Biomaterials Plenary Session
Room: 108 - Session BP-SuA

Challenges in Biomaterials Analysis

Moderator: L. Gamble, University of Washington

3:00pm **BP-SuA1 Wants, Needs, and Challenges in Biomedical Surface Analysis**, ***D.G. Castner***, University of Washington **INVITED**

Biomedical surface analysis has undergone significant and numerous advances in the past 30 years in terms of improved instrumentation, introduction of new techniques, development of sophisticated data analysis methods, and the increasing complexity of samples analyzed. Comprehensive analysis of surfaces and surface immobilized biomolecules (peptides, proteins, DNA, etc.) with modern surface analysis instrumentation provides an unprecedented level of detail about the immobilization process and the structure of the immobilized biomolecules. Results from x-ray photoelectron spectroscopy (XPS or ESCA), time-of-flight secondary ion mass spectrometry (ToF-SIMS), near edge x-ray absorption fine structure (NEXAFS), surface plasmon resonance (SPR) biosensing, atomic force microscopy, and sum frequency generation (SFG) vibrational spectroscopy provide important information about the attachment, orientation, conformation, etc. of biomolecules. However, even with the advances that have been achieved with these powerful surface analysis techniques, there still remains many significant challenges for biomedical surface analysis. These include characterizing the surface chemistry and structure of nanoparticles, determining the structure of protein bound to surfaces, and maintaining biomolecules and materials in a biological relevant state when using ultra-high vacuum based analysis techniques.

This talk will discuss the current challenges in biomedical surface analysis and what is being done to address them. Also discussed will be the role of well-defined standards to develop new biomedical surface analysis methods for characterizing more complex, biological relevant samples.

3:40pm **BP-SuA3 Depth Profiling and 3D Analysis of Organic Surfaces**, ***A.G. Shard***, National Physical Laboratory, UK **INVITED**

Cluster ion impacts have been shown to sputter organic materials, whilst imparting low levels of damage to the freshly exposed surface. When coupled with a surface analytical technique, such as SIMS or XPS, it is possible to generate depth profiles with truly molecular information. Concurrent 2D spectroscopic imagingenables a three dimensional reconstruction of molecular distributions. This offers enormous potential for the label-free and multiplexed imaging of biological materials and medical devices.

The mechanism of cluster ion beam sputtering has been established over the past ten years and the most important factor that permits organic depth profiling is the large sputtering yield of organic material following a cluster ion impact. This is typically of the order of 100 nm^3 of material per individual impact. However it has been shown that, for many materials, the sputtering yield changes as the cluster ion dose increases and therefore the interpretation of organic depth profiling data is, in general, not trivial. Additionally, this change in sputtering yield is often associated with sputter-induced roughening with a concurrent degradation of depth resolution. Recently, there has been a growing emphasis on the development of methods by which a wider range of materials can be depth profiled and a constant sputtering yield maintained. The most significant advances have been the use of sample cooling, low ion beam incidence angles and sample rotation. Large argon clusters appear to offer significant improvements over traditional cluster beams, such as C_{60} in these regards.

The reliability of organic depth profiling was tested recently in two VAMAS interlaboratory studies. Results from these studies highlight the rapid developments that have recently been made. The application of this technique to medical devices and biological materials will be reviewed and the remaining challenges described.

4:20pm **BP-SuA5 Nanoscale Surface Analysis of Living Cells using Atomic Force Microscopy**, ***Y.F. Dufrene***, Université catholique de Louvain, Belgium **INVITED**

The emerging new field of "live-cell nanoscopy" has revolutionized the way biologists explore the living cell to molecular resolution. Whereas far-field fluorescence nanoscopy enables to study the nanoscale localization and dynamics of biomolecules in cells, recent developments in atomic force microscopy (AFM) techniques offer unprecedented opportunities for imaging the supramolecular organization of cell surfaces, and for probing the functional properties and interactions of their molecular machineries. In the past few years, AFM-based nanoscopy has enabled key breakthroughs in cell biology, including deciphering the nanoscale architecture of cell surfaces and their remodelling upon changing the cells functional state, understanding cellular mechanics and its functional implications, quantifying cell adhesion forces contributing to processes like tissue development and bacterial infection, unravelling the molecular elasticity of cellular proteins such as sensors and adhesion molecules, and elucidating how cells reassemble membrane receptors into nanodomains and modulate their functional state. In this talk, I will provide a survey of the recent work we have done using the AFM multifunctional toolbox, emphasizing its potential for understanding cell surface properties and interactions on the nanoscale.

References

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Nat. Methods, 8 (2011), 123-127.

5:00pm **BP-SuA7 AVS 2011 Biointerphases Lecture - Tissue Engineering and Surface Science: 2D to 3D, Dry to Wet, Dead to Living and the Challenges to the Instrumentation**, ***B.D. Ratner****, University of Washington Engineered Biomaterials **INVITED**

The biointerface and related surface science ideas have had profound impact on biomaterials science since at least the 1960's. In the 21st century there is much discussion of tissue engineering, clearly a "3-D" phenomenon. This talk will review some history of the biointerface, illustrate modern trends, and show how biointerface ideas can be applied to tissue engineering and 3-D scaffolds. Techniques such as electron spectroscopy for chemical analysis (ESCA) and secondary ion mass spectrometry (SIMS) will be featured. SIMS has proven to be powerful for cell identification in culture dishes and for the analysis of decellularized extracellular matrix scaffolds. SIMS also provides much information on synthetic scaffold materials. There are now profound challenges in interpretation of complex spectra and in gleaning useful, biomedically relevant information from complex data sets. Finally, this talk will discuss healing, biointegration and regeneration, particularly in the context of new scaffolds made by a sphere-templating process.

* AVS 2011 Biointerphases Lecture

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