IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Computational Multi-scale and multiphase modelling of metal additive manufacturing**	
Project Number	**IMURA0896**	
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IITB Department:	Mechanical Engineering	

Research Clusters: / Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**Highlight which of the Academy's Theme(s) this project will address?** *(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*	
1	*Material Science/Engineering (including Nano, Metallurgy)*	***1***	*Advanced computational engineering, simulation and manufacture*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Infrastructure Engineering*
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Water*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*	5	*Nanotechnology*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Biotechnology and Stem Cell Research*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Humanities and social sciences*
8	*HSS, Design, Management*	8	Design

The research problem

Define the problem

This study aims to develop a computational multi-scale model to predict macroscopic melting and solidification during metal additive manufacturing, combined with a microstructural prediction. The multi-phase nature of the same arises from the fact that the porosity such as keyhole and gas can be simulated in the proposed integral framework. The complexity and challenges are multi-scale (at least two length scales to be resolved computationally) and multi-phase (solid (more than 1 phase within), liquid, and gas) in nature. Thus, a comprehensive predictive capability can be extremely beneficial to understand and explore process-structure-property relationships.

Project aims

Define the aims of the project

1) Integrate an existing macroscopic solver of binary alloy solidification in open-foam (for example) with a volume-averaged microstructural representation
2) Simulate material flow in the melt pool using CFD
3) Devise methodologies to represent and simulate microstructural features, based on existing in-house simulation tools
4) Incorporate gas and keyhole porosity prediction in the model
5) Validation experiments for each of the above using both lab and synchrotron based measurements
6) Demonstrate an integrated computational materials engineering framework

Expected outcomes

Highlight the expected outcomes of the project including likelihood of patents

1. The study would develop a novel, state-of-the-art computing framework to understand and design process-structure-performance correlations of 3D printed metal parts.
2. A new and exciting aspect of the proposed work is the incorporation of material specific microstructural prediction at the microscale.

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

The core objectives of the project are well aligned with computational and mathematical modelling, CFD and application to an advanced and emerging manufacturing technique.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

B.Tech/Masters in mechanical engineering, with knowledge of CFD, transport phenomena, math modeling, and materials processing