High Quality Nano Imprint

NIL Technology

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Technology Summary

Nano imprint lithography (NIL) has over the last decade gone from being a new and exciting research topic, to be a technology used in the most advanced parts of industry. Since the first test with nano imprint was carried out, the technology has been greatly improved. Today NIL can be used for, fast and inexpensively, production of large areas of nanostructures.

Over the last couple of years the entire NIL process have been improved. Imprint machines have been made better and faster and capable of imprinting on larger substrates. The resolution of imprint resists have improved and the features size on the imprint templates have been made smaller and smaller. Altogether NIL has now been turned into a reliable fabrication technology within the area of nanotechnology.

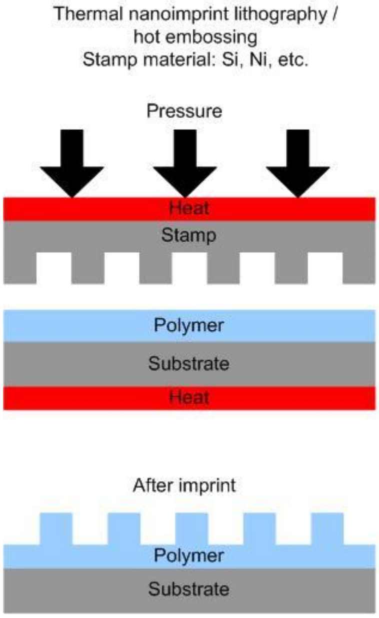

Figure 1: Schematic drawing of a thermal NIL process.

Despite the great improvement of the technology, one still needs to optimize on the individual imprints processes, depending on protrusion coverage, imprint feature shape, imprint area size and resist thickness. The imprint parameters must be optimized for each specific application. An optimized imprint process will result in an imprint, which is well defined, has very low defect density and a thin residual layer. All of these are very important properties of an imprint, because they will ensure a good pattern transfer into the substrate.

NIL Technology has worked intensively with nano imprint and optimization of the imprint process. We have the ability to imprint large areas with nanostructures, with very low defect density and to transfer this imprinted pattern into the substrate, so the linewidth is conserved. In order to do this, one needs precise control of both stamp production, imprinting and pattern transfer.

Stamp fabrication

NIL technology stamps are produced using, state of the art e-beam lithography systems: JOEL JBX9300FS (Gaussian beam) or Vistec SB352HR (shaped beam). This ensures that parameters such as the pitch and linewidth of the structures are very well defined and uniform across the entire stamp. The stamp is then etched in an ICP dry etcher, in order to transfer the e-beam written pattern into the stamp material typically silicon or quartz. The ICP etching ensures a very good height uniformity of the etched structures and also enables good control of the sidewall angle of the structures. Finally, the stamp is normally coated with an anti-sticking layer, which ensures the release of the stamp and substrate after imprint. SEM pictures of four different stamps with nano structures can be seen in figure 2.

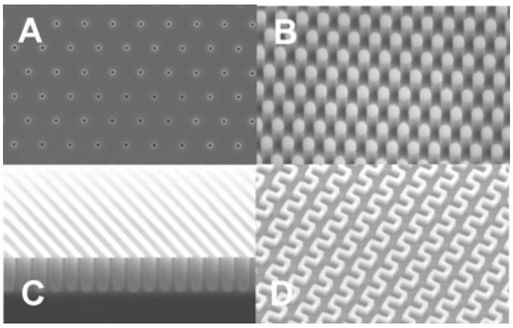

Figure 2: SEM image of NIL stamps produced by NIL Technology. A) stamp typically used for LED manufacturing, B) stamp used for anti-reflection coatings, C) stamp used for grating production and D) stamp used in nano fluidic industry.

Imprint process

The imprinting is performed on an EVG 520 thermal imprinter. An AFM scan of an imprinted substrate can be seen in fig. 3. When a substrate has been imprinted the residual layer of resist needs to be removed. This is done using anisotropic plasma etching. Although the plasma etch is optimized for strong anisotropy in the vertical direction there will always be a small etching in the lateral direction as well. This will cause the imprinted structures to be widened and the linewidth of the imprint will therefore be larger than that of the stamp. To avoid this problem the imprint process is optimized to produce very thin and uniform residual layers. In this way only a few seconds of plasma treatment is enough to completely remove the residual layer on the entire imprint and the widening of the structures is minimized.

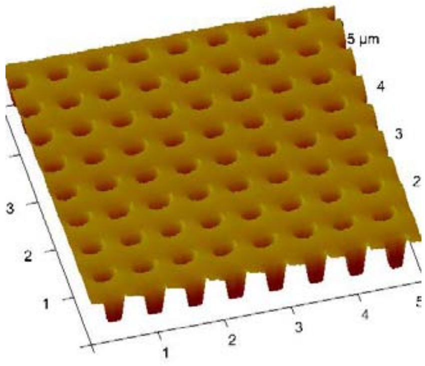

Figure 3: AFM scan of an imprint of 250 nm wide nano structures, with great uniformity.

Results

The imprinted substrates can be further processed after the residual layer has been removed. The imprint resist can be used as a soft etch mask for direct pattern transfer into the substrate. Alternatively the imprint resist can be used as a lift-off resist, for metal lift-off. A substrate with metal dots produced by lift-off can be seen in fig. 4.

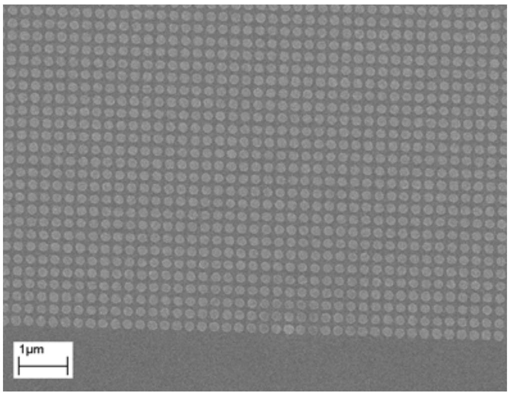

Figure 4: Imprint substrate after lift-off of aluminium. The metal dots are well defined and adhere to the silicon surface without problem.

After lift-off the metal pattern can be used as an etch mask for dry etching of the substrate. The metal mask will function as a hard mask and the etch process will produce a substrate which is a copy of the stamp. Fig. 5 shows a substrate where the metal pattern has been transferred into the silicon substrate, resulting in the formation of nano pillars, which can be used, in this case, for anti-reflection coatings.

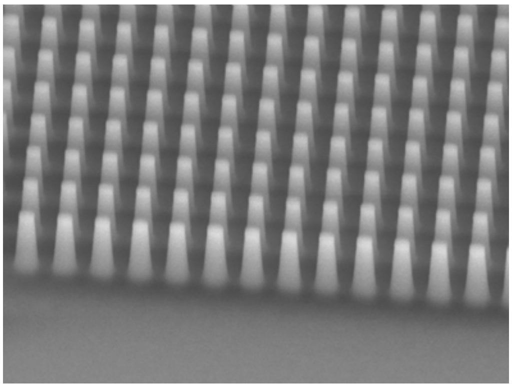

Figure 5: The finished substrate where the Al mask has been used to etch 150 nm round metal dots into 1 µm high pillars.