Structure-Property Relationship of Photocurable Silsesquioxane Resists for Nanoimprint Lithography

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We report the development of new UV curable silsesquioxane (SSQ) based resists for Nanoimprint Lithography (NIL). The SSQ materials possess a variety of characteristics desirable for NIL, such as a high modulus, good mold release, and excellent dry etch resistance. The presence of acrylate or epoxy functional groups allows the resists to be crosslinked via an UV-initiated free radical or cationic polymerization process at room temperature. Several types of SSQ materials were synthesized and evaluated to understand their structure-property relationship.

The SSQ resins were synthesized through a base-catalyzed hydrolytic-condensation process and possess a good shelf-life. The high molecular weight of these materials is appropriate for forming very stable and uniform thin films through a spin coating process, to allow large area high-throughput NIL application. Apart from studying two different curing mechanisms, methyl and phenyl functional groups were also incorporated into the structures of the SSQ materials to study their impact on the properties of the imprinted structures. The molar ratio of the different monomers was varied to achieve broader compositions for each individual type of resin.

It was observed that all of the materials presented a low degree of shrinking upon UV crosslinking, a property highly desirable for nanoscale patterning. In particular, only less than 6% shrinkage was obtained for the epoxy-based material, attributed to the conversion of the oxirane ring into a more flexible open-chain segment in the cured material. It was also observed that the viscosity of the prepolymers increases with the molar ratio of the phenyl groups in the resin.

Finally, the modulus of these SSQ resins measured after UV cure was in the range of few GPa (0.4-5.0GPa), a value that is sufficient for nanoscale resolution and sharp edge definition. Figure 1 and 2 show the nanoscale gratings replicated in several of these materials, illustrating that these SSQ materials present suitable properties for nanoscale imprinting.

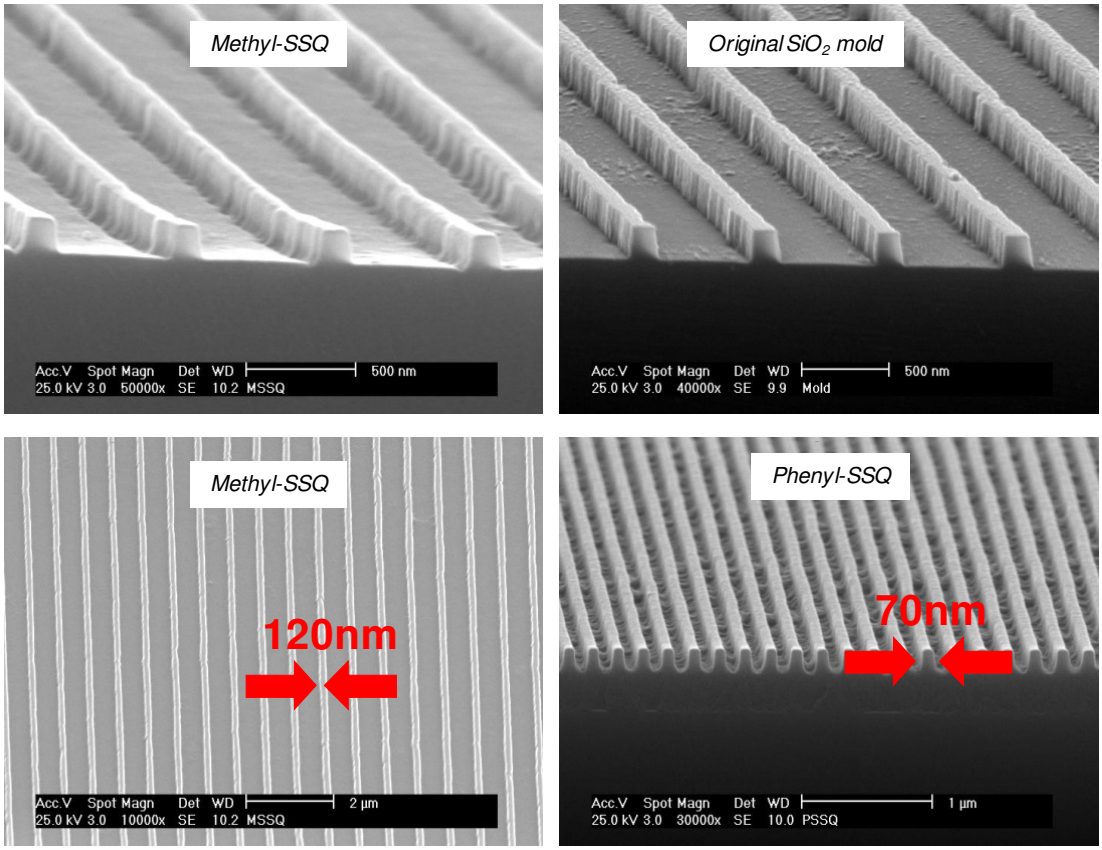

Figure 1. SEM pictures of imprinted nanograting patterns in several SSQ resins cured by cationic polymerization.

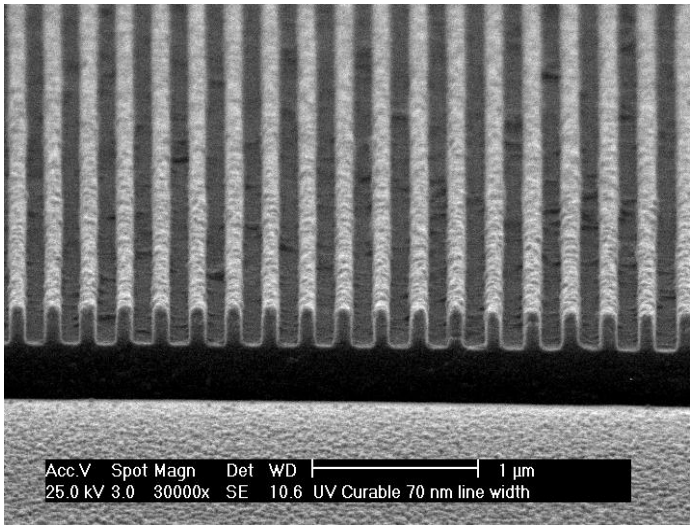

Figure 2. SEM pictures of imprinted patterns in SSQ resin cured by free-radical polymerization.