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Fabrication of PDMS Microfluidic via Room Temperature Rapid Prototyping Process

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Abstract. An in-expensive way of fabricating PDMS microfluidic using room temperature curing process is presented; the device can be used for both laboratory and commercial scale. It was designed using AutoCAD for master mold preparation and subsequently created with SU8 for rapid prototyping process; the micro mixer and the whole mixer were fabricated in less than without using costly fabrication steps. The device profiles were observed for structural integrity and evaluation by dropping two food coloring dyes through the two inlets and collecting the sample at outlet. Flow rate and mixing efficiency were quantitatively measured by analyzing the recorded flow profiles and values of the image collected from the high powered microscope at inlet and outlet locations is fully obtained and will be presented in our next publication.

Introduction

Microfluidics in biomedical application has received in many fields of applications due its various advantages and functions and in quest for miniaturization a rapid mixing is essential in many of the micro-fluidic systems used in biomedical analysis, drug delivery and sequencing or synthesis of nucleic acids. Biological processes such as cell activation, enzyme reactions and protein folding often involve reactions that require mixing of reactants for initiation. Mixing is also necessary in lab-on-a-chip (LOC) platforms for complex chemical reactions [1-5]. Micro fluidic can be integrated in a micro-fluidic system or work as stand-alone devices device for various applications such as drug production. Furthermore, the investigation of microfluidic is fundamental for understanding transport phenomena on the micro scale and beyond. Various application such as extraction, polymerization, organic synthesis, analytical assay, drug delivery studies, clinical diagnostics the miniaturized systems, designed for the above cited applications, are generally implemented with a micro scale mixer to provide an intimate contact between there agent molecules for interactions chemical reactions. Furthermore, beside their integration in more complex micro total analysis systems (mTAS) micro scale mixers could also work as stand-alone devices for applications where a superior control and a scaling-down of the mixing process are required[6-10].

Through the capillarity it is possible to create spontaneous movement of liquids based on cohesive forces within the liquid and adhesive forces between the liquid and its surroundings, among the fields of application for capillarity is microfluidics, where capillarity enables the filling of micro/ Nano channels without external actuators or cumbersome fluidic connectors[11-15]. The concept of capillary filling phenomenon to drive a mobile phase through a porous material, such as paper, silica gel, alumina, or cellulose, which serves as stationary phase. Difference in affinities leads to the separation of the analytes. Since recent years, advances in micro/nanotechnologies allow for the fabrication of structures at Nano scale and here in this study we would to take this advantages within enhanced approach by supporting the capillary with geometry creation for mixing and flow as well [16-18].

Materials and Methods

The fabrication of the mixer was conducted with SU-8 photo resist which was used to produce the mould, PDMS was used the material for the mixer, curing agent, Isopropanol (IPA) Glass and Acetone. The acetone and IPA serve in substrate cleaning to remove the contaminants and particles. SU-8 is a typical used epoxy-based negative photo resist which is used to create patterns with high aspect ratio structures. Su-8 is a very viscous polymer that can be spun or spread over a thickness. During exposure, the molecular chains of SU-8 are cross-linked and hardened. The developer used for SU-8 is 1-Methoxy-2-propanol acetate. SU-8 was used once as a high-resolution mask in fabrication process. But it is mostly used in the fabrication of micro fluidics device and MEMS parts. SU-8 has high transparency in the ultraviolet region, which allows the fabrication of thick structures with nearly vertical side walls. After exposure and developing, the high cross-linked structure has strong immunity to chemicals and radiation damage. Polydimethylsiloxane (PDMS) is the polymeric organ silicon material. It is usually used as silicon-based organic polymer for its extraordinary performance in rheology. The transparency of PDMS is high and it is chemically inert, non-flammable and non-toxic. The shear modulus of PDMS depends very much on preparation conditions, but it varies in the range of 100 kPa to 3 MPa. The loss tangent is very low, which is less than 0.001. The chemical formula for the material is $CH_3[Si(CH_3)_2O]_nSi(CH_3)_3$, where n is the number of repeating monomer $[SiO(CH_3)_2]$ units.

The development begins with the device layout planning. Computer aided design (CAD) program will be used to define the layout and geometry of the desired pattern of the device. Micro channel or chambers will be fabricated first by developing the master template and subsequent replication process is done for various shape needed depending on the master template design and fabrication. Photolithography process of micro fabrication is performed to create patterns on the substrate. The process steps involved are spin coating, soft baking, exposure, hard bake and development. The photo resist used is SU-8 which is a negative photo resist. Initially, very small amount of SU-8 is dropped at the centre of the silicon wafer. The speed is set to 800rpm for 10s. This process step is purposed to spread the thin SU-8 layer all over the surface of the substrate and improve the adhesion of the whole SU-8 layer on the silicon segment. After that, about 3ml of SU-8 is dropped at the centre of the wafer, and undergoes the second spin coating. The spin speed is set to 2000 rpm for 20s with the ramp up speed at 800rpm for 20s. After spin coating with SU-8, the wafer is soft baked at temperature of 65ºC for 10 minutes by using hot plate. After that, the wafer is baked at the temperature of 95ºC for 20 minutes. This soft baking process is to produce the high aspect ratio imaging. During the soft baking process, the solvent level of SU-8 layer is reduced, and hence decreases the risk of exposed resist loss, swelling and the adhesion defects. The wafer is then left on a cold plate to cool down for 30 minutes. Upon cool down, the wafer is exposed to UV light by using mask aligner through the designed mask. Since negative photo resist is used in our cases, the exposed region will remained after development. The exposure process goes on for 55s. After exposure, the wafer is transferred to hot plate to hard bake at the temperature of 95ºC for 20 minutes. Shapes of patterns can be observed clearly on the SU-8 layer of wafer after the post exposure baking. The wafer is then proceeding to development. The substrate is immersed into 1-Methoxy-2-propanol acetate, which is the developer for SU-8 photo resist. The exposed region will be hardened while the unexposed region will be removed by developer. The development time is approximately 8-10 minutes. If white stain of unfinished development is observed on the surface of the substrate, the wafer is developed for another 5 minutes. The photolithography process ends by spinning the wafer on spin coater at high speed to remove the liquid on the substrate Fig.1.

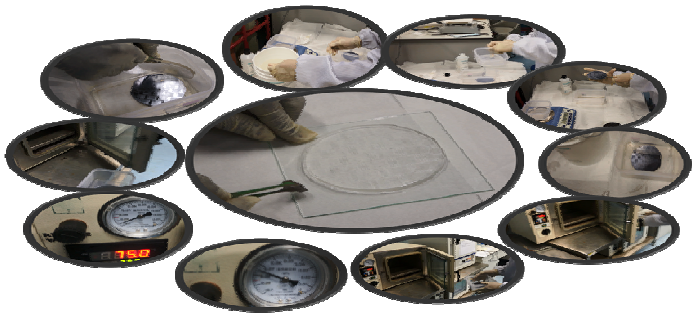

Fig.1, Show the process block undergoing photholithography process by using Su-8 photoresist. , Wafer is cleaned, SU-8 is spin coated and soft baked, UV light exposure through mask aligner.

Results and Discussion

Fig.2, show geomtry enhanced micromixer mask that will support capillary and capillarity is the spontaneous movement of liquids based on cohesive forces within the liquid and adhesive forces between the liquid and its surroundings, among the fields of application for capillarity is microfluidics, where capillarity enables the filling of micro/ nano channels without external actuators or cumbersome fluidic connectors[1]. The concept of capillary filling phenomenon to drive a mobile phase through a porous material, such as paper, silica gel, alumina, or cellulose, which serves as stationary phase. Difference in affinities leads to the separation of the analyte. Since recent years, advances in micro/nanotechnologies allow for the fabrication of structures at nanoscale

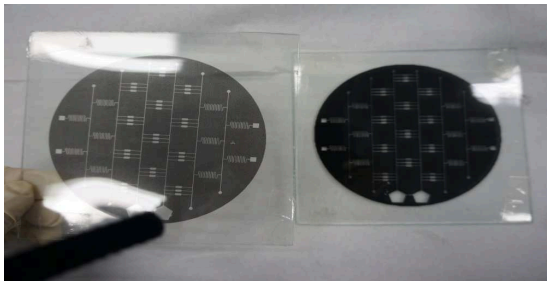

Fig.2, Printed transparent mask for the mast mould fabrication

One of the characteristic features of microfluidics is the dominance of surface effects due to the large surface to bulk ratio on the micrometer scale. A prominent class of surface effects is known as capillary effects particularly strong in microchannels having bore diameters equal to or less than about 50 μm Various researchers investigated the flow characteristics of different fluids in Microchannels including nitrogen and helium gases, isopropyl liquid and silicone oil.

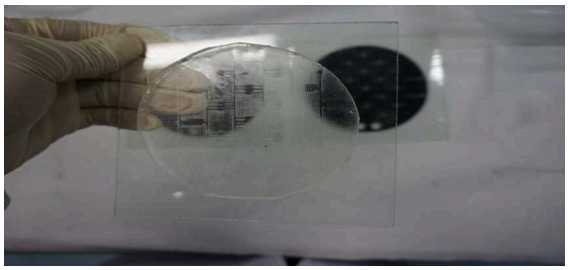

Fig.3, Fabricated multistages microchannels

The study focus on design and fabrication of an inexpensive and rugged sample delivery system, namely PDMS Microfluidics, which has capabilities of higher efficiency permitting greater probabilities of interactions between bio-samples (analyze) and fabricated nano based transducer as shown in fig3. We specifically interesting to study the influence of Microfluidics chamber and tube (inlet and outlet) design and sizes for capillary and flow mechanic effect of bio-molecule sample dynamic flow. and to understand the performance of the proposed integrated PDMS Microfluidics

with nano size transducers to function as Nano LAB-On-Chip for smooth delivery of bio-molecule samples to the fabricated nano based transducer for sensitivity and selectivity detection using electrical measurement,

The fig.3, show the multi stage microchannels that have capalities for testng various semples simutaneous. Surface tension is a property that relates to the surface or interfaces and depends on the state of the substance on both sides of the interface, the Fig.4b shows the ratating mixer that will exposure the fluid molecule within the channel . The surface tension of an interface is defined as the Gibbs free energy per area for fixed pressure and temperature, A molecule in the bulk forms chemical bonds with the neighbouring thus gaining a certain amount of binding energy. A molecule at the surface cannot form as many bonds since there are almost no molecules in the gas. This lack of chemical bonds results in a higher energy for the surface molecules. This is exactly the surface tension: it costs energy to form a surface. Using this model it is easy to estimate the order of magnitude of surface tension for a liquid-gas interface, Another fundamental concept in the theory of surface effects in microfluidics is the contact angle that appears at the contact line between three different phases, typically the solid wall of a channel and two immiscible fluids inside that channel. The two concepts, contact angle and surface tension, allow for understanding the capillary forces that act on two-fluid flows inside microchannels in lab-on-a-chip systems. Since ,both the channel cylindrical, we used the axis symmetric geometry Initially, the thin cylinder is filled with air. Wall adhesion causes water to creep up along the cylinder boundaries, here we used water but the component can be used subsequently for all low density fluids. The deformation of the water surface induces surface tension at the air/water interface, which in turn creates a pressure jump across the interface. The pressure variations cause water and air to move upward. The fluids continue to rise until the capillary forces are balanced by the gravity force building up as the water rises in the channel. In the present Fig.4, Show the fabricated and integrated however, the testing result will be shown in our next publication.

Fig.4, Completed microchannels device

Summary

The study demostrated a simple design and fabrication of geometry enhanced micro mixer that the is supprot by capillary based within microfluidic channel, the channels were used to create micromixer focus on obtaining minimum possible gab between two surfaces to enhance flow aand mixing profile. We have fabricated two different geometry structures of 1μm and 2μm roughness between within the micro channel and the feature study will be focused on flow and mixing mixing profile optimisation.

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