Optimization of mixing in an active micromixing device

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Abstract

Microscale mixers can be divided into two broad classifications: passive and active. Passive mixers rely on geometrical properties of channel shape to induce complicated fluid particle trajectories and thus mix. Active mixers induce time-dependent perturbation in the fluid flow to achieve mixing. In this work we consider the question of optimization of mixing in an active micromixer. in microchannels.

The active mixing device that we study consists of a main mixing channel and three pairs of secondary channels that perturb the flow in the main channel. Two unmixed, miscible fluids enter the main channel, and are then manipulated by pressure-driven flow from the secondary channels. The flow from the secondary channels is specified to be oscillating at different frequencies and amplitudes, to provide enhanced mixing efficiency. The micrograph and schematic of the micromixer are shown in figure 1. Using the newly developed measure of mixing, the so-called "mix-norm", we study optimal mixing protocols (i.e. choices of frequencies and amplitudes) in this micromixer.

It is shown that optimal amplitude and frequency for a single side channel operating shows nonrobust fatures, where "tongues" of poor mixing parameter values interlay with good parameter values for mixing. This non-robustness is rectified by the application of the second side channel. Mixing now becomes robust over a large range of frequencies and amplitudes. In figure 2 we show optimization diagrams for 1, 2 or 3 side channels operating, for a model of the flow in the micromixer. Blue indicates good, uniform, mixing (low value of the mix-norm) while red indicates poor mixing (large value of the mix-norm). The middle diagram was obtained by fixing the value of frequency and amplitude for the first side channel that gives optimal mixing. The bottom diagram is obtained by fixing optimal values for the first and the second channel.

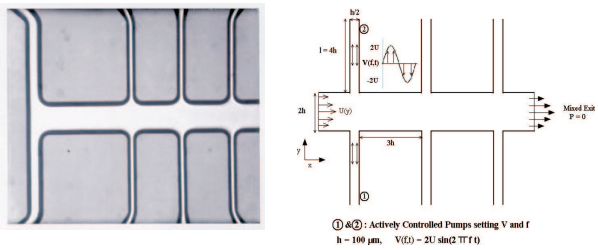

Figure 1: Left: micrograph of the working portion of the mixing microchip. Right: Schematic of the fluid flow in the channel.

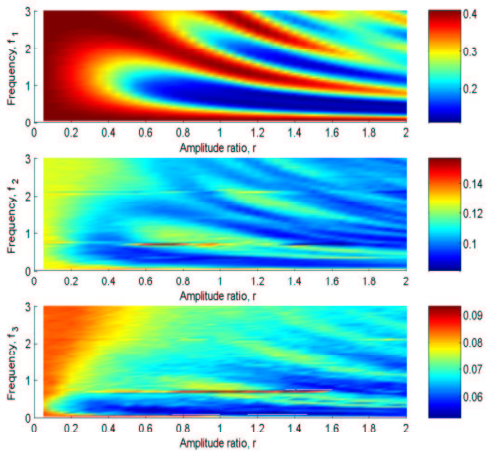

Figure 2: Results for optimization of mixing in the microchannel with 1 side channel operating (top), two side channels operating (middle) and 3 side channels operating (bottom)