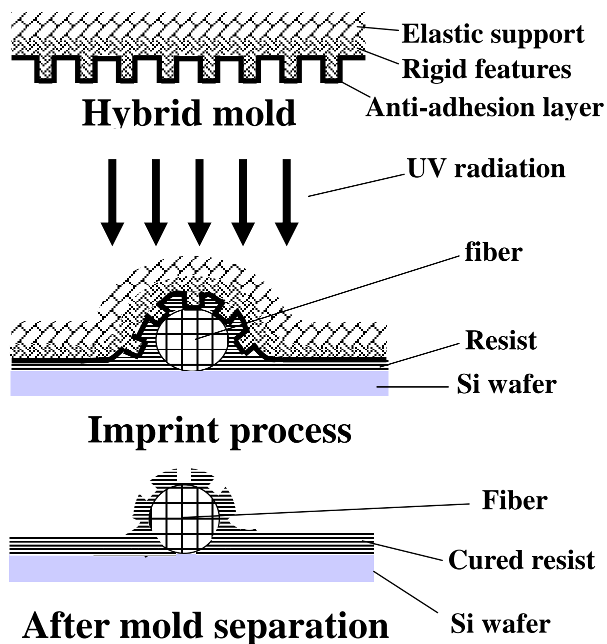
Patterning Curved Surface Using Hybrid Nanoimprint-soft Lithography Mold

Zhiwei Li, Haixiong Ge, Changsheng Yuan, Minghui Lu, Yanfeng Chen,
Department of Materials Science and Engineering, National Laboratory of Solid State Microstructure, Nanjing University, Nanjing 210093, P. R. China,
Wei Wu, Qiangfei Xia, R. Stanley Williams
Hewlett-Packard Laboratories, Palo Alto, CA 94304,
E-mail: haixiong@nju.edu.cn, wei.wu@hp.com

Nanoimprint lithography (NIL) has been demonstrated as a high-throughput and low cost lithographic technique with sub-10 nm resolution [1]. The mold is the crucial component for NIL, and is typically fabricated on a stiff material such as silicon, nickel, silicon dioxide, or quartz. The use of hard materials for imprint molds has enabled high spatial resolution for NIL. The ability to pattern curved surfaces is desired in many fields, such as MEMS, electronic devices and optics [2]. This type of patterning task is impossible to accomplish with a conventional rigid NIL mold.
We have developed a hybrid nanoimprint-soft lithography mold composed of a UV-cured rigid polymer used as the patterning template on an elastic poly(dimethylsiloxane) (PDMS) support. As shown in figure 1, the thin (100~200 nm) photo-cured feature layer and the thick (~2 mm) elastic PDMS support were fused via an interpenetrating polymer network to create a mold that combined the advantages of a high-resolution nanoimprint mold and a conformal soft lithography stamp. The hybrid molds were demonstrated in high fidelity pattern transfer. For example, a dot array at 100 nm pitch and 15 nm in diameter was accurately replicated by the hybrid mold (figure 2). As a demonstration for patterning curved surface, a standard UV-NIL process (figure 1) using a hybrid mold with 200 nm pitch gratings was carried out on a segment of a cylindrical single-mode optical fiber (125 μm in diameter) placed on a Si wafer. The 200 nm pitch gratings were duplicated onto the fiber surface with the grating line directions both parallel with and perpendicular to the fiber axis (figure 3a and b). The quality and uniformity are excellent as the lines extend in the scale of several tens of microns without cracks and variation in period.

Reference

[1] S. Y. Chou, P. R. Krauss, P. J. Renstrom, Vac. Sci. Technol. B **14**, 4129 (1996).
[2] Y. N. Xia, G. M. Whitesides, Angew. Chem. Int. Ed. **37**, 550 (1998).



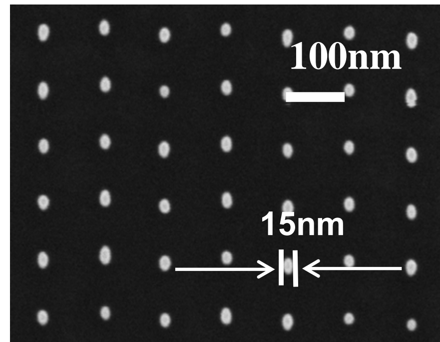


Figure 2 .SEM image of the imprint result of the hybrid mold, the dot array at 100 nm pitch and 15 nm in

Figure 1. Schematic illustration of the hybrid nanoimprint -soft lithography mold and its imprint process

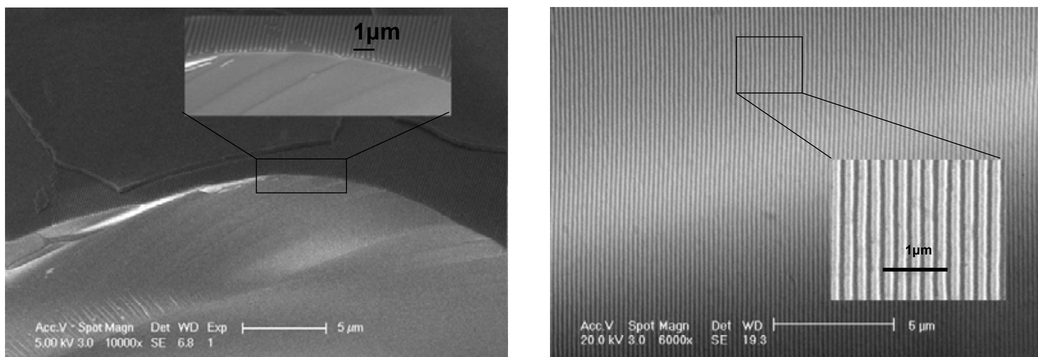


Figure 3. SEM images of 200 nm pitch grating on the fiber surface with the direction (a) parallel with and (b) perpendicular to the fiber axis. In (a), a large part of the grating area was covered with an overturned grating film peeled off from another fiber segment as we cut off it for SEM measurement.