FORMATION OF 3-DIMENSIONAL MICROFLUIDIC COMPONENTS USING DOUBLE-SIDE EXPOSED THICK PHOTORESIST MOLDS

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ABSTRCT

We propose a new 3-D mold technology which allows the direct formation of complicated 3-D microfluidic components without multi-stacking of PDMS layers. The proposed technology has utilized double-exposed thick photoresist replica molds with combination of partial exposures and single development. We have successfully fabricated various 3-D photoresist molds including recessed cantilevers, suspended beams and complex plates with micro-pits and micro-villi for possible embodiment of microfluidic components such as micromixers, multi-layer fluidic interconnection channels and microfilters.

Keywords : Microfluidic channel, Microfilter , PDMS, 3D mold

1. INTRODUCTION

PDMS (Polydimethylsiloxane) has been drawing an increasing attention in the fabrication of microfluidic components. Many groups have reported PDMS micro-molding techniques to fabricate microfluidic systems. Unlike traditional microfabrication materials, such as silicon and glass, PDMS can provide versatile shaping of many variations in microchannels at low-cost. Micro-molding processes typically used for PDMS channel formation are very simple and have a much faster turn-around time compared to conventional microfabrication processes used in etching and bonding approaches. However, in order to construct complex 3-D microchannels using typical PDMS fabrication processes, it is required to align and multiple stack the patterned PDMS layers which are relatively thin [1][2]. In this work, we propose a new 3-D mold technology for the direct formation of 3-D microfluidic components using double-exposed thick photoresist replica molds with combination of partial exposures and single development.

2. FABRICATION PROCESS FOR 3-D PHOTERESIST MOLDS

Fig. 1 shows the proposed fabrication processes for 3-D photoresist molds. Fabrication starts using a glass wafer. At first, Cr is deposited and patterned as a mask for back side UV exposure which will be used in the later process step (Fig. 1(a)). Next, thick photoresist (AZ9260) is spin coated over the Cr patterned glass wafer (Fig. 1(b)). The

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thickness of photoresist is about 80μm. A partial UV exposure from the back side defines the amount of suspended height of the PR mold. Next, a partial front-side UV exposure is performed to define the front side shaping of the PR mold (Fig. 1 (d)), followed by a deep exposure all the way down to the glass substrate (Fig. 1 (e)). During the front-side exposures, multiple exposures with different photomasks are performed to expose respective partial depths in the thick photoresist [3]. Finally, the 3-D PR mold is obtained after single development, delineated in the unexposed volume of the photoresist (Fig. 1 (f)).

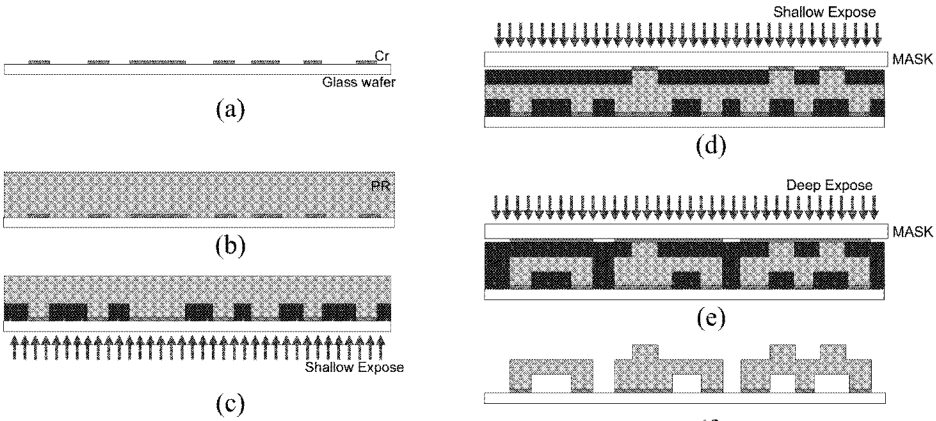

Figure 1. Fabrication process flow for 3-D photoresist molds. (a) Cr deposition & patterning, (b) Thick PR (AZ9260) coating, (c) Back side shallow exposure, (d) Front side shallow exposure, (e) Front side deep exposure, (f) Development

3. FABRICATED 3-D MOLDS

Fig. 2 shows SEM photographs of the suspended 3-D photoresist molds fabricated by the proposed method. The partial exposure has made the PR molds suspended about 20μm from the bottom and recessed about 20μm from the top as well. These suspended and recessed thicknesses can be adjusted by partial exposure control. Various shapes of photoresist molds can be fabricated including recessed cantilevers, suspended beams, suspended plates with micro-pits and micro-villi, and complicated fluidic channels and orifices as shown in Fig. 3.

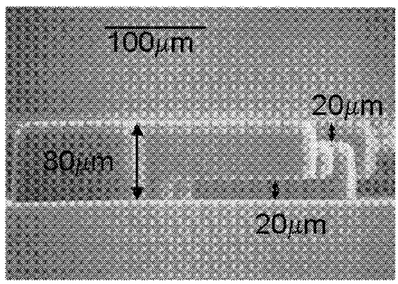

Figure 2. Cross-section of suspended PR molds.

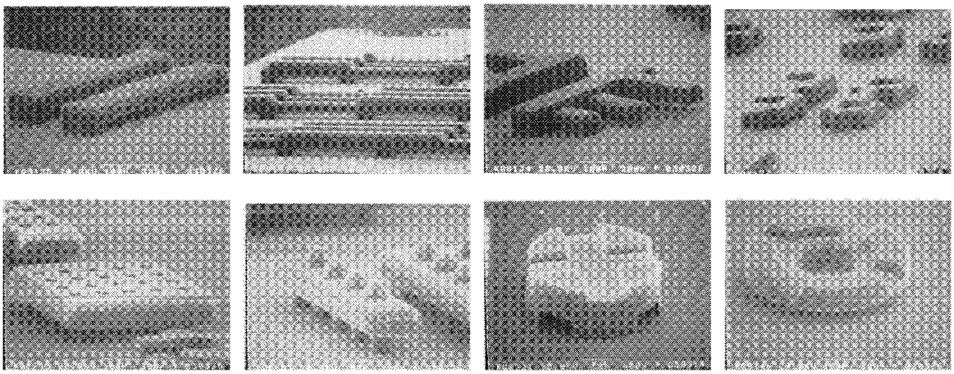

Figure 3. Various PR mold structures for microfluidic components

4. APPLICATIONS TO MICROFLUIDIC COMPONENTS

Fig 4 shows how 3-D microfluidic components can be formed using the fabricated PR molds. A suspended bridge mold can be used to form multi-layer fluidic interconnection channels as shown in Fig. 4(a). Fig. 4(b) shows an application for micro filters. The filter hole size can be adjusted by the size of micro-villi formed on the top of the suspended plate mold. Fig. 4(c) shows an application for passive micro-mixers. In our previous work [4], two PDMS structures were aligned and bonded together for the fabrication of micro-mixers. On the contrary, if we use the proposed process, fabrication can be simplified and the channels are accurately self-aligned with the masks used during the mold processes. This can reduce misalignment error and provides precise control of fluidic channel sizes. Fig. 5 shows the fabricated PDMS structures by using thick PR molds. Fig. 5(a) shows the holes formed inside a microfluidic channel for microfilters, while Fig. 5(b) shows the 3-D fluidic channels formed for micro-mixer applications.

5. CONCLUSIONS

We have proposed a new 3-D mold technology for the direct formation of 3-D microfluidic components using double-exposed thick photoresist replica molds with combination of partial exposures and single development. We used a glass wafer deposited with a patterned Cr mask for back side UV exposure. Thick photoresist (AZ9260) mold of 80μm has been shaped with multiple partial UV exposures from the back side as well as from the front-side to define a suspension height from the bottom and a recess height from the top. An additional deep exposure followed by single development has delineated the unexposed volume of the photoresist molds. Using the fabricated 3-D molds, we have successfully demonstrated the simple and precise embodiment of various microfluidic components such as micromixers, multi-layer fluidic channels and microfilters.

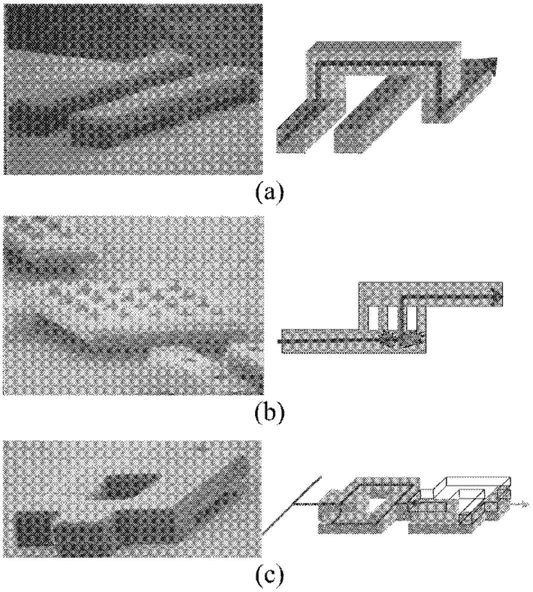

Figure 4. Applications of 3D PR molds (a) Fluid bridge (b) Microfilter (c) Passive micro-mixer

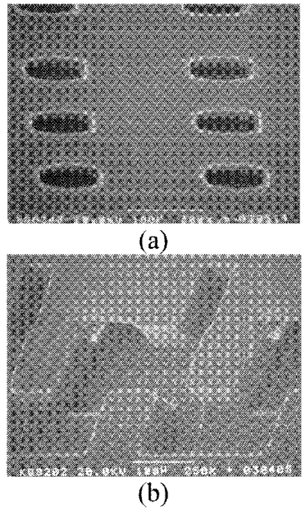

Figure 5. Fabricated PDMS structures (a) holes formed inside the microfluidic channel for microfilters (b) 3-D channels of micro-mixer

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