Fabrication of Patterned Multilayer Structure by using Novel Reversal Imprinting

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1. Introduction

There is a wide range of application for three-dimensional (3D) nano/micro structures in photonic, μ-TAS devices. The reversal imprinting [1], where the patterned film on stamp is transferred to a substrate, is a powerful technique for obtaining 3D structures by repeating the stacking process. However, there is a big issue in the demolding step where the stamp is released from the substrate. The adhesion between the patterned film and the substrate has to be stronger than that between the patterned film and the stamp for the successful transfer.

In this report, we propose novel reversal imprinting by using patterned poly-vinyl alcohol (PVA) film as a tentative stamp. Since PVA film is dissolved in water, no demolding step is necessary. The 180 nm polymethylmethacrylate (PMMA) pattern can be obtained. The three layer structure of patterned PMMA film can be also successfully fabricated.

2. Experimental

The process flow is shown in Fig. 1. The commercial PVA film laminated on polyethylene terephthalate (PET) film (SO sheet supplied by Aicello [2]) is used. The thicknesses of PVA and PET films are 30 and 75 μm, respectively. The PET film can be easily removed by hand. (a) The PVA film is patterned by the thermal imprint process. The imprint temperature, the press pressure and the press time are 120 °C, 10 MPa and 10 min, respectively. (b) The PMMA film is spin-coated on the patterned PET film, and, the PET film is removed. (c) The PMMA/PVA film is bonded on a Si substrate. The bonding pressure is fixed to 4 MPa. The combination of the bonding temperature, T, and the press time, t_p, (T, t_p) are changed. (d) After the bonding, PVA film is dissolved in hot water of 75 °C for 30 min. The patterned PMMA film is obtained on the substrate.

3. Results and Discussions

Figure 2 shows the fabricated PMMA pattern for (T, t_p) = (90 °C, 4 min). A PMMA line pattern of 180 nm width is successfully obtained. Figures 3 show the two layer structures of the patterned PMMA film for various (T, t_p) combinations. A good two layer structure can be obtained for (T, t_p) = (90 °C, 3 min) as shown by Fig. 3(a). On the other hand, the bottom PMMA pattern collapsed for both (T, t_p) = (90 °C, 6 min) and (T, t_p) = (100 °C, 2 min). It is very important that the bonding process should be carried out under suitable (T, t_p). Figure 4 shows the three layer structure of the patterned PMMA film for (T, t_p) = (90 °C, 3 min). The three layer structure can be also successfully obtained. It is clear that the proposed process can be used for fabricating patterned multi-layer structure.

[1] X. D. Huang et al., J. Vac. Sci. Technol. B, 20, 2872 (2002)
[2] AICELLO corporation, http://www.aicello.com/

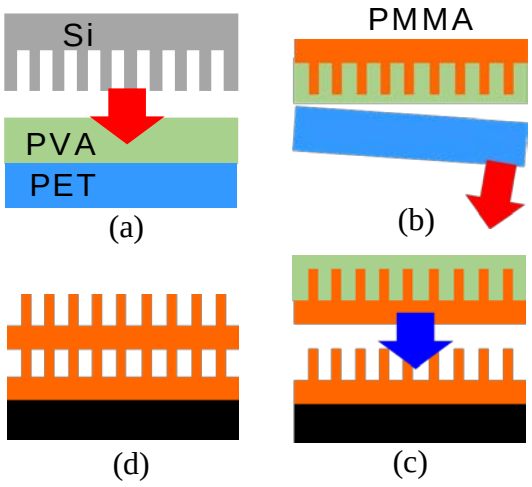


Fig. 1 Schematic view of process flow

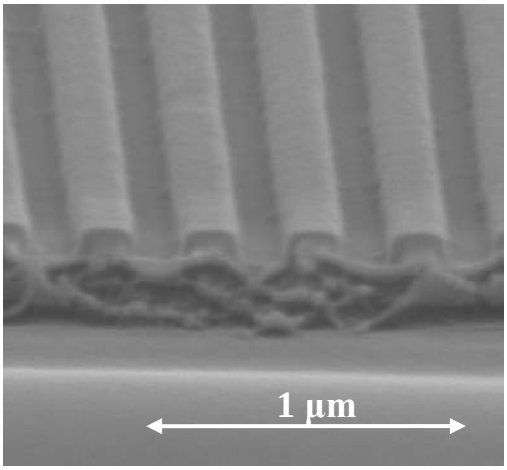
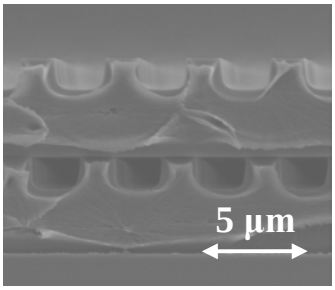
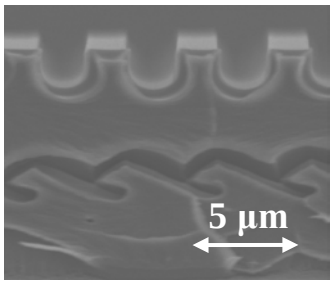


Fig. 2 Fabricated 180 nm PMMA pattern



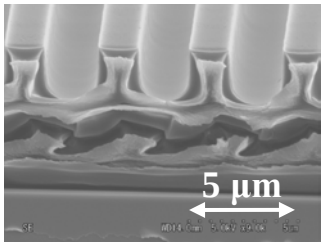
(T, t_p) = (90 °C, 3 min)

(a)



(T, t_p) = (90 °C, 6 min)

(b)



(T, t_p) = (100 °C, 2 min)

(c)

Fig. 3 Two layer structures of the patterned PMMA film for various (T, t_p)

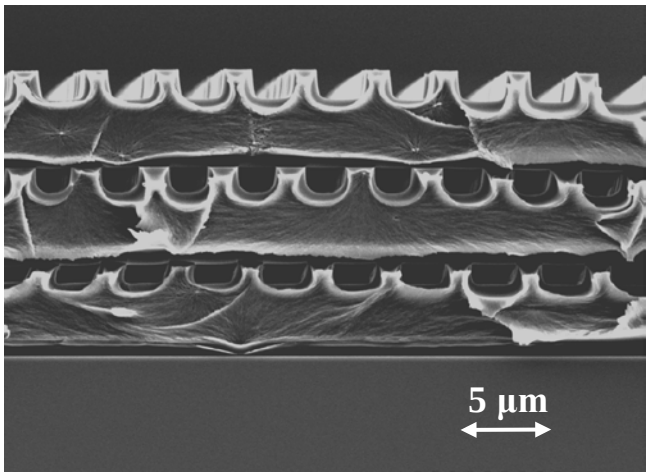


Fig. 4 Three layer structure of the patterned PMMA film for (T, t_p) = (90 °C, 3 min)