Brief Encounters – ABSTRACTS

A novel platform for regenerative medicine

Thomas Chalklen – tac49@cam.ac.uk

4th-year PhD candidate in the Device Materials group, supervised by Prof. Sohini Kar-Narayan

Regenerative medicine has the potential to vastly improve the long-term health of a huge subset of the population. There are a number of challenges to be solved before it can be effectively implemented however. This presentation aims to outline one of the most important issues for the field, the lack of representative human biological conditions in current efforts, and our attempt to better replicate a soft biological environment.

Ultra-thin GaAs photovoltaics for space applications

Larkin Sayre – ls778@cam.ac.uk

4th-year PhD candidate in the Space Photovoltaics group, supervised by Dr Louise Hirst

Ultra-thin photovoltaics (<100 nm) have shown an intrinsic tolerance to radiation-induced damage which makes them an exciting potential power source for spacecraft which need to withstand harsh environments outside Earth's atmosphere. In the ultra-thin regime, high transmission losses can be mitigated by integrating light management. A new type of ultra-thin single-junction GaAs solar cell was designed, optimized and characterized before and after exposure to 3 MeV proton radiation. Pre- and post-irradiation results have shown boosted absorption of light compared to previous ultra-thin designs while maintaining no degradation in short-circuit current up to extremely high fluences.

Development of a material to reduce the incidence of aseptic loosening in tibial components of total knee replacements

Matt Meek – mm838@cam.ac.uk

3rd-year PhD in Cambridge Centre for Medical Materials supervised by Profs Ruth Cameron & Serena Best

Total knee replacement (TKR) surgeries are being performed on an increasingly young population, but only 82% of TKRs survive 25 years post implantation. Most TKRs fail due to aseptic loosening, caused in part by poor osseointegration, and excessive implant stiffness relative to the surrounding bone. This presentation investigates the potential of a novel polymer/collagen scaffold composite material, consisting of a 3D-printed polymer lattice structure, with the lattice voids filled with ice-templated collagen scaffold. This composite material has the potential to capitalize on the favourable mechanical properties of the polymer, and the enhanced biological characteristics of the collagen scaffold.

3D imaging of nanoscale magnetism

George Lewis – grl31@cam.ac.uk

3rd-year PhD candidate in the Electron Microscopy group, supervised by Prof. Paul Midgley and Dr Emilie Ringe

At the nanoscale, magnetic materials display intriguing behaviours due to a combination of confined geometries and quantum effects; for example, we find unusually stable 'knots' of magnetism in *skyrmions* (which have exciting low-power computing applications), and 'whirlpool'-like vortices in nanorings (extremely promising candidates for magnetic cancer treatments). I have been working on a technique to visualize these complex magnetic fields in 3D so that we may further understand and improve these materials. In this talk I will demonstrate how we can achieve this using the electron microscope, and how we can refine our results by incorporating prior knowledge.

What is the origin of polarization in thin-film dielectrics?

Atif Jan – aj619@cam.ac.uk

2nd-year PhD candidate in the Device Materials group, supervised by Dr Giuliana di Martino

Ferroelectric materials offer a low-energy, high-speed alternative to existing computer memory technologies. Within the class of ferroelectric materials, hafnium zirconium oxide (HZO) has been confirmed to exhibit room-temperature-stable ferroelectric phases. However, HZO exhibits non-ideal behaviours, specifically the wake-up effect and polarization fatigue. We fabricated ferroelectric devices of 5-nm HZO in a nanoparticle-on-mirror (NPoM) geometry to allow for non-destructive and simultaneous optical and electrical probing at the nanoscale. This presentation explores that efficient switching of polarization for HZO comes from vacancy-induced phase transition

In-situ optical tracking of memristive switching in MoS_2

Joanna Symonowicz – jks68@cam.ac.uk

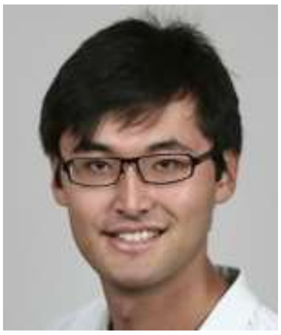
3rd-year PhD candidate in the Device Materials group, supervised by Dr Giuliana Di Martino

Data transfer between logic and memory units consumes up to 80% of the energy in computers, impeding miniaturization and causing us to lose our work if we forget to click 'Save'. Memristors combine memory and logic in one device, and by using them, we could save up to 10% of world energy usage! Though promising memristors have been fabricated, their commercial utilization is still held by the lack of understanding of their switching, which in turn prevents good fabrication reproducibility. I have developed non-destructive characterization of memristive switching, in-situ, in real-time, and under ambient conditions. Characterization of monolayer MoS_2 shows that switching is driven by gold intercalation.

Luminescent waveguide-encoded lattices for indoor photovoltaics

Takashi Lawson – tl457@cam.ac.uk

Post-doctoral researcher in the Photoactive Materials group led by Professor Rachel Evans



The rapid growth of the Internet-of-Things (IoT) ecosystem is expected to lead to one trillion interconnected devices by 2035. Many of these devices will need to be standalone and portable, creating an urgent demand for off-grid power sources. Luminescent waveguide-encoded lattices (LWELs) are a new class of photonic material, consisting of a thin (*ca.* 1 mm) luminescent polymer film that contains a patterned array of cylindrical channel waveguides. This presentation explores how LWELs can enhance the harvesting of indoor artificial light for powering the IoT.

Squeezing materials: Predicting the unexpected at high pressures

Lewis Conway – ljc83@cam.ac.uk

Post-doctoral researcher in in the Materials Theory group led by Professor Chris Pickard

Applying pressure to a material can invoke transitions to novel crystal structures with desirable properties such as superconductivity. Using *ab initio* random structure searching (AIRSS), we model the thermodynamic and vibrational properties of thousands of crystal structures to identify those seen in experiment. A recent application is the discovery of an unusual composition of a methane-hydrogen compound.

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Triboelectric energy harvesting for implanted medical devices

Kalliope Margaronis – km642@cam.ac.uk

3rd-year PhD candidate in the Device Materials group, supervised by Prof. Sohini Kar-Narayan

Implantable medical devices are important in modern medicine, providing necessary medical intervention for tens of millions of people. Currently, the main source of power for these devices is batteries. When depleted, battery replacement surgeries are required to keep the device functioning. Exchanging batteries for triboelectric energy harvesters would remove the need for these replacement surgeries, freeing up medical resources and decreasing the risk to patients from surgery. Triboelectric generators rely on contact-generated surface charge transfer between materials, converting mechanical energy (harvested or supplied) into useful electricity. The main considerations (other than biocompatibility) are power-output optimization, frequency response, and environmental stability of the fabricated devices.