UV Curable Silsesquioxane Materials for Nanoimprint Lithography

Carlos Pina[a], Jin-Sung Kim[b], and L. Jay Guo[a,b]

[a]*Macromolecular Sciences and Engineering,*
[b]*Department of Electrical Engineering and Computer Science*
University of Michigan, Ann Arbor, MI 48109

Peng-Fei Fu

[c]*Dow Corning Corporation, Midland, MI 48686*

Nanoimprint lithography (NIL) is a patterning approach that promises high-throughput replication of nanostructures with great precision. The success of this technique as a next generation lithography will require the development of new materials that are better suited as the nanoimprint resist. The resist materials used in imprinting should be deformed easily under an applied pressure. Polymeric systems that can be imprinted in short time at low temperatures and pressures are required. High etching resistance and easy demolding are also desired characteristics. UV curable monomers are materials that can potentially satisfy such requirements because they can be solidified within seconds or shorter time at room temperature, and the replicated pattern is not subject to distortions during heating-cooling cycles. Moreover, the viscosity of the monomer can be easily adjusted such that only low pressure (< 50 psi) is required for nanoimprinting.

We report here the development of novel UV curable silsesquioxane (SSQ) based resists for NIL. The SSQ materials, containing phenyl substituents, possess a variety of characteristics desirable for NIL, such as a high modulus 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. The imprinting processes were carried out in few seconds at room temperature with a 365 nm UV light source. Patterns with several feature sizes ranging from sub-micron scale to the nanometric regime were successfully replicated at room temperature using UV transparent and flexible fluoropolymer molds (Figure 1). The smaller feature size patterned so far consists of a 70nm line width dense grating with an aspect ratio of 2.7:1 (Figure 1c). In addition, the UV cured resist showed appropriate plasma etching characteristics, i.e. a very high resistance for CHF_3 (12nm/min) and O_2 (1 nm/min) plasma etching, making it suitable as etch mask for pattern transferring directly into SiO_2 substrates. In addition, these materials show an outstanding thermal stability, high modulus (in the order of several GPa) and low surface energy.

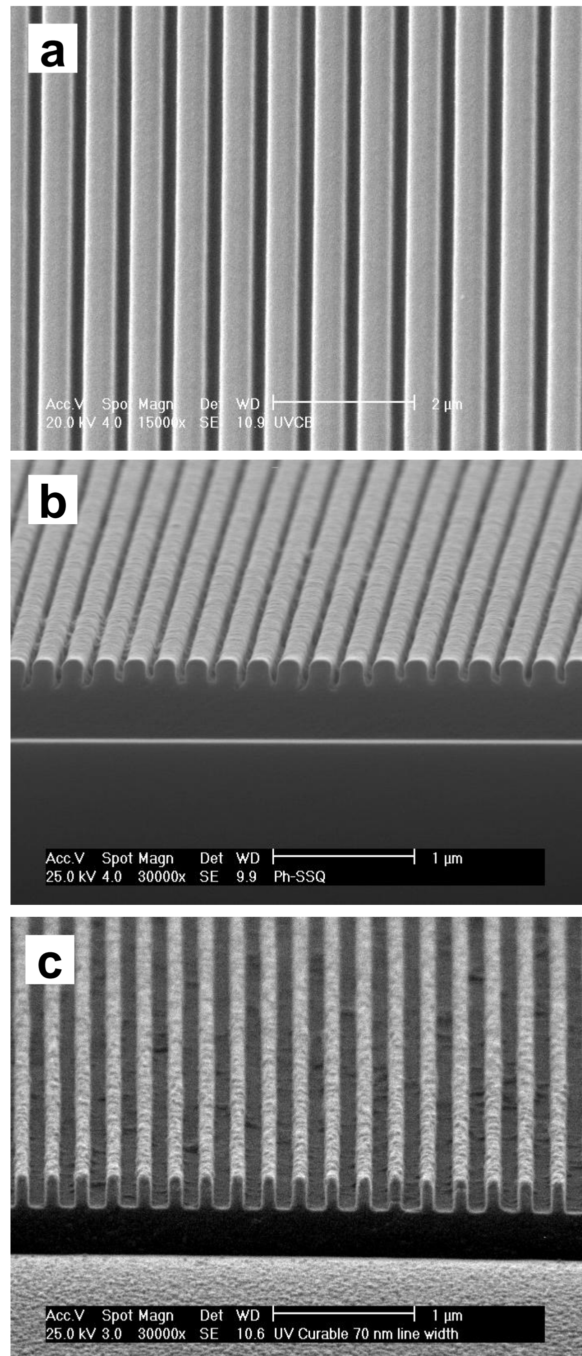

Figure 1. SEM images of silsesquioxane replicated gratings, a) 700 nm period (acrylate based SSQ), b) 120 nm line width, and (epoxy based SSQ) c) 70 nm line width (acrylate based SSQ).