Toward Successful Nanoimprint Mould Fabrication: Large Area Hexagonally Ordered Si Daughter Stamps by Guided Anodization

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Abstract

Nanoimprint lithography (NIL) has become one of the versatile lithographic techniques to create nanometer sized features due to its large area capability for pattern transfer to a substrate. However, despite the benefit of relatively easy and fast process, some difficulty still exists especially in inexpensive creation of well-defined master stamp having sub 100 nm pore/hole patterns. This hinders the NIL progress toward practical applications since the preparation of NIL stamps by an e-beam lithography is too costly. In order to make NIL approach more viable for industrial applications, alternative methods for large area stamp fabrication would be desirable.

In this presentation, we report on successful demonstration of long-range hexagonally ordered Si daughter stamps by reactive ion etching utilizing NIL-patterned anodized aluminum oxide (AAO) template as an etch mask. An aluminum film deposited on Si substrate was pre-textured by NIL followed by anodic reaction. It is well known that the interpore distance in porous anodic alumina is proportional to the applied voltage during anodization. Physical impression locations defined by nanoimprinting can be turned into vertical pores via guided anodization, which not only shortens anodization time but also guarantees a desirable long-range periodicity, for example, covering a 6 mm x 6 mm wide area in this report. Otherwise a rather extended anodization time is required for self-ordering with reasonable and acceptable periodicity. Nanoimprint-guided anodization of aluminum films enabled the generation of periodic nanopores at the impressed locations as well as in-between locations, thus leading to a pattern doubling. These patterns were utilized as a reactive ion etch mask for low-cost and easy creation of Si stamps for use in nanoimprint lithography applications.

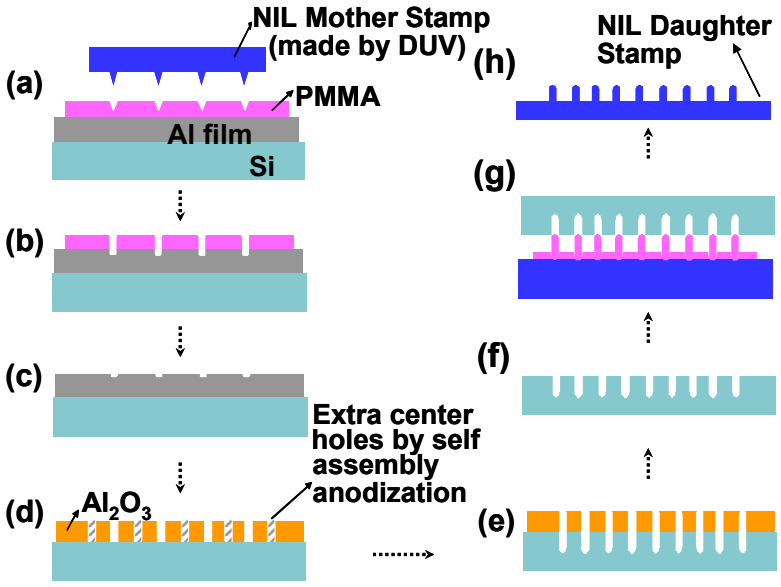

Fig. 1 Schematic daughter stamp fabrication procedures: (a) nanoimprinting on PMMA resist, (b) pattern transfer into Al film surface by RIE, (c) PMMA removal, (d) guided anodization, (e) pattern transfer into Si substrate by RIE, (f) AAO removal, (g) nanoimprinting on PMMA resist, and (h) pattern transfer into Si daughter stamp by RIE

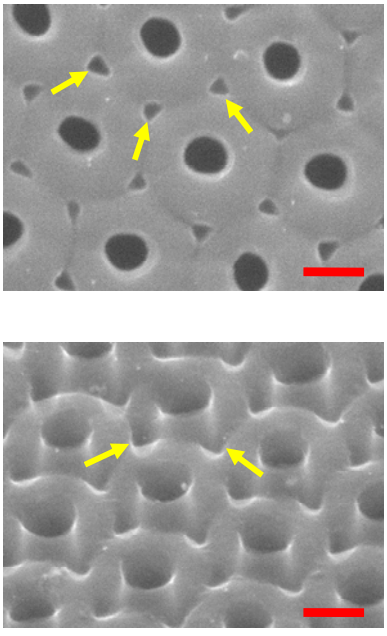

Fig. 2 SEM images of AAO: top view (upper panel) and tilted view (lower panel). Note that larger pores shown in the micrograph represent NIL mother stamp patterns replica while smaller pores indicated by yellow arrows represent newly formed pores during the course of guided anodization. Scale bar in the both images is 200nm.