Organosilicate Materials for High Resolution Patterning using NIL and Self-Assembly

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Organosilicate glasses (OSGs) of the form [$RSiO_{1.5}$], where R is an organic functional group, have significant potential for nanoimprint lithography (NIL). We present and quantify two methods for fabricating sub-20 nm scale nanostructures from OSG materials. The first utilizes conventional NIL templates, with patterns as small as 10 nm being directly imprinted into as-cast OSG films. The imprinted patterns are then vitrified into hard ceramic-like materials that can be used to imprint subsequent replica patterns with high precision. The high pattern fidelity and reproducibility is determined from precise shape characterization using specular X-ray reflectivity (SXR) and field emission-scanning electron microscopy (FE-SEM). The second method employs a self-assembly using a diblock copolymer to direct highly ordered sub-20 nm nanostructures. In this case, the OSG prepolymers is selectively rendered soluble within the ethylene oxide domains in the poly(styrene)-*b*-poly(ethylene oxide) (PS-*b*-PEO) block copolymer. The high miscibility between silanol groups in the OSG prepolymers and ethylene oxide group in the diblock copolymer enable the mixture to behave like a diblock copolymer, resulting in highly ordered nanoscale phase-separated morphology during spin coating and solvent annealing. When the films are subjected into the high temperature vitrification process, the BCP burns off while the OSG converts into a hard pattern. This approach offers incredible latitude in tuning the morphology of organosilicates surface. Unlike previous efforts that use a similar approach, these results are unique in that a 50/50 diblock copolymer under neat conditions shows a lamellar morphology can be driven through nearly all of the morphologies of the phase diagram by simply changing the ratio of the OSG to the BCP in the spin casting solution. The resulting OSG patterns templated from the PS-*b*-PEO can be heated to volatize

the PS domains and vitrify the OSG-containing PEO domains to directly create NIL templates that replicate the former BCP morphology into a range of polymeric materials. Figure 1 shows the representative morphologies of OSG patterns after vitrification those are (a) vertically aligned lamellae and (b) hexagonal sphere array patterns. Those patterns were directly used as molds for patterning polystyrene surface using thermal NIL and resulted in reverse replica of OSG patterns with high pattern fidelity as shown in Figure 1.

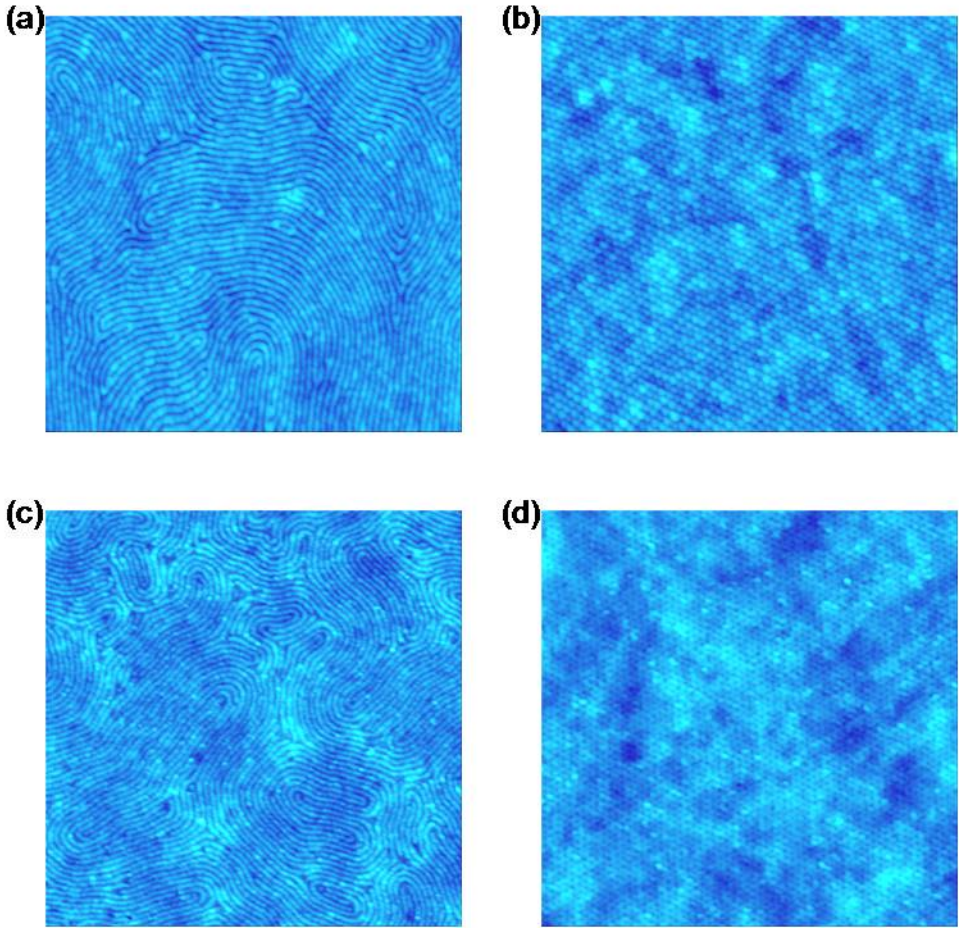

Figure 1. AFM tapping mode images of OSG patterns with (a) vertically aligned lamellae and (b) hexagonal sphere array and their PS imprints with (c) vertically aligned lamellae and (d) hexagonal hole array, those are reverse replica of (a) and (c), respectively. (size: 2 ìm ×2 ìm)