Fabrication and Evaluation of an Active Electromagnetic Mixer for Lab-on-a-Chip Applications

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In this paper, we propose a novel mixer fabrication process using low-cost materials and fast prototyping applied to microchannels actuation. Lab-on-a-chip applications intend to bring all conventional instrumentation to a few square centimeters device. In this sense, the integration of active micropumps, micromixers and valves are currently the major challenges [1]. The active mixer was fabricated over conventional microfluidic devices techniques, using polydimethylsiloxane (PMDS) membrane thin-film and NdFeB magnet, and its characterization was done by gradient color analysis.

Several articles reported fast and controlled mixing of fluids in microchannels [2][3]. The active mixers devices are based on disturbance induced by external fields, because flows in microchannels have Reynolds numbers far below the critical Reynolds number, transversal disturbance is needed for making the interface between the two mixed phases to become unstable for enhancement of mass diffusivity [4]. Our actuator causes a pressure-driven disturbance through electromagnetic physical effect.

The device consists of two functional layers both fabricated with PMDS. The upper PDMS layer provides a compliant membrane with an NdFeB permanent magnet attached for actuation, while the lower PDMS layer incorporates the microchannels and the mix chamber (Fig. 1). Evaluation of the prototype, shown in Fig. 2, has been performed by studying the dependence of its mixing efficiency on the driving frequency of magnetic actuation. A system with injection of different kinds of colored fluids by syringe pump and a camera attached to an optical microscope was used for the process characterization. Experimental results show that this actuator is capable of mix fluids enhancement changing the flow regime (from laminar to turbulent) and the mass diffusivity line (Fig. 3) by controlling the two key parameters for hydrodynamic instability in active micromixers: the magnitude and the frequency of the disturbance. Results demonstrated the potential of applications of this mixer for a wide range of integrated lab-on-a-chip systems.

References:

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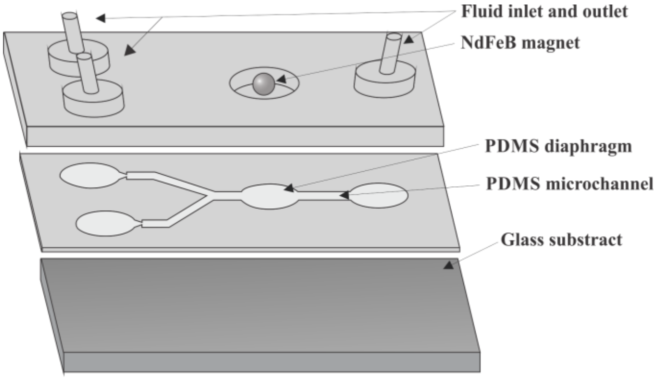

Figure 1. Multilayer structure schematic of the mixer design.

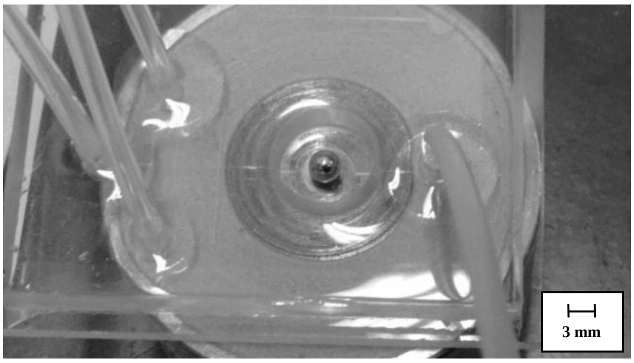

Figure 2. Picture of prototype over an electromagnet actuator.

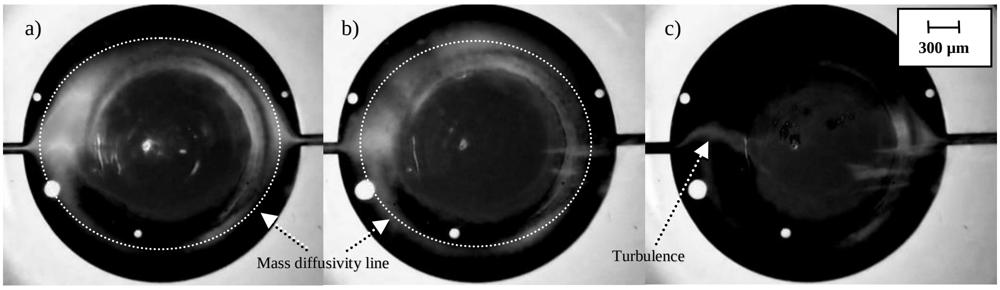

Figure 3. Micrograph of mix chamber a) laminar flow without actuation b) loss of mass diffusivity line with start of actuation; c) turbulent regime with full actuation.