Nano/Microengineered Molecular Systems in Nanotechnology

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THE 4TH ANNUAL IEEE INTERnational Conference on Nano/Microengineered Molecular Systems (IEEE-NEMS) was held at the Sheraton Dameisha Resort in Shenzhen, China, 5–8 January 2009. More than 300 papers were presented by leading micro/nanotechnology researchers in academia and industry from around the globe. Topical areas of the conference included microelectromechanical systems (MEMS), BioMEMS, microfluidics, nano/molecular-scale simulation, micro/nanofabrication, nanomaterials, nanoelectronic devices, carbon nanotube-based devices, and nanowires. More information can be found at the conference Web site www.ieee-nems.org. In this special section, selected papers that appeared in the conference are discussed.

SINGLE-CELL PATCH-CLAMP MEASUREMENT SYSTEM

Over the past several years, scientists have become increasingly interested in the study of individual cells, which allows them to gain insight into cellular behavior under specific conditions. One popular approach to cellular analysis is the patch-clamp technique, in which a glass pipette is connected to an individual cell for electrical recording of ion channel activity. As can be expected with a manual technique, this is a laborious and time-consuming process; thus, researchers have looked at automated approaches for performing patch-clamp analysis.

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A group at Louisiana Tech University has recently developed such a system that uses a microfluidic chip to manipulate and analyze individual cells. In their approach, a microfluidic chip is fabricated by casting poly (dimethylsiloxane) (PDMS) against a negative master and then bonding to a glass cover slip. The chip contains cell sorting, positioning, and analysis functions,

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which are realized by a fluorescence-activated cell sorter (FACS), integrated air-bubble actuators, and lateral patch-clamp electrodes, respectively. The device theory of operation is as follows. The FACS, which is located at the chip input, is used to select a target cell. As the target cell flows through the central channel of the chip, an air-bubble actuator is used to generate positive pressure that pushes the cell toward a pipette, which is integrated directly across from the actuator. At the same time, a negative pressure is applied to the pipette, thus aiding in the capture of the cell and preventing random cells from being attached.

The researchers demonstrated preliminary results in which fibroblast cells (3T3) were analyzed using the automated system, yielding electrode impedances of 1 MΩ before cell capture and 5 MΩ after cell capture. The authors hope to improve the seal resistance by optimizing the pipette dimensions, including its shape and size.

REFERENCE

[1] Z. Gong, K. Nagarajan, S. Penmetsa, S. Madisetti, D. Mills, and L. Que, “A patch-clamp device with integrated actuators for cell selection and positioning,” Louisiana Tech Univ.

MOISTURE SENSOR USING CANTILEVER WITH NANOWELLS

Sensors for the measurement of moisture are becoming increasingly popular for process and product control in the chemical, food processing, and agricultural industries. Although a wide range of sensor types has been explored for moisture measurement, cantilever-based sensors have, perhaps, attracted the most interest because of their relatively fast response.

Recently, researchers at Pohang University of Science and Technology in South Korea demonstrated an improved moisture sensor by modifying the surface of the cantilever through the incorporation of nanowells. The theory behind their improved sensor has to do with the way that cantilever-based sensors are typically operated. When used in static mode, the deflection of the cantilever is measured as a result of adsorption-induced surface stress; thus, flexible cantilevers are required for high stress sensitivity. For the dynamic operation of the sensor, the variation in the resonant frequency of the cantilever is measured as a result of mass-change due to adsorption, thus requiring a large-surface area to achieve high mass sensitivity.

To optimize their sensor for both static- and dynamic-mode operation, the researchers decided to fabricate cantilevers with both increased surface area and flexibility by using anodic aluminum oxide as their cantilever material. The surface of their fabricated cantilever (250-µm long × 35-µm wide × 2-µm thick) was covered with nanowells that were 50-nm wide and 2-µm deep. When compared with unmodified aluminum oxide surface, the nanowell-modified surface showed significantly increased surface area. Additionally, the Young's modulus of the anodic aluminum oxide cantilever, which is a measure of the material's stiffness, was measured to be 26.7 GPa, which is significantly more flexible than silicon (170 GPa) and regular dense aluminum oxide (140 GPa). The researchers demonstrated results using their new sensor for the detection of moistures in the range of 45–230 ppm in both static and dynamic mode.

REFERENCE

[1] D. Lee, M. Lee, N. Shin, K.-H. Lee, and S. Jeon, "Moisture sensors using anodic aluminum oxide microcantilevers with nanowells," Pohang Univ. of Science and Technology, South Korea.

QUANTUM DOT-BASED RADIATION SENSOR

One of the principle methods used for the treatment of cancer is radiation therapy, which uses ionizing radiation to destroy cancerous cells and tumors. In order for this treatment to be effective, an appropriate dose of radiation must be delivered to the target area; thus, accurate measurements of radiation dosage are sought.

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Recently, researchers at the University of Waterloo in Ontario, Canada, developed a new technology for radiation detection that uses quantum dots (QDs) as the radiation sensing material. The authors created a 5 × 5 mm^2 sensor region that contained hundreds of electrodes in array configuration. On top of the electrodes, a layer of ZnO QDs was deposited, and the sensor was exposed to a photon beam. The results showed a linear relationship between the sensor output current and the incident photon energy. Additionally, by reducing the spacing between electrodes in the array or by increasing the thickness of the QD layer, higher output currents could be obtained during radiation exposure. The authors speculate that the repeatable and linear response of QDs to photon beams may prove to be a promising technology for accurate dosimetry.

REFERENCE

[1] J. X. Gao, J. T. W. Yeow, and R. B. Barnett, "Quantum dots-based radiation sensor for cancer diagnostic and radiotherapy," Univ. of Waterloo, Waterloo, Ontario, Canada.

MEMS SENSOR FOR VEHICLE DETECTION AND RECOGNITION

One of the most prominent industrial applications of MEMS technology has come from the automotive industry, where MEMS-based accelerometers have been used for advanced braking systems. It may not be long before MEMS devices begin to make inroads in another automotive application: vehicle detection and recognition.

Toward this goal, researchers at the University of Science and Technology Beijing in China have recently developed a MEMS magnetic sensor that is used for detecting and recognizing moving vehicle targets. Their system combines a commercially available three-axis MEMS magnetic AMR sensor with an amplifier, filter, high-speed analog-to-digital (A/D) to digital-to-analog (D/A) converter, and a computer.

To demonstrate their system for vehicle detection and recognition, the authors conducted a series of experiments in which the sensor was installed on the side of a road and vehicle targets passed by it at a distance of 3 m. Various vehicle targets were used, including heavy- and light-tracked vehicles and light-wheeled vehicles. The results showed that the sensor was capable of detecting the passing vehicle and correctly determining its vehicle type with recognition rate as high as 92%. By using MEMS technology, their sensor shows superiority in cost, size, and weight when compared with other sensors, and is also less sensitive to noise and Doppler effects.

REFERENCE

[1] J. Lan and Y. Shi, "Vehicle detection and recognition based on a MEMS magnetic sensor," in *Proc. 4th IEEE Int. Conf. Nano/Micro Engineered and Molecular Systems, 2009.* Univ. of Science and Technology Beijing, China, pp. 404–408.