PDMS 칩 제작을 위한 하이드로젤 몰드 제작 방법

A novel preparation method of a hydrogel mold for PDMS chip fabrication

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1. Introduction

In this report we present a novel method of hydrogel micro molding for poly(dimethyl siloxane) (PDMS) chip fabrication. Hydrogels are a promising class of biomaterials since they can be easily tailored to produce desirable mechanical and chemical properties that resemble the native extracellular matrix and exhibit high permeability to oxygen, nutrients, and other water-soluble metabolites. Particularly, microscale hydrogels have been used for cell encapsulation, cell-based therapy, and bioprocess applications [1, 2]. But, hydrogels, to the best of our knowledge, have never been used as template materials in the mold preparation. These materials were commonly thought to be too weak for the intended applications. Indeed, most synthetic physical hydrogels are mechanically very weak, limiting their usefulness as templates for microfabrication. Thus, in this study, we demonstrate that hydrogels, particularly poly(ethylene glycol)-diacrylate (PEGDA), can be used as a photo-resist materials in microfabrication like a mold to fabricate PDMS microfluidic chip. Moreover the proposed fabrication process of a microfluidic mold is easy, fast and inexpensive with variuos applications.

2. Experiment

Hydrogel PEGDA from Aldrich was mixed with 3 wt% photo-initiator (2-hydroxy-2-methylpropiophenone 97% from Aldrich). Rhodamin B concentrated at 10mM was used as a color dye for optical observation. Adhesion promotor (trimethylsilyl methacrylate 98% from Aldrich) was poured and dried on a glass slide to improve adhesion between a hydrogel mold and the glass substrate. Then, three other glass slide and one poly-ethylene film were used to form a jig. Hydrogel solution was added into the jig and exposed under an UV source and through a film mask for 15 second at an UV intensity, 26 mW/cm^2. Rinsing with distilled (DI) water removed unexposed hydrogel and formed hydrogel patterns. Hydrogel was dried in oven at 65^{0}C in 20 minutes.

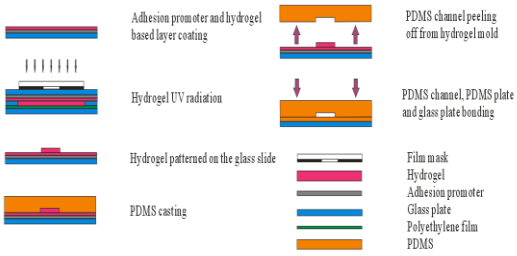

Fig. 1. Hydrogel mold and PDMS chip fabrication process.

In this study, the hydrogel patterns were used as a mold for PDMS casting to prepare a fluidic chip. The PDMS (Sylgard 184, Dow Corning) elastomer solution was prepared by mixing prepolymer with cross-linking agent in the weight ratio of 10:1. Then PDMS mixture was poured onto the master and cured in an oven at 65^{0}C for 2 hour. After curing, the PDMS replica was peeled from the master followed by drilling to place the posts that allocate the inlets and outlets. Then, the PDMS mold was bonded on other PDMS plate after plasma treatment for 2 minutes. This PDMS structure was put on a glass

substrate and finally, polyethylene tubes were placed into the holes and sealed with epoxy glue. This fabrication process was shown in Figure 1.

3. Results and discussion

Figure 2 shows photos of the fabricated hydrogel mold and PDMS casted replica which were taken by Stereo-scope (Olympus S22-STU1). These photos show a smooth and flat face of mold and replica. The hydrogel mold are reusable for next casting. The aspect ratio of the hydrogel mold is also high. In the figure 2c, the maximum aspect ratio of height and width is approximately 6. This property is important for a material which we want to use as a master mold. The hydrogel mold showed enough mechanical stability for casting.

The PDMS channels which were formed from hydrogel mold were tested in some fluidic experiments. Figure 3 shows a microfluidic device. Polyethylene tube were attached to syringes operated by digitally controlled syringe pump and liquids were supplied to the channel. In this experiment, the solution of polyethylene glycol monoethanolamin (PEG MEA) 20% in DI water Rhodamin and blue ink as red and blue color dye were supplied from two input channels. Flow rate was changed to control mixing process. The mixed solution range (brow color) or mixing rate will depend on the flow rate of input. This test setup can be use as a fluidic mixer or to prepare Janus particles [3]. In our case, by control the flow rate and mask window position for UV curing, janus or ternary (the third part is the mixed range) particles can be prepared and the color dyes can be changed by other functional group to have a various of functioned particles.

4. Conclusion

A novel method to prepare master for molding was advanced. Hydrogel mold can be formed without normally step-photolithography and used successful for PDMS casting . Some expensive materials like silicon wafer, photo resist, development solution could be replaced by inexpensive materials such as glass slide, hydrogel and DI water. This method is also fast compared with photolithography because it have not baking, developing process. This method is economic, fast and simple way to prepare master for molding.

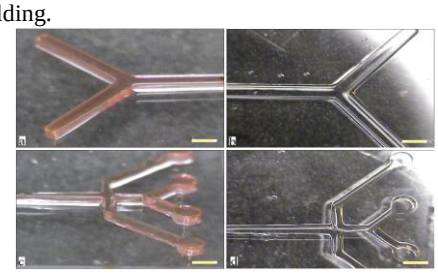

Fig. 2 Fabricated hydrogel mold and PDMS replica. Scale bar is 1mm. (a, b) design 1-fluidic mixer; (c, d) design 2-fluidic flow focusing.

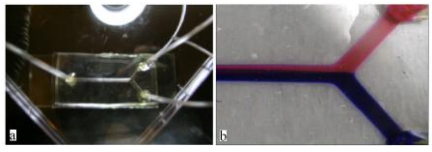

Fig. 3 (a) PDMS fluidic chip and (b) fluidic mixing experiment

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