IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Recycling of Photovoltaic Modules	
Project Number	**IMURA0968**	
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IITB Department:	Metallurgical Engineering And Materials Science	

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

There are several challenges in the recycling of PV modules:

- Modules designed to be hermetically sealed for more than 20 years. Even at 'End-of-life', the module is still likely to be intact, only with localized defects or producing less power. Delamination of such a well-sealed composite structure is not simple. It is even more challenging to delaminate if recovery of intact components is desired.
- The Silicon wafers are 150-180µm thin and are fragile. Most of the delamination processes cause a significant amount of physical and thermal stress on the wafers, so recovery of intact cells is difficult. It may be prudent not to aim to recover intact cells due to the reasons mentioned below.
- Recovery of Ag, Al, Sn, Pb, Cu, etc., from the cells, requires extensive chemical processing. This may lead to the generation of chemical effluents.
- The components recovered will be ~ 20 years old and may not match the current technology.

Project aims

Define the aims of the project

The process is envisaged to be carried out in two stages – first, on a single cell mini-module fabricated in-house, and then on small commercial modules

- Delamination to separate Aluminum frame, intact glass, and possibly intact solar cells.
- Leaching and electrowinning of Ag and Al from the Solar cells
- Explore the use of the recovered Si in steel refining
- Fabricate new modules using the intact solar glass. Potentially re-use the Aluminum frame too.
- Alternate encapsulant materials will be evaluated which can help in making the module easier to recycle while providing lifetime equivalent or better than EVA.

Expected outcomes

Highlight the expected outcomes of the project

- Demonstration of module delamination by various methods – Chemical/Thermal/Physical
- Recovery of module components – Glass, Solar cell (Intact or broken)
- Re-use – If the intact glass is recovered, attempt re-manufacture of a fresh panel
- Recovery of Al, Ag from the Solar cell by chemical leaching
- Explore the use of the recovered Si in steel refining
- Alternate encapsulant materials will be evaluated which can help in making the module easier to recycle while providing lifetime equivalent or better than EVA.

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.

The aim of the project is to develop methodologies for recycling end-of-life Photovoltaic modules. This is in good consonance with the theme of 'Clean Energy'. As the adoption of PV technology is poised to increase exponentially over the next decades, so is the amount of waste that will be generated by discarded modules. Unless a solution to responsibly manage this problem is found, the large-scale adoption of this Clean Energy source will result in burgeoning landfills.

The materials recovered from the recycled modules can potentially be re-used for fabricating new modules or for other applications.

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.

M.Sc. in Chemistry,

M.Tech in Polymers, Materials Science, Mechanical Engineering, Chemical Engineering or other related disciplines

Candidates from other disciplines are also welcome to apply if they have expertise relevant to the project.

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)

The courses for the student will be decided mutually based on the student's background. Some of the potential courses at IITB could be the following:

Department	Course code	Name
Chemical Engineering	CL 624	Polymer Processing
Chemistry	CH 442	Molecular Spectroscopy
Chemistry	CH 602	Characterization of Polymers
Energy	EN 640	Solar Photovoltaic, Fundamentals, Technologies and Applications
Met. Eng & Mat. Sci.	MM 452	Plant Engineering
Met. Eng & Mat. Sci.	MM 453	Engineering polymers and composites
Met. Eng & Mat. Sci.	MM 644	Mathematical Methods of Materials Engineering.

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.

From IIT Bombay:

1. Prof. Anil Kottantharayil (Electrical Engineering): He leads the Si PV group the National Centre for Photovoltaics Research and Education (NCPRE)

2. Prof. Narendra Shiradkar (Electrical Engineering): He leads the PV module reliability group at NCPRE

Both Prof. Anil and Prof. Narendra also have close interactions with Module manufacturers and Large scale PV power organizations.

3. Prof. Arup Bhattacharya (Metallurgical Engineering and Materials Science): He has expertise in polymer processing, which will be beneficial for the project.

From Monash:

1. Prof. Jacek Jasieniak (Materials Science and Engineering): He is an expert in energy harvesting and storage materials, and former Director of Monash Energy Institute

2. Prof. George Simon (Materials Science and Engineering): He has tremendous expertise in polymer materials development and materials durability. 3. A/Prof Kei Saito (Chemistry): He is an expert in polymers from renewable resources

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.

Energy, Energy Storage, Energy Materials	2
Waste to Wealth	3
Green Chemistry and Renewable Energy	18
Materials Chemistry/Science	20