Imperial College London
Department of Materials
Two PhD Studentships
Duration: 48 months
Starting on 1st October 2017

Imperial College London is pleased to offer two PhD studentships funded through the EPSRC Centre for Doctoral Training in Fuel Cells and their Fuels (http://www.birmingham.ac.uk/research/activity/chemical-engineering/energy-chemical/fuel-cells/CDT/index.aspx). The projects will be based at Imperial College London, under the supervision of Professor Stephen Skinner and/or Dr Ainara Aguadero, with integrated training activities taking place at the University of Birmingham. The available projects are described below:

1) In operando analysis of the electrochemical processes governing solid oxide fuel cell electrode degradation

Environmental Scanning Electron Microscopy (ESEM) is a powerful tool in which chemical processes that control reactions in a range of devices can be examined in real-time. The function of a solid oxide fuel cell cathode is to undertake oxygen reduction and incorporation, supplying ions to the electrolyte. This requires the oxide material selected to demonstrated stability over an extended period of time (up to thousands of hours), whilst operating at temperature in excess of 600 °C. It is apparent that cation species migrate within the cathode structure, but that current methods of analysing these processes involve post-mortem analysis. In this project the objective is to develop detailed understanding of the stability of electrode materials in operating fuel cells using the ESEM, and developing the capability to include studies as a function of temperature, oxygen partial pressure and polarisation. This will involve preparing a number of model systems to examine the degradation of the components as a function of each parameter, before undertaking a systematic study of an operando solid oxide fuel cell. The use of ESEM will be complemented with a suite of advanced characterisation capability, providing full complementary structural and electrochemical data.

2) Water splitting by thermochemical redox reactions

Water and carbon dioxide splitting through thermochemical redox reactions can directly convert concentrated solar energy to fuel. To increase the efficiency of the process is fundamental to employ materials with high oxygen storage capacity. Among the different possibilities, oxygen exchange materials offer great potential [1, 2]. In this project, we are proposing to improve the efficiency of thermochemical reactions for H2O splitting by integrating a new class of materials with topotactic redox behaviour and large oxygen exchange capabilities at intermediate temperatures (RT-800 °C). To achieve this we are going to study a family of transition-metal oxides (TMO) with wide range of oxygen stoichiometries such as perovskite and pyrochlore-based materials. The project will focus on:

- Analysis of the redox behaviour under different temperatures, atmospheres (P(O2) and P(H2O)) by thermo gravimetric analysis and in situ analysis using neutron power diffraction techniques
- Optimization of 3D porous architectures of the ceramic oxides to achieve a stable architectures with maximised surface volume ration utilising ceramic processing techniques (i.e. Impregnation and 3D printing) and microstructural characterization with electron microscopy and tomography techniques
- Study of the reaction kinetics by combined isotopic labelling and surface analysis techniques

3) **Anode reaction mechanisms in intermediate temperature solid oxide fuel cells**

A solid oxide fuel cell anode operates under reducing conditions and is typically composed of a composite material in which an ionic conductor is paired with a metal, providing both ion and electron conduction pathways. At the interface between the anode and the electrolyte there is the potential for the microstructure to be poisoned (deactivated) by the deposition of fuel stream contaminants such as Cr and S. The mechanism by which this occurs is unclear and the focus of this project will be in determining the rate determining step in the degradation of the anode performance. There are several areas that will be examined including the effect of protons in the electrolytic component. We will work with an industry partner to ensure that we have representative devices and develop industrially relevant data. In this work the role of the reducible ceria based electrolyte is thought to be key, and our attention will be directed at analysing the evolution of the microstructure with electron microscopy, correlating this with electrochemical studies and cell performance data.

You will hold, or be expected to achieve, a Master's degree in addition to a Bachelor's degree (or equivalent) at 2:1 level (or above) in a relevant subject (e.g. Materials, Physics, Chemistry, Mechanical, Electrical or Chemical Engineering).

This funding stream is available for UK citizens and EU nationals who have spent the last three years in the UK. The studentship will cover tuition fees plus the standard maintenance stipend of £16,296 per year (this year’s rate).

For more information please contact Prof Stephen Skinner (**s.skinner@imperial.ac.uk**) or Dr Ainara Aguadero (**a.aguadero@imperial.ac.uk**). Formal applications will be accepted through the Imperial College web page: [https://www.imperial.ac.uk/study/pg/apply/](https://www.imperial.ac.uk/study/pg/apply/)

The prospectus, entry requirements and application form (under ‘how to apply’) are available at: [http://www.imperial.ac.uk/pgprospectus](http://www.imperial.ac.uk/pgprospectus)

**Closing date: one month from placement**

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