On-Chip Microfluidic Device Using Geometrically Induced Fluid Flux Control for Capturing Circulating Tumor Cells in Whole Blood

Sunki Cho[1], Yoo-sang Yoon[1], Seonil Kim[1], Onejae Sul[2], Seung-Beck Lee[1,2*]

[1]Department of Electronics and Computer engineering, and [2]Institute of Nano Science and Technology, Hanyang University, 133-791, Seoul, Korea

*sbl22@hanyang.ac.kr

Abstract

Clinical diagnosis is one of the most promising applications for microfluidic lab-on-a-chip type micro-total-analysis systems (μ-TAS). The reduced use of reagents and reduced human generated sample decreases the analysis time and prevents possibility of manipulation error. Recently, the detection and enumeration of circulating tumor cells (CTCs) in cancer patients has made it possible to apply tailored treatment for increasing life expectancy by detecting the onset of metastasis before radiological diagnosis [1]. Applying a cell-trapping functionality to the CTC detection system, the μ-TAS will be possible not only to increase the accuracy of enumeration, but also to allow further analysis of CTCs for enhanced patient treatment development. Here, we developed an on-chip microfluidic device that was capable of capturing CTCs individually from whole blood specimens. It is reported that the size of CTCs are generally larger than other cell types in the blood, which enables size-based isolation of CTCs [2]. Figure 1 shows the mechanism of single-cell capture of CTCs; the difference in fluid flux between the drain channel and the branched channel caused by their respective length and width. A cell at the branch will be guided to the faster channel, where it will self-plug the drain channel, if the size of the cell is bigger than the width of the drain channel. Once plugged, the fluid pressure becomes high enough to stop further cell trapping [3]. The microfluidic device consists of three layers: silicon chip for the substrate, SU-8 for the vertical fluid channel walls, and poly(dimethyl siloxane) (PDMS) for the top channel sealing. To prevent leakage caused by weak adhesion between the layers, SURPASS 3000 and (3-Aminopropyl)triethoxysilane solution were applied to the fabrication process [4]. With further development, our microfluidic system may be applied to various cancer-related clinical evaluations.

References

[1] Mi-Young Kim et al. Cell, **139** (2009) 1315
[2] Songdong Meng et al. Clinical Cancer Research, **10** (2004) 8152-8162
[3] Wei-Heong Tan et al. Proceedings of the National Academy of Sciences of the United States of America, **104** (2007) 1146-1151
[4] Pengfei Li et al. Sensors and Actuators B, **166-167** (2012) 870–877

Figures

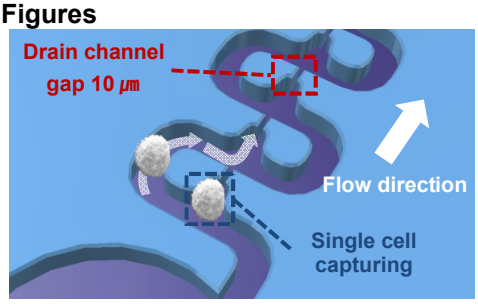

Fig. 1. Capturing mechanism of CTCs

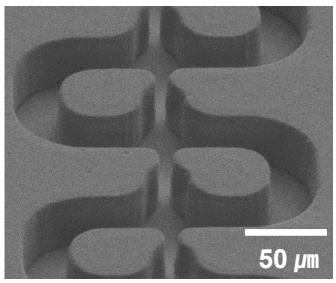

Fig. 2. SEM image of the device

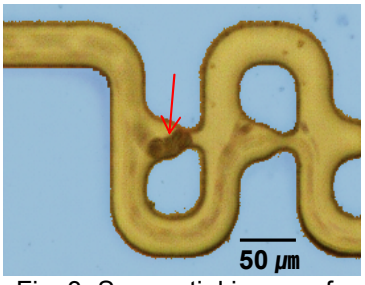

Fig. 3. Sequential image of a CTC capture