Plasma Science and Technology
Room 2009 - Session PS1+BI-ThM

Plasmas in Bioscience

Moderator: S.G. Walton, US Naval Research Laboratory

8:00am **PS1+BI-ThM1 Study of Plasma Modified PTFE for Biological Applications : Relationship between Non Fouling Properties - Plasma Treatment - Surface Composition and Surface Roughness**, ***N. Vandencasteele*** [1], Université Libre de Bruxelles, Belgium; *B. Nisol,* Unviersité Libre de Bruxelles, Belgium; *P. Viville, R. Lazzaroni,* Université de Mons-Hainaut, Belgium; *D.G. Castner,* University of Washington; *F. Reniers,* Unviersité Libre de Bruxelles, Belgium

Polytetrafluoroethylene was treated by oxygen or nitrogen RF low pressure plasmas. The modified samples were characterized by XPS for surface composition, contact angle for surface energy and atomic force microscopy for surface roughness. The adsorption of bovine serum albumine (BSA) was used as a probe for the (non)fouling properties and potential biological applications. Evidence for BSA adsorption was determined by the appearance or the increase of the N 1s XPS peak. PTFE modified by Nitrogen plasma shows a strong decrease of the contact angle that has previously been correlated to an increase of the nitrogen surface concentration due to grafting and to a decrease of the fluorine concentration.@footnote 1@ Further exposure to BSA leads to an increase of the N 1s signal, and to a concomitant decrease of the F 1s peak, indicating that some protein was adsorbed onto the plasma modified surface. The exposure of PTFE to an oxygen plasma leads to virtually no grafting. XPS results show that there is less than 1% of oxygen on the surface after the treatment. A strong increase in the chamber pressure was observed during the treatment, and optical emission spectrometry reveals the presence of CO, CO@sub 2@ and F in the gas phase, indicating a strong etching of the surface. Depending on the plasma power, water contact angles as high as 170 deg. could be obtained, indicating a super-hydrophobic behaviour, and new surface structures were observed by AFM. At high power, a strong increase in roughness is evidenced, together with the formation of a regular structure. According to the Cassie Baxter model, this increase of roughness is responsible for the super hydrophobic behaviour. Lower amounts of BSA adsorption were detected on high power oxygen plasma-modified PTFE samples compared to nitrogen plasma-modified PTFE samples. @FootnoteText@ @footnote 1@ N. Vandencasteele, D.H. Fairbrother, F. Reniers. Plasma processes and polymers 2, 493-500, (2005).

8:20am **PS1+BI-ThM2 Patterning of Plasma Polymers for Bioarrays**, ***G. Mishra***, *S.L. McArthur,* University of Sheffield, UK

Protein arrays are solid-phase ligand binding assay systems. They require the immobilisation of proteins on a range of surfaces which include glass, Si wafers and a range of polymers. The assays are highly parallel (multiplexed) and often miniaturised (microarrays, protein chips). Their advantages include being rapid and automatable, capable of high sensitivity, economical on reagents, and giving an abundance of data for a single experiment. Plasma polymerisation presents a versatile approach to surface modification of these devices. The range of monomers available for plasma polymerisation makes this approach even more suitable for use in systems where multiple coatings with specific properties are required for a single device. This project investigates the use of plasma polymerisation to produce arrays with a range of chemical functionalities. The ability to spatially define reactive regions is integral to the project. The challenge lies in simultaneously obtaining high spatial and chemical resolution. In this study we use a range of patterning techniques including photolithography and physical masks and compare the resultant pattern resolution and chemical functionality using XPS, ToF-SIMS and AFM. The results highlight the complexities introduced by the gas phase deposition process and the undercutting that can occur with the physical masks. The issue of compatibility of reactive plasma polymers with the photolithographic process is an important aspect under scrutiny. Our results suggest that complex multilayer layered plasma coatings can be produced without compromising chemical properties of deposits.

8:40am **PS1+BI-ThM3 Plasma Polymerized Thin Films for Tailored Interaction with Human Blood and Cells**, ***C. Oehr,*** Fraunhofer Institute for Interfacial Engineering and Biotechnology, Germany **INVITED**

Plasma Polymerization is used since for more than four decades to develop thin films for different kinds of applications. At least since the seventies of the last century application of these films is mentioned in the fields of medicine and pharmacy. Due to the fact that polymers are used to design low-weight devices and to realize different geometries very easily, the films are mainly deposited onto polymeric substrates. It is a characteristic property of plasma polymerized films to show strong adhesion onto this materials due to the creation of chemical bonding between film and substrate. Such thin layers with good adhesion, a defined amount of chemical functionalities and stability to sterilization processes are generated and fulfill the needs for medical application. The interaction of biological systems with materials can be divided in three subsystems. First, the interaction with bio-molecules. Here the binding of molecules with specific activities on one hand and the minimizing of unspecific protein adsorption on the other hand can be influenced by thin plasma polymers deposited on medical devices. Second, the interaction of bacteria can be modulated via depositing of thin films with bacteriostatic or bacteriocidic properties on devices. Third, the interaction of mammalian cells can also be influenced to enhance the cell growth and proliferation for the development of test kits or implants. In the talk examples of the first and the third category will be given. Beside the preparation of the mentioned films also the analytic tools necessary for film development and control of its properties are stressed in this contribution. A correlation between physico-chemical properties of the applied plasma polymerized films and the biological requirements will be given.

9:20am **PS1+BI-ThM5 RF(13.56MHz) Glow Discharges fed with Acrylic Acid and Allylamine vapours to obtain Functional Coatings for Biomedical Applications**, *E. Sardella,* ***P. Favia***, *L. Petrone, M. Nardulli,* University of Bari, Italy; *R. Gristina,* IMIP-CNR, Italy; *R. d'Agostino,* University of Bari, Italy

Today, a broad range of plasma processes is used to control cell adhesion and growth on biomaterials for tissue engineering and manufacturing of biomedical devices. N-@footnote 1@ and O-@footnote 2@ groups are considered very attractive because they are able to improve cell adhesion and function as "anchor" sites for biomolecules immobilization.@footnote 3@ In this work plasma deposition of acrylic acid (AA), allylamine (AAm) vapours and their plasma co-polymerization have been carried out to deposit functional coatings for several kind of biomedical applications. In particular AA/AAm co-polymerisation can provide different "anchor" sites usable for grafting biomolecules with different activities (ex. antibacterial vs. eukaryotic cell-adhesiveness) on the same substrate. Moreover, these coatings can exhibit zwitterionic characteristics in water and they may find utility in the separation of proteins from solution. A correlation between surface diagnostic analyses (XPS, WCA, FTIR) and plasma phase characterizations (AOES) allowed to provide a correlation between relative density trends of the emitting species in the plasma and the chemical-physical properties of the modified substrate. A titration with water solutions at different pH allowed picking out acid/base properties of the films that can render them very attractive both as supports for cell adhesion and as "smart"materials in drug delivery approaches. In vitro cell culturing of 3T3 fibroblast cell line, were performed to assess the ability of such kind of coatings to influence cell adhesion and growth. Acknowledgements MIUR-FIRB RBNE012B2K is gratefully acknowledged for the financial support. @FootnoteText@ @footnote 1@A. Harsch et al. Journal of neuroscience methods, 2000;98:135-144@footnote 2@Detomaso et al. Biomaterials 2005; 26-18: 3831-3841@footnote 3@D.A. Puleo et al. Biomaterials, 2002;23:2079-2087.

10:20am **PS1+BI-ThM8 Fabrication of High Density and High-Aspect Silicon Nano-column Using Neutral Beam Etching and Ferritin Iron Core Mask**, ***S. Saito***, *T. Kubota,* Tohoku University, Japan; *T. Matsui,* Matsushita Electric Industrial Co., Ltd., Japan; *Y. Uraoka, T. Fuyuki,* Nara Institute of Science and Technology, Japan; *I. Yamashita,* Matsushita Electric Industrial Co., Ltd. and Nara Institute of Science and Technology, Japan; *S. Samukawa,* Tohoku University, Japan

Semiconductor devices has been getting smaller and following Moore's Law. The design rule, the smallest line width, of these devices will be less than 50 nm nanometers within the next decade. Conventional optical lithography process has a theoretical limit to draw patterns smaller than the light wavelength and finer processing techniques are now being intensely surveyed but no methods meet the requests for mass nano-structure production. In order to breakthrough this limit, we have already

[1] **PSTD Coburn-Winters Student Award Finalist**

proposed a new method to fabricate 7 nm nano-dots using the ferritin iron-core as an etching mask and Cl neutral beam for Si etching processes. The ferritin is one of the proteins and has a spherical protein shell with a cavity of 7 nm diameter. It can biomineralize iron as hydrated iron oxide in the cavity and store it in vivo. The Cl neutral beam could realize high etching anisotropy and high etching selectivity to ferritin iron-core without any radiation damages. In this study, we also tried to fabricate higher density and high-aspect Si nanocolumn structure using high-density array of ferritin iron core. The ferritin array could be made just over thin SiO@sub 2@ film (~3nm thick) on Si substrate. In this condition, however, the diameter of Si nanocolumn was enlarged to 14 nm and the etching profile had a slight taper because of extremely low SiO@sub 2@ etching rate using Cl neutral beam. To overcome the problem, we tried two-step neutral beam etching process. For quickly etching the surface SiO@sub 2@, F neutral beam was used. After that, the bulk Si was etched with high anisotropy using Cl neutral beam. As a result, for the first time, the diameter of Si nanocolumn could be shrunk with keeping highly anisotropic etching profile even at narrow space of less than 6nm. This study was supported by Leading Project of Ministry of Education, Culture, Sports, Science and Technology.

10:40am **PS1+BI-ThM9 The Influence of Bond-Coating on Plasma Sprayed Alumina-Titania, Doped with Biologically Derived Hydroxyapatite, on Stainless Steel**, ***S. Salman***, *B. Cal, O. Gunduz,* Marmara University, Turkey*; S. Agathopoulos,* Ioannina University, Greece*; F.N. Oktar,* Marmara University, Turkey

The influence of bond-coating on the quality of thin coatings (~100 µm) of alumina-titania (60%-40%), doped with 5% and 10% bovine hydroxyapatite, plasma-spayed on stainless steel (316), was experimentally investigated by measuring the tensile strength and the ratio of adhesive/cohesive strength of the coatings. The bond-coating layer was alumina-titania (60%-40%). The experimental results (mainly the values of the ratio adhesive/cohesive strength and the microstructure of the coating layers) and their discussion in the light of earlier similar studies show that bond-coating process can result in coating composite structures of high quality, which is of high importance for devices used in biomedicine.

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