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

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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 formulars Me₄SiOₓSiMe₄ (n = 1–4) and (Me₃SiO)ₓ (n = 3–6) respectively. The extent of these reactions, particularly characterized by high current densities and an electric field profile between the electrodes, not depend significantly on the feed composition even if the O₂-to-HMDSO feed ratio is varied in a wide range (i.e. 0-25). However, O₂ addition influences the quanti-quantitative 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. Ghebre, L. 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, 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 the usual filamentary 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 a cathode, a negative glow, a Faraday 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 leads 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 precisely, 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.


Atmospheric dielectric barrier plasma glow-like discharges over 1 meter in length and 500 square centimeters in area have been generated in air with a custom high voltage driving source. Pulse peak currents well in excess of 1 kiloampere at atmospheric pressure with total charge transfer up to 90 microcoulombs have been repeatedly generated in homogeneous discharges at frequencies up to 100 hertz. A rapid voltage rise time at 20-30kV is readily achieved by the source and is sufficient to produce a voltage across the electrodes in excess of the DC breakdown voltage prior to the onset of breakdown. The overvoltage condition plays an important role in determining the uniformity of the plasma discharge. Electrical modeling of the discharge characteristics show the resistivity of the plasma to change over the course of an individual pulse causing the discharge characteristics to switch from an oscillatory state to a critically damped state. Charge transfer and power densities in dielectric barrier discharge are limited by the electrode size and the intrinsic material properties of the dielectric used to define the plasma characteristic. It will be shown that the charge transfer of each pulse scales proportionally with the size of the electrodes for a given dielectric as should be expected for a complete homogeneous discharge. This paper will emphasize the correlation between overvoltage conditions, dielectric material properties, and electrode size to the electrical charge transfer of the glow-like discharge. The impact of the charge transfer scaling behavior on the scaling of other critical parameters like current density will also be discussed.

10:40am PS2-TuM9 Optical Emission Spectroscopy of an Argon DC Microdischarge: Electron Density and Gas Temperature Profiles. S.G. Belostotsky*, T. Ouk, V.M. Donnelly, D.J. Economou, University of Houston, N. Sadeghi, Université Joseph Fourier de Grenoble, France

Optical Emission Spectroscopy was employed to study a high pressure (100s of Torr) DC microdischarge in argon, with traces of N₂ and H₂ present and acting as optical tracers. Spatially resolved measurements of gas temperature across the 600 µm slot-type discharge were obtained from analysis of the rotational structure of two transitions of the first positive band of N₂; B'Π(v=4) → A'Σ⁺(v=1) and B'Π(v=5) → A'Σ⁺(v=2). Gas temperature profiles peaked at the cathode side of the discharge and slowly decreased towards the anode. Such behavior is consistent with the physics of DC discharges, where most of the power dissipation occurs in the cathode layer. The gas temperature increased with increasing current, reaching a maximum of Tₑ = 1200 K at I ≈ 30 mA and P = 600 Torr. Electron densities were extracted from the spectral profile of the H₂ line. The profile was fit with a Voigt function, which included Doppler, pressure, instrumental and Stark broadening. The electron density was estimated from the contribution of Stark broadening. The spatial profile of electron density...