E&I Research Studentship project proposal 2019

Project title: Advanced functional materials for electrocatalytic and photocatalytic water oxidation

Supervision Team:
Satheesh Krishnamurthy, School of Engineering & Innovation (satheesh.krishnamurthy@open.ac.uk)
Nick Braithwaite, School of Physical Sciences (n.s.braithwaite@open.ac.uk)

Project Highlights:

- New materials for artificial photosynthesis
- International travel to field trips
- prototype development and high end characterisation

Project Description:
The ever increasing population and the continuous thrive for economic development has raised the global energy demand by orders of magnitude. As of now, majority of our energy needs are derived from fossil fuels such as coal, oil, and natural gas. However, the gradual depletion of fossil fuels and the adverse effects fossil fuels pose to the environment have stimulated intense research to develop novel strategies to derive energy form sustainable and clean sources. Conversion of solar energy to chemical energy via artificial photosynthesis could be an ideal solution to address these energy and environment issues providing us with carbon free energy resources. Water oxidation is the most crucial part of both natural and artificial photosynthesis processes. The major hurdle in achieving high efficiency in artificial photosynthesis is the inherent slow kinetics of the water oxidation reaction. In a practical water-splitting system oxygen evolution reaction (OER) occurs at the anode and hydrogen evolution reaction (HER) at the cathode. To overcome the energy demanding bottleneck of OER, developing catalysts that are highly active, have excellent stability, and need low overpotential is crucial. RuO2 or IrO2 are currently the leading OER catalysts due to their stable performance in a wide pH range i.e from acidic to alkaline media. But their applications are restricted to a great extent due to their low abundance and high cost. Therefore, it is important to develop highly efficient OER catalysts that are earth-abundant and low in cost.
Atmospheric pressure plasmas are a novel tool for materials processing. It has been found that atmospheric pressure plasma jets can enhance the crystallinity and charge transport properties of both inorganic and organic materials in-addition to improving hydrophilicity. In this project atmospheric pressure plasmas would be used to functionalise/synthesise nanostructures i.e nanoparticles and thin films as OER catalysts. The catalysts would tested for stability in alkaline, neutral and acidic pH conditions. Traditional, metal oxide catalysts fail to show the high activity in pH < 7 conditions. Hence, it is highly desired that the catalyst operates optimally at neutral pH (ideally in lower pH regimes) in comparison to commercial RuO2 or IrO2 OER catalysts.

Research Methods:
The aim of the PhD studentship is to synthesise novel transition metal oxides with band gaps between 1.9 – 2.2, which will be potential photochemical water splitting catalysts. The properties will then be optimised by chemical and plasma functionalisation. The samples will be synthesised by conventional solid state and plasma techniques .and analysed by X-ray diffraction, X-ray photoelectron spectroscopy neutron powder diffraction, UV-visible spectroscopy, thermogravimetric analysis and electrochemical techniques. There will also be the opportunity to attend conferences and training courses.

Indication of project timeline:
Year 1: Literature survey and selection of new materials and optimisation

Year 2: Optimisation of selected material and its deeper mechanism. Conference presentation and field trials
Year 3: manuscript writing, Complete thesis write-up.

References

1. Synthesis of MoS 2-TiO 2 nanocomposite for enhanced photocatalytic and photoelectrochemical performance under visible light irradiation, M. Mehta, A. P Singh, S. Kumar, S. Krishnamurthy, B. Wickman, S. Basu, 2018, Vacuum, 6,6
2. Plasma Jet Printing and in situ Reduction of Highly Acidic Graphene Oxide, Avishek Dey, Satheesh Krishnamurthy, James Bowen, Dennis Nordlund, M Meyyappan and Ram P Gandhiraman, 2018, ACS Nano, 5,23
3. Tuning the properties of a black TiO 2-Ag visible light photocatalyst produced by rapid one-pot chemical reduction, Michael Coto, Giorgio Divitini, Avishek Dey, Satheesh Krishnamurthy, Najeeb Ullah, Cate Ducati and R Vasant Kumar, Materials Today Chemistry, 2018 142-149

Candidate Applications

- 1000 word cover letter outlining how they are equipped in their educational background and expertise to conduct the research project,
- a CV including contact details of two academic references
- An Open University application form, downloadable from: http://www.open.ac.uk/postgraduate/research-degrees/how-to-apply/mphil-and-phd-application-process (Note: This is an Advertised studentship and you do not need to submit a proposal).
- IELTs English Language test scores on application. An average of 6.5 and no less than 6 in anyone of the four components. Applicant should have these results when applying.

Applications should be sent to **STEM-EI-Research@open.ac.uk** by 28 February 2019