

A washboard-type passive micromixer

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Abstract- In this paper, we present our study on a new type of passive micromixer based on a washboard microfluidic configuration. Periodic geometrical barriers like washboard are built inside a microfluidic channel that alters the flow patterns transversely and vertically. The advantages of this type of mixer is its mixing barriers are at the bottom of the microfluidic channel, and it does not need a complex 2-D or 3-D configurations to perform mixing process. This micromixer can easily be fabricated by one step SU-8 photolithographic process and one molding process. Solutions to be squeezed vertically and laterally while encounter the periodic barriers. Thus, the laminar flow pattern is distorted to create mixing process. To study the mixing mechanism of the skew corrugated micromixer, we study the mixing efficiency of washboard structures at three different angles, including 30, 45, and 60 degrees. Finite element simulations are conducted to study the mixing pattern and efficiency. Simulation results suggested that a skew corrugated microchannel with 45° angle can provide highest mixing efficiency, and a 95% mixing efficiency can be achieved within 8 stage within a 2.38 mm long microchannel.

Introduction- Concentration generation process is one of the common tasks implemented inside a Lab-on-a-Chip system. A specific concentration or a range of different concentrations of a reagent are usually needed to be generated for screening or processing purposes, such as drug screening platforms, immunoassays, or a Polymerase chain reaction (PCR) systems [1]. In these concentration generators, an effective process to generate mixing process plays crucially to the success of concentration control. This is because laminar flow is the dominant flow pattern in the microfluidic pattern, and diffusion is usually the mixing process [2]. However, the process of mixing based on diffusion is very time consuming and it usually need a very long microfluidic channel to complete the process. Thus, lots of efforts have been made to create chaotic flow pattern or squeeze fluidic flow to increase the mixing efficiency [3]. The mixing mixer can be separated into active and passive method. The active method can be very effective, but it requires external power source and the overall system can be bulky. On the contrary, passive methods use different microfluidic configurations to enhance mixing process. Approaches include creating zig-zag microfluidic channels, microgrooves, and a more complex 2-D or 3-D microchannel. These approaches are very effective but the fabrication process could be cumbersome, for example, an experienced alignment and filling processes could be necessary. To largely simplified the fabrication, assembly, and operating steps, we developed a skew corrugated micromixer based on the washboard structure. Detail study of this micromixer will be presented.

Current results- Figure 1 and 2 show the finite element models of the micromixer built in a COMSOL software. Three types of skew angles are studied, including 30°, 45°, and 60°. The length, width, and height of the mixing channel are 4 mm, 300 μm, and 100 μm, respectively. The height and width of the corrugated pattern are 50 μm and 30 μm, respectively. The pitch w is 30 μm. The length L_1 and L_2 are 255 μm and 195 μm. Figure 3 shows the simulation results of the 45° skew corrugated micromixer, it shows that fluidic flow is squeezed laterally and vertically while it passes through each barrier. Figure 4(a-c) compare the mixing efficiency of three different types of skew corrugated mixers, which are 30°, 45°, and 60°, respectively. It suggested that micromixer with a 45° skew corrugated has the highest mixing efficiency and it is verified on Figure 5. A 95% mixing efficiency can be achieved at 8 stage within a 2.38 mm long microchannel.

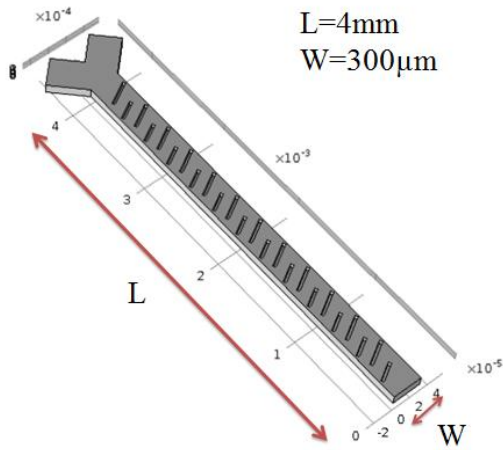


Fig. 1 Configuration of a skew corrugated micromixer

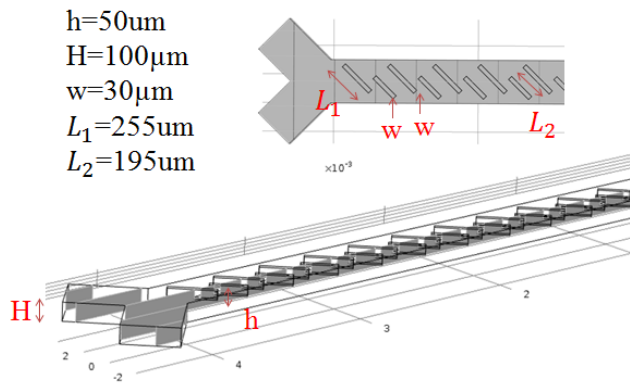


Fig. 2 Illustrations of a skew corrugated micromixer

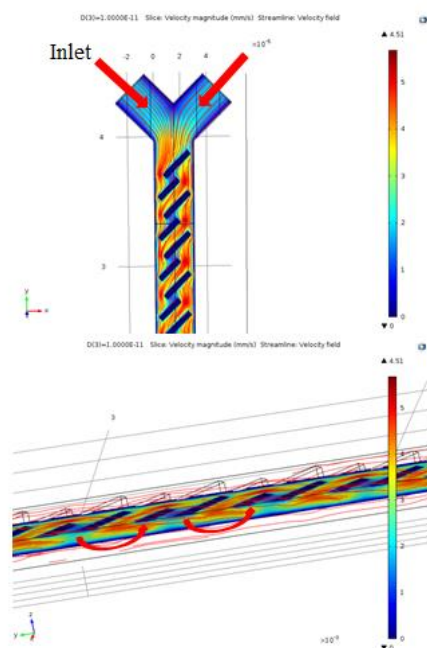


Fig. 3 Simulated streamlines and flow pattern of a washboard-type mixer

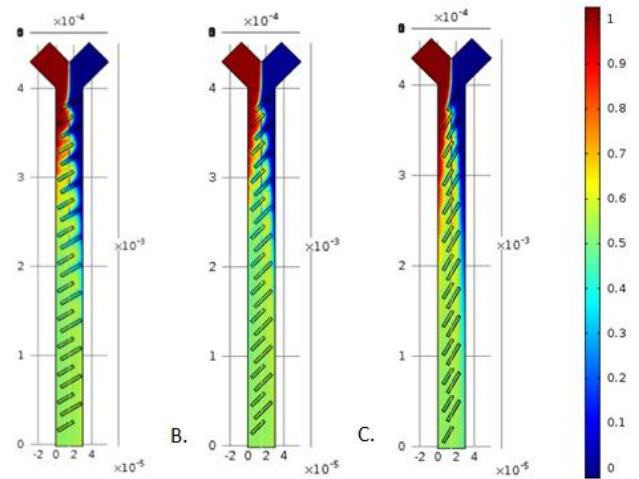


Fig. 4 Results of COMSOL simulation depending on the barrier angle (a)30°, (b)45°, (c)60°.

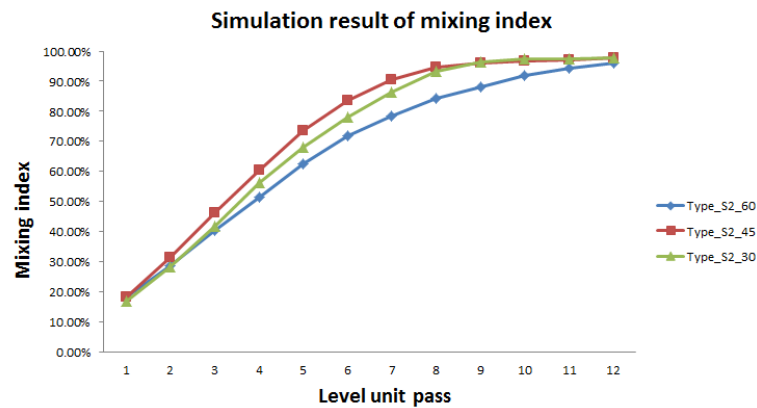


Fig. 5 Mixing efficiency of skew corrugated micromixers with 30° (green line), 45° (red line), 60° (blue line).

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