Plasma Science and Technology
Room 302 - Session PS+BI-TuM

Plasmas in Bioscience

Moderator: P. Favia, University of Bari, IMIP-CNR, Plasma Solution Srl, Italy

8:20am **PS+BI-TuM1 Plasma Polymerisation of Ethanethiol**, ***S.L. McArthur,*** *G. Mishra, A.G. Shard,* University of Sheffield, UK

The past years have seen significant development and use of functional polymer surfaces for bio-medical applications. Plasma polymerisation has proved to be one technique to generate functional surface in a single step process. Spontaneously reactive thiol surfaces produced by various wet chemistry routes have been extensively characterised as models to study surface-ligand interactions. This project aims to develop thiol functionalized surfaces utilizing plasma polymerisation of ethanethiol and with 1, 7 Octadiene as a diluent monomer. The deposited film properties were determined by X-Ray photoelectron spectroscopy and a fluorine marker was used to label any functional thiol groups present. It was observed that plasma polymerisation of ethanethiol at low discharge power resulted in a sulphur rich stable coatings and by increasing the power the coating resembled monomer composition in terms of atomic percentages, but none of the used conditions generated any detectable thiol groups. Mixing 1-7 Octadiene in a ratio of 1:1(v/v) in the gaseous feed resulted in an interesting change at high powers in the film properties with generation of 3-4% detectable active thiol groups without affecting the stability of the film. It is believed that the introduction of a diluent monomer at high powers has reduced the amount of available sulphur for crosslinking which dominates the deposition mechanism at low powers and has created a reaction pathway which favours the generation of thiol groups at the surfaces.

8:40am **PS+BI-TuM2 A Novel, Single-Step Method for the Preparation of Chemical Gradient Surfaces Using Non-Uniform Plasma-Deposition**, ***T.R. Gengenbach,*** *P.G. Hartley, H. Thissen, K.M. McLean, L. Meagher, G. Johnson,* CSIRO Molecular Science, Australia

Gradient surfaces are characterised by a gradual and systematic variation of one or more chemical and physical properties along a specific direction. They are of increasing importance in combinatorial chemistry and materials science where they are being used to generate libraries of widely varying surface properties to study interfacial phenomena. In biomaterials research gradient surfaces can be employed to rapidly explore multi-variable parameter space, either to investigate how relevant variables (e.g. surface chemistry, wettability, charge) affect biocompatibility, or alternatively, to accelerate the optimisation of coupling strategies for covalent attachment of secondary layers. Radio frequency glow discharge plasma polymer coatings form robust thin films which contour and adhere strongly to the surfaces of polymeric and other materials. Their ability to modify surface properties, either by enhancing biocompatibility, or by introducing defined chemical functionalities at interfaces for the subsequent coupling of bioactive molecules, have seen their widespread application in the field of biomaterials research. We have developed a novel method to deposit plasma polymer coatings with systematically varying properties along the surface. In a standard plasma reactor with capacitively coupled electrodes the substrate to be coated is placed on a large flat horizontal base electrode (earthed); the second, specially shaped top electrode (active) is lowered to within millimetres of the substrate surface. The resulting plasma discharge is spatially non-uniform and produces surfaces with a strong gradient of chemical/physical properties. By controlling the shape of the top electrode we have also prepared patterned surfaces with well defined regions of widely different properties (e.g. density of specific functional groups). These gradient surfaces have been evaluated with respect to the biological response, such as protein adsorption and cell attachment.

9:00am **PS+BI-TuM3 Mechanistic Musings on Plasma-Enhanced CVD of Polymeric Materials**, ***E.R. Fisher,*** Colorado State University **INVITED**

Plasma-enhanced chemical vapor deposition (PECVD) is a valuable technique for deposition of polymeric materials with wide ranging applications, including micropatterns for fabrication of multianalyte biosensors, diagnostic tests, DNA microchips, and genomic arrays. One ongoing issue with PECVD processes is controlling and tailoring the molecular level chemistry, both in the gas-phase and at the gas-surface interface such that predictable and reproducible film chemistries can be created. One method for controlling the overall deposition is to use pulsed, downstream or remote deposition processes. Moreover, understanding surface interactions of plasma species provides critical molecular level information about PECVD processes. The imaging of radicals interacting with surfaces (IRIS) technique examines interactions of radicals during plasma deposition using laser-induced fluorescence (LIF) to provide spatially-resolved 2D images of radical species involved in film formation. IRIS allows for direct determination of radical-surface interactions during plasma processing. IRIS data for species in plasma polymerization and plasma modification systems will be presented, along with addition film and gas-phase composition data. IRIS results that will be discussed include data on fluorocarbon radicals (CF and CF@sub 2@), main group hydrides (SiH, OH, NH, and CH), and nitrogen-containing molecules (NH, NH@sub 2@, CN) in relationship to various plasma polymerization systems of interest to the microelectronics and coating industries. Correlation of gas-phase data, surface analysis, and plasma-surface interface reactions will also be presented to provide more comprehensive mechanisms for overall plasma polymerization processes. Examples will also be provided from polymer film and fiber modification systems.

9:40am **PS+BI-TuM5 Application of Plasma Discharges in the Biomedical Field: Biological Decontamination and Sterilization of Surfaces**, ***F. Rossi,*** European Commission-Joint Research Centre, Italy **INVITED**

Every year, thousands of patients die from nosocomial infections got in hospital after surgical intervention. Those infections are directly linked to bacterial contamination of medical devices surfaces that are used during operation. Moreover, interaction of specific biomolecules like phospholipids or lipopolysaccharides (LPS) or certain proteins with organisms can be a major cause of diseases. Prominent examples are pyrogenes - lipopolysacharides (LPS) and lipoteichoic acids (LTA) -, which cause fever in human body and are potentially lethal after contact with blood. In some cases the secondary or tertiary structure of proteins is responsible for their biological properties. Important example is PrP (prion) which becomes pathogenic after a change of its structure. The contaminated surface (e.g. medical devices, accessories, work surface or tissue) cannot be decontaminated with current sterilisation practices without inducing major damage to the substrate or tissue itself, because of the high temperature used, or chemical reaction with the surface. In the present work, the inactivation or modification of biologically potentially harmful molecules is addressed in a combined approach using low pressure plasma discharges with non toxic gas mixtures. The emerging species fluxes of these plasmas are measured. Different characteristic biomolecules (LPS, LTA, proteins etc. as well as whole micro-organism cells) are exposed to the plasmas and the changes induced are monitored in-situ using infrared spectroscopy as well as ex-situ using biochemical and structural analysis as a function of the gas mixture and plasma parameters. Different potential mechanisms (etching, UV radiation, chemical reactions) are presented. The gained knowledge on the interaction of plasma discharges with pathogenic biomolecules and microorganisms allows a targeted development of decontamination strategies for very resistant species. The potential applications are in the field of surface decontamination and sterilisation of medical objects and opens large possibilities of applications in the field of security.

10:20am **PS+BI-TuM7 Biological Response to Plasma Processed Materials**, ***L.C. Lopez,*** University of Bari, Italy*; R. Gristina,* CNR-IMIP Bari, Italy*; L. Detomaso, P. Favia, R. d'Agostino,* University of Bari, Italy **INVITED**

The demand of biomedical implants significantly increases every year and several approaches have been investigated to develop surfaces which are recognized by specific proteins of the biological milieu, ranging from template materials, to surfaces that mimic receptor sites, to biologically inspired materials. Other surface modifications approaches deal, instead, with the immobilization of biomolecules (heparine, carbohydrates, peptides, enzymes, etc.) on biomedical surfaces, to induce the growth of cells, to act as sensors in immunodiagnostics or to exhibit blood compatibility. Low temperature plasma modification processes represent an appealing tool, versatile and environmental friendly, to selectively modify materials to be used for medical devices. Surface properties of biomaterials (chemical, biological, tribological) can be selectively plasma driven to achieve specific biological response, leaving the bulk features unaltered.@footnote 1@ Furthermore, a promising strategy to control the interaction between biomaterials and biological environments, applies to binding of biomolecules to plasma modified polymers by a stable bond with surface functional groups (OH, COOH, NH@sub2@, etc.).@footnote 2@ RGD-containing peptides and galactose immobilization on plasma processed substrates, recently investigated in our group, clearly highlighted a strict correlation between specific cellular behaviour and immobilised

molecules. These results plainly indicate that coupling plasma modification processes with precise biomolecules immobilization pathways may represent a successful approach to address biocompatibility and biorecognition requirements of biomaterials. @FootnoteText@ @footnote 1@ B.D. Ratner in: Plasma Processing of Polymers, R. d'Agostino, P. Favia, F. Fracassi ed., Kluwer Acad. Publ., NATO ASI Series, E: Appl. Sci., Vol. 346, 1997.@footnote 2@ L. C. Lopez, R. Gristina, G. Ceccone, F. Rossi, P. Favia, R. d'Agostino Surface and Coatings Technology, 2005, in press.

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