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Brief Encounters – ABSTRACTS

Effect of surface-hardening techniques on single-crystal nickel-based superalloys

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Increased fatigue resistance of turbine blades in aerospace jet engines, necessary to facilitate improved engine efficiency, can be achieved by surface hardening through such techniques as mechanical shot-peening (MSP), laser shock-peening (LSP) and deep cold-rolling (DCR). Each of these is thought to introduce a layer of surface cold-work, but exact interactions with the blade material are not well understood. In this research, the effects of MSP, LSP and DCR on sample microstructure and subsequent fatigue life are being studied and compared using various electron microscopy techniques, with the aim of optimizing surface hardening of single-crystal nickel-based superalloys.

Superelastic alloys for vibration-damping applications

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Metastable β-titanium alloys, such as Ti-24Nb-4Zr-8Sn, have potential for application in vibration-damping systems due to their ability to display superelastic behaviour. However, their use is currently limited due to large variations in the temperature range over which this behaviour is stable, which can additionally be shown to depend on the thermal history of the sample. Understanding this variability enables better design of alloys and processing routes in order to achieve materials with the desired properties required for industrial application.

Predictive data analytics for high-Q CNT fibre production

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Post-doctoral researcher in the Macromolecular Materials Laboratory led by Professor James Elliott

The extraordinary properties of carbon nanotubes (CNT) in the nanoscale can be harnessed by assembling them into macroscopic fibres. In this presentation, I will discuss how the application of statistical methods can significantly improve the Cambridge direct-spinning method of CNT fibre production, increasing both the quality and throughput of CNTs. We present CNT fibres as a material that is simultaneously strong and conductive, and as such is on par with benchmark materials such as electrical wires of copper or high-strength steel cables.

Designing oxide heterostructures for superior resistive switching

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Post-doctoral researcher in the Device Materials group, led by Prof. Judith Driscoll and Dr Giuliana Di Martino

Resistive switching (RS) devices are an emerging solution for meeting the need for energy-efficient and area-efficient memory and computing. Oxide-based RS devices are promising contenders to address current challenges of RS devices with respect to key performance parameters such as uniformity and scalability. I am on a mission to design superior RS devices by achieving synergy between ionic-conduction and ferroelectric-driven RS in oxide heterostructures. Optical investigation of the microscopic processes in RS devices aims to provide indispensable insight for the optimization of this RS approach.

Conformable and robust force sensors to enable precision joint-replacement surgery

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2nd-year PhD candidate in the Device Materials group, supervised by Dr Sohini Kar-Narayan

The number of hip replacements is increasing due to our ageing and more active population. During a hip replacement, it is crucial that the forces on the joint are balanced to avoid patient pain and the requirement for further surgeries. Currently, force balancing depends on the surgeon's skill: there is currently no technology that can inform surgeons information of the forces in the hip joint. To solve this problem, we have invented a thin and flexible force-sensor. Several sensors were incorporated into a model hip implant, and were proved to be very sensitive across the range of forces typically applied during surgery.

Magnesium nanoparticles for sunlight capture

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Magnesium has gained much attention as a sustainable and efficient plasmonic metal, *i.e.* a metal capable of strong light-matter interactions leading to photon scattering, absorption, and electric-field enhancement. Magnesium's hexagonal crystal structure sets it apart from most common nanomaterials, and colloidal synthesis gives twinned nanoparticle shapes that resemble tents, chairs, tacos, and kites! This talk reviews the modelling of these shapes, using a modified Wulff construction, as well as their size- and shape-dependent plasmonic response calculated *via* electromagnetic simulations.

Light-responsive Pickering emulsion encapsulants

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Light-responsive Pickering (or solid-particle stabilized) emulsions are a new class of encapsulant capable of demulsifying and re-emulsifying upon the application of two different wavelengths of light. The enhanced control offered by light makes these materials desirable in drug delivery or oil-biphasic catalysis, where material can be stored and released without making direct contact with the droplets. This presentation explores how the solid-particle emulsifiers can be designed so that they are capable of exhibiting this light-responsive behaviour.

Exploring potential mechanisms by which silicon-substituted hydroxyapatite influences angiogenesis for bone-tissue engineering

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Blood-vessel formation in scaffolds through angiogenesis is of great importance for the success of tissue-engineered bone grafts as it regulates nutrient and waste exchange crucial for cell survival. To date, achieving the appropriate vascularisation remains one of the major obstacles for bone-tissue engineering, stemming from the complex mechanisms involved in angiogenesis. Attempts to improve the bioactivity of hydroxyapatite grafts have led to increased interest in silicon-substituted hydroxyapatite. This presentation explores how, and to what extent, silicon substitution in the hydroxyapatite lattice improves cell attachment in co-culture, a method designed to assess blood-vessel formation in vitro.

Predicting crystal structures from first principles efficiently

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Research Fellow in the Materials Theory group led by Professor Chris Pickard and Dr Bartomeu Monserrat

How can we predict stable crystal structures entirely from first principles? The Materials Theory Group applies quantum and statistical mechanics to answer such questions, frequently using random structure searching as a core tool. This talk will introduce structure searching, with emphasis on recent work applying orbital-free density-functional theory to compute the energies, forces, and stresses associated with candidate structures.