FABRICATION OF PDMS MICROLENSES WITH VARIOUS CURVATURES USING A WATER-BASED MOLDING METHOD

Hong-Ki Kim and Kwang-Seok Yun*

Department of Electronic Engineering, Sogang University, Korea

ABSTRACT

In this paper we report a PDMS microlenses with various curvatures fabricated using a water-based molding method. The surface of Polypropylene (PP) substrates was modified by corona discharge using tesla coil and hydrophobic recovery to have various contact angles from less than 25^o to about 90^o. By using the water droplets with various contact angles as replica molds for PDMS process, we could obtain PDMS microlenses with various curvatures.

KEYWORDS: PDMS, microlens, contact angle, surface modification

INTRODUCTION

Recently, various PDMS microlenses were reported for the application of optical systems or biochips. They have been accomplished by various fabrication methods, such as diffuser lithography [1], photoresist thermal reflow [2], gel trapping technique [3], PDMS microdoublet lens [4] and replica molding method using non spherical surface [5]. But most of the PDMS microlenses fabricated using solid state molds had difficulty in achieving perfect curvature or relatively large size.

In this paper we report fabrication method of PDMS microlenses with perfect circular curvatures which can be obtained from surface tension of water droplet [6]. In addition, the size of PDMS microlenses can be controlled by the volume of droplet and the curvature of microlenses can also be controlled by adjusting contact angle of the droplet.

EXPERIMENTS

Fig. 1 (a) shows PP substrate with original contact angle of over 90^o before surface treatment. In this study PP surface was treated by electric discharge using tesla coil for 150 sec to obtain hydrophilic surface. After surface treatment, the hydrophobicity was recovered as time goes by as sown in Fig. 1 (b)~(h). The substrate was heated at 80^oC to obtain faster recovery rate of hydrophobicity. It can be confirmed that the contact angle was almost recovered to about 89^o after 6840 min.

Fig. 2 shows process flow for the proposed PDMS microlenses. We used cheap and plentiful PP substrates; (a) First the PP surface was modified by corona discharge using tesla coil. (b) By heating on hotplate at 80^oC, we obtained several substrates with desired contact angles. Because the hydrophobic recovery rate was quite slow as shown in Fig .1, we can easily obtain surfaces with desired contact angles. (c) Droplets with desired sizes were placed on the surface by using micropipette, (d) and PDMS prepolymer (10:1) is directly poured onto it followed by subsequent removal of air bubbles in PDMS by using vacuum suction. Then the

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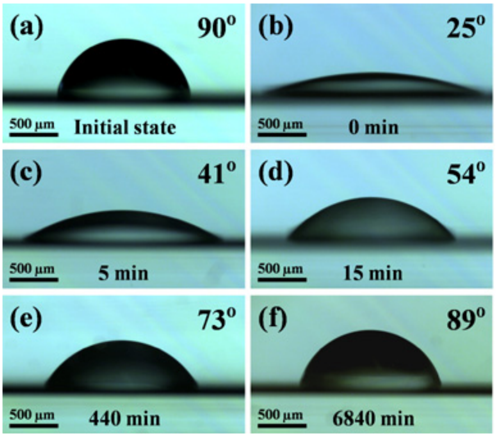

Figure 1. Side views of the contact angle of water droplet on PP substrate. (a) Before surface treatment. (b) Immediately after surface treatment. (c)~(h) Hydrophobic recovery at 80°C.

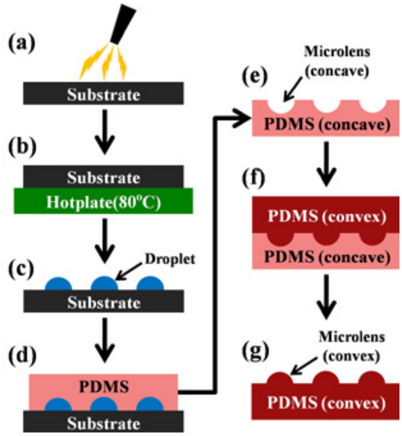

Figure 2. Process flow of the PDMS microlens.

PDMS was cured for 60 min at 80°C. (e) Next the PDMS was separated from substrate showing concave PDMS microlenses. (f) Finally, PDMS prepolymer was poured onto the fabricated concave PDMS molds, (g) and then we could obtain convex PDMS microlenses after curing.

RESULTS

Fig. 3 shows side view of fabricated convex PDMS microlenses with various curvatures with angle of around 45°, 75°, and 83°. Comparing with the original contact angles of water molds (41°, 73°, and 89°, respectively), there are little

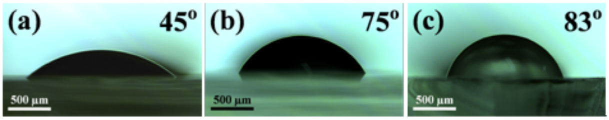

Figure 3. Side views of fabricated convex PDMS microlenses obtained from water droplet with contact angle of (a) 41°, (b) 75°, and (c) 89°.

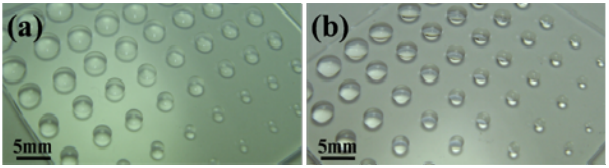

Figure 4. PDMS microlens array with various sizes. (a) PDMS microlens array fabricated by using droplet with contact angle of 41°. (b) PDMS microlens array fabricated by using droplet with contact angle of 75°.

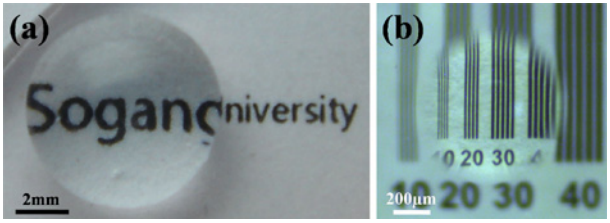

Figure 5. (a) Magnification with convex PDMS microlens. (b) Reduction with concave PDMS microlens.

variation in curvature. Fig. 4 shows PDMS microlens array with various sizes. We fabricated the microlenses with minimum size of 700 μm and maximum size of 7.5 mm in diameter. Fig. 5 (a) shows the image magnifying texts by using convex lens with 7.5 mm in diameter, and (b) shows the image that reducing patterns by concave lens with 700 μm in diameter.

CONCLUSIONS

We have fabricated the PDMS microlens with various sizes and curvatures by using droplet molds. This fabrication method has special advantages of simplicity and cost-effectiveness. In addition, with this technique, PDMS microlens can be fabricated with perfect and desirous curvature. Also, the fabricated PDMS microlens can be used for the lab-on-a-chip and optical system applications.

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