IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Substructure and Residual Stresses in Aluminum Alloys**	
Project Number	**IMURA0991**	
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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	~~*Artificial Intelligence and Advanced Computational Modelling*~~
2	~~*Circular Economy*~~
3	~~*Clean Energy*~~
4	~~*Health Sciences*~~
5	*Smart Materials*
6	~~*Sustainable Societies*~~

The research problem

Define the problem

Aluminum alloys are used extensively for advanced aerospace applications. The thermomechanical processing of these alloys often involves 'stretching', which is expected to provide residual stress relief. It is apparent that substructure evolution is intimately related to the residual stresses. However, the topic has rarely been quantified. Availability of recent experimental tools (namely micro-Laue diffraction [1,2] and SEM (scanning electron microscopy) [3] plus TEM (transmission electron microscopy) [4] based residual stress measurements provide potential breakthroughs for microstructural engineering on tailored residual stress relief. This is the motivation behind the present proposal.

References

1) Arijit Lodh, Tawqeer Nasir Tak, Aditya Prakash, P. J. Guruprasad, Christopher Hutchinson and Indradev Samajdar (2017): Relating Residual Stress and Substructural Evolution During Tensile Deformation of an Aluminum-Manganese Alloy, **MMTA**, 48A, 5317-5331.
2) Arijit Lodh, Tawqeer Nasir Tak, Aditya Prakash, P. J. Guruprasad2, Shyam M. Keralavarma, A. Amine Benzerga, Christopher Hutchinson and Indradev Samajdar (2019): Microstructural Origin of Residual Stress Relief in Aluminum, **MMTA**, 50A, 5038-5055.
3) H. K. Mehtani, M. I. Khan, A. Durgaprasad, S. K. Deb, S. Parida, M.J.N.V. Prasad, D. Fullwood, R.D. Doherty and I. Samajdar (2020): Oxidation Behavior of Interstitial Free Steel: The Defining Role of Substrate Crystallographic Texture, **Acta Mater.**, 190, 43-57.
4) Chang Ye, Abhishek Telang, Amrinder S. Gill, Sergey Suslov, Yaakov Idell, Kai Zweiacker, Jörg M.K. Wiezorek, Zhong Zhou, Dong Qian, Seetha Ramaiah Mannava and Vijay K. Vasudevan (2014): Gradient nanostructure and residual stresses induced by Ultrasonic Nano-crystal Surface Modification in 304 austenitic stainless steel for high strength and high ductility, **MSEA**, 613A, 274-288.

Project aims

Define the aims of the project

Relate substructure evolution with the state of residual stress. This will be attempted in aluminum alloys with and without coherent or semi-coherent 2nd phase.

- Al-Mg alloys with and without micro-alloying elements Sc and Zr will be selected for this project. The micro-alloying addition of Sc and Zr can introduce nano-scale and coherent precipitates of $Al_3(Sc,Zr)$. These alloys will be subjected to controlled cold deformation and post-deformation heat treatment, and both ex-situ and in-situ (straining and heating stages in a TEM) experiments will be used to characterizes the distribution and evolution of dislocations and precipitates.
- State of residual stresses is to be identified by micro-Laue XRD, TKD and by precession electron diffraction.
- Quantification between substructure and residual stress.

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

Highlight how the project will gain from the students stay at IITB and at Monash

IITB: Thermomechanical deformation, Residual stress measurements at a different scale.
Monash: Substructure characterization and atomic resolution scanning transmission electron microscopy.

Expected outcomes

Highlight the expected outcomes of the project

Basic understanding in a subject of tremendous applied interest: The Residual Stress Relief in Aluminum Alloys.

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 objective of this project is to understand the relationship between substructure and residual stress in advanced aluminum alloys. Therefore, this project falls under the category: smart materials in the Research Cluster of Material Science/Engineering (including Nano, Metallurgy)

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.

BTech or MTech in Metallurgical Engineering.

Necessary Courses

Name three tentative courses relevant to the project that the student should complete during his/her coursework at IITB (the student will require to secure 8 point in these courses)

Advanced Physical and Mechanical Metallurgy

X-ray and Electron Diffraction

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.

PJ Guruprasad, Aerospace IITB

Anirban Patra, MEMS IITB

Chris Davies, Monash

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

Metallurgy, smart manufacturing, materials chemistry/science, Materials modeling, and simulation