Design and Fabrication of Electrokinetic Microfluidics for Transportation and Manipulation of Biomolecules

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Microfluidics has been widely used for transportation, trapping, and hybridization of biomolecules and charged nano-particles. However, the flow patterns in microfluidic devices based on electrokinetics are strongly dependent on the interactions between electroosmosis and electrophoresis. A five-cross microfluidic network design free of coupling between electrophoretic motion and electroosmotic flow has been demonstrated in a fluidic device at macro scale [1]. In this work, we demonstrate that such devices can be scaled down to micro scale for generating electrokinetically-modulated flow patterns, which are rotational, extensional and mixed shear flows, by simply changing the DC voltage input without the need of surface patterning and coating. For device fabrication, inductively-coupled plasma reactive ion etching was employed to etch 20 μm wide and 10 μm deep channels (Fig. 1a) using SF_6 plasma [2]. The etched Si sample was bonded to Pyrex glass by wafer bonding. Before formation of electrodes, a thermal oxide layer was grown in the microfluidic channels for isolation. Ti/Au metal contacts were deposited by electron beam evaporation using a shadow mask to provide electrical paths to the channels. The sample was mounted on a carrier and wire bonded before electrokineic study (Fig. 1b). The whole chip was mounted onto the stage of an inverted epi-fluorescence microscope for flow monitoring. The micro-channels were first filled with DI water, followed by adding fluorescence dyed polystyrene microspheres with a diameter of 700 nm as the tracer for flow visualization. The streamlines of the flow pattern were generated by compounding the video graphs (Fig. 2b). The simulation of electrokinetic flows (Fig. 2a) on this 5 cross microfluidic design was performed by solving the incompressible Navier-Stokes application mode and conductive media DC mode. Extensional and rotational flow patterns of polystyrene rigid microspheres generated in experiments agree well with the simulation results. The results on flexible biomolecules such as DNAs on three different flow patterns will be presented at the conference.

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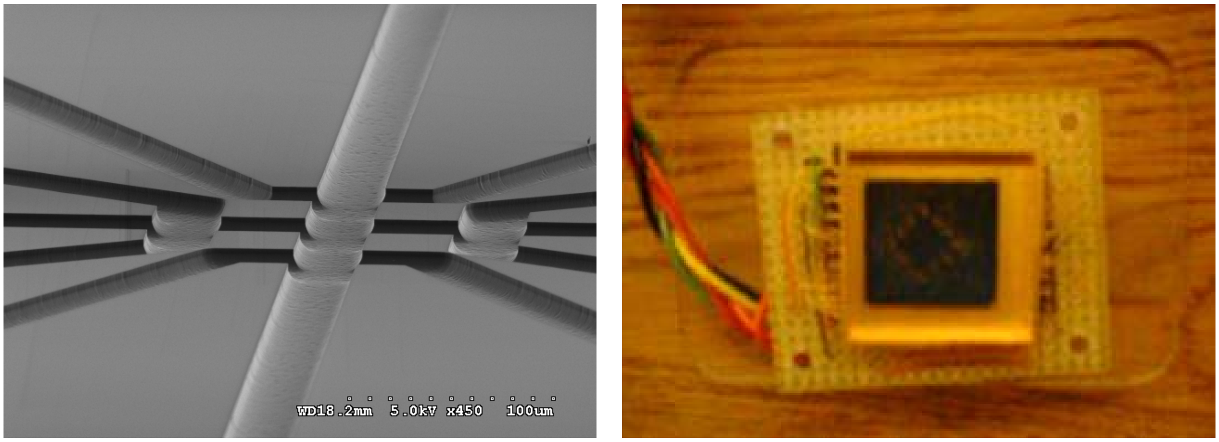
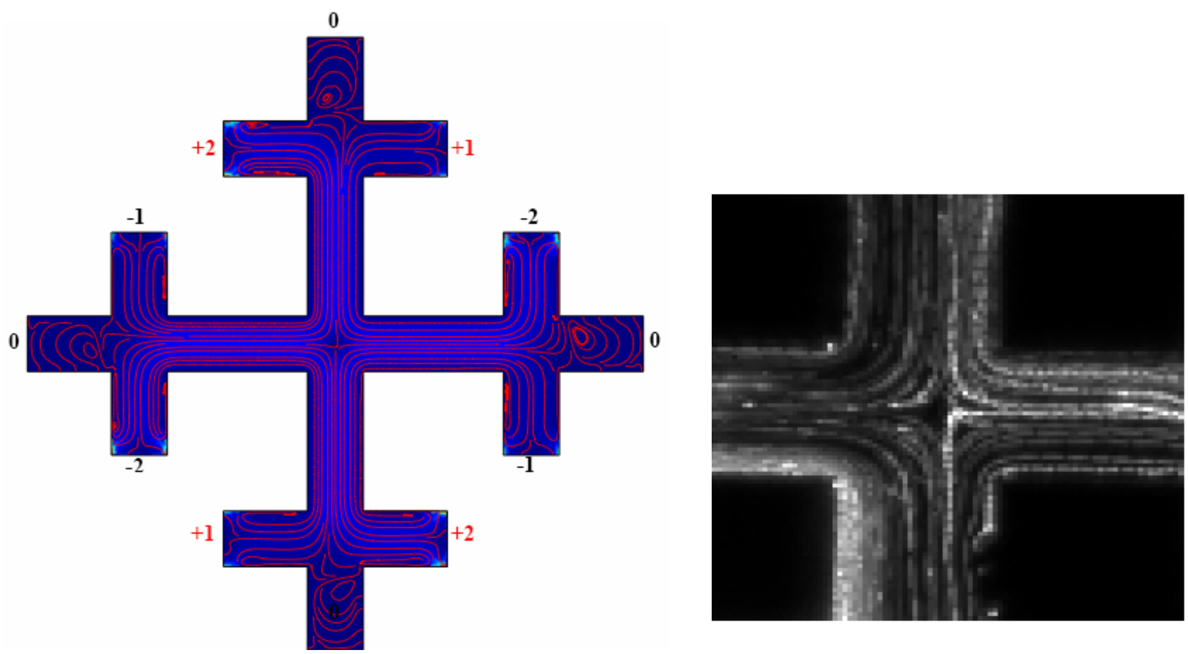


(a) (b)

Figure **1**. SEM micrograph of (a) 5 cross microfluidic channels and (b) photograph of packaged device.



(a) (b)

Figure **2**. Extensional flow patterns in a 5 cross microfluidic device: (a) simulation result and arrangement of electrodes and (b) experimental result of the compounded path lines of polystyrene microspheres, representing an extensional flow in the center cross.