Biomaterial Interfaces Division
Room A120-121 - Session BI+AS+NS-MoM

Biofabrication, Bioanalytics, Biosensors, Diagnostics, Biolubrication and Wear

Moderators: Joe Baio, Oregon State University, Caitlin Howell, University of Maine

8:20am **BI+AS+NS-MoM1 Bio-inspired Peptide-polymer Hybrid Mucin Analogues: Applications in Osteoarthritis and Kidney Stone Disease**, ***Daniel L. French***, *L.A. Navarro, S. Zauscher,* Duke University

Mucins play diverse and crucial roles in the body. These functions range from lubrication of articular joints and the eye, to protection of stomach endothelium, to modulation of oral and gut microflora populations. Despite their diversity, these functions commonly stem from modifications in a general structure shared by all mucins: a blocky polypeptide backbone comprised of terminal moieties for binding surfaces or crosslinking and a characteristic glycosylated bottlebrush. Inspired by this adaptable structure, we have created a mucin analogue platform which engenders key structural features preserved among native mucins. We have emulated the mucinous bottlebrush with a lysine-rich elastin-like polypeptide backbone, which provides primary amines for conjugation of synthetic polymer "bristles." Binding modules target surfaces of interest, to facilitate intramolecular associations, or to direct surface conformation of our construct. To demonstrate the application of our platform to clinically-relevant problems, we have tailored our mucin analogues to osteoarthritis and kidney stone disease, conditions infamous for profound morbidity and high prevalence. We will demonstrate that collagen-targeted mucin analogues adsorb to model surfaces and prevent protein fouling. This recapitulates the function of lubricin, a mucin downregulated in osteoarthritis. Similarly, we will show that we can target mineral surfaces relevant in kidney stone disease by exchanging the binding module of our analogue mucins. We will show that these altered analogues also inhibit protein-fouling, which is implicated in stone growth. In this platform technology, we have been inspired by the diverse functions of native mucins. By harnessing the general structure which gives rise to these properties, we endeavor not only to replicate the in vivo function of mucins, but also to harness the properties of natural mucins and apply them to systems not naturally protected by mucinous coatings, such as inhibiting the growth of kidney stones.

8:40am **BI+AS+NS-MoM2 Investigation of the Mechanical and Dielectric Properties of Bone Scaffolds**, ***Kimberly Cook-Chennault***, Rutgers University

Despite the vast number of biomaterials and synthesis technologies available to treat bone defects and disease, few are readily employed for clinical use due in part to challenges in the development of materials that functionally mimic and facilitate the hierarchal processes of bone healing and regeneration. Calcium phosphate based bone replacement materials have been developed over the years for bioengineered bone structures due to their ability to mimic the general properties of mineralized bone. These bone replacement materials have mainly be fabricated in the form of hydroxyapatite (Hap), which can suffer from premature fracture when subjected to typical human load conditions. On the other hand, it is well known that enhanced osteobonding and bone growth results from the exposure of the bone to polarized Hap, which presents a negatively charged surface. Composite hydroxyapatite (Hap) – barium titanate scaffold materials are compared and contrasted with hydroxyapatite (Hap) samples for mechanical elastic moduli, compression strength and dielectric properties. Composite structures were observed to present better mechanical and dielectric properties when compared to HaP samples. For example, the elastic modulus of the HaP and composite samples were 2655.4 MPa and 3559.1 MPa, respectively. Understanding the interrelationship between scaffold architecture/material composition and mechano-transduction will improve our ability to realize patient specific solutions that eliminate hindrances to bone healing such as, lack of vascularization and lack of adequate mechanical stability.

9:00am **BI+AS+NS-MoM3 Bioelectronics with Graphene and Graphene-Based Hybrid-Nanomaterials – From Transparent to Fuzzy Interfaces**, ***Tzahi Cohen-Karni***, Carnegie Mellon University **INVITED**

We focus on developing a new class of nanoscale materials and novel strategies for the investigation of biological entities at multiple length scales, from the molecular level to complex cellular networks. Our highly flexible bottom-up nanomaterials synthesis capabilities allow us to form unique hybrid-nanomaterials. Recently, we have demonstrated highly-controlled synthesis of 3D out-of-plane single- to few-layer fuzzy graphene (3DFG) on a Si nanowire (SiNW) mesh template. By varying graphene growth conditions, we control the size, density, and electrical properties of the NW templated 3DFG (NT-3DFG). This flexible synthesis inspires formation of complex hybrid-nanomaterials with tailored optical and electrical properties to be used in future applications such as biosensing, and bioelectronics. Currently, we target the limits of cell-device interfaces using out-of-plane grown 3DFG, aiming at electrical recordings with subcellular resolution (<5μm). Moreover, NT-3DFG unique optical properties allows formation of remote interfaces with tissue and cells. We demonstrate photostimulation of tissue and cells by using the photothermal effect of NT-3DFG. Last, we have developed a unique transparent graphene-based electrical platform that enables concurrent electrical and optical investigation of ES-derived cardiomyocytes' intracellular processes and intercellular communication. In summary, the exceptional synthetic control and flexible assembly of nanomaterials provide powerful tools for fundamental studies and applications in life science, and open up the potential to seamlessly merge either nanomaterials-based platforms or unique nanosensor geometries and topologies with cells, fusing nonliving and living systems together.

9:40am **BI+AS+NS-MoM5 Experimental Observation of Multiple Plasmon Induced Transparency and Fano Resonance in Titanium Nitride Based Devices**, *J.D. Asencios,* ***Arturo Talledo***, *R.A. Moro, C.A. Luyo,* Facultad De Ciencias Universidad Nacional De Ingeniería, Perú

Abstract: We built three types of plasmonic structures based on titanium nitride thin films by using the technique dc magnetron sputtering and D-shaped prisms as substrates. The prisms were made of glass or sapphire. Devices with structure Prism/TiN, Prism/TiN/SiO_2 and Prism/TiN/SiO_2/Nb_2O_5 were called devices type 1, type 2 and type 3, respectively. Attenuated Total Reflection in the Kretschmann configuration was studied in the three types of devices. Experimental angular spectra were fitted by using a calculation program based on the solutions to Maxwell equations. ATR spectra of devices type 1 show a wide absorption band. The main feature for ATR spectra of devices type 2 was a series of maxima and minima of reflectance within a wide absorption band. ATR spectra of devices type 3 are identified with a very sharp window within the absorption band. The spectra of devices type 2 and type 3 were associated with the phenomena of Multiple Plasmon Induced Transparency (MPIT) and Fano Resonance, respectively. Based on calculations of the square of the electric fields in the involved media, we proposed some simple phenomenological explanations for the phenomena of MPIT and Fano resonance. Potential use of these structures as refractive-index sensors was also discussed.

10:00am **BI+AS+NS-MoM6 Breaking the Mass Resolution Limit of Shear Wave Resonators in Liquid through Integrated Microfluidic Channels**, *Z. Parlak, S. Zhao, D.L. French,* ***Stefan Zauscher***, Duke University

Acoustic shear wave resonator sensors (SWRS), e.g., quartz crystal microbalance, are widely used in applications (e.g., thin film deposition) where their high quality factor in air or vacuum provides exquisite mass resolution. SWRS are also used as biosensors in liquid environments; however, they have not yet found widespread use outside the research environment despite their simple and robust detection modality. This is because current SWRS suffer from viscous contributions to shifts in resonance frequency, which inherently leads to low mass resolution. Furthermore, current SWRS require accurate temperature control and use large liquid volumes (~ml). Together these limitations prohibit accurate and economic measurement of surface bound mass, e.g., in protein binding assays. We show through experiments and simulations that by confining fluid into small, rigid channels oriented perpendicularly to the shear direction of the SWRS, we can manipulate liquid to behave as a lossless layer and thus perform precise mass measurements of the confined liquid. Canceling viscous effects in μ-fluidic SWRS not only enhances their mass resolution in liquid to levels observed in air/vacuum, but also enables efficient device miniaturization. Combined with the extremely small volume requirements for sensing (~nL), we show that μ-fluidic SWRS can overcome current barriers for their widespread use in diagnostic sensing and point of care applications.

11:20am **BI+AS+NS-MoM10 All Inkjet Printed Biosensor for Easy and Rapid Detection of Immunoglobulin G (IgG) Protein**, ***Ridwan Fayaz Hossain***, *A.B. Kaul,* University of North Texas

Protein detection biosensors are interesting tools for detecting and measuring the levels of specific proteins in biological and environmental

samples, offering certain operational advantages over standard photometric methods, notably with respect to rapidity, ease-of-use, cost, simplicity, portability, and ease of mass manufacture. Although inkjet printed electrode based sensor is widely reported, the number of fully inkjet printed biosensors is still limited [1,2]. Here, we report the design, fabrication, and evaluation of a flexible field-effect transistor (FET) for biosensing based on the inkjet printing technique, where the insulator layer is uniquely functionalized for Immunoglobulin G (IgG) protein detection. IgG is a plasma-cell protein that is produced within the lymph nodes, spleen, bone marrow, respiratory tract mucosa, tissue, etc. Since IgG protein is produced as part of the body's response to bacteria, viruses, and tissue antigens, measurement of blood IgG levels can reveal any of the body's abnormal conditions. Until now, proteins are detected mostly by antibodies in analytical formats like ELISA, immunobead assay, western blotting, and microarrays, etc. but their performance is limited by low sensitivity. This new generation biosensor is more stable and well adapted to the conditions of real samples. The protein detection biosensor reported here represents an important starting point for the design and fabrication of flexible, rapid detection biosensing devices by inkjet printing. This work shows a promising aspect of protein detection that will pave the way for the development of a fully functional device for point-of-care diagnosis.

Reference:

[1] Jensen, G. C., Krause, C. E., Sotzing, G. A., & Rusling, J. F. (2011). Inkjet-printed gold nanoparticle electrochemical arrays on plastic. Application to immunodetection of a cancer biomarker protein. Physical Chemistry Chemical Physics, 13(11), 4888-4894.

[2] Carvajal, S., Fera, S. N., Jones, A. L., Baldo, T. A., Mosa, I. M., Rusling, J. F., & Krause, C. E. (2018). Disposable inkjet-printed electrochemical platform for detection of clinically relevant HER-2 breast cancer biomarker. Biosensors and Bioelectronics, 104, 158-162.

11:40am **BI+AS+NS-MoM11 Biosensing Applications of Silver Nanorods Array Fabricated by Glancing Angle Deposition (GLAD)***, Shashank Gahlaut,* Indian Institute of Technology Delhi, India

Silver being most widely used material due to its unique electrical and optical properties. Here we have investigated biosensing properties of silver nanorods array (AgNRs) fabricated by glancing angle deposition. GLAD grown silver nanorods are found to be highly sensitive and selective for hydrogen sulfide (H_2S) gas. Color and water wetting (contact angle) of AgNRs array are parameters affected in the presence of this gas. H_2S is one the major gaseous products evolved in bacterial metabolic process. On the basic of H_2S production, we have shown the detection of viability as well as antibiotic resistance in different strains of bacteria.

Another potential application of as synthesized AgNRs array in Surface enhanced Raman scattering (SERS) based detection. The dengue is a viral disease and a serious global health concern. About 2.5 billion of world's population has been living at the risk of dengue infection. It causes a spectrum of illness ranges from acute febrile illness called dengue fever (DF) to more severe life threatening forms dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) causing vascular leakage that may lead to death. So far, neither specific treatment nor effective vaccine available for the prevention and treatment. Therefore, early detection is the key of the survival of the patients. The earlier symptom starts with mild dengue fever, at this stage the concentration of the biomarkers are very less which pose a problem in early detection. In the present study, we have demonstrated the detection of dengue from clinical blood samples employing AgNRs array as SERS substrates with hand held Raman spectrometer. A notable change in SERS spectral signature observed in the blood of dengue infected patients in comparison to that of healthy subject. This change was further confirmed using the statistical tool principal component analysis (PCA) and the samples were differentiated as healthy, dengue positive and dengue negative. All the blood samples were also dually verified with Antigen (NS1) as well as Antibody (IgM) ELISA kit. This method provides a field deployable, rapid diagnosis of dengue at its early stage.

Author Index

Bold page numbers indicate presenter