Project title: Hybrid structures for low cost batteries and supercapacitors


Key words: Energy Storage, Batteries, Supercaps, Plasma functionalisation, synchrotron radiation, surface engineering

Supervisory team: Dr. Satheesh Krishnamurthy, Prof. N.S. Brathwaite and Prof. J. Darr (UCL)

Project Highlights:
[3 bullet points]
1. Advanced functionalisation of materials for low cost batteries and supercaps
2. Spectroscopic and microscopic investigation of the materials
3. Testing and commercialisation pathways

Overview:
Low cost sodium ion batteries and hybrid supercapacitors will be investigated in this project and with a view to developing nanomaterials (for domestic energy storage devices such as those employed in smart micro-grids) to replace Li ion batteries. For example, we will investigate cathode materials such as NaFeO$_2$ and its derivatives for low cost cathode material for sodium ion batteries.

The key to good performance is not only related to composition of these systems, but also in material synthesis, process and depositing them through different techniques. We will therefore investigate the synthesis parameters, structural, electronic, electrical and morphological relationships for low cost iron based materials of the type ABO$_2$. B may be Fe and related transition metals and A = Na (atomic substitutions for Fe onto the B atom could be from Mg, Ti, Mn, Mo). For the electrodes in our devices, interfacing with graphene will be key to improve the electrochemical properties and reduce impedance. We will employ continuous hydrothermal synthesis as well more conventional solid state synthesis (to optimise the particle size and morphology of these materials). Electrodes will be deposited via a novel route atmospheric plasma deposition route to ensure good electrical contact. The materials will be studied using a range of analytical methods such as in situ and ex situ x-ray diffraction techniques and electron microscopy in combination with electrochemical studies, X-ray photoelectron spectroscopy and NEXAFS. Access to the Diamond Light Source, Advanced Light Source in Berkeley and Stanford Synchrotron Light Source, will provide high-resolution data to analyse fully the atomic and chemical positions in these materials. Electrochemical properties will be studied using impedance and battery cycling facilities in coin cells or Swagelok cells. We will link up with a number of industry partners either directly or via EPSRC energy hubs, which will also provide a route to evaluation of any promising materials which can be scaled up and tested on larger cell sizes.

Methodology:

Objectives:
- Investigate inorganic doped systems for Na ion batteries based on low cost oxides of iron and related transition metal oxides
- Develop and optimise synthesis methods for particle size, morphology and surface area, using low cost and scalable methods, functionalise through advanced plasma and chemical synthesis routes
- Structural, electrical and electronic property elucidations using x-rays and neutron diffraction techniques.
- Testing and optimise materials in sodium ion battery cells
- Work with industry and other partners for some scale up activity for optimised materials

Partners and collaboration (if applicable)
This project will bring two strong research groups from Open University STEM and UCL Chemistry groups, namely Prof. Jawwad Darr and Prof. Ivan Parkin. There is a possibility to work with Warwick Manufacturing group and other small scale battery manufacturing industry. Candidates may get access to perform experiments at synchrotron light source at Stanford synchrotron Light Sorce, Advanced Light Source in USA.

Further reading:
[3-4 papers]

Further details:
Students should have a strong background in materials chemistry, solid state chemistry, materials physics, electrochemistry and enthusiasm for surface engineering of materials and plasma functionalisation of materials. Experience of synthesis of materials, knowledge of electrochemistry is desirable. The student will join a well-established team researching in Advanced
function of materials, Plasma group and surface engineering and Microscopy group at the Open University and world leading facilities at UCL Chemistry

Please contact Satheesh.krishnamruthy@open.ac.uk for further information.

Applicants should have an upper second (2.1) honours degree or equivalent, in a relevant discipline such as Physical Science or Engineering. International and UK studentship and Full tuition fee will be covered.

Applications should include:

- A 1000 word cover letter outlining why the project is of interest to you and how your skills match those required
- an academic CV containing contact details of three academic references
- an Open University application form, downloadable from: 
  http://www.open.ac.uk/students/research/sites/www.open.ac.uk.students.research/files/documents/Application%20form.docx
- SETS test scores where English is an additional language (Secure English Language Test)

Applications should be sent to STEM-EI-Research@open.ac.uk by 19 February 2018