

Design and fabrication of a Micro Flow Cytometer with Integrated Microlens

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We report a research work on design and fabrication of a MEMS flow cytometer device with integrated out-of-plane microlens and a three-dimensional (3-D) hydrofocusing unit. Multiple steps of tilted UV-lithography of SU-8 were used to fabricate the device on silicon substrate. Cured SU-8 polymer was used as the structural material for both the microlens and the fluid channels.

Conventional cytometer often has a hydrofocusing unit to focus the sample cells into a single file flow; a detection unit to collect the scattering light emitted by the pre-dyed sample cells; and other functional units for cell-sorting or other purposes. Due to the fact that UV-lithography is a planar process, most reported MEMS flow cytometer only focus the sample cells in a two-dimensional fashion [1, 2] and only thin cylindrical lens has been integrated into MEMS flow cytometers [3]. To achieve better sample hydro-focusing and higher detection efficiency, a MEMS flow cytometer with integrated focusing lens and 3-D hydro-focusing unit was developed. Schematic of the designed MEMS flow cytometer is shown in Figure 1.

Tilted UV-lithography was used to fabricate the proposed device. In tilted lithography process, wafer and mask were fixed in a home-designed chuck which can rotate from 0° - 90° and a 45° prism was used to conduct the UV-light onto the mask in desired angle (more details about tilted UV-lithography were presented in our group's previous paper [4]). The fabrication process can be briefly described here. After the first layer of SU-8 (500 nm) was spin-coated on silicon substrate and soft-baked, tilted UV-lithography was conducted to fabricate three 30° slopes which were parts of the hydro-focusing chamber. A second layer of SU-8 was spin-coated on the wafer and soft-baked to make the total thickness to 1000 nm. Then, $\pm 45^{\circ}$ tilted exposures were performed to make the microlens and the fiber holder. The last step was to use conventional UV-lithography to define the fluidic channels. After post-bake, the wafer was developed in glycol methyl ether acetate (PGMEA) for 2 hours to obtain clear fluidic channels and smooth spherical microlens surface.

Figure 2 shows some key structures in the fabricated MEMS flow cytometer. Inclined slopes shown in Figure 2 (a) are clear and smooth. Figure 2 (c) shows a microlens array which is embedded into one of the fluidic channel walls (as shown in Figure 1). By controlling the exposure dosage and development time, out-of-plane spherical microlenses are formed. Since the microlens array and optical fiber holder were fabricated using the same photo mask, inserted output fiber is precisely aligned with one of the microlens pixel without any manual adjustment.

Some work has also been done to investigate the fast replication of the out-of-plane micro lens array with PDMS molding process. This provides a method to fabricate out-of-plane micro lens

with other curable polymer material with better optical property comparing to SU-8 and can potentially broaden the application of our out-of-plane micro lens array.

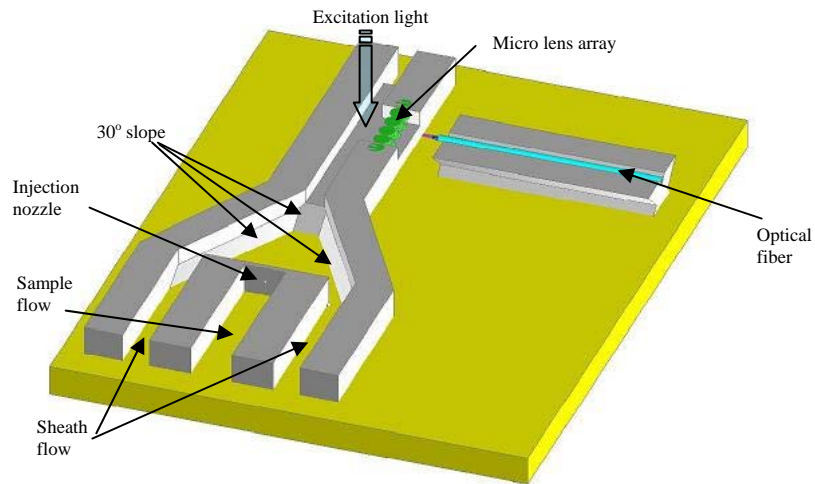


Fig. 1. 3-D layout of the designed MEMS flow

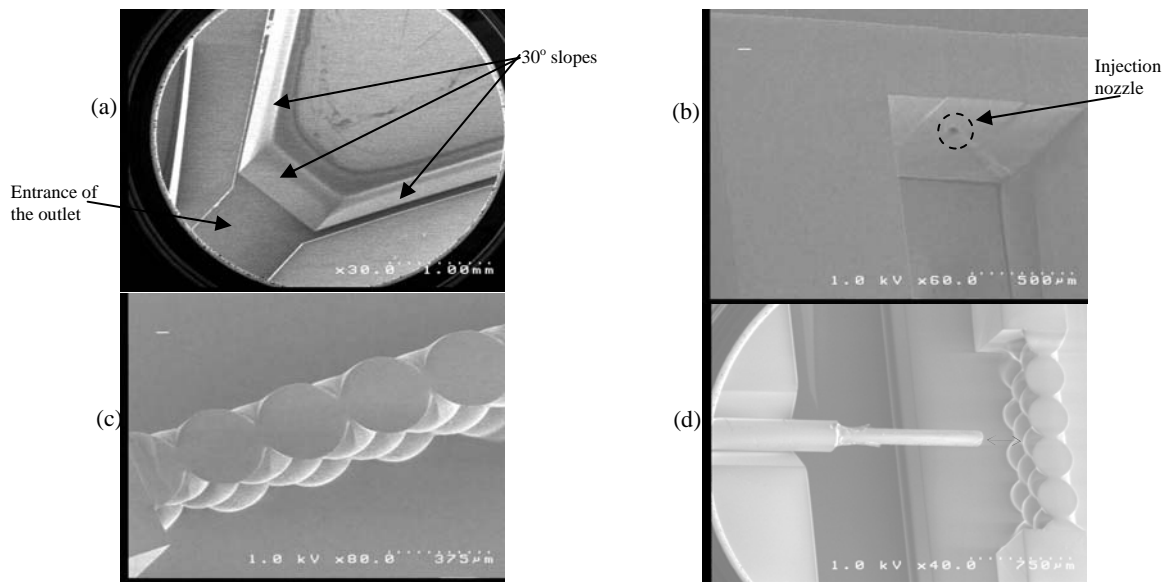


Fig. 2. SEM pictures of the key structures on the fabricated MEMS flow cytometer

References

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