CONFIGURABLE AC ELECTROOSMOTIC GENERATED IN-PLANE MICROVORTICES AND PUMPING FLOW IN MICROCHANNELS

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ABSTRACT

This paper proposes the patterned AC electroosmotic flows (AC-EOF) by simply grouping discrete electrodes together to form various electrode configurations for generation of in-plane microvortices with clockwise/counter-clockwise rotation, and pumping flow in a microchannel. The rotational direction of in-plane microvortices and pumping flow direction can be controlled using the same electrode pattern by simple switching of the voltages on the electrodes. Microparticle image velocimetry (μPIV) was used to characterize the flow fields of the generated in-plane microvortices and pumping flow. The rotational strength of microvortices and flow rates of pumping flows were found to increase with the increase of the applied voltages, and an optimal value was achieved at an appropriately applied frequency. The configurable in-plane microvortices and pumping flow in microchannels provide the potential for micromixing applications.

KEYWORDS: AC-EOF, in-plane microvortices, μPIV

INTRODUCTION

In our previous research [1], we demonstrated the patterned AC-EOF flow using interdigitated electrode configurations to generate in-plane microvortices with clockwise or counter-clockwise rotation in microchannels as shown in Fig.1 (a). However, the rotational direction of in-plane microvortices depends on the geometric asymmetry of the interdigitated electrode configurations, which can not directly switch clockwise and counter-clockwise microvortices using the same electrode configuration. The AC-EOF pumping flow has been shown to reverse at higher voltages and frequencies [2-3], but the mechanism is yet unclear. Therefore, we here propose a novel configurable ac electroosmotic system by simply grouping discrete electrodes together to form various electrode configurations for generation of in-plane microvortices with clockwise, counter-clockwise rotation, and pumping flow using the same electrode configuration at both low and high voltage.

DESIGN

Figure 1 shows the schematic diagrams of the configurable ACEOF systems. By applying the AC voltage on grouping electrode 1 and 2 with grouping electrode 3 and 4, the new electrode configuration involves a pair of discrete electrodes in an opposite configuration, where the upper half and lower half of the electrodes can simultaneously produce flows in opposite directions. An in-plane microvortex with the counter-clockwise rotation would then be realized (Fig.1 (b) left). By grouping elec-

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trode 1 and 3 with grouping electrode 2 and 4, a clockwise in-plane microvortex was generated using the same electrode configuration (Fig.1 (b) right). Besides, by applying the AC voltage on grouping electrode 2,3 and 4 with electrode 1, a series of the electrode configuration with each small electrode located on the left side of the large electrode (Fig. 1(c), produces a right-directed flow, and vice versa for a left-directed flow using the same electrode configuration. Figure 2 shows the images of the configurable ACEOF systems.

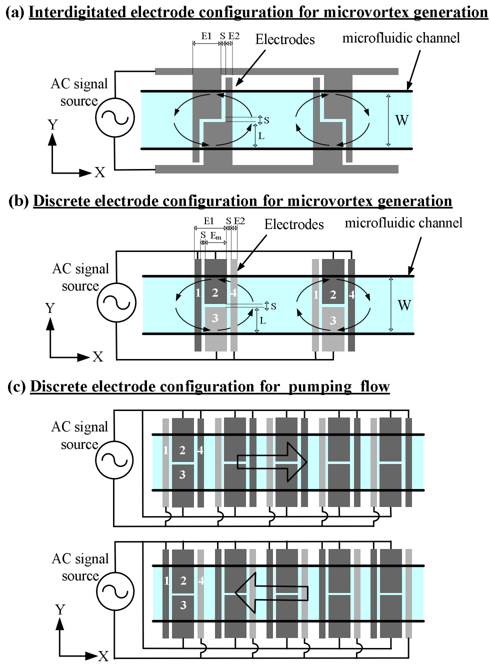

Figure 1. The schematic diagrams of the configurable ACEOF systems

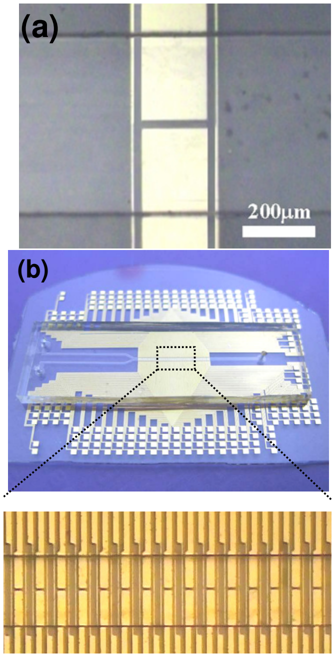

Figure 2. Images of (a) the discrete electrode configuration, and (b) the configurable AC-EOF micropump

RESULTS AND DISCUSSION

Figure 3 shows the velocity fields of the in-plane microvortices with clockwise rotation, and pumping flow measured by μ-PIV technique. Figure 4 shows the typical transverse velocity V(x) along the centerlines across the clockwise and counter-clockwise microvortices. The velocity profiles show typical viscous microvortices, antisymmetric with respective to the centerline of the microvortex. The magnitudes of V(x) start to increase, reach maximum values, and decrease to zero as they approach to the vortex core. Figure 5 shows the voltage dependence of the rotational strength for in-plane microvortices and maximum velocity for pumping flow. Increasing the applied voltages can lead to the increase of the rotational strength of the in-plane microvortices and the maximum velocity for pumping flow. Both the rotational strength (Ω) and maximum velocity show the same tendency of the voltage dependence.

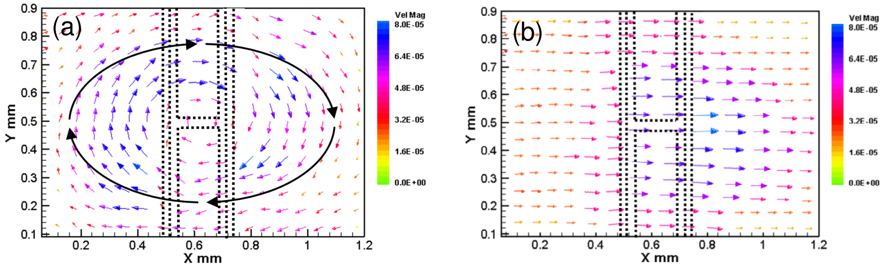

Figure 3. The velocity fields of the in-plane microvortices with clockwise rotation, and pumping flow measured by μ-PIV technique.

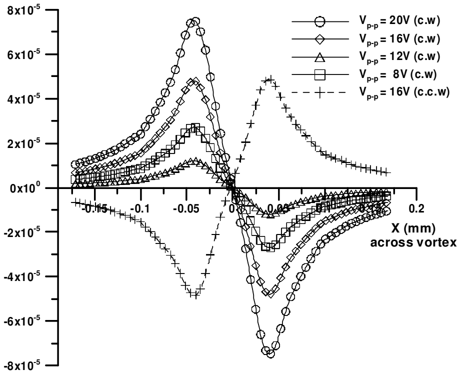

Figure 4. Typical transverse velocity V(x) along the centerlines across the clockwise and counter-clockwise microvortices.

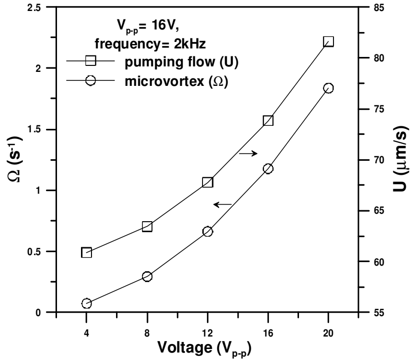

Figure 5. Voltage dependence of the rotational strength for in-plane microvortices and maximum velocity for pumping flow.

CONCLUSIONS

We proposed a novel design concept of the configurable AC-EOF systems by simply grouping discrete electrodes together to form various electrode configurations for generation of in-plane microvortices with clockwise/counter-clockwise rotation, and pumping flow in a microchannel. The rotational direction of in-plane microvortices and pumping flow direction can be controlled using the same electrode pattern by simple switching of the voltages on the electrodes

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