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Additive Manufacturing of Smart and Complex Structures

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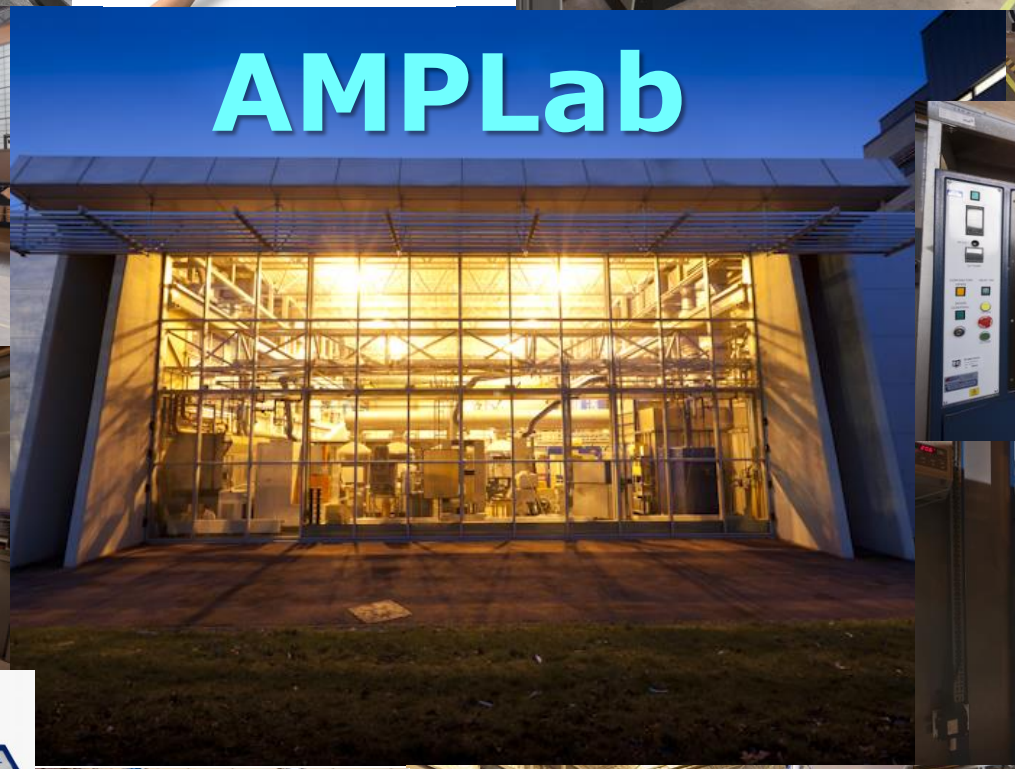
AMPLab






Research Scope & Emphasis

AMPLab Key Technologies

- The scientific emphasis is on the material-process interaction, studied using electron microscopy, synchrotron X-rays and neutron diffraction, and micro-CT, to assess the impact of the advanced processing techniques on the microstructure-property development in advanced materials.

Additive Manufacture Selective Laser Melting	Laser Deposition	Net Shape Powder HIPing	Friction Welding
❑ Metals: Ni, Ti, Al, NbSi ❑ Novel structures ❑ Process modelling	❑ Repair + netshaping ❑ Alloy development ❑ Process modelling	❑ Powder pressing ❑HIPing of Ti & Ni ❑ Process modelling	❑ Friction Stir ❑ Linear Friction ❑ Rotary Friction

Research Highlights

The Materials Science & Engineering of AM

- This presentation summarises the research activities of AMPLab in the field of AM, in the form of brief snapshots of our research projects.

- The activities cover the following themes:
  - Tooling development using AM
  - Multi-functional AM
  - Micro and macro modelling of AM

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Research Highlights

Tooling Development using AM

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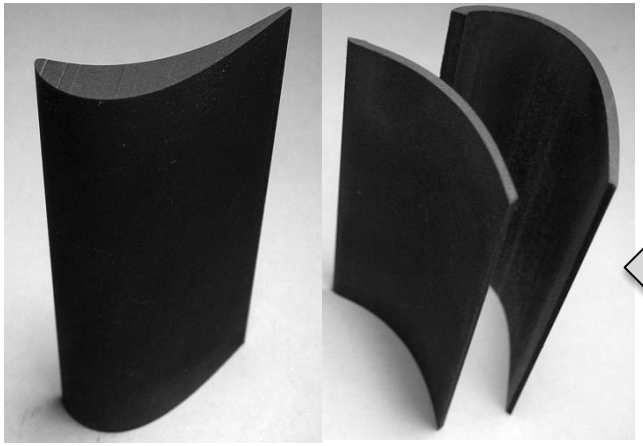
Processing of NbSi

How to Produce Complex-shaped Components?

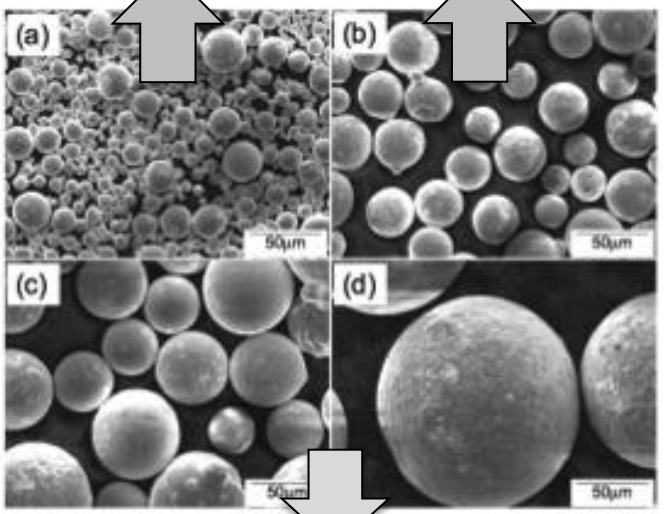
- Nb/Nb_5Si_3 is a lighter weight HT material (< ~6.5 gcm^{-3}) with application potential above 1300°C.



EDM

MIM

SLM



Net Shape HIP

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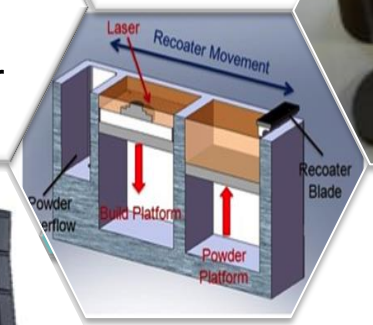
Niobium Silicide Processing Route

Net Shape Tooling by SLM (Blade)

CAD design of HIP container

SLM with iron powder



Weld, fill can & HIP

Then pickle

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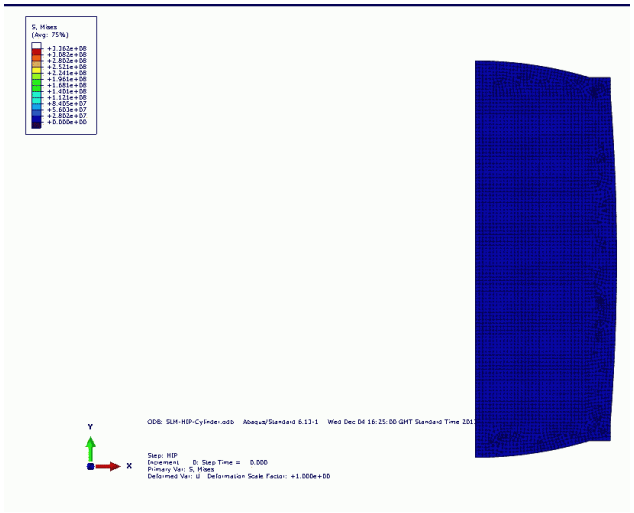
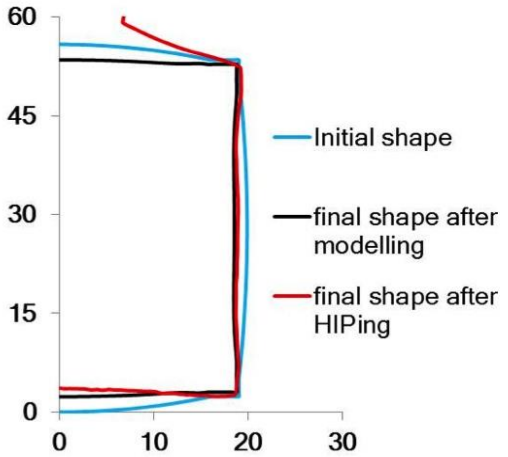
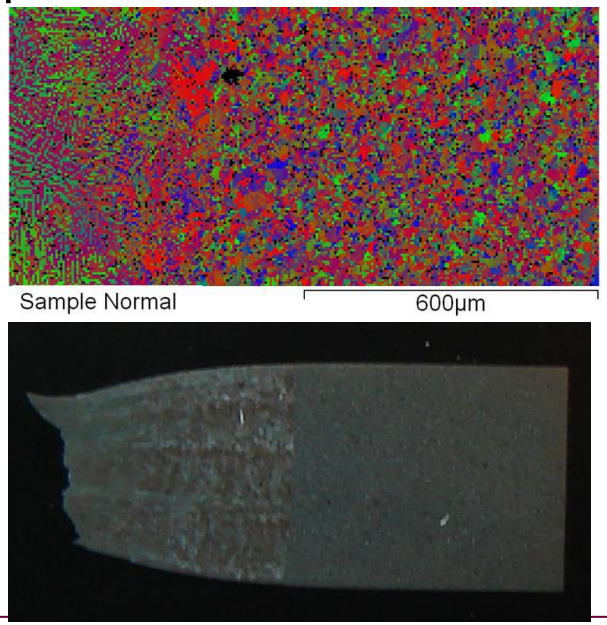
Research Highlights

In-situ Shelling via selective laser melting

- **Aim:** Develop a novel in-situ shelling route (modelling+SLM+HIP) to produce net-shape components with improved efficiency.
- **Approach:**
  - Develop modelling to predict shape change during HIPing, contributing to the design of tooling to be fabricated by SLM
  - Assess bond between tooling and HIPed powder







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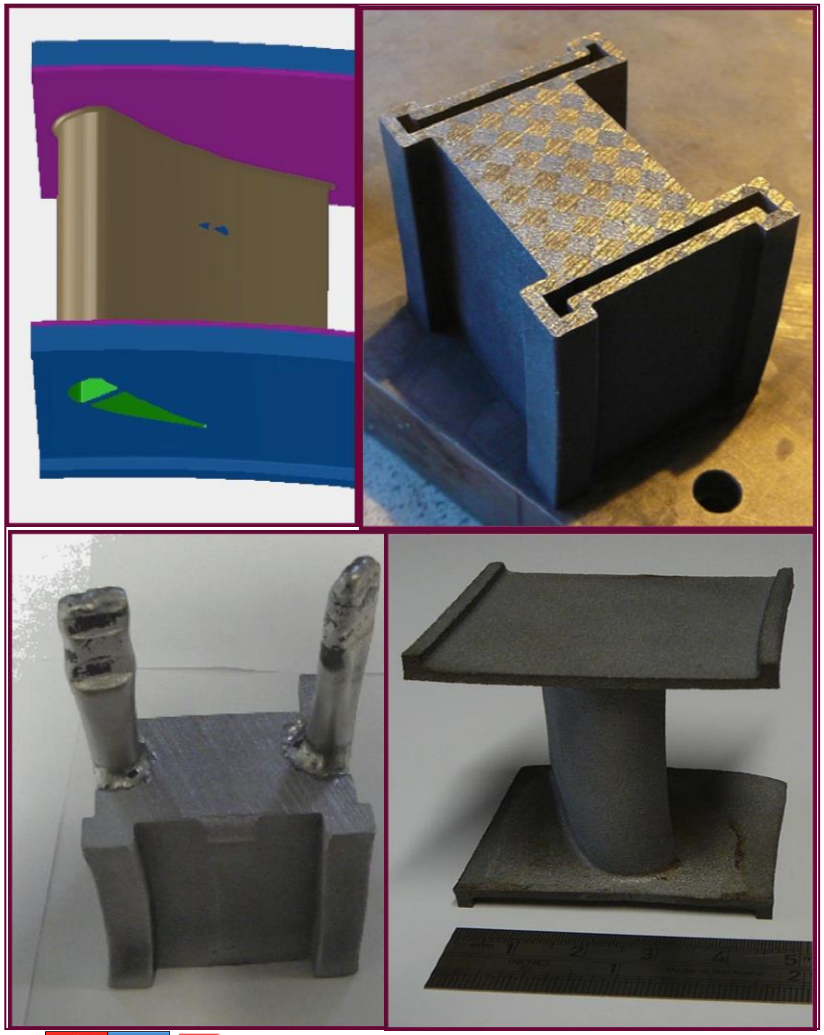
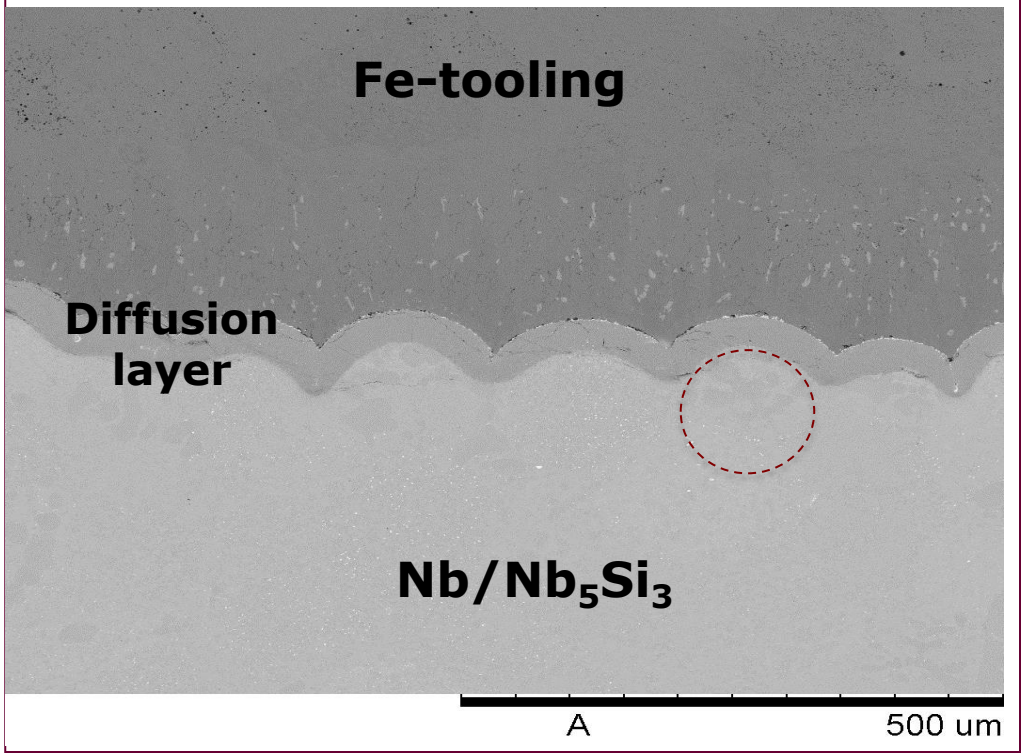
Niobium Silicide Processing Route

Net Shape Tooling by SLM (Vane)



- Post-processing is required to remove the diffusion layer between the Fe-tooling and the component.



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Research Highlights

Multi-Functional AM

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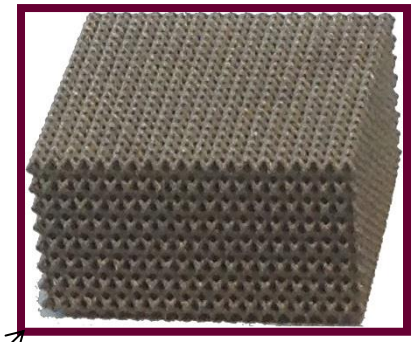
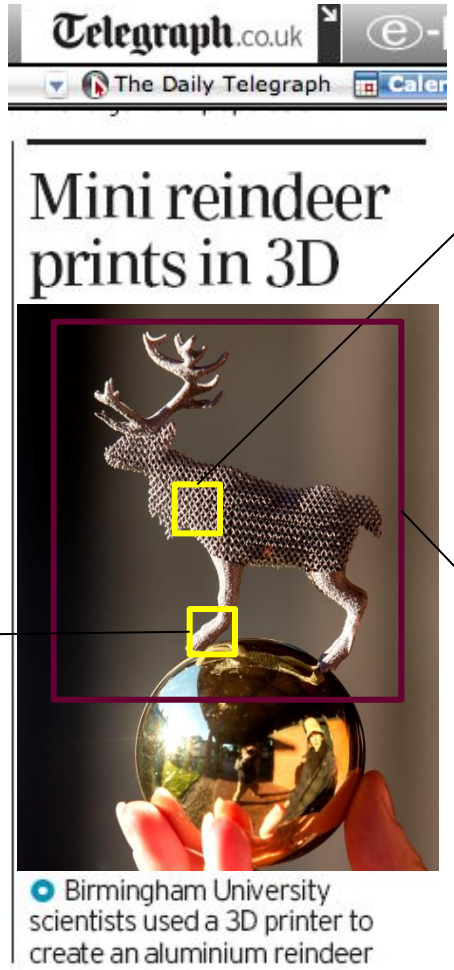
Multi-Functional AM



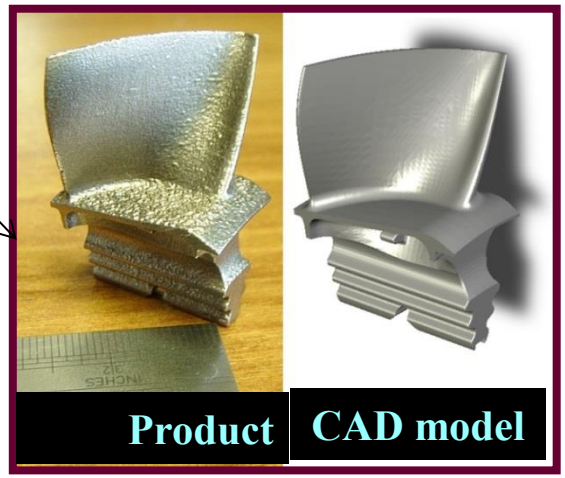
Mesh structure

- Engineered porosity
- Catalytic applications
- Medical implants
- Filters



Dental implant

- Engineered surface



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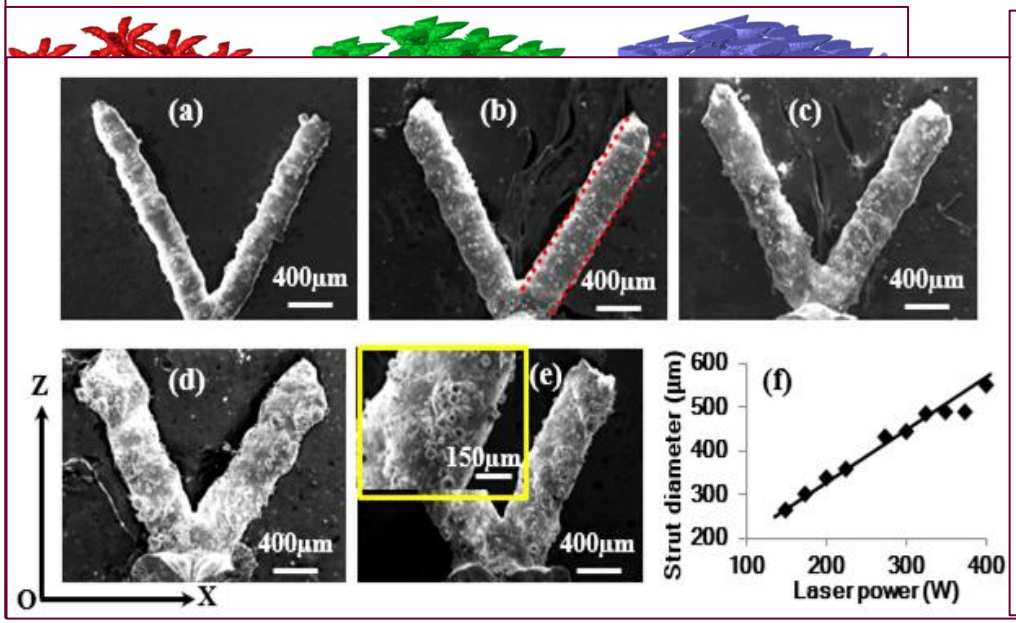
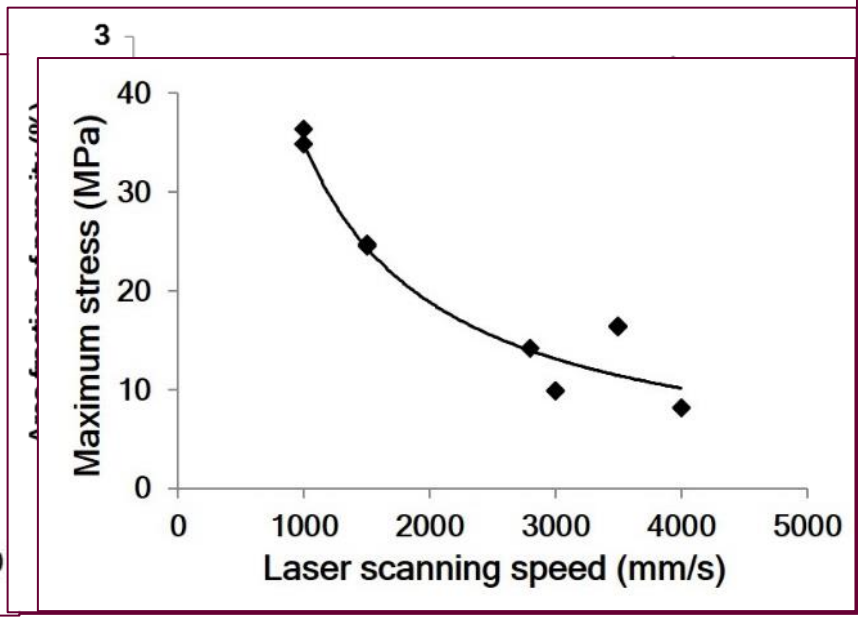
Research Highlights

Selective Laser Melting of Lattice structures

- **Aim:** Investigate the influence of SLM parameters on the strut size, internal porosity and compressive strength of lattice structures.
- **Approach:**
  - Characterisation of the internal porosity of lattices.
  - Microstructural and mechanical properties characterisation.





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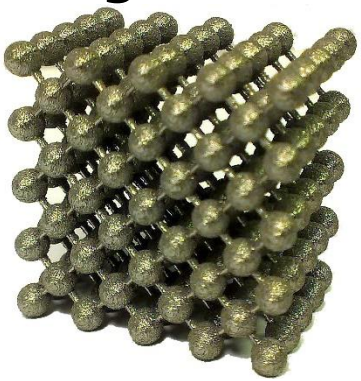
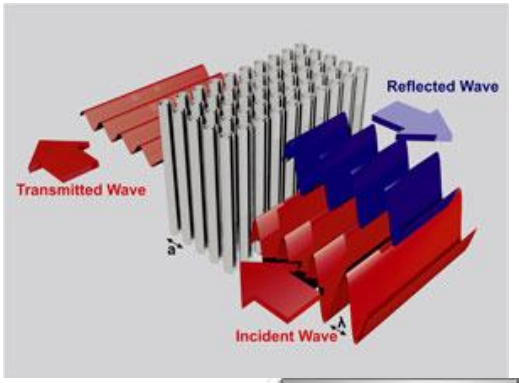
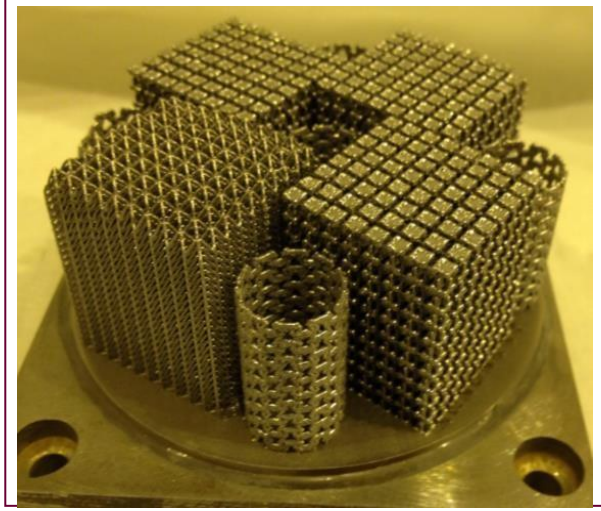
Research Highlights

AM Functional Structures

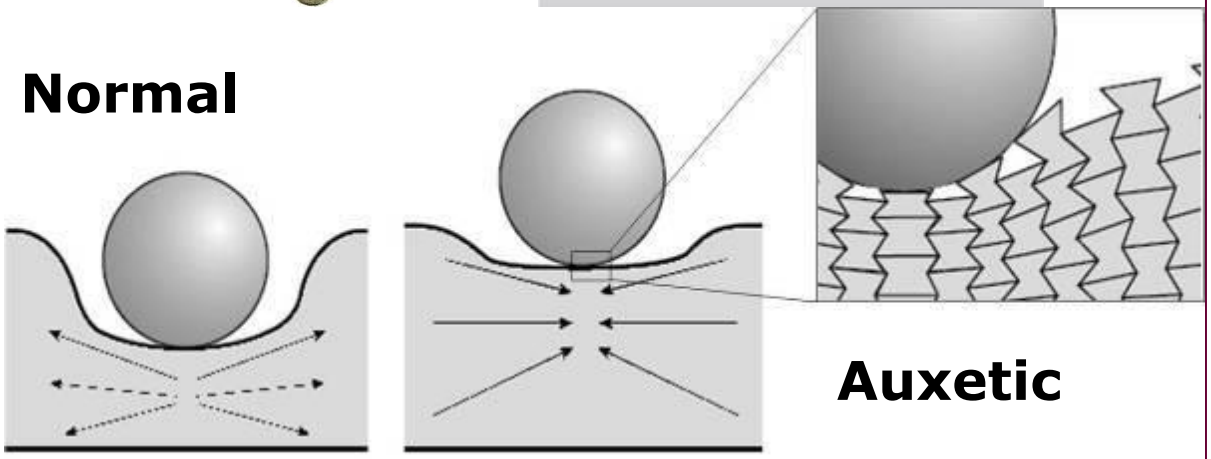
- Sonic crystals: Structure blocks certain wavelength.
- Auxetic structure: Negative Poisson's ratio.







Normal

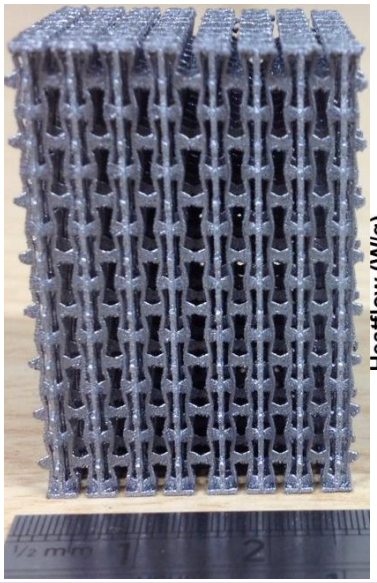


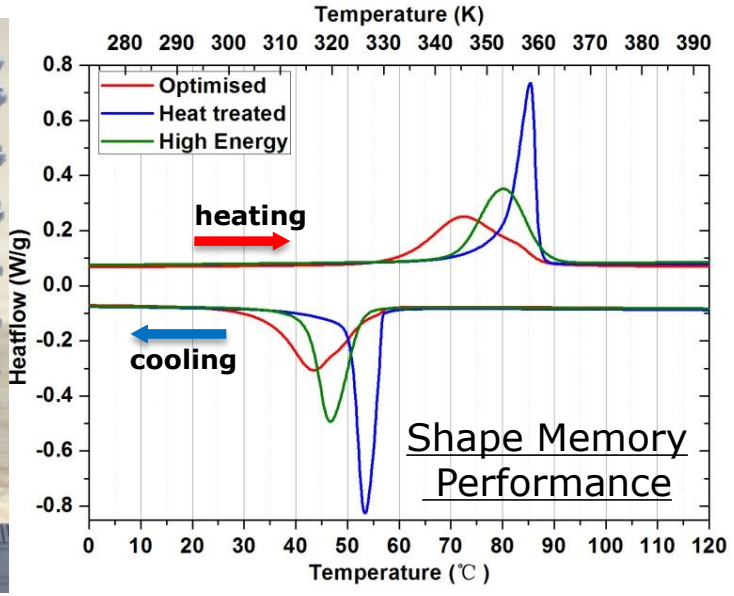
Auxetic

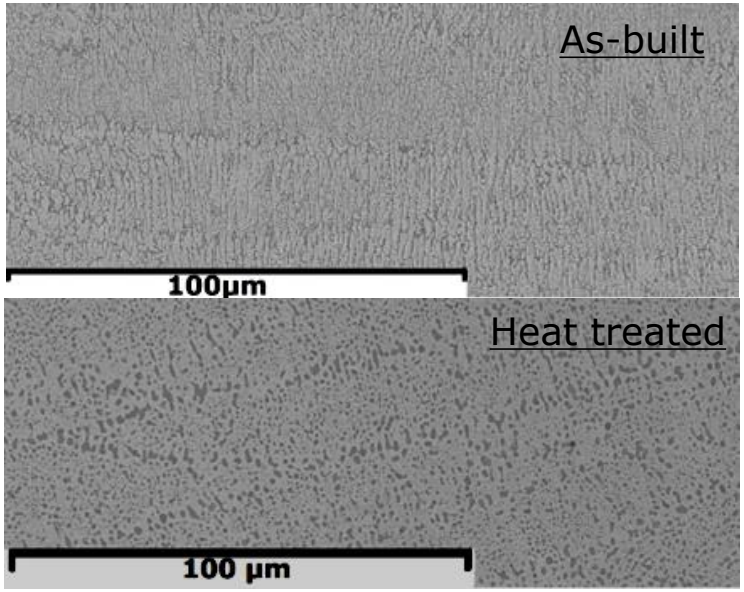
Research Highlights

Selective Laser Melting on NiTi Shape Memory Alloys

- **Aim:** Using selective laser melting (SLM) to produce NiTi auxetic structure components with superelastic effect.
- **Approach:**
  - Using DOE to explore SLM parameters for NiTi alloys;
  - Using heat treatment to improve shape memory performance;
  - Produce NiTi auxetic structure for mechanical test.







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Research Highlights

Micro and Macro-Modelling

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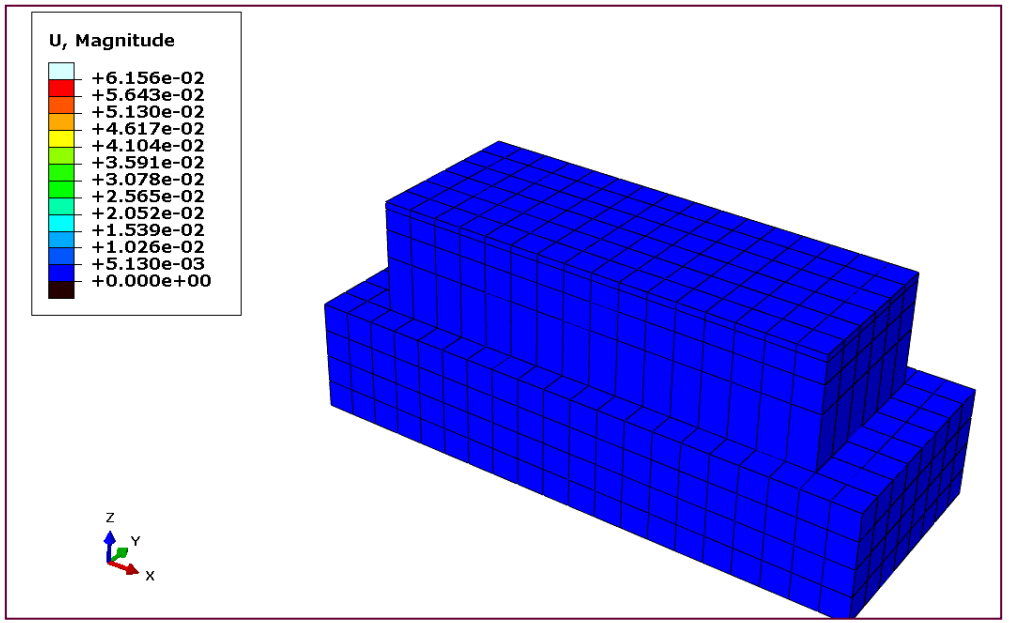
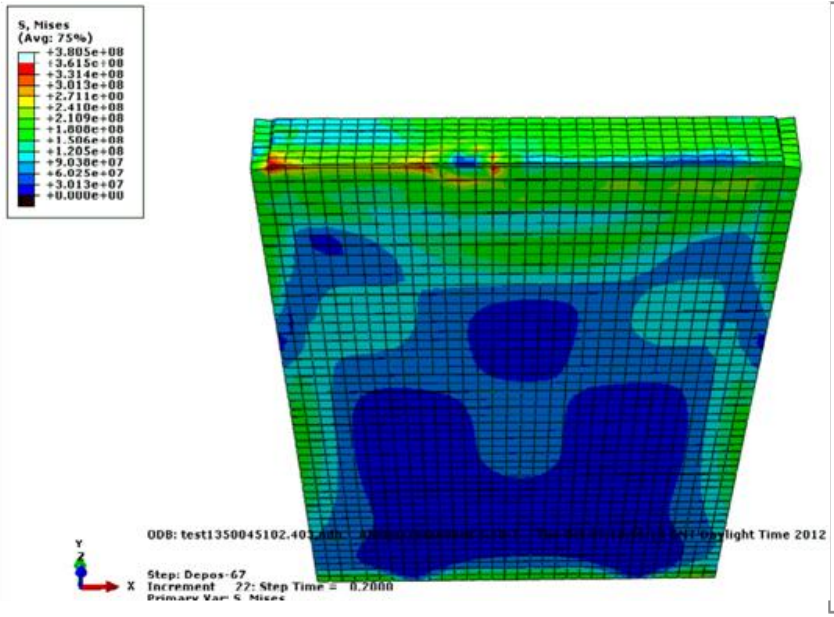
Direct Laser Deposition for repair and large structure

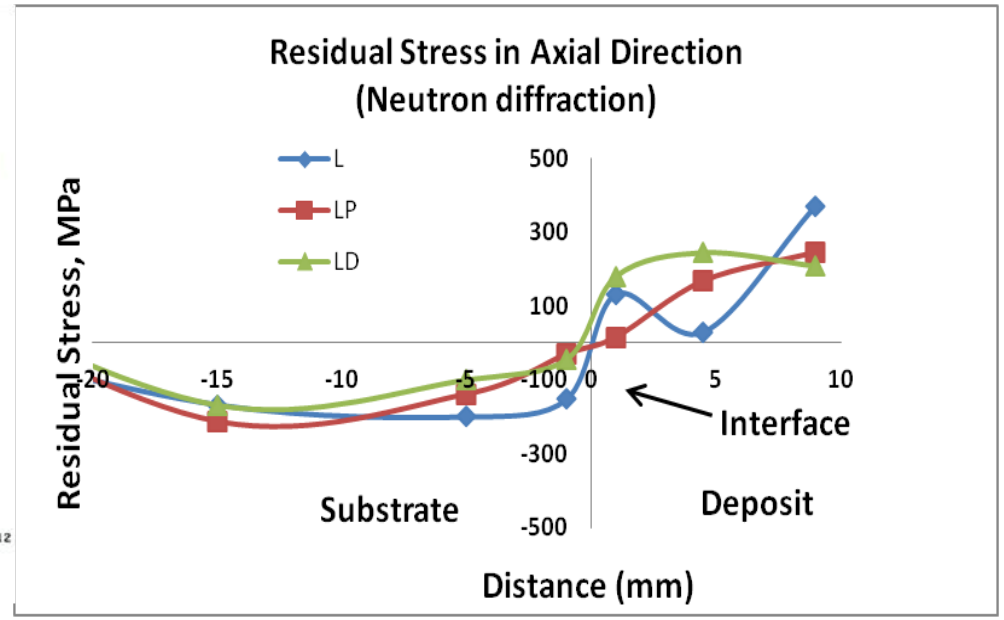
- **Repair of turbine blades**
  - Modelling framework: element birth method or dummy element



Direct Laser Deposition for repair and large structure

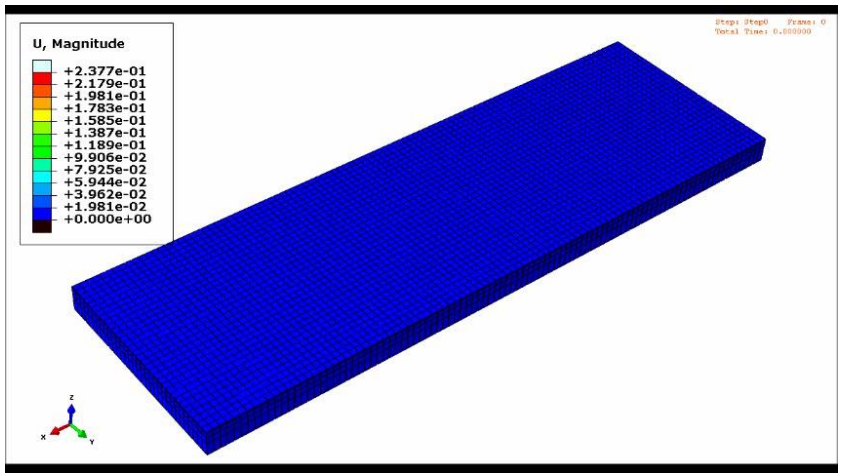
- **Repair of turbine blades**
  - Residual stress development
  - Validation using Neutron diffraction

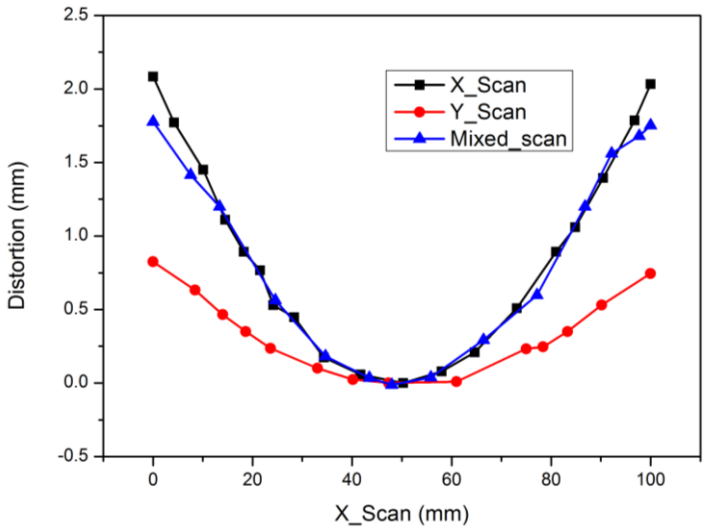




Direct Laser Deposition for repair and large structure

- Activating element line by line:
- Number of elements: 28, 800; CPU Runtime: X-scanning: 2 days, Y-scanning: 8 days.
- Lower distortion in Y-scanning

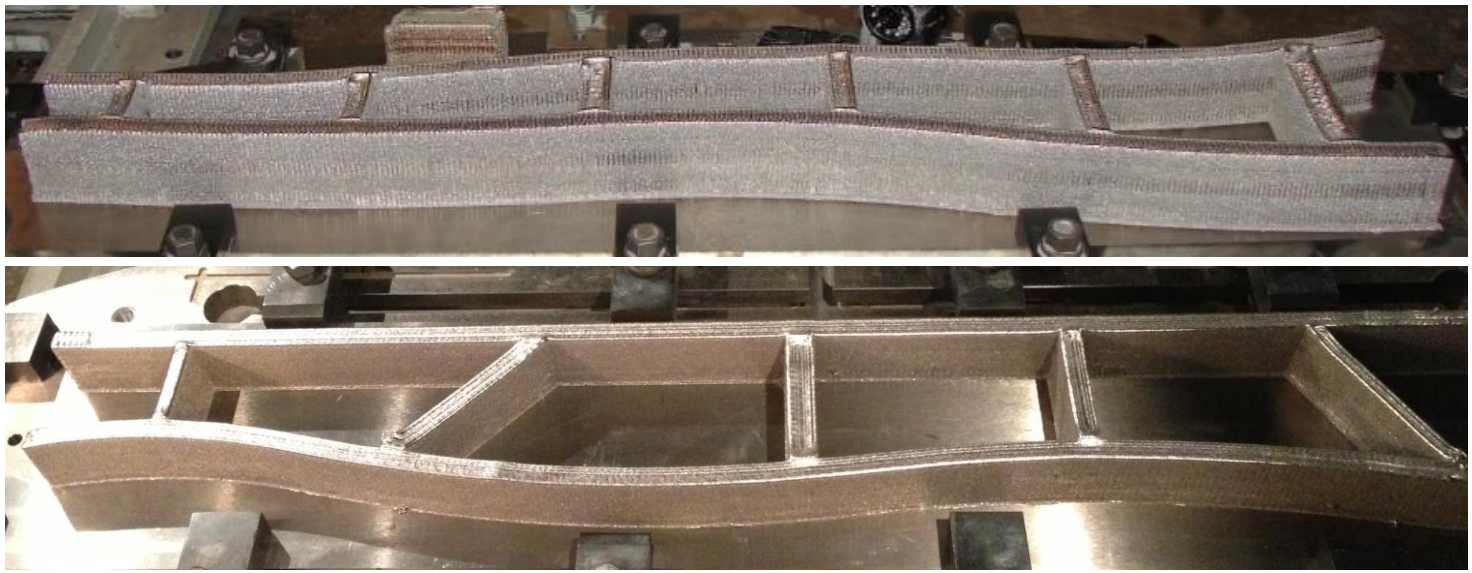




Direct Laser Deposition for repair and large structure

- **Build large structure (SPAR)**

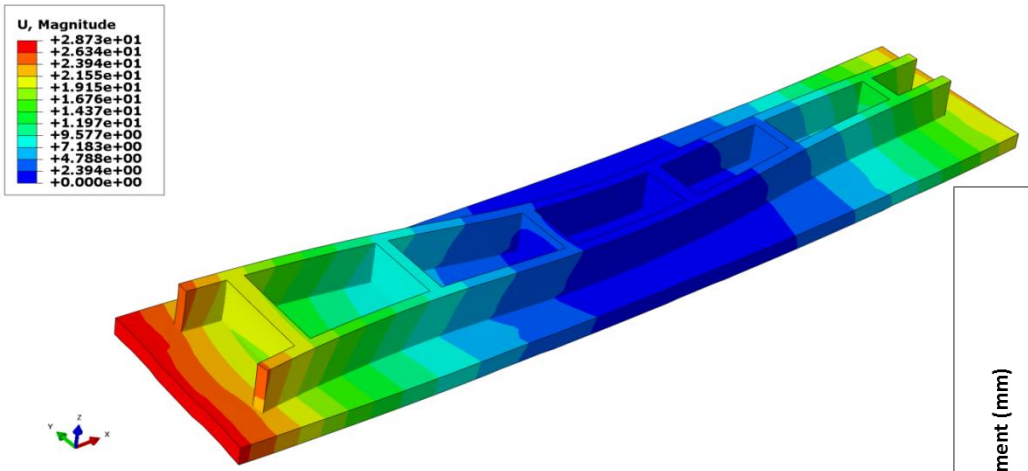
  - Technology scale up at UoB to produce large (>1m long structures) through optimisation of the process parameters and tool path to minimise porosity and microstructural heterogeneity, and maximise the geometrical consistency.

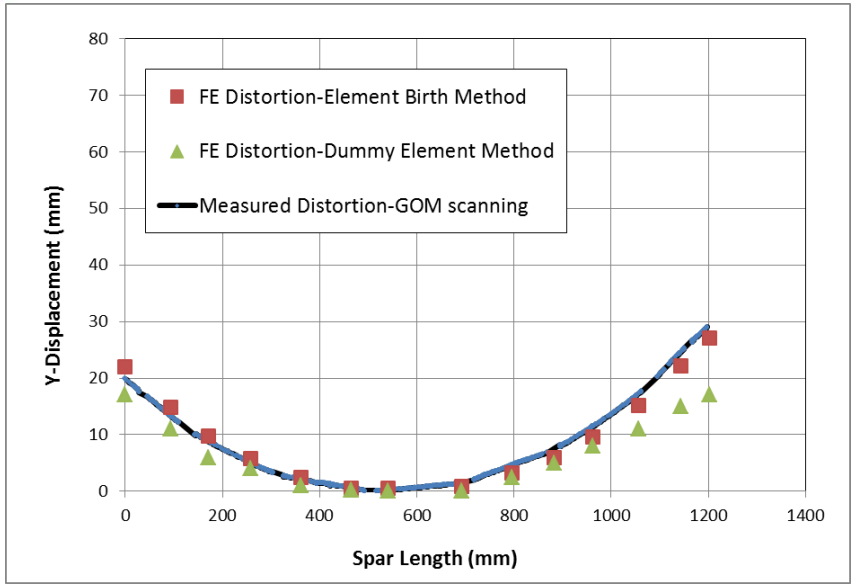


Direct Laser Deposition for repair and large structure

❑ Build large structure (SPAR)

➢ Tool path optimisation to minimise geometrical distortion



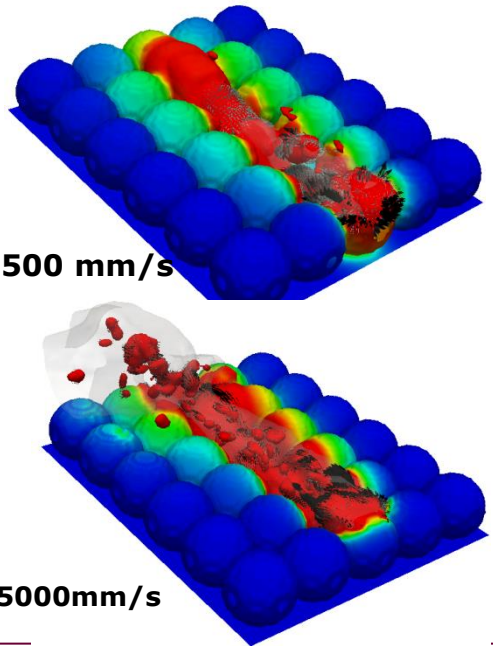


Research Highlights (SLM)

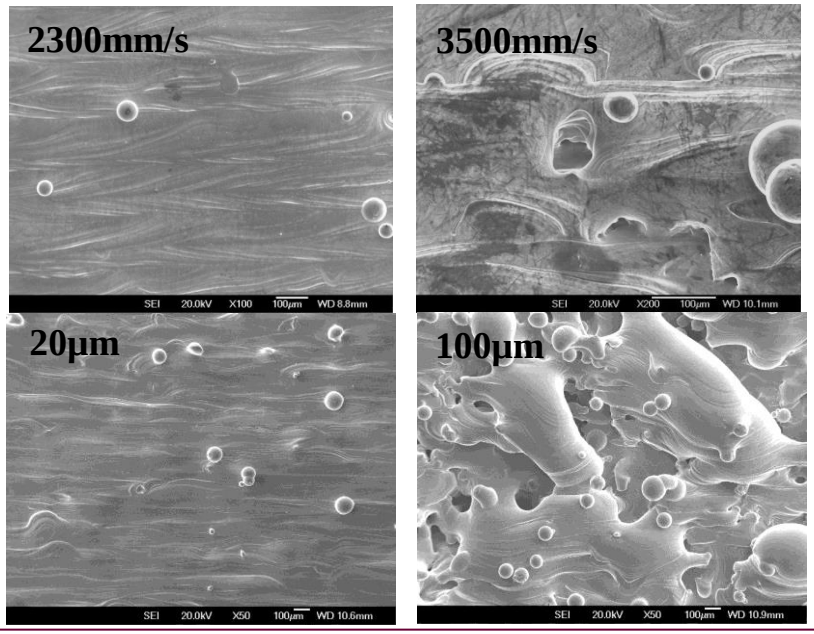
Micro-Modelling of SLM of Ti-6Al-4V

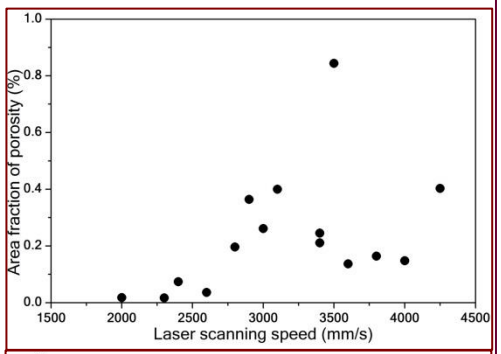
- **Aim:** Investigate the role of melt flow on the morphology of the build surface structure and porosity development during SLM.
- **Approach:** Modelling the laser-powder interaction (melt splashing and pore formation), and linking the surface structure and porosity to melt flow.

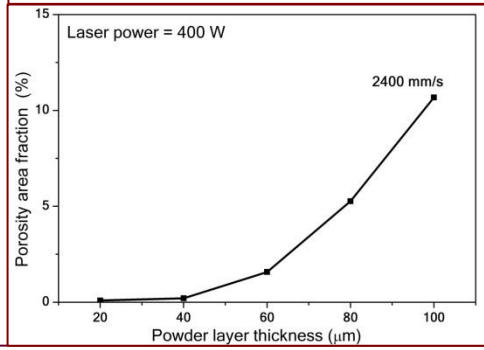
Modelling



Surface structure







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Thank You
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