PhD Studentships in the
Dept of Materials Science
University of Cambridge

This document lists project studentships which are fully funded and usually available immediately, if not then usually they are available from the start of the next academic year. The majority are available to ‘home rate fee’ paying students only.

For other information, please contact:
Dr Rosie Ward
Department of Materials Science and Metallurgy
University of Cambridge
27 Charles Babbage Road
Cambridge CB3 0FS

Tel: +44 1223 331955
Email: remw2@msm.cam.ac.uk

Please include a CV and state your project(s) of interest.
PhD Studentships

PhD Position: Inorganic-organic 3D-structured multiferroics for electronics and biomedical applications

Supervisor: Prof Judith Driscoll

Objectives: Development of novel 3D structured multiferroics based on mesoporous magnetostrictive oxides, and combining these with ferroelectrics (e.g. PVDF-based or other oxides); assessment of the ferroelectric and ME performance; cytotoxicity tests.

Expected results: Growth of mesoporous oxide magnetostrictive films filled with a ferroelectric (inorganic/organic multiferroic) with enhanced magnetoelectric effects and/or no cytotoxic effects; local assessment of the ferroelectric behaviour using innovative customized micro-coils systems; enhanced energy efficiency in the resulting devices.

Skills to be developed: Oxide thin film growth by physical vapour deposition, use and modification, where appropriate, of magnetic and electrical characterization equipment (range of magnetometers, ferroelectric testing, atomic force microscopy, x-ray diffraction, working with cell cultures). Previous experience in one or more of these areas is beneficial but not essential.

Degree Requirement: The ideal candidate will have a Masters (or in exceptional circumstances a Bachelors) in Materials Science, Physics, Electrical Engineering, or closely related discipline.

Prof. J. Driscoll is one of the group leaders in the Device Materials Group, in which materials systems currently under study are complex magnetic oxides, magnetoelectrics, superconductors, and resistive memory materials (https://www.dmg.msm.cam.ac.uk/directory/jld35).

BeMAGIC project is a Marie Sklodowska-Curie Innovative Training Network that offers the possibility to pursue the PhD within the Network at different universities/research centres/companies across Europe. The duration of the appointment is 3 years, starting in February 2020, and the salary will comprise a living allowance of €44,895.96 and a mobility allowance of €7,200 per year. Importantly, the Marie Curie eligibility criteria must be respected.

Eligible early-stage researchers (ESRs) are those who are, at the date of recruitment by the host institution, in the first four years (full-time equivalent) of their research careers. This is measured from the
date when they obtained the degree which would formally entitle them to embark on a doctorate. In addition, researchers must not have resided or carried out their main activity (work, studies, etc.) in the country of the host organization for more than 12 months in the 3 years immediately prior to their recruitment. Researchers can be nationals of any country (including all countries outside Europe). Please see full eligibility criteria here: https://bemagic-ett.eu/project/eligibility

Application procedure: Interested applicants should provide a full CV and a letter of interest on the following website: https://bemagic-ett.eu/project/offered-esr-positions
Closing date: 31/01/2020

PhD Studentship: Powder routes to platinum group metal doping of nickel superalloys for extreme environmental operations

Supervisor: Dr Howard Stone
Sponsor: EPSRC and Johnson Matthey
Start date: October 2020
Full studentship, available to ‘home rate’ fee payers only

Applications are invited for a PhD studentship studying the effect of platinum additions to nickel-based superalloys. This studentship is fully funded for a student paying ‘home rate’ fees, and will run for up to 3.5 years from October 2020. It will be based in the Department of Materials Science and Metallurgy at the University of Cambridge and will be run in close collaboration with Johnson Matthey*.

Nickel-based superalloys are widely used in the power generation and aviation industries for high temperature structural components. Efforts to develop new, more efficient products in these sectors to reduce emissions is constrained by the temperature capability of existing alloys. This is motivating the development of new alloys that can tolerate more hostile service conditions whilst simultaneously being amenable to processing by modern manufacturing routes. One approach by which this may be achieved is through additions of platinum group elements. Such additions are known to improve environmental resistance and mechanical performance, however, achieving the appropriate balance of properties, whilst maintaining suitable component cost remains to be established.

In this PhD studentship, powder-processed nickel-based superalloys with varying platinum additions will be fabricated by metal injection molding and hot isostatic pressing. The phase equilibria, microstructural stability, oxidation resistance and mechanical behaviour of the alloys will be characterised and the benefits of such additions will be assessed. This will require the extensive use of scanning and transmission electron microscopy, X-ray diffraction, differential scanning calorimetry, thermal analysis and mechanical testing. Limited thermodynamic modelling will also be required to rationalise the phase equilibria observed.

Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) and should be should meet the EPSRC criteria for UK/EU residency and liability for ‘home rate’ fees.

The on-line application system is available at https://www.graduate.study.cam.ac.uk/. Further information on the application process is available from Rosie Ward (remw2@cam.ac.uk).

*Johnson Matthey is an international FTSE 100 speciality chemicals company and a global leader in sustainable technologies. We apply our cutting-edge science, creating solutions with our customers that make a real difference to the world around us. Johnson Matthey employs around 13,000 people in over 30 countries.
PhD Studentship: Nanionic Energy Devices

Supervisor: Professor Judith Driscoll
Sponsor: EPSRC and Cambridge Display Technology (CDT)
Start date: October 2020
Full studentship, available to ‘home rate’ fee payers only

Applications are invited for a PhD studentship fully funded for a student paying ‘home rate’ fees, and will run for up to 3.5 years from October 2020. It will be based in the Department of Materials Science and Metallurgy at the University of Cambridge and will be run in close collaboration with Cambridge Display Technology (CDT)*.

The first grand challenge in the Government’s 2017 industrial strategy white paper is, ‘put the UK at the forefront of the artificial intelligence and data revolution’. NVM technologies are key to advances in cognitive computing, boosting the development of artificial intelligence. The second grand challenge relates to adoption of energy efficient materials, e.g. batteries, photocatalysts. These systems have in common electrochemical processes.

Controlling and understanding the ionic motion at the nanoscale is critical for performance optimization of the aforementioned energy devices. However, so far, there has been little nanoscale probing undertaken of these processes. There is a real opportunity to advance these widely varying energy technologies by studying model thin film single-crystal-like systems, utilizing new characterization tools to probe model systems of different dimensionalities. Hence, ideal nanoscale films and interfaces will give us an unprecedented opportunity to understand surface vs. bulk processes, and to learn about the influences of strain and defect processes.

Work to be done
Designed nanostructured systems
We will create single crystal thin films and multilayers using advanced pulsed laser deposition. We will use in-situ XPS to probe chemical and electronic states. We will work with many groups within Cambridge to probe ionic and electronic processes using a combinations of tools in collaboration with Physics, Chemistry, Engineering in Cambridge and teams abroad (e.g. nanoplasmonics, interferometric scattering microscopy, electrochemical AFM, in-operando TEM and NMR).

Potential Big Wins
The ability to design and fabricate industrial memristors for memory and AI, which are easy to grow, stable over trillions of cycles, controlled on-off states which can be trained, to fulfil a $Trillion market. Creating highly stable, high performance solid state batteries Systems with high rate catalytic processes.

Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) and should be should meet the EPSRC criteria for UK/EU residency and liability for ‘home rate’ fees.

The on-line application system is available at https://www.graduate.study.cam.ac.uk/.
Further information on the application process is available from Rosie Ward (remw2@cam.ac.uk).

* https://www.cdtltd.co.uk/
PhD Studentship: Lorentz Electron Microscopy and Analysis of Magnetic Skyrmions

Sponsor: EPSRC studentship – see below exact detail of awards available.
Supervisor: Prof Paul Midgley
Start date: October 2020
Duration: 3 years in the first instance

Magnetic skyrmions are an extraordinary magnetic phenomena that can be thought of as topological defects in the magnetic texture of certain materials. Cambridge is a key member of the EPSRC-funded UK-wide magnetic skyrmion project (https://www.skyrmions.ac.uk/) which aims to understand at a fundamental level the structure and dynamics of skyrmions and to develop novel magnetic devices. The project student will be an integral part of the Cambridge team collaborating with four other UK institutes to investigate the fundamental physical behaviour of magnetic skyrmions.

The project will involve TEM-based Lorentz imaging of skyrmion materials and devices using the FIB to create prototype structures. Low temperature in situ microscopy will correlate structures and composition with skyrmion lattice development and understanding better the dynamics of skyrmion motion and order/disorder transitions using applied magnetic fields and electrical bias. The project will also involve micromagnetic simulations, image processing and big data analysis. Skyrmionic materials will be readily available through the Programme grant consortium.

False colour image showing the in-plane magnetisation of a lattice of FeGe skyrmions. Field of view ca. 1um.

The minimum academic requirement for admission is an upper second class UK honours degree at the level of MSci, MEng, MPhys, MChem etc, or a lower second with a good Master’s, (or overseas equivalents) in a relevant subject.

The studentship provides a maintenance grant at the minimum Research Council UK rate and tuition fees at the UK/EU rate for students who fully satisfy the residence requirements of the UK Research Councils. A fees-only award will be available to EU nationals who are not ordinarily resident in the UK. Students who are liable for fees at the ‘overseas’ rate are not eligible for these studentships.

An on-line application form is available at https://www.graduate.study.cam.ac.uk. Further information on the application process is available from Dr Rosie Ward (remw2@cam.ac.uk). Informal enquiries may be made to Prof Paul Midgley by email to pam33@cam.ac.uk

PhD Studentship: Towards Sustainable Plasmon-Enhanced Catalysis: Synthesis and Characterization of Earth-Abundant Plasmonic Nanoparticles

Supervisor: Dr Emilie Ringe
Sponsor: ERC
Start date: October 2020
Full studentship, available to ‘home rate’ fee payers only
Industries creating inorganic, organic, and agricultural chemicals use a staggering 4.2% of the worldwide delivered energy, mainly from unsustainable fossil fuels. Meanwhile, the sun provides energy that could be utilized to power photochemical reactions sustainably and cleanly. Recent advances revealing how localized surface plasmon resonances (LSPRs), light-driven electron oscillations in metal nanoparticles, can concentrate light at the molecular scale made the dream of efficient photochemistry one step closer [1-3]. However, plasmonic materials are almost exclusively constructed from the rare and unsustainable metals Ag and Au. In addition to being incompatible with current industrial practices relying on catalytic surfaces to lower energy barriers and guide reactions, Ag and Au cause prohibitive cost challenges for real-world applications. But there is hope: several of the few metals predicted to sustain LSPRs and become potential alternatives to Ag and Au are amongst the most abundant, i.e. sustainable, elements on Earth (Al, Mg, Na, K).

The plasmonic behavior of Al has been experimentally demonstrated over a decade ago, and created a new era for high energy plasmonics. Last year, we have published the first report on the plasmonic properties of colloidal synthesized Mg nanoparticles [4] and envision a plethora of discoveries and applications for this exciting new materials.

The goal of this project is to unravel and control the fundamental plasmonic properties of magnesium nanoparticles and decorated nanoparticles. As this is a completely new tool in the plasmonics toolbox, questions to answer range from very fundamental (how do we control particle shape?) to very applied (how does the plasmon-enhanced reaction rate vary with decoration by a platinum-group metal?).

A background in materials science, chemistry, experimental physics or closely related disciplines is required, however previous experience on plasmonic nanostructures is not. The student selected for this project will be trained on air-free chemical techniques, optical spectroscopy, and electron microscopy, and join a growing interdisciplinary group. Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) and should be eligible for ‘home rate’ fees.


For more information contact Emilie Ringe (er407@cam.ac.uk)

Application forms and the Graduate Studies Prospectus are available from the Graduate Admissions Office at https://www.graduate.study.cam.ac.uk/. Further information on the application process is available from Rosie Ward (remw2@cam.ac.uk).

**PhD projects for which funding is available from the Department on a competitive basis**

**New oxide interface electronics**

In the last few years, there have been very exciting reports about the new functional properties which can be achieve at the interface between oxide films, e.g. there is the possibility to achieve new kinds of
fast, energy efficient semiconductor processors and even possibly room temperature superconductors. This project involves exploring such phenomena. It will involve growth of ultrathin, single crystal thin films using a world leading, state-of-the-art advanced pulsed laser deposition system with in-situ diagnostic tools (XPS, UPS), followed by their measurement using a variety of means including electrical measurements, synchrotron studies, and atomic force microscopy (scanning probe) techniques.

For further information contact Prof J Driscoll (jld35@cam.ac.uk).

Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) in a relevant subject (Materials Science, Physics, Chemistry) and should be liable for ‘home rate’ fees to be eligible for a studentship from the Department. Other competitive studentship schemes available to overseas fee paying students, deadline 3 December 2019, are described at https://www.graduate.study.cam.ac.uk/finance/funding/graduate-funding-competition.

Applications can be made on-line via http://www.graduate.study.cam.ac.uk/courses/directory/pcmmpdmsm.

Further information on the application process is available from Dr Rosie Ward (remw2@cam.ac.uk).

**Oxide memristors for next generation non-volatile memory in computing**

Non-volatile memory (NVM) is critical for all aspects of modern computing, as well in future generation digital technologies like the Internet of Things (IoT) and neuromorphic computing—technologies that will penetrate into many realms of society. Among NVM technologies, resistive random access memory (RRAM) based on metal oxide (MO) films as the resistive switching (RS) layers has the potential of high-speed, low operation voltage, low power consumption, and good endurance that enables the highest performance at the lowest cost possible. There are a number of challenges which need to be addressed with these materials, relating to their nanostructuring and composition. We have solved these problems in a model system and now wish to take this forward to more simple systems. This project will develop such systems. We will collaborate with a number of groups on testing and implementation of industry prototypes.

For further information contact Prof J Driscoll (jld35@cam.ac.uk).

Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) in a relevant subject (Materials Science, Physics, Chemistry) and should be liable for ‘home rate’ fees to be eligible for a studentship from the Department. Other competitive studentship schemes available to overseas fee paying students, deadline 3 December 2019, are described at https://www.graduate.study.cam.ac.uk/finance/funding/graduate-funding-competition.

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**Three dimensional nanoscale structure of novel nitride materials and devices**

The Cambridge Centre for Gallium Nitride is developing a range of photonic devices which exhibit complex three-dimensional structure. These include micro- and nano-cavities for the confinement of light and the exploration of light-matter interactions. Furthermore, we are developing nanoporous gallium nitride and incorporating it into a range of photonic architectures. For these photonic device developments to succeed, it is vital that we fully understand the three-dimensional (3D) structure of these materials and devices at the nanoscale, and this represents an exciting and challenging microscopy problem. In this project, the student will develop characterisation techniques based on
focussed ion beam microscopy and transmission electron microscopy which provide detailed quantitative insight into the 3D structures of such devices. The structural insights will be incorporated into models of materials and device properties to understand what structural factors enhance or limit the performance of photonic devices and to drive the future development of improved fabrication techniques.

For further information contact Prof RA Oliver (rao28@cam.ac.uk).

Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) in a relevant subject (Materials Science, Physics, Chemistry) and should be liable for 'home rate' fees to be eligible for a studentship from the Department. Other competitive studentship schemes available to overseas fee paying students, deadline 3 December 2019, are described at https://www.graduate.study.cam.ac.uk/finance/funding/graduate-funding-competition.

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http://www.graduate.study.cam.ac.uk/courses/directory/pcmmpdmsm.

Further information on the application process is available from Dr Rosie Ward (remw2@cam.ac.uk).

**Time-resolved cathodoluminescence measurements of carrier drift and diffusion in semiconductors**

Time-resolved cathodoluminescence imaging in the scanning electron microscope is an exciting new technique for assessment of the properties of light emitting materials at the nanoscale. It gives access to the time-scales on which the process of light emission occurs, down to resolutions of a few tens of picoseconds, whilst providing a spatial resolution down to about 10 nm. In this project, we plan to extend this astounding capability still further by developing methods to allow the measurement of carrier diffusion lengths and drift velocities and the impact of local nanoscale features such as defects on these processes. The aim is for the project to assess a range of semiconductor materials, starting by using materials whose properties are well known and whose diffusion lengths are relatively large as a test system for the new technique. Thereafter – having validated the technique - the student will apply the same methodology to poorly understood semiconductor systems and push the limits of its resolution in materials with short diffusion lengths.

For further information contact Prof RA Oliver (rao28@cam.ac.uk).

Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) in a relevant subject (Materials Science, Physics, Chemistry) and should be liable for 'home rate' fees to be eligible for a studentship from the Department. Other competitive studentship schemes available to overseas fee paying students, deadline 3 December 2019, are described at https://www.graduate.study.cam.ac.uk/finance/funding/graduate-funding-competition.

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Further information on the application process is available from Dr Rosie Ward (remw2@cam.ac.uk).

**Structure-property relationships in nitride high electron mobility transistors**

Power switching devices based on gallium nitride have the potential to offer much greater efficiency than well-established silicon-based devices and to handle higher powers. However, the performance of such devices is limited by the defects and inhomogeneities arising in the nitride materials on which they are based. Device processing and the overall device architecture are also key to achieving optimal device characteristics. This project will use a range of microscopy techniques including electrical characterisation in the atomic force microscope, cathodoluminescence in the scanning electron microscopy and advanced transmission electron microscopy to explore the vital structure property
relationships in nitride high electron mobility transistors intended for power switching applications. A range of device architectures will be addressed including devices transferred from their original substrates onto diamond heat sinks to reduce the negative impacts of device heating on performance.

For further information contact Prof RA Oliver (rao28@cam.ac.uk).

Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) in a relevant subject (Materials Science, Physics, Chemistry) and should be liable for 'home rate' fees to be eligible for a studentship from the Department. Other competitive studentship schemes available to overseas fee paying students, deadline 3 December 2019, are described at https://www.graduate.study.cam.ac.uk/finance/funding/graduate-funding-competition.

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Further information on the application process is available from Dr Rosie Ward (remw2@cam.ac.uk).

**Nitride materials and devices for transfer printing and heterogeneous integration**

The rapidly developing technique of transfer printing on the micro and nanoscales allows the manufacture of high quality, high performance devices on a wide range of substrates in almost any location. This highly versatile capability features a high-precision mechanical pick-and-place assembly technique that utilises the adhesive properties of soft stamps. In the context of nitride devices, micro-transfer printing has recently delivered micro-LED arrays that feature in flexible displays and provide inorganic analogues of flexible organic light-emitting diodes (OLEDs) - something that was previously thought to be extremely challenging if not impossible. However, to optimise devices and systems based on transfer printing of nitride materials, it is necessary to both optimise the nitride material for separation from its original substrate and optimise the device design so that its performance is unaffected or even improved by its integration into a heterogeneous system. This project will explore both the development of materials which allow the transfer printing of a wide range of different nitride devices, both electronic and optoelectronic, and the design of those devices to achieve enhanced performance.

For further information contact Prof RA Oliver (rao28@cam.ac.uk).

Applicants should have (or expect to be awarded) an upper second or first class UK honours degree at the level of MSci, MEng (or overseas equivalents) in a relevant subject (Materials Science, Physics, Chemistry) and should be liable for 'home rate' fees to be eligible for a studentship from the Department. Other competitive studentship schemes available to overseas fee paying students, deadline 3 December 2019, are described at https://www.graduate.study.cam.ac.uk/finance/funding/graduate-funding-competition.

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Further information on the application process is available from Dr Rosie Ward (remw2@cam.ac.uk).

*The University of Cambridge and the Department of Materials Science & Metallurgy value diversity and are committed to equality of opportunity.*