IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Development of Graphene-based Anti-corrosion Coatings for Bipolar Plate Materials in PEM Fuel Cells**	
Project Number	**IMURA0621**	
Monash MainSupervisor (Name, Email Id, Phone)	Prof. Raman Singh,raman.singh@monash.edu, +6139905	*Full name,Email*
Monash Co-supervisor(s) (Name, Email Id, Phone)		
Monash Head of Dept/Centre(Name,Email)	Prof Karen Hapgood, karen.hapgood@monash.edu	*Full name, email*
Monash Department:	Department of Chemical Engineering	
Monash ADRT (Name,Email)	Prof Emanuele Viterbo, emanuele.viterbo@monash.edu	*Full name, email*
IITB Main Supervisor (Name, Email Id, Phone)	Prof. Siva Bohm, sivabohm@iitb.ac.in, 91-7506029112	*Full name,Email*
IITB Co-supervisor(s) (Name, Email Id, Phone)	Prof. MJNV Prasad, mjnvprasad@iitb.ac.in, 022-25767642	
IITB Head of Dept (Name, Email, Phone)	Prof. VenkatRamani, ramani@iitb.ac.in, 022-25767600	*Full name, email*
IITB Department:	Metallurgical Engineering and Materials Science	

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
7. Humanities and Social Sciences

The research problem

Define the problem

Low carbon steel is very cost effective but its corrosion resistance is too low for its application as a Bipolar Plate (BPP) material. To control corrosion of steel, they are generally subjected to surface treatments such as galvanizing and chromatizing. Due to serious concerns about use of chromium (VI) (released as a result of chromatizing) on human health and environment, its use is restricted in many countries. Hence it has to be replaced with alternative coating system.

Graphene has gained wide attention for various applications right from its inception due to its phenomenal electronic and mechanical properties. Its various applications include solar cells, batteries, super capacitors, flexible display touch panels, conductive inks, automobile components etc. Protection against corrosion is one such important and emerging application.

This study aims at synthesis of graphene adopting bottom up approach for development of natural graphite based BPPs for stationary fuel cells and then the development of graphene based conducting/anti-corrosive coatings and hybrid composite coatings (Graphene/CNT) for BPP materials. These coatings aimed at providing extremely low contact resistance, while also providing excellent corrosion resistance, while being cost effective.

Project aims

Define the aims of the project

- Using high purity natural graphite from various sourcesand development of surface treated natural graphite based BPPs for stationary fuel cell applications.
- Graphene synthesis using bottom up approach such as chemical vapour deposition (CVD) coating for polymer electrolyte membrane (PEM) fuel cells.
- Functionalization of graphene and formulation of graphene based coatings without impacting the conductivity of coating and to fulfil the standards aimed by DOE for corrosion properties of PEM fuel cells.
- Electrochemical co-deposition using graphene particles on stainless/mild steel substrates
- Development of hybrid composite coatings (Graphene/ CNT/ carbon allotrope such as 2D materials) for PEM fuel cells.
- Performance of novel coated BPPs in a PEM fuel cell system shall be evaluated in conjunction with Tata group and final formulation and would be scaled up to industrial production.

Expected outcomes

Highlight the expected outcomes of the project

- Currently, synthetic graphite based BPPs are mostly used for developing PEM fuels. In this work, for stationary performance of PEM fuel cells,BPPs are developed using surface treated natural graphite since the natural graphite has higher electrical conductivity than sythetic graphite. The weight of graphite based BPPs doesnot have any deleterious effect on stationary fuel cell application. No work has been reported so far regarding surface treatment of natural graphite for BPPs.

- Development of graphene based anit-corrosive coatings for BPPs of PEM fuel cells, without effecting the electrical conductivity of graphene: eloped. These coatings would be developed to meet the requirements specified by DOE, USA. The specific advanatges ofsuch coatings will be : low corrosion rate, (1 $\mu A/cm^2$) and low contact resistance (20 $m\Omega$-cm^2 at 200 psi). Graphene would be chemically functionalised before its application as coating.

- Hybrid composite coatings involing initial functionalization of Graphene/CNT and other 2D materials and coating application on BPPs for improved mechanical properties and longevity.

- The developed Graphene/carbon composite coatings on carbon steel and stainless steel shall possess very low contact resistance and corrosion resistance. The work shall also be aimed at improving the mechanical properties (durable strength, adhesion). The optimised methodology and technology, on succesful implementation will be patented, without infringing on existing patents.

- Commercially viable product shall be targetted to be achieved by the end of the specified time frame (36 months), which can be replicated on an industrial scale and marketted globally by Tata group.

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 project is obviously both in two themes, nanotechnology (as the project will develop coatings of atomically thin graphene) and energy (as it addresses the technologically challenge of a fuel cell type).

Improved conductivity and corrosion resistance of the Coated Stainless/Mild steel for application of Fuel BPPs. Developed Technology will be implemented in India.
In addition the graphite available from Talga resources that is of high purity will be utilised for BPPs along with graphene based coating treatment.

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.

For this interdisciplinary yet a highly specialised project, the candidate must possess a deep interest and preferably some demonstrable background in nanomaterial and their properties for electrochemical applications such as corrosion, fuel cells etc.

The candidate should have Materials Engineering, Materials Chemistry, Chemical Physics or Chemical Engineering degree at Master or a good Honours with reasonable research component, but most important attribute will be a deep interest nanomaterial and their electrochemical properties.

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.

Group Technology Office-Tata Sons Limited (Dr. Mahesh Murthy), Tata Steel Europe (Dr. Siva Bohm) &Tata Power (Mr. Sydney Lobo)
Potential Industry Collaboration: Talga Resource Limited (Dr Mark Thomson)

Please provide a few key words relating to this project to make it easier for the students to apply.

Graphene, Corrosion Resistance, PEM fuel cells, Bipolar Plate