High Quality Secondary Templates for Nanoimprint Lithography from Cubic Silsesquioxanes (SSQs)

H. W. Ro,[1] V. Popova,[2] L. Chan,[3] Y. Ding,[1] K. J. Alvine,[1] D. J. Krug, [2] R. M. Laine,[4] and C. L. Soles[1]

[1] *Polymers Division, NIST, 100 Bureau Drive,, Gaithersburg, MD 20899*

[2]*Mayaterials, Inc. Ann Arbor, Michigan 48108*

[3]*Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, MD 20899*

[4] *Department of Material Science and Engineering, University of Michigan, Ann Arbor, Michigan 48109*

Nanoimprint lithography (NIL) is an exciting next-generation lithography combining the potential of a sub-5 nm patterning resolution with the high throughput, low-cost and inherent simplicity of a stamping process.[1,2] However, one of the biggest impediments to the wide spread implementation of NIL is the availability of high quality molds. The fabrication of high resolution, 1× molds still requires costly and time consuming serial patterning techniques, such as electron beam lithography, followed by multiple etching or lift-off process. In many applications template fabrication and development are too formidable of a barrier to enable penetration of NIL into different technology sectors. Here we present a class of specially designed cubic silsesquioxane (SSQ) materials that can be easily patterned with nanoscale dimensions via single thermal nanoimprint lithography (NIL) and then used directly as daughter NIL templates. The hydrophilic SSQ precursors can be easily spin cast into films directly imprinted at elevated temperatures. During the NIL process the SSQ is converted into hydrophobic ($CA_{H_2O} > 100^{o}$) cross-linked material, which facilitates the release of mold. After imprinting, the patterns are vitrified at elevated temperatures into a fully cross-linked organosilicate material with a low surface energy, high UV transparency, high modulus, and low coefficient of thermal expansion. These imprinted patterns can be directly used as secondary molds for both ultra-violet UV and thermal NIL, without applying a fluorinated mold release coating. In this presentation we will describe these materials in detail and quantify the fidelity of the pattern transfer process, with respect to dimension control from the NIL master to the secondary mold and through the imprinted pattern for both thermal and UV NIL systems, with critical dimension as small as 10 nm. Our examples of high quality imprints, without the use of mold release coatings, at high temperatures and pressures illustrate the utility of these materials for NIL mold replication.

---

[1] J. L. Guo, *J. Phys. D: Appl. Phys.* **37**, R123 (2004).

[2] S. Y. Chou, P. R. Krauss, P. J. Renstrom, *Science* **272**, 85 (1996)

(a) **(b)**

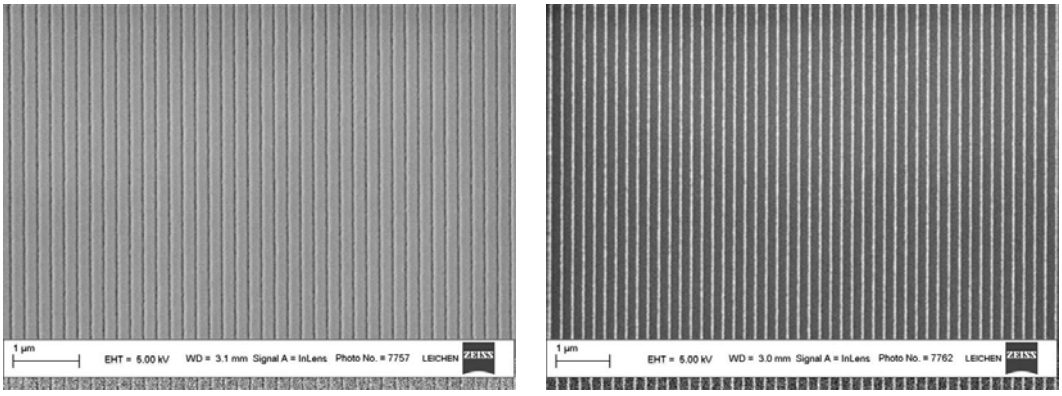

Figure 1. Top-down FE-SEM images for (a) SSQ replica of the master SiO_2 mold and (b) PMMA imprint from the SSQ replica. Uniform PMMA imprints with line width approximately 30 nm from SSQ replica with trench width of 30 nm, indicate that the secondary SSQ mold can create high quality replica from SiO_2 master mold and can be used as a daughter mold to generate polymeric imprint with high pattern fidelity over large area.