Concentration Generator With On Chip Vacuum Pump

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***Abstract-* We present an innovative concentration generator with on chip vacuum pump. The concentration generator is contained the microfluidic channel and self-priming microfluidic device. The microfluidic channel structure is made up from polypropylene which characteristic are ultra-thin (under than 100 um), cost effective, mass producible, rapid fabrication process. The self-priming microfluidic device also has many feature, like thin residual layer (under than 100 um), on chip new pumping method, standing alone device, minimal manual operation, commercialize. In this paper, we propose the design of microchannel which generating concentration gradient, and introduce the fabrication process, simulation, and experimental result. Due to all the advantages, we think this concentration generator system can be used on biochip.**

I. BACKGROUND

With the increase in population and global aging, biotechnology demand gradually increased. Because of technological advances in process, "Lab on a chip", which is the tendency of the research like biochemical, biomedical and pharamacological has been developed for decades all over the world. The spirit of lab on a chip is just like the term literally, to concentrated the laboratory work on a small chip. This approach will bring many advantages like-reduce the size of instrument, directly lower the sample amount and experimental time. Particularly suitable for vitro diagnostics, point of care and have the potential to become a portable platform product.

II. INTRODUCTION

Concentration generation is one of the branch of microfluidics, which can produce the desired concentration or concentration gradient. In microfluidic-based biochemical analysis systems, mixing of the liquid sample is considered one of the most chanllenging task to achieve an appropriate reaction in a short period of time. Mixing in microfluidic systems is typically dominated by diffusion instead of turbulence due to the low Reynolds number on the micro scale [1] [2]. However, mixing by diffusion only is very time-consuming and inefficient. In order to produce turbulent flow to accerlerate the mixing process.in microfluidic systems, many active mixing method, such as ultrasonic [3], magnetic stirring [4], and bubble-induced acoustic actuation [5], have been applied in the development of active micromixers to enhance mixing. However, active micromixers, which can have excellent mixing performance, are not easy to integrate with other in-plane microfluidic components and are often not suitable for a disposable microfluidic platform due to their high cost.

Compared with active micromixers, passive mixers have the advantages of low cost, simple of fabrication and integration with microfluidic system, without any complex control units, and addition power input. Most passive micromixers usually depend on diffusion mixing of two or more substreams because of low Reynolds numbers in microfluidic devices usually produce a laminar flow. We proposed an innovative in plane passive micromixer which try to produce turbulences. This new type of mixing channel and then with the vacuum pump, in order to, increased mixing efficiency and rapid generation of specified concentrations.

III. CURRENT RESULTS

The mircochannel pattern was adhered on the wafer by using SU-8 process. A mold was fabricated sing conventional UV-lithography with negative photoresist of SU-8 2050. Then, using the mold to fabricate the microchannel by hot embossing. Schematic illustration of the microfabrication process of the hot embossing is summarized (Fig 2、5). We use the hot embossing system that we designed to manufacture micorchannel (Fig 3). It has the advantage of rapid production and flexibility (Fig 4). The microchannel is made of Polypropylene which its depth is 50 um, and the residual layer is also 100um. The ultra-thin layer brings many benefits like enhance the thermal conductivity and the residual stress easy to release. We drive the liquid with on chip vacuum pump (Fig 6)

We use COMSOL to simulate the mixing of liquid by the Finite Element Methods (FEM) (Fig 7、9). The velocity of the liquid at the inlet is 1 mm / s. In this research, we demonstrate that a change in concentration occurs in a very short time (Fig 8)

REFERENCES

[1] W. Ehrfeld, V. Hessel and H. Lowe, *Microreactors—New Technology for Modern Chemistry*, New York: Wiley-Vch, 2000.
[2] K. Benz, K.-P. Jackel, K.-J. Regenauer, J. Schiewe, K. Drese, W. Ehrfeld, V. Hessel and H. Lowe, Utilization of Micromixers for Extraction Processes, *Chem. Eng. Techno*l., 2001, 24, 11.
[3] Z. Yang, S. Matsumoto, H. Goto, M. Matsumoto and R. Maeda, Ultrasonic Micromixer for Microfluidic Systems, *Sens. Actuators*, A, 2001, 93, 266.
[4] L.-H. Lu, K. S. Ryu and C. Liu, A Magnetic Microstirrer and Array for Microfluidic Mixing, J. *Microelectromech. Syst.*, 2002, 11, 462.
[5] R. H. Liu, J. Yang, M. Z. Pindera, M. Athavale and P. Grodzinski, Bubble-Induced Acoustic Micromixing, *Lab Chip*, 2002, 2, 151.

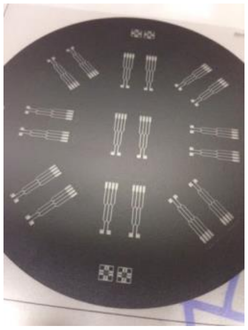


Fig. 1. Microchannel pattern

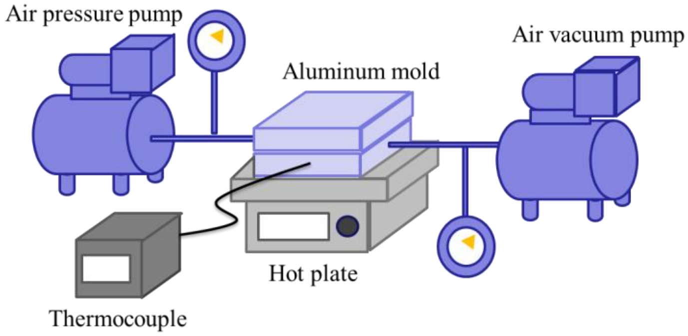


Fig. 3. Hot embossing system

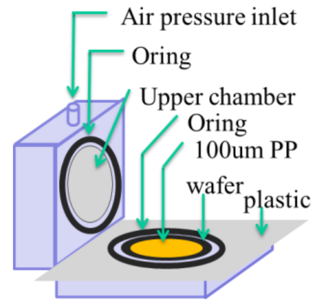


Fig. 4. Aluminum mold

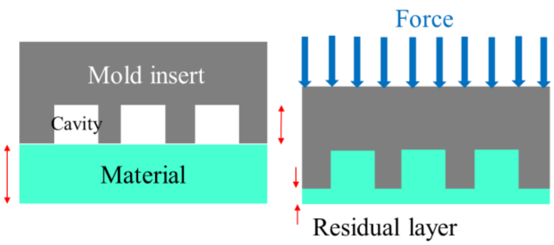


Fig. 2. Hot embossing process

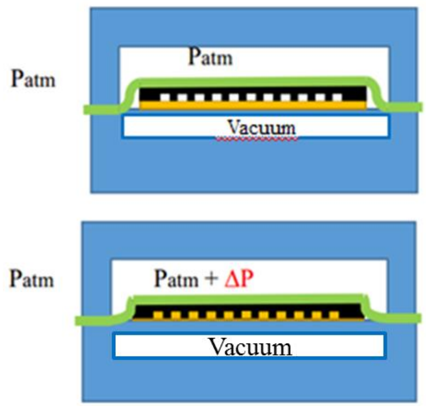


Fig. 5. Hot embossing working principle

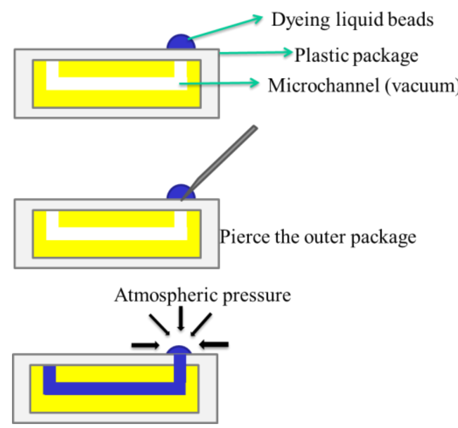
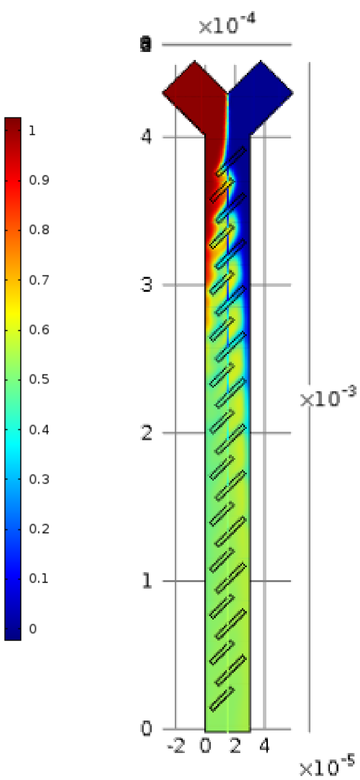


Fig. 6. Air pump working principle



Name	Expression	Value	Description
D	5e-11[m^2/s]	5.0000E-11 m...	Diffusion constant
fr	0.03[mm^3/s]	3.0000E-11 m...	1mm/s
c0	1[mol/m^3]	1 mol/m³	Inlet concentration
alpha	0.5[(m^3/mol)...	0.5 m⁶/mol²	

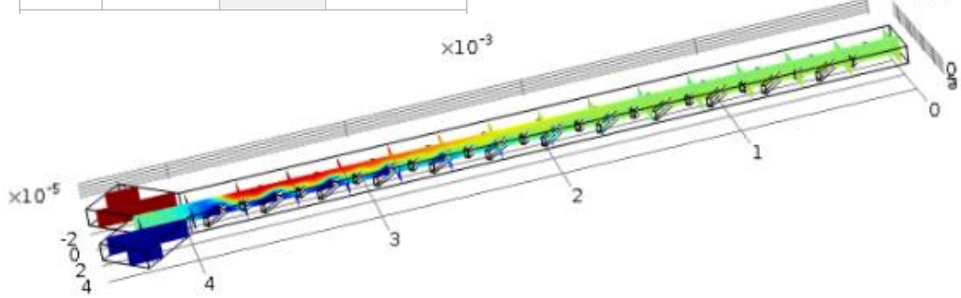
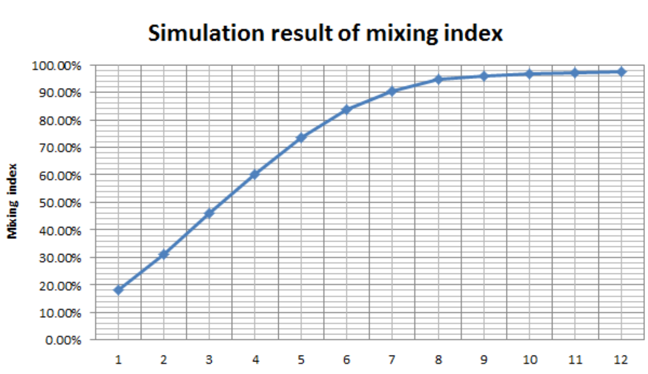


Fig. 7. Comsol simulation

(a)



(b)

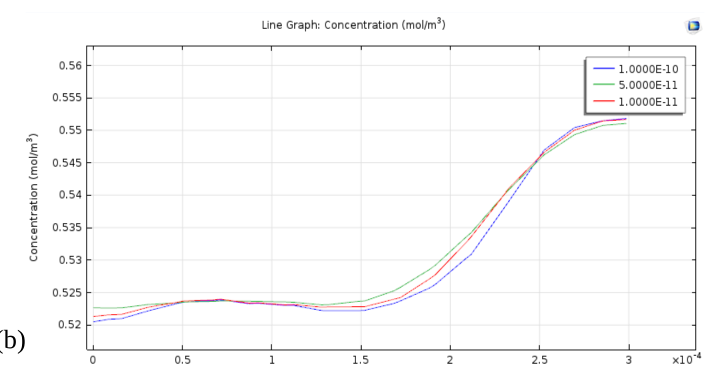


Fig. 8.(a) simulation result (b) Outlet concentration