High Aspect Nanopore Array Fabrication by Nanoimprint Employing Novel Demolding Process

M Mamuro, K. Shimomukai, H. Kawata, M. Yasuda and Y. Hirai
Osaka Prefecture University, Sakai city, Osaka 599-8531, Japan
kawata@pe.osakafu-u.ac.jp

1. Introduction

Nanopores are expected to provide high performance bio-devices and energy devices [1]. Simple fabrication process for high aspect nanopores is strongly desired. Although nanoimprint process is a powerful method for fabricating nano patterns, it is often difficult to obtain high aspect patterns because of the demolding problems. In this report, high aspect nanopore array is fabricated by the thermal nanopmprint employing novel demolding process. Polystyrene (PS) nanopores, whose aspect ratio exceeds 6, can be obtained without pattern defects.

2. Experimental

2-1 Demolding process

Si mold (10mm*10mm) is fixed to the mold holder and pressed to PS film on the Si substrate. The Si substrate size and thickness are 30mm*30 mm, and 700 μm, respectively. After the press, the mold sticks to the substrate. Figures 1 shows the demoding tool. As shown in Fig. 1(a), the mold holder is fixed via the force gauge. The substrate holder is fixed to the computer controlled z stage. The substrate is fixed to the substrate holder by two different ways. For the vacuum chucking (Fig. 1(b)), the substrate deformation must be very small and the vertical release is obtained. For the screw chucking (Fig. 1(c)), the substrate deforms and the peeling release is obtained.

2-2 High aspect nanopore fabrication

Si mold with high aspect pillar patterns is fabricated by the Si RIE and the pattern size is reduced by the thermal oxidation and the oxide layer remove [2]. The fabricated mold is shown in Fig. 2. The sizes of the pillar top and the pillar height are approximately 100 nm and 800 nm, respectively. The patterned area is 4mm*4mm. The conventional anti-sticking treatment (OPTOOL Daikin Co.) is carried out and the mold is imprinted to PS film about 400 nm thick.

3. Results and Discussions

When the vacuum chucking is used, a large part of the PS film in the pattern area is removed from the substrate surface. The defect area is over 90 %. On the other hand, when the screw chucking is used, the demolding force is 16 N and the PS nanopores are obtained without the pattern defects. In the previous paper [3], it was shown that the push-back release, where the releasing force was increased and decreased repeatedly, was effective for reducing the pattern defects. The push-back release is used for the screw chucking. Figure 3 shows the time variation of the demolding force. The demolding force is decreased to 13 N. Figure 4 shows the fabricated PS nanopores. The pattern height is approximately 700 nm and no residual PS film is found. The high aspect PS nanopores without residual layer can be successfully obtained by improving the demolding process.

[1] D. Branton, et al., Nature Biotechnol. 26, 1146 (2008).
[2] A. P. Bonifas et al., Microelectro. Eng. 88, 3256 (2008).
[3] T. Kitagawa, et al., Microelectro. Eng. 123, 65 (2014).

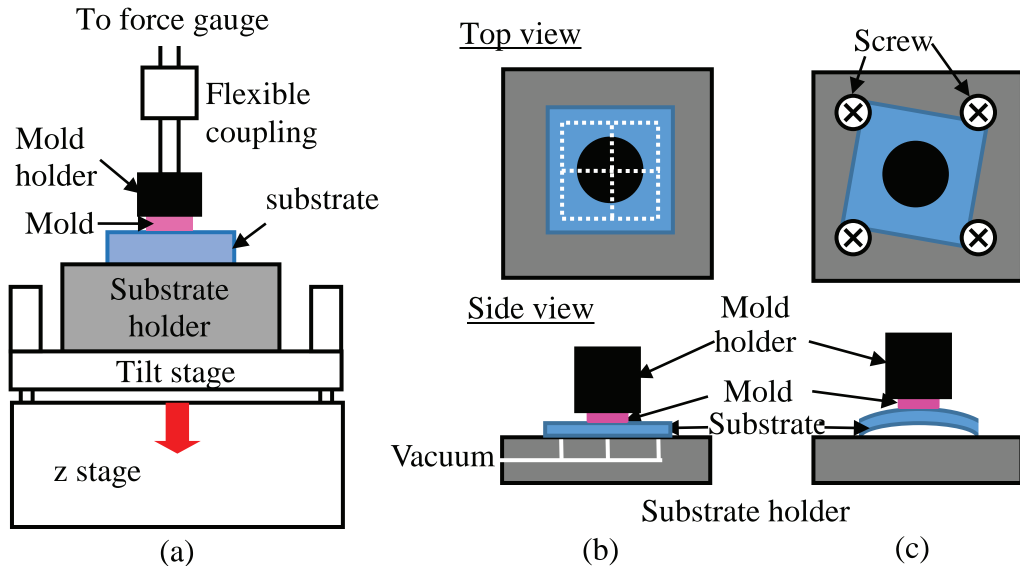

Fig. 1 Demolding tool. (a) Over view, (b) vacuum chucking and (c) screw chucking

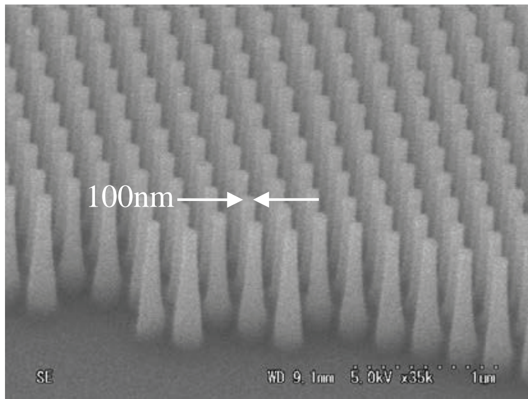

Fig. 2 Fabricated nanopillar Si mold

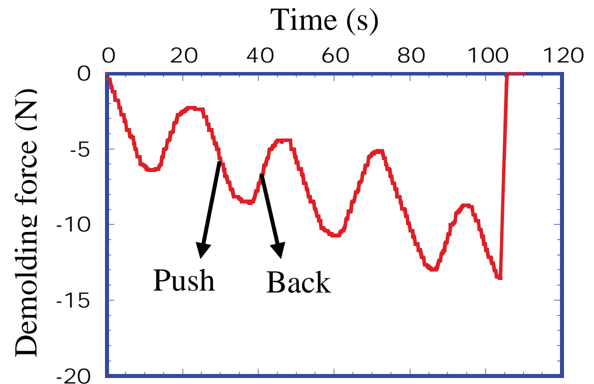

Fig. 3 Time variation of demolding force for push-back release

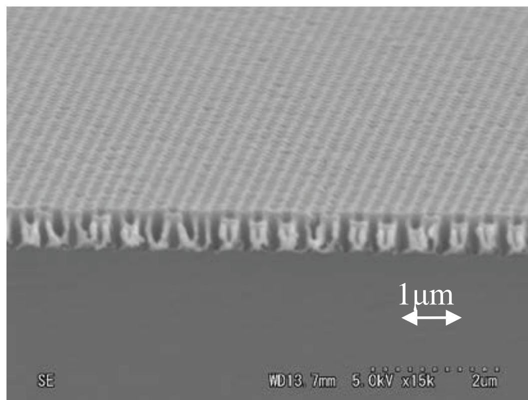

Fig. 4 Fabricated high aspect PS nanopores