A MICROFLUIDIC DEVICE FOR PARTICLE SEPARATION UTILIZING EAVES STRUCTURES

Huei-Wen Wu[1], Chun-Wei Huang[1] and Gwo-Bin Lee[1,2*]

[1]Department of Engineering Science, National Cheng Kung University, Taiwan and [2]Medical Electronics and Device Technology Center, Industrial Technology Research Institute, Hsinchu, Taiwan

ABSTRACT

This study presents a new microfluidic device for particle separation utilizing tilted eaves-like structures to separate small particles from a large volume of bio-samples with various particle sizes without clogging in the microchannel. Experimental results showed that the microchip was capable of separating microparticles with diameters of 5, 20 and 60 μm using the proposed device. The developed microfluidic device also provides a simple way to perform a reasonable separation (86%).

KEYWORDS: microfluidics, separation, MEMS

INTRODUCTION

In the past decade, various particle separation techniques utilizing dielectrophoresis, optical forces, magnetic forces or gravity forces have been reported in the literature. However, such systems always require complicated fabrication processes and delicate fluid control to attain higher separation efficiency. Moreover, particle samples may be damaged while applying external forces [1]. To solve the problems, the microfilter devices with different geometries in the microchannel have been proposed with the advantage of simplicity to operate. Nevertheless, the issue regarding clogging of the microchannel should be addressed properly. Therefore, this paper reports a passive separation chip with eaves-like structures in the microchannel. It can alleviate the clogging problem and avoid the use of the external force such that cells are not damaged during the separation process.

DESIGN AND FABRICATION

A simplified schematic diagram of the microfluidic device is shown in Fig. 1(a). Buffer solution was used to squeeze the sample flow to form a narrow stream so that the sample flows close to the eaves-like structures to obtain a higher separating efficiency. Moreover, a sharp corner structure was used to enhance the focusing effect [2] (Fig. 1(b)). Figure 1(c) shows schematically the eaves-like structures with a gap of 10 μm. Particles or cells with a diameter less than 10μm can flow through the gap and be collected in the collection reservoir. Large particles can flow downwards due to the fluidic force without clogging the gap. The flow manner of the particles with different sizes was depicted in Figure 2. The smaller particles flowing through the gap of the eaves structures can be separated from large particles. The microfluidic structures were formed using polydimethylsiloxane (PDMS) fabricated on a silicon wafer. Figure 3(a) shows a photograph of the particle separation device. The dimen-

978-0-9798064-1-4/μTAS2008/$20©2008CBMS

sions of the chip are 17 mm × 20 mm. The SEM images of the SU-8 structure and PDMS mold of the eaves-like structures are shown in Figure 3.

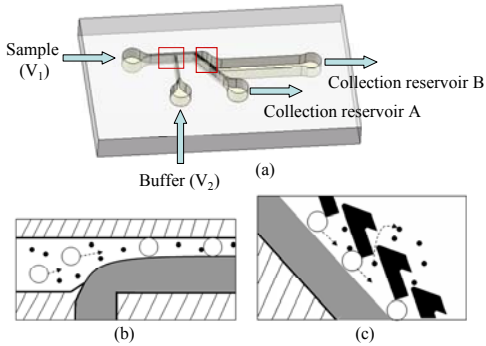

Figure 1. (a) Schematic illustration of the particle separation device; (b) Enclosed view showing that particles can be focused to form a narrow stream ; (c) Enclosed view showing that the eaves-like structures can separate small particles from large ones.

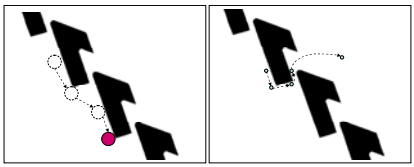

Figure 2. Schematic diagram of the working principle of the particle separator. (a) The larger particles are separated; (b) The smaller particles flow through the gap of the eaves structures.

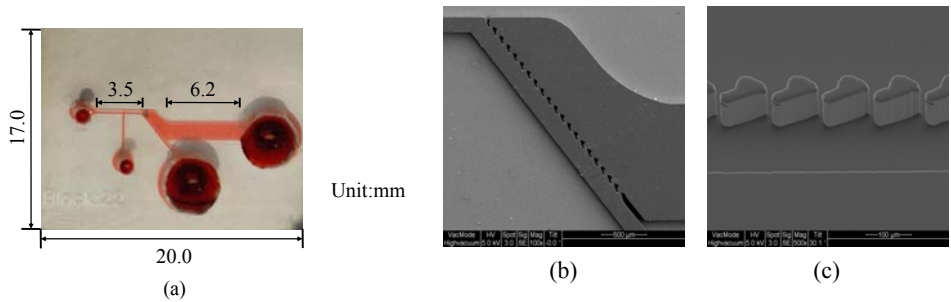

Figure 3. (a) A photograph of the assembled separation chip; (b) SEM image of the SU-8 structures; (c) SEM image of the PDMS mold of the eaves-like structure.

RESULTS AND DISCUSSION

Figure 4 shows a series of CCD images indicating that particles with various sizes flowing near the eaves-like structures. The diameters of these particles are 5, 20 and 60 μm respectively. From the images, it is clearly seen that 5-μm particles can successfully flow through the gap. The 20- and 60-μm particles can flow downwards and will not clog the filters. It indicates that the larger particles have stronger inertia forces while the flow rate is faster. The separation efficiency of small particles (5μm) is determined by the sample and buffer flow velocity ratio and is shown in Fig. 5. The experiments were performed by operating the beads with the diameter of 5 μm on the development chip, and then counted the number of the beads taken off from the collection reservoirs A and B. Finally the separation efficiency was ob-

tained by calculating the ratio of the counted number of reservoir B to the one of the sum of the reservoirs A and B. Experimental results show that lower velocity rate ratio can result in higher separation efficiency. The developed microfluidic device provides a reasonable average separation of 86% for the first separation, while the numbers of the counted particles are 4777 and 5048 in reservoir A and 24300 and 31481 in reservoir B. The higher separation efficiency can be enhanced for multiple separation processes.

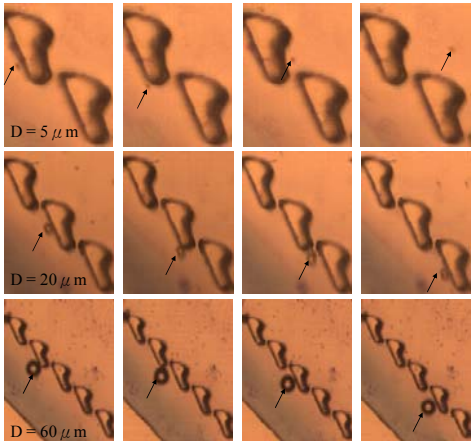

Figure 4. CCD images for tracing particles with various diameters. (a) D=5 μm; (b) D=20 μm;(c) D=60 μm.

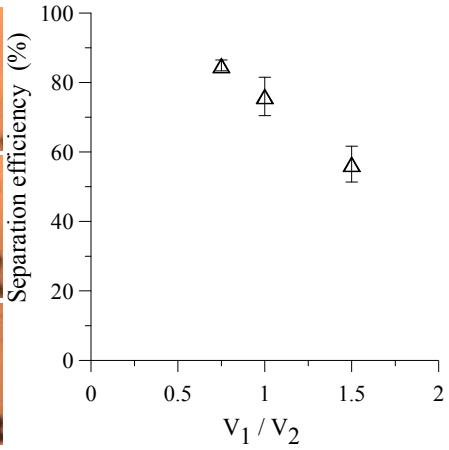

Figure 5. Relationship between the separation efficiency of particles (5 μm) and sample/buffer flow velocity ratio.

CONCLUSIONS

The current study has successfully demonstrated a microfluidic separation device using tilted eaves-like structures to separate different sizes of particle. Compared with conventional microfluidic devices employing similar techniques, high throughput can to be realized by injecting a large number of particle samples into the proposed microchannel. No clogging has been observed. Moreover, the developed microfluidic separation device may be a simple approach for further biomedical cell separation.

ACKNOWLEDGEMENTS

The authors would like to thank the National Science Council in Taiwan for financial support.

REFERENCES

[1] N. Pamme, W. Wijnaart, and G. Stemme, Continuous flow separations in microfluidic devices, Critical Review, Vol.7, pp.1644 (2007).

[2] C. H. Lin, C. Y. Lee, and L. M. Fu, Continuous particle sorting utilizing cascade squeeze-jumping effect under microfluidic configuration, 19th IEEE International Conference on Micro Electro Mechanical Systems (2006).