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Plasma monitoring of a hollow cathode activated PECVD process

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Plasma-enhanced chemical vapor deposition (PECVD) is widely used for the deposition of thin films for a variety of applications. Radio-frequency or microwave plasmas are commonly used plasma sources to deposit e.g. silicon nitride, silicon oxide or plasma-polymer coatings using silicon-organic precursors. These plasma sources are, however, often rather limited by their scalability and deposition rates being usually below 400 nm*(m/min) in a dynamic roll-to-roll process.
In this paper, a novel high rate PECVD process based on a hollow cathode arc discharge (arcPECVD) is used to deposit $SiO_xC_yH_z$ plasma-polymer layers on a polymer substrate by evaporating hexamethyldisiloxane (HMDSO)in a reactive oxygen plasma. This process allows for deposition rates up to 3000nm*(m/min) in a dynamic roll-to-roll deposition. However, there is still little understanding on the fundamental chemical reactions as well as ionization and plasma-physical properties during PECVD deposition using the hollow cathode arc plasma. During the deposition, optical emission spectroscopy and mass spectrometry are used to monitor the plasma. Both techniques have the advantage that they are non-invasive and can be used to characterize the plasma without disturbing the deposition process. The dissociation of the HMDSO is determined in dependence of the plasma power, the monomer flow and the oxygen flow. Afterward, the deposited thin films are analyzed using scanning electron microscopy (SEM), x-ray photoelectron spectroscopy (XPS) and X-ray reflectometry (XRR) to determine the relationship between the thin film properties and the fragmentation of the monomer in the plasma.
It was found that with low plasma power, large fragments of the HMDSO are still present in the reactive plasma. Consequently, the layers exhibit a high carbon concentration. However, above a critical plasma power, no large fragments are observed any more. This results in a lower carbon concentration and an increase of the mass density of the deposited films.

Keywords
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X-Ray Reflectivity