Novel nanofabrication method to achieve high aspect ratio metallic patterns by thermal nanoimprint lithography

N. Alayo, J. Llobet, F. Perez-Murano
Centro Nacional de Microelectrónica, IMB-CNM (CSIC) Campus Universtat Autónoma de Barcelona, Bellaterra, E 08193
nerea.alayo@imb-cnm.csic.es

X. Borrisé
Institut Catalá de Nanotecnologia (ICN-CIN2). Campus Universitat Autónoma de Barcelona, Bellaterra. E 08193

Since 1996 when S. Chou[1] developed the nanoimprint lithography process, hundreds of works have used this technique to fabricate nanometer scale structures and devices with high throughput over large areas. The nanoimprint is a simple, fast and cheap technology, but the removal of the residual layer and the post-processing complicates the practical realization of some types of nanostructures. In the cases that high aspect ratio metallic nanopatterns are desired, the lift-off is usually difficult due to the resist profile and the need to remove the residual layer. In this work, we present a novel process to easily obtain high aspect ratio metallic patterns by the combination of thermal NIL and lift-off, adapted from previous processes developed for UV NIL[2, 3]. The method will enable the fabrication by thermal NIL of multilayer metallic nanostructures deposited by sputtering, evaporation or other thin film deposition methods.

The first stage of the process consists on the preparation of a *sandwich* type substrate composed by a silicon wafer, PMMA thick layer (370 nm), a thin layer of SiO_2 deposited by PECVD (23 nm) and a 100 nm layer of PMMA (see Figure 1a). Thermal imprint is carried out in the top PMMA layer. Then, in a first step of RIE, the residual layer and the SiO_2 are etched, followed by a second RIE step in which the thick layer of PMMA is etched using the SiO_2 as a mask (Figure 1b). The obtained undercut facilitates the subsequent lift-off, where 6 nm of Cr and 200 nm of gold were deposited. As a result of this process arrays of 206 nm high pillars were obtained with a radius of 165 nm (Figure 1c). It is remarkable that by using this process, the resolution is not dependent on the thickness of the bottom PMMA layer, so that high aspect ratio nanostructure can be reliably performed by metal lift-off.

This technique will allow the fabrication of multilayer stacks consisting of customized materials with high interest in fields like nanomagnetism. Furthermore, selective deposition of biological material or increase of effective electrode area are other interesting features that can be achieved.

[1] S. Y. Chou, P. R. Krauss and P. J. Renstrom, J. Vac. Sci. Technol B **14**, 6 (1996).
[2] I. Bergmair *et al.*, Nanotechnology **22**, 325301 (2011).
[3] C. Peroz *et al.*, in Proceeding of the International Conference SPIE, San Jose (2013).

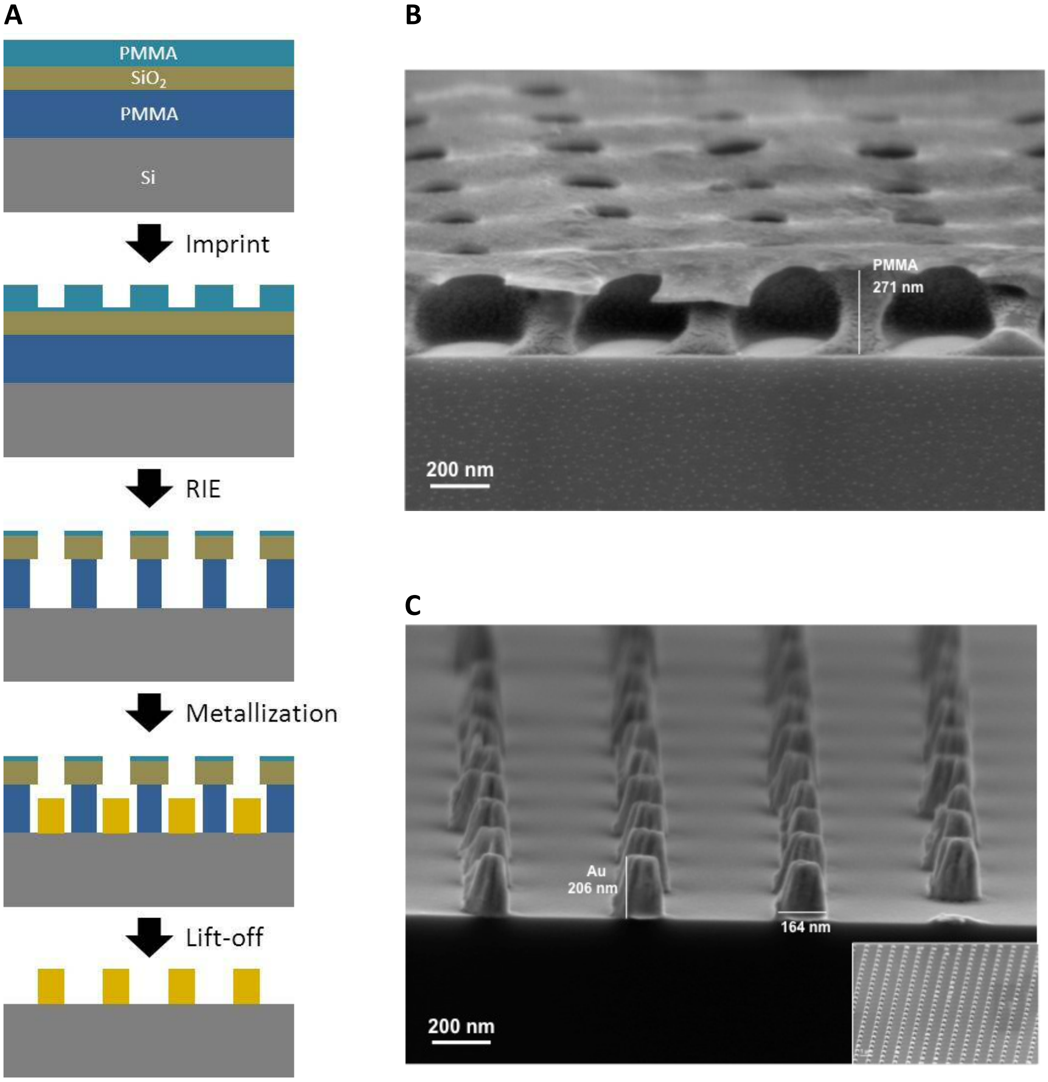

Figure 1: a) Fabrication process of gold nanopillars. First the sandwich type substrate is prepared. Then, the imprint is carried out and followed by a RIE process to remove the residual layer, SiO_2 and the thick layer of PMMA. The sample is metallized and after the lift-off the patterns are defined in gold. b) Cross-section SEM image of sample after the RIE. (the deformation of the patterned resist is due to SEM Imaging) c) SEM image of the array of gold nanopillars.