Monash_IITB_masthead

Project Title:	**Spin orbit torques using 2D materials and heterostructures**	
Project Number	**IMURA1013**	
Monash Main Supervisor (Name, Email Id, Phone)	Prof. Julie Karel, julie.karel@monash.edu	*Full name, Email*
Monash Co-supervisor(s) (Name, Email Id, Phone)		
Monash Head of Dept/Centre (Name,Email)	Prof. Neil Cameron, neil.cameron@monash.edu	*Full name, email*
Monash Department:	Materials Science and Engineering	
Monash ADGR (Name,Email)	Prof. Timothy Scott, Eng-ADGR@monash.edu	*Full name, email*
IITB Main Supervisor (Name, Email Id, Phone)	Prof. Ashwin Tulapurkar, ashwin@ee.iitb.ac.in	*Full name, Email*
IITB Co-supervisor(s) (Name, Email Id, Phone)		*Full name, Email*
IITB Head of Dept (Name, Email, Phone)	Prof. Kishore Chatterjee, kishore@ee.iitb.ac.in	*Full name, email*
IITB Department:	Electrical Engineering	

Research Clusters:

Research Themes:

	Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**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	***Material Science/Engineering (including Nano, Metallurgy)***	***1***	*Artificial Intelligence and Advanced Computational Modelling*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Circular Economy*
3	*Math, CFD, Modelling, Manufacturing*	3	***Clean Energy***
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Health Sciences*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*	5	*Smart Materials*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Sustainable Societies*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Infrastructure*
8	*HSS, Design, Management*		

The research problem

Energy used to power electronic devices represents ~8% of total global energy consumption. This fraction is only expected to grow in the future, indicating a clear need to develop low energy electronic devices. The 2020 International Roadmap for Devices and Systems, as well as experts from the largest semiconductor manufacturer, Intel, place spin orbit torque (SOT) switching as a crucial technology for future logic and data storage devices. The mechanism underpinning this technology is the conversion of a charge current into a spin current, and the present challenge is to develop materials with large conversion efficiency (spin orbit torque efficiency).

Project aims

The aim of this project is ultimately to develop two-dimensional (2D) materials with large spin orbit torque efficiency, and this goal will be achieved through the following objectives:

(i) synthesis and characterisation of promising 2D materials
(ii) fabrication of devices
(iii) magnetotransport (including magnetoresistance, Hall effect, etc) and spin orbit torque efficiency measurements

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

Dr Karel has more than a decade of experience studying electronic and magnetotransport properties in thin films, including fabricating devices for these measurements. She has also performed extensive synchrotron-based characterisation of the electronic and magnetic properties of materials and will thus be able to support experiments at the Australian Synchrotron.

Prof Tulapukar has extensive experience in studying spin-based phenomena and devices. He has expertise in nano-fabrication of devices and rf measurements such as ferromagnetic resonance, phase locking of oscillators, magnetic noise etc. This would be useful for measuring spin-orbit torques.

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

Monash: The student will perform advanced characterisation of the 2D materials including (but not limited to): electronic and magneto-transport at rotatable high magnetic fields up to 14T and low temperatures (mK), Raman spectroscopy, X-ray absorption spectroscopy and photoemission experiments at the Australia Synchrotron

IIT-B: The student will fabricate devices based on 2D materials using the clean room facilities. The student will carry out measurements such as spin-transfer ferromagnetic resonance (STFMR), spin-pumping etc.

Expected outcomes

- A clear understanding of the electronic and magnetic properties of the 2D material and device heterostructure
- Realisation of a large spin orbit torque efficiency in the device heterostructure

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

The aim of the project is to realize materials with large spin torque efficiency. These materials in turn can be used can be used for switching nano-magnets placed in contact with them. Thus, the outcome of the project would be highly useful for writing MRAM (Magnetic Random Access Memory) cells in an energy efficient way.

Potential RPCs from IITB and Monash

Monash: A/Prof Nikhil Medhekar – theoretician with extensive expertise in electronic and magnetic properties of materials and interfaces; Dr Mark Edmonds – experimentalist with expertise in thin film growth, photoemission and electronic transport measurements.

IITB: Prof. Muralidharan Bhaskaran- theory and simulation of electronic transport in devices; Prof. Dipankar Saha: Extensive experience in spintronics, nanofabrication, characterization.

Capabilities and Degrees Required

Ideally the student would have a physics background (perhaps an undergraduate or masters degree). A background in Materials Science and Engineering or Electrical Engineering would also be useful.

Necessary Courses

Nanomagnetism and spintronics, Physics of Nanoelectronic devices 1, Solid State Devices

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.

Monash: A/Prof Nikhil Medhekar, Prof Michael Fuhrer, Dr Mark Edmonds, Dr Agustin Schiffrin, Prof Kiyonori Suzuki

IIT-B: Prof. Muralidharan Bhaskaran, Prof. Dipankar Saha, Prof. Swaroop Ganguly

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.

Novel functional materials, Energy Materials, Nanotechnology