Design, Fabrication & Simulation of Microchannel Network for MEMS

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Abstract

The greatest challenge being faced for realization of Micro-Electro Mechanical System (MEMS) technology is the lack of a simple, quick and reliable method for the fabrication of 3-D microchannel in the range of micrometers. A novel fabrication technique which opens possibilities for the production of these microfluidic channels is presented in this paper. The present paper highlights the possibility of a low cost microchannel network fabrication on glass substrate using micro ultrasonic machining (Micro USM). This high frequency low amplitude based micro machining technique is fast and inexpensive, and will enable flexible fabrication of various kinds of 3-D micro fluidic system and lead to new applications of MEMS in biomedical engineering. Based on existing/current techniques such as Photolithography, Additive Techniques, Subtractive Techniques, and Pattern Transfer, the microchannel fabrication is a complex multi-step process, which requires high cost for implementation [1,2]. These fabricated microchannels are limited in shape and size, and most of microchannels are formed on the surface of substrate.
The vast majority of microdevices are built out of silicon but for some applications, silicon is not an appropriate base material - and that for a significant subset glass is better. Due to superior material properties of glass like transparency, mechanical robustness and chemical resistance the usage of glass for micro mechanical, micro fluidic and micro optical MEMS devices is emerging [3]. The Micro USM, a non conventional process is ideally suited for such a hard and brittle materials which are otherwise difficult to machine. In this process, the removal of material takes place because of the impact forces generated by the vibrating tool on to the abrasive particles [4]. The abrasives further hit the workpiece and erode the surface. The frequency is above 20 kHz and amplitude is set in the range of 10 to 15μm. A schematic view of micro USM is shown in Figure 1. The different types of microchannels fabricated on glass substrate are depicted in Figure 2. As the channel size decreases to the order of a few microns, the effect of the surface roughness on the flow of liquid through the microchannels becomes important [5]. Thus, scanning electron microscopy (Fig. 3) and atomic force microscope (AFM) investigations were carried out in order to elucidate the surface roughness of the microchannel.
An understanding of fluid flow is crucial before new and efficient microfluidic devices can be fabricated. Fluid flow in these devices is often through channels with changes in cross-sectional area, and/or channels with bends and bifurcations. A systematic study of these different configurations will provide valuable insight into the flow physics. Therefore, a model is developed and simulation for the flow of liquid is presented by using COMSOL Multiphysics®

finite element package as shown in Figure 4. The overall goal of the present study is to explore the feasibility of fabrication of glass microchannels through an inexpensive machining method for MEMS application and to see the fluid flow pattern within the fabricated microchannel.

Reference

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Figures used in the abstract

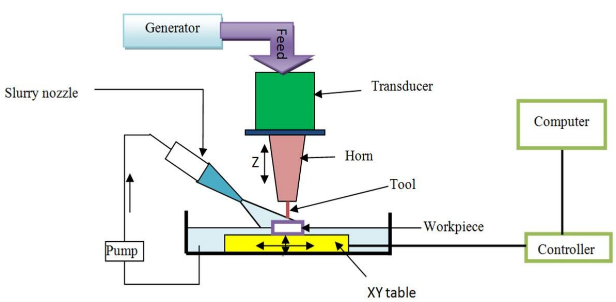

Figure 1: Micro USM set up.

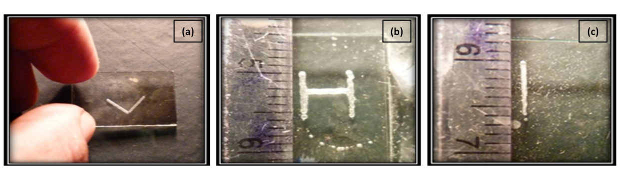

Figure 2: Different types of microchannels on glass (a) V- type (b) H- type (c) I- type.

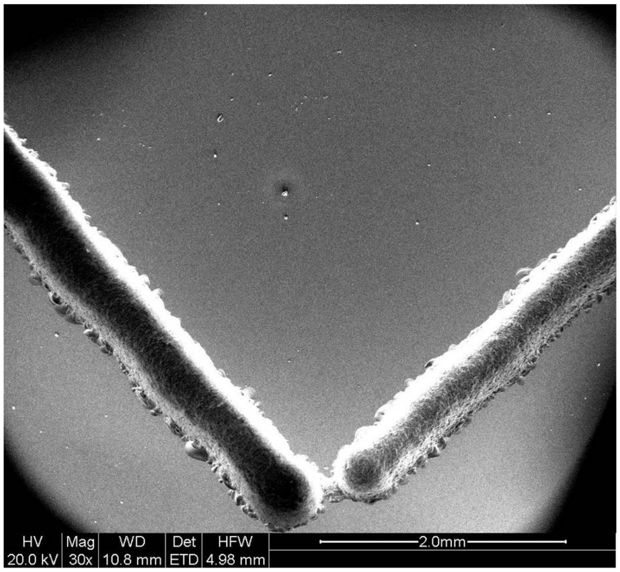

Figure 3: SEM of V type microchannel.

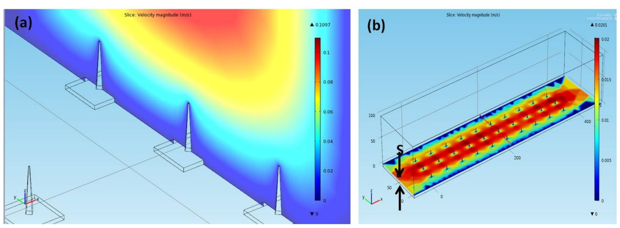

Figure 4: Flow in microchannel.