Cite this: *Lab Chip*, 2011, **11**, 1191

www.rsc.org/loc

EDITORIAL

10th Anniversary Issue: UK

DOI: 10.1039/c1lc90024b

The United Kingdom has a long history of innovation and development, much of which has its roots in the Industrial Revolution of the 18th and 19th centuries. Starting with the mechanisation of the textile manufacturing industry, major advances, particularly in the mechanical and chemical engineering fields, soon followed. One of the early pioneers of mechanical systems was James Watt who made significant improvements to steam engines, turning them into reliable, powerful, energy efficient machines that would drive the manufacturing centres of the country. His partner John Roebuck was one of the early pioneers (along with figures such as William Henry Perkin) to develop new methods for the mass production of chemicals, laying the foundations for the chemical industry as we know it today. Indeed, by the end of the 19th century Britain had large industrial plants manufacturing a large array of chemicals, and was exporting products and technology all over the world.

Over a century later, this tradition of exploiting technological innovations meant that many British scientists and engineers were quick to embrace the concepts of miniaturisation presented by early pioneers such as Manz and Harrison. It is interesting to note that the first volume of *Lab on a Chip* published in 2001 contained twenty eight research papers from academic and industrial research groups throughout the world. Of these, eleven originated from UK universities such as Durham, Imperial College London, Hull and Newcastle. Importantly almost all of these British contributions came from groups that were members of the £3.2m Foresight LINK "Lab on a Chip" Consortium. The consortium, formed in 1998, was a multidisciplinary research forum, comprising seven UK universities, and ten industrial partners including Glaxo-Wellcome, Unilever and Kodak. The simple aim was to refine the new generation of microfluidic tools being developed and apply them to problems faced in the fields of drug discovery, process control, environmental analysis and DNA analysis. The early realization that microtechnologies were essential in addressing some of the most important challenges in modern day chemistry and biology led to strategic

Andrew deMello

Andrew deMello is Professor of Chemical Nanosciences and Head of the Nanostructured Materials and Devices group in the Chemistry Department at Imperial College London. He obtained a 1st Class Degree in Chemistry and PhD in Molecular Photophysics from Imperial College London in 1995 and subsequently held a Post-Doctoral Fellowship at the University of California, Berkeley before returning to the UK. His research group is engaged in a range of activities including the development of microfluidic devices for high-throughput analysis, ultra-sensitive optical detection techniques, nanofluidic reaction systems for chemical synthesis, segmented flow microfluidics and the exploitation of semiconducting materials in diagnostic applications. He is co-founder of Molecular Vision Ltd, a company developing low-cost diagnostic devices. He has published 150 papers in refereed journals, and co-authored two books. Professor deMello was awarded the 2009 Clifford Paterson Medal by The Royal Society for contributions to Nanotechnology and the 2009 Corday Morgan Medal by the Royal Society of Chemistry.

Hywel Morgan

Hywel Morgan obtained both his first degree and his PhD at the University of Wales, in 1981 and 1985 respectively. After a post-doc in Israel, he was appointed to a lectureship at the University of Glasgow in 1993. He was appointed professor of Bioelectronics at Glasgow in 2000. In 2001 he was awarded a Royal Society-Leverhulme Senior Research Fellowship for a sabbatical at the University of Oxford. In 2003 he moved to the University of Southampton where he manages a group with a range of research interests in microfluidics, particularly AC electrokinetics and electro-hydrodynamics. He is also developing microfluidic systems for cell separation, medical diagnostics and environmental monitoring. In 2004 won the Desty memorial prize for innovation in separation science and he is a fellow of the Institute of Physics. He has given numerous invited lectures, published over 170 papers in peer reviewed journals, a similar number in refereed conference proceedings and has co-authored a textbook.

investment in both personnel and infrastructure. For example in 2003, the UK government invested £90 million over a six year period to allow industry to harness the commercial opportunities offered by micro and nanotechnologies in the widest sense. Additionally, key appointments at UK universities, most notably the arrival of Andreas Manz at Imperial College London from Ciba Geigy in 1996, were instrumental in building a strong knowledge base in this new field.

Today, the UK is still home to a number of groups active in the microfluidic arena. Although, not huge in number, these activities represent internationally leading programmes not only in fundamental science and technology but also in the translation of these ideas to challenges faced in the chemical, pharmaceutical and biotech industries. Accordingly, we are delighted to showcase some of these activities in this special issue of *Lab on a Chip*. In the first of two critical reviews, Oreffo and colleagues from the Southampton University School of Medicine write from the perspective of an end user, reviewing the utility of skeletal stem cells for bone and cartilage repair. New techniques for rare cell isolation and enrichment are being developed and in stem cell biology methods are required for production of high purity cell fractions from human bone marrow. When assessing microfluidic systems one often talks about microlitre volumes. However, the combination of micro-scale physics and chemistry with macro-scale engineering to process tens of millilitres of sample should lead to new high throughput methods of cell sorting and isolation with diverse applications.

The plethora of fundamental microfluidic research over the past decade has meant that the technology is now seen as an enabling tool in experimental science. Several papers in this special issue illustrate this potential. For example, John deMello and colleagues at Imperial College London demonstrate a droplet flow reactor for synthesizing metal oxide and compound semiconductor nanoparticles over a wide range of flow conditions and temperatures and for extended periods of time. The exceptional control and stability of the capillary-based reactor offers an ideal environment for a diversity of solution phase syntheses with exquisite control over reaction conditions.

Microfluidic sample pre-processing is at last making a significant impact in clinical diagnostics. A collaboration between the University of Southampton and Phillips Research Cambridge has developed a point-of-care microfluidic system for assaying Human Full Blood Count from a finger prick of blood. The microfluidic platform provides accurate timing and control of the chemistry together with precise control of cell concentrations in a single sample preparation block. Such technology is likely to find application in a range of cell identification and enumeration assays. Herein, the contribution from Spencer and Morgan analyses the microfluidic impedance cytometer used to count and identify cells. The authors demonstrate through numerical simulations how the impedance signal is related to the trajectory of cells passing through the microfluidic channel, and show how to optimise both sensitivity and accuracy. In addition to cell identification and enumeration, there is also considerable interest in cell separation technologies. As highlighted by Pamme and co-workers from the University of Hull, many particle-focusing methods require complex setups or channel designs that limit many applications. To this end, the authors demonstrate a novel approach for particle and cell-focusing based on diamagnetic repulsion forces between a paramagnetic medium and a magnet.

In the second critical review Padgett and Di Leonardo recount the history of optical tweezers and describe how this technology has provided a completely new field of optical manipulation, actuation and sensing. Optical tweezers typically rely on bench-top optics integrated with microscopes, which poses some constraints on system integration. Indeed the authors note, "*For lab-on-chip technologies to truly take advantage of their potential scalability and parallelism, the need for a traditional microscope needs to be removed*." Recent advances in the integration of optical components with chip-based platforms have opened up further applications of this technology. An example of how optical systems can be efficiently integrated with microfluidic systems is reported by researchers at Imperial College London, The Institute of Cancer Research, and Cancer Research UK. In this contribution Klug and co-workers implement a microfluidic protocol for analysing protein copy numbers from single cells. The control system is entirely optical, with cells being manipulated with optical traps, lysed by laser microcavitation and released proteins assayed using total internal reflection fluorescence microscopy.

The theme of small volume detection is further exemplified by Ashok and colleagues at the University of St Andrews who demonstrate microfluidic waveguide confined Raman spectroscopy. In proof of principle experiments they embed optical fibers on-chip in a geometry that confines both excitation and collection photons. The alignment free detection scheme is then used to monitor reactions and perform analyte detection in microdroplets. Finally, Yamazaki and co-workers at Imperial College London and Molecular Vision describe a new way to manufacture high quality optical filters using nano-structured metal-oxide films containing monolayers of dye molecules. Although a range of optical assays have previously been integrated into microfluidic devices, sensitivity is often limited by the ability to fabricate high-efficiency optical components in a cost-effective fashion. The authors demonstrate functionality on glass substrates that points towards viable and low cost alternatives to traditional interference filters for diagnostic and analytical devices.

Andrew deMello
Department of Chemistry, Imperial College London, South Kensington, London, SW7 2AZ, UK

Hywel Morgan
School of Electronics and Computing Science, University of Southampton, Highfield, Southampton, SO17 1BJ, UK

