CaMPUS
Research Projects in Cambridge
Summer 2020

You may find it helpful to contact the supervisors of 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: CCMM Group (Best/Cameron)*

Number of placements available: 1

Period of placement(s): 6-8 weeks dependent upon funding, flexible start date

Outline of project(s): ***Ice-templated collagen scaffolds for tissue regeneration***

Demonstrator: Malavika Nair (mn404@cam.ac.uk)

Collagen is of interest as a "scaffold" material for soft tissue repair and can be produced with highly interconnected 3D porous architectures to deliver cells into the body. These sponge-like, bioresorbable architectures can be produced through the processes of ice-templating and crosslinking. The constructs created by manipulating the two processes result in scaffolds of distinct physicochemical and biological properties. Understanding the interplay of the numerous processing parameters to create a materials-selection map for collagen scaffolds is a difficult task that is yet to be achieved. A student working on this project would have the choice of working with a range of experimental (synthesis, SEM, Micro-CT, cell culture) and/or computational (database management, improving the automated data interpretation, use of machine learning algorithms to help understand and predict the properties of scaffolds) techniques.

Contact: Prof Serena Best (smb51@cam.ac.uk) or Prof Ruth Cameron (rec11@cam.ac.uk)

URL for further information: http://www.ccmm.msm.cam.ac.uk/

2. *Research Group: Rolls Royce UTC (Jones)*

Number of placements available: 1

Period of placement(s): 6-8 weeks dependent upon funding, flexible start date

Outline of project(s): ***Establishing the effect of alloying on the superelastic behaviour of Ti-Nb alloys***

Ti-Nb based alloys can undergo a reversible martensitic transformation in response to an applied stress. The hysteric nature of the resulting superelastic behaviour is of interest to several industrial sectors for use in damping applications. One critical aspect when selecting alloys for industrial use is to ensure that the transformation occurs at specific temperatures and applied stress, and these conditions are often modified by changing the alloy composition or by introducing additional elements. Yet, despite the importance of these changes, there is still a significant lack of understanding and many contradictions in the literature. Several datasets from Ti-Nb based alloy series already exist within the Rolls-Royce UTC, and the aim of this project is to assimilate and analyse these data to develop a better understanding of the influence of multiple coadditions on alloy behaviour. The project will include a complete overview of alloy production, processing and testing using techniques such as rolling, tensile deformation, electron microscopy and analysis of *in situ* diffraction data.

Contact: Dr Nick Jones (ngj22@cam.ac.uk)

URL for further information: https://www.rrutc.msm.cam.ac.uk/

3. *Research Group: Macromolecular Materials Laboratory (Elliott)*

Number of placements available: 1

Period of placement(s): 6-8 weeks dependent upon funding, flexible start date

Outline of project(s): ***Materials analysis of biomass***

In recent years, bio-compostable materials for replacing single use plastic materials has become an active area of research with some niche products already on the market. More research is needed on a wider range of suitable feedstock. This summer student project aims to systematically characterises biomass from different terrestrial plant sources, such as hemp stalk, birch and arabidopsis, using existing experimental techniques (choosing from thermogravimetric analysis, differential scanning calorimetry, scanning probe microscopy, atomic force microscopy, Raman and IR spectroscopy). Films can be produced and tested for their mechanical strength, establishing a correlation between feedstock materials properties and resulting mechanical strength.

Contact: Prof James Elliott (jae1001@cam.ac.uk)

URL for further information: https://www.mml.msm.cam.ac.uk/

4. *Research Group: DMG: Materials for Nanogenerators and Sensors (Kar-Narayan)*

Number of placements available: 1

Period of placement(s): 6-8 weeks dependent upon funding, flexible start date

Outline of project(s): ***Piezoelectric bio-nanomaterials and applications***

Piezoelectric materials are capable of producing electricity when deformed, and have widely used in the creation of scaffolds for bone and tissue regeneration. In the case of bone repair, piezoelectric charges induced by mechanical stress can enhance bone formation, and in neural tissue engineering, in which electric pulses can stimulate neurite directional outgrowth to fill gaps in nervous tissue injuries. Prior to this, the majority of the research effort has been in creating scaffolds with appropriate biocompatibility and microstructure to allow a cell culture to survive and multiply. However, attention is now turning to the possibility of creating functional, 'smart' scaffolds using piezoelectric bio-nanomaterials, that can more accurately recreate the conditions found in vivo. For example, we have recently demonstrated shear piezoelectricity in poly-L-lactic acid nanowires [1], which are biocompatible and can be integrated into scaffolds. The ability to artificially grow new tissue has significant implications in the field of regenerative medicine and also offers insight into the fundamental mechanisms of tissue growth and repair. This project thus focuses on the field of piezoelectric biomaterials and their applications in tissue regeneration, as well as in the development of biocompatible energy harvesting for biomedical implants.

[1] M Smith, Y Calahorra, Q Jing, S Kar-Narayan, APL Materials 5, 074105 (2017)
[2] Vogel & Sheetz, Nature Reviews Molecular Cell Biology 7, 265 (2006)

Contact: Dr Sohini Kar-Narayan (sk568@cam.ac.uk)

URL for further information: https://www.dmg.msm.cam.ac.uk/

5. ***Research Group: DMG: Materials for Nanogenerators and Sensors (Kar-Narayan)***

Number of placements available: 1

Period of placement(s): 6-8 weeks dependent upon funding, flexible start date

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

Biomolecular detection systems based on microfluidic devices are powerful analytical tools useful for a wide range of applications ranging from drug discovery, to medical diagnostics, food safety, and agricultural and environmental monitoring. Such biosensors can provide real-time, high performance detection of selective analytes quantitatively or semiquantitatively with inherent miniaturization and low cost. The ability to integrate detection methods and biological components onto a single platform is highly desirable, 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. 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, including 2D materials for biosensors and bioelectronics.

[1] Luka et al., Sensors 15, 30011 (2015)
[2] Waheed et al., Lab Chip, 16, 1993 (2016)

Contact: Dr Sohini Kar-Narayan (sk568@cam.ac.uk)

URL for further information: https://www.dmg.msm.cam.ac.uk/

6. ***Research Group: DMG: Materials for Nanogenerators and Sensors (Kar-Narayan)***

Number of placements available: 1

Period of placement(s): 6-8 weeks dependent upon funding, flexible start date

Outline of project(s): ***Printed force sensors for orthopaedic surgery and implants***

The treatment of weight bearing joints such as knees and hips is a complex problem, with challenges ranging from objective assessment of the damage to tissue and understanding of the forces in organic joints, and monitoring the forces within the implant post-surgery. The past five years have seen a growing global interest in technologies to enable biocompatible, implantable mechanical sensing. This project seeks to establish novel printed, flexible and biocompatible force/pressure sensors suitable for orthopaedic surgery and post-operative telemetry, based on techniques developed in our group [1]. These devices will be optimised through finite element modelling, and compared in view of the requirements set by the clinical application. This project will open up significant opportunities for future work and commercialisation, through establishing new technologies, and taking them forward through optimisation and in-vivo trials.

[1] Jing, Qingshen, et al. Advanced Materials Technologies 1900048, 2019.
[2] Forchelet, David et al. Sensors 14, 15009-15021, 2014.
[3] Curry, Eli J., et al. PNAS 115.5: 909-914, 2018.

Contact: Dr Sohini Kar-Narayan (sk568@cam.ac.uk)

URL for further information: https://www.dmg.msm.cam.ac.uk/