Tailored synthesized silsesquioxane based resists for UV-assisted nanoimprint lithography

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Ultra-Violet NanoImprint Lithography (UV-NIL) is a promising technique for the low-cost fabrication of nanoscale structures at low temperature and low pressure. However, researchers and industrials are facing important lacks concerning the UV curable imprinting material: only a few are commercially available and their properties and characteristics do not always match the targeted application.

In this paper, we present results on the development of low-viscosity hybrid organic / inorganic UV-NIL resists based on polyhedral silsesquioxane (SSQ) functionalized with photo-polymerizable aliphatic epoxy groups. These materials are very attractive because they present a high thermal and mechanical resistance. Thus, they have an interest in nanoimprinting as etch masks (the high silicon content ensuring a high plasma etch resistance) or to fabricate mould replicates. With the aim of improving the release properties of such materials, we compare here the performance of two different materials with different surface free energy (SFE) values. SSQ-Epoxy with a SFE value of 52.3 mJ/cm^2 (water contact angle 54.8^o) and SSQ-$C6_3F_5$, a fluorinated product (epoxy and fluorinated ligands are grafted on the SSQ T8 cage) with a SFE value of 18.9 (water contact angle 100.1^o).

Both materials were optimized to be spin coated on a Si substrate giving us a film thickness of 300 nm at 1000 rpm. Transparent stamps made of Ormostamp (microresist GmbH, Germany) have been used throughout all our experiments (Figure 1). All imprints were performed at room temperature using a homemade imprinting module and were exposed to UV light (source: Omnicure 2000) for 1 min. After separation, the imprinted samples were developed in acetone for 10 sec and isopropanol for 15 sec to remove any residual resist that had not been fully cross linked. Figures 2 and 4 shows top view Scanning Electron Microscope (SEM) images of SSQ-Epoxy and SSQ-$C6_3F_5$ materials respectively. Figure 3 illustrates a cross sectional SEM image of 200 nm line width SSQ-$C6_3F_5$ grating with uniform residual layer.

In conclusion, two tailored synthesized SSQ based materials have been developed and demonstrated as candidate materials for UV NIL. The low SFE improves the release properties during the UV NIL process which is strongly correlated to the mould lifetime.

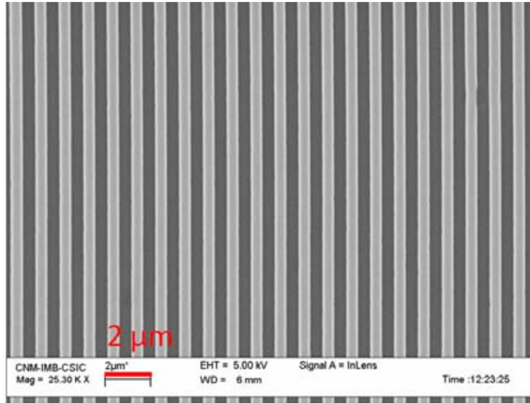

Figure 1. Top view SEM image of the transparent Ormostamp mould used throughout our experiments

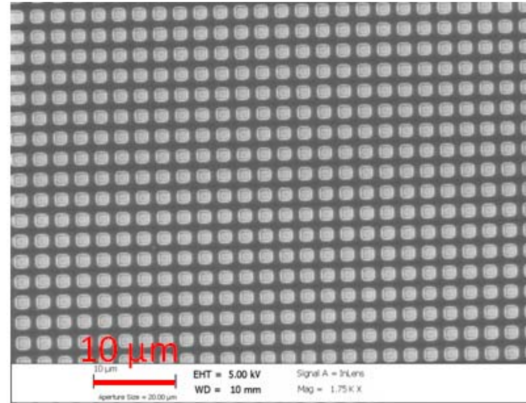

Figure 2. Top view SEM image of 1.3 µm square structures imprinted in SSQ-Epoxy

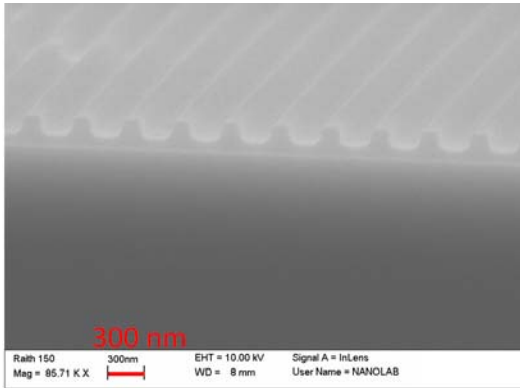

Figure 3. Cross sectional SEM image of 200 nm SSQ-$C6_3F_5$ imprinted gratings

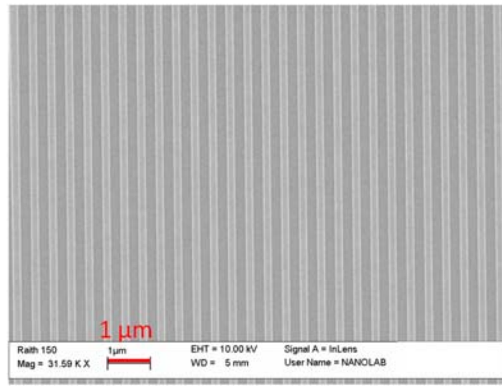

Figure 4. Top view SEM image of 200 nm SSQ-$C6_3F_5$ imprinted gratings

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