IN-SITU FORMATION OF HYDROGEL MEMBRANES AND GROWTH OF COLLOIDAL CRYSTALS IN MICROCHANNELS USING ONE STEP STAMPING

Eunpyo Choi¹ and Jungyul Park¹*

¹Department of Mechanical Engineering, Sogang University, Seoul, Korea

ABSTRACT

This paper reports a novel method for in-situ formation of hydrogel membranes and geometrically controlled self-assembly of colloidal crystals in microchannels using one step stamping. The simple elastomeric stamp was made of PDMS from SU-8 patterned master using standard soft lithography. Then the selective hydrophobic pattern on the PDMS stamp surface was achieved using Pluronic F127 coating and staircase design. Finally, with this PDMS stamp, not only the formation of the In-situ hydrogel membranes with closed loop, but also the growth of colloidal crystals within microchannels was carried out.

KEYWORDS: One step stamping, In-situ hydrogel membrane, Closed loop, Photonic crystal, Microfluidic

INTRODUCTION

The formation of hydrogel membranes in microchannels has attracted considerable interest due to various applications, such as separating of components and tissue engineering [1]. Self assembly of colloidal crystals with controlled size, shape, and position is essential for fabricating a large-scale integrated microfluidic system [2]. However, so far, the existing methods for in-situ formation of hydrogel membranes are intrinsically impossible to form the closed loop and to grow colloidal crystals in the microchannels has only been achieved through the uncontrolled evaporation-induced self-assembly [3]. Moreover, there has been no possible common technique for formation of hydrogel membranes and growth of colloidal crystals in microchannels. The proposed one step stamping method can not only resolve previous problems, but also be applied into two different areas.

FABRICATION PROCESS

Figure 1(a) - (f) shows the fabrication process for the surface modified stamp with multilayered design: (a) A 4 inch silicon wafer was patterned with SU-8 resist (Microchem Inc.). The height of first layer for the shallow channel that can form the desired patterns was 7 μm for formation of hydrogel membranes and 25 μm for growth of colloidal crystals. Subsequently, SU-8 2050 was patterned on the first SU-8 layer (target: 200 μm, this layer is for the deep channel) (b) A PDMS precursor (Sylgard 184 Silicone Elastomer, Dow Corning) and a curing agent were mixed at the ratio of 10 to 1, based on weight. The PDMS mixture was poured onto the master and cured at 95 °C for 1 hr. (c) The PDMS was then peeled off. (d) Pluronic F127 was spin-coated on Si substrates. (e) PDMS was placed on the Pluronic F127 coated wafer and maintain at 35 °C temperature. (f) PDMS was stained with Pluronic F127 only outer surface. This stamp was applied to two cases as follows: (g, h) In hydrogel case, photo-curable poly (ethylene glycol)-diacrylate (PEG-DA) solution was spin coated on the silicon wafer or in colloidal case, the diluted silica bead (diameter: 300 nm) was coated on the wafer. Photo-curable PEG-DA solution was prepared from 99 wt% PEG-DA and 1 wt% of a water soluble photoinitiator 2-hydroxy-2-methylpropophenone. (i, j) Pluronic F127-stained PDMS was placed on the surface and was pressed carefully. (k, l) Since the Pluronic F127 is very hydrophobic, PEG-DA liquid droplet or diluted silica bead were stained on the only shallow-channels. (m) In hydrogel case, the PDMS was stamped on the glass and exposed to UV for a few tens of seconds 90 mW/cm². (n) In colloidal case, the PDMS was stamped on a PDMS-coated glass.

Figure 1: Schematic illustration of fabrication process
RESULTS AND DISCUSSION

Figure 2: Various patterns of in-situ hydrogel membranes with open loop and closed loop.

Figure 2 shows the various patterns of in-situ hydrogel membranes using one step stamping method. The upper row pictures show the linear shape hydrogel membranes and its value is 100 μm to 900 μm. Moreover, the lower row pictures show the various patterns of hydrogel membranes with closed loop. Scale bars are 200 μm.

Figure 3: Principle idea of the stable multi-chemical concentration gradient and the device characterization

We also showed the possibility to generate the concentration gradients with more than two kinds of chemicals simultaneously. In figure 3(a), the opened reservoir with four channels was isolated by the closed loop membrane formed by the proposed method. After all channels were filled with 0 % concentration chemicals, the high concentrated chemicals were introduced into channel A and B, respectively. We verified this concept by changing the direction of the fluorescence concentration gradients sequentially (figure 3(b)).

Figure 4: In-situ colloidal membrane within microfluidic channel. (a) rectangular-shaped (b) horn-shaped

Figure 5. Unidirectional colloidal growth within the shallow-channel of horn-shaped with hyperbolic edges
Moreover, the colloidal crystallization in microchannels were demonstrated using the one stamping method. The direction of colloidal growth was controlled by the geometrical shape of shallow-channel. Unlike the rectangle-shaped channels (figure 4(a)), the colloidal growth was unidirectional when the channel has horn-shaped with hyperbolic edges (figure 4(b)) and this performance was visualized using microspheres with 6 μm size. As shown in figure 5, the colloidal growth was formed from a wide to a narrow-opening unidirectionally and finally, figure 6 shows the corresponding optical micrographs and the SEM image of the formed colloidal crystals.

![Image of colloidal crystals](image)

*Figure 6: Optical micrographs and SEM image of colloidal crystals in the horn shaped channels.*

**CONCLUSION**

The proposed one step stamping method showed its versatility by successful demonstration for the formation of hydrogel membranes and colloidal crystals in microchannels and it can enhance the functionality of a wide range of microfluidic systems such as bio/chemical sensors, optoelectrical devices and filters.

**ACKNOWLEDGEMENTS**

This work was supported by the Pioneer Research Center Program "Bacteriobot" through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology (2009-0082953) also supported from the Mid-career Researcher Program through National Research Foundation Science (NRF) (2008-0062056).

**REFERENCES**


**CONTACT**

*Jungyul Park, tel: +82-2-705-8642; sortpark@sogang.ac.kr*