

Fabrication of Micro-channels using CO₂ LASER Machining & Soft Lithography for Lab-on-Chip Applications

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ABSTRACT

Microchannels are one of the most significant parts for the Lab-on-Chip applications. The microchannels fabrication is a crucial task. The Soft Lithography is one of the most favored methods of microchannel fabrication. The use of CO₂ LASER machining for microchannel fabrication using Acrylic sheet is studied in this paper. The experimentation is carried out to see the effect of LASER scanning speed and laser power on the depth of the microchannel mold. It has observed that the channel depth is increasing linearly with increasing LASER power and decreasing with increase in speed. The straight microchannel configuration with Y shaped inlet having circular & elliptical obstacles has been fabricated using CO₂ laser machining on acrylic sheet. Also, the fabricated molds are used to prepare the further microchannel molds using the Soft Lithography technique and then the microchannels prepared from Soft Lithography are used as a mold for the lab-on-chip applications like check the mixing length & mixing phenomenon etc.

Keywords: CO₂ LASER, Soft Lithography, Acrylic Sheet, Micro-Channel, Molds, Lab-on-chip.

1 Introduction

Now a day's micro total analysis systems (μ TAS) play significant role in many of the applications and Microchannel is one of the prominent part of these systems. The Microchannels are having applications in various fields like medical, diagnostics, chemical, biological, etc. [1][2]. The Microchannels can be fabricated by using the Acrylic material more economically and efficiently as compared to other materials like Polymers, Silicon, and Glass. Due to low cost and straight forward fabrication these Microchannels are mostly used in Engineering and Medical applications [3] [4] [13] [15]. There are various methods to fabricate the Microchannels such as hot-embossing [5][6][14] injection molding [7] micro milling [8] infrared laser ablation [9] Photo chemical machining [10] [11] [12].

The CO₂ laser machining is mostly suitable for fabrication of Microchannels or molds of it [16]. The use of CO₂ laser machining not only speeds up the fabrication process, also there is flexibility to change the channel design as per the requirements. The CO₂ laser machining is very more useful for micromachining [17]. The use of CO₂ LASER machining for microchannel fabrication using Acrylic sheet is studied in this paper. The experimentation is carried out to see the effect of LASER scanning speed and laser power on the depth of the microchannel mold. It has been observed that the channel depth is increasing linearly with increasing LASER power and decreasing with increase in speed. The transparent acrylic sheet is used for the fabrication of molds using LASER machining. The straight Microchannel configuration with Y shaped inlet having circular & elliptical obstacles has been fabricated using CO₂ laser machining on an acrylic sheet. Also, the fabricated channel molds are used to prepare the microchannel using the Soft Lithography method



and then the microchannels prepared from Soft Lithography are used as a mold for the lab-on-chip applications like check the mixing length & mixing phenomenon etc.

2 Materials and Methods

The acrylic sheet is commonly used material for various applications. We have used this material (an acrylic sheet) in transparent shown in figure 1 below from for fabrication of microchannel molds or directly microchannels. The channels fabricated from this material will be used for lab-on-chip applications. The CO₂ LASER machining process is used for fabrication of molds using acrylic sheet and. The Soft Lithography is also one of the techniques used for the fabrication of channels or molds. The molds fabricated from laser machining are also be used in the Soft Lithography techniques based on requirement of channel in lab-on-chip applications. As per the requirement we can use any mold or channel fabricated from LASER machining and the Soft Lithography.

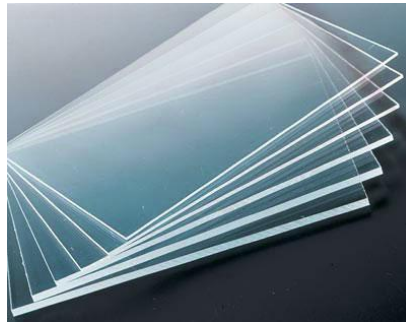


Figure 1: Acrylic Sheet

3 Fabrication of Micro-channels or Molds using LASER Machining

In the Laser cutting technology laser is used to cut the materials and mostly used in industrial applications. Laser machine works by giving high laser power as an output through computer and then it cuts the material as per design. The melting of material taking place and leaving the edges with a high surface finish. This machine can cut the various materials like acrylic, paper, pressboard, rubber, fiberglass wood, plastic, cloth, leather etc.

Thus, the CO₂ LASER machining is mostly useful for micromachining. The use of CO₂ LASER machining for microchannel fabrication using Acrylic sheet is studied in this paper. Then, the detailed experimentation is carried out to check the effect scanning speed and laser power on its depth. It is observed that there is increase in depth of channel or molds, when laser power increases and vice-versa.



Figure 2: CO₂ LASER Machine

The above figure 2 indicates the CO₂ LASER machine used for the microchannels or molds fabrication. The acrylic sheet will keep cutting or engraving area of machine. The input will be

given through computer as image or Auto-CAD or CATIA drawing. We have to set required cutting laser power and travel speed through same computer and the fabrication is carried out as per given inputs and molds or channels are fabricated.

3.1 Design of Micro-channel or Molds

The following figure 3 indicates the drawings (with dimensions in mm) of microchannels with different configurations (Y type channel with Circular & Elliptical obstacles). This drawing will be given as a input to the machine and accordingly the fabrication will be carried out on acrylic sheet.

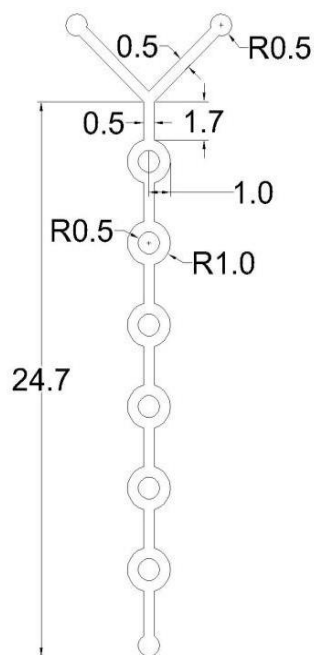


Figure 3: Microchannel with Circular Obstacles

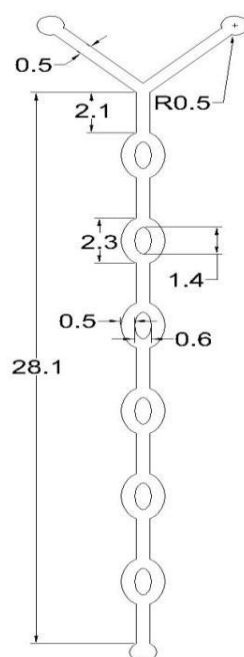


Figure 4: Microchannel with Elliptical Obstacles

3.2 Fabrication of Micro-channels or Molds using LASER Machine

Laser machine works by giving high laser power as an output through computer and then it cuts the material as per design. The following micro-channels shown in figure 5 & figure 6 with Circular & Elliptical obstacles are fabricated using LASER machining process and using following selected parameters on LASER machine.

Table 1: Performance Parameters of LASER Machine

Width of Channel	Scanning Speed	Laser Power	Depth of channel Achieved
0.5	100	60	0.516
	100	40	



Figure 5: Fabricated microchannel or mold with Circular Obstacles



Figure 6: Fabricated microchannel or mold with Elliptical Obstacles

4 Fabrication of Micro-channels or Molds using the Soft Lithography

The Soft Lithography process includes fabrication channel or mold using Polydimethylsiloxane (PDMS). After the CO₂ fabrication of channel or mold it is filled by PDMS and then degassed in vacuum designator to remove the sir bubbles. Then, the PDMS solution is cured at room temperature or by baking in oven. After cooling, the PDMS mold can be peeled off from the mold and it will be used for micro molding. The detailed soft lithography process used for fabrication of channels is shown by following figures 7 & 8.

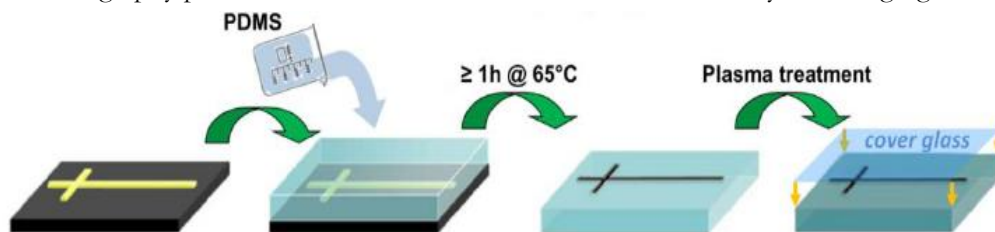


Figure 7: Soft Lithography Process for Microchannels fabrication



Figure 8: Pouring of PDMS during fabrication of Microchannels using Soft Lithography

5 Conclusions

The Microchannel is one of the essential components for Lab-on-Chip applications like biological, medical and chemical applications. The fabrications of Y-shaped micro-channels are carried out using Laser machining with circular & elliptical obstacles is straight microchannel or molds. The fabrication is carried out for given dimensions. The depths recorded as around 0.5 mm. The fabricated molds from laser machining are used the soft lithography process for fabrication of PDMS micro-channels.

The Y-shape micro mixers with two different geometries such as circular and elliptical have designed. CO₂ Laser Machining is used for mold making of micro mixer. The Y-shape PDMS channel with circular and elliptical obstacles will be used for further experimental analysis or testing in Lab-on-Chip applications.

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