SEMS: RESEARCH PROJECT DESCRIPTION

1. Project Background and Description

Phosphorene nanoribbons and 2D materials for thermoelectric applications

Thermoelectric generators, which can directly convert waste heat into electricity, are devices currently used in space and military applications. New nanomaterials have recently been predicted to have the excellent strength, flexibility and thermoelectric properties that will allow for this technology to be opened up to a much wider set of applications. In order for these applications to be realized, it is most important to have a repeatable, scalable, cheap method to produce these nanomaterials.

We have developed methods that, importantly, produce single layered 2D materials (e.g. graphene, TiS_2, Bi_2Te_3) and a brand new class of materials known as Phosphorene Nanoribbons. These methods scalably produce high quality materials using liquid based techniques, allowing for them to be printed. Many of the materials we have produced at scale have been predicted to have record breaking thermoelectric properties.

By combining our expertise in the production of these nanomaterials, and the characterization of thermoelectric thin films we aim to arrange our nanomaterials in an architecture that maximizes their thermoelectric properties. Imagine being able to print any pipe or surface with these remarkable materials in order to directly turn waste heat directly into electricity. This project will produce flexible thin film thermoelectric generators that allow for new applications, such as, medical sensors powered by each patient's own body. It will also economically produce new materials for the use in devices for the salvaging the energy of waste heat from various chemical processes, for example, in the tail-pipes of cars, factory chimneys and boilers.

In the wider team, we are using these materials in these applications: lithium-ion batteries, sodium ion-batteries, supercapacitors, hydrogen fuel cell catalysts, electrolyzers, redox-flow cells and anti-corrosion coatings. In light of this there will be considerable support and crossover in this project.

2. Project Scope

Learn how to scalably make and characterize nanomaterials using our methods

Use different techniques to create and characterize thermoelectric thin films from our nanomaterial containing liquids

Develop high performance flexible thermoelectric generators for various applications

3. Desired Skills from the Student

Key skills needed for the PhD project:

Experience of working collaboratively in a research environment

Experience in thin film characterization or electronic materials

A commitment to undertaking the training required of a high impact researcher

4. Supervisory Team

Primary: *Dr. Patrick Cullen*
Secondary: *Dr. Oliver Fenwick*
Additional: *Dr. Christopher Howard, Department of Physics & Astronomy, University College London.*