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nanobiotechnology news

SPOTLIGHT

Hisham Mohamed is a Postdoctoral Fellow at the Wadsworth Center, Albany, NY. His research interests include the implementation of Micro-Electro-Mechanical Systems (MEMS) for biomedical applications.

Lori Lepak is currently a graduate student in Chemistry and Chemical Biology at Cornell University, studying with Professor Michael Spencer. Her research interests include the application of nanofabrication and scanned probe microscopy to build devices for biomolecular filtration and biosensing.

James N. Turner is Director of the Three-Dimensional Light Microscopy Facility and the Nanobiotechnology Program at the Wadsworth Center of the New York State Department of Health, Albany. He is professor of Biomedical Engineering at Rensselaer Polytechnic Institute and of Biomedical Sciences in the School of Public Health at the University at Albany. His research interests include applications of light imaging methods and quantitative image analysis in biology and medicine with a specific emphasis on the nervous system.

Michele Caggana heads the Newborn Screening Molecular Laboratory and regulates laboratories performing genetic testing for the New York State Health Department. She is an Assistant Professor at SUNY Albany in the Department of Biomedical Sciences. Her research interests include streamling molecular diagnostics and isolation of rare cells from peripheral circulation and bone marrow.

David Martin is Deputy Director of the Wadsworth Center. He research includes inhibitory synaptic function in mammalian brain, in the metabolic functions of astroglial cells in brain, and in the use of transmitter receptors as elements in biosensors.

Michael Spencer is currently a Professor in the School of Electrical and Computer Engineering at Cornell University. His research interests include the correlation of electronic device performance with material growth and processing parameters. Recent work has emphasized wide bandgap materials and emerging work in biotechnology.

Donald H. Szarowski is currently a Research Scientist at the Wadsworth Center, Albany, NY, where he is the supervisor of the Three-Dimensional Light Microscopy Facility.

Development of On-chip Biopolymer Membranes

The miniaturization of analysis systems has been motivated by enhancing analytical performance, decreasing reagent consumption, providing the potential of running multiple tests in parallel, and integrating multiple functions such as sample handling, analysis and detection on a single device [1,2]. This field has grown rapidly since its debut around 1975 evolving to what is called now micro total analysis systems or lab-on-a-chip.

A typical on chip system would be capable of controlling fluid transport (injection, pumping, valves), in addition to performing its functions such as separation (diffusion based, size, field flow, laser trap), purification and analysis (chromatography, electrophoresis, isoelectric focusing), sensing (chemical, biological, flow, viscosity), and/or detection (fluorescence, electrochemical, etc.). Other systems have been developed for more specific biological applications such as protein separation, PCR, DNA separation and sequencing, and clinical diagnostics [3].

In many of these systems, sample purification or pre-concentration is required to enhance the device sensitivity and specificity. Sample purification strategies have focused mainly on using chromatography or electrophoretic separations. While these methods have enabled the use of highly sensitive detectors that are capable of quantifying extremely low solute concentrations without fear of contamination, they are not sufficient for use with a highly complex mixture such as biological fluids that require an intermediate separation step. Membrane separations may be an efficient method for simple size- and charge-based purification in the lab-on-a-chip environment. Previously, filtration has been either performed prior to sample loading or through the use of commercial membranes adhered to the substrate [1,4]. These membranes cannot be patterned to micron resolution and the adhesion process might be incompatible with fabrication processes, or may introduce contaminants. Our group's main objectives are to integrate filtration onto microfluidics devices in a way that is compatible with existing microfabrication processes, and to develop a methodology for changing the membrane's chemistry and rejection characteristics to be suitable for a wide range of biological applications. We are investigating the use of polymer membranes, mainly cellulose acetate and collagen.

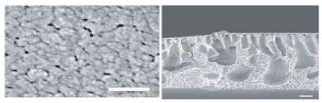

Figure 1

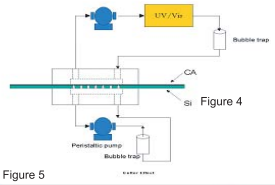

Figure 4

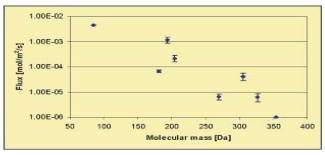

Figure 2

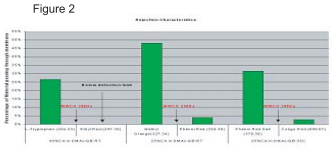

Figure 3

Figure 5

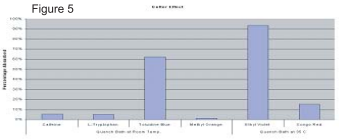

Figure 1: Images of cellulose membranes. (a) an SEM of the surface showing relatively large holes. (b) SEM image of a freeze fractured membrane showing the internal structure. Bars=500nm.

Figure2: Experimental set-up showing the Si wafer with the CA membrane sandwiched between the PDMS microfluidic pieces.

Figure 3: Results for the flux versus molecular weight.

Figure 4: The binding of (+) charged molecules to themembrane, toluidine blue and ethyl violet.

Figure 5: Shows control of the molecular weight cut-off (MWCO) for different casting conditions

Silicon wafers were coated on both sides with a thin layer of low stress silicon nitride, the top (polished side) was patterned with a two dimensional array of squares ranging in size from 2mm by 2mm to 8mm by 8mm, and etched using reactive ion etching (RIE). The bottom was patterned with 1mm by 1mm squares, etched using

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message from the director

Barbara Baird

The NBTC begins its second five years as a Science and Technology Center of the National Science Foundation. We are building on our strengths and extending our reach in the areas of research, education and knowledge transfer, based upon achievements in our first five years. Our Center has pioneered the field of Nanobiotechnology and has attracted substantial interest internationally, as we continue to be a leader in this exciting field.. This success is based on effective collaborations among life scientists, physical scientists and engineers to create an array of micro- and nanofabricated devices to address biological systems on the subcellular and molecular levels. Integral to that process is the training of students and postdoctoral associates who go forward to advance the field in other venues.

These next five years will be an important transitional period as we plan for and move toward a vibrant future beyond the ten years of the NSF-STC program. NBTC research, to create new classes of tools that can elucidate biology at fundamental scales, will increasingly take these new technologies to applications that impact a wide range of life processes. This will be facilitated by knowledge transfer and by building relationships with other groups in industry, academia and government. Facilities are being created in Duffield Hall that provide essential technical support as well as an environment that nourishes interdisciplinary interactions. A continuing crucial aspect of our growth is communication throughout the Center and beyond, particularly engaging the minds of the next generation with a vision of an exciting scientific field that extends well into the future.

Research, continued from previous page...

RIE followed by KOH etch through the entire wafer thickness to expose the top nitride layer. Polymer solution was spin cast onto the wafer (top side) using variable speed and time conditions, followed by quenching in a non-solvent solution for pore formation.

The resulting wafer had polymer membrane bridging across the 1mm by 1 mm holes supported by the porous (2mm by 2mm to 8mm by 8mm square holes) nitride layer. SEM pictures for the membrane (top view and inside structure) are shown in Figure 1. The rejection characteristics of assembled membrane filtration devices were determined by passing single- and multi-component solutions across the membrane in a tangential flow mode, the microfluidics were cast in PDMS and assembled as shown in Figure 2.

The results for the membrane cast from a 25% cellulose acetate (CA) dissolved in N,N–dimethylacetamide (DMAc) (w/v, CA/DMAc) showed a decrease in flux with an increase in molecular weight to a cut-off (MWCO) of 350 Da as shown in Figure 3. We found that the non-monotonic decrease in flux was due to the secondary effects; molecules with higher solubility, that were neutral or negatively charged had less resistance passing through the membrane, while less soluble molecules confronted a higher resistance, thus decreasing their flux, and positively charged molecules adhered to the membrane (Figure4). The secondary effects played a role only for the molecules smaller than the MWCO; a highly soluble and neutral molecule such as phenol red salt (MW=376.34) did not pass through, confirming the MWCO of 350 Da for this membrane.

We were capable of modifying the rejection characteristics in very fine steps by changing the polymer concentration and/or quenching bath temperature to form two additional membranes with MWCOs of 300Da and 700Da (Figure 5). We also controlled the rate at which molecules pass through the membrane by changing its thickness due to altering the casting speed and time, while keeping the same rejection characteristics [5].

This work provides a novel capability to integrate filtration onto a chip using standard processes without contaminants, control the rejection characteristics, and the flow rate. Such a technology is highly desirable and can be adapted as a front end to many systems to study cell signaling or to carry out DNA purification from whole blood for PCR, our group is actively pursuing both of these applications.

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Nanobiotechnology Course Bursting at the Seams

A graduate level course in nanobiotechnology continues to attract students from around the world. The course, which is videoconferenced live to five locations spanning from Dublin, Ireland to Portland, Oregon, is once again off to a strong start. With over 130 students representing engineering, life sciences, and physical sciences, the course places students in teams to design a nanobiotechnological solution to a biological problem. The challenges of working at the nanoscale are compounded by the challenges of working with fellow students who speak different languages based on their disciplines. When asked a basic question, 'what is a control', engineers respond with 'exerting influence over something' while biologists write 'a variable that is held constant in an experiment'. Overcoming these challenges in a team based environment provides students with a real experience in the challenges facing scientists and engineers who work in the field of nanobiotechnology.

Nanobiotechnology course spans the globe

Science Club for Girls Continues to Thrive

What began as an experiment to keep girls engaged in science has become a fad at three rural schools in Central New York. Tri-Sci Club for girls started as a science club program for girls in grades 7 and 8 at Groton, Spencer Van Etten, and Newark Valley schools. With their teachers as coaches and scientists from Cornell as mentors, girls participate in hands-on science activities every month at their schools. Members also take field trips to science museums, nature centers, and local science companies. The club started in 2000 with 49 members, and enrollment has increased every year to the current membership of 132 girls. The popularity of the club continues to increase at each school, and many of those who have 'graduated' from middle school have asked to continue being involved as they progress through high school.

Experimenting with floating mirrors at the Sciencenter

Why are these girls so excited to be involved in the club? "I like doing labs...it's better than doing book work," said one student from Groton. The overwhelming answer was simply "I like science."

What does this mean for girls in science? If the program is hands-on and fosters interaction between girls, they show up in droves. It couldn't be any simpler than that.

Now Accepting Applications for Summer 2005 Nanobiotechnology Institute for Teachers: go to http://www.nbtc.cornell.edu/mainstreetscience/nit.html

Wageesha Senaratne was born in Colombo, Sri Lanka, and graduated with a Bachelors of Science in Chemistry from the University of Colombo, Sri Lanka. She is currently a graduate student at Cornell University in the Chemistry and Chemical Biology Department and is part of Professor Christopher Ober's research group. She has been working on chemically modified surfaces using self-assembled monolayers and surface-initiated polymer brushes for highly selective and specific biosensors, applying nanotechnology for immune cell signaling studies, and investigating surface-initiated polymer brushes for non-biofouling applications. Her future research interests include incorporating nanotechnology into biological systems as revolutionary tools for ultrasensitive detection of disease markers and infectious agents.

Wageesha was recently recognized by the Cornell Nanoscale Science and Technology Facility with the Nellie Yeh-Poh Lin Whetten Memorial Award. This award is given in fond memory of Nellie Whetten, a CNF staff member from 1984 to 1987 who died March 24, 1989. It recognizes outstanding young women in science and engineering whose research was conducted in the CNF, and whose work and professional lives exemplify Nellie's commitment to scientific excellence, interdisciplinary collaboration professional and personal courtesy and exuberance for life.The award consists of a plaque, a check and the awardee's name added to the Nellie Yeh-Poh Lin Whetten Memorial Award plaque.

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