IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**The relationship between substructure evolution and the nucleation of recrystallization in metals**	
Project Number	**IMURA0613**	
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Research Academy 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

The research problem

The deformation of metals, such as occurs during rolling, extrusion or forging operations, increases the internal energy of metals through the storage of dislocations. Following deformation, the system reduces its energy by lowering its dislocation content. Depending on the conditions of pre-deformation and heat-treatment, this approach to thermodynamic equilibrium may occur in one of two ways: the system may undergo a process of continuous rearrangement and annihilation of dislocations and one then speaks of "recovery". Recovery is a gradual process which occurs everywhere throughout the deformed structure simultaneously. Alternatively, the system may lower its energy through the nucleation of new grains, free of dislocations, growing into a matrix which is heavily loaded with structural defects. This process is referred to as "recrystallization". Recrystallization is an abrupt process and occurs at specific sites in the evolving substructure.

Recovery and recrystallization are traditionally considered separately even though recovery certainly occurs at the high temperatures where recrystallization occurs, and it is has been shown that some recovery is actually beneficial for the important nucleation stage of recrystallization. Greater nucleation means a finer final grain size and metals with greater strengths and toughnesses.

The nucleation of a new recrystallization grain from a deformed metal matrix is not a process that is well understood, despite its huge importance. There are probably many mechanisms but one which operates often in low to medium stacking fault materials (such as high temperature steel, Cu and Brasses, stainless steels, etc) is known as grain boundary bulging. It is observed in both static and dynamic recrystallization and is associated with dislocation rearrangements (recovery and cell formation) in the vicinity of the grain boundary. However, nucleation of new grains also occurs under conditions where the applied deformation rate does not provide time for recovery. Nucleation also occurs in alloys with such low stacking fault energies that dislocation cell formation is difficult. In these cases how does grain boundary bulging to form a new grain occur? And how is this process affected by solute additions that are known to affect recovery processes. None of these important questions are currently know but at their core is the question of the coupling of the recovering dislocation substructure and the nucleation of new recrystallized grains.

Further advances in modelling recrystallization processes (both static and dynamic) during thermo-mechanical processing are currently limited by the lack of a quantitative understanding of the nucleation of recrystallization. This project is designed to help contribute to this understanding.

Project aims

- *To identify 'sites' of dynamic recrystallization and the correlation these have with the evolving dislocation substructure*
- *To understand the effects of solute on the evolving substructure and how this influences the nucleation stage of recrystallization.*
- *An overall understanding of Dynamic Recrystallization in terms of stored energy advantage (from dislocation dynamics) and solute drag.*

Expected outcomes

Basic understanding in an area of applied interest.

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

This is a collaborative project in which Monash's expertise on dynamic recrystallization will be combined with IITB expertise on microtexture and dislocation dynamics.

Capabilities and Degrees Required

The student should have a Bachelors + Masters degree in Materials Engineer (with focus on Metallurgy) from Reputed Institute
The student should have basic programing skills.

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.

Please provide a few key words relating to this project to make it easier for the students to apply.

Dynamic Recrystallization, Dislocation Dynamics, Recovery, Thermo Mechanical Processing