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Characteristics of Plasma Polymer Thin Films for Low-dielectric Application

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This study investigated the interaction of varied plasma power with ultralow-k toluene-tetraethoxysilane (TEOS) hybrid plasma polymer thin films, as well as changing electrical and mechanical properties. The hybrid thin films were deposited on silicon(100) substrates by plasma enhanced chemical vapor deposition (PECVD) system. Toluene and tetraethoxysilane were utilized as organic and inorganic precursors. In order to compare the electrical and the mechanical properties, we grew the hybrid thin films under various conditions such as rf power of plasma, bubbling ratio of TEOS to toluene, and post annealing temperature. The hybrid plasma polymer thin films were characterized by Fourier transform infrared (FT-IR) spectroscopy, atomic force microscopy (AFM), nanoindenter, I-V curves, and capacitance. Also, the hybrid thin films were analyzed by using ellipsometry. The refractive indices varied with the RF power, the bubbling ratio of TEOS to toluene, and the annealing temperature. To analyze their trends of electrical and mechanical properties, the thin films were grown under conditions of various rf powers. The IR spectra showed them to have completely different chemical functionalities from the liquid toluene and TEOS precursors. Also, The SiO peak intensity increased with increasing TEOS bubbling ratio, and the -OH and the CO peak intensities decreased with increasing annealing temperature. The AFM images showed changing of surface roughness that depended on different deposition rf powers. An nanoindenter was used to measure the hardness and Young' modulus and showed that both these values increased as the deposition RF power increased; these values also changed with the bubbling ratio of TEOS to toluene and with the annealing temperature. From the field emission scanning electron microscopy (FE-SEM) results, the thickness of the thin films was determined before and after the annealing, with the thickness shrinkage (%) being measured by using SEM cross-sectional images.