ORC103

Plasma polymerization from Ar-HMDSO mixtures by single-filament dielectric-barrier discharges

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Hexamethyldisiloxane (HMDSO) has been used for plasma deposition of organosilicon thin films for several decades. Plasma polymerization from single-filament dielectric-barrier discharges (SF-DBDs) may be used to test and advance models of the deposition process and to develop new deposition methods. In the present study Ar-diluted HMDSO is used to deposit thin films from SF-DBDs between a tip electrode, covered by a plane dielectric, and silicon wafer pieces serving as substrates. Owing to the dominance of Penning ionization for HMDSO fractions larger than $x \approx 10$ ppm, discharge durations are in the microsecond range and relatively wide truncated-cone-shaped microdischarges are visible with diameters of several millimeters close to the dielectric and typically 1 mm near the Si substrate. Thickness distributions and IR spectra of the deposits are measured using an FTIR microscope. For average cross-flow gas velocities $v_{av} \geq 100$ cm/s, nearly circular-symmetric bell-shaped deposits with widths of the order of the filament diameter are obtained. We attribute this observation to the rapid drift and deposition of ions such as $(CH_3)_3Si\text{-}O\text{-}Si(CH_3)_2^+$, formed by about 30 % of reactions between energetic Ar species and HMDSO, while neutral products of these reactions are carried away by the gas stream without being deposited. It is found that the deposition profiles are virtually not affected by the gas flow. FTIR spectra show characteristic differences with respect to typical spectra of plasma-polymerized (pp) HMDSO films deposited from DBDs with extended electrodes. These differences consist of e.g. a shift of the ν_{as}(Si-O-Si) mode to short wavenumbers even below 1000 cm^{-1}, and a pronounced band from 2120 to 2130 cm^{-1} due to the $\nu(Si\text{-}H_x)$ mode. These features are generally observed in low-pressure pp-HMDSO spectra, but absent in spectra of pp-HMDSO deposited at 1 bar.

Keywords
DBD
Single-filament
HMDSO
Plasma polymerization