Monday, May 11

9:30 a.m. JAPT-1 Development of Adhesive-Free Lamination Technique Using a Plasma Surface Treatment at Atmospheric Pressure

M. Kogoma, Sophia University, Tokyo, Japan; A. Manabe, Fujimori Kogyo Co. Ltd., Yokohama, Japan; and K. Tanaka, Sophia University, Tokyo, Japan

Invited 40 min. Talk

The laminated polymer films are widely used for the packaging materials of foods, cosmetics and so on. These laminated films are generally two or more kinds of polymer films pasted together with an organic adhesive diluted by the toxic organic solvent. Thus, a new adhesive-free lamination technique is desired. In this study, we tried to develop an adhesive-free lamination technique using the atmospheric pressure glow (APG) plasma surface treatment and the thermo-compression of the treated super posed films. The popular lamination materials, PET/PE, NY/PE were treated by N_2 /He or He APG plasma reactor. The reactor can treat the film surfaces faster than 10 ms/cm. The adhesive strength of the laminated film was measured with a 180 degree peel tester. In the results, the maximum adhesive strength of both materials were attained much higher value (>500 N/m) than that of the required in the industry. XPS spectra in the valence band region of the treated LDPE surfaces show some decreasing of the main peak obtained around 15 eV that should be related to C-C bonds of the PE structure. We supposed that some low molecular weight PE were produced on the film surface and that they acted as an adhesive for the heat-press lamination.

Monday, May 11

10:10 a.m. JAPT-2 A Novel Atmospheric Microplasma Source with Integrated GaN HEMT Microwave Power Oscillator

R. Gesche, S. Kuehn, and H.E. Porteanu, Ferdinand-Braun-Institut, Berlin, Germany; and R. Kovacs and J. Scherer, Aurion Anlagentechnik GmbH, Hessen, Germany

A novel atmospheric microplasma source is presented where the microwave power is generated by an integrated power oscillator, which is based on a GaN HEMT transistor. A microwave resonator acts as plasma electrode, performs the impedance transformation for ignition and plasma operation and determines the oscillation frequency. The source operates at a frequency of around 2.45 GHz with a maximum oscillator power of 30 W. The size of the complete source module including electrode, resonator and microwave oscillator is as small as 30 mm by 30 mm by 40 mm, the visible afterglow plasma flame has an diameter of approx. 1 mm and a length up to 5 mm. The paper describes the concept and presents procedure and results of ignition voltage and impedance measurements. Ignition voltage of air at atmospheric pressure is found to be less than 400 V. As a first application example, we present data on surface energy enhancement. Contact angle profiles on several polymers we show shown as a function of the distance between source and polymer. Promising activation results are achieved for oxygen as well as for air (nitrogen) plasmas.

Monday, May 11

10:30 a.m. JAPT-3 Influence of Substrate to Source Distance on the Properties of Siloxane Coatings Deposited Using an Atmospheric Plasma Jet System

D.P. Dowling and M. Ardhaoui, University College Dublin, Dublin, Ireland

Atmospheric plasmas combined with liquid deposition of precursors can be used to deposit a wide range of functional coatings onto ceramic, metal and polymer substrates. In this study a TEOS precursor is nebulised into a helium plasmas formed using a PlasmaStream system. In this system the atmospheric plasma is formed between two metallic electrodes and has an operating frequency in the range 15- 25 kHz. A Teflon tube is mounted at the orifice of the applicator with length of 75 mm and diameter of 15 mm. Due to the flow of He gas, the plasma extends approximately 10 mm out from the base of this tube. The size of the plasma flame is dependent on the He flow rate and in this study it was systematically altered between 2 and 30 l/min. The silicon wafer to jet orifice distance was also changed from 1 to 10 mm and the effect of changing both of these parameters was investigated on deposited siloxane coating properties. Due to increased air mixing siloxane coatings deposited at larger substrate to nozzle distances and lower He flow rates exhibited more SiO_x rich chemistry. This was demonstrated based on XPS analysis, FTIR spectroscopy and contact angle measurements. The area of coating coverage was measured using spectroscopic ellipsometry; coating thickness was mapped across the wafer. As anticipated with increase distance from the wafer the area of coating coverage on the 6 cm diameter wafers increased, but the maximum coating thickness directly under the jet decreased.

Monday, May 11

10:50 a.m. JAPT-4 Biomedical Applications of Atmospheric Pressure Plasma

K.-D. Weltmann, Th. von Woedtke, R. Brandenburg, and J. Ehlbeck, INP Greifswald e.V., Greifswald, Germany

Progress in life sciences is increasingly caused by utilization of unrelated technologies and knowledge. Microelectronics, optics, or material sciences as well as nanotechnology, nowadays, are key technologies in modern medicine. A similar trend can be expected concerning plasma technology. Plasma medicine can be subdivided into three main components: plasma surface modification, plasma bio-decontamination, and, as the central field, therapeutic plasma application. The scientific basis of plasma medicine is a fundamental knowledge of the mechanisms of plasma interaction with living cells and tissue. In the areas of plasma surface modification and plasma bio-decontamination, plasma is used to treat surfaces and products to improve their bio-applicability or bio-performance to use it for therapeutic purposes. Whereas in these fields, both low-pressure and atmospheric pressure plasmas can be used, for direct therapeutic plasma applications only atmospheric pressure plasma sources can be used. An extremely promising field will be the plasma-based treatment of chronic wounds. A selective antimicrobial (antiseptic) activity without damaging surrounding tissue, combined with a controlled stimulation of tissue regeneration could revolutionize wound care. Other fields are the treatment of skin diseases, tissue engineering, or tumor treatment based on specific induction of apoptotic processes. Selected plasma sources will be discussed regarding possible applications in this field. Results of the treatment of cells and clinical relevant microorganisms will be presented.

Monday, May 11

11:10 a.m. JAPT-5 Chemical and Morphological Study of Atmospheric Pressure Plasma Treated Fibers and Polymer Films

D.D. Pappas and A.A. Bujanda, United States Army Research Laboratory, Aberdeen Proving Ground, MD; J.H. Yim, Department of Chemical and Biological Engineering, Drexel University, Philadelphia, PA; and K.E. Stawhecker, J.A. Orlicki, J.D. Demaree, R.E. Jensen, United States Army Research Laboratory, Aberdeen Proving Ground, MD

Invited 40 min. Talk

The recent introduction of high density atmospheric plasmas for treatment of powders, thin films, fibers and woven fabrics has overcome the large cost of the conventional low pressure (vacuum) plasma systems. The main limitations of the latter are limited throughputs and the higher capital and operation costs of vacuum equipment. Atmospheric pressure plasmas, however, offer the potential for high throughput, roll-to-roll wide web treatments due to the high species flux, inherent to atmospheric pressure operation. In this work, we present results from the surface modification of various polymer films and fibers due to the exposure to a helium-oxygen, nitrogen, and air dielectric barrier discharge (DBD), operating under atmospheric pressure. Contact angle, X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM) data, and atomic force microscopy (AFM) are presented and the dependence of the surface chemical and topological changes on the discharge parameters such as treatment time and gas composition is investigated. Experimental results reveal improved hydrophilicity of the plasma exposed polymers and an increase of their surface energy. This can be attributed to the surface functionalization during plasma treatment, as confirmed by XPS analysis. SEM and AFM data show changes in the surface morphology and roughness depending on the plasma processing conditions, suggesting that mild etching occurs in a controlled fashion. The above observations indicate that the plasma treatment leads to an improvement of the surface properties such as wettability and adhesion and can be therefore used in a variety of applications. Standard lap-shear evaluations reveal that plasma treatments lead to significant increases in the bond strength of polymer films and resins. Most importantly, this uniform modification occurs within a few seconds of exposure, time comparable to continuous on-line industrial processing.

Monday, May 11

11:50 a.m. JAPT-6 Large Area SiO_2 Films Deposition by Atmospheric Pressure Plasma Enhanced Chemical Vapour Deposition (AP-PECVD): Growth Mechanisms by Surface Characterization

P.A. Premkumar and S. Starostin, Eindhoven University of Technology, Eindhoven, The Netherlands; H. de Vries and R. Paffen, FUJIFILM Manufacturing Europe B.V., Tilberg, The Netherlands; and M.C.M van de Sanden and M. Creatore, Eindhoven University of Technology, Eindhoven, The Netherlands

Smooth, homogeneous and transparent SiO_2 layers deposited on wide area polymers are receiving much attention in packaging industries as well as in the field of encapsulation of flexible electronics. This layer deposited in AP-PECVD, using dielectric barrier discharge, is considered as a promising technology due to its economical and ecological advantages. The control on the layer properties requires a deep understanding of the plasma physics and film growth mechanisms. This work reports the predominant growth processes involved in AP-PECVD and their contribution to the quality of SiO_2 over polymeric substrates fed with Ar-N_2-O_2-hexamethyldisiloxane (HMDSO) mixtures in a roll-to-roll configuration. Detailed surface analysis on films (thickness, composition, morphology, roughness and homogeneity) grown under static and web roll conditions with various gas flow directionalities unraveled the different stages of growth involved in the deposition of smooth and uniform layers, as being controlled by the diffusive flux of HMDSO radicals generated in the plasma as well as by the surface modification of the polymer substrate by the reactive species (O, OH). The negligible influence of morphology and roughness with film thickness (up to 300 nm) and comparable to that of uncoated polymer indicates the SiO_2 growth follows the topology of the substrate.