Biomaterial Interfaces
Room 311 - Session BI1-ThM

BioMEMS and Microfluidics

Moderator: G.P. Lopez, University of New Mexico

8:20am **BI1-ThM1 Long Lifetime Polymer Microfluidic Devices for HPLC-MS Applications**, ***K.L. Seaward***, *D.L. Ritchey, K.P. Killeen, H. Yin, R.A. Brennen,* Agilent Laboratories

Polymer microfluidic devices have been developed for High Performance Liquid Chromatography with integrated nano-electrospray tips for interfacing to Mass Spectrometry. HPLC-MS is regarded as a preferred analytical technique for protein identification in very small (nanoliter) volumes of sample and has been used, for example, to determine protein content in blood. Commercially available microfluidic devices consist of separate parts for liquid chromatography and electrospray functionality connected with fittings. This leads to difficulties in use, compromised performance, and complicated fabrication. The devices described in this presentation are made in a biocompatible polyimide and contain sample enrichment and liquid chromatography columns plus electrospray tips. Their size is approximately 2.5cm x 6cm with 200-400 micron thickness in a multi-layered structure made by direct laser writing of patterns followed by vacuum lamination. Laser cutting of electrospray tips and incorporation of metal traces in the layer structure provide electrospray functionality. A rotary valve interface between high-pressure fluids delivered by a nanoflow pump and the microfluidic device itself provides efficient fluid switching between various ports on the device. Gas-phase plasma processes, similar to those found in microelectronic device manufacturing, are used in the fabrication process. These are critical to ensure long lifetime performance of the devices, resulting in repeatable high-pressure performance of the column structures and stable electrospray behavior. In combination with mass spectrometry, state-of-the-art attomole level detection of protein digests has been demonstrated using these microfluidic devices. The device fabrication will be outlined and recent applications to proteomics will be shown.

8:40am **BI1-ThM2 BioMEMS Chip and Package Design for Surface-Controlled Bioreaction Processes**, ***J.J. Park***, *M.A. Powers, X. Luo, R. Ghodssi, G.W. Rubloff,* University of Maryland

BioMEMS research exploiting multi-step, multi-site biomolecular reactions for metabolic engineering and other applications requires an integrated chip, packaging, and control system designs to accommodate fluidic, electrical, and optical networks. We have developed approaches for sealing and re-opening bioMEMS systems to allow reuse and post-process analysis. Photoimageable SU-8 is used on pyrex wafers to create microfluidic channels as micro-knife-edges for sealing to flexible PDMS gaskets. Electrical networks provide Au and ITO electrodes for selective assembly and functionalization of amine-rich chitosan as the platform for biomolecular reaction steps, while integrated SU-8 waveguides enable fluorescence sensing at these sites. PDMS is spun onto a Plexiglas top wafer, inverted, and placed onto the SU-8 channels. The two wafers are then compressed by bolting together a Plexiglas package comprised of top and bottom plates, along with a Plexiglas ring which carries the inputs and outputs to external control systems. The design enables optical microscopy observations from above, which confirm leak-free sealing when colored dye is transported through the microfluidic network. Chitosan polysaccharide, positively charged in low pH solution, is electrodeposited at negative electrodes in the bioMEMS system. This provides a promising avenue for extending to bioMEMS environments our prior work using patterned electrodes on chips in solution, which included selective conjugation of proteins and nucleic acids, as well as enzymatic conversion of small molecules.

9:00am **BI1-ThM3 Artificial Extracellular Matrices: Polymer Films Modified with Positive Cues to Promote Cell Adhesion and Neurite Extension**, ***G.T.R. Palmore***, *H.-K. Song, D. Hoffman-Kim,* Brown University **INVITED**

Nerve growth is modulated in vivo by positive (permissive or growth-promoting) and negative (growth-inhibitory) biochemical cues. Neurons of the peripheral nervous system (PNS) are able to regenerate after injury because of the endogenous growth-promoting environment provided by Schwann cells. Traumatic injury to the central nervous system (CNS), however, often results in irreversible loss of function because the neurons in the CNS reside in an environment that contains too many negative cues and too few positive cues. We seek to calibrate the quantity of positive cues relative to negative cues needed for CNS regeneration and thus have fabricated patterned substrates of specific dimensions for this purpose. These substrates consist of a conductive polymer matrix doped and chemically modified with biologically-active molecules in varying spatial relationships. The preparation of these substrates will be discussed, including their spectroscopic, microscopic and immunochemical characterization. In addition, results will be shown that demonstrate how these substrates promote cell adhesion and guide neurite extension of neurons in the presence of both positive and negative cues.

9:40am **BI1-ThM5 Study of Molecular Transport in Nanofluidic Channels by Integrated Multiple Internal Reflection Infrared Waveguide**, ***T.C. Gamble***, *Y.J. Oh, C.H. Chung, D.R. Petsev, S.R.J. Brueck, G.P. Lopez,* University of New Mexico*; C.F. Ivory,* Washington State University*; S.M. Han,* University of New Mexico

We have successfully integrated nanofluidic channels into Si multiple-internal-reflection (MIR) infrared waveguides for the purpose of biomolecular separation and detection. Biomolecules, electrolyte solution, and their reactions can be probed by the MIR waveguide, provided that the channel width is substantially less than the IR wavelength. In the regime where the channel width (10 to 100 nm) is comparable to the Debye length (~20 nm) of the electrolyte solution, we have investigated the electrokinetic transport of fluorescent dyes in a range of pH with the application of transverse "gate" bias in the field effect transistor (FET) configuration.* The gate bias controls the zeta potential and therefore the electroosmotic flow of dye molecules with a possibility of reversing its flow direction. Fluorescent dyes are chosen for the purpose of initial transport studies and visualization. We will also present the effect of ionic strength on the electrokinetic transport of fluorescent dye molecules. The addition of salt increases the ionic strength, but it also adds mobile ions that can move through the thermal SiO@sub 2@ layer that insulates the Si substrate from the electrolyte solution. We evaluate the use of a Si@sub 3@N@sub 4@ sub-layer as a means of preventing the leakage current due to mobile ions moving through the SiO@sub 2@. We compare our observations with fluorescence spectroscopy and current measurements. * U.S. Patent Application was filed on July 19, 2004.

10:00am **BI1-ThM6 Electrochemical Programming of Bioactive Surfaces**, ***B.C. Bunker***, *M. Farrow, K.R. Zavadil, W.G. Yelton,* Sandia National Laboratories

Self-assembled monolayers containing cyclodextrin have been used as a template for the reversible electrochemical patterning of surfaces. Electrochemical patterning occurs as a result of the oxidation and reduction of functionalized ferrocene in solution. When Fe(II) is present in the ferrocene, this neutral aromatic species is adsorbed by the cyclodextrin surface. When Fe(II) is oxidized to Fe(III), the ferrocene desorbs from the cyclodextrin. The electrochemically switchable surface is of interest in microfluidic systems when the ferrocene is functionalized to interact with specific biological species. We have succeeded in attaching biotin to the ferrocene via an ethylene glycol linkage. The biotinylated ferrocene can be made to adsorb and desorb from cyclodextrin deposited on gold electrodes. We have demonstrated that the biotin on the ferrocene is active toward the adsorption of streptavidin. With programmable streptavidin surfaces, we can create patterns with a wide range of biological species (i.e. any species that can be biotinylated). The synthesis, characterization, and electrochemical switching of the films are described, involving techniques such as cyclic voltammetry, electrochemical stripping, secondary ion mass spectroscopy, ellipsometry, and the quartz crystal microbalance. Use of the switchable films for creating programmable patterns of antibodies in sensors is described.

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