Thursday, May 14

8:30 a.m. W-15 Efficacy of Flexible Moisture Barrier Films Produced Using a Roll-to-Roll Coater as Measured by the Calcium Test

S. Louch, Centre for Process Innovation, Redcar, United Kingdom; M. Hodgson, Dupont Teijin Films, Middlesbrough, United Kingdom; and S. Edge and K. Luxmore, Centre for Process Innovation, Redcar, United Kingdom

Until recently, flexible barrier films implied films for food or medical packaging with oxygen transmission rates (OTR) and water vapour transmission rates (WVTR) down to ~$10^{-1}$ cc/m$^2$/day and ~$10^{-2}$ g/m$^2$/day, respectively. However, since the discovery of organic semiconductors, with their inherently flexible nature, a plastic electronics revolution is imminent. In order for this to be realised, suitable substrate materials (with gas barrier performance similar to glass) and processing technologies must be developed. For example, it is often quoted that the moisture barrier performance required of polymer based substrates for organic light emitting diode (OLED) devices is of the order $10^{-6}$ g/m$^2$/day. The work presented here will explore what this level of barrier really means and, if it is achievable using roll-to-roll vacuum coating of polymer based substrates. In addition, the calcium test, a methodology for measuring WVTR barrier performance at these low levels of moisture permeation will be discussed in some detail, and results presented.

Thursday, May 14

8:50 a.m. W-16 All-in-Vacuum Deposited Transparent Multilayer Barriers on Polymer Substrates

J. Fahlteich, Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Dresden, Germany

To meet the high water vapour and oxygen permeation barrier requirements of flexible electronic devices many groups suggest multilayer stacks. We have developed a concept for roll-to-roll all-in-vacuum production of multilayer barrier stacks. It is based on the combination of reactively sputtered layers with an interlayer grown by Magnetron-PECVD. Magnetron-PECVD is a novel technology that allows the deposition of both silicon-oxide like and polymer like layers using a dual magnetron system. The combination of reactive sputtering and Magnetron-PECVD has been installed in a pilot-scale roll-to-roll coating unit. Process parameters like long term stability of both processes and their combination are characterized as well as coating uniformity. Also the single and multilayer permeation barriers are characterized regarding their barrier properties against water vapour and oxygen permeation. The multilayer concept also allows the deposition of multifunctional layer stacks. An example of a combination of barrier layers and TCOs will be shown.
9:10 a.m. W-17 Study of High Gas Barrier Performance of Film with Coated SiO\textsubscript{x}N\textsubscript{y} Layers

H. Yanagihara, Mitsubishi Plastics, Nagahama, Japan; C. Ookawara and S. Yoshida, Mitsubishi Plastics, Inc., Ibaraki, Japan; and K. Ohdaira and H. Matsumura, Japan Advanced Institute of Science and Technology, Ishikawa, Japan

Recently, a film with high gas-barrier performance for penetration of oxygen and water vapor has been strongly expected in the food packaging and the coating of electronic devices. In order to get high gas barrier performance, we have tried to coat SiO\textsubscript{x}N\textsubscript{y} layers on film by catalytic CVD (Cat-CVD). Cat-CVD is a method to make thin film by decomposing gas molecules on heated surface of catalyzer using catalytic cracking reactions and transporting them to cooled substrates. In this study, the water vapor transmission rate (WVTR) of SiN\textsubscript{x}/SiO\textsubscript{x}N\textsubscript{y} double-layer coated film showed one order superior to that of monolayer coated samples with same thickness. We will show some WVTR results mainly of samples produced by Cat-CVD, and also show measurements and other approach.

9:30 a.m. W-18 High Rate Roll-to-Roll Deposition of ALD Thin Films on Flexible Substrates

E. Dickey and W. Barrow, Lotus Applied Technology LLC, Hillsboro, OR

Thin, transparent, dielectric barrier films were deposited on plastic web in a roll-to-roll configuration using a novel approach to Atomic Layer Deposition (ALD). The films were deposited in a roll-to-roll coater prototype in which web is transported multiple times through different precursor zones separated by slit valves. Pulsing of precursors as used in conventional ALD processes was eliminated. This resulted in very high deposition rates by eliminating the pulse and purge times. Furthermore, since different precursors were isolated from each other at all times except for the monolayer chemisorbed on the web, there was no film deposition anywhere except on the web itself. Water Vapor Transmission Rate (WVTR) data are provided showing barrier film performance as a function of film thickness for titanium dioxide films on PET. The prototype tool is described. Process parameters, including web translation speed, deposition temperature and pressure are provided. Based on these data, it is demonstrated that this technique can deposit roll-to-roll films utilizing an ALD process at extremely high rates.
Thursday, May 14

9:50 a.m. W-19 Innovative Transparent Barrier for Packaging

S. Guenther, S. Straach, and N. Schiller, Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Dresden, Germany

The trend towards transparent barrier coatings for flexible packaging gains momentum. Product visibility is a powerful marketing tool. Vacuum coated transparent barrier film has been pushed forward during the last years mainly by electron beam evaporation technology with equipment installations in Japan and Europe. But as the investment cost for electron beam web coaters is high, and also as most metallizing companies are not familiar with this process, the number of running electron beam web coaters, compared to the number of Al metallizers using boats, is low. To use this basic technology of standard Al evaporation from boats also for the production of transparent barrier layers was a dream for many years. In the presentation, a new development will be described. Based on the combination of an innovative plasma-technology with standard Al evaporation from boats, transparent barrier coatings with outstanding barrier performance and optical clarity on BOPP, PET and PLA films have been achieved. A close cooperation between an equipment manufacturer, an R&D institute, and a BOPP film producer, all three partners, being leaders in their fields, have boosted this innovative development. An adapted production machine has been manufactured by Applied Materials and upscaling of this technology to production level was done in close cooperation between those involved. A first production machine using this process has been in operation since 2008 on a customer’s site.

Thursday, May 14

10:30 a.m. W-20 Polymer Nanofilms from a Topochemical Deposition/Polymerization Process

J. Lauterbach, Department of Chemical Engineering, University of Delaware, Newark, DE

Invited 40 min. Talk

Current polymer thin-film formation techniques give adequate film properties for the specific polymer systems and applications for which they were designed. However, they all have deficiencies that restrict their use in applications beyond those for which they were developed. Our deposition/polymerization (DP) process is a two step method to create polymer nanofilms through topochemical polymerization. First, monomer is dosed onto a sample at low temperatures in vacuum. UV radiation is then used to initiate polymerization. Using this process, the polymer films have controllable thickness in the nanometer region. As a result of the monomer being dosed onto a surface at low temperatures, the diffusion of monomer in the film is restricted. This inability of the monomer to diffuse allows for construction of complex monomer film structures, such as stacked layers. The monomers also interact when dosed as a mixture. The ability to create such mixtures allows for the use of photoinitiators and the creation of copolymers. One important characteristic of the DP process is the ability to polymerize molecules previously thought unpolymerizable. Normally, 1,2-disubstituted ethylenes are unable to polymerize because the rate of radical termination is much faster than radical propagation. In the DP process, however, high molecular weight polymers were produced.
Thursday, May 14

11:10 a.m. W-21 Plasma Enhanced Chemical Vapor Deposition (PECVD) on Web Using Novel Linear, High Density Plasma Source

M.A. George, H. Chandra, P. Morse, L. Birch, and J. Madocks, General Plasma, Inc., Tucson, AZ

General Plasma has invented a novel source technology that enables large area plasma enhanced chemical vapor deposition (PECVD) for continuous processes such as web coating. The novel source has advantages over conventional PECVD, such as no electrode coating, high precursor dissociation and no powder formation. The PBSTM deposition rates are also admirable; for examples SiO$_2$ at > 1000 nm-m/min and SiN at > 200 nm-m/min. This paper reviews the historical progress of the new technology and presents the latest results. Films deposited by the source include hard coatings on plastics (SiO$_2$), barrier films (SiC, SiN), transparent conducting oxide (SnO$_2$), anti-reflection layers (ZnO, FeO, SiN, TiO$_2$) and active layer passivation in solar cells (SiN). Property and characterization results for these films are discussed.

Thursday, May 14

11:30 a.m. W-22 Chemistry of Powder Formation in SiO$_x$ Deposition Plasmas

M. Rieci, J.L. Dorier, and Ch. Hollenstein, École Polytechnique Fédérale de Lausanne (EPFL); and P. Fayet, Tetra Pak (Suisse) SA, Romont, Switzerland

The plasma enhanced chemical vapor deposition (PECVD) process for coating polymer films has several advantages over evaporation processes. A disadvantage of PECVD is the relatively low deposition rate which limits the line speed. The deposition rate could be increased by reducing powder formation and by an optimized use of the monomer while keeping excellent barrier characteristics. In particular, the powder formation in SiO$_x$ deposition plasmas is far from being understood compared to other PECVD processes. The plasma chemistry during powder formation has been investigated in a small capacitively coupled RF reactor equipped with advanced plasma and powder diagnostics. In particular time resolved in situ Fourier Transform Infrared Absorption Spectroscopy has been applied to elucidate the formation of the nanometer sized particles. Several different monomers for SiO$_x$ deposition, such as HMDSO, HMDSN and TMS, with various amount of oxygen admixture, have been studied. In a first phase, the chemical nature of the organosilicon compound is important, since the nucleation of the particle is induced by polymerization of the highly reactive fragments of the monomer in the plasma. In a second phase the particle size increases due to SiO$_x$ accretion which depends strongly on the oxygen content in the plasma. These results indicate the importance of the chemistry of the monomer in the nucleation phase of the particle in these reactive plasmas.
The use of optical density is key for many products in many industries. It is one of the primary measurement techniques for the determination of how thick the aluminum is on the substrate. While we in industry always hope that our Optical Density (OD) sensor never breaks, the reality is that everything will eventually fail, including your optical density sensor. While repairing a key instrument is always a priority, it may take several days depending on the type or extent of the damage. In this case, it may not be economically feasible to shutdown the machine until the sensor is repaired. How, though, can one be fairly assured to the aluminum thickness on the web over time without a sensor? The purpose of this presentation is to demonstrate how one can effectively forego the use of an OD sensor for a period of time. This presentation will go through the regression analysis by investigating the metrics chosen, the rational for choosing them, the regression models explored, and the implementation of that model.