Characterization of advanced k1.9, 2.0 and 2.2 ultra-porous SiOC(H) films deposited by Plasma-Enhanced Chemical Vapor Deposition

The semiconductor industry has spent a significant effort in order to engineer ultra-porous low-κ inter-level dielectrics which can withstand the plasma and mechanical damages induced during the interconnect integration scheme. Obtaining an integrated dielectric constant below 2.6 has turned out to be challenging. Additionally, the synthesis of integration-suitable low-k films with dielectric constant around and below 2.3 through plasma-enhanced chemical vapor deposition (PE-CVD) was considered to be unattainable.

In the present work, we consider new PE-CVD ultra-low-κ SiCHO films with pristine κ values as low as 2.2, 2.0 and 1.9. The chemical composition of the films was investigated with Fourier transform infrared (FTIR) spectroscopy. The spectra indicate hydrophobic films. Additionally, the surface water contact angle of each film was found to be higher than 100°. As a result, the films were not modified by dilute HF treatment for dipping time longer than 5 minutes, showing a good chemical stability. Ellipsometric porosimetry measurements showed a correlation between larger pore size and increased porosity, indicating porogen agglomeration. Together with the low refractive indices, comprised in the range between 1.22 and 1.26, it is important to note that the ellipsometric fitting resulted in non-zero extinction coefficients, indicating the possible presence of sp^2 C, which could be correlated with the presence of residual porogen in the films. Absorption in the UV region gives a better insight on the presence or absence of sp^2 C. Therefore, spectroscopic ellipsometric measurements were performed in the wavelength range between 150 and 900 nm. Finally, the dielectric constants were determined from the capacitance values observed for metal-insulator-semiconductor (MIS) structures.