IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

NO

Project Title:	**Novel In-situ Process Diagnostics and Monitoring for Hybrid Additive-Subtractive Manufacturing**	
Project Number	**IMURA0943**	
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Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?

*(Please nominate JUST **one**. For more information, see www.iitbmonash.org)*

1	*Material Science/Engineering (including Nano, Metallurgy)*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3	*Math, CFD, Modelling, Manufacturing*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research Themes:

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	*Advanced computational engineering, simulation, and manufacture*
2	*Infrastructure Engineering*
3	*Clean Energy*
4	*Water*
5	*Nanotechnology*
6	*Biotechnology and Stem Cell Research*
7	*Humanities and social sciences*
8	Design

The research problem

Define the problem

Poor surface finish and dimensional inaccuracies often require additively manufactured metallic parts to undergo post-processing such as semi-finishing or finishing operations. Therefore, hybrid manufacturing processes with alternate additive and subtractive cycles are used to manufacture high-tolerance parts in a single setup. In such a process, the additive cycle enablesrapid and free-form deposition of complex structures, while the subtractive cycle such as CNC milling acts asa corrective process to maintain the required part dimensions, tolerances, andsurface finish. However, in additive cycles, the material deposition process often presents multiple challenges in terms of inherent surface defects, anisotropy, and uneven layer thickness.

This proposal seeks to develop a high-performance hybrid additive-subtractive process for manufacturing metallic parts with carefully tailored properties. The key idea here is to utilize the finish-machining process in the subtractive cycle as input to diagnose the bulk properties of the deposited materials. These properties include porosity, strength, residual stresses, thermal stresses, and warping. Monitoring machining signals in terms of cutting forces, vibrations, acceleration, and temperature during the subtractive cycles, monitored continuously or after several additions of material layers, could provide localized structural information in the manufactured parts that can lead to actions such as correction of the 2D-deposition patterns, or removal and re-deposition of layers. The outcome of this research would enable in-situ diagnostics and process monitoring and significantly improve the overall part quality in hybrid manufacturing.

Project aims

Define the aims of the project

The overarching goal of this project is to develop a high-performance hybrid additive-subtractive process for manufacturing metallic parts with carefully tailored properties. Specifically, the project aims to

(a) Develop an understanding of process parameters in the additive process on the properties of the deposited layers. These properties include porosity, anisotropy, and uneven layer thickness.
(b) Develop correlations between the localized material defects such as porosity and the machining signals, i.e., cutting forces, acceleration, and temperature. This will provide an in-situ diagnostic to assess the properties of deposited layers.
(c) Devise process control strategy based on the feedback from machining signals for the manufacturing of metallic parts with carefully tailored properties.

Expected outcomes

Highlight the expected outcomes of the project

(a) A computational model of the direct energy deposition-based additive manufacturing (AM) process, which provides a detailed understanding of AM process parameters on the quality of deposition
(b) A computational model of machining of the additively manufactured metallic parts, which provides a detailed understanding of the cutting mechanism and dependence of machining signals on properties of AM material
(c) In-situ diagnostic technique for quality assessment of additively manufactured parts
(d) Feedback-based process parameter selection strategy for the manufacturing of additively manufactured parts with superior properties

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 primary outcome of this project is the development of a high-performance hybrid additive-subtractive process. Parts manufactured from this process have diverse applications in prosthetics, catalytic converters, filters, acoustic mufflers, and heat exchangers.Thus, it is believed that this research will contribute to addressing the current and future needs in manufacturing.

Besides manufacturing, the research proposed here also enables an enhanced understanding of both additive and subtractive manufacturing processes via computationalmodeling studies. Simulation experiments will be conducted to explore the effect of different process parameters on the quality of the part manufactured.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to 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.

The student needs to have good analytical and programming skills, background in computational mechanics, material and microstructure characterization, data acquisition and analysis etc.

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

Dr. Yunlong Tang and Prof. Aijun Huang from Monash University