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Replication of large-area nanostructures by injection molding

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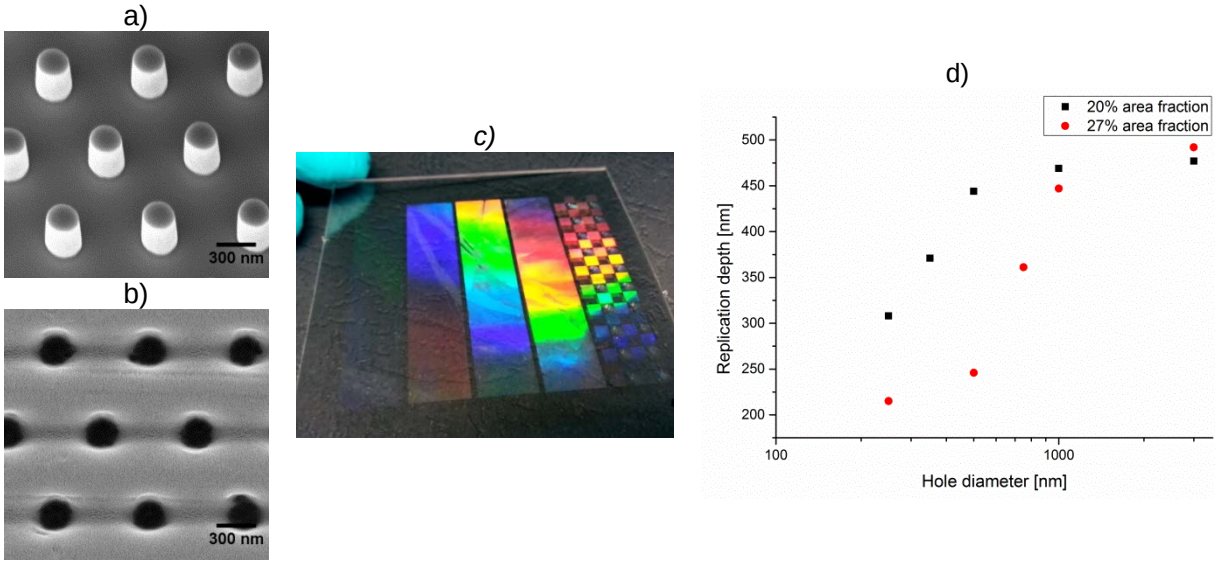
In this work, we present the results from large-area (~90 cm^2) nanopatterning of mold inserts and subsequent replication in a cyclic olefin copolymer (COC) by injection molding. One of the possible applications are production of functional plastic substrates for cell culturing.

By using a deep UV stepper (248 nm) and a laser-written reticle, it is possible to produce holes in photoresist with a diameter down to 200 nm, covering the area of a full 6" silicon wafer. Nickel mold inserts are subsequently fabricated by electroplating, by sputter coating a metallic seed layer either directly on the developed photoresist or on etched silicon.

The nickel mold insert are laser-cut into the right dimensions, before being coated with a tri-layer anti-stiction coating of Al_2O_3 – SiO_2 – FDTS in an atomic layer deposition (ALD) process, to facilitate separation during de-molding.

The polymer replicas are being fabricated in an isothermal injection molding process, with cycle times reaching down to 30 seconds.

We are currently working on developing new steel/HSQ (hydrogen silsesquioxane) mold inserts for improved replication quality at low mold temperatures. The pattern is transferred to the mold by nanoimprinting of PDMS. HSQ is thermally cured to form amorphous SiO_2, which has a much lower thermal conductivity than metallic nickel. In this way, we believe the formation of a frozen skin in the polymer melt is delayed, thus improving the replication quality while maintaining a low cycle time.



a) Nickel mold. b) and c) Polymer replica. d) Replication measured by AFM for different hole diameters and hole area fraction.