Design and fabrication of a T Mixer Using a Glass based microfluidic method

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***Abstract*—** Fabrication, simulation and characteristics of a microfluidic T-mixer is investigated. The glass based substrate is used for fabrication of this mixer, which can be used in different bio applications in drug delivery and bio-mixing. The mixture of a distilled water and air is applied in T junction that results in micro droplet generation in the microchannel.

***Keywords*—**T-mixer, Microfluidics, Droplet.

I. Introduction

In many applications Droplets are used for better precision and accurate results. Among those inkjet printers are most well-known due to their vast use in printing date and barcodes in food products. However, generation of drops in micro-scales has some other benefits in bio-applications. The need for new emerging problems in bio-science especially in drug delivery and pharmaceutical applications brings new frontiers in fabrication of new micro-devices. Some of the drugs need exact mixture amount of fluids in micro and nano scales which is vital in some diseases. It makes the problem more complicated when the fluids are not soluble and can not be mixed together. Meanwhile, the amount of the mixing agents plays an important role in design and fabrication of a micro-device. In addition, the fluid behavior in micro-scale changes due to its scale and new fluid governing equations.

Therefore, design and fabrication of the microfluidic devices for mixing different amounts of agents is one of the ongoing fields in current studies. The size of a droplet is investigated theoretically and experimentally using laminar flow theory and changing controllable parameters such as flow rate ratio and capillary number [1]. The effect of the softness of a microchannel on droplet size in a T-junction is studied using a mixture of oil and water [2]. Another important use of droplet generators are in drug and cell encapsulation which is surveyed in many ongoing research and development groups [3-4]. Meanwhile, the easy fabrication methods for different designs with low cost and repeatability are the focus of many research efforts [5-7].

In this paper, we present a low cost fabrication technique for different microfluidic devices and especially focused on design and fabrication of a microdroplet generator. The simulation and experimental results are illustrated. The results show that the air bubbles that are injected to the T-junction generate air droplets inside water agent within the microchannel.

II. Design and Fabrication

Glass-based procedure for fabrication of this microfluidic T-mixer is applied. A numerical simulation has been performed to ensure the generation of droplets in the proposed microstructure. The micro-droplet generator has two inputs and a single output. The microchannel has 300 μm width and 100 μm depth, which is different from fabricated microdevice due to isotropic wet etching process and its circular etching characteristics. However, the width in simulation and fabrication are the same. Water is injected from one input and the air is introduced from the other simultaneously using a controllable micro syringe pump. Laminar flow for both fluids has been selected in simulation. The fluid is injected with the rate of 8 mm/s for the water input and 1.8 mm/s for the air input. The results are shown in Fig. 1. In this figure, generation of droplets is shown step by step.

Glass as a well-known material is used for microfluidic systems. Glass wet etching fabrication technique has been utilized for this microdevice. Fig. 2 shows the summarised process of wet etching of the glass. In our experiment, the protection layer of photo-resist and chromium is used to protect unwanted areas from etchant attacks. The concentrations of acids affect the roughness of glass in etched regions. The adhesion of the protective mask to the glass also is a significant factor in wet etching process. Therefore, controlling different factors in wet etching process is concerned.

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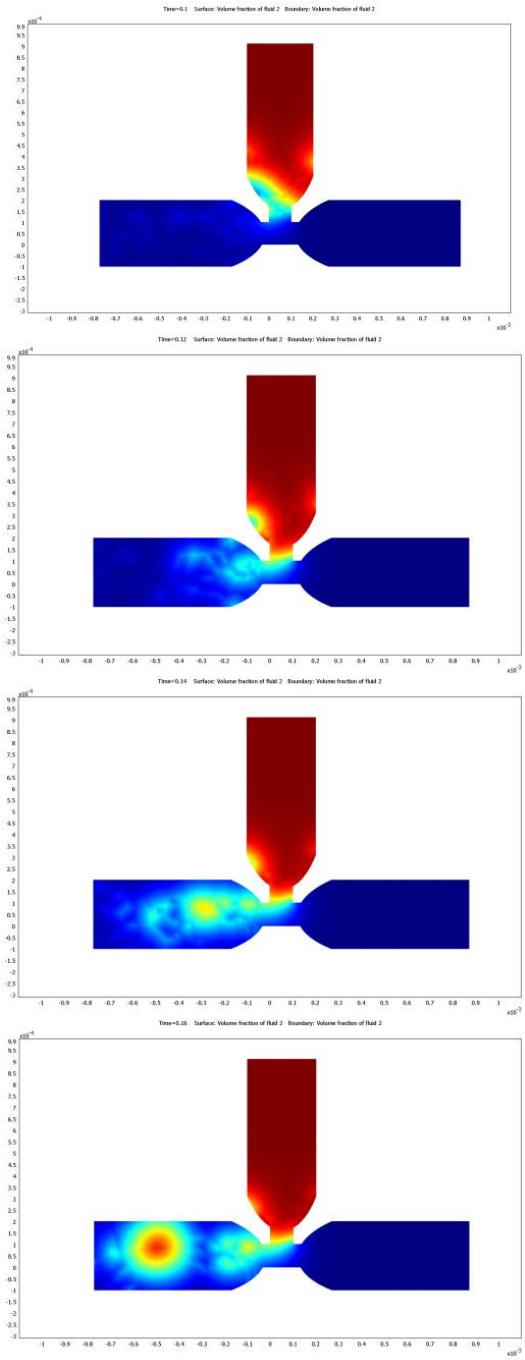

Fig. 1 Droplet Generation

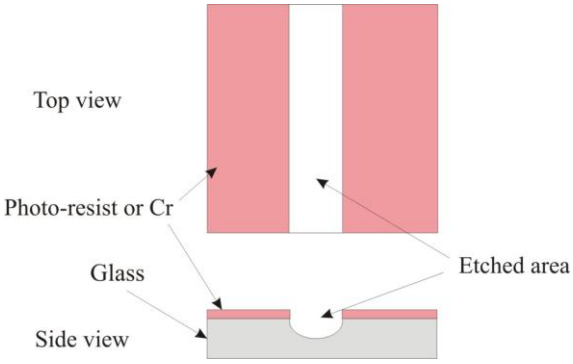

Fig. 2 Glass wet etching materials

The fabrication process is started by cleaning the glass substrates in acetone and methanol in 10 minutes separately and boiling in piranha solution (H_2SO_4:H_2O_2= 3:1) for 15 minutes. Immersing in Deionized Water (DI) water and drying with nitrogen gas is the next step. Removing residual humidity on glass substrate can be achieved by putting them in an oven with 100ºC for 15 minutes. Using spin coater to coat the glass with photo-resist (PR) is the next step. After coating, pre-baking procedure for de-bubbling and removing humidity is applied to avoid sticking the PR to the transparent photo-mask under the UV exposure. Hard baking step is applied next. Etching process was performed in a magnetic stirring buffered oxide etch, BOE, (6:1) bath. Fabrication results before and after PR removal is illustrated in Fig. 3.

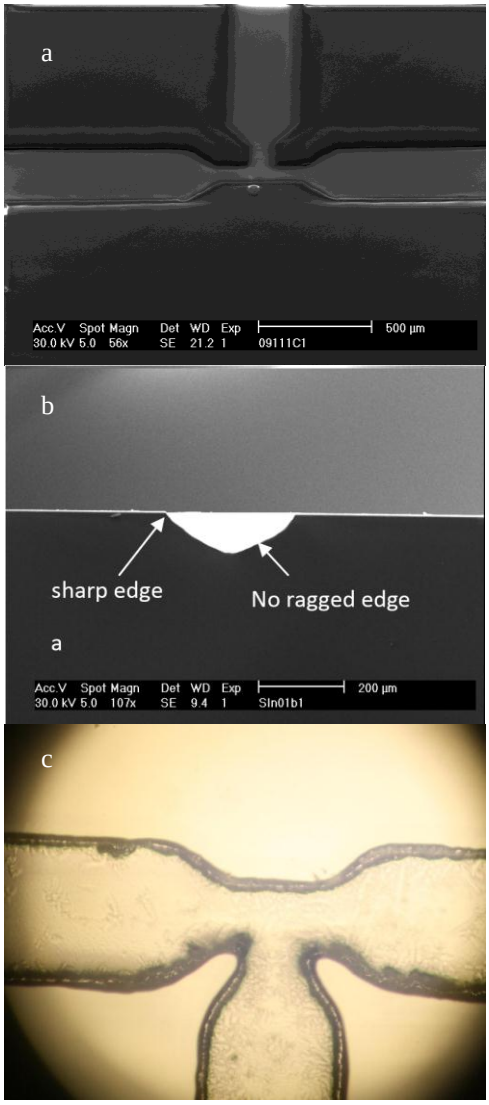

Fig. 3 (a) SEM results with PR, (b) SEM results after etching (cross section), (c) After etching under microscope

III. Results

The generation of each air bubble needs an accurate flow rate which is related to the micropump that is used for the experiment. Moreover, the velocity of the fluids and the fabricated surface itself are significant factors in drop

generation. Therefore, the stability and durability of the proposed method should be investigated thoroughly.

The fabricated micro-droplet generator has been used in real world to verify simulation results. Tubings and connections are attached to the microfluidic device and the fluids have been injected via inlets. For visualization purposes a blue artificial color has been added to the water. The steps of the bubble generation are shown in Fig. 4 under the microscope.

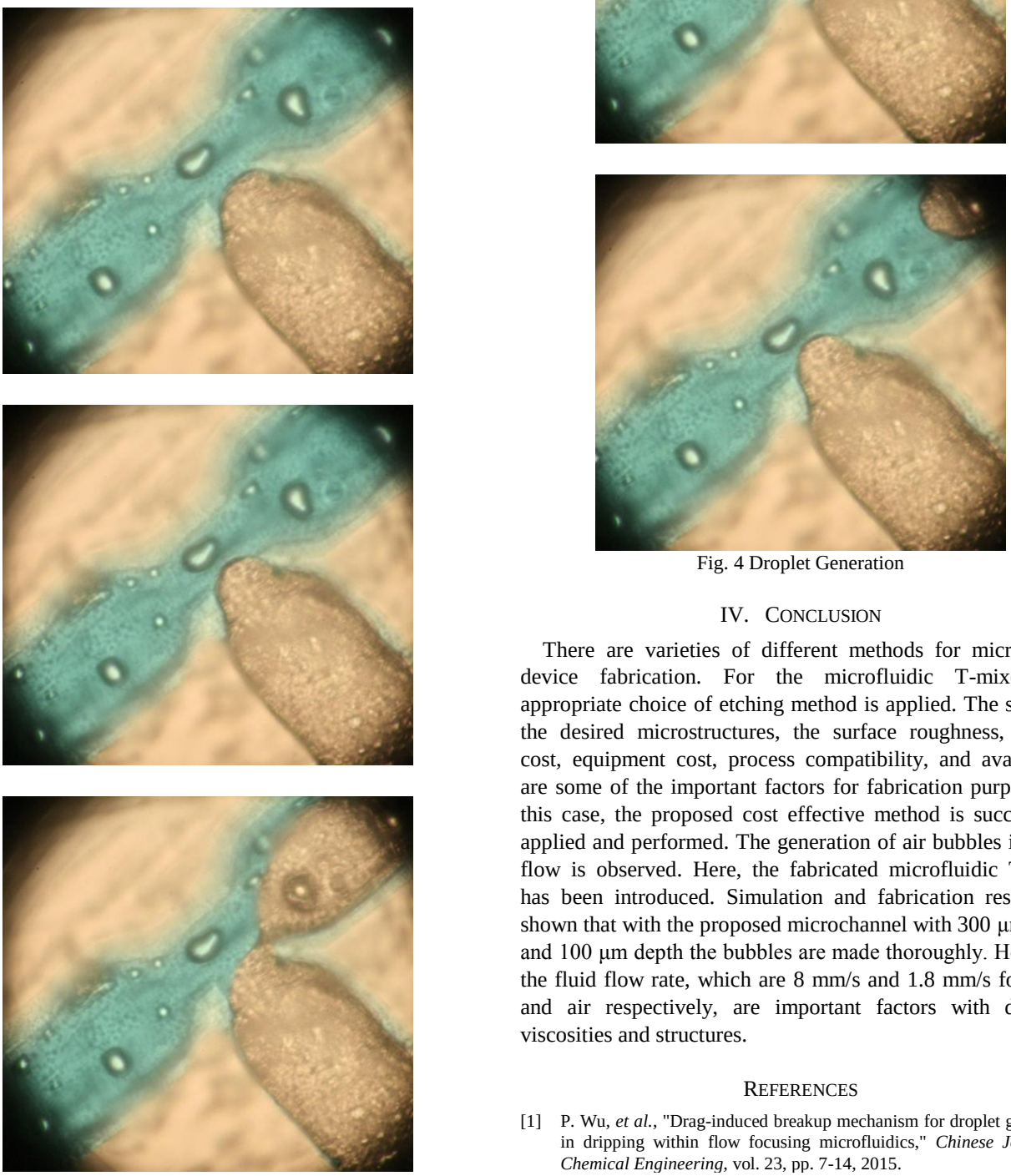

Fig. 4 Droplet Generation

IV. Conclusion

There are varieties of different methods for microfluidic device fabrication. For the microfluidic T-mixer, the appropriate choice of etching method is applied. The shape of the desired microstructures, the surface roughness, etchant cost, equipment cost, process compatibility, and availability are some of the important factors for fabrication purposes. In this case, the proposed cost effective method is successfully applied and performed. The generation of air bubbles in water flow is observed. Here, the fabricated microfluidic T-mixer has been introduced. Simulation and fabrication results are shown that with the proposed microchannel with 300 μm width and 100 μm depth the bubbles are made thoroughly. However, the fluid flow rate, which are 8 mm/s and 1.8 mm/s for water and air respectively, are important factors with different viscosities and structures.

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