Materials, processes and quality inspection methods for photonic and bio related applications

N. Kehagias[1], T. Kehoe[1], M. Chouiki[2], M. Sa1aün[2], M. Zelsmann[2]and C. M. Sotomayor Torres[1,3,4]

[1]*Catalan Institute of Nanotechnology (CIN2-CSIC), Campus Bellaterra - Edifici CM3, 08193-Bellaterra (Barcelona), Spain*
[2]*LTM-CNRS, CEA-LETI-MINATEC, 17 rue des Martyrs 38000, Grenoble, France*
[3]*ICREA, Institució Catalana de Recerca i Estudis Avançats, 08010 Barcelona, Spain,*
[4]*Dept. Physics, Universitat Autònoma de Barcelona, de la UAB, 08193 Bellaterra (Barcelona), Spain*
Email: nikolaos.kehagias.icn@uab.es

Nanoimprint lithography (NIL) has proven to be a low cost and ownership "free" nanofabrication method suitable for medium scale production lines. Moreover nanoimprint lithography based methods have found more and more users in academic research laboratories which have taken the opportunity to explore (mainly the IC industry) various (potential) application. Towards this step new materials and alternative processes have driven NIL to a technological level which favors flexible and low cost device production at high throughput. In association to device manufacturing, non destructive inspection methods for quality control, have become essential.

In this paper we discuss the synthesis of novel resists suitable for UV based nanoimprint lithography which have opened new fields of applications such as graphoepitaxy, permanent photonic applications and bio compatible surfaces. In particular low-viscosity hybrid organic / inorganic UV-NIL resists based on polyhedral silsesquioxane (SSQ) functionalized with photo-polymerizable aliphatic epoxy groups have been synthesized [1]. These materials are very attractive because they present a high thermal and mechanical resistance. We discuss the properties of two similar materials but 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$_3$F$_5$, 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). Figure 1 illustrates two scanning electron microscope (SEM) images of SSQ-C6$_3$F$_5$ and SSQ-Epoxy resists imprinted at room temperature, with a pressure of 4 bar for 1 min and exposed to UV light for 2 min. Such surfaces have been used as templates on which block copolymer (BCP) systems are deposited. By controlling the surface energy we managed to form micro-droplet periodic arrangements with sub-50 nm hexagonally arranged domains (figure 2).

The adoption of nanoimprint lithography as a widely used fabrication technique depends upon the use of suitable, reliable and cost-effective metrology techniques. We have developed a nanometrology technique based on sub-wavelength diffraction [2] which allows us to detect non-destructively sub wavelength polymer features. We compare our theoretical and experiments results showing that sub-wavelength diffraction is sensitive enough to changes of the line shape below 10 nm (figure 3), including rounding, induced by thermal relaxation, and that it is possible to accurately simulate the optical signal produced from complex three-dimensional profiles.

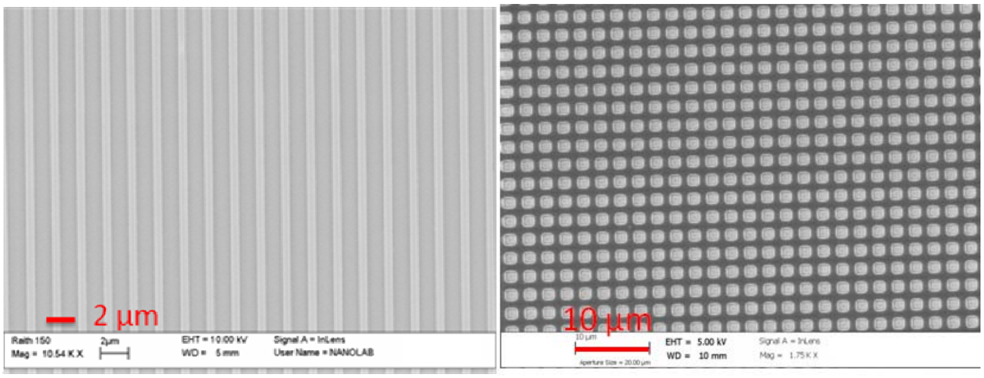

Figure 1 *(left) Top view SEM image of 500 nm SSQ-C6$_3$F$_5$ gratings imprinted by means of UV assisted NIL, (right) Top view SEM image of 1.3 µm square structures imprinted in SSQ-Epoxy*

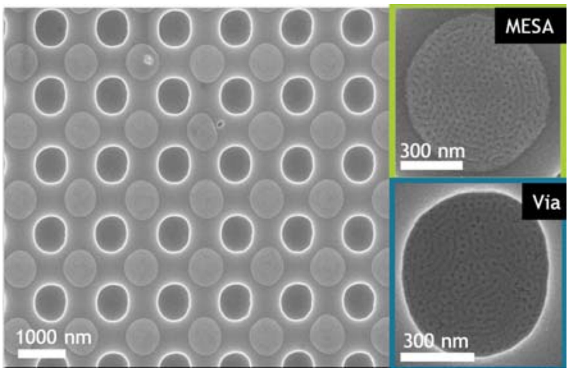

Figure 2 *SEM images of a regular array of ~675 nm microdroplets formed on top of the diagonal mesas between the 600 nm via-holes as a result of dewetting processes for a 1% wt PS-PMMA (46-21 kg/mol) solution; (insert) SEM images of microphase separation within the microdroplet on the mesa and within the via-hole (reservoir) taken from image*

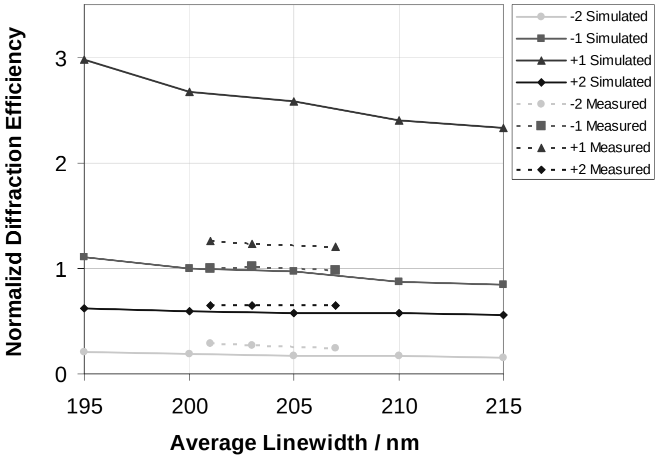

Figure 3 *Measured and simulated diffraction efficiencies, as a function of average grating line-width.*

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References

[1] N. Kehagias, V. Reboud, J. De Girolamo, M. Chouiki, M. Zelsmann,J. Boussey, C.M. Sotomayor Torres, Microelectronic Engineering 86 (2009) 776–778.
[2] T Kehoe, V Reboud, C M Sotomayor Torres, Microelectronic Engineering 86, 1036–1039 (2009)