Reversal nanoimprint lithography of Glasia® towards stacking glass structure

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Nanoimprint lithography (NIL) is an emerging lithographic technology that promises high-throughput patterning of nanostructures[1]. Reversal NIL has been developed to pattern 3D structures[2], which is indispensable for patterning of various structures such as photonic crystals and biochips. These techniques have been mostly applied to organic materials, since they easily deform at low temperatures and low pressures. However, organic materials have the major disadvantage of low thermal and mechanical properties, which limits the number of stacking layers for reversal NIL.

We have succeeded to replicate wide range and high aspect ratio structures onto SiO_2-based glass material using Glasia® as a precursor[3]. A main constituent of the Glasia® is polysilane. The polysilane is a semiconducting polymer, which consists of a Si main chain and organic side chains of phenyl and methyl. Photo-oxidation under ultraviolet (UV) irradiation decomposes the Si-Si bonds in the polysilane and transforms them to the SiO_2-based glass material. The glass material endures heat treatment higher than 350 °C and its Vickers hardness is comparable to the low melting temperature glasses. In this article, we propose reversal NIL towards stacking glass structures.

Figure 1 shows schematic views of the proposed process flow. The Glasia® films are deposited on Si molds by a spin-coating technique (Fig. 1 (a)). The films on the molds are transferred to the SiO_2 substrates by reversal NIL (Fig. 1 (b)). The UV and O_2 plasma and heat treatments are performed to transform the polysilane to a SiO_2-based material (Fig. 1 (c)). These procedures are repeated to stack the SiO_2-based structure (Figs. 1(d)-(f)).

The molds with Glasia® films were pressed to the substrates under an appropriate imprint condition. Line and space structures of 25 μm with a height of 200 nm were successfully transferred to the substrates. The structures were transformed to the glass material by the subsequent processes. Figure 2 shows an optical micrograph of a line and space structure of SiO_2-based material patterned by the proposed process. The result indicates that 3D structure of the SiO_2-based material can be patterned by the method using very short process time. Patterning of smaller structures and detail of the glass formation will also be presented at the conference.

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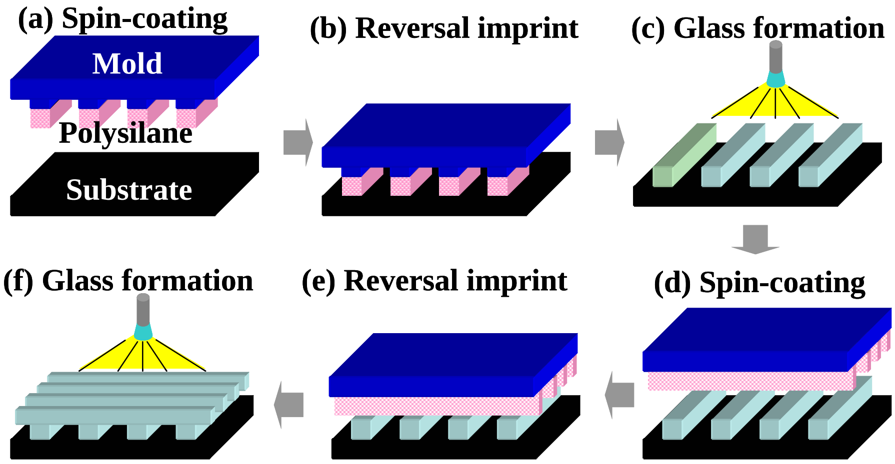

Figure 1. Schematic views of the proposed process flow. (a) Spin-coating of the Glasia® films on molds, (b)Reversal imprint, and (c) Glass formation by UV and O_2 plasma irradiation, and heat treatment. Stacking structures are achieved by repeating the processes from (d) to (f).

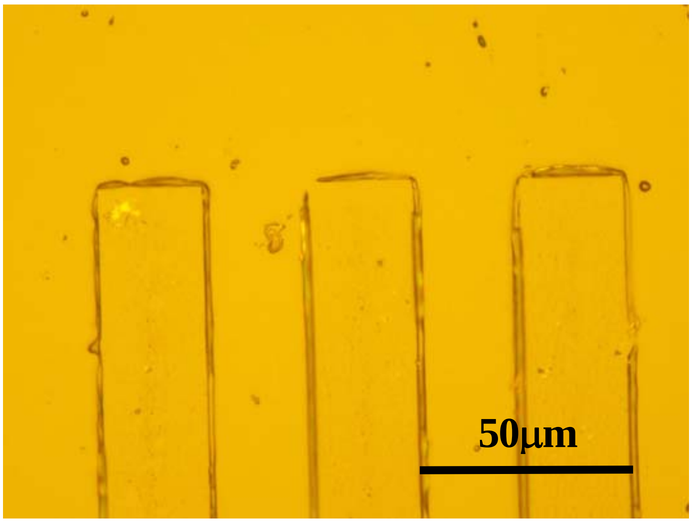

Figure 2. Transferred line and space structure by reversal NIL. The line width was 25 µm.