Tuesday Afternoon Poster Sessions

Biomaterial Interfaces
Room: Mauka - Session BI-TuP

Biomaterial Interfaces Poster Session

BI-TuP1 Three-dimensional Conducting Polymer-based Bioelectronic Interfaces for Rare Cell Isolation and Detection, ***Yu-Sheng Hsiao***, Ming Chi University of Technology, Taiwan, Republic of China, *H.-h. Yu*, Academia Sinica, Taiwan, Republic of China, *H.-R. Tseng*, University of California, Los Angeles, *P. Chen*, Academia Sinica, Taiwan, Republic of China

Here we develop a universal solution-processing approach for producing three dimensional (3D) conducting polymer-based bioelectronic interfaces (BEIs), which can be integrated on chips for rare circulating tumor cell (CTC) isolation and detection. Based on the modified poly(dimethylsiloxane) (PDMS) transfer printing technology and bioconjugation process, the poly(3,4-ethylenedioxythiophene) (PEDOT)-based micro/nanorod array films can be fabricated with topographical and chemical control, respectively. This 3D PEDOT-based BEI film features the advantageous characteristics: (1) diverse dimensional structures (tunable from the microscale to the nanoscale), (2) varied surface chemical properties (tunable from nonspecific to specific), (3) high electrical conductivity, and (4) reversible electrochemical switching, and (5) high optical transparency. Furthermore, we integrated this 3D PEDOT-based BEI onchips, which exhibited optimal cell-capture efficiency from MCF7 cells was approximately 85%; featured highly efficient performance for the cell isolation of rare CTCs with minimal contamination from surrounding nontargeted cells (e.g., EpCAM-negative cells, white blood cells); preserved the cell viability with negligible effect on cells. According to the electric cell-substrate impedance sensing concept, the 3D BEI-based device was also demonstrated as a rapid, sensitive and specific tool for CTC detection. Therefore, it is conceivable that use of this platform will meet the requirements on developing for the next-generation bioelectronics for biomedical applications.

Keywords: Poly(3,4-ethylenedioxythiophene) (PEDOT), bioelectronic interfaces (BEIs), circulating tumor cell (CTC), epithelial cell adhesion molecule (EpCAM).

BI-TuP3 For the Development of Auto-Injection System to Cells: Coating of Inserting Pipettes, Gas-Flow Evaluation Method for Prepared Pipettes, and SPM-inspired Pipette-Top Sensing System, ***Tomohide Takami***, *J. Uewaki*, *H. Ochiai*, Hiroshima University, Japan, *M. Koyama*, *Y. Ogawa*, *M. Saito*, *H. Matsuoka*, Tokyo University of Agriculture & Technology, Japan, *Y. Ojiro*, *K. Nishimoto*, *S. Ogawa*, *Y. Takakuwa*, Tohoku University, Japan, *S. Tate*, Hiroshima University, Japan

Glass nanopipettes have been used as a bridge to connect macro world and micro world.[1] They can be used as an ion-selective probe,[2-6] and as an injector to deposit a small amount of materials onto a surface.[7]

Injection to cell is a hot topic for the statistical experiments on the live dynamics of injected molecules in cell as well as the application to genetic engineering. Several auto-injection systems are already commercially available. However, the fatal problem of these auto-injection systems is the viability of cells after the injection; usually less than 10%.

We have been developing an auto-injection system in which the distance between the injecting pipette tip top and the cell is monitored and the signal depending on the pipette-cell distance is put into the feedback system to achieve the controlled insertion/extracion motion of the pipette to the cell in order to increase the viability of cells. This system is inspired from scanning tunneling microscopy on which the tip-sample distance is well-controlled for the nanoscale observation and molecular manipulation.[8]

Also, we have developed two methods for the auto-injection. One is the coating of the pipette top with chlorobenzene-terminated polysiloxane to reduce the damage to the inserted cell. The other is the gas-flow method to evaluate the inner diameter and the shank length of the pipette before using since the pipettes after the observation with electron microscope cannot be used.

In this paper, we will show our progress to realize the auto-injection system for the use of statistic and quantitative studies. We will demonstrate the ability of manual injection system to show the limit of the manual injection study. We will also demonstrate how the surface science technologies including scanning probe microscopy (SPM), surface coating, and vacuum science can be utilized for the development of the auto-injection system.

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BI-TuP4 Correlative Imaging of Single Mammalian Cells in their Native Environments, ***Xin Hua***, *C. Szymanski*, *Z. Wang*, *B. Liu*, *Z. Zhu*, *J. Evans*, *G. Orr*, Pacific Northwest National Laboratory, *S. Liu*, Southeast University, China, *X. Yu*, Pacific Northwest National Laboratory

Mammalian cell analysis is of significant importance in providing detailed insights into biological system activities. Due to the complexity and heterogeneity of mammalian cell behavior and the technical challenge of spatially mapping chemical components in a hydrated environment, correlative chemical imaging from multiplexed measurement platforms is needed. Fluorescence structured illumination microscope (SIM), with super high resolution and visualization of proteins and sub-cellular structures in 3-D, provides more detailed information in cell structure and dynamics. Time-of-flight secondary ion mass spectrometry (ToF-SIMS) is a unique surface-sensitive tool that provides molecular information and chemical mapping with a sub-micron lateral resolution. However, the understanding of how the spatial heterogeneity and structural difference affect the mammalian cell activities in an unperturbed, hydrated state by ToF-SIMS is severely limited due to the challenge to detect liquids with high volatility in high vacuum using surface sensitive surface techniques.

We recently developed a novel microfluidic reactor enabling correlative imaging of single mammalian cell (e.g., C10 mouse lung epithelial cell) growth by SIM and ToF-SIMS. Cells were introduced in the microchannel, incubated at 37 ^{o}C for 24 hr., fed with 5 Nm quantum dots, and then fixed with 4% paraformaldehyde before SIM imaging. In subsequent ToF-SIMS analysis, an aperture of 2 μm in diameter was drilled through the SiN membrane to form a detection window to image biological surfaces directly; and surface tension is used for holding the liquid within the aperture.

SIM images show that cells are successfully cultured on the SiN membrane, and quantum dots are uptaken by cells and dispersed in the cytoplasm. The ToF-SIMS *m/z* spectra were compared among dried cell samples, hydrated cells, and medium solution. Characteristic lipid fragments are identified. Moreover, 2D mapping of representative cell fragments were obtained. In addition, depth profiling was used to provide time- and space-resolved imaging of the single cell inside the microchannel. Furthermore, principal component analysis is conducted to evaluate the intrinsic similarities and discriminations among samples. Our results demonstrate the feasibility for *in situ* imaging of single mammalian cells in the hydrated state using ToF-SIMS for the first time. Correlative imaging using SIM and ToF-SIMS provides much sought-after information across different space scales for investigating cell dynamics. This novel approach has great potential for studying intracellular processes in the future.

BI-TuP5 Nano-Bio Interfacial Analysis using time-of-flight Medium Energy Ion Scattering, ***KwangWon Jung***, DGIST, Korea, Republic of Korea, *K.S. Park*, KMAC, Republic of Korea, *W.J. Min*, KMAC, *H.J. Lim*, *S.J. Moon*, DGIST, Korea, *D.W. Moon*, DGIST, Korea, Republic of Korea

We have developed a TOF-MEIS system using 70~100 keV He+. A TOF-MEIS system was designed and constructed to minimize the ion beam damage effect by utilizing a pulsed ion beam with a pulse width < 1 ns and a TOF delay-line-detector with an 120 mm diameter and a time resolution of 180 ps. The TOF-MEIS is an useful tool for interfacial analysis of the composition and structure of nano and bio systems. Our recent applications are reported.

#1) UltraShallow Junction: As doped Si ultra shallow junctions were fabricated with various annealing conditions. We measured the compositional depth profile of 2 x 10^{15} atoms/cm^2 As doped silicon (annealed/unannealed) by the random and channelling phenomenon in Si(100) lattice. The result clearly indicates that the As dopant profile depends on the annealing temperature and conditions. Monitoring of As

activated/deactivated ratio in ultra shallow junction by TOF-MEIS will be beneficial to the manufacturing processes of semiconductor industry.

#2) NanoParticles: We measured the quantitative compositional profiling with single atomic layer resolution for 0.5~3 nm CdSe/ZnS QDs with a conjugated layer. We also investigated the effect with Polyaspartic Acid (pAsp) and Osteocalcin on the initial bone growth of calcium hydroxyl appatite on a carboxyl terminated surface. When pAsp is not added to the self-assembled monolayers of Ca 2mM with Phosphate 1.2 mM, the growth procedure of calcium hydroxyl appatite cannot be monitored due to its rapid growth. When pAsp is added to the SAMs, the initial grow stage of the Ca-P can be monitored so that the chemical composition and their nucleus size can be analyzed.

#3) Liquid interface: Using a graphene as a MEIS analysis window, the electric double layer structure of liquid interface was depth profiled with atomic layer depth resolution. The electric double layer of KI solution is reported with discussions on further studies.

BI-TuP10 Enhancing Protein Adsorption Simulations by Using Accelerated Molecular Dynamics, ***Herbert Urbassek***, *X. Muecksch*, Physics Department, University of Kaiserslautern, Kaiserslautern, Germany

The atomistic modeling of protein adsorption on surfaces is hampered by the different time scales of the simulation (<< 1 ms) and experiment (up to hours), and the accordingly different 'final' adsorption conformations. We provide evidence that the method of accelerated molecular dynamics is an efficient tool to obtain equilibrated adsorption states. As a model system we study the adsorption of the protein BMP-2 on graphite in an explicit salt water environment. We demonstrate that due to the considerably improved sampling of conformational space, accelerated molecular dynamics allows to observe the complete unfolding and spreading of the protein on the hydrophobic graphite surface. This result is in agreement with the general finding of protein denaturation upon contact with hydrophobic surfaces.

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