Chemical Nanoimprint Lithography for Step-and-Repeat Si Patterning

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Nanoimprint lithography is a promising technique for next generation patterning processes. With conventional nanoimprint lithography, the mold is physically pressed against softened resist films, and the patterns on the mold are transferred to the films. Therefore, this nanoimprint process can be defined as "physical nanoimprint". It involves hot embossing lithography, and UV-nanoimprint lithography (step and flash imprint lithography). On the other hand, "chemical nanoimprint" has recently been proposed in which the surface reaction is more important than the press. With this process, the chemical reaction generated on the surface of the mold is the main factor in the nanoimprint, rather than physical penetration. A typical such technique is nanoelectrode lithography (1). This is based on a process in which a voltage is supplied between a mold and a Si substrate, and consequently an oxide is formed on the Si surface. The nanoimprint process utilizes an electrochemical reaction, which is based on the anodic oxidation of moisture existing between the mold and the substrate.

This study investigated the process and apparatus needed to realize chemical nanoimprint as a mass production technology. We show the results of silicon (Si) patterning using a novel nanoimprinter.

Figure 1 shows the process flow of conventional physical nanoimprint and chemical nanoimprint. The specific difference between the processes is the presence of a resist film. With a conventional nanoimprint, the mold has to penetrate the resist film and be released from it. The resist process can induce a significant problem, namely the appearance of pattern defects caused by the sticking force in the release step. On the other hand, with our nanoimprint process, there is no such problem because there is no resist. Fine Si patterns can be successfully obtained, as shown in Fig. 2.

Figure 3 shows the prototype nanoimprinter, which we have developed. A step-and-repeat system is installed. By controlling the amount of moisture, which is essential to anodic oxidation, we can form fine Si patterns.

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1) A. Yokoo, Jpn. J. Appl. Phys. 42, L92 (2003).

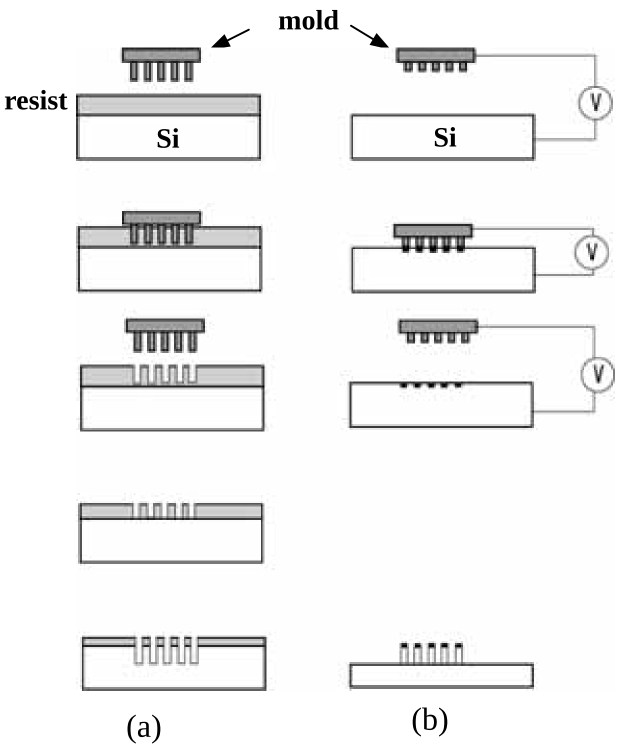

Fig. 1 Schematic process diagrams of (a) conventional physical nanoimprint, and (b) chemical nanoimprint using anodic oxidation.

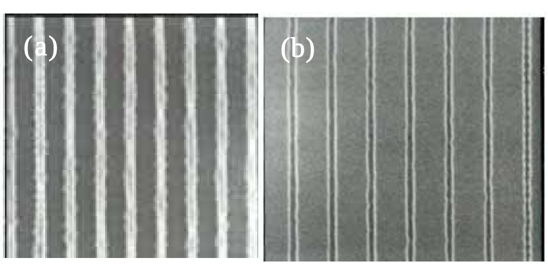

Fig.2. Si patterns of (a) 100 nm wide line and (b) 100 nm wide gap formed by chemical nanoimprint using anodic oxidation.

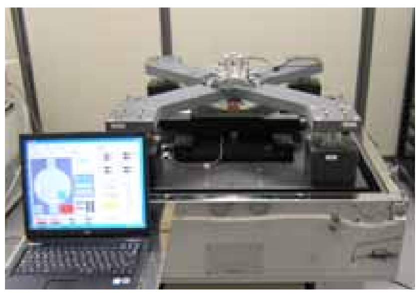

Fig. 3. Photograph of our nanoimprinter.