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Microfluidic Flow of Dyed Water in the SU-8 based Glass Devices

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Abstract
Two individual SU-8 based glass microfluidic devices are fabricated by the maskless lithography and indirect bonding technique. Dyed water is used as working liquid to record the surface-driven capillary flow in each microfluidic device. In the indirect bonding technique, polymethylmethacrylate (PMMA) dissolved in EC solvent is used as the adhesive material to fabricate the leakage-free microfluidic device. CMOS camera is used as the recording tool in this work. This work will be suitable to fabricate the SU-8 based microfluidic lab-on-a-chip systems.

Keywords: *SU-8, lithography, microchannel, dyed water, CMOS camera*

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INTRODUCTION

According to the published literatures, surface-driven capillary flow is governed by the surface tension forces at the solid-liquid interface in any sealed microfluidic device [1, 2]. Surface-driven capillary flow is applicable in the lab-on-a-chip systems according to different designs of microfluidic networks [1–23]. Surface-driven capillary flow has many advantages with respect to active capillary flow in microfluidic lab-on-a-chip systems for biomedical applications [23–33]. Different materials are useful to fabricate the microfluidic devices [13]. Different bonding techniques are available to fabricate the leakage-free microfluidic devices [18]. The bonding technique should be properly selected with respect to the chosen material for fabrication. According to the research on microfluidics, polymethylmethacrylate (PMMA), SU-8 and polydimethylsiloxane (PDMS) are the common materials to fabricate the leakage-free microfluidic devices for different applications [1–33].

The bonding techniques related to the leakage-free microfluidic devices are categorized as direct bonding technique and indirect bonding technique [18]. In the direct bonding technique, no adhesive material is needed between the microchannel substrate and the lid substrate to achieve leakage-free sealing [18]. Suitable adhesive material is used between the microchannel substrate and the lid substrate to fabricate the leakage-free microfluidic device in the indirect bonding technique [18]. In this work, the SU-8 based glass microfluidic devices are fabricated by the indirect bonding technique to record leakage-free surface-driven capillary flow of dyed water.

EXPERIMENTAL TECHNIQUES

In this work, SU-8 is the negative photoresist used to fabricate two individual microfluidic devices by indirect bonding technique [13, 18]. Maskless lithography is the photolithographic technique for SU-8 in the fabrication of these microfluidic devices [13, 18]. Colourless liquid EC solvent is used as the SU-8 developer in maskless lithography [13]. PMMA is dissolved in EC solvent to have the resulting solution as an adhesive material in the indirect bonding technique. This resulting solution is coated on glass lid to bond the glass lid with SU-8 based microchannel substrate [13]. CMOS camera is used to record the surface-driven microfluidic flow [13]. Red dye is used to prepare the dyed water [13]. Glass is an optically transparent material. Therefore, dyed water facilitates the recording of surface-driven capillary flow.

RESULTS AND DISCUSSION

SU-8 based glass microfluidic devices are fabricated by the maskless lithography using the SF-100 instrument (Intelligent Micropatterning, LLC, Florida) inside the cleanroom laboratory of class 1000 standard according to the Federal Standard 209E. At the beginning of fabrication process, the glass slides are cleaned by acetone and deionized (DI) water. In the next step, the glass slides are dehydrated on the digital hot plate (Cole-Parmer, USA) at 115°C for 5 minutes [13]. Then, the glass slides are cooled down up to the cleanroom temperature of 26°C by a natural cooling on the digital hot plate. Next, SU-8 50 (CHESTECH Ltd., England) is coated on each glass slide by a spin speed of 2500 RPM in a SCS G3 Spin Coater (Specialty Coating Systems, Indiana, USA). Then, the coated glass slide is soft baked on the digital hot plate at 65°C during 15 minutes. After that, the temperature of the digital hot plate surface is ramped from 65°C to 95°C, and then the coated glass slide is soft baked at 95°C during 30 minutes [13].

After this baking procedure, this soft-baked sample is used in the maskless lithography by SF-100. The baked sample is properly placed on the exposure bench in the SF-100. The soft baked SU-8 layer is exposed to the UV light of 365 nm in SF-100 at a radiation intensity of 311 μW.cm^{-2} (measured by an Ultra Violet Intensity Meter) for 35 seconds. Two individual portions of this soft baked sample are exposed by one after another UV-exposure of equal exposure time and equal UV-intensity in the SF-100. For sufficient cross-linking, the sample is baked on the digital hot plate at 65°C for 5 minutes.

The next fabrication steps are described as follows: (a) the temperature of the digital hot plate surface is ramped from 65°C to 95°C, and the sample is baked at 95°C during 15 minutes; (b) after the post-exposure bake, the sample is cooled down on the digital hot plate surface up to the cleanroom temperature of 26°C by a natural cooling; (c) then the sample is developed by the colour less liquid EC solvent (SU-8 developer supplied by MicroChem, USA) during 5 minutes on the chemical bench [13].

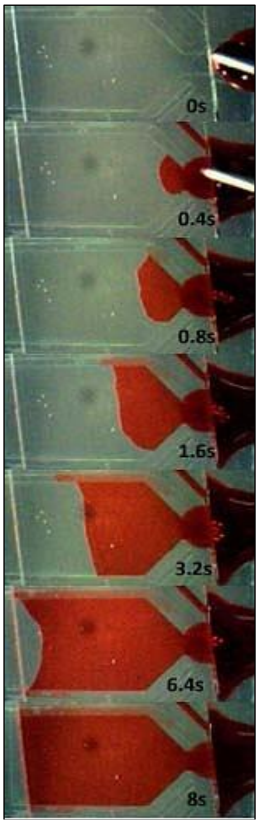

Fig. 1: *Surface-driven Capillary Flow of Dyed Water in the First Microfluidic Device is Recorded by the CMOS Camera.*

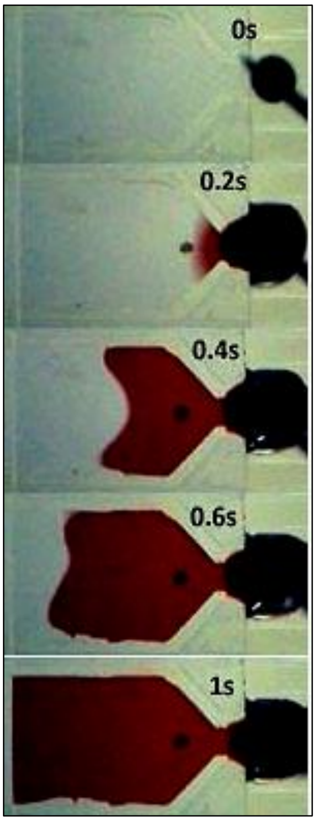

Fig. 2: *Surface-driven Capillary Flow of Dyed Water in the Second Microfluidic Device is Recorded by the CMOS Camera.*

Another glass slide is coated by the prepared adhesive liquid (PMMA dissolved in EC solvent). This coated glass slide is cut into two different glass lids using a glass cutter according to the selected lid dimensions. The next bonding steps are briefly described as follows: (a) the individual glass lids are properly placed on the microchannel substrate fabricated by SU-8; (b) the sample is hard baked on the digital hot plate surface by a temperature ramp from 120°C to 195°C (well below the glass transition temperature of SU-8) during 26 minutes maintaining a continuous pressure of 4 kg-wt on the glass lids; (c) the sample is cooled down up to the cleanroom temperature of 26°C by a natural cooling. In the Figures 1 and 2, the surface-driven capillary flow is recorded individually by the CMOS camera catching 25 frames per second with a corresponding time-scale resolution of 0.04 second. In both of the Figures 1 and 2, the air-water meniscus is very prominent. A concave meniscus-profile is observed in the second half of each microfluidic device (Figures 1 and 2).

CONCLUSIONS

In this work, the SU-8 based glass microfluidic devices are fabricated by the maskless lithography and indirect bonding technique. The surface-driven capillary flow of dyed water is recorded by the CMOS camera. The meniscus profile is recorded and observed during each capillary flow. This work will be suitable to fabricate the SU-8 based microfluidic lab-on-a-chip systems.

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