On the Deposition Mechanism of the Silica Like Films in Atmospheric Pressure Glow Discharge

Citation for published version (APA):

Document status and date:
Published: 01/01/2009

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
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contained in the exhaust gas, and formed by plasma activation, was performed by gas chromatography coupled with mass spectrometry (GC-MS). The influence of feed composition, in terms of chemical structure of the organosilicon compound and of the oxygen-to-monomer feed ratio, on the properties of the films as well as on monomer depletion and by-products concentration, was investigated.

Results show that in the absence of O₂, polymer-like coatings are deposited. Oxygen addition to the feed leads to a decrease of the carbon content of the film which is more evident when the number of methyl groups in the monomer is lower. GC-MS analyses allowed to appreciate that many linear and cyclic compounds, containing up to five silicon atoms, are formed in the plasma. As an example, in the case of HMDSO, the presence of species containing the dimethylsiloxane (-Me₂SiO-) repeating unit appears to be indicative of oligomerization processes (e.g. chain propagation, ring formation, and expansion reactions) which bring to linear and cyclic compounds with general formulas Me₂(SiO)ₙMe₃ (n = 1-4) and (Me₂SiO)ₙMe₃ (n = 3-4), respectively. The extent of this process, not dependent significantly on the feed composition even if the O₂:HMDSO feed ratio is varied in a wide range (i.e. 0-25). However, O₂ addition influences the quantitatively distribution of by-products.

The results allow to support hypotheses on the nature of films precursors as well as to clarify some aspects of the overall deposition mechanism and of plasma-surface interaction.

8:40am PS2-TuM3 Atmospheric Pressure Plasma Enhanced Chemical Vapor Deposition by Homogeneous Dielectric Barrier Discharge. N. Ghenassia, L. M. El Ouad, L. Enache, C. Sarrs-Bournet, N. Naudé, H. Caquieune, LAPLACE - CNRS - Université de Toulouse, France, F. Massines, Promes - CNRS, France. INVITED

Low pressure plasma enhanced chemical vapor deposition (LP-PECVD) is widely used in the industry since it allows obtaining thin films without any substantial temperature increase. On the other hand, these last years, there has been an increasing interest in atmospheric pressure PECVD (AP-PECVD) since it can lead to an appreciable cost reduction. The potential cost saving is related to the suppression of the vacuum equipment and to the on-line processing capability.

In case of two dimensional materials such as rolls of thin polymer films, metal foils or glass plates, dielectric barrier discharge (DBD) appears as one of the most suitable discharges because it is a cold discharge, which is robust, and not disturbed by the motion of the substrate. DBDs normally operate in an oscillatory mode, but it is now well-known that depending on the gas, electrical parameters, and electrode configuration, DBDs can also operate in homogeneous modes. Depending on the gas in which they are ignited, these homogeneous DBDs generally present different features. In the rare gases (helium, argon, neon...) they are known as atmospheric pressure glow discharges (APGD) as they are characterized by high current densities and an electric field profile between the electrodes showing the cathode sheath, a negative glow, a dark space and a positive column. In nitrogen, they are called atmospheric pressure Townsend discharge (APTD) as they show lower current densities and a constant high field in between the electrodes.

If AP-PECVD can be achieved using filamentary discharges, the filamentary and statistical nature of this regime helps most of the time to a lack of control of the thin film quality, deposition rate and coating uniformity on large surface. Hence this paper focuses on an AP-PECVD process using homogeneous DBDs.

More specifically, we report here on the deposition of silicon based thin films using homogeneous DBDs working at atmospheric pressure, from hexamethyldisiloxane (HMDSO) diluted either in N₂ or in He, with or without small admixture of nitrous oxide (N₂O) as the oxidizing gas. Our approach consists in studying the thin film properties as a function of the discharge type (APGD or APTD) and N₂O content in the gas phase, using various surface analysis techniques: ellipsometry, profilometry, scanning electron microscopy, Fourier-transform infrared spectroscopy and X-ray photoelectron spectroscopy (XPS). The gas phase is characterized mainly through optical emission spectroscopy. Results obtained either without motion of the substrate or in a roll-to-roll configuration are discussed, showing the capability of AP-PECVD to realize multilayers.

9:20am PS2-TuM5 On the Deposition Mechanism of the Silica Like Films in Atmospheric Pressure Glow Discharge. S.A. Starostin, Eindhoven Univ. of Technology, The Netherlands, A.P. Prekurnak, Materials Innovation Institute (M2i), The Netherlands, M. Creatore, Eindhoven Univ. of Technology, The Netherlands, H. de Vries, R.M.J. Paffen, FUJIFILM Manufacturing Europe BV, The Netherlands, M.C.M. van de Sanden, Eindhoven Univ. of Technology, The Netherlands. Atmospheric pressure plasma enhanced thin film deposition (PECVD) is nowadays in focus of increasing scientific and industrial interest. The benefits of this newly emerging technology are in possibilities for cost-efficient in-line roll-to-roll production without expensive and cumbersome vacuum equipment. Yet, comparing to the well studied low pressure PECVD, there is a serious lack of insights on thin film deposition mechanisms on the moving substrates at high pressure.

In this contribution we present a study of the deposition process of silica-like films in the diffuse high power variety of the dielectric barrier discharge referred as atmospheric pressure glow discharge (APGD) [1, 2]. This process is capable to produce uniform carbon-free silica-like films on the polymeric webs in low cost gas mixtures [2]. Considering deposition mechanisms in a roll-to-roll atmospheric PECVD reactor with a moving polymer substrate and gas flow, three different pathways which are simultaneously contributing to the film formation can be identified: a) ionic deposition, where ionized products of the decomposed precursor drift in the electric field towards the surface; b) diffusive deposition of neutral radicals produced in plasma and afterglow phases and c) deposition of large particles or dust. Due to the gas flow and depletion of the precursor, each of these pathways is characterized by a spatial distribution of ion concentration, morphology and location within the discharge area. In this contribution we will address the influence of the different mechanisms on film deposition, supported by space-resolved spectroscopic ellipsometry, XPS, SEM and water contact angle measurements. The experimental profiles of the deposition rate along the gas flow were analyzed with a 2D numerical convection-diffusion deposition model.


Tuesday Morning, November 10, 2009

* PSTD Coburn-Winters Student Award Finalist