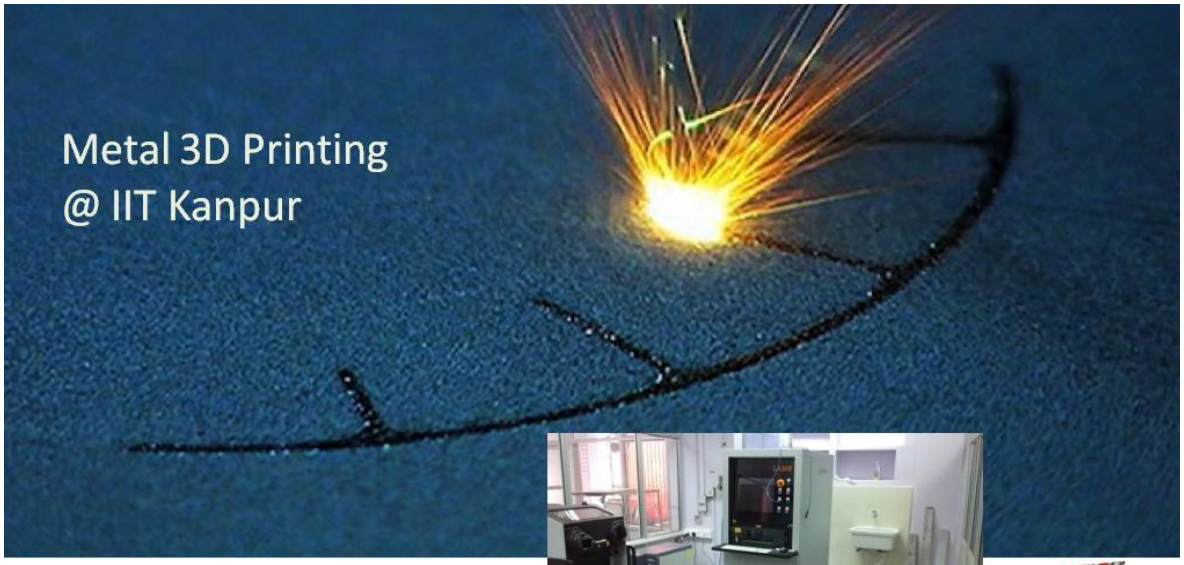
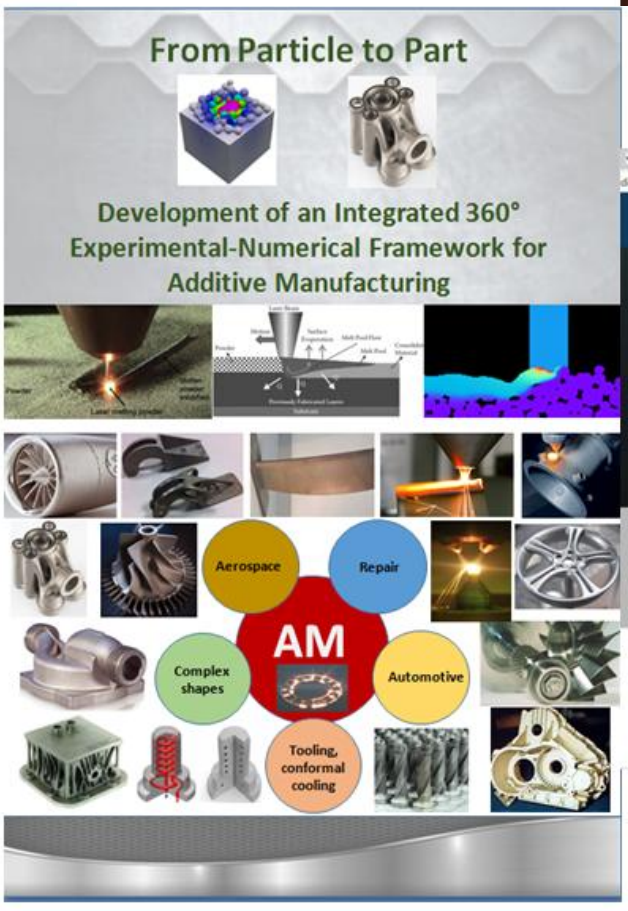
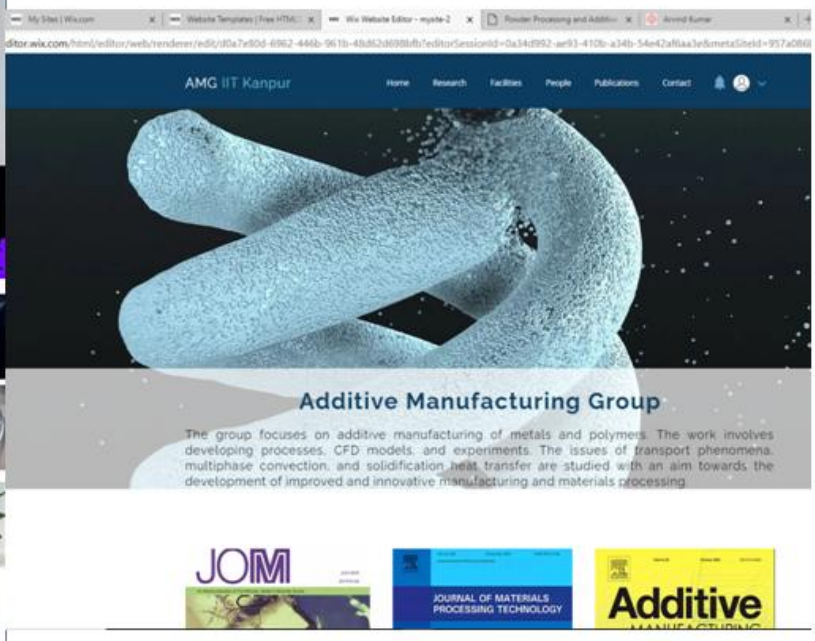


DST-FIST Additive Manufacturing Facility



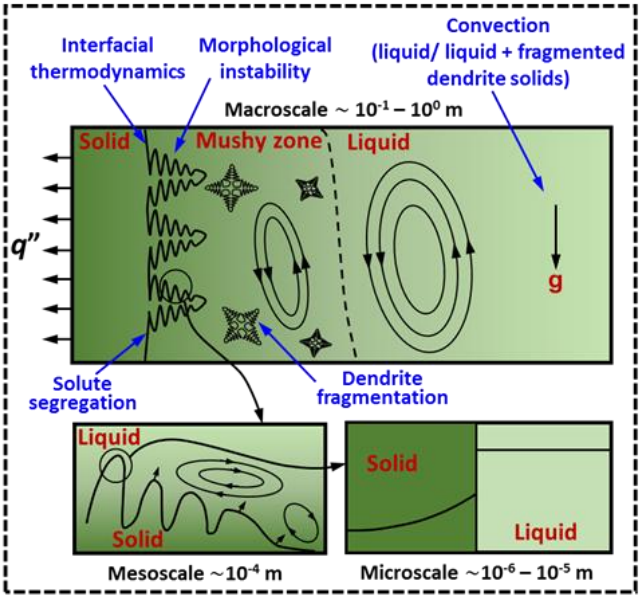


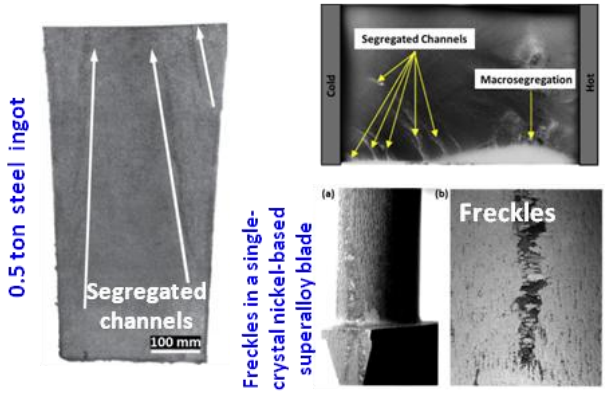
Opensource AlloySolidification software and In-situ PIV, PLIF and high-speed imaging facility

AlloySolidfication Solver (open FOAM)

Models

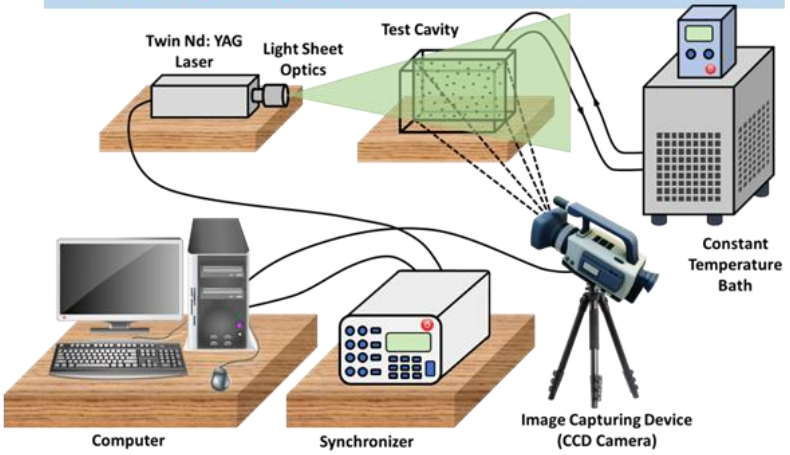
- Fluid flow
- Heat transfer
- Solidification
- Species transport
- Mushy zone



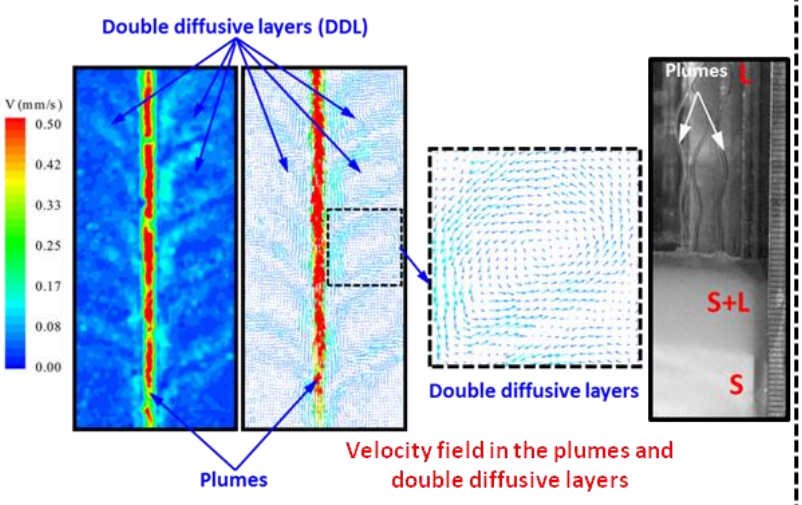


In-situ experimental facility

- Particle image velocimetry (PIV)
- Plane laser induced florescence (PLIF)
- High-speed imaging



Experimental facility

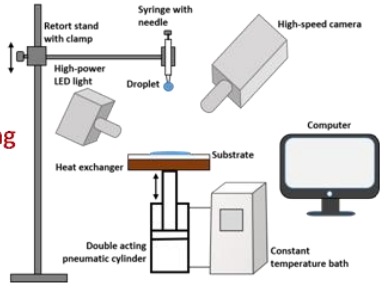


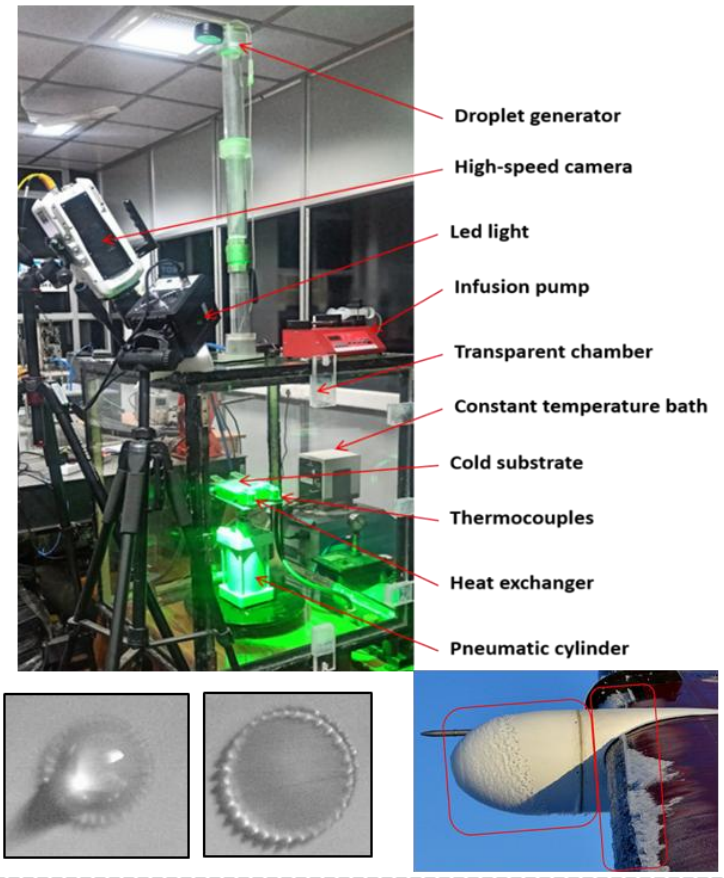
Velocity field in the plumes and double diffusive layers

In-situ experimental facility and computational tool for droplet impact, spreading and freezing on surfaces

Experimental facility

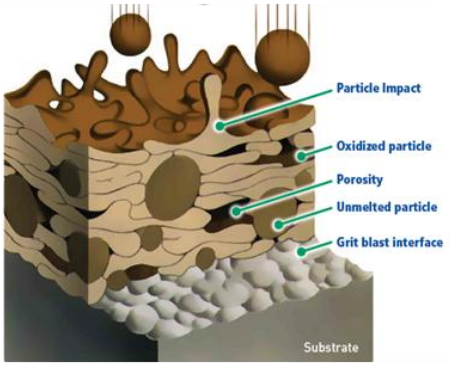
- Experimental setup
- Hydrodynamics and freezing of droplet impact
- Ice accretion and coating applications

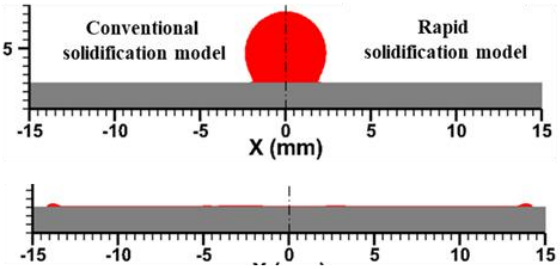


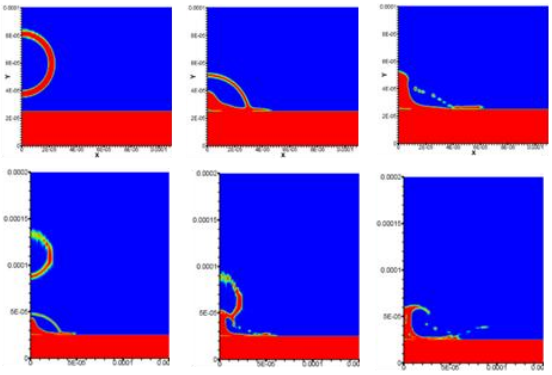


Computational solver (code)

Fluid flow
Heat transfer
Rapid solidification

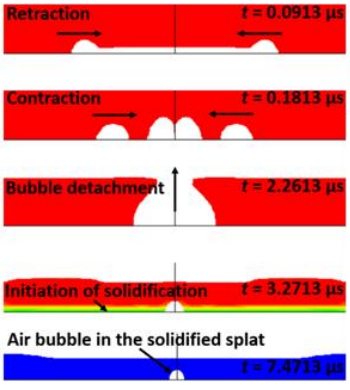


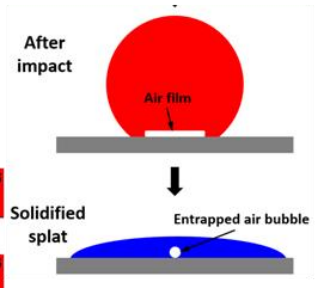


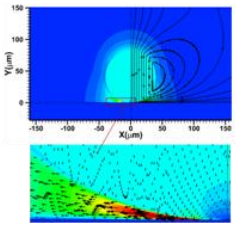


Coating structure in thermal spray coating

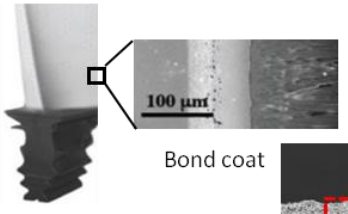
- Air bubble formation
- Pore formation
- Interfacial heat transfer

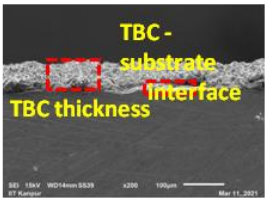


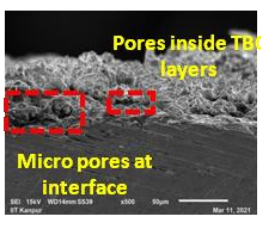


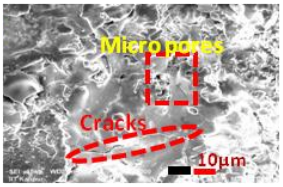


Thermal barrier coating (TBC)









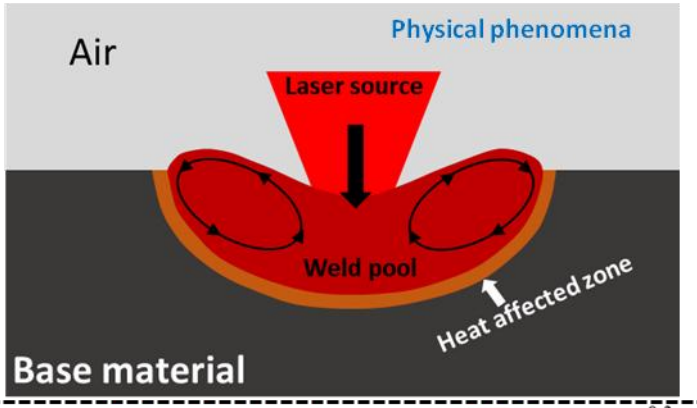
Applications

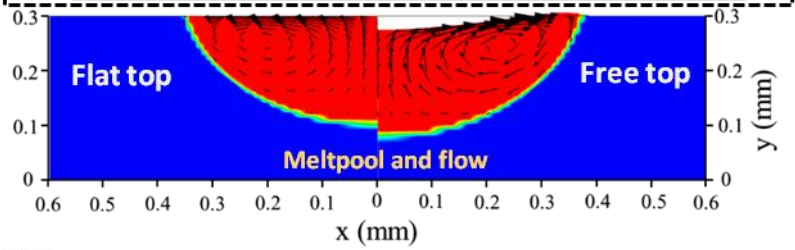
Software tool for laser welding and experimental facility

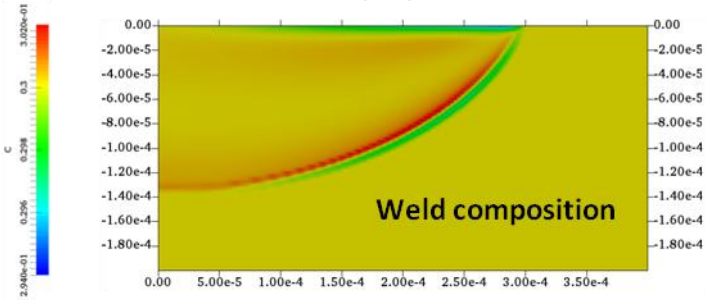
Software Solver

Models

- Fluid flow
- Heat transfer
- Species transport
- Solidification
- Mushy zone
- Undercooling







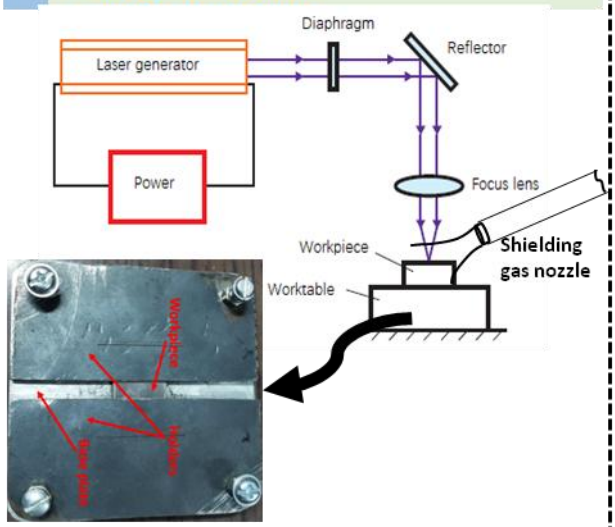
Experimental setup

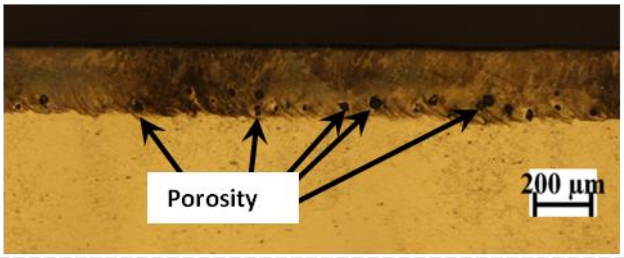
Method

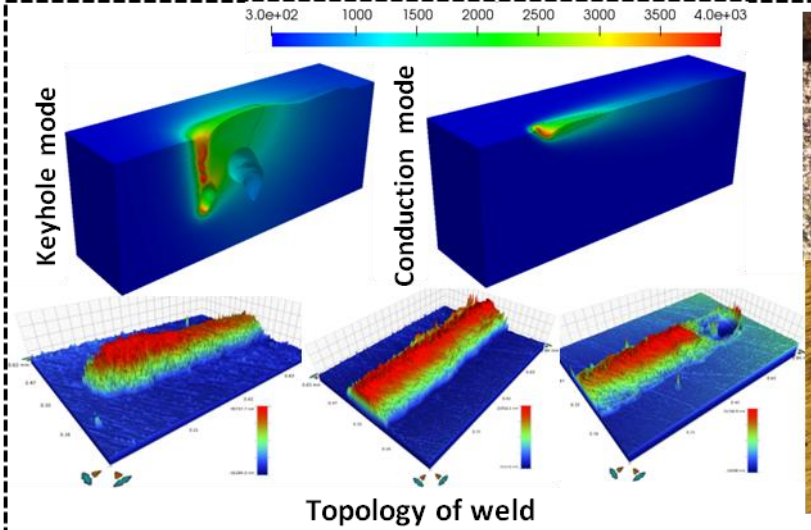
- Laser beam welding
- Microscopy
- Optical profilometry

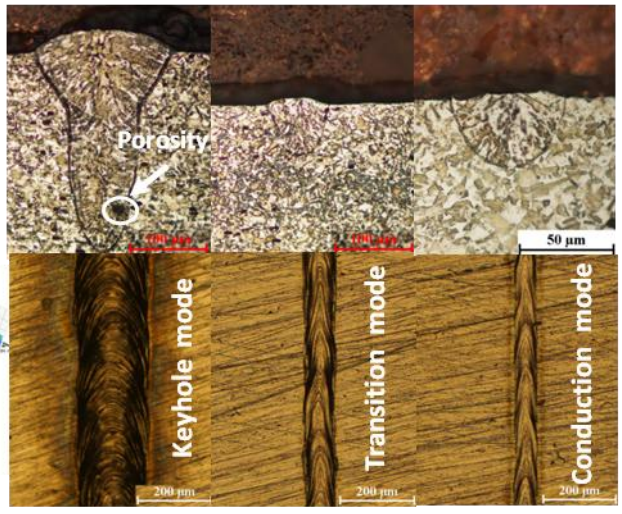
Output

- Flow field
- Temperature field
- Concentration field
- Solidification interface morphology
- Solver validation



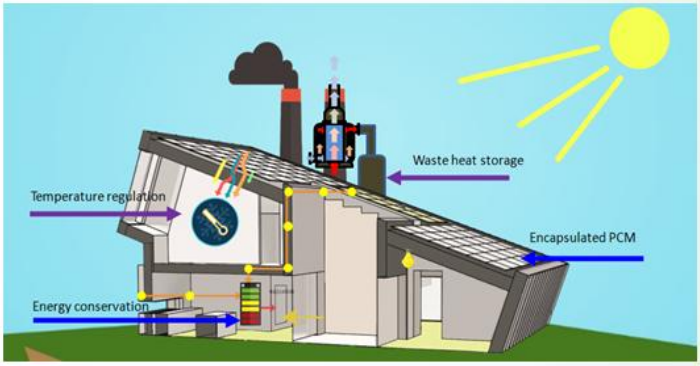






Thermal Energy Storage and Waste Heat Recover

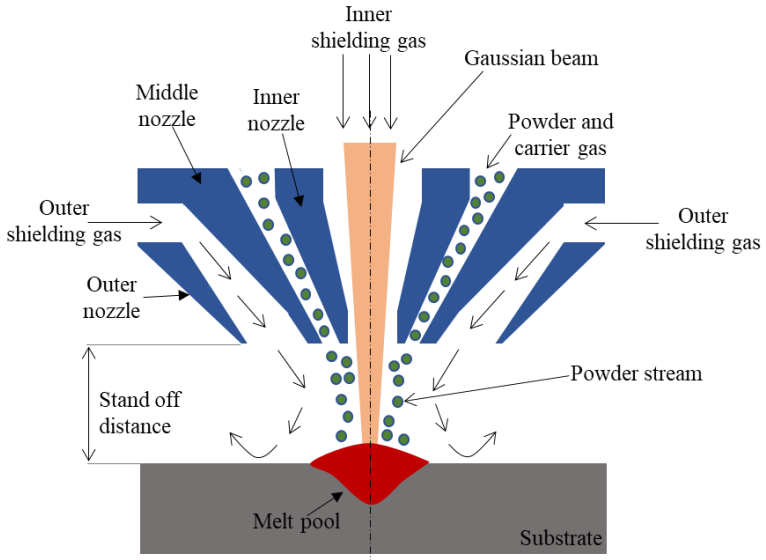
Water distiller with PCM Thermal Energy Storage unit



Research in Our Additive Manufacturing Group (AMG)

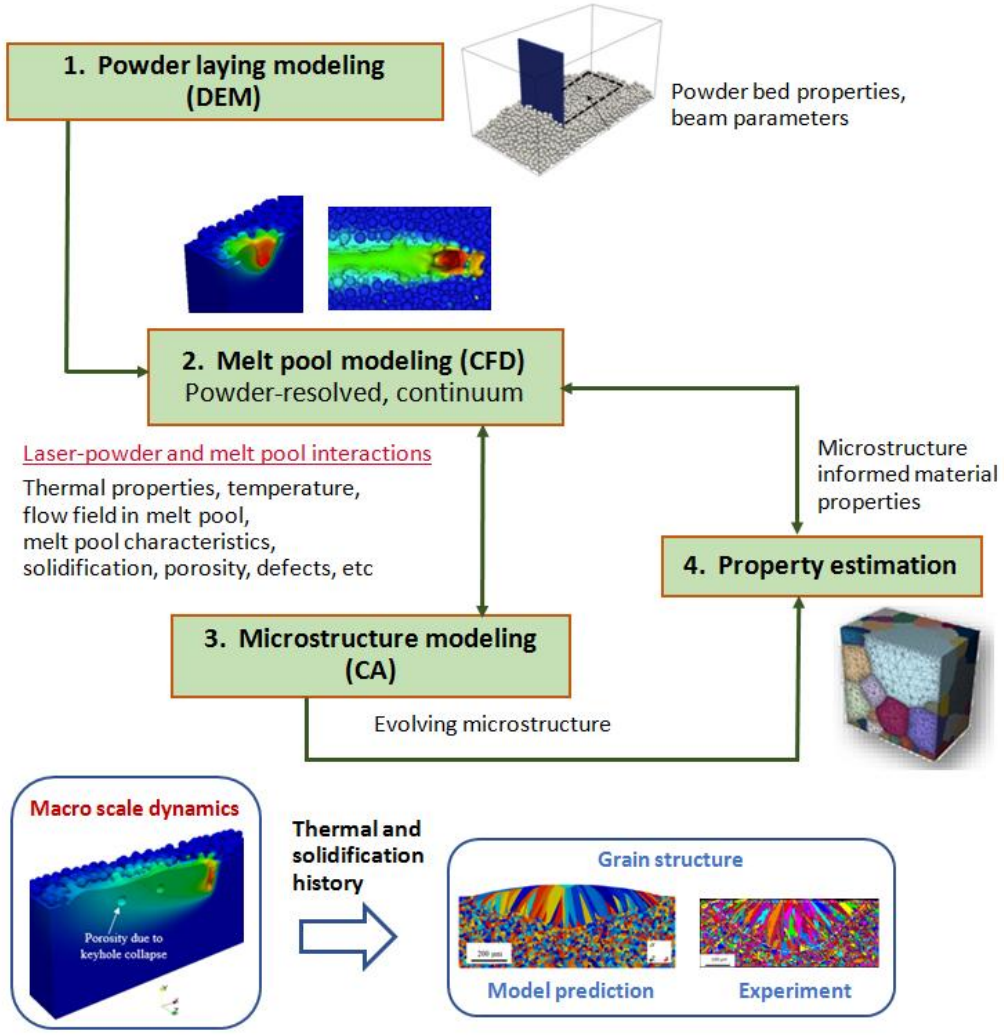
- PBF and DED metal AM – Integrated experimental-numerical approach
- Computational modelling at micro, meso and part scale
- Steel, Al, Ti materials
- Metal parts for aerospace, biomedical applications

DED: Integrated multi-physics predictive computational platform

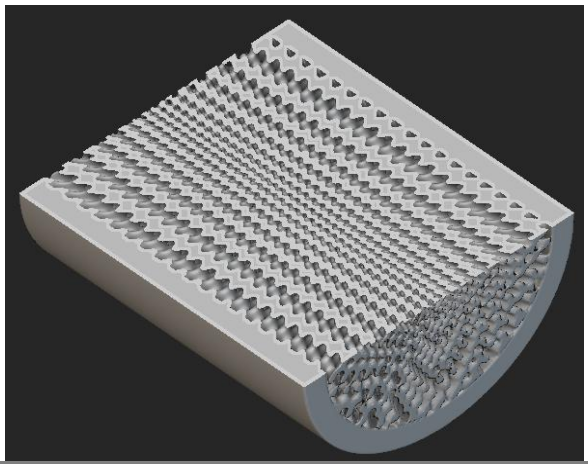


- Gas-powder flow
- Melt-pool dynamics and particle impingement
- Grain growth (CA)

PBF: Integrated multi-physics predictive computational platform

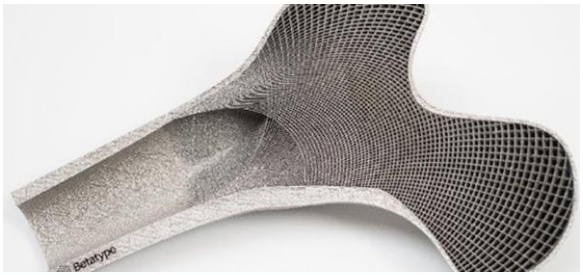


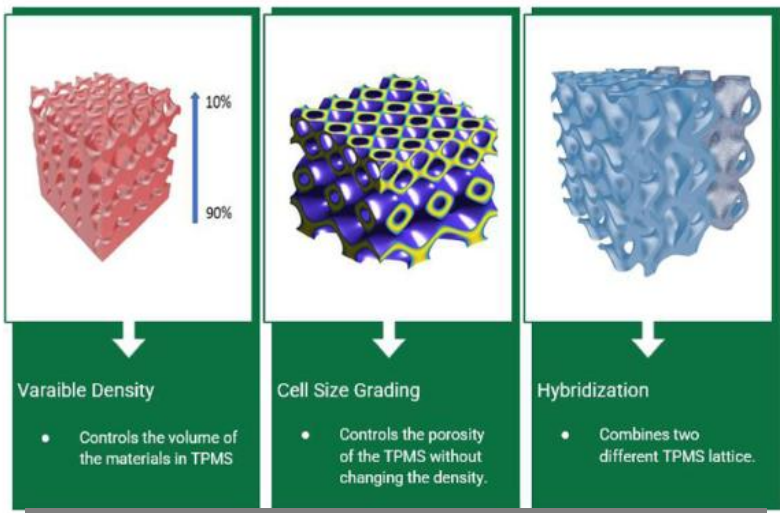
Development of Functionally Graded Porous Structure for Biomedical Implant Application Processed by Laser Powder Bed Fusion AM



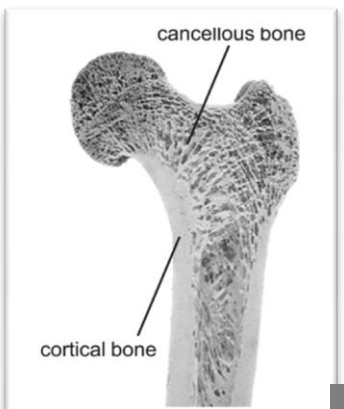
FG TPMS infill with both cell size and relative density grading to retain porosity similar to that of bones

- Design of TPMS through implicit modelling focusing on mechanical strength and biocompatibility
- Focus on materials such as Ni-Ti (Nitinol) for properties like shape memory effect and super-elasticity
- Achieving relative density, porosity and weight ratios similar to bones in the human body while considering and avoiding effects such as stress shielding

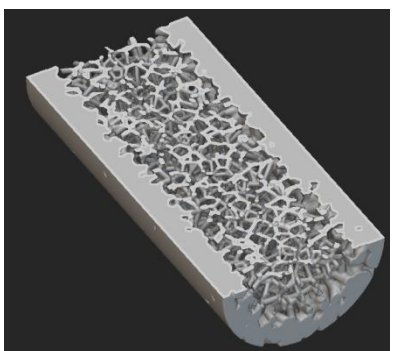




Functionally gradient TPMS-approaches

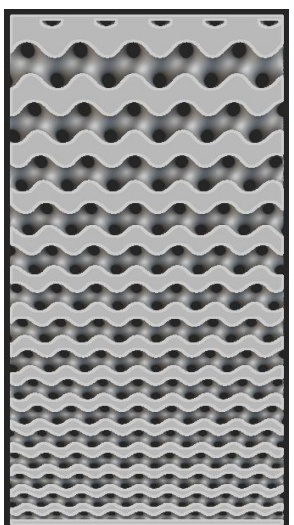


Cortical and cancellous bone in human femur

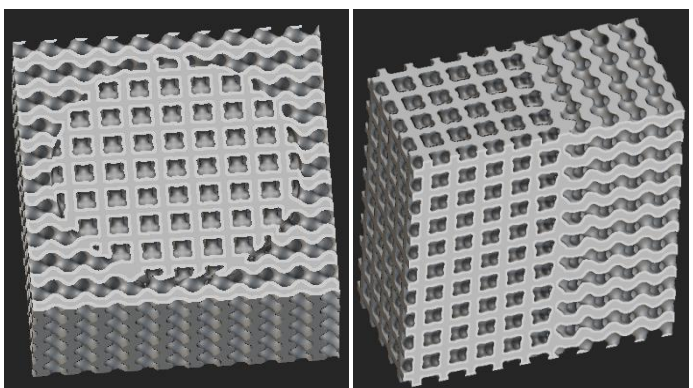


Mimicking bone trabecular strut structure using Voronoi Lattice Tessellation to create conformal TPMS infill for implants

FEA and CFD Analyses



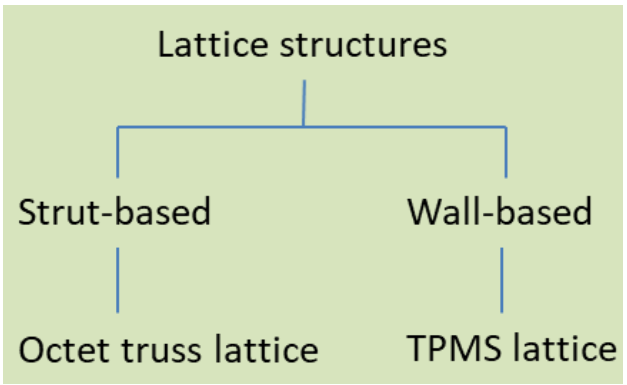
Field driven design through equations



Circular Transition Linear Transition

Development of Lattice Structure for Lightweight Structural Application Processed by Laser Powder Bed Fusion AM

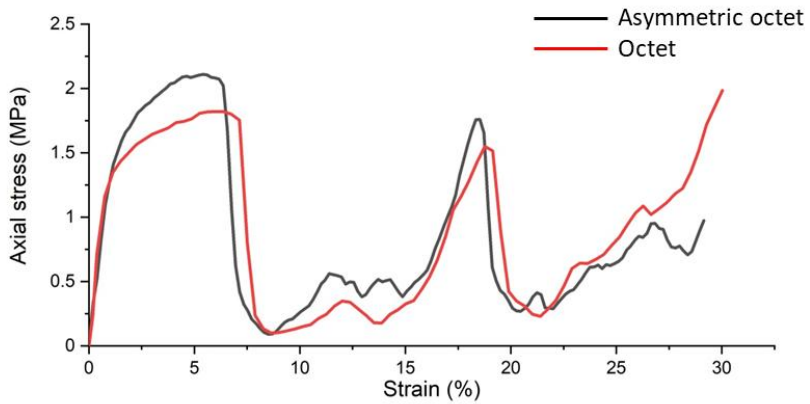
- Lattice structures have high specific mechanical properties.
- Can be used in compressive load supporting structure.
- Also useful as filling structure in sandwich structures.
- Can also be used in thermal applications.



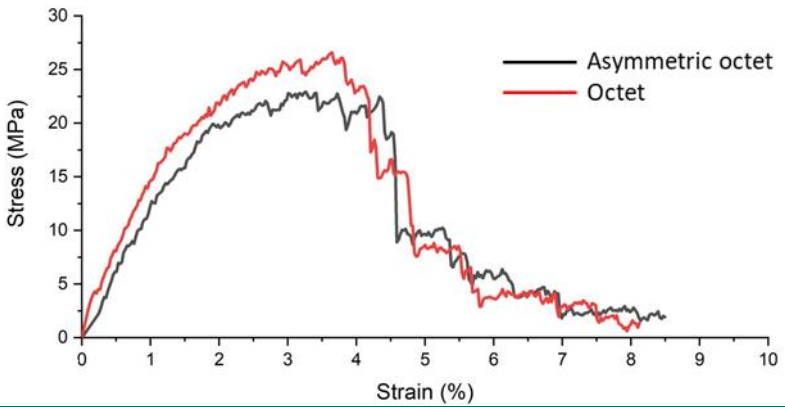
Applications

- Compressive loading
- Sandwich structures
- Impact energy absorption
- Thermal application
- Support structures

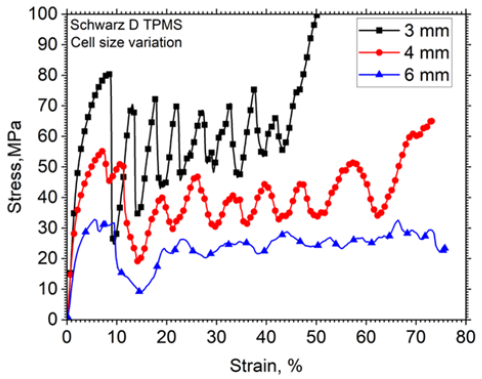
Compression behavior of octet truss lattice structure

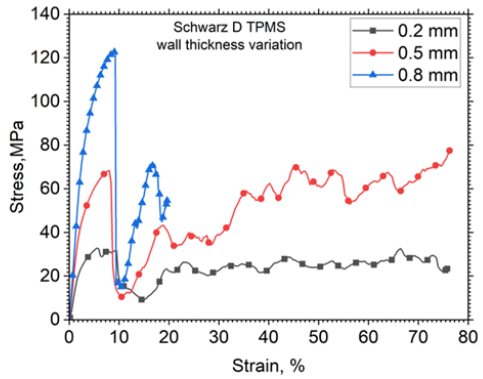


Bending behavior of octet truss lattice structure



Compression behavior of TPMS lattice structure

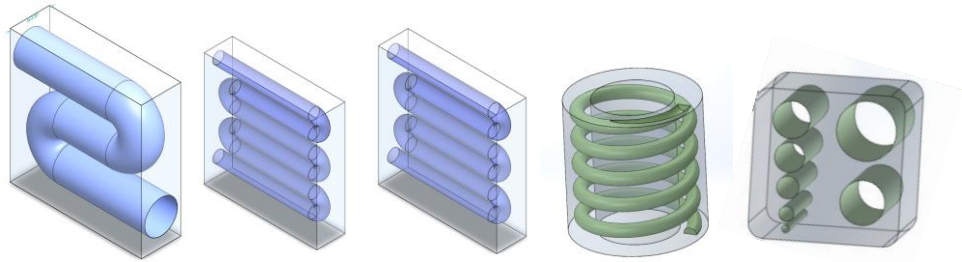




Development of Conformal Channel Processed by Laser Powder Bed Fusion AM for Internal Cooling

- Conformal cooling channels can take heat away from the critical locations which are not possible in conventional cooling channels.
- Useful in permanent molds, engine castings, tooling.
- LPBF AM is suitably placed to make randomly oriented conformal cooling channels of very small diameters.

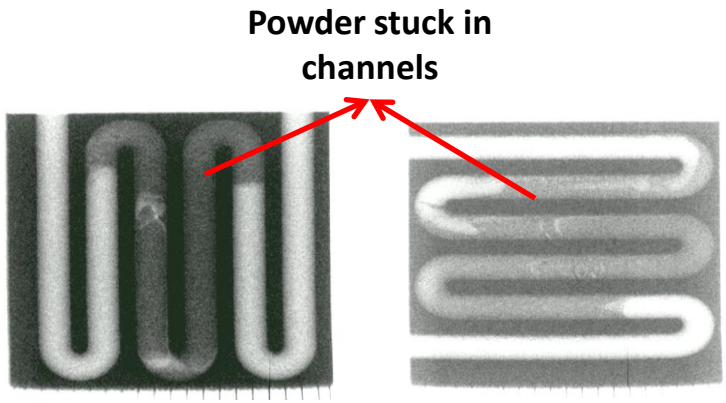
As-designed



As-3D printed

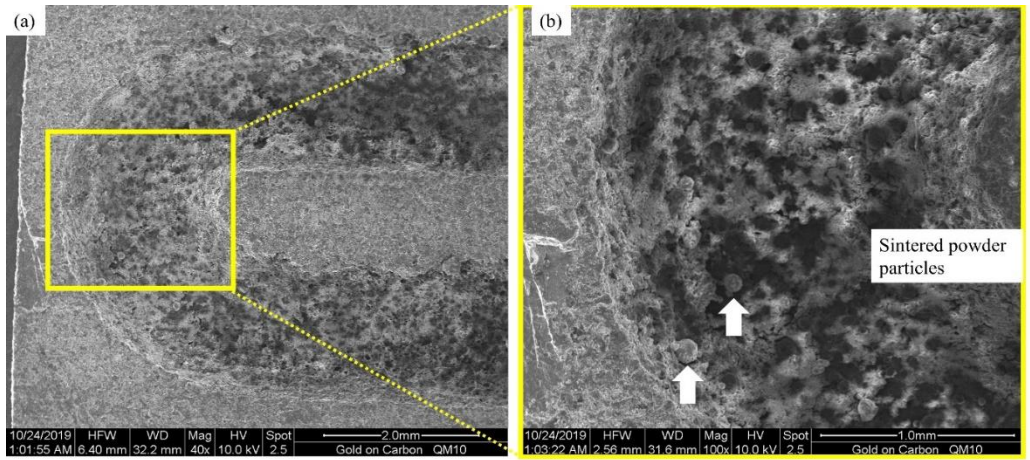
Internal cooling channels (lowest size up to 1 mm) of different shapes fabricated by LPBF AM

CT scan images of fabricated internal cooling channels shows that the metal powder stuck inside the channel



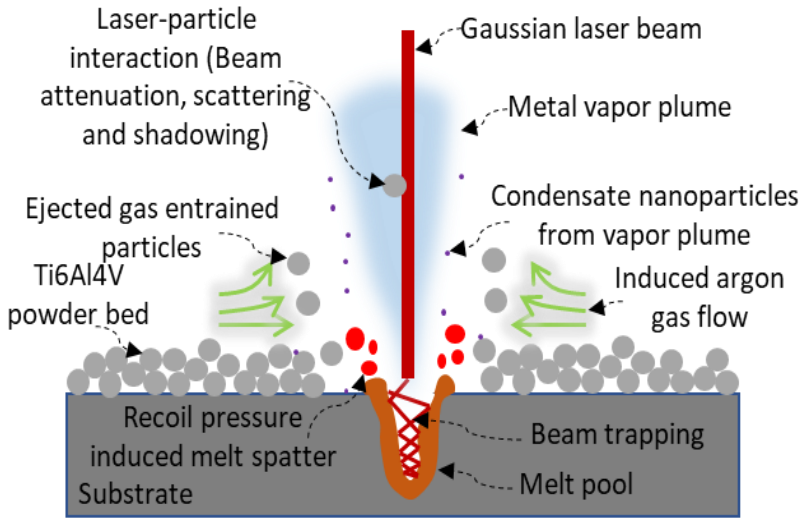
Vertical Positioned during SLM fabrication

Horizontal Positioned during SLM fabrication

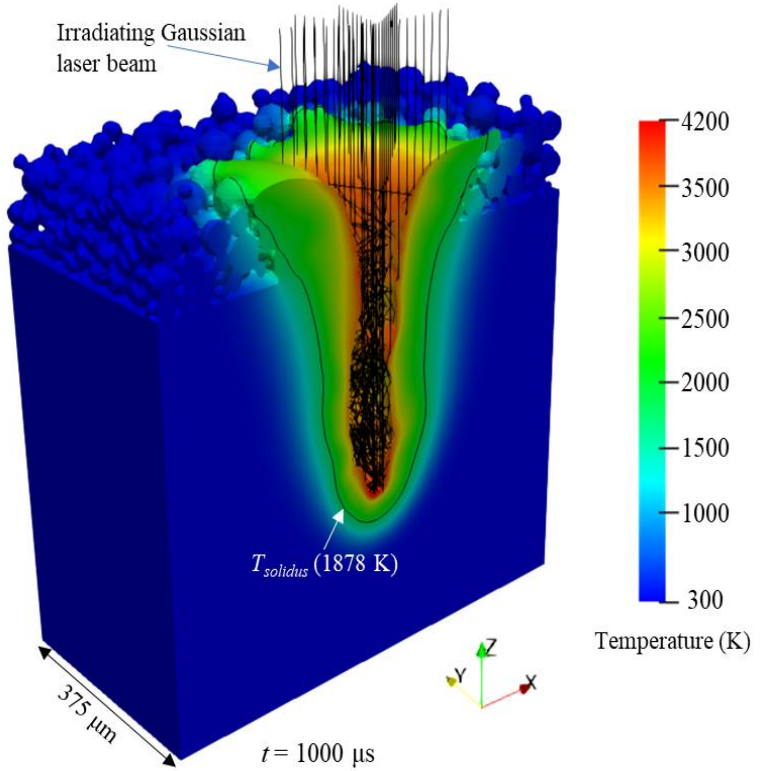


SEM images of sintered powder and unmelted powder inside the channels

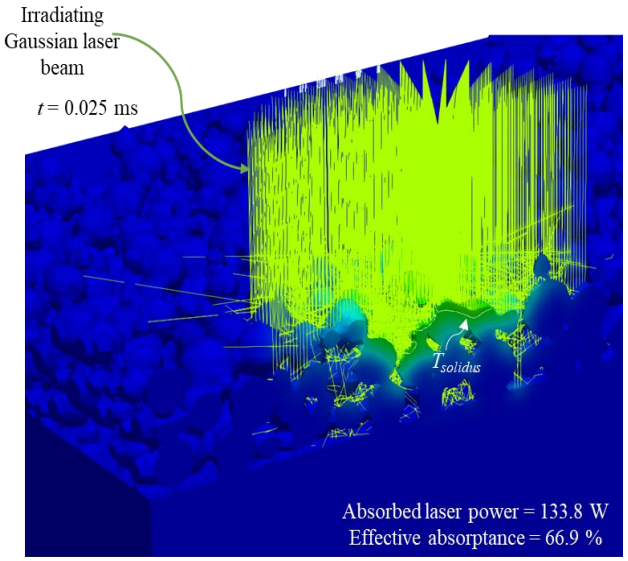
Development of Process Map for Additive Manufacturing of Inconel 718 and Inconel-SS316 Multi-material Component



High-fidelity ray tracing model for LPBF process



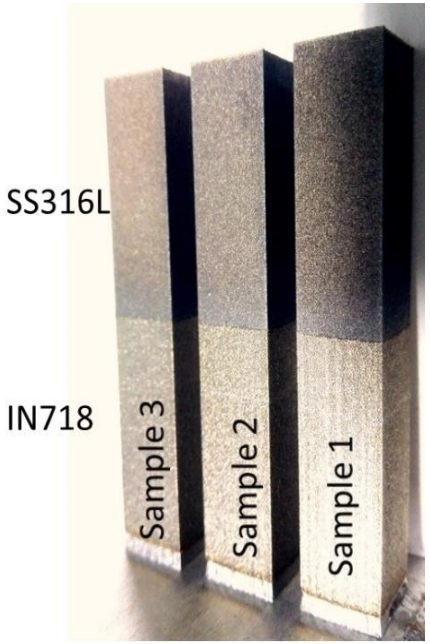
Multiple reflections of laser beam in the keyhole resulting in re-distribution of the laser beam intensity over the keyhole wall



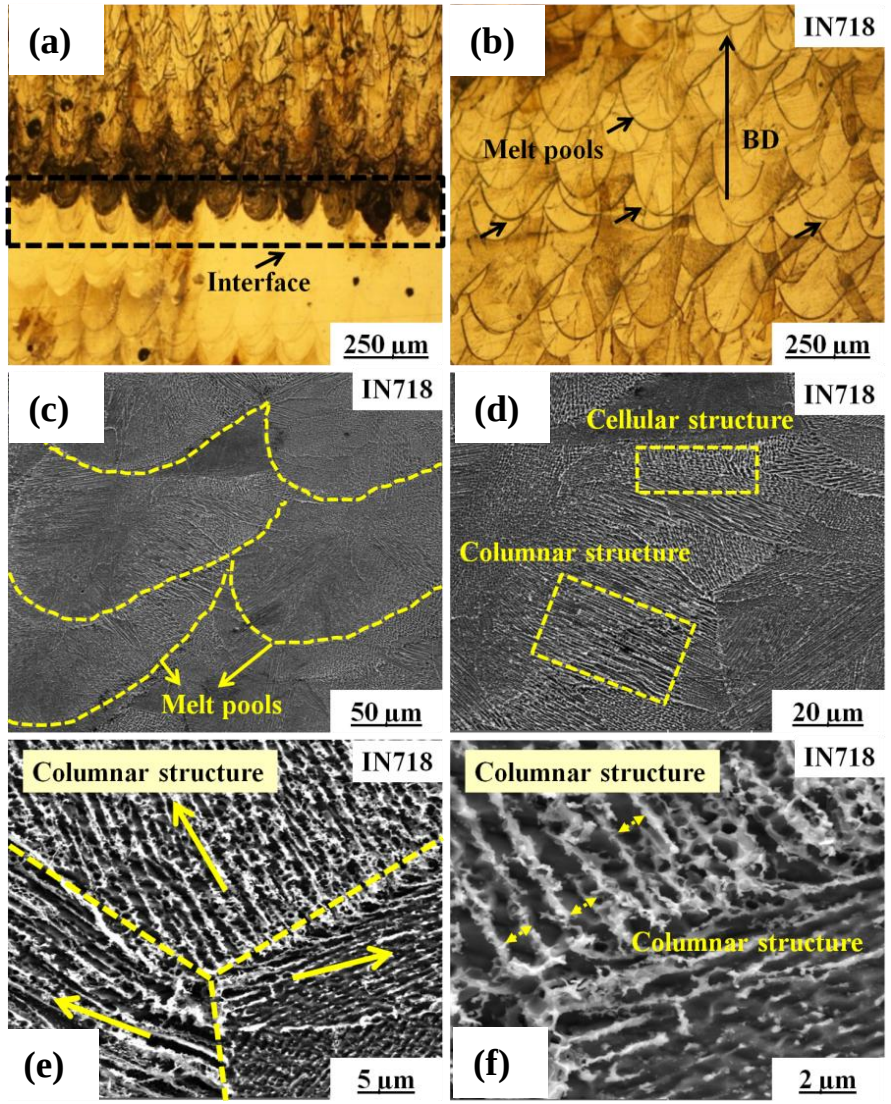
Local absorptance and reflectance of laser beam at curvature of the solid powder particles

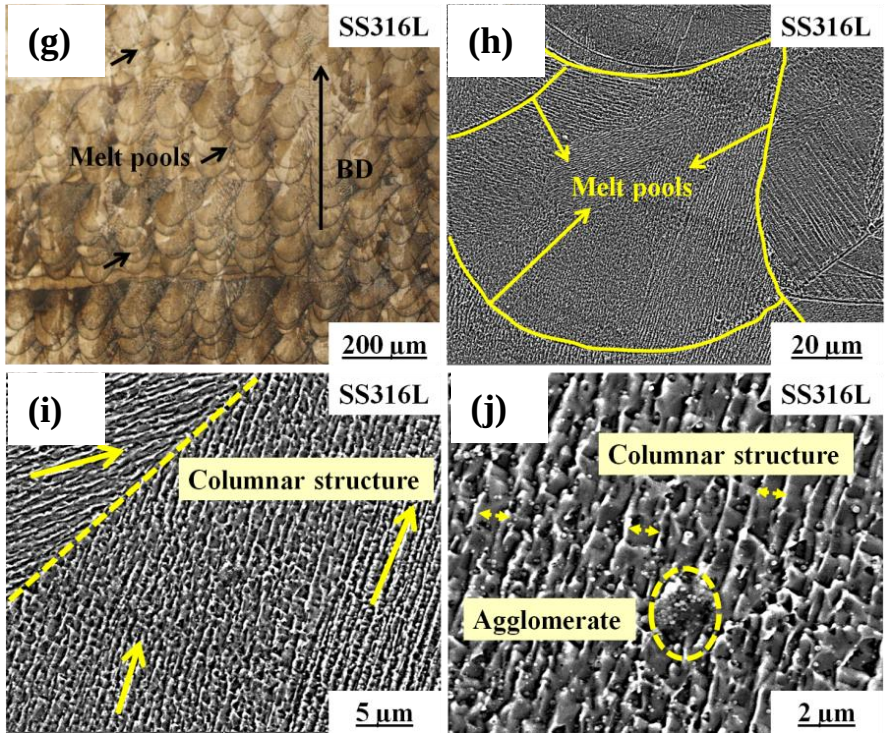
Components Printed from IN718, and Inconel-SS316 Multi-material

Defect-free fan printed



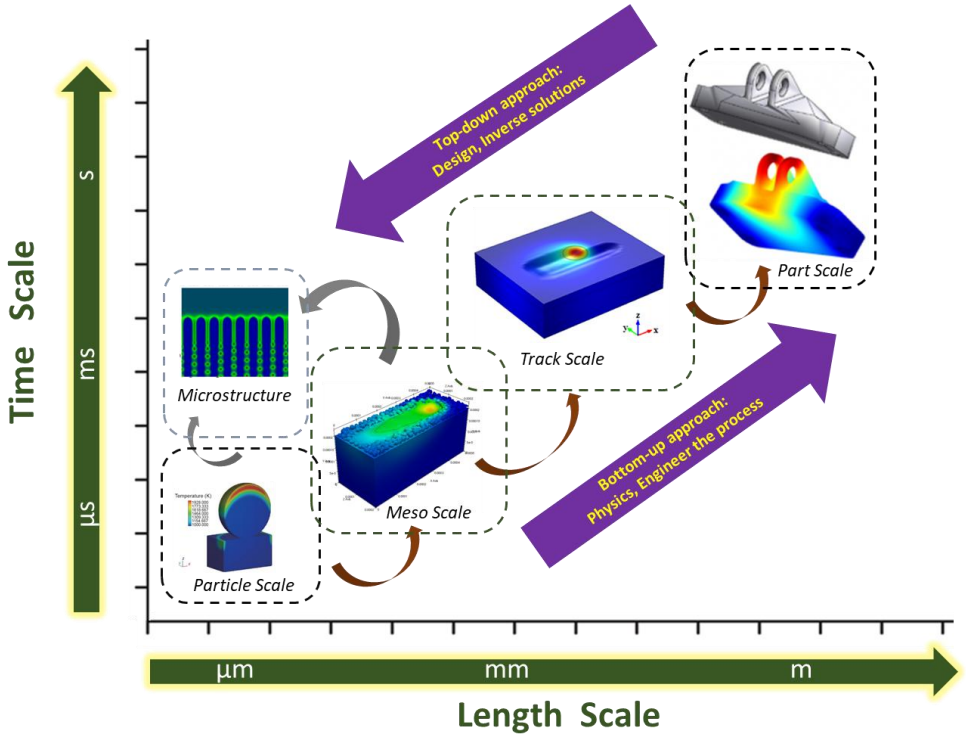
Defect-free bimetallic structure

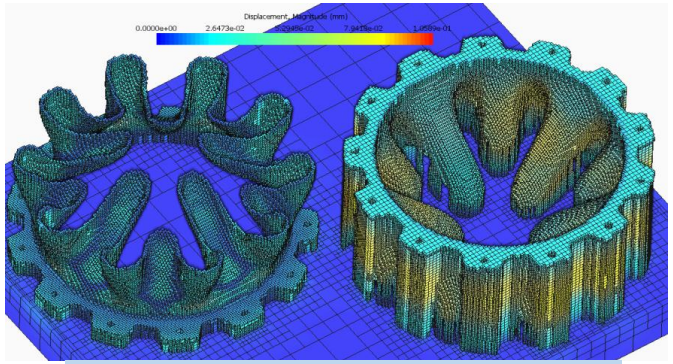




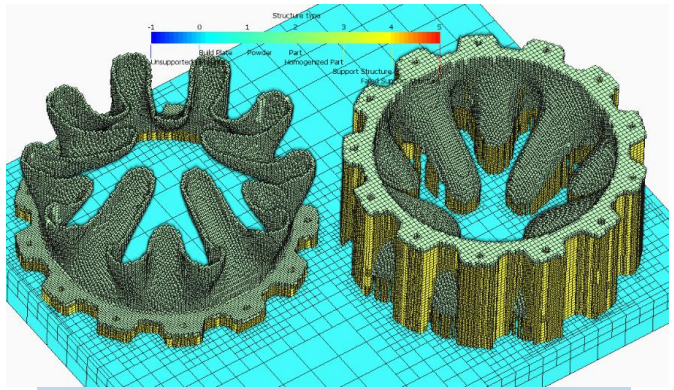
The processing parameters, such as laser power, hatch spacing, layer thickness and beam spot diameter were optimized

Additive Manufacturing of Aerospace Structural Component

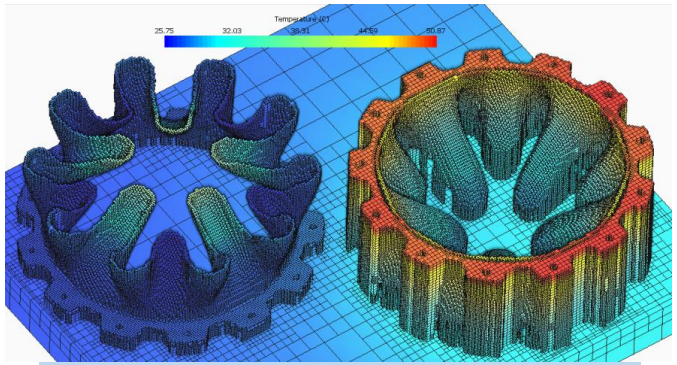




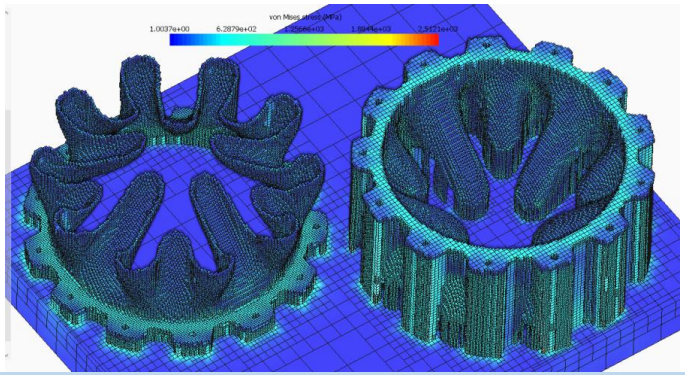
Simulation of displacement in the part during part building



Simulation of support structure and part failure during part building

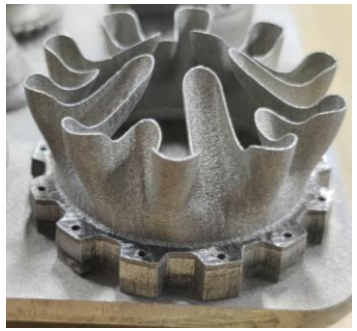


Simulation of temperature field during part building



Simulation of von-Mises stress generated in the part and support structure during part building

Defect-free 3D printed part prototype



Modelling of Multi-material Composite Fabricated by LPBF AM and Mitigation of Cracking

Validation and recursive training of computational models

Discrete element modelling of micro-nano powder bed (IN738 + TiC/TiB_2)

Powder configuration information

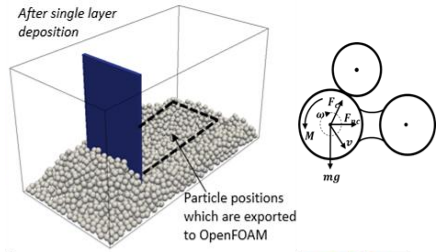
High-fidelity thermo-fluidic micro-nano particle scale modelling

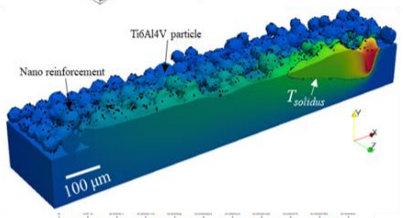
Undercooling and nucleation site information

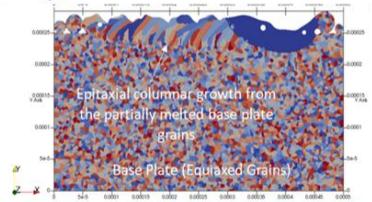
3D parallelized OpenMPI based Cellular Automata simulations

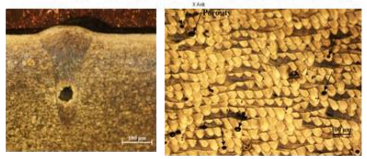
Benchmarking and validation

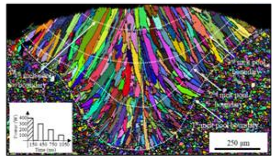
Benchmarking, controlled LPBF experiments and characterization

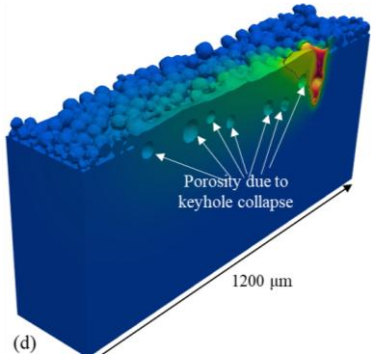




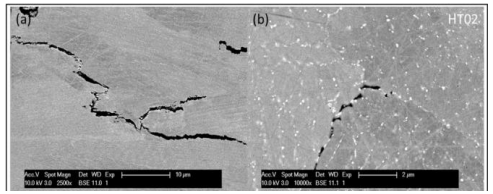








Porosity



Cracking in printed parts

Reinforcement powder and LPBF process development

Identification of nano-particles material for LPBF experiments

Selection of suitable nano powder as additive as per microstructure and density

LPBF process development for a chosen AM powder

LPBF process development for the selected powder and inputs obtained from the numerical tool

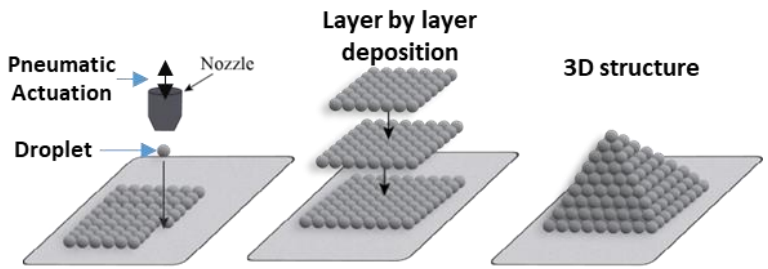
Process parameter optimization for LPBF system at IIT Kanpur

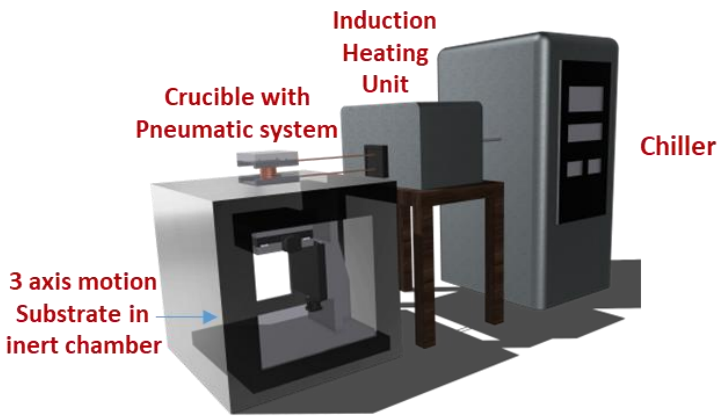
Benchmarking and validation of developed LPBF material using LPBF system at IIT Kanpur (Concept Laser Mlab R)

Analysis of material properties ("inner" properties - hardness, tensile, creep, etc, and "outer" properties - detail resolution, surface roughness of LPBF built specimens)

Inkjet Metal 3D Printing

Inkjet 3D printing





Schematic of Experimental setup

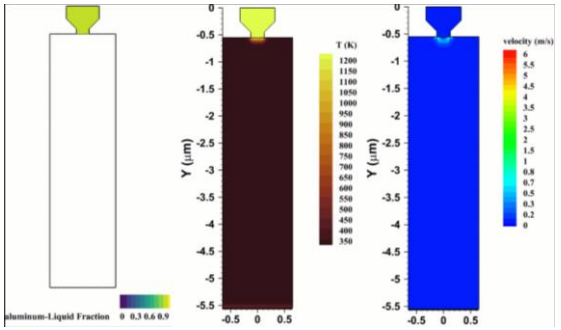
Experimental Setup

Crucible assembly

Development of multi-scale model to simulate physical phenomena

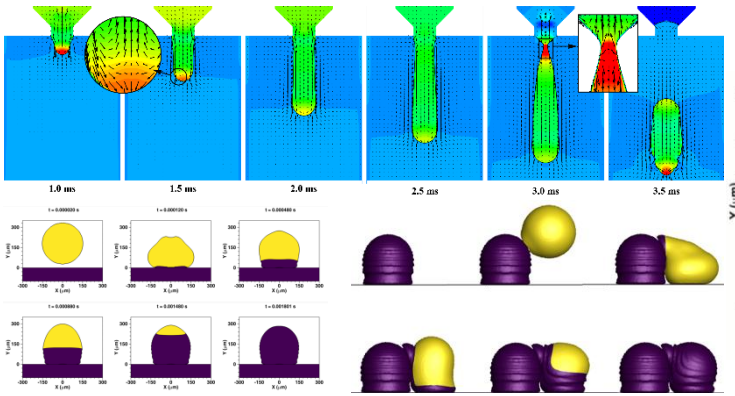
- Heat transfer model
- Solidification model
- Surface tension model
- Viscosity model

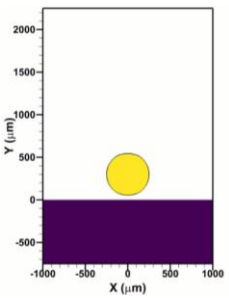
→ Modelling and Simulations

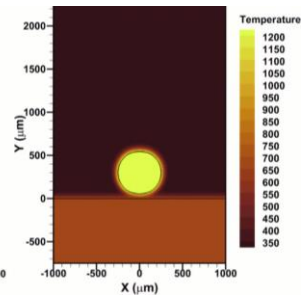


→ Physical Phenomena

- Printability Regimes
- Single droplet dynamics
- Multiple droplet line morphology
- Pillar Structure dynamics







→ Thermo-physical aspects of droplet deposition, coalescence and solidification