

An Indian-Australian research partnership

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| Project Title: | Focused Ion Beam Nanostructuring of Optical Fibers/Probes for Sensing and Beam Engineering | |
| Project Number | IMURA1273 | |
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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*
- 7 *Infrastructure*

The research problem

Recent developments of focused ion beam (FIB) instruments have unique capabilities to manufacture novel products at the nanoscale. With the aid of multiple inert ion species, the FIB nanostructuring has emerged as a tool to fabricate structures directly over various media, like optical fibers, optical probes, etc. The site-specific direct writing of structures aids in innovations in sensing and metrology applications. However, a lack of understanding of the fundamental physics involved in material processing and characterizing the devices limits the development and repeatable applications.

Project aims

This project aims to investigate the nanostructures on optical fibers and optical probes at sub-100-nanometre resolution with a focused ion beam of different ion species. Through investigating the particle interactions with target materials, we plan to develop a prototype device and draft protocols to fabricate unprecedented nanostructures and surface modifications. Preliminary results will be obtained with recursive refinement of computational studies and physical experiments on optical fibers and probes used in AFM or NSOM, to foster ground-breaking applications that are previously infeasible.

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

Prof. Rakesh Mote has expertise in Micro/nano manufacturing, FIB processing, and ion-matter interactions. Prof. M. Aslam has expertise in tuning and understanding the materials physics and chemistry at the nanoscale to design new electronic, and optoelectronic nanodevices. The Monash collaborator Prof. Jing Fu has expertise in advanced applications of Focused Ion Beam (FIB) and Atom Probe Tomography (APT) for various domains, like material science and biomedical engineering.

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

At IIT Bombay

- Mandatory Coursework
- Training on Micro/Nano fabrication and Characterization Techniques
- Theoretical study of ion-material interactions
- FIB based Fabrication/Synthesis/Patterning
- Device Fabrication/Characterization

At Monash

- Theoretical study of ion-material interactions and FIB experiment using multi-ion beam species
- Training in sample preparation and nanocharacterisation. FIB experiments to understand various ion species and their interactions with optical fibers/probes
- Device development and characterization

Expected outcomes

- Protocols and novel approaches for nanostructure fabrication on optoelectronic elements like optical fibers, AFM/NSOM probes

- Insights into fundamental interactions of different ion species (Ga, He, N, O) on the target materials in FIB processing and underlying mechanisms
- Development of prototype devices using FIB-processed optical fibers/probes based sensing or micro/nanophotonic devices for applications in biomedical, nanometrology, etc.

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

The project aims at modelling and optimizing nanofabrication processes for structures and material property assessment. Further, the study is aimed at realization of complex micro/nanostructures with specific applications in sensing and beam engineering addressing the Theme 5.

How well the IITB and the Monash supervisor(s) know each other

Prof. Rakesh Mote and Prof. Mohd. Aslam (IITB) and Prof. Jing Fu (Monash) have jointly mentored 2 PhD students to complete the FIB-based research project, with more than 10 joint publications in leading journals. Notable achievements include Naik and Ratsogi Award for Excellence in Ph.D. Research for the year 2019-2021, IIT Bombay (PhD student Vivek Garg) and frequent student scholar and micrograph competition awards from Microscopy and Microanalysis (M&M) conferences and Australian Conference on Microscopy and Microanalysis (ACMM). The work (PhD student Bhavesh) received recognition Dr. S K Aggarwal Memorial Award for the Best Poster (International Workshop On Physics Of Semiconductor Devices, IIT Delhi) and TATA Chemicals Best Paper Award.

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

Capabilities and Degrees Required

The interested candidates should have knowledge/skills in the following:

- 1) Mechanical/Manufacturing/Materials Engineering/Electrical Engineering/Physics
- 2) Strong aptitude to take up interdisciplinary research
- 3) Skills in characterization of sensing devices (MEMS/optoelectronics)
- 4) Exposure to experimental and characterization techniques in the microfabrication domain will be an additional advantage

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)

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.

Keywords relating to this project to make it easier for the students to apply.

Micro/nanofabrication, Nanoscience, Micro/nano photonics, Optoelectronics, Bioengineering