Flow Visualization and Characterization of an Electrostatically Activated Resonant Plate Micropump-mixer

K. MOHSENI AND O. NILSEN

Department of Aerospace Engineering
University of Colorado
Boulder, CO 80309-429, USA

An active mixing and pumping strategy is investigated to enhance mixing of two fluids through vortex accumulation and formation. A resonant plate micropump-mixer is designed and fabricated, where an electrostatically activated plate is placed at or in close vicinity of the interface between the two incoming streams at the junction of a Y- or T-shaped microchannel. Mixing is enhanced by increased interface area between the two fluids during the vortex formation at the tip of the resonant plate. Several packaging techniques are employed so that the two initially segregated streams flow underneath and above the resonant plate. Fabrication of the micropump-mixer is achieved in two steps. The resonant plate is fabricated using PolyMUMPs process and then it is flip-chip bonded into a prefabricated microchannel. The resonant plate scales at 250 micron and oscillates at 10-30 kHz. Laser Induced Fluorescence (LIF) technique is used in order to characterize the mixing quality of the device. While, the mixing quality is investigated by LIF, we were not able to visualize the nature of the mixing and pumping process at the tip of the resonant plate. To remedy this, dimensional and scaling analyses are employed in order to design a macro scale system that is a fluidic equivalent of the micropump-mixer. The larger, but dynamically equivalent, system does not have the visualization restrictions of the microscale system. The scaled system is, then, used to characterize the flow regime around the tip of the resonant plate. Two distinct flow regimes of vortex shearing and vortex shedding are identified. It is observed that by increasing the oscillation frequency of the resonant plate the flow transition from vortex shearing to vortex shedding. This transition take place in a gradual manner over a range of Reynolds numbers between 20 to 98. Below this regime the resonant plate will only generate limited deformation of the interface between the two fluids. However, for larger Reynolds numbers, equivalent to higher plate frequencies, organized vortex roll-up is observed. Vortex roll-up indicates significant fluid entrainment, and consequently mixing.

Keywords: mixing, micromixer, vortex, laser induced florescence.