Task ID: 425.017
Task Title: Environmentally Benign Vapor Phase and Supercritical CO_2 Processes for Patterned Low k Dielectrics
Deliverable: Report on the uniform organosilicate ULK film containing ~ 2 nm pores with a dielectric constant less than 2.1 and a hardness > 1 GPa. Optimize film composition and chemistry. Begin template development for directly patterned films.

$scCO_2$ Processing of Low k Materials

The **Watkins** group produces mesoporous ultra-low k (ULK) silicate films via 3-D replication of self-assembled block copolymer templates in $scCO_2$. The approach, which involves the deposition of polymer films and infusion with inorganic precursor, yields families of films with highly ordered spherical pore structures and dielectric constants as low as 1.8. A film with a dielectric constant of 2.2 was shown to survive a planar CMP test under conditions typically employed for dense carbon doped oxides. We are now advancing the performance of the films in three areas. We are exploring a second-generation template system based on the self-assembly of blends of amphiphilic block copolymer surfactants and homopolymers that exhibit strong interactions with the hydrophilic segment of the template that yields well ordered films with spherical pores of less than 2 nm. With **Ober** we are developing photopatternable block copolymer template systems for directly patterned ULKs. Finally we are enhancing the mechanical properties of ULK films by doping templates with structure reinforcing molecules and/or nanoparticles, including polyhedral oligomeric silsesquioxanes (POSS) prior to infusion and condensation of the silicate network. These reinforcing species are covalently bound to the organosilicate network through pendent functional groups. We report progress in the third area in this period.

Recent Progress

We have conducted initial experiments to demonstrate enhancements in mechanical properties by doping block copolymer templates with functionalized POSS additives prior to Si alkoxide infusion. POSS compounds are a good choice for mechanical reinforcement for ULK films. They exhibit full or partial Si-O_x cage structures (1.5 nm) that offer mechanical stability and provide inherent porosity upon calcination. Moreover, the POSS cages can bear pendant silanol functionality that enables covalent incorporation into the silicate film network structure. A schematic of the process is shown s in figure 1. Feasibility experiments were conducted using

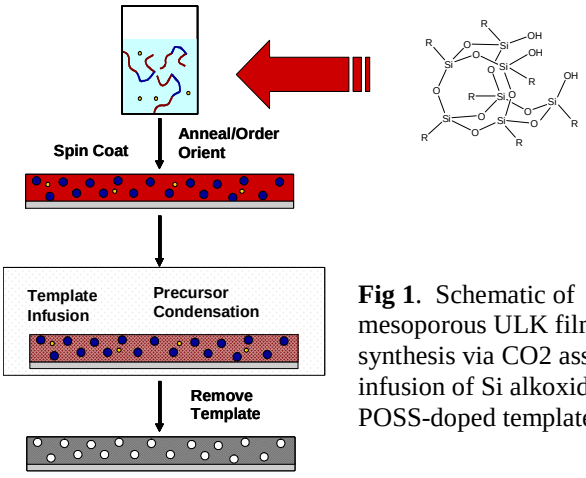

Fig 1. Schematic of mesoporous ULK film synthesis via CO2 assisted infusion of Si alkoxides within POSS-doped template films.