IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Light weight, flexible, low cost high efficiency tandem solar cells	
Project Number	**IMURA0866**	
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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*	*Advanced computational engineering, simulation and manufacture*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Infrastructure Engineering*
3	*Math, CFD, Modelling, Manufacturing*	3	***Clean Energy***
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Water*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*	5	***Nanotechnology***
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Biotechnology and Stem Cell Research*
7	***Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng***	7	*Humanities and social sciences*
8	*HSS, Design, Management*	8	Design

The research problem

Define the problem

This project aims at demonstrating flexible tandem solar cells with efficiency > 35% by developing a TMDC photovoltaic (PV) technology and by advancing current III-V semiconductor PV technologies. Bandgap tunable TMDCs and III-V semiconductors can provide the ideal bandgap combination of 1.7 eV and 1.1 eV for maximising the limiting efficiency of dual bandgap solar cells.

Project aims

Define the aims of the project

The major challenge facing any flexible technology is the extremely low optical path length (due to thin absorbers necessary for flexible solar cells). We will address this issue by incorporating photon management structures to maximise light absorption in flexible material. We will develop a new (ALD) based materials platform for photogenerated carrier separation in the dual bandgap absorbers, thereby eliminating the need to form p-n junctions. This novel approach will eliminate several complex and technologically challenging tasks associated with controlled doping of semiconductor materials.

This project is the first attempt to combine III-V and TMDC technologies and hence is complementary to current research in PV, worldwide. Our proposed ALD material platform and device structures enable this innovative technology.

This proof of concept demonstration provides a much-needed premium product for the multi-billion USD market of niche applications like light weight aerial drones, battle-field radio and communication equipment, e-mobility or green transport and the Internet of Things (IoT) and has the potential to significantly reduce the '$/W' figure of merit for the general electricity market as the technology matures.

This project addresses the important issue of efficiency to cost ratio of flexible PV, promoting faster uptake of the technology into the consumer market. The technology developed in this project will generate intellectual property (IP) related to flexible PV technology. We will transfer our research outcomes to industry, creating technological jobs in the energy sector.

Expected outcomes

Highlight the expected outcomes of the project

1. Deposition of ALD based selective layers with variable free-carrier concentration with thickness control on nm scale.
2. Establish an understanding of carrier dynamics in III-V – selective layer and TMDC – selective layer heterostructures.
3. Optimize the deposition parameters, structural (thickness) and electrical (conductivity) properties for the selective layers.
4. Demonstrate flexible III-V solar cells
5. Demonstrate high efficiency, light weight, flexible tandem TMDC-III-V solar
6. Publish results in peer reviewed journals and presented at International conferences.

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.

Clean Energy:

This project addresses the important issue of efficiency to cost ratio of flexible PV, promoting faster uptake of the technology into the consumer market. The technology developed in this project will generate intellectual property (IP) related to flexible PV technology. We will transfer our research outcomes to industry, creating technological jobs in the energy sector.

Nanotechnology:
The project will involve building of optical devices using 2D materials, whose thickness is few nanometers. In this work, we will combine III-V and TMDC technologies and hence this effort is complementary to current research in PV, worldwide.

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.

Capabilities: Through project or coursework

1) Basic solid state Physics theory (proficient)
2) Optics or basic electrodynamics - theory and experiment (medium)
3) Micro and nanofabrication (some exposure)

Qualifying degrees:

1) MSc. Physics
2) B.E./B.Tech./M.Tech. in Engineering Physics, Chemistry, Electrical Engineering or Materials Science

Strong plus:

1) Some cleanroom experience
2) Exposure to basic optical characterization (microscope / Raman / PL, etc)
3) Exposure to Data analysis in MATLAB or Python

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.

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, Photonics, Nanotechnology