Wednesday 10 December

09.00 to 09.45

Nanostructured Coatings for Electronic and Optical Devices

Dougal G. McCulloch, Applied Physics, School of Applied Sciences, RMIT Univ. (Australia)

Coatings play a critical role in enhancing the properties of materials and allow the construction of complex electronic devices and durable components. There is an increasing need to devlop new types of advanced coatings that can be used in the next generation of electronic devices, sensors and tools. Advances in deposition techiques allow coatings to be produced with properties tailored for particular applications. In this talk, I will present our latest findings in the synthesis and characterisation of nanosturcutured coatings. Examples will include the prepration of carbon films ranging from diamond-like with high hardness to graphtie-like with high through film electrical conductivity. These graphitic coatings were also found to provide a low-resistance Ohmic contact to silicon with a potential application as high conductance interconnects in electronic devices. Other examples of the synthesis of coatings tailored to particular applications includes the preparation of high quality metal oxides films for use in sensors, advanced optical devices or as novel gate oxide materials.

Prof. McCulloch has published 105 refereed research papers in the fields of microscopy & microanalysis, carbonaceous solids and thin film coating materials. He has performed the most comprehensive investigation yet undertaken of the effects of ion bombardment on the structure of non-crystalline carbons. These include glassy carbon, tetrahedral amorphous carbon and amorphous carbons with mixed graphitic and diamond character. His work on glassy carbon alone has been cited more than 150 times as reported in the Web of Science. He has developed high spatial resolution analysis techniques for the study of interface layers in coatings by transmission electron microscopy and electron energy loss spectroscopy. Professor McCulloch established and is the Director of the RMIT Microscopy and Microanalysis Facility which serves researchers from many disciplines both within RMIT and beyond. He is the President of the Australian Microscopy & Microanalysis Society (AMMS).

09.45 to 10.30

Applications of High-frequency Ultrasonics in Microfluidics and Microactuation

James R. Friend, Associate Professor and Deputy Head of the Dept. of Mechanical and Aerospace Engineering Mechanical and Aerospace Engineering, Monash Univ. (Australia)

The transmission of acoustic waves through materials and across interfacial discontinuities is a centuries-old area of research. A rather curious application of ultrasonic acoustic radiation-actuation of fluids, particles and solids-has renewed interest in this area and exposed phenomena that are not explained by previous theories that were once viewed as canon. During the talk, examples will be provided of powerful microactuators that fullfill Feynman's original criteria on size (1/64th of an inch on a side, or 400 microns) in his talk, "There's plenty of room at the bottom", rotary actuators to enable in- vivo swimming microrobots small enough to navigate arteries of the human brain, fingernail-sized devices to atomize sessile droplets for drug encapsulation and nanoparticle formulation, devices for droplet jetting and manipulation, and a device to enable micro and nanoparticle concentration in a sessile droplet in a matter of seconds. Along the way, a discussion of the phenomena that enable these devices to work and a few reasons why past work appears to fail to adequately describe what is going on will be provided.

James Friend is an associate professor and deputy head of the Department of Mechanical and Aerospace Engineering at Monash University, Melbourne Australia, and has interests in the physics and applications of small technologies. He is a member of the IEEE Nanotechnology for Biology Committee, on the advisory board of the Lifeboat Foundation, and on the steering committee for the $45 million Melbourne Centre for Nanotechnology to open in 2009. From 2001 to 2004, Dr. Friend was an assistant professor at the Precision and Intelligence Laboratory, Tokyo Institute of Technology. He joined Monash University in late 2004, and co-founded and co-directs the $7.5 million MicroNanophysics Research Laboratory with Dr Leslie Yeo; the lab currently has a staff of three academics, three post-doctorates and twelve PhD students. He has over eighty peer-reviewed publications, with five book chapters, thirty-nine peer-reviewed journal papers, and thirteen patents and patent applications in progress.

Thursday 11 December

09.00 to 09.45

Plasmon-enhanced Fluorescence Near Metallic Nanostructures: Biochemical Applications

Ewa M. Goldys, Personal Chair in the Department of Physics, Division of Information and Communication Sciences, Macquarie Univ. (Australia)

Amplification of fluorescence is a nanoscale phenomenon that is particularly pronounced in close proximity to metal nanostructures. Due to its sharp distance dependence it is ideally suited to monitor biorecognition reactions. Using this effect we have been able to demonstrate ultrasensitive bioassays. Two types of metal nanostructures have been employed, these were nanometric silver islands deposited over an ultrathin metal mirror and silver fractal structures. In the first instance metal mirrors (aluminum, gold, or silver protected with a thin silica layer) were coated with SIFs, and an immunoassay (model assay for rabbit IgG, or myoglobin immunoassay) was performed on this surface using fluorescently labeled antibodies. Our results showed that SIFs alone on a clean glass surface enhance the immunoassay signal approximately 3 to 10-fold. Using a metal mirror instead of glass as support for SIFs leads to up to 50-fold signal enhancement. The second type of metal nanostructures, silver fractals, were produced by electrochemical reduction of silver nitrate deposited on sapphire covered with a thin conductive film of indium tin oxide. These structures were used as a substrate for a model rabbit IgG bioassay. The fluorescence resulting from the binding of antibody labeled with Rhodamine was highly nonuniform with distinctive hot spots. These highly fluorescent regions were correlated with areas of higher Ag thickness and coverage. Such high values of fluorescence amplification in both types of nanostructures have been interpreted by using time-resolved fluorescence data and by considering the radiative properties of plasmons in the environments that promote plasmon coupling. Current work focusing on silver fractal deposition on silicon and on membranes will also be discussed.

Prof. Ewa M. Goldys holds a Personal Chair in the Department of Physics, Division of Information and Communication Sciences, Macquarie. Her expertise spans the fields of biophotonics, optical characterisation, ultrasensitive detection of analytes, biosensing, bioimaging. materials synthesis and characterisation and cathodoluminescence. Her present projects belong at the interface of materials science, photonics and biotechnology and she is drawing on her earlier achievements in materials science and ultrasensitive optical characterisation.

With the ARC support she has developed advanced methods of synthesis and characterisation of fluorescent nanoparticles for applications in fluorescence labelling. Her advanced expertise in ultrasensitive optical characterisation and nanotechnology leads to the development of novel approaches to biochemical and medical sensing and diagnostics, documented in numerous publications concerning self-organised growth and characterisation of nanostructures. Work in progress focuses on an innovative ultrasensitive surface plasmon resonance sensing system for the application in bioassays capable of sensing ultrasmall volumes. She demonstrated feasibility of the directional two-photon induced surface plasmon-coupled emission and demonstrated that surface plasmon sensing can be done using inexpensive plastic substrates. Her work concerned with metal nanoparticles led to the development of homogeneous silver-coated nanoparticles for their applications in fluorescence enhancement.

Her publication track record includes over 150 refereed journal publications and a similar number of conference publications. She is presently editing a book "Fluorescence Applications in Biotechnology and Life Sciences" which will be published by Wiley in January 2009. She has established the Optical Characterisation Facility at Macquarie University.

Ewa is Convenor of ARC/NHMRC Network "Fluorescence Applications in Biotechnology and Life Sciences".

09.45 to 10.30

Nanoscale and Optical Properties of Chalcogenide and Tellurite Glass Film-based Devices

Steven J. Madden, Leads Research on Chalcogenide and Tellurite Integrated Ooptical Devices, Laser Physics Centre, The Australian National Univ. (Australia)

Chalcogenide and Tellurite glasses display a rich range of optical functionalities and effects some intimately linked to the nanoscale. From an applications perspective, of particular interest are their Mid-Infrared transmission, large optical nonlinearities, magneto and accousto-optic merits, suitability as hosts for multi-window rare earth based amplifiers, and the tantalising possibility of realising system on a chip devices based on them. To effectively engage some of these attractive features often requires devices in the nano regime, and also throws up some challenges caused by the nanoscale properties of the materials. The talk will address the properties of and opportunities for these materials, the challenges in accessing these properties in a real planar device, some demonstrations of what has been accomplished to date, and what the future might hold for these technologies.

Dr. Madden currently leads research on Chalcogenide and Tellurite integrated optical devices at the Laser Physics Centre within the Australian National University. His research career in fibre and integrated optics spans much of the period from 1984 to the present in start-ups, Multi-nationals, and academia covering a diverse range of areas including Liquid Crystals, seven different materials systems for planar devices, all fibre devices, Hybrid integration, Bragg gratings and devices, planar tunable lasers, optical transmission systems and all optical networking, and non-linear effects in SOAs and planar waveguide devices. The spectrum of work has covered fundamental science through to putting new high technology products into volume production and out onto the market.

Friday 12 December

09.00 to 09.45

Medical photonics for imaging in humans

David D. Sampson, Director, Centre for Microscopy, Characterisation & Analysis, Univ. of Western Australia (Australia)

There has been a revolution in our ability to image at cellular level resolution in situ in living animals and humans. In the laboratory, optical microscopic imaging of cells is a mainstay of biomedical research - under a microscope cells are imaged in exquisite detail. By contrast, in the clinic, medical imaging provides images of tissues deep within the body, but at much lower resolution and specificity. A technology revolution is taking place that bridges this gap between laboratory microscopy and clinical imaging. High-resolution imaging in living, subsurface tissues in animals and human subjects is developing rapidly via the fields of intravital microscopy (microscopic analysis of processes within a living animal or human) and endomicroscopy (using an endoscope). In this talk, examples will be chosen to highlight the emerging capabilities, such as confocal fluorescence endomicroscopy and optical coherence tomography, and some areas of application, such as cancer, as well as the issues associated with the uptake of these new photonics methods. These new methods of 'histopathology in situ' will profoundly alter the way in which disease is diagnosed and treated and call for a new generation of 'bedside pathologists' to operate them.

Prof. David Sampson is Director of the Centre for Microscopy, Characterisation and Analysis, which is the University of Western Australia's micro-imaging core facility, and a node of the Australian Microscopy and Microanalysis Research Facility. He also heads the Optical+Biomedical Engineering Laboratory in the School of Electrical, Electronic and Computer Engineering and is Director of the Western Australian Centre of Excellence in eMedicine. His personal research interests are in optics and photonics applied to medicine and biology - the fields of biomedical optics and biophotonics. His interests span the spectrum from the fundamental - novel methods in optical microscopy and light propagation in tissue, to the engineering of optical instruments, to the application of novel optical imaging methods in clinical medicine. He is particularly motivated to stimulate integration and exploit synergies across this spectrum, and to promote and engage in interdisciplinary research, interests which have crystallised in his leadership of the UWA Bioimaging Initiative. Current research highlights include the development of synthetic aperture holographic microscopy, and the application of anatomical optical coherence tomography in lung cancer and breast cancer. Prof. Sampson has recently chaired in Perth, Western Australia, the international conferences Focus on Microscopy in 2006 and Optical Fibre Sensors-19 in 2008. He is an elected member of the Australian Optical Society Council.

09.45 to 10.30

Recent Advances in Optical MEMS Technologies for Electrically Tuneable Multispectral Infrared Sensors and Arrays

Lorenzo Faraone, Head of the Microelectronics Research Group (MRG), Director of the WA Centre of Excellence for Semiconductor Optoelectronics and Microsystems (WACSOM), The Univ. of Western Australia (Australia)

State-of-the-art infrared (IR) focal plane array (FPA) technologies aim to improve the performance of IR imaging systems by reducing cooling requirements and/or adding so-called multi-colour capability, which allows on-pixel information to be gathered from two or more spectral regions. Spectral information allows improved target recognition and reduced false alarm rates in military applications, and accurate temperature determination in civilian applications. It has been recognised, however, that in order to extract spectroscopic or detailed information from a cluttered image, much better spectral resolution is required than can be afforded by such multi-colour systems. A number of research programs are aiming to address this issue by obtaining significantly better spectral resolution by developing technologies for the integration of individual tuneable optical filters on each pixel of a detector array. The approach chosen by The Microelectronics Research Group (MRG) is to develop a micro-electromechanical systems (MEMS) technology that is compatible with large format two-dimensional infrared focal plane arrays. Such a device structure consists of an electrostatically controlled Fabry-Perot filter that is integrated optically ahead of the individual detectors in an array. The demonstration of this technology has involved major advances in the deposition of silicon nitride (SiNx) thin films for mirror support structures, and the development of new Bragg mirror designs. This presentation will outline the basic concept of the approach, modelling results giving predicted device performance, several of the major hurdles to be overcome in this technology, results related to control of film stresses in SiNx films, as well as demonstration of an integrated microspectrometer technology comprising a MEMS filter and an infrared sensor capable of low-voltage tuning across the SWIR and MWIR wavelength bands.

Prof. Faraone is Head of the Microelectronics Research Group (MRG) at The University of Western Australia (UWA), and Director of the WA Centre of Excellence for Semiconductor Optoelectronics and Microsystems (WACSOM). Prior to joining UWA in 1987, he worked primarily in the area of silicon-based microelectronics technology with RCA Labs in Princeton, NJ, USA: in particular, silicon dioxide growth technology, degradation and failure, as related to non-volatile memory devices and radiation-hard silicon-on-sapphire CMOS. Since joining UWA he has worked on compound semiconductor devices, including AlGaN/GaN HEMTs and 2D electron gas transport studies, HgCdTe-based infrared sensor technology, as well as MEMS technologies for infrared applications. The MRG has a vertically integrated capability in HgCdTe semiconductor MBE growth, infrared sensor array fabrication, and packaging/testing facilities. Recent research has focussed on MEMS and the infrared microspectrometer concept, which provides enhanced tuneable hyperspectral and/or multi-spectral capabilities to IR focal plane arrays. The activities at UWA also include research into laser beam induced current (LBIC) imaging, as well as mobility spectrum techniques for magneto-transport studies. This has resulted in the development of the Quantitative Mobility Spectrum Analysis (QMSA) technique that allows the transport properties of individual carriers in a multi-layer/multi-carrier semiconductor system to be determined accurately and unambiguously.