Development of a Single Cell Trapping Microfluidic Device

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Introduction: A large-scale array of single cells allows high-throughput monitoring of the behavior of individual cells in parallel, avoiding the lack of cell specificity. Here, we designed a passive-pumping microfluidic device for trapping single cells in an array and used COMSOL to simulate the velocity field of the laminar flow within the device.

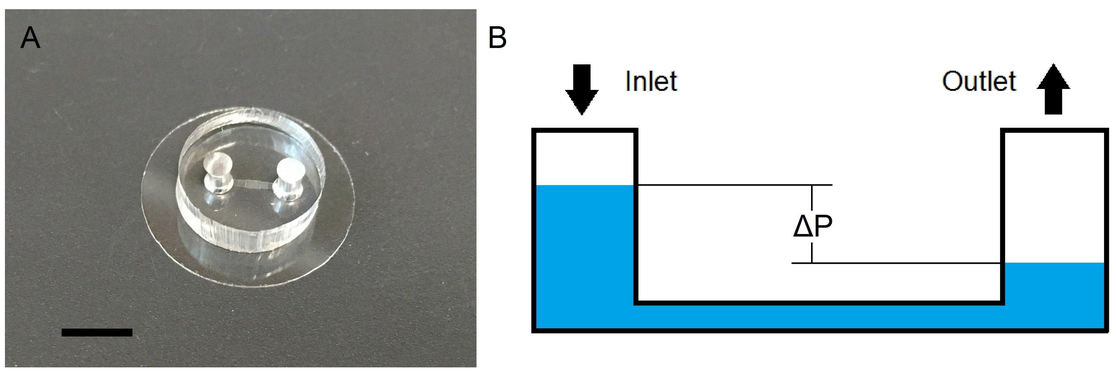

Figure 1. A: The single cell trapping microfluidic device with featured PDMS (3 mm in thickness) bonded to a cover glass (scale bar: 5 mm); B: Passive-pumping mechanism: the fluid flow is driven by the pressure difference between the inlet and outlet reservoirs.

Computational Methods: The geometry of the single-layer flowing channels and the dual-layer trapping array are shown in Figure 2. To increase the trapping efficiency, we designed a 10 μm gap between each pair of trapping posts and a 2.5 μm gap between the trapping posts and the cover glass. The CFD module was used to simulate the velocity field of the laminar flow within the device.

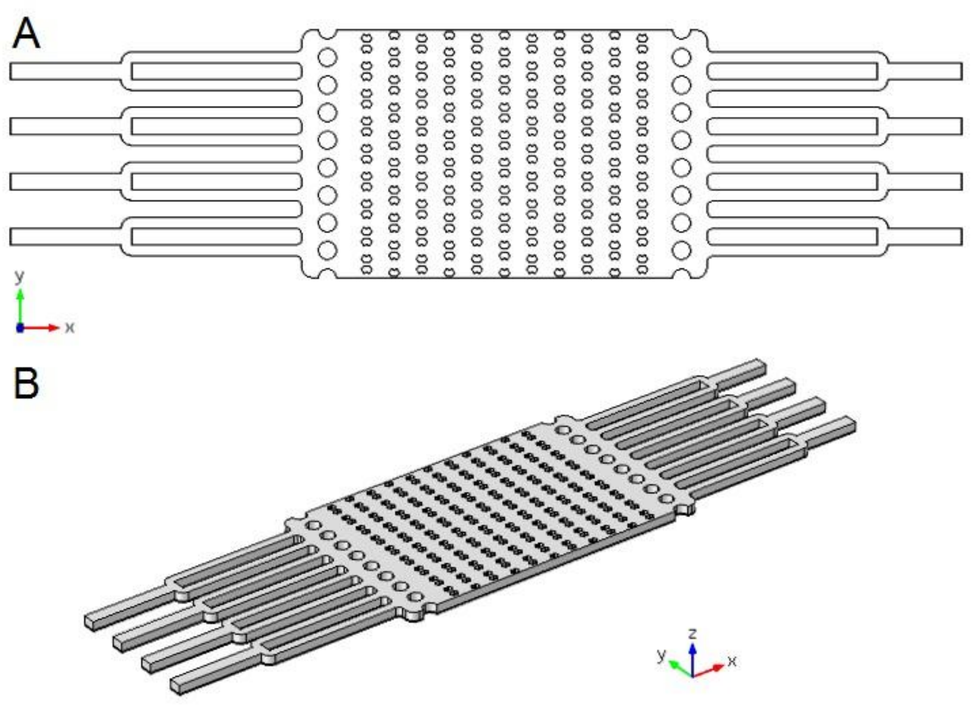

Figure 2. The geometry of the channels and trapping array. A: The orthogonal projection on x-y plane; B: The three dimensional view.

Results: The velocity between different pairs of traps is up to 800 μm/s, compared to ~300 μm/s in the central gap (Figure 3). The trapped cell partially occluded the gap and reduced the velocity through the central gap to less than 150 μm/s. About 93.5% of the traps were occupied by cells and ~71% captured only a single cell (Figure 4).

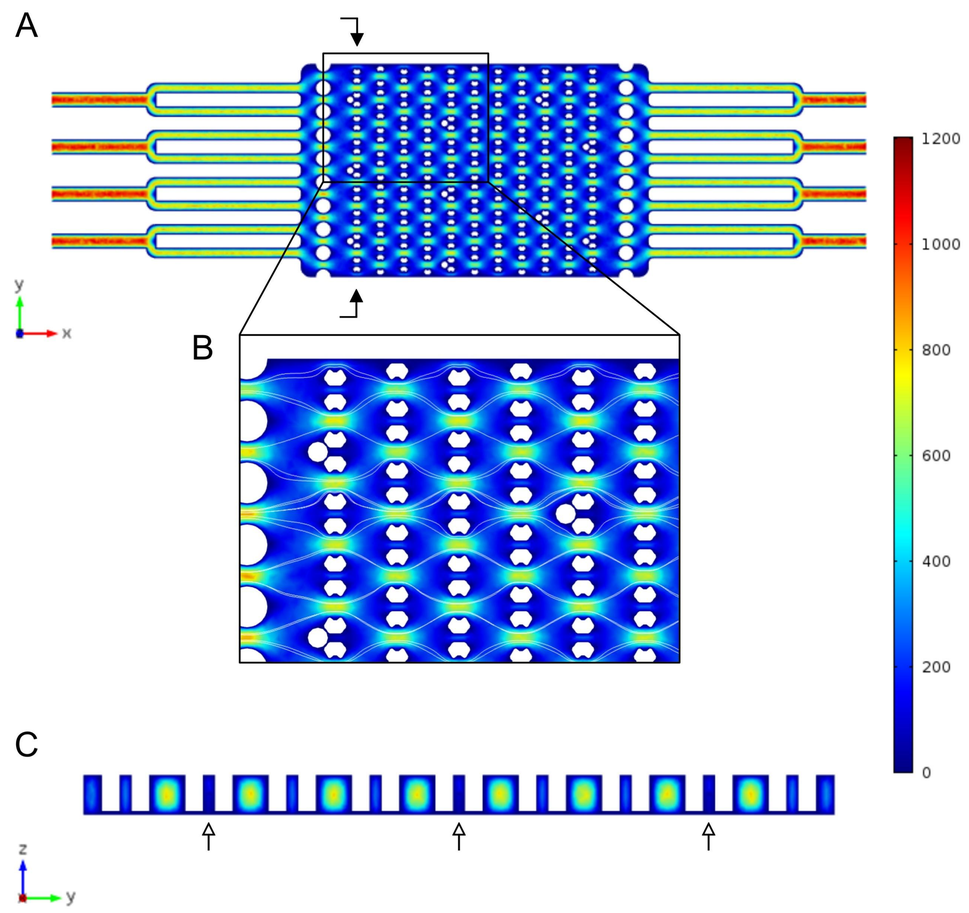

Figure 3. The velocity field in the cell trapping microfluidic device. A: The x-y plane at z=14 μm; B: The zoomed-in view of the velocity field; C: The y-z plane at x=969 μm.

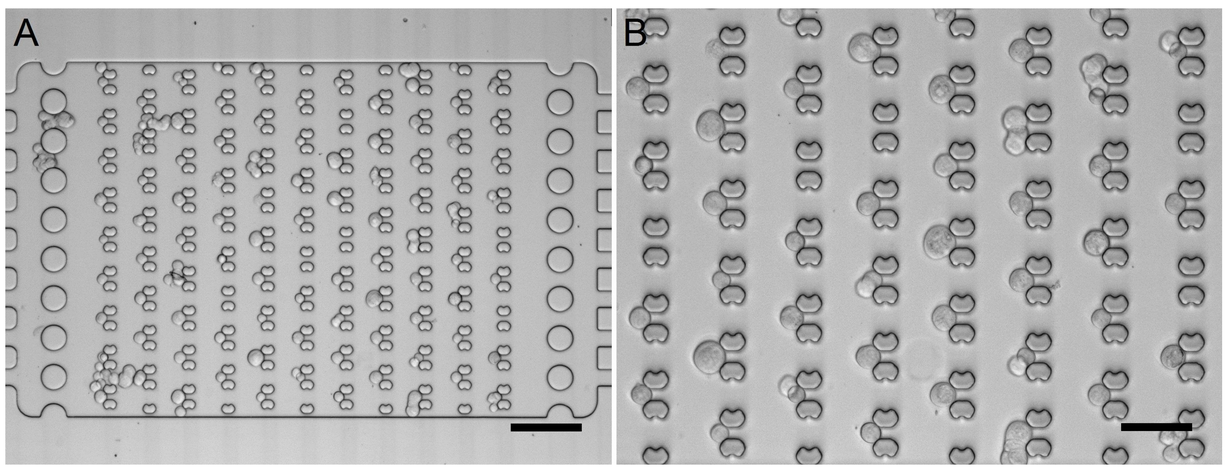

Figure 4. Micrographs of the microfluidic device trapping patient cultured circulating tumor cells. (A: 10X and B: 20X. Scale bars: 100 μm)

Conclusions: The single cell trapping microfluidic device developed in this study can be useful in experiments requiring monitoring of single cells, due to its high efficiency and the ease of operation.