Lateral Flow Particle Filtration and Separation with Multilayer Microfluidic Channels

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Three-dimensional multilayer polymer microstructures have many applications in electronics, photonics and bioengineering. They are particularly attractive for building multilevel microfluidic channels, which allows for three-dimensional integration of microfluidic components in a lab-on-a-chip system to increase its functionality for biomedical applications. The multilayer microfluidic channels can be easily fabricated by reversal nanoimprint and transfer-bonding under optimized conditions[1]. In this work, we present a lateral flow particle filtration and separation device based on multilayer microfluidic channels. In this device, each layer contains microchannels of different sizes and the channels are stacked on top of each other. When a solution with particles of various sizes flows along the channels in each layer, larger particles will be retained in the top channels, while smaller particles can migrate into bottom channels (Fig.1). Unlike vertical membrane filtration and separation, lateral flow prevents pore clogging and the device can operate continuously for large volume processing. Particles of different sizes can be extracted in each layer. Another significant advantage is that such device allows particles to be separated into multiple size ranges in one run according to the number of the layers and the width of the channels in each layer in the device.

The multilayer particle filtration and separation device is fabricated by double-side nanoimprint with two different molds[2] and transfer-bonding. The molds for nanoimprint were fabricated from thermally grown silicon oxide wafer by electron-beam lithography or photolithography and reactive ion etching. A PDMS precursor film was coated on Si wafer and then imprinted with 1H,1H,2H,2H-perfluorodecyltrichlorosilane (FDTS)-coated mold (Fig.2(a)). This PDMS layer will serve as the bottom microchannels of the device. In the double-side imprint process (Fig. 2(b)), the top mold was coated with FDTS while the bottom mold was coated with octadodecyltrichlorosilane (OTS) so that the PDMS layer could stay on the bottom mold after nanoimprint. The double-side imprinted PDMS layer on the OTS-coated mold was then transfer-bonded with the first layer as shown in Fig. 2(c). To ensure an excellent bonding between two PDMS layers, a brief oxygen plasma treatment was performed on both layers. More layers can be added by repeating those steps to construct multilayer PDMS structures. Figure 3 shows the multilayer PDMS microfluidic structures obtained by this technique. Particle filtration and separation will be demonstrated in such three-layered microfluidic device.

Due to the excellent bonding between the PDMS layers, the process yield is very high. Also good bonding ensures that there is no limitation on how many layers can be added into the device. This can be very useful for filtration and separation applications with stringent particle sorting requirements.

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[1] H. Park, H. Li, X. Cheng, *J. Vac. Sci. Technol. B* **2007**, *25*, 2325.
[2] N. Lucas, S. Demming, A. Jordan, P. Sichler, S. ttgenbach, *J. Micromech. Microeng.* **2008**, *18*, 075037.

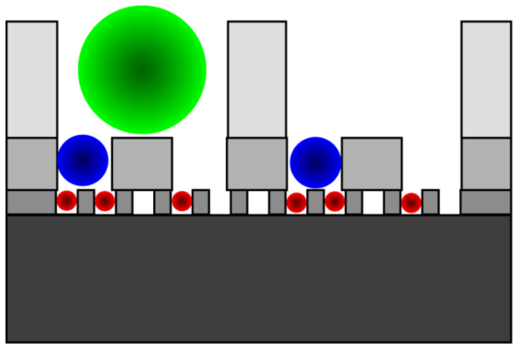

Figure 1. A schematic of the cross-sectional view of the lateral flow particle filtration and separation device based on multilayer microfluidic channels. Colored circles represent particles of different sizes.

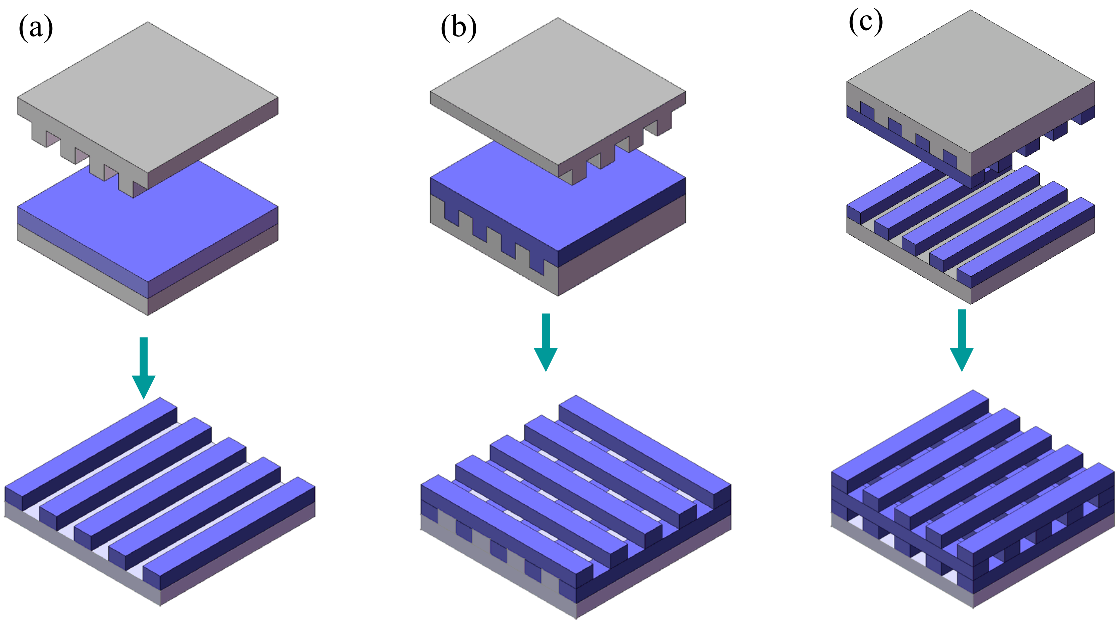

Figure 2. Schematics of the fabrication process for the multilayer PDMS microchannels. (a) Nanoimprint to create the bottom PDMS layer; (b) Double-side imprint with two different molds for middle and top PDMS layers; (c) Transfer-bonding to complete the multilayer device.

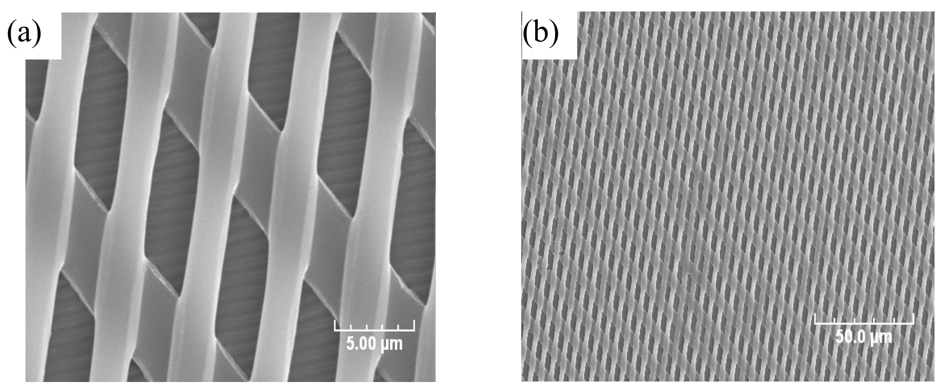

Figure 3. SEM micrographs of multilayer PDMS microfluidic channels. (a) Three-layered PDMS channels. The channel widths in the multilayer structure are 0.35 µm, 5 µm and 10 µm, scale bar 5 µm; (b) A zoom-out view showing the high yield of the fabrication process, scale bar 50 µm.