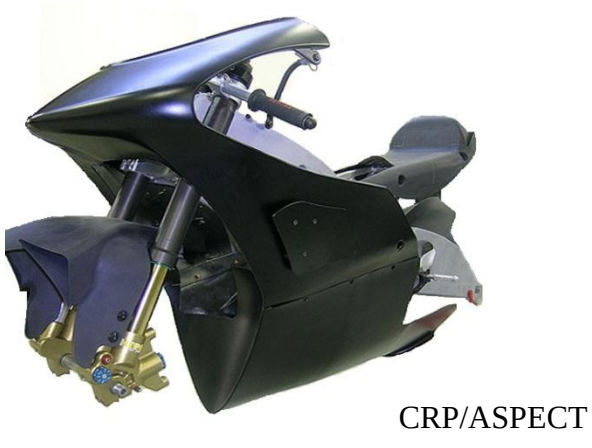
  Polymer and filler added version



Proposal model of fighter jet air duct, PA



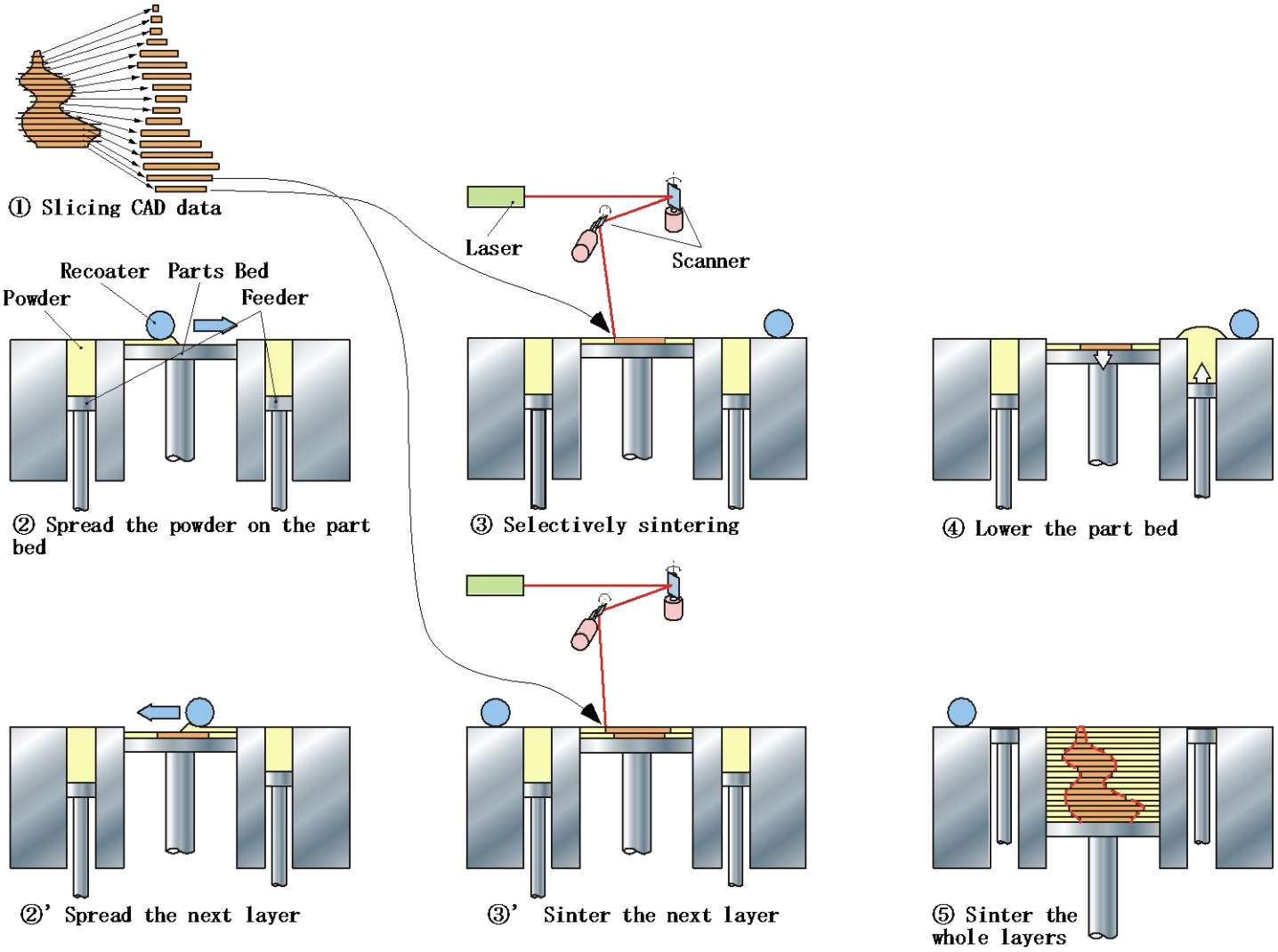
Benchmark test manifolds, glass filled PA



Motorbike fairing, cabon fiber filled PA

Violin, PEEK

Plastic Laser Sintering



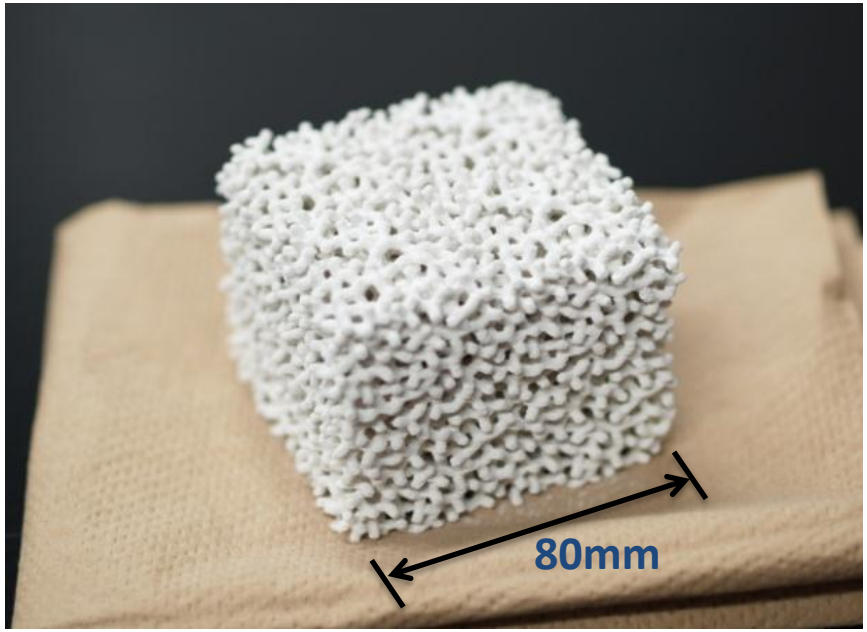
Photonic Device

● Wavelength ordered structure with high dielectric contrast has an optical band in light wavelength spectrum, which is known as photonic crystal.

●We proposed amorphous structure can have the gap as well.

● We apply selective laser sintering to fabricate such structure.

●To obtain high dielectric constant, we are using filler-binder system.



Tissue Engineering Scaffold –Introduction

- Objective

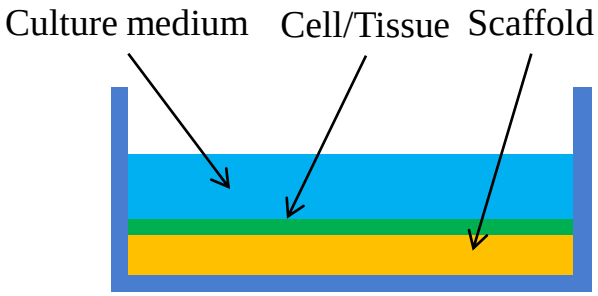
  Reconstruction of a large scale organ in vitro

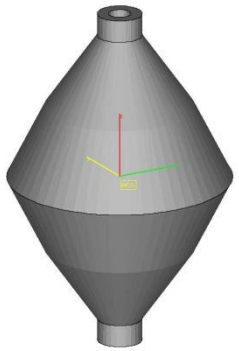
- Challenge

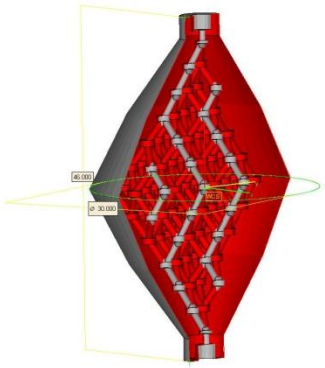
  There is a limitation in thickness of tissue growth on a scaffold due to necrosys.

- Approach

  Embed a fine flow channel network system in 3D scaffold to supply culture medium not only its surface but in the scaffold as well; increase surface area of a scaffold by using complex topology

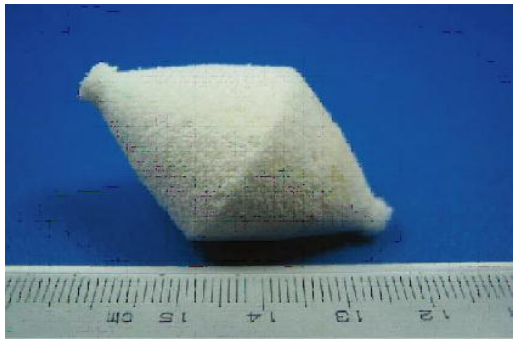


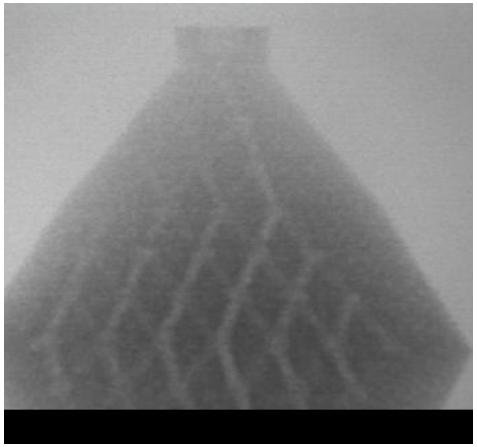


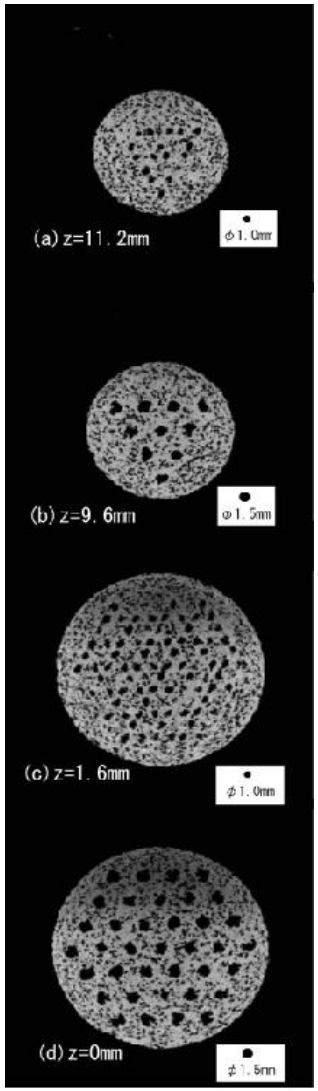


Tissue Engineering Scaffolds –Results

- AM is the unique solution to fabricate the scaffold.
- Poly-caprolactone biodegradable plastic was used for scaffold material.
- SLS was selected because of its high adaptability of new material.







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- Preheat Free Laser Sintering
  1. Process
  2. Results
- Conclusions

Preheating in Plastic Laser Sintering

- Preheating in plastic laser sintering

  In normal plastic laser sintering process, powder bed is preheated to the range called as "process window" which is between melting and recrystallizing temperatures. This temperature control is performed in order to prevent the in-process parts from warping.

- Drawbacks of preheating

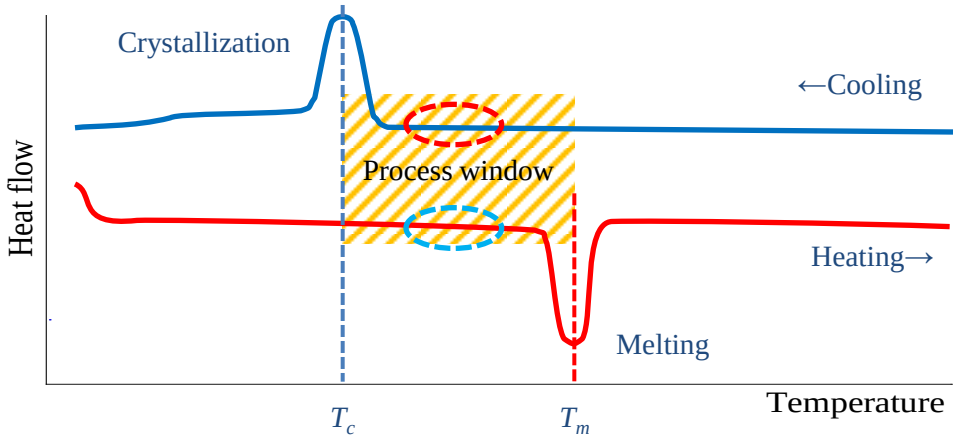
  Some plastic does not have process window, and some additive agent can close the opening window; preheating is drag of material development.

  Requirement of precise temperature control and high heat resistance.

  Preheating unused powder might affect powder recyclability.

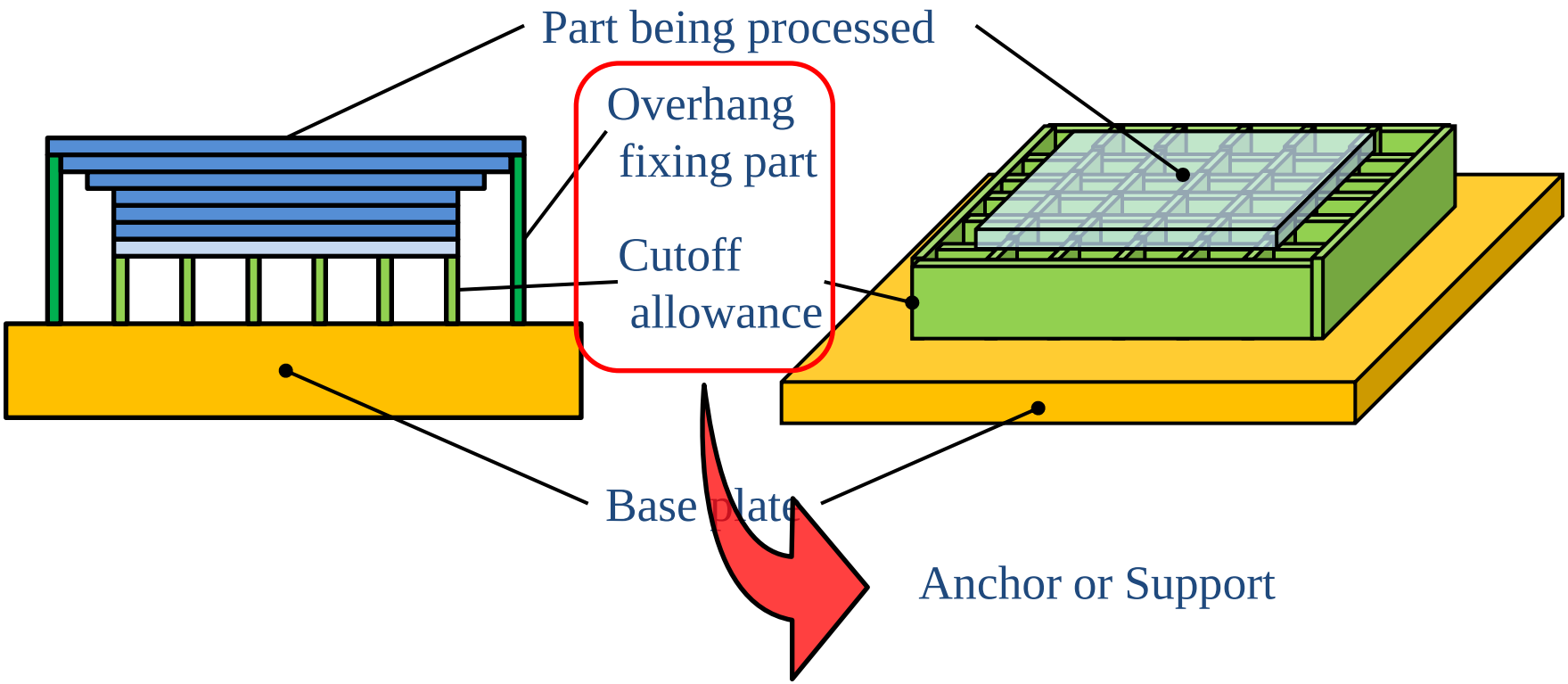
  Preheating consumes more than 50% of total power consumption of a typical commercial laser sintering machine.

Preheating solves the warping problem elegantly, but we have many reasons to quit it!!

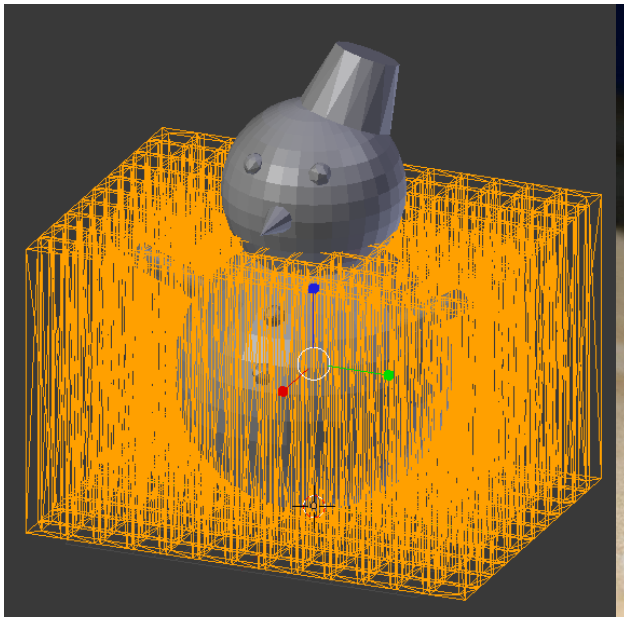


Preheat free Plastic Laser Sintering –Process

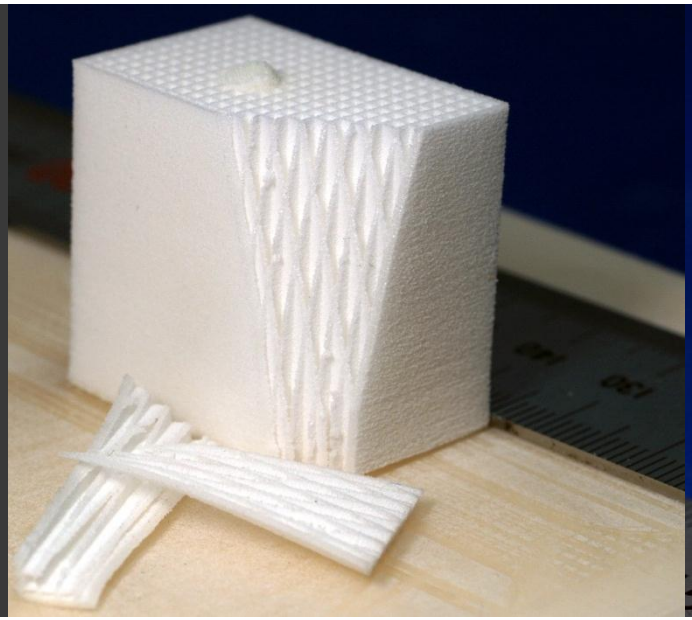
To prevent parts from warping, the parts is fixed to a base plate with supplemental structure, “anchor” and “support.”



Result 1



3D model data



As build

After anchor removal

It works!!

Now we have a lot of things to do.

Result 2 –Density and Tensile Test

- Maximum density

  PF: 92% HT: 96 %

- UTS @ 87%

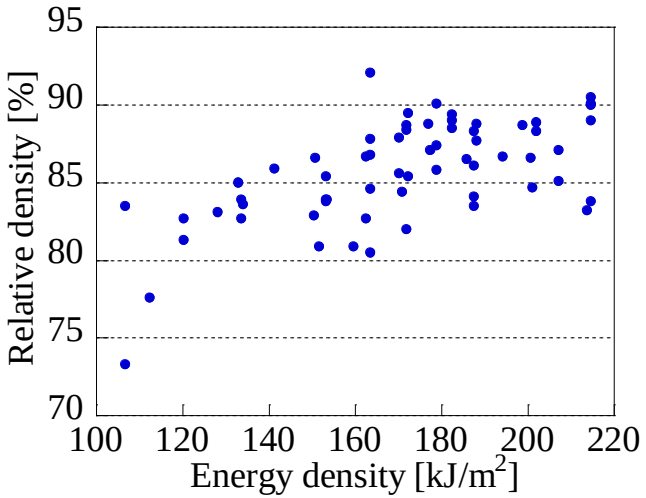
  PF: 29MPa HT: 29MPa

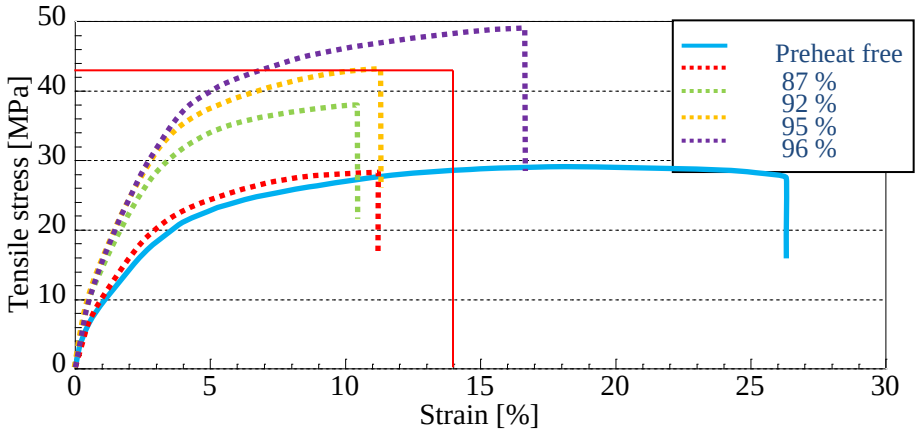
- UTS from HT

  96% RD: 48MPa Datasheet: 44MPa

- Elongation at break

  PF: 26% HT: 11%

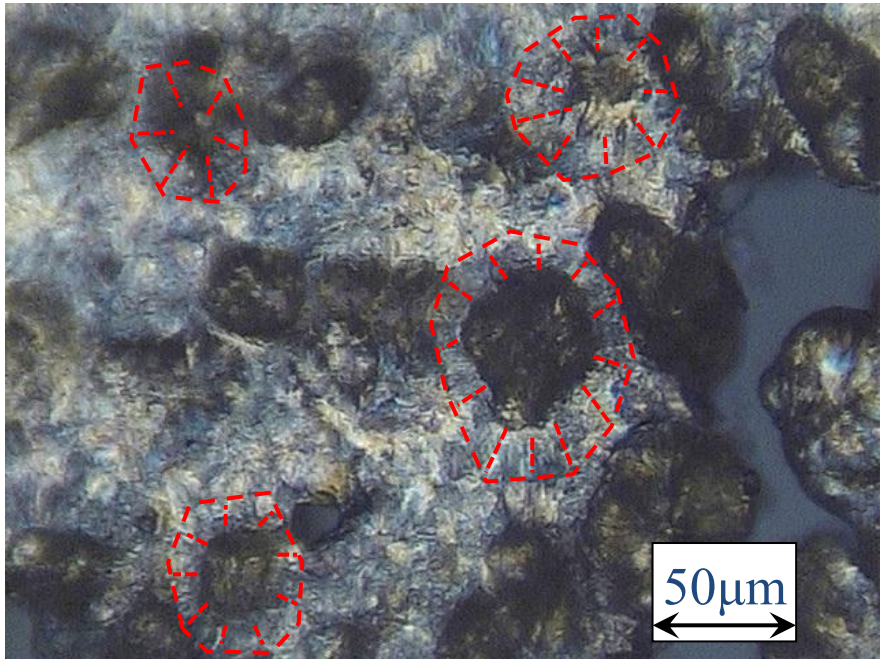




PF: Preheat free
HT: High temperature (conventional process)
RD : Relative density

Result –Microstructure

Preheat free process

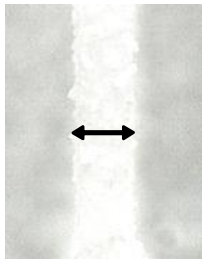
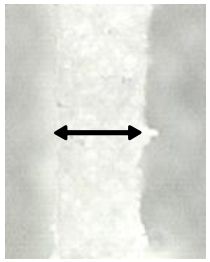
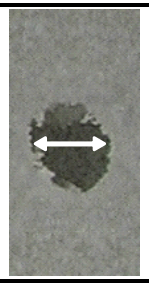
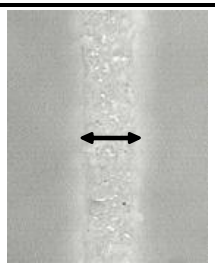
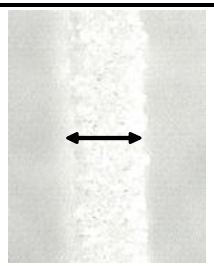
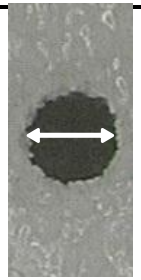
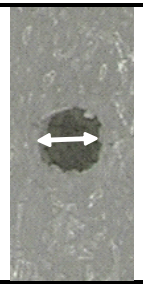


High temperature Process

- Completely different morphology.
- Fully melt?
- More like amorphous. Strong relation with better improvement in elongation.

Result –Precision

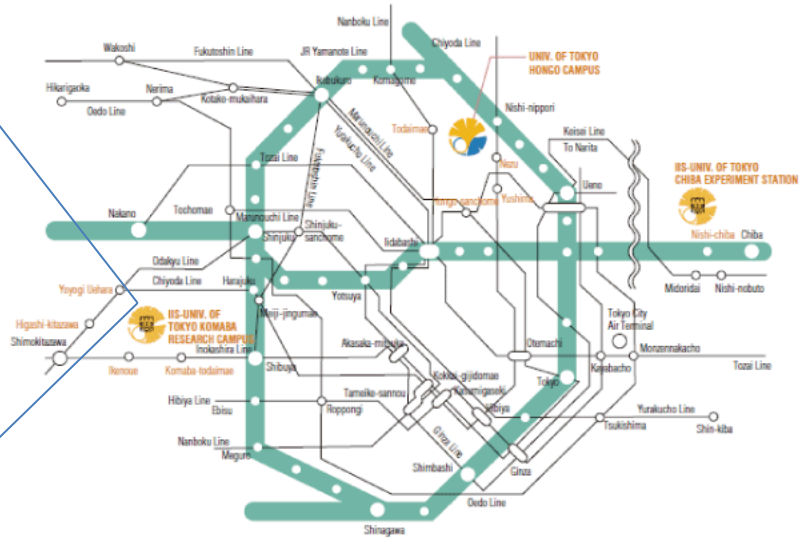
- Preheat free process reduces excessive sintering.
- Edge sharpness is improved.
- Precision is improved.

Profile / Dimension		Wall / 0.1mm	Wall / 0.2mm	Hole / 1.2mm	Hole / 1.0mm
High Temperature					
	Actual Value	0.32mm	0.43mm	0.50mm	0.54mm
Preheat Free					
	Actual Value	0.24mm	0.37mm	0.40mm	0.45mm

Conclusions

- AM technologies have made progress better and more than many industry people are thinking or expecting.
- It is good time to start using AM for production.
- Good application and technological improvement are still required for the success.
- There are a lot of rooms for AM since it is immature.
- IIS, the University of Tokyo, is working on plastic laser sintering about the both of application development and science research for fetching water and technological backup (plus their own curiosity), respectively.

Any comments and questions?



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