Automated Reverse Rotation Centrifugal Microfluidic Chip System for Reflow and Trapping of Single Cells

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Single cell trapping has proven to be one of the key strong points of microfluidics technology in the field of Life Sciences. Many reports have been presented claiming to have very high trap efficiency (~100%). However, when compared to the number of cells perfused through the trap arrays, most of the cells go to waste. This poses an issue when dealing with rare cells such as circulating tumor cells, stem cells, cell infected by virus or parasites, or to a suspension from a biopsy sample where all cells are desired to be analyzed. To address this concern, a reflow system has been envisioned to increase the probability of particle trapping. Hydrodynamic trapping has been highly favored among single cell trapping technologies for its easy parallelization of particle manipulation and handling. In addition, centrifugal microfluidics is a preferred flow control microfluidics technology due to its simplicity and familiarity of most individuals in operation. With the combination of the two technologies and utilizing the conservation of momentum theory, a reflow system has been envisioned by simply changing the rotation. This report presents the design and operation of the developed centrifugal microfluidic system that utilizes alternating reverse rotation to induce the reflow in the designed microfluidic chip. A good trapping capability has been observed with 15 um bead and with THP-1 cells after 10 flips. A trapping efficiency of ~55% has been observed and doesn't seem to vary as the number of flips changes. A close inspection of the inlet and outlets shows that there are particles that didn't enter the channel. Thus, the constant trapping efficiency indicates that the particles that enter the channels remained and get trapped. Still, a new design for the inlet is needed to ensure that all particles will enter the channel.

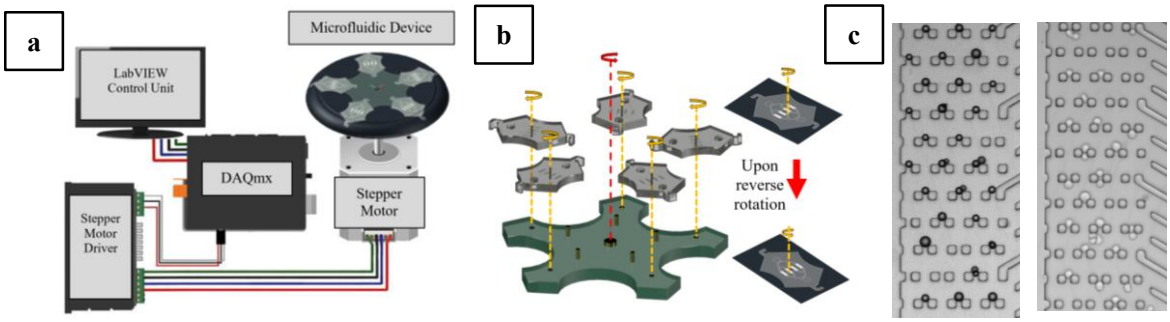

Fig. 1. Design and operation of the microfluidic device. (a) Schematic Diagram of the system. (b) Illustration of the rotating stage and microfluidic chips placed 4cm (from chip center) away from the center. The reverse orientation of the chip is also illustrated. (c) Trapped beads and THP-1 cells.