### Project Title:
Evaluating elevated temperature mechanical properties of Additively manufactured materials

### Project Number
IMURA1049

### Monash Main Supervisor
Aijun Huang, aijun.huang@monash.edu

### Monash Co-supervisor(s)

### Monash Head of Dept/Centre
Neil Cameron, neil.cameron@monash.edu

### Monash Department:
Department of Materials Science and Engineering

### Monash ADGR
Timothy Scott, Eng-ADGR@monash.edu

### IITB Main Supervisor
Deepak Marla

### IITB Co-supervisor(s)

### IITB Head of Dept
Sreedhara Sheshadri, head.me@iitb.ac.in

### IITB Department:
Mechanical Engineering

### Research Clusters:

### Research Themes:

<table>
<thead>
<tr>
<th>Cluster/Theme</th>
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<tbody>
<tr>
<td>Material Science/Engineering (including Nano, Metallurgy)</td>
<td>Artificial Intelligence and Advanced Computational Modelling</td>
</tr>
<tr>
<td>Energy, Green Chem, Chemistry, Catalysis, Reaction Eng</td>
<td>Circular Economy</td>
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<tr>
<td>Math, CFD, Modelling, Manufacturing</td>
<td>Clean Energy</td>
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<tr>
<td>CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control</td>
<td>Health Sciences</td>
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<td>Earth Sciences and Civil Engineering (Geo, Water, Climate)</td>
<td>Smart Materials</td>
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<tr>
<td>Bio, Stem Cells, Bio Chem, Pharma, Food</td>
<td>Sustainable Societies</td>
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<td>Semi-Condutors, Optics, Photonics, Networks, Telecom, Power Eng</td>
<td>Infrastructure</td>
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<td>HSS, Design, Management</td>
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The research problem

Define the problem

Ni-based superalloys has been widely used in the aerospace industry due to its excellent mechanical properties at elevated temperatures and superior oxidation resistance. However, recent studies show the high temperature properties of additively manufactured (AM) Ni-based superalloys are not optimised due to two main reasons: 1) the AM intrinsic defects 2) the initial microstructure of AM as-fabricated alloys are completely different with that of conventionally manufactured (CM) alloys. Therefore, the post treatment designed for CM alloys is not suitable for AM alloys. On this basis, optimised high temperature performance of AM alloys can be achieved in two main aspects: 1) printing process parameter optimisation, 2) fully understand the initial microstructure produced by AM process, and design post heat treatment to maximise high temperature mechanical properties.

In this project, Ni-based superalloy will be fabricated by AM process, e.g., laser powder bed fusion. The influence of printing parameters on the initial microstructure will be investigated. Meanwhile, the post treatment, e.g., heat treatment or hot isotactic pressing, will be applied to the alloys to tailor the microstructure and mechanical properties.

Many critical components particularly in the aerospace industry is used at elevated temperature. The additive manufacturing process has opened the design and manufacturing window for such components. However, not many studies and data are available in investigating the elevated performance of AM metallic materials particularly in the area of creep and fatigue. This work will look into the elevated temperature mechanical performance of AM produced metallic alloy having different initial processed microstructure. The evolution of the deformed microstructure will be characterized using in-situ and ex-situ techniques.

Project aims

1. Fully understand the initial microstructure produced by AM process via numerical modelling and experiments.
2. Optimization of AM printing process parameters using Machine Learning for enhanced mechanical properties.
3. Design and development of post heat treatment process to maximise high temperature mechanical properties.

How skills/experience of the IITB and the Monash supervisor(s) support the proposed project

Highlight the purpose of the collaboration and/or the complementary skills/experience that you bring to the project. Do you have any joint or independent publications in the area of the proposed project?

1. At IIT Bombay: Prof. Deepak Marla’s primary research is in laser materials processing. He will be supervising the student in laser powder bed fusion process, which is the additive manufacturing processes to be used in this project.
2. At Monash: Prof. Aijun Huang has a background in material science and works in additive manufacturing. He would be supervising the candidate on understanding the microstructure and designing of heat treatment process.

What is expected of the student when at IITB and when at Monash?

Highlight how the project will gain from the student's stay at IITB and at Monash

1. At IIT Bombay: The student is expected to complete the course work and work on laser powder bed fusion process. This would involve conducting experiments and developing numerical models for understanding the evolution of microstructure. This will be followed by parameter optimization using Machine Learning.
2. At Monash: The candidate will continue to work on fully understanding the microstructure evolution in the AM process, and subsequently in designing and development of a heat treatment process to improve characteristics at elevated temperatures.

### Expected outcomes

1. Development of a process for enhanced properties of Ni-based super alloys at elevated temperatures.
2. Enable the use of AM technologies for Ni-based super alloys.

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

1. The research would lead to the development of additive manufacturing for aerospace applications.
2. The research would enable the use of additive manufacturing for Ni-based super alloys in the aerospace industry.

### Potential RPCs from IITB and Monash

Provide names of the potential research progress committee members (RPCs) and describe why they are most suited for the proposed project.

1. Prof. Sushil Mishra (Mechanical Engineering, IIT Bombay): He has expertise in microstructure evolution.
2. Prof. Deepoo Kumar (MEMS, IIT Bombay): He has a good background in materials science.
3. Prof. Wenyi Yan (Department of Mechanical and Aerospace Engineering, Monash University): One of his research area is additive manufacturing.

### Capabilities and Degrees Required

**Essential skills:**
- Strong background in manufacturing, material science, basic physics, mathematical modeling, and computational methods
- Computer programming in C/C++, Java or Fortran, Matlab

**Additional skills (not mandatory):**
- Python

**Qualifications:**

### Potential Collaborators

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

1. Prof. Ramesh Singh (Mechanical Engineering, IIT Bombay)
2. Prof. Xinhua Wu (Materials Science and Engineering, Monash University)

Select up to (4) keywords from the Academy’s approved keyword list ([available at http://www.iitbmonash.org/becoming-a-research-supervisor/](http://www.iitbmonash.org/becoming-a-research-supervisor/)) relating to this project to make it easier for the students to apply.

- Materials chemistry/science