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Design, development and experimental evaluation of micro channel using Soft Lithography

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Abstract:

Micro channels are one of the most crucial parts of a Lab on a Chip device. The creation of Micro Channels is a crucial task. Soft lithography is one of the most widely used methods for producing Micro Channels. The investigation into using a commercial CO2 laser system to make micro-channel molds out of acrylic material is covered in this article. The purpose of the pilot experiment is to examine how the LASER power and scanning speed affect the depth of the Micro Channel mold. With increasing LASER power and decreasing with increasing speed, it is observed that the channel depth increases linearly. Utilizing CO2 laser machining on PMMA, which can serve as a mold for the soft lithography process, the straight Micro Channel configuration with Y-shaped inlet and circular obstacles' (Split and Recombine approach, SAR) has been created. The experimentation of fluid flow through micro-channels of different geometries is done, and experimental results at various inlet velocities in all of the aforementioned micro- mixers are obtained in the micro fluidic laboratory. The results of the simulation will then be compared to the experimental results for flow pattern.

Keywords: CO2 LASER Machine, PMMA, Micro-Channel, Soft Lithography

Introduction

In many applications today, Micro Channel is one of the most crucial elements of Micro Total Analysis Systems (TAS), which also play a significant role in many applications. There are uses for micro channels in a number of industries, including biology, chemistry, diagnostics, and medicine [1] [2]. Comparing acrylic materials to commercially available materials like silicone, glass, and polymers, micro channel fabrication with acrylic is more cost-effective and efficient. Due to their low cost and ease of fabrication, these micro channels are frequently used in the engineering and medical fields [3] [4]. The Micro Channels can be manufactured using a variety of techniques, including hot embossing [5], [6], injection molding [7], [8,] micro milling [9], [10], [11], [12], and infrared laser ablation. For the creation of molds or direct Micro Channels, CO2 laser machining is a suitable alternative. Aside from

accelerating the manufacturing process, CO2 laser processing also makes it possible to react quickly to changes in the design. For micromachining, CO2 laser systems are therefore very beneficial. This study used CO2 laser machining with three different widths to create a Y-shaped Micro Channel with straight and circular obstacles. Input parameters are also changed to produce the various depths for the Micro Channel molds. A variety of micro-channel geometries are used in experiments to study fluid flow, and the results are obtained in micro.

Design and Development of Micro-channels

A powerful laser is used to cut material using lasers, and this process is known as laser cutting. A high-quality surface finish results from the material melting, burning, evaporating, or being blown away by the gas jet. Utilizing CO-2 laser machining, the channel development process is completed.

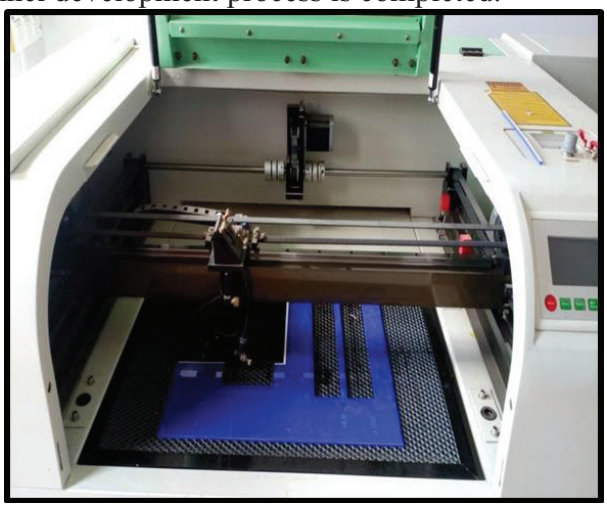

Fig. 1 CO2 Laser Machine

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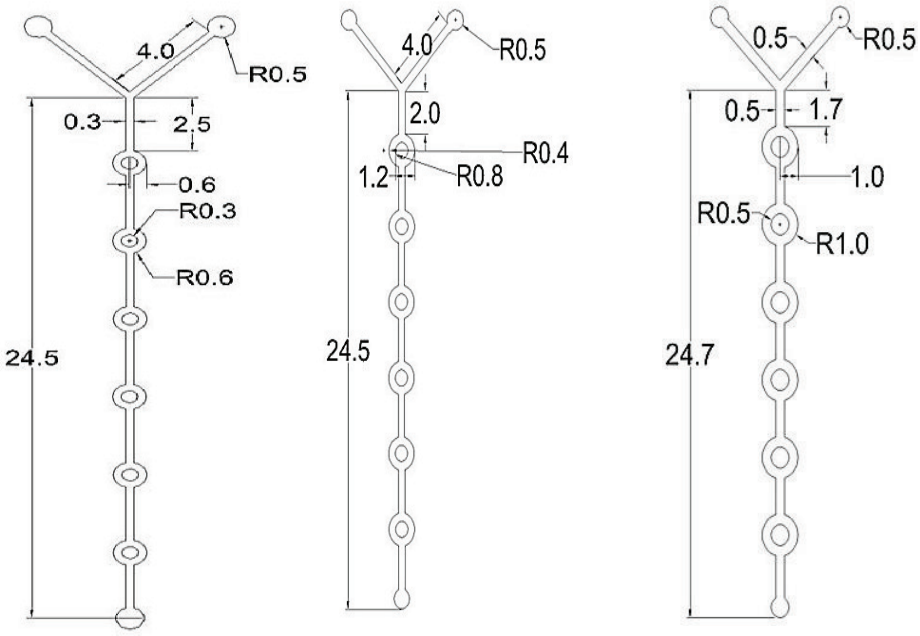
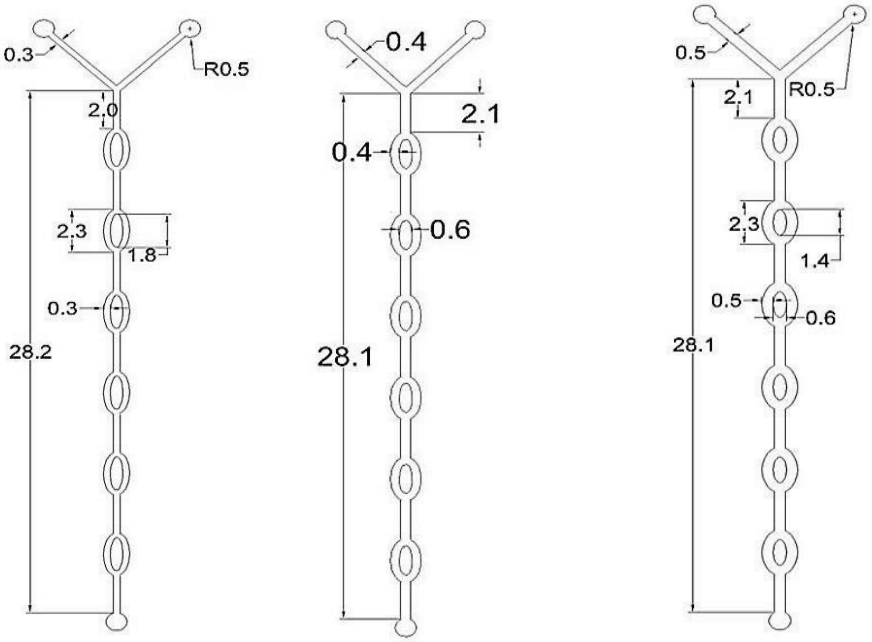
1.1 Design of Micro-channels:



Width - 0.3 mm **Width - 0.4mm** **Width- 0.5mm**

Fig. 2 Microchannel with Circular Obstacles



Width - 0.3 mm **Width - 0.4mm** **Width- 0.5mm**

Fig. 3 Vertical Elliptical Obstacles Microchannel

Fabrication of channels: Laser cutting machine permits you to form perplexing plans and exceedingly point by point trims with a low-cost, exceedingly productive tool. Attached to the computer similar to a printer, the framework will cut plans we make in most realistic program programs. imental Study

For the experimentation purpose the micro channels are prepared using Soft Lithography process and used for checking the mixing of fluids with different channels. The experimentation of fluid flow through micro-channel of various geometries is carried out and Experimental results obtained in micro fluidic laboratory at different inlet velocities in all mentioned micro-mixers.

1.2 Soft Lithography for Fabrication of PDMS Molds:

In order to create highlights with geometries characterized by the mold's relief structure, the delicate lithography process involves creating the elastomeric form, which is typically made of polydimethylsiloxane (PDMS). Following creation, PDMS forerunner is added to the ace form, which is then degassed under vacuum. To completely expel bubbles, this last step may be repeated several times. Finally, preparation allows for the treatment of the PDMS precedent arrangement. The PDMS shape can be used for stamping or small-scale molding after cooling to room temperature and being peeled off the substrate.

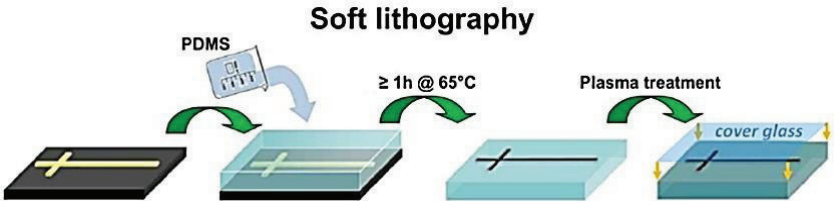


Fig. 6 Soft Lithography Process

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Fig. 7 Pouring of PDMS into Mold cavity

1.3 Experimentation:

The experimentation of fluid flow through micro-channel of various geometries is carried out and Experimental results obtained in micro fluidic laboratory at different inlet velocities in all mentioned 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. Generally the density of water is 1000 kg/m3.

1.3.1 Experimental Setup

Following are the equipment‘s are used for Experiment:

1. Twin Syringe Pump
2. Silicon Tubing
3. Fittings (Connectors)
4. Glass ware or beaker
5. Samples
6. USB Digital Microscope integrated with Computer

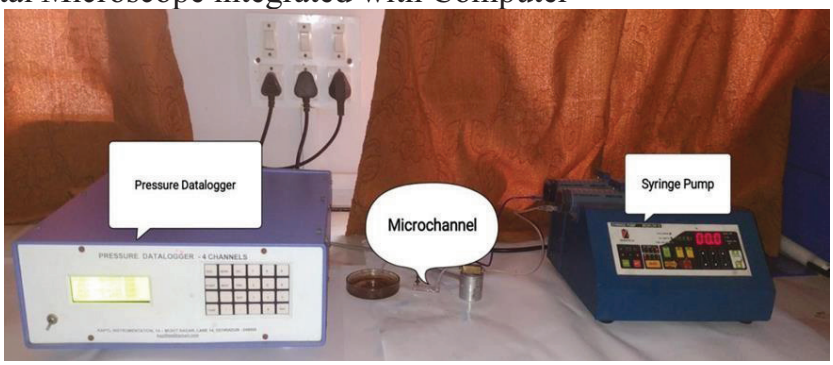

Fig. 8 Y- Experimental setup

Case I: Results of the experimental investigation in Y-shaped micro-channel

with circular obstacles for inlet velocity 5 mm/s are presented below.

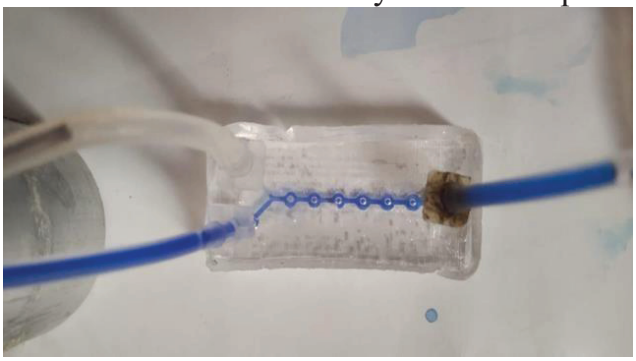

Fig. 9 Y- Shaped Microchannel with Circular obstacles

Case II: Results of the experimental investigation in Y-shaped micro-channel with vertical elliptical obstacles for inlet velocity 5 mm/s are presented below.

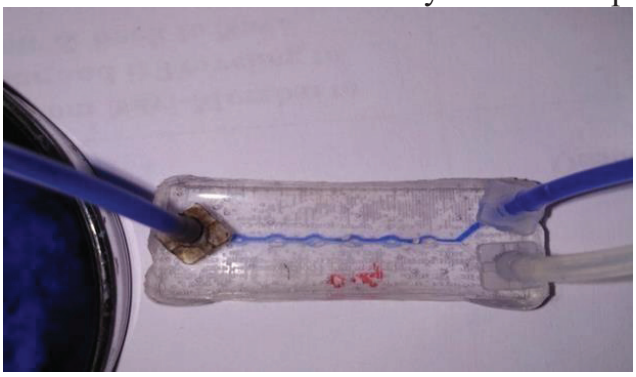

Fig. 10 Y- Shaped Microchannel with Vertical Elliptical obstacles

4. Conclusion

One of the fundamental elements in coordinating microfluidic frameworks for medicinal, organic, and chemical uses is the micro-channel. Using laser cut machining, Y-shaped micro-channels with various configurations, such as straight with circular impediments, have been manufactured. The molds are made with two different parametric conditions and three different widths. The recorded profundities are 0 point 5 and 0 point 52 mm. The molds that are produced can be used to create PDMS micro-channels using a careful preparation for lithography. Miniaturized scale blenders in the shape of a Y have been planned, featuring two distinct geometries: circular and curved. The miniature scale blender is shaped using CO2 laser machining. PDMS fabric creates the Y-shaped channel with curved and circular deterrents for exploration and investigation.

The effect of obstacles on the mixing length is studied. The effect of different parameter on micro mixer performance is concluded as:

- Reduced inlet velocities of incoming fluids are used to achieve the minimum mixing length of microchannels.
- In comparison to a Y-shaped micro mixer with circular obstacles, a Y- shaped microchannel with elliptical obstacles provides better mixing length.
- Micro-channel mixing time and length decrease with a reduction in channel width.

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