IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Nanostructured Alloys for Corrosion Resistance	
Project Number	IMURA0299	
Monash Supervisor(s)	Prof. Raman Singh	*Full names and titles*
Monash Primary Contact:	Raman.singh@monash.edu	*Email, phone*
Monash Head of Department:	Prof Chris Davies Chris.Davies@monash.edu	*Full name, email*
Monash Department:	Mechanical & Aerospace Engineering	*Full name*
Monash ADRT:	Prof Murray Rudman Murray.Rudman@monash.edu	*Full name, email*
IITB Supervisor(s)	Dr. V.S. Raja (Professor) Dr. Smrutiranjan Parida (Assistant Professor)	*Full names and titles*
IITB Primary Contact:	1. V.S.Raja vsraja@iitb.ac.in - +91-22-2576 7892 2. S.Parida ,paridasm@iitb.ac.in / +91-22-2576 7643	*Email, phone*
IITB Head of Department:	Prof. Rajiv O. Dusane rodusane@iitb.ac.in	*Name, Email,*
IITB Department:	Metallurgical Engineering & Materials Science	*Full name*

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

The research problem

For their unique physico-mechanical properties and exciting industrial applications, nanostructured materials are the most widely investigated materials research topic. However, corrosion of nanomaterials has received very limited research attention, even though the materials will be required to demonstrate acceptable corrosion resistance in most potential applications.

This project is based on the hypothesis that was developed at Prof Raman Singh's group at Monash University, i.e., it may be much easier to develop a protective film on nanocrystalline alloys. This hypothesis has also been validated through very recent research in Prof Singh's group (1,2). This work has shown for the first time that a nanocrystalline Fe-10%Cr alloy provides similar resistance to oxidation

at moderately high temperatures as a microcrystalline Fe-20%Cr alloy (that has Cr contents similar to common stainless steels). However, nanocrystalline Fe-Cr alloy has also been found to suffer from poor thermal stability (3), which restricts processing of such alloys at high temperatures. Hence there is a great value in identifying alloying additions that could substantially improve thermal stability and hence processabilty of nanocrystalline Fe-Cr alloys.

1. R.K. Singh Raman and R. K. Gupta, Oxidation Resistance of Nanocrystalline vis-à-vis Microcrystalline Fe-Cr Alloys, *Corrosion Science*, 51 (2009) 316 - 321.

2. R.K. Singh Raman, R. K. Gupta, Carl C. Koch, Synthesis Challenges and Extraordinary Resistance to Environmental Degradation of Nanocrystalline vis-à-vis Microcrystalline Fe-Cr Alloys, *Philosophical Magazine*, 90 (2010) 3233.

3. R. Gupta, R K Singh Raman and C. C. Koch, Grain Growth Behaviour and Consolidation of Ball Mille Nanocrystalline Fe-10Cr Alloy, *Materials Science and Engineering A,* 494 (2008) 253-56.

Project aims

The principal aim is the successful development of nanocrystalline alloys with the properties listed below:

1. Nanocrysalline Fe-based alloys that can be processed at considerably high temperatures (~1000 ^{o}C),
2. Nanocrystalline Fe-based alloys with oxidation and corrosion resistance with much lower Cr or considerably less expensive alloying additions.

Expected outcomes

The expected outcomes are:

1. Fabrication of nanocrystalline powders of Fe-Cr alloys with suitable additions, by powder metallurgical (ball milling) route,
2. Identifying alloying additions that could substantially increase the temperature of compaction and sintering of the powders, while retaining the nanocrystalline structure,
3. Fabricating Fe-based nanocrystalline alloys with less expensive alloying elements for oxidation resistance (such as Al and Si) than the expensive Cr.
4. Fabricating Fe-based nanocrystalline alloys with less expensive alloying elements for ductility/toughness of alloys (such as Mn) than the expensive Ni.
5. Characterization of oxidation and electrochemical corrosion resistance of the nanocrystalline alloys with their microcrystalline counterparts.

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

The project is of the Nanotechnology theme, and can lead to development of the next generation inexpensive alloys for corrosion resistance.

Capabilities and Degrees Required

The student will need the intellectual and infrastructural resource for:

1) *Mechanical Alloying / Ball milling, compaction and sintering: This will be accomplished at ARCI, Hyderbad, under collaboration with Dr. S Joshi, Deputy Director, ARCI.* ***This will be coordinated by Prof Raman Singh at Monash University****.*
2) *Characterization of Nanostructure by XRD and TEM techniques: XRD will be carried out both at Monash and IITB, and TEM at IITB.*
3) *Oxidation and Electrochemical Corrosion Testing: This will be carried out both at IITB and at Monash, using existing facilities with the Monash and IITB supervisors.*
4) *Post-oxidation/corrosion Characterization using XPS, SIMS, FIB, SEM/EDXS: These will be carried out primarily at IITB and Monash.*
5) *Synchrotron XRD would be carried out at Monash.*