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Hybrid Configuration Micro-Mixers: A Synergistic Approach to Fabrication and Performance

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ABSTRACT
The lab-on-a-chip device mostly relies on the microchannel components. Micro mixers find their application in microfluidic devices and biomedical devices. Using traditional manufacturing techniques to fabricate micro mixers is highly difficult. Many techniques are applied to the fabrication of microchannels in order to characterize technology utilizing a combination of traditional and unconventional methods, such as laser ablation processing, lithography, micro milling, and embossing procedures. Acrylic is available in many different standard sizes these days. These days, it's highly sought after that some of them can withstand bullets. Acrylics are available in different forms. Numerous methods exist for processing them; the method involving the use of laser cutter machines is the one covered here. The method is referred to as the laser-cutting procedure. This work examines the creation of micro-channel molds out of acrylic material using a commercial CO2 laser system. Fabricated molds are the primary factor influencing the micro mixer's accuracy. Microchannel depth can be controlled by varying the scanning speed and laser power. Primary experiments are carried out to examine the impact of laser power and scanning speed on the depth of the micro mixers mold. It can be seen from analysis that as laser power increases, the depth of the micro mixer mold increases linearly and decreases with increasing velocity. An experimental and numerical analysis is conducted on the hybrid configurations of Y-shaped micro mixers.

Keywords: Micro-mixer, CO-2 Laser, Hybrid Configuration, COMSOL.

I. INTRODUCTION

Micro Channel is one of the key components of today's micro total analysis systems (TAS), which are important in many applications. Applications for microchannels can be found in many different domains, including biological, chemical, medical, and diagnostics. [1][2]. Acrylic is a more cost-effective and efficient material to use to fabricate Micro Channels than commercial materials like silicon, glass, polymers, etc. The medical and engineering fields make extensive use of these Micro Channels because of their low cost and simple fabrication [3] [4]. The creation of the Micro Channels can be done in a number of ways, including hot-embossing [5][6], injection moulding [7], micro milling [8], infrared laser ablation [9], and photochemical machining [10] [11]

[12]. For the creation of Molds or direct Micro Channels, CO2 laser machining is an appropriate alternative. CO2 laser machining offers a high degree of design flexibility in addition to expediting the fabrication process. Therefore, CO2 laser systems are highly beneficial for micromachining. In this work, CO2 laser machining is used to fabricate Y-shaped micro mixers with hybrid configurations. The different depths for the Micro mixers are also achieved by varying the input parameters. Fluid flow through micro-mixers with two different geometries is experimented with, and the results are presented. Software called COMSOL Multiphysics is also used for numerical analysis.

II. DESIGN AND FABRICATION OF MICRO-CHANNELS

The process of laser cutting, which is primarily employed in industrial manufacturing, involves using a laser to cut materials. When using laser cutting, the material to be cut is targeted by a computer that controls the high-power laser's output. After that, the material evaporates, burns, melts, or is blown away by a gas jet, leaving behind an edge with a superior surface polish. Flat-sheet material, structural, and piping materials are all cut with industrial laser cutters. Industrial laser cutters are used for cutting structural and plumbing materials, as well as flat sheet material. They can also be very efficient, with an output power to pump power ratio of up to 20%. In addition to many other materials, this machine can cut through wood, acrylic, plastic, cloth, leather, matte board, melamine, paper, pressboard, rubber, wood veneer, fiberglass, and cork.

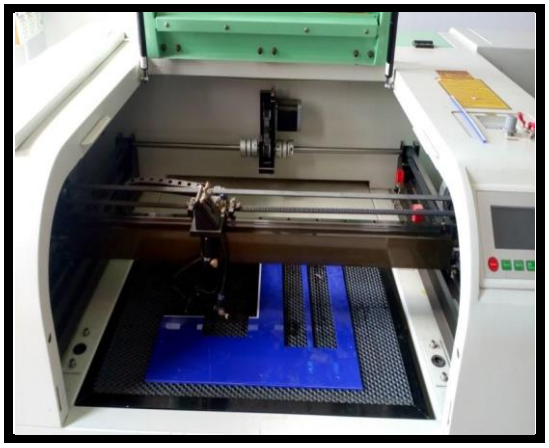

Figure1:CO-2 Laser Machine

A. Design of Hybrid Configurations Micro-Mixers

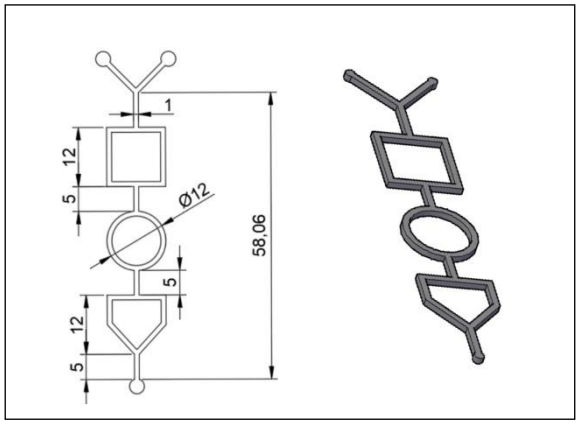

Figure2:Design of Micro-mixer-1

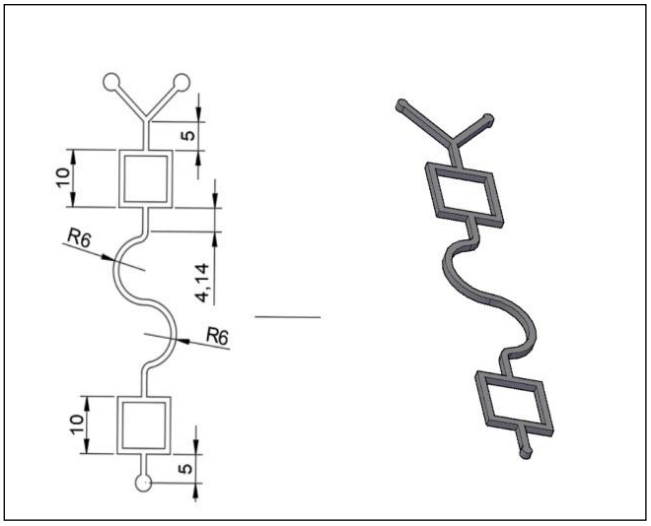

Figure3:Design of Micro-mixer-2

B. Fabrication of Hybrid Micro-Mixer using CO-2 LASER Machining

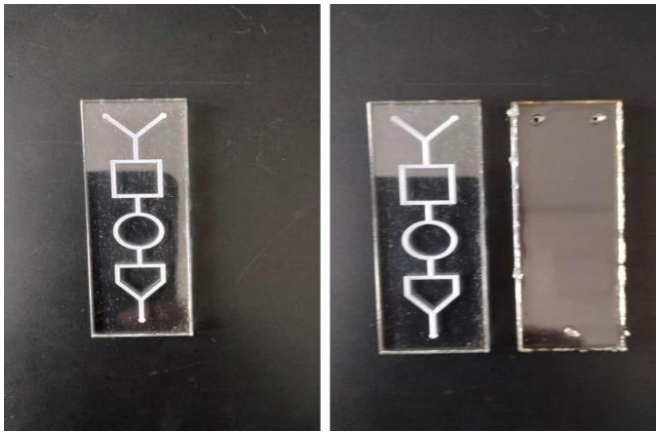

Figure4:Fabricated Micro-mixer-1

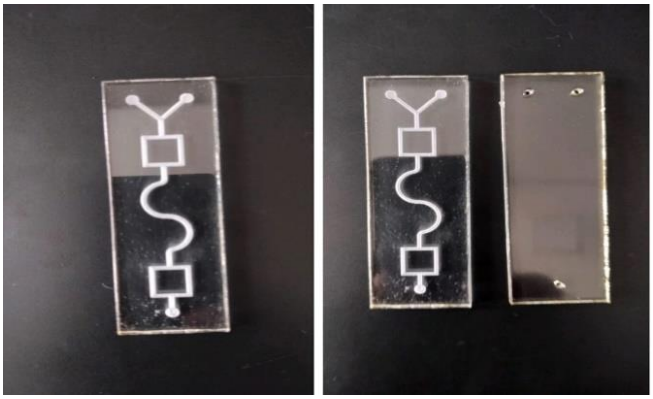

Figure5:Fabricated Micro-mixer-2

Using CO-2 LASER machining, the micro mixers shown above are made. Micromixer fabrication will be impacted by the power and speed of the laser. Micro mixer depth will be impacted by changes in laser power and speed. No. a final measurement of the mixer's depth is made in this respect.

III.EXPERIMENTAL ANALYSIS

Fluid flow through micro-mixers with different geometries is thoroughly experimented with in this work. Results from experiments conducted in a microfluidic laboratory at various input velocities and flow rates in each of the aforementioned micro-mixers will be presented in this section. This figure below illustrates the fluid flow through a micro mixer that was manufactured. Subsequently, the flow pattern data from the experiments and simulations are compared.

Figure6:Schematic of Experimental Setup

A. Experimental Visualization of Fluid flow through Micro Mixers

To conduct the experiment, Blue Ink and Water was taken as the sample. So, the property of the fluid was nothing but the property of the ink only.

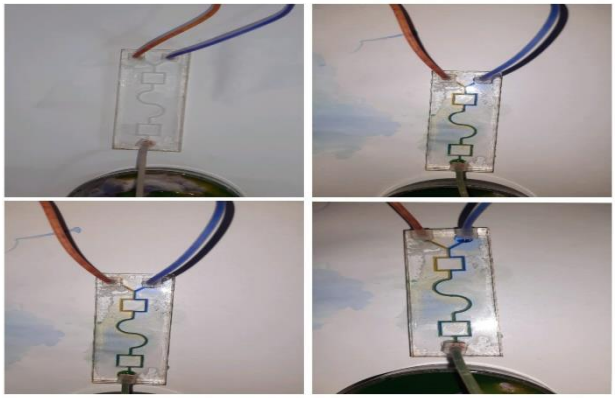

Figure7:Fluid flow through micro mixer-1

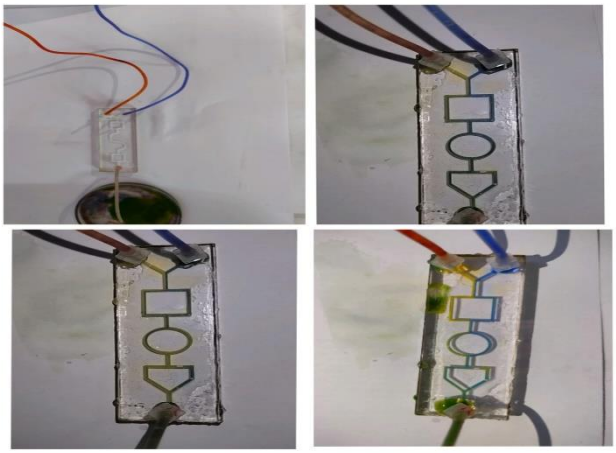

Figure8:Fluid flow through micro mixer-2

IV. NUMERICAL ANALYSIS OF COMSOL

COMSOL Multiphysics is the software used for the numerical analysis channel. AutoCAD is used for the design of the micro mixer, and COMSOL software is then imported for analysis. The simulated results of micromixers are represented shown in figures below.

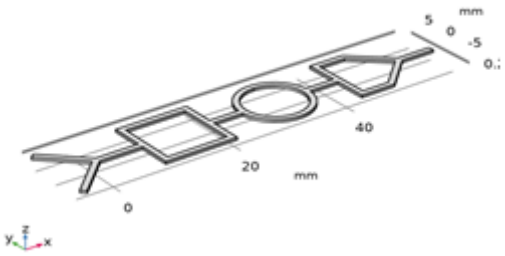

Figure9:Design of geometry

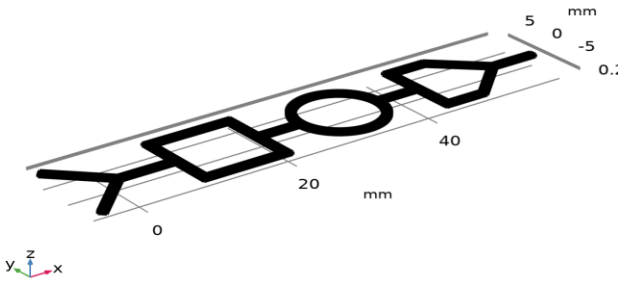

Figure10:Meshing of geometry

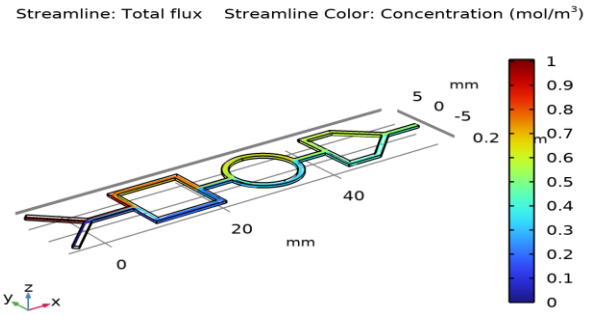

Figure11:Mixing analysis of micro mixer using COMSOL (a)

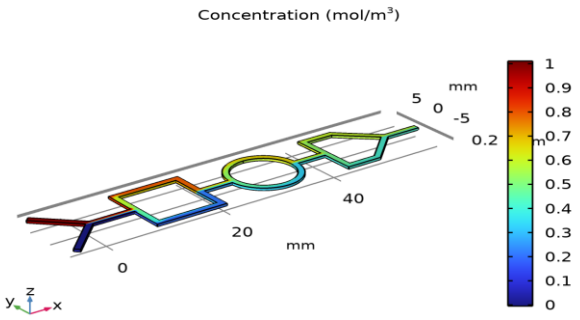

Figure12:Mixing analysis of micro mixer using COMSOL (b)

V. CONCLUSION

Micro mixer is one of the essential components in integrated nanofluidic systems in biology, medicine, and chemistry. Simulations of fluid flow and mixing through variously configured channels are performed using the COMSOL Multiphysics software package. LASER cutting machining has been used to fabricate Y-shaped micromixers in various configurations. A pair of distinct geometries have been designed for Y-shaped micro mixers. The mold for the micro mixer is made using CO-2 laser machining. Analysing experiments is done using the artificial Y-shaped channel

The following conclusions are drawn through this study.

- The incoming fluids' minimum mixing length for a micro mixer is determined by their decrease in inlet velocities.
- The Y-shaped micro mixer produces a slightly lower pressure drop than other models, but it offers a longer mixing duration.
- Mixing length and time in the Micro mixer both decrease with decreasing channel width.
- For blending the two fluids in the shortest amount of time, the hybrid-configured micro mixers are better suited.

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