SEALING OF POROUS LOW-*k* DIELECTRICS DURING PLASMA ETCHING WITH H_2 PLASMA CLEANING*

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In order to reduce the RC time delay in integrated circuits, porous dielectric materials are used to lower the capacitance of the interconnect wiring insulation. Typical pore sizes are up to many nm with porosity of up to 50%. The *low-k* materials are typically SiOCH – silicon dioxide with carbon groups, principally CH_3, lining the pores. The pores are open to the surface and internally connected, and so can offer pathways for reactive species to enter into the porous network. Reactions which remove CH_x groups can increase the *k* value of the material. To maintain the low-*k* value of the dielectric, sealing of the surface pores is desired.

Treatment of the porous material with successive He and NH_3 plasmas has been successful in sealing the pores[1]. This usually occurs after a fluorocarbon plasma, such as a $Ar/C_4F_8/O_2$ plasmas, is used to etch a trench or via into the porous material. This process leaves fluorocarbon polymers in the trench which must be removed prior to sealing the pores. If an oxygen containing plasma is used to remove the polymer, there is danger of also removing the CH_3 groups. Instead, H_2 plasmas are being investigated to remove the polymer. Due to the light mass of H atoms and the endothermic nature of many of the polymer removing reactions, hot H atoms are required for the polymer removal.

Using results from a computational investigation, the etching, cleaning and sealing of porous SiOCH in sequentially applied $Ar/C_4F_8/O_2$, H_2, He and NH_3/Ar plasmas will be discussed. The Hybrid Plasma Equipment Model was used to obtain the ion energy and angle distributions of reactive fluxes from inductively and capacitively coupled plasmas. These are used as input to the Monte Carlo Feature Profile Model to predict profiles of the low-*k* materials. Results will be discussed, including validation, for the densification, cleaning and sealing of pores as a function of treatment time, bias voltage, pore radius and plasma power. Mechanisms for producing hot H atoms in H_2 plasmas will be discussed.

1. A. M. Urbanowicz et al., Electrochem. Solid-State Lett. **10**, G76 (2007).

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