UV-Nanoimprint Mold Repair by Ga^+ Focused-Ion-Beam

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Nanoimprint lithography (NIL) is very useful technique, because nanostructure devices are fabricated with a high-throughput and low cost. To date, many works on NIL in molds, apparatuses, processes and devices have been reported. In particular, NIL mold repair is essential. However, there are only a few papers reporting on the repairing of the NIL mold. So far, we reported Si mold repair for thermal NIL by Ga^+ Focused-Ion-Beam (FIB) [1]. In this paper, we report on quartz mold repair for UV-NIL by Ga^+ FIB.

First, to confirm whether the deposited SiOx can be applied to UV-NIL mold repair, we performed transmittance measurement of SiOx film deposited by FIB Chemical Vapor Deposition (CVD) using a precursor gas of tetraethoxysilane [$Si(OC_2H_5)_4$] with halogen lamp as a light source. In this experiment, UV-NIL was carried out using mercury lamp with a main peak of 365 nm. Figure 1 shows the transmittance measurement result of SiOx film deposited by FIB-CVD. The transmittance of SiOx film is 97% at 365 nm. This result indicates that FIB-CVD using a precursor gas of tetraethoxysilane can be applied to repair the hollow-defective UV-NIL mold.

Next, we show how to repair a hollow-defective mold by FIB-CVD. First, we fabricated a hollow-defective line on a quartz substrate by electron beam (EB) lithography and reactive ion etching (RIE) as shown in Figure 2(a). The linewidth and hollow-width were 650 nm and 170 nm. UV-NIL was carried out using the defective mold on the UV-NIL resin PAK-01 (Toyo Gosei Co.) layer coated on Si substrate. The imprinted result is shown in Fig. 2(b). The defective line was clearly imprinted.

Second, Espacer (Showa Denko K.K.) layer was spin-coated onto the defective mold for prevention of electrical charge. SiOx deposition was carried out on the hollow defect by FIB-CVD at 30kV Ga^+ and 0.4pA using tetraethoxysilane gas at 5.0×10^{-4}Pa for about 3 minutes. After FIB-CVD, soaking in deionized water washed Espacer layer away. Figure 3(a) shows the repaired mold by FIB-CVD. Then, UV-NIL was carried out on PAK-01/Si substrate using the repaired mold. The imprinted line is shown in Fig. 3(b). The repaired line was successfully imprinted.

We will also present the repairing of protrusion defective UV-NIL mold at the conference.

REFERENCE

[1] K. Watanabe et al., Jpn. J. Appl. Phys. 43 (2004) 7769

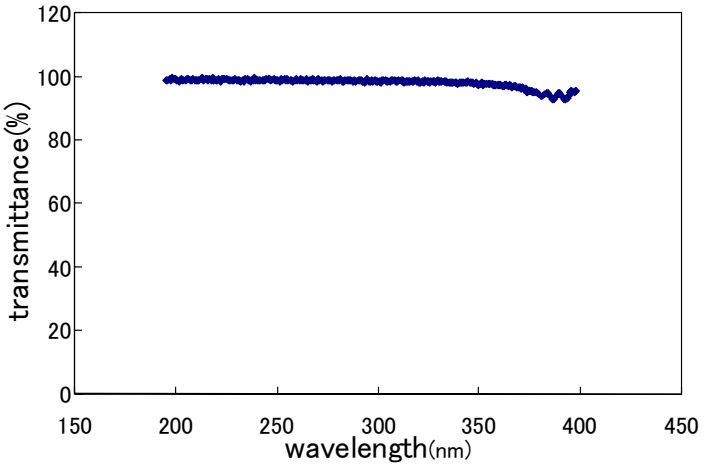

Fig.1 Transmittance measurement of SiOx film deposited by FIB-CVD.

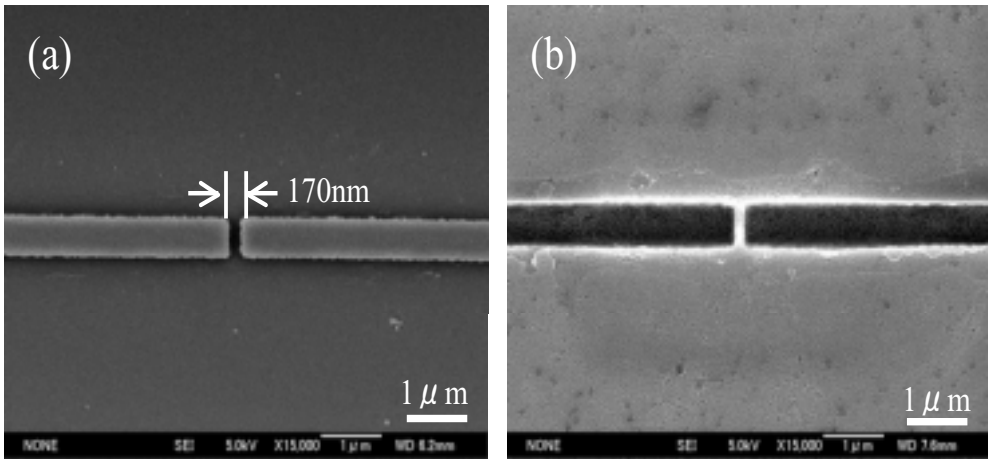

Fig.2 SEM images of (a) the hollow-defective line on the mold and (b) the imprinted line onto PAK-01/Si substrate using the defective mold.

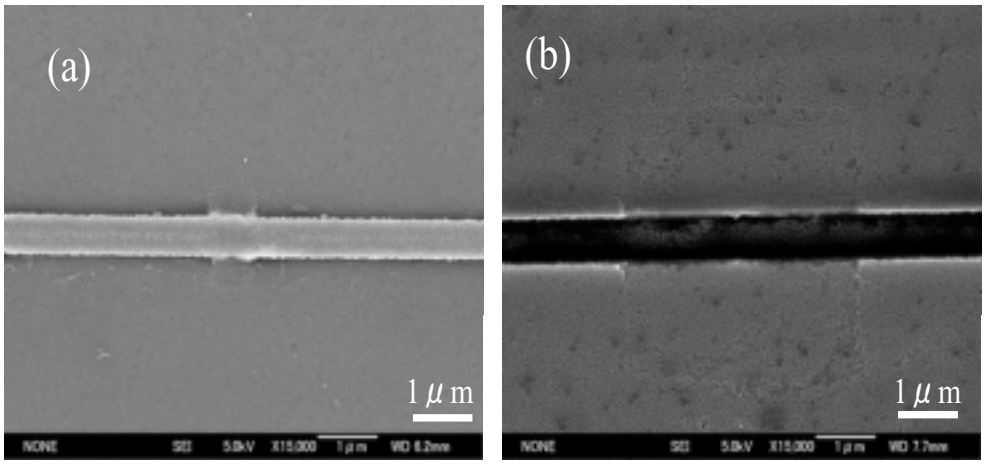

Fig.3 SEM images of (a) the repaired line on the mold and (b) the imprinted line onto PAK-01/Si substrate using the repaired mold.