EDITORIAL

Nanodevices come to life

To cite this article: Anna Demming 2011 Nanotechnology 22 090201

View the article online for updates and enhancements.

Related content
- Constructing nanomechanical devices powered by biomolecular motors
  Carlo Montemagno and George Bachand
- The fabrication, characterization and application of aptamer-functionalized Si-nanowire FET biosensors
  Ki Su Kim, Hyun-Seung Lee, Jeong-A Yang et al.
- Processive behaviour of kinesin observed using micro-fabricated cantilevers
  T Scholz, J A Vicary, G M Jeppesen et al.

Recent citations
- Stepwise motion of a microcantilever driven by the hydrolysis of viral ATPases
  Johann Mertens et al
- Design and characterization of nanoknife with buffering beam for in situ single-cell cutting
  Yajing Shen et al
EDITORIAL

Nanodevices come to life

Anna Demming
Publishing Editor,
IOP Publishing, Bristol, UK

In the late 1990s, progress in nanofabrication techniques enabled scientists to generate structures with unprecedented control over feature size. At nanosizes inorganic devices could conceivably be compatible with the force production and dimensions of biomolecular motors. In addition, advances in molecular biology around the same time galvanized the field of research into hybrid organic/inorganic nanosystems: research into nanodevice development had truly come to life.

Atomic force microscopy (AFM) has played a pivotal role in the characterization of biomaterials and biosensing [1]. First developed by Bining, Quate and Gerber in the mid 80s [2] AFM extended the potential of scanning probe techniques to insulating surfaces, a property that had previously caused limitations for applying high-resolution scanning tunnelling microscopy to biological systems. AFM is now a potent imaging and sensing tool, and recent developments towards high-speed imaging have further developed the potential of this technology to follow the dynamics of biological processes [3,4].

A number of new tools and techniques have been developed in order to investigate how the best attributes of the organic and inorganic worlds can be exploited to study and create nano-electro-mechanical systems powered by biological motors and chemical energy sources. Researchers at Cornell University in the US investigated the potential of a hybrid organic/inorganic nanoscale system that both provides insight into the basic mechanics of motor protein motion and establishes a technological foundation for functionally integrating these molecules with manufactured devices [5]. In their work, F1-ATPase was attached to a nanofabricated substrate with the $\gamma$ subunit of the molecule attached to a microsphere. By measuring the movement of the microsphere using a differential interferometer, the rotational velocity and angle of deformation of the $\gamma$ subunit could be monitored.

Microspheres have since been widely used to study processive molecular motors such as kinesin, often with the microsphere trapped in the focus of optical tweezers. However, such set-ups have certain limitations pertaining to the decoupling required with respect to the measuring sensor and the nanosystem. A bead in an optical trap will have several rotational and translational degrees of freedom, whereas the directions of motion measured may be restricted to allow the critical coordinates for molecular functionality to be determined, and this introduces distortions. In this issue, a collaboration of researchers in Germany, Lithuania and the UK describe an innovative new technique for the mechanical characterization of a molecular motor [6]. Their set-up uses a vertical cantilever with sub-piconewton resolution. By limiting the relevant experimental degrees of freedom in this way, the de-coupling of the microscopic sensor and the nano-scale machine is facilitated, thus aiding tests of theoretical models. The work bridges the gap in force sensitivity between atomic force microscopes and optical tweezers.

Various techniques have been developed to investigate a range of mechanical properties of biomaterials including the piezoresponsive properties in collagen, suggested as potentially stimulating cellular response and thus the growth and healing in bone, skin and connective tissues such as tendons. Researchers at the University of Illinois in the US used piezoresponsive microscopy to probe the piezoelectricity in individual type I collagen fibrils [7]. Aptamers are also attracting high research interest as a result of their potential in diagnostics and...
therapeutics. They have many advantages including stability at room temperature, no immuno-genicity or toxicity, versatile chemical modification of end groups, and they can be produced by a scalable chemical process with a low production cost. Researchers at Pohang University of Science and Technology in Korea have developed an aptamer-functionalized silicon-nanowire field-effect-transistor biosensor [8] and have applied the device to real-time electrical detection of electronic signals during and after binding with a target protein.

High resolution imaging and sensing techniques have seen enormous developments that have moved the field from point measurements and still image collection to the direct measurement of biomolecular dynamics and nanoscale motion pictures. The field continues to buzz with new ideas, promising many further exciting advances. As Thomas Edison, inventor and a pioneer in motion pictures, once said: ‘to have a great idea, have a lot of them’ [9].

References