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Correlation between chemical structure and functional properties of as-deposited and annealed organosilicon plasma polymers

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Organosiloxane and organosilizane films were deposited in capacitively coupled radio-frequency discharges (pressure 1-40 Pa) using hexamethyldisiloxane (HMDSO) and hexamethyldisilazane (HMDSZ) monomers, respectively. Different chemical structure of the films was achieved by changing the percentage of the monomer in the gas mixture. The organosiloxane films were prepared from HMDSO/O2 varying the rf power (and simultaneously dc self-bias) and the HMDSO concentration from 5 to 100%. The organosilazane films were prepared from HMDSZ/N2/CH4 mixture varying the percentage of HMDSZ and CH4. The chemical structure of all the films was investigated by FTIR. The information about chemical bonds was accomplished by ion beam analyses (RBS and ERDA) of the film compositions. The optical properties, i.e. refractive index and extinction coefficient, in the UV/VIS/NIR range were determined by fitting the reflectance and ellipsometric measurements. The film hardness, elastic modulus and fraction toughness were obtained from depth sensing indentations. Selected films were annealed in vacuum in order to study the thermal stability of film structure and functional properties. The films deposited from HMDSO/O2 had the hardness above 6 GPa when deposited under bombardment of energetic ions obtained at high dc self-bias, i.e. higher rf power, regardless the HMDSO concentration. The structure of these films contained less Si-(CH3)x groups when compared with the films deposited at the same HMDSO concentration but lower bias. Different organic character of the films was reflected in their optical properties. The inorganic films deposited at the low HMDSO concentrations had optical properties similar to silicon dioxide and increased HMDSO percentage led to increased refractive index and absorption in UV. However, the films from HMDSZ offered better possibility for the deposition of transparent coatings protecting against UV radiation due to steeper onset of absorption at about 350 nm.

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