# Monday Afternoon, October 29, 2001

### Plasma Science Room 104 - Session PS2-MoA

#### **Plasma Modification of Organics**

Moderator: D.B. Graves, University of California at Berkeley

#### 2:00pm **PS2-MoA1 Treatment of Bone Tissue using an Inductively Coupled Plasma, C.Y.M. Maurice,** J.H.R. Feijen, E. Stoffels, G.M.W. Kroesen, Eindhoven University of Technology, The Netherlands

Nowadays, the frontiers between physics, chemistry and biology are disappearing: polymer films are deposited via plasma processes, and numerous applications for medical purposes are emerging every day. However, the actual consequences of plasma interactions with organic matter have not yet been resolved. One of the interesting plasma applications is the possibility of refined modification of bone tissue. In this work we investigate the impact of positive ions formed in a low-pressure plasma on the bone surface. The sample is subjected to controlled ion bombardment and the post treatment response is investigated using microscopy. For plasma treatment we employ a low pressure Inductively Coupled Plasma (ICP) source. This type of reactor is capable of independently control the energy and the density of the positive ions impinging on the surface. At present, it is used for selective etching of inorganic samples. To monitor the ion energy, an energy resolved mass spectrometer is placed at the plane of the sample on the bombarded electrode and records the Ion Energy Distribution Functions. A Langmuir probe gives densities and potential measurements in the bulk plasma and the DSLIF (Doppler Shifted Laser Induced Fluorescence) technique gives access to IVDFâ€<sup>™</sup>s (Ion Velocity Distribution Functions) of the plasma ions. We characterise the plasma produced ions while processing the bone samples. This kind of treatment can have a large impact on the structure of the bone surface, such as reducing micro fractures, or selectively removing cancer cells. Understanding plasma-surface interactions under vacuum conditions may be useful in the future for the design of an atmospheric plasma source for bone treatment.

2:20pm PS2-MoA2 Nitrogen Uptake Kinetics of Poly(ethylene-2,6naphthtalate) Webs in Low-Radiofrequency Nitrogen Discharges, J.M. Grace, H.K. Zhuang, L.J. Gerenser, D.R. Freeman, Eastman Kodak Company Low-radiofrequency capacitively coupled nitrogen discharges are surprisingly effective at modifying the surface chemistry of polymeric materials. Such discharges are likely to have a variety of energetic species. Furthermore, the variety of interactions that such species may have with surface atoms in the repeat unit of a polymer such as poly(ethylene-2,6naphthalate) (PEN) is considerable. Hence, it is difficult to determine the dominant surface reactions responsible for the chemical modification. Nonetheless, it is helpful to examine the nitrogen uptake kinetics and compare them with inferred species fluxes to gain insights into the surface modification process. Using optical emission spectroscopy (OES) and ion flux probe (IFP) techniques, fluxes of atomic nitrogen and ions were measured in a relative sense over a range of discharge conditions. X-ray photoelectron spectroscopy was used to measure the nitrogen content of the PEN surface as a function of exposure time at given discharge conditions. The OES and IFP data suggest that applied power primarily controls the flux of ions to the substrate, while pressure primarily controls the flux of atomic neutral nitrogen. Using a surface sites model to interpret the nitrogen uptake data it is found that ion flux, neutral atomic nitrogen flux, and their interaction contribute to the nitrogen uptake rate, with the interaction term being quite significant. This apparent ion-neutral synergy suggests a two-step nitrogen incorporation process consisting of formation of a surface radical by ion bombardment (or by some other species whose flux scales with the ion flux), followed by reaction with atomic neutral nitrogen. In addition, direct reaction of atomic ions or atomic neutrals may contribute to the nitrogen uptake rate. Using the parameters obtained from analysis of the linear uptake regime, analysis of the surface saturation regime suggests that sputtering and recombination both contribute to loss of surface nitrogen.

2:40pm **PS2-MoA3 Control of Spatial Distribution of Adsorbed Proteins Using Plasma Surfaces**, *N.A. Bullett*, University of Sheffield, U.K.; *R.D. Short*, University of Sheffield, U.K., UK; *C.W.I. Douglas*, University of Sheffield, U.K.

The adsorption of proteins occurs whenever a material contacts with biological media. In cell culture, proteins rapidly adsorb to the plastic from serum and the adsorbed protein layer subsequently influences cell adhesion, proliferation and differentiation. The ability to control and direct specific protein adsorption and conformation would enable culture surfaces to actively influence the behaviour of cells. This work aims to show that we can exert a degree over control of the adsorption and conformation of proteins from both single solution and serum. The ability to control the spatial distribution of adsorbed proteins will also be demonstrated. Plasma-co-polymerisation of acrylic acid with 1,7-octadiene was used to create a range of carboxylic acid functionalised surfaces. Protein adsorption to these surfaces was measured using an antibody recognition technique (ELISA) and radio-labelling, FITC-labelling and XPS analysis of adsorbed proteins. For single protein solutions and serum, radio-labelling, FITC-labelling and XPS showed a decrease in the amount of adsorbed protein binding with surface acid content. ELISA results would appear to show the opposite, more protein binding to the acid functionalised surfaces. This apparent contradiction in data may be explained by a change in the nature of the adsorbed proteins. Chemical micropatterns were created by the plasma polymerisation of either acrylic acid or allyl amine onto 1,7-octadiene through TEM grid masks. Imaging ToF-SIMS and XPS was used to verify the chemical differentiation in the surface. The micropatterned surface was shown to influence the adsorption and spatial distribution of FITC-labelled adsorbed proteins.

3:00pm **PS2-MoA4 Characterization of Pulsed Plasma Chemistry for the Deposition of Polyethylene Glycol-like Polymer Thin Films,** *D.C. Guerin,* Naval Research Laboratory, National Research Council; *D.D. Hinshelwood, V.A. Shamamian,* Naval Research Laboratory

We have deposited organic thin films with pulsed RF inductively coupled plasmas. We used two organic precursors, isopropyl alcohol and 1,4 dioxane, in argon. We characterized the plasmas with Langmuir probe measurements. Using in situ mass spectrometry, we identified the primary ionized species that diffuse to the surface. These species are different for the two precursors. We propose mechanisms for the creation of these species, which are primarily electron-impact dissociation ionization and ion-molecule reactions. Tuning the plasma parameters varied the mass distributions of the ionic flux to the surface. For example, at low pressure, the species due to electron-impact were predominant. We also used the mass spectrometer to measure the flux of neutral species to the surface. We determined that varying the plasma conditions has a large effect on the relative importance of ions and neutrals in the deposition process. At certain pressures and RF power levels, the flux of reactive neutrals is minor compared to the ion flux, which dominates the deposition process, X-ray photoelectron spectroscopy was performed on the samples. For isopropyl alcohol, a simple relation was discovered between the ion mass distributions and the chemical bonding character of the deposited film.

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