Nanoimprint lithography for large-scale fabrication of micro- and nano-structures

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Nanoimprint lithography is a high resolution patterning technique in which a master with nano- and/or micrometer scale features can be used to replicate several times a specific pattern. The combination of nanometer scale resolution, high throughput and low cost of fabrication makes this nanopatterning process ideal for large volume manufacturing [1]. Since the seminal work of Chou et al. [2, 3], nanoimprint lithography has quickly evolved to become one of the most promising nanopatterning techniques, widely employed in areas such as semiconductors, for fabrication of magnetic disk storage devices, photonics, for nanopatterned solar cells, biosensing, for detection of various biomolecules, as well as in micro- and nanofluidics, to cite just few applications [4].

In this work, we present the complete fabrication method used for large volume manufacturing of complex nano-structures at 8 inch wafer scale. In particular, a large area of nano-wells, required for biochemical detection as well as manipulation of nanoparticles [5] was fabricated.

The fabrication process starts with the creation of a silicon mold by conventional micromachining methods, namely e-beam and/or direct writing laser lithography followed by silicon reactive ion etching. The silicon mold is then used to obtain an Intermediate Polymer Stamp (IPS®, Obducat) used for pattern replication under nanoimprint lithography using the Simultaneous Thermal and UV (STU®, Obducat) technology. The use of the intermediate stamp allows a longer lifetime of the silicon mold (only used to create the IPS®) and allows the fabrication of the same structures existing in the original silicon mold with high fidelity. In a first step the IPS® is created from the silicon mold by means of thermal nanoimprint, and in a second step, this IPS® is used to pattern the STU® resist coated on test wafers with a simultaneous thermal and UV-curing process. In this work, a silicon mold composed of nano-wells has been employed. Wells are 1μm in diameter and about 300 nm in depth, and are arranged in a hexagonal lattice with 2μm pitch, as shown in Fig. 1(a). The same structures were patterned by NIL (Eitre®8) in STU® resist using the IPS® obtained from the silicon mold and then, the silicon substrates were etched in an Inductively Coupled Plasma Etching – Reactive Ion Etching (ICP-RIE) tool to create a replica of the original nano-wells as presented in Fig. 1(b). A comparison between Fig. 1(a) and Fig. 1(b) shows a good agreement between the dimensions of the original silicon master and the replica obtained using the NIL process. Comprehensive analysis will be completed to assess consistency of the replica at wafer scale, as well as the possible consistency degradation related to the repeated use of a same IPS® for the NIL process.

This work illustrates how a single nanoimprinting setup can be used for the fabrication of an IPS® suitable for the STU® NIL process, leading to an inexpensive path for the large volume fabrication of devices with high resolution features, by extending the lifetime of original silicon molds.

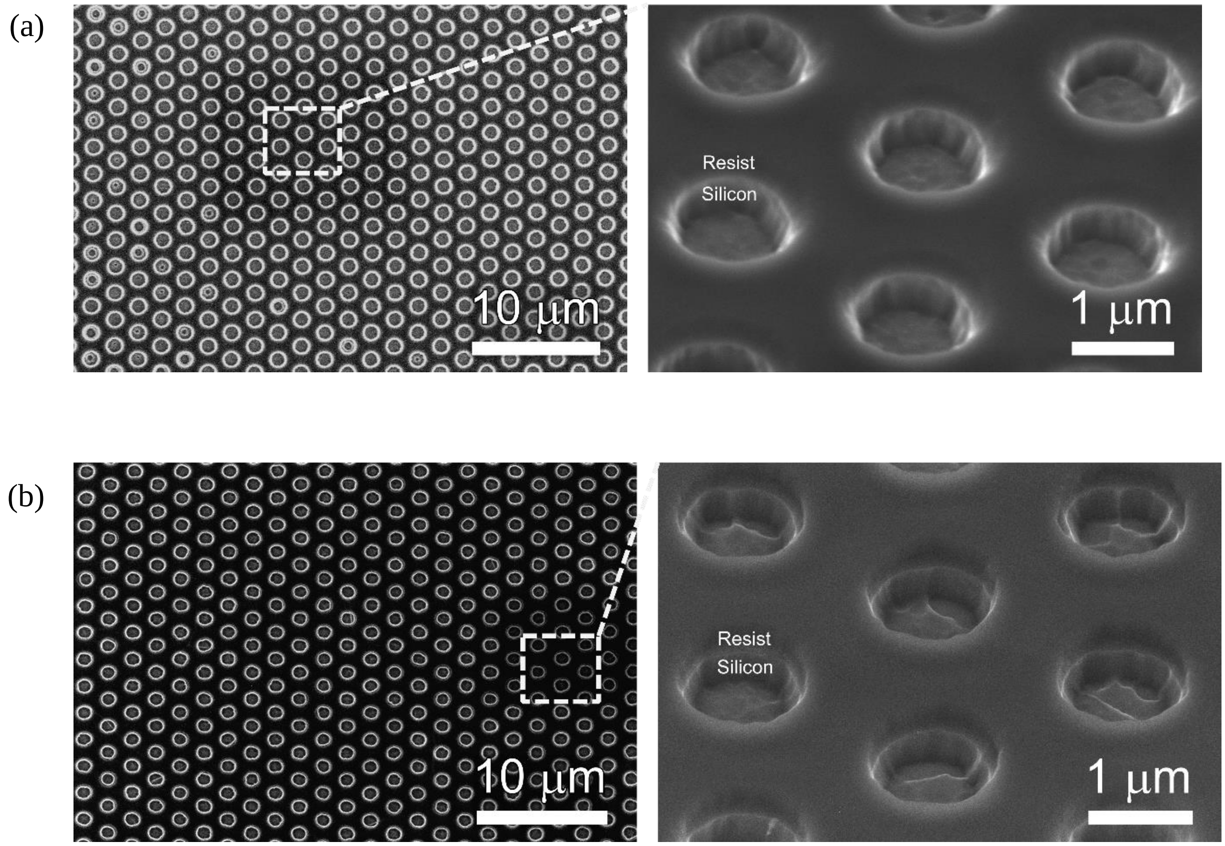

Figure 1. Original silicon mold (a) and silicon replica (b) obtained using the STU® nanoimprint lithography process.

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