# Effects of Plasma Damage on Low-k Film Surface Properties and Moisture Adsorption

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Plasma etch/ash processes can induce changes in low-k film surface/bulk chemistries and topographies resulting in increased water absorption, surface roughness, and metal intrusion. In this work, we describe the effects of plasma damage on the surface roughness and chemistries of two porous low-k dielectrics (i.e., spin-on and CVD) and detail the use of deuterium oxide as means of measuring moisture penetration into low-k films. Preventing plasma processes from making a low-k film susceptible to water adsorption has been a subject of considerable interest. The origin of the moisture can be difficult to determine (i.e., downstream cleans or ambient environments). Deuterium oxide has a distinctly different infrared adsorption spectrum than water, but has very similar physical properties to water under ambient conditions. Consequently, the adsorption of deuterium oxide can be used as a marker for moisture uptake. A number of factors contribute to moisture adsorption: film hydrophobicity (or lack thereof), surface roughness, porosity, and pore size. Plasma processes can significantly affect each of these characteristics; however, different ashes impact differently. To study the diffusion and reactions of aqueous and moisture moieties in a porous low-k, unashed and ashed low-k (k~2.3) films have been exposed to $D_2O$ liquid and vapor treatments under "dry" nitrogen. The extent of $D_2O$ uptake, removal and exchange reactions has been studied using FTIR methods because the $D_2O$ and O-D adsorption peaks are distinct from water and O-H as well as other low-k adsorptions. The CVD low-k film is considerably less rough then the spin-on low-k, but both are roughened during plasma exposure. FTIR spectra of unashed low-k films show some $D_2O$ adsorption, but no O-D adsorptions. Spin-on hydrogen-ashed films appear to have both deuterium oxide and O-D peaks. Further, $D_2O$ adsorption appears to be considerably higher for ashed films as would be expected due to the hydrophobicity of these films. The ashed CVD films appear to adsorb less $D_2O$ than the spin-on films, but the level of adsorption is dependent on the ashing conditions. The use of $D_2O$ permits the introduction of a chemical "marker" into low-k wet and ambient processes allowing one to distinguish among adsorptions from different aqueous sources.