You may find it helpful to contact the hosts of the projects in which you have an interest, before you finalise your choices. This is probably best done via email – addresses are included in this document. It may also be advisable to visit the websites of the research groups concerned, in order to obtain information about associated resources, activities etc.

1. Research Group: Cambridge Centre for GaN

Number of placements available: 1

Suitable for: Part II only

Period of placement(s): expected to be 8 weeks

Outline of project(s): **Printing nanoparticles into porous GaN**

Micro light emitting diodes (microLEDs) are a key enabling technology for augmented reality (AR), but current materials cannot meet the stringent requirements that microdisplays for these applications impose in terms of efficiency, brightness, manufacturability and cost. One potential solution to this problem is to integrate nanoparticle (NP) phosphors (for red, amber and green emission) with highly efficient blue microLEDs, achieving cheap, large-scale precision manufacturing by printing NPs in suspension form into nanoporous layers. The aim is to use capillary action from the nanoscale pores to prevent spreading of the NP ink. Encapsulation of the NPs in the porous structure will prevent NP environmental degradation and clustering.

To test this idea, this project will use aerosol jet printing to deposit NP suspensions onto porous GaN layers, and will examine the extent of pore infilling using scanning electron microscopy techniques. The characteristics of both the NP inks (NP surface chemistry and concentration) and the porous GaN substrates (pore surface chemistry, degree of porosity, pore shape and pore size) will be varied to identify optimum materials combinations for this novel additive manufacturing approach. The optical characteristics of the printed NPs will then be measured to demonstrate their suitability as phosphors in microLEDs.

Host academic: Prof. Rachel Oliver / Dr Simon Fairclough

Daily supervisor: to be confirmed

Informal enquiries: Prof. Rachel Oliver, rao28@cam.ac.uk
2. **Research Group: Cambridge Centre for GaN**

Number of placements available: 1

Suitable for: Part IB or II only

Period of placement(s): expected to be 8 weeks

Outline of project(s): *Optical and structural properties of Cu(InGa)S$_2$ solar cells*

To make a significant impact on the sustainability of our current energy consumption; new, highly efficient and low CO$_2$ emitting power sources be made available for use by large numbers of consumers. Solar power plants are one of the main options available. Presently, most commercial solar cells work as single absorber cells. These devices are limited in their efficiency as high energy light will be down-converted due to inherent bandgap restrictions. The most promising technology to increase solar cell performance is the tandem solar cell, in which layers of different bandgap are stacked on top of each other, reducing energy loss due to down-conversion and both enhancing efficiency and offering a short energy payback time.

Sulfide chalcopyrites Cu(InGa)S$_2$ are particularly suited for these applications as they cover the whole bandgap range of interest for top cells in tandem devices from 1.5 to 2.5eV. One major current challenge in further enhancing the efficiency of these devices is to increase the open-circuit voltage, which is strongly influenced by non-radiative recombination at defects.

In this project the optical and structural properties of Cu(InGa)S$_2$ solar cells will be investigated by state of the art scanning electron microscopy (SEM). An important part of the project will be linking cathodoluminescence hyperspectral maps with secondary electron images and electron backscatter diffraction images to study the influence of defects and grain boundaries on performance.

**Host academic:** Prof. Rachel Oliver

**Daily supervisor:** Dr Gunnar Kusch

**Informal enquiries:** Prof. Rachel Oliver rao28@cam.ac.uk
3. **Research Group: Space Photovoltaics**

Number of placements available: 1

Suitable for: Part IB or Part II

Period of placement(s): expected to be 8 weeks, commencing in mid-June

Outline of project(s): **Best research cell efficiency chart for AM0**

The U.S. National Renewable Energy Lab maintains a best research cell efficiency chart which compares record solar cell energy conversion efficiencies characterized in independent certified lab settings for different technology categorizations. All these reported efficiencies are characterized under a standardized reference spectrum (ASTM G173), which is selected as a reasonable average for the 48 contiguous U.S. states over a period of one year.

Photovoltaic devices which power space systems will see a different solar spectrum, which does not suffer from atmospheric absorption in the near IR. As a result, more light is available; however, for many devices on the NREL chart, photons in the IR are not converted into useful electric power as they lie below the bandgap of the solar cell material. This results in lower solar energy conversion efficiency.

In this summer project the student will source the original published data for devices reported on the NREL efficiency chart, to extract the external quantum efficiency and current voltage characteristics which underpin the record results. They will use these to evaluate an estimated solar energy conversion efficiency for each device using an extra-terrestrial (AM0 spectrum). The student will then populate their own “Best research cell efficiency chart for AM0” as a reference document for researchers developing space photovoltaic technologies.

**Host academic:** Prof. Louise Hirst

**Daily supervisor:** Prof. Louise Hirst

**Informal enquiries:** Prof. Louise Hirst, lh619@cam.ac.uk
4. Research Group: Optical Nanomaterials

Number of placements available: 1

Suitable for: Any student could undertake this project (Part IA, IB or II)

Period of placement(s): expected to be 8 weeks

Outline of project(s): **Refractive index sensitivity of Mg nanoparticles via correlated single particle measurements**

The strong interaction of plasmonic nanoparticles (NPs) with light can be exploited for a variety of applications including in sensing, for instance via detecting changes in the refractive index of their environment. Mg NPs have been recently added in the toolbox of plasmonic materials as a cheap and abundant alternative to the commonly used Au and Ag and feature a plethora of unusual and sharp shapes. These stem from Mg’s hexagonal structure, which is unique among the plasmonic metals. Mg’s sharp shapes and steep real part of the dielectric function imply that Mg NPs could exhibit enhanced refractive index sensitivity. Inspired by this potential, the aim of this project is to explore how the different Mg NP sizes and shapes affect their refractive index sensing ability, i.e. the shift in position and width of the plasmon peak, and how this compares to currently used NP compositions and shapes. The student will perform refractive index measurements in single particle level using a hyperspectral dark-field scattering spectroscopy setup available in the group. The single particle scattering spectra obtained in solutions of varying refractive index will then be correlated with scanning electron microscopy, to allow for NP shape and size characterisation. Experimental results will be complemented with electromagnetic simulations using a user-friendly shape modelling interface developed in the group and DDSCAT, a commonly used tool for solving Maxwell’s equations.

Host academic: Prof. Emilie Ringe

Daily supervisor: Christina Boukouvala

Informal enquiries: Prof. Emilie Ringe, er407@cam.ac.uk
5. Research Group: Hybrid Materials Group and Cambridge Centre for Medical Materials

Number of placements available: 1

Suitable for: Part II only

Period of placement(s): expected to be 8 weeks

Outline of project(s): The Use of MOFs for Tissue Engineering and Regenerative Medicine

The synthesis of Metal-organic Frameworks (MOFs) and their evaluation for various applications is one of the largest research areas within materials sciences and chemistry. This project will review the use of MOFs in biomaterials for bone regeneration, and implants. Some work has been done in the group, which will be summarized in the project, and placed into context with the larger body of work done in the community.

Host academic: Dr Tom Bennett

Daily supervisor: To be confirmed

Informal enquiries: Dr Tom Bennett, tdb35@cam.ac.uk
6. Research Group: Device Materials Group

Number of placements available: 1

Suitable for: Any student could undertake this project (Part IA, IB or II)

Period of placement(s): expected to be 8 weeks

Outline of project(s): **Printed microfluidic bio-sensors based on functional nanomaterials**

Microfluidics has emerged as a powerful analytical tool for biology and biomedical research, with uses ranging from single-cell phenotyping to drug discovery and medical diagnostics, and only small sample volumes are required for testing. Microfluidic devices can combine sensors and biological components onto a single platform, offering challenges and opportunities for novel biosensing applications, with a focus on portability, disposability, real-time detection, and improved accuracy of detection, to name a few. There is therefore enormous interest in developing microfluidic devices with improved capabilities and enhanced functionalities, where higher level of integration can lead to complex and complete microfluidic systems in a single chip. This project aims to explore such integration through the direct incorporation of functional nanomaterials (e.g. piezoelectric, electrochemical, thermoelectric) within microfluidic devices using "aerosol-jet printing" of bespoke inks \[1\]. This particular printing technique is distinctly versatile when it comes to rapid prototyping of functional inks, and will be used extensively in this work to explore a variety of nanomaterials for microfluidic sensing applications for novel biosensors and bioelectronics. \[2\]


Host academic: Prof. Sohini Kar-Narayan

Daily supervisor: to be confirmed

Informal enquiries: Prof. Sohini Kar-Narayan sk568@cam.ac.uk
7. Research Group: Device Materials Group

Number of placements available: 1

Suitable for: Any student could undertake this project (Part IA, IB or II)

Period of placement(s): expected to be 8 weeks

Outline of project(s): *Printed electroactive polymer nanocomposites for actuation and biomedical implants*

Electroactive polymers (EAPs) can be excited using electric fields to change their shape and size, giving rise to biologically inspired capabilities [1]. Broadly speaking, there are two classes of EAPs: field-activated EAP materials are driven by Coulomb forces and require high activation fields that may be close to the level of dielectric breakdown level, and ionic EAP materials that are driven by diffusion of ions, and require relatively low activation voltages. The latter is particularly attractive in biomedical settings where low activation voltages are preferable. However, the application of EAP materials as actuators still involves many challenges related to actuation forces, scalability, durability and reliability. The processes of synthesizing, fabricating, electroding, shaping, and handling need to be understood and optimized to maximize the actuation capability and durability. In this project, ion-based cation systems will be combined with printable polymer hosts such as Nafion, to create voltage-tuneable bending on the nano- to micro-scale. While on the large scale such bending takes seconds, it is predicted that switching can be much faster as the devices scale down, and dependent on the cation conductivity in the polymer host. The novelty here is to develop methods to "aerosol-jet print" [2] such devices in their entirety, opening up a wide range of potential applications. Such printing has not been demonstrated previously, and has the potential for rapid prototyping of devices for optimisation and testing. It is expected that developing this type of capability will serve to identify niche applications such as soft robotics and guided surgery and insertion of biomedical implants.


Host academic: Prof. Sohini Kar-Narayan

Daily supervisor: to be confirmed

Informal enquiries: Prof. Sohini Kar-Narayan sk568@cam.ac.uk