Preface

Biosensors: surface structures and materials

Nanotechnology literally means any technology done on a nanoscale that has applications in the real world. Nanotechnology encompasses production and application of physical, chemical and biological systems at scales ranging from individual atoms or molecules to submicrometre dimensions, as well as the integration of the resulting nanostructures into larger systems. Nanotechnology is likely to have a profound impact on our economy and society in the early twenty-first century, comparable with that of semiconductor technology, information technology, or cellular and molecular technology. Science and technology research in nanotechnology promises breakthroughs in areas such as materials and manufacturing, nanoelectronics, medicine and healthcare, energy, biotechnology, information technology and national security. It is widely felt that nanotechnology will be the next industrial revolution. There is an increasing need for a multi-disciplinary, system-oriented approach to design and manufacturing of micro/nanodevices that function reliably. This can only be achieved through the cross fertilization of ideas from different disciplines and the systematic flow of information and people among research groups.

The development of micro/nanoelectromechanical systems (MEMS/NEMS) technology, along with new fabrication techniques and their applications to the field of biology and medicine, have led to the field of BioMEMS/NEMS. Applications of BioMEMS/NEMS include micro/nanofluidic type and microarray type biosensors for chemical and biochemical analysis (biosensors) in medical diagnostics (e.g. DNA, RNA, proteins, cells, blood pressure and toxin identifications), and implantable pharmaceutical drug delivery. Polymers have been used, in addition to silicon, for BioMEMS/NEMS devices because polymer microfabrication processes can be orders of magnitude less expensive than traditional microfabrication processes. Various polymer materials that are commonly used in microdevices produced by soft lithography include poly(methyl methacrylate), polycarbonate and polydimethylsiloxane. As an example, a wristwatch type biosensor based on microfluidics referred to as a lab-on-a-chip system was developed for the US Defense Advanced Research Project Agency. These systems are designed to detect either a single or class of (bio)chemicals, and have the advantage of incorporating sample handling, separation, detection and data analysis onto one platform. The chip relies on microfluidics and involves manipulation of tiny amounts of fluids in microchannels using microvalves. The test fluid is injected into the chip generally using an external pump or syringe for analysis.

One contribution of 10 to a Theme Issue ‘Biosensors: surface structures and materials’.
Bioadhesion and fluid drag in the micro/nanofluidic channels play an important role in the successful operation of devices. Accumulated surface charge on the polymeric channels may impede fluid flow. The boundary condition at the solid–liquid interface on the micro/nanoscale is an important issue in micro/nanofluidic systems, where drag forces between fluids and solid walls need to be minimized. On hydrophobic and superhydrophobic surfaces, the fluid velocity near the solid surface is not equal to the velocity at the solid surface, a phenomenon called boundary slip. The boundary slip is directly related to the fluid drag. The surface charge present affects boundary slip and fluid drag. Surface structures and materials for channels are being developed to minimize fluid drag as well as bioadhesion.

In the field of biomimetic surfaces, a number of ideas have been suggested so far for surface structures for reduction of fluid drag. These include the lotus-leaf surface, which has superhydrophobic and self-cleaning properties, and shark skin that can move underwater with low drag thus suppressing turbulence. The common feature found among many of these surfaces is that they have hierarchical roughness with roughness details ranging from nanometres to millimetres.

For implanted biosensors and drug delivery as well as in tissue engineering, the materials should be biocompatible. Some materials can be made biocompatible by deposition of surface coatings.

The purpose of this Theme Issue is to present an overview of the field of biosensors. We have selected topics of surface structures and materials for the issue. The appeal of this Theme Issue is expected to be broad. Papers in this issue have an overview along with new research data with future outlook to identify where the field is going.

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