IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Two-dimensional metal-organic nano-materials for transistor-based sensors**	
Project Number	**IMURA0644 (1)**	
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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	*Advanced computational engineering, simulation and manufacture*
2	*Infrastructure Engineering*
3	*Clean Energy*
4	*Water*
5	***Nanotechnology***
6	*Biotechnology and Stem Cell Research*

The research problem

Organic thin film transistors (OTFT) have great potential for the design of nano-sensors because of their simple processing techniques, cost efficiency, flexibility, capability of nanoscale control

and large area substrates, as well as tunability of the chemical reactivity of their active organic materials. Transistor-based sensors rely on interactions (chemical or physical) between the active organic channel material and the targeted analytes, without need of extra amplification, and allowing for easy scale-up. These sensors are multi-parametric, that is, interactions between active materials and analytes can affect multiple electronic parameters such as charge mobility, on/off ratio, threshold voltage, subthreshold slope; a combination of these parameters can be used as a response to the sensing stimuli. As the active channel material, metal-organic frameworks (MOFs) – nano-systems with well-defined geometry consisting of organic molecules coordinated with metal ions – have shown great potential for sensing applications for a large variety of targets, including gases, solvents, pesticides, explosives and bio-molecules. Notably, MOFs offer a wide range of tunability of their nanoscale morphology and hence of their electronic properties. Their use in OTFTs holds promise for the design of ultra-sensitive, orthogonal and cost-efficient sensing devices. In this proposed project, we will aim to use atomically precise low-dimensional MOFs as active materials in transistor-based sensors targeting analytes such as gases, vapor phase compounds, chemical solvents, bio-molecules and explosives. The project will deal with synthesis of the metal-organic nano-materials, device engineering and performance assessment, and fundamental atomic-scale characterization via low-temperature scanning tunneling microscopy and spectroscopy, non-contact atomic force microscopy and Kelvin probe force microscopy.

Project aims

1. Identifying and synthesizing the relevant MOFs for a particular analyte

2. Developing the film deposition process of MOFs. This will include both deposition from solution and bottom-up supramolecular chemistry on surfaces approaches

3. Device fabrication, characterization and performance assessment of organic thin film transistors

4. Atomic-scale characterisation of low-dimensional MOFs on surfaces with low-temperature scanning probe microscopy techniques; correlation between atomic-scale properties and overall device performance

Expected outcomes

1. Highly sensitive and selective sensors for various gas, vapor and chemical based analytes
2. Establishing the protocols for integrating MOFs with OTFTs
3. Determining the fundamental link between atomic-scale properties and overall device performance

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

The research area in the field of MOFs based sensors can be considered as sub-research area of ‘Nanotechnology’, wherein MOF based and organic semiconductor films are highly nanostructured and interact with the targeted analytes at the atomic level

Capabilities and Degrees Required

We are looking for 1 Ph.D. student in this project; Candidates with following academic background is desired.

1. M.Tech in Materials Science/Materials Engg/Chemical Engg,
2. M.Sc in Chemistry/Physics

Potential Collaborators

Monash: Prof. Michael S. Fuhrer, Prof. Nikhil Medhekar, Dr. David Turner. Dr. Allison Funston, Prof. Douglas MacFarlane, Dr. Matthew Hill

Select up to **(4)** keywords from the Academy's approved keyword list **(available at www.iitbmonash.org)** relating to this project to make it easier for the students to apply.

Novel functional materials; Nanotechnology/nanoscience; Sensor and Sensor Networks; Materials Chemistry/Science