

The Grand Challenges in Microelectronics Design



μ GC2: Silicon Meets Life – Interfacing Electronics to Biology

4th Sept, Chancellors Hotel and Conference Centre,
Manchester

Supported by the
Health Technologies KTN



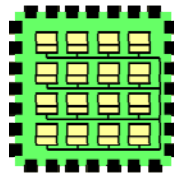
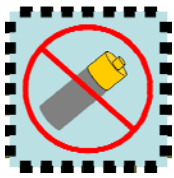
Objectives

The objective of this Grand Challenge is to develop advances in technology and design that will enable a seamless bi-directional interface between living organisms and electronic systems.

New - and remarkable - life-changing medical treatments will be brought about by tightly integrating microelectronics and biology. Devices such as cochlear implants are already in wide use today, delivering good-quality hearing to those with impairment. Deep brain stimulation via surgically-inserted electrodes is used to reduce tremors caused by Parkinson's disease. Research on brain-computer interfaces is providing hope of a communication route for locked-in patients. However, these pioneering applications are still in their infancy, and far more can be expected if we master the construction and understanding of tightly-coupled electronic/biological systems.

Agenda:

- 9:30: Registration
- 10:00 **Dr Piotr Dudek** – Introduction to the Silicon Meets Life Theme
- 10:15 **Dr Brian McGovern, Imperial College**, “Optoelectronic visual prosthesis”
- 10:45 **Dr Christoph Walti, University of Leeds**, “Label-free high-density protein arrays”
- 11:15 Coffee Break
- 11:45 **Prof. Leslie Smith, University of Stirling**, 'Interfacing Electronics and Neural Systems: what are the issues?'
- 12:15 **Prof. David Cumming, Glasgow University**, 'Using Integrated Circuits to Build Biosensors'
- 12:45 Networking Lunch
- 13:45 **Dr Anna Sigurðardóttir, Staff Engineer, ST Microelectronics** – 'ST Microelectronics - Enabling Healthcare Solutions'
- 14:15 **Norman Stockham, Business Development Manager, TWI** – 'Interfacing materials and electronics with biology'
- 14:45 **Workshop Session** – facilitated by partner organisations and aimed at identifying research project that might be of use to industry
- 15:45 Coffee
- 16:00 Feedback Session
- 16:30 **Daniel Dearing, eKTN** – Summary and follow-up
- 16:45 **Networking and close**



Presentation Abstracts

Dr Brian McGovern, Imperial College. "Optoelectronic visual prosthesis"

There increasing excitement in the neuroscience community about the optogenetic method of stimulating nerve cells with light. It is now moving from a scientific curiosity to a full blown revolution in the way scientists can probe neurons down to the subcellular level. Perhaps even more importantly, it has huge potential in the field of prosthetics. At present however, the technique needs large instantaneous light intensities, which are a challenge to microelectronics community. In this talk I will give an overview of the Imperial optoelectronic research project and more specifically the processing architectures required to communicate with the neurons.

Dr Christoph Walti, University of Leeds. "Label-free high-density protein arrays"

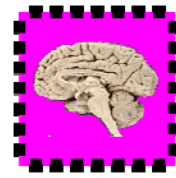
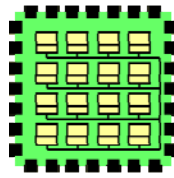
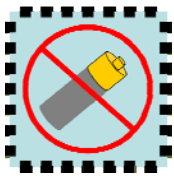
Proteins play a significant role in almost all biological processes. A comprehensive understanding of cell biology requires devices for the analysis of a staggering number of protein isoforms and protein– protein interactions in a cell. We present a novel protein microarray, featuring peptide aptamers as protein detectors arrayed on gold electrodes with feature sizes an order-of-magnitude smaller than existing formats. We use a robust, label-free electronic sensing system and demonstrate specific protein recognition in whole cell lysates. The sensitivity equals or exceeds that of other devices and is within the clinically relevant range. The use of peptide aptamers selected in vivo to recognise specific protein isoforms, the electronic nature and scalability of the detection, and the scalability of the array fabrication combine to yield the potential for highly multiplexed devices with increasingly small detection areas and higher sensitivities that may ultimately allow simultaneous monitoring of hundreds of thousands of protein isoforms.

Prof Leslie Smith, University of Stirling. "Interfacing Electronics and Neural Systems: what are the issues?"

There are a number of reasons why one might want to join silicon and living systems together, for example (i) biomedical applications, whether directly in healthcare (replacing damaged systems with prosthetic systems), or in medical research (to better understand living systems), (ii) enhancing animal performance (using electronics where it performs better, for example in speed and precision, or in controlling external electronic systems), or (iii) hybrid systems, where the electronics uses tissue to perform some specific function which is better performed by living systems. All three of these require bidirectional signal transfer in a manner which is effective, robust and long-lived. Although robustness and longevity are critical issues, we concentrate here on effective transfer. The issues which arise in trying to achieve effective bidirectional communication range from low-level current or ion transfer through to issues of representation of information: we remain a very long way from the fictional ideas expressed by William Gibson in his novels!

Prof. David Cumming, Glasgow Uni. "Using Integrated Circuits to Build Biosensors"

Integrated circuit technology is best known for the effect it has had on miniaturising electronics products whilst simultaneously increasing the functional complexity. In this talk I will show several examples of how, by adopting integrated circuit technologies, new biomedical devices such as the laboratory-in-a-pill can be realised, as well as novel sensor platforms for use in applications such as cell-based assay.



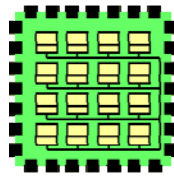
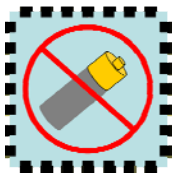
These new devices benefit from the traditional advantages offered by microelectronics, but also exploit the integrated circuit materials to enable sensor integration on to the same chip.

Dr Anna Sigurðardóttir, Staff Engineer, ST Microelectronics. 'ST Microelectronics - Enabling Healthcare Solutions'

No abstract yet

Norman Stockham, Business Development Manager, TWI. 'Interfacing Materials and Electronics with Biology'

The HealthTech market is increasingly integrating electronics for passive and active devices to support human health and life. Applications range from the devices used in the home to support care in the community (e.g. fall monitors) to existing heart pacemakers, but there is increasing use of and interest in devices that are worn or implantable to monitor vital signs (ECG), to aid diagnosis (ambulatory measurement), to treat disease (cochlear implants) and ultimately to diagnose and treat in one device (e.g. drug delivery). Any device acting directly with the human has to contend with the physical/biological interface, whether this be skin sensitisation or direct contact with internal bodily fluids which see the implant as a foreign body and respond accordingly. This paper will describe applications of medical electronics, drawing out particular challenges and the potential for future technologies and products



Speaker Bios

Dr Piotr Dudek, University of Manchester



Dr Piotr Dudek is a Senior Lecturer in Integrated Circuit Engineering in the School of Electrical and Electronic Engineering at the University of Manchester, leading the Microelectronic Design Lab. His research interests are in the area of analogue and mixed-mode circuit design, integrated sensing/processing systems and massively parallel architectures. He has led a series of EPSRC grants designing “vision chips” with pixel-parallel cellular processor arrays, and is currently involved in two multidisciplinary research projects in the area of brain-inspired circuits and systems: Computing with Laminar Microcircuit (COLAMN) researching analogue/digital VLSI implementations of novel computational architecture based on the cortical microcircuit, and Reverse Engineering the Vertebrate Brain (REVERB) investigating neural hardware implementing biologically plausible attention and action-selection models. He is a member of IEEE Circuits and Systems Society technical committees on Cellular Neural Networks and Array Processing and on Sensory Systems, and has been coordinating the activities of the “Silicon meets Life” Grand Challenge working group.

Prof Leslie Smith, University of Stirling



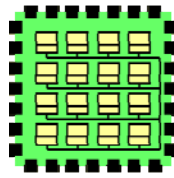
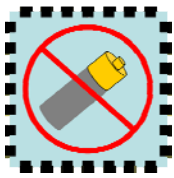
Professor Leslie Smith has been working at the boundary between electronics and neuroscience for over 20 years. He has been fascinated by the similarities and differences between neural and electronic systems for many years. Initially, his work took the form of developing neural network techniques and applications, but later it moved on to sensory systems, and signal processing for neurophysiological signals. This has required a great deal of interdisciplinary understanding, and this has been the hallmark of his work for the last decade. Professor Smith is Head of the Department of Computing Science and Mathematics at the University of Stirling.

Dr Brian McGovern, Imperial College



Brian is a research associate in the Institute of Biomedical Engineering at Imperial College, London. Previously he graduated with a B.Eng. degree in Electrical and Electronic Engineering (1988), a M.Sc. degree in Electronics (1989) and a Ph.D. in VLSI array processors (1993) from the Queen’s University of Belfast. He also completed a B.Sc. in Optometry (2006) from the City University, London and is a fully qualified optometrist. He has experience with a number of electronics companies including ST microelectronics in Belgium (2001-2003) and Nokia in the UK (1994-1997, 1999-2000). More recently he has been working as an optometrist including a year in the Ophthalmology department at Maidstone hospital (2006-2007). Brian has published several papers and has 5 patents.

His research interests are focused in the area of vision and visual systems, in particular the development of an optoelectronic visual prosthesis.



Dr Christoph Walti, University of Leeds



Dr Christoph Wälti graduated with an MSc in Physics from ETH Zürich, Switzerland. In 2000, he received a PhD in Physics from the Laboratory of Low Temperature Physics at same institution for his studies on the superconductivity of heavy fermion materials. Shortly afterwards, he was awarded a Swiss Marie Curie Fellowship which allowed him to extend his research interests into a new area and he moved to the Cavendish Laboratory at the University of Cambridge, UK, where he worked on DNA- based self-assembled nanoscale molecular complexes. In 2003, he was awarded an EPSRC Advance Fellowship and since 2004 he is at the University of Leeds working on molecular nanotechnology with particular focus on self-assembly applications and the interface between biology and semiconductors.

David Cumming, Glasgow University



David Cumming has B.Eng (Glasgow, 1989) and PhD (Cambridge, 1993) degrees. He has worked variously on mesoscopic device physics, RF characterization of novel devices, fabrication of diffractive optics for optical and sub-millimeter wave applications and microelectronic design. He is presently Professor of Microsystem Technology and EPSRC Advanced Research Fellow in Electronics and Electrical Engineering at the University of Glasgow, U.K. where he leads the Microsystem Technology Group

Dr Anna Sigurðardóttir



Anna Sigurdardottir studied Electrical Engineering at the University of Iceland and Solid State Electronics at the Technical University Darmstadt, Germany. She worked as 'Wissenschaftliche Mitarbeiterin' at the Institute for Microwave Electronics, Technical University Darmstadt, 1993-1999. During this period she authored and co-authored round 20 publications, most of them in the field of high-speed semiconductor devices and quantum electronics.

In 1999 Anna joined STMicroelectronics in Marlow, UK, as Analogue Design Engineer. She has been involved in and technically responsible for the design of a number of analogue and mixed-signal chips, primarily for power-management- and medical applications.

Norman Stockham



Norman Stockham is TWI's Electronics, Sensors & Medical Sector Manager. He has over 25 years experience in medical, electronic, optoelectronic and sensor packaging covering a wide variety of process and assembly technology. Within medical electronics, he has worked on active implantable devices, device interconnect and encapsulation, biocompatibility, high temperature co-fired ceramics, MEMS technology. Throughout this period he has been closely involved with research projects, product development and troubleshooting with medical and electronics companies worldwide. He has led tours of UK experts to Japan, Korea & USA to study electronic and photonic manufacturing technology and has lectured widely, in Europe, USA & the Far East, on the subjects of electronic packaging, medical products and joining technology.