ON-CHIP MICRO-DROPLET DISPENSER WITH DISPOSABLE STRUCTURE

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ABSTRACT

We succeeded in dispensing micro-droplet by a disposable on-chip inkjet mechanism. Novelty of this paper is summarized as follows. (1) We employed a glass bonded PDMS to obtain leaf spring structure whose spring coefficient is 14 times of the conventional PDMS chip. As a result, we succeeded in dispensing of droplets by vibrating the membrane using the piezoelectric actuator attached to the PDMS disposable chip. (2) The nozzle for droplet dispensing was fabricated by SU-8 to obtain the hydrophobic surface which prevents any undesired satellite droplets produced. Consequently the accuracy of position of the droplet dispensing was achieved ±5 μm. The size of the droplet produced from the disposable nozzle (diameter = 100μm) was in the range of 95−105 μm at the applied voltage of 105 V.

KEYWORDS: Inkjet, Microfluidic chip, Droplet dispenser, Photolithography

1. INTRODUCTION

In the medical field, automation of bio-manipulation by non-contact actuation is demanded using a disposable PDMS chip. Conventional PDMS disposable biochips have many functions such as separation, sorting and so on [1], however limited study is available on retrieving of the manipulated cells from the chip systematically [2]. Therefore we proposed the automation of on-chip particle retrieving by spotting on a microarray using a novel on-chip disposable inkjet system which avoids any risk of contamination (Fig.1).

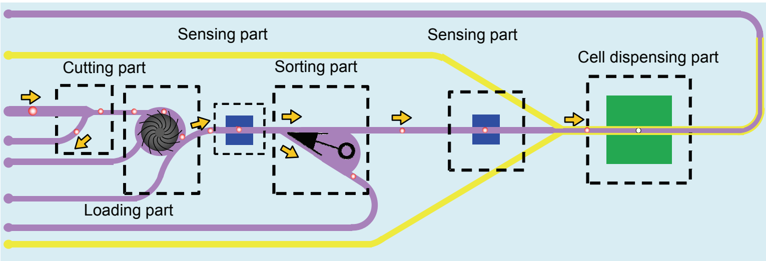

Figure.1 Concept of on-chip cell manipulation and dispensing cell-laden droplet system

2. EXPERIMENTAL

The independent drive system was consisted of a piezoelectric actuator and a pin. A disposable bio-chip part has a glass bonded PDMS and SU-8 nozzle (Fig.2). A sheet of glass was mounted between the vibrating drive system and the PDMS chip to gain the rigidity of the vibration membrane. We used the sandblast and photo-

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lithography technique was employed to fabricate the disposable inkjet system (Fig.3). The glass with tapered hole and PDMS chip was bounded and the position of the nozzle can be precisely aligned to the exit of the nozzle since the chip is transparent. The result of the FEM analysis (Fig. 4) showed the glass bonded PDMS provide leaf spring structure whose spring coefficient was 14 times of conventional PDMS chip.

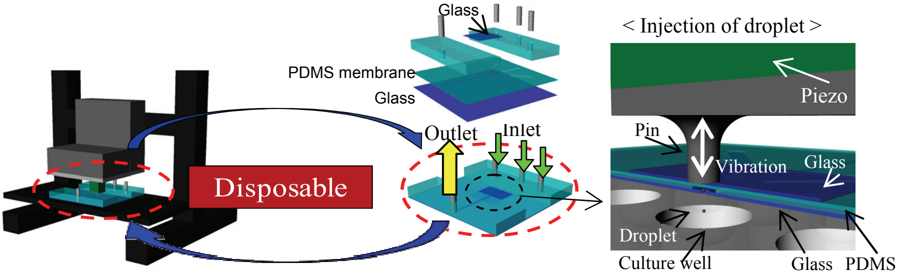


Figure. 2 Schematic of micro-droplet dispenser with disposable mechanism

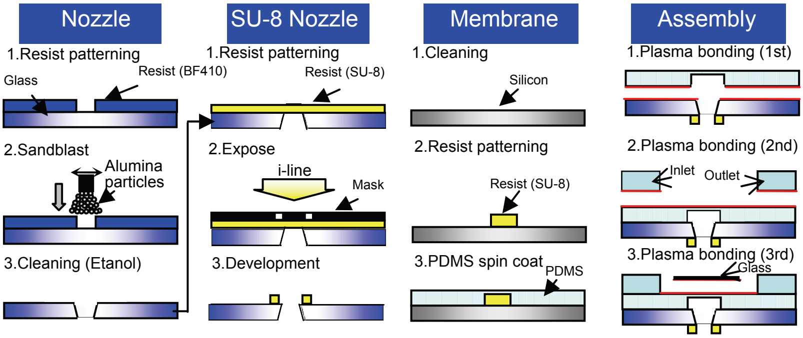
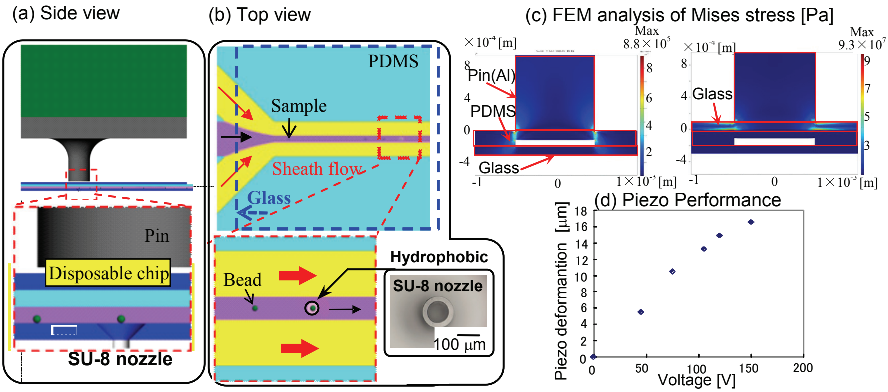


Figure.3 Fabrication process of disposable ink-jet on a chip



	Young's modulus [Pa]	Poisson Ratio	Density [kg/cm^3]
PDMS	5×10^6	0.30	1110
Glasss	70×10^9	0.17	2200

Figure. 4 Mechanism of droplet generation through SU-8 nozzle and FEM analysis of Mises stress and Piezo performance.

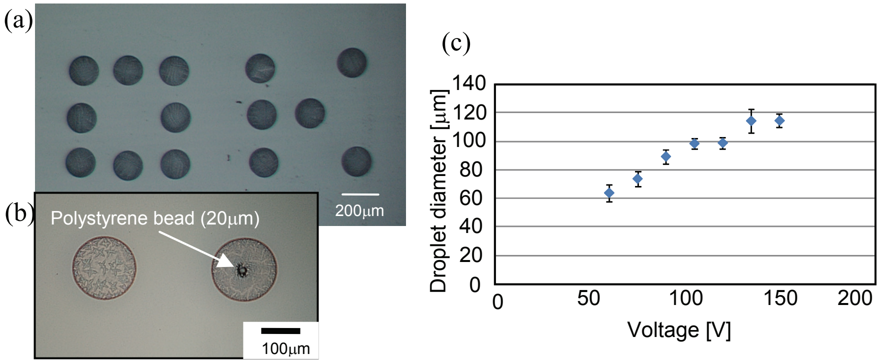


Figure.5 (a) Automation of patterning of droplets and (b) a single bead laden droplet injected and (c) size of injected droplet as a functions of applied voltage.

3. RESULTS AND DISCUSSION

By controlling the flow rate of syringe pumps (+ 1 ml/h of three syringes to produce sheath laminar flow, and -5 ml/h pulling from exit), we solved the leaks of solutions from the nozzle. The hydrophobic SU-8 nozzle prevents undesired satellite droplets around a main droplet. The size of the droplet produced from the disposable nozzle (diameter = 100 μm) was in the range of 95-105 μm at the applied voltage of 105 V to the piezoelectric actuator (Fig. 5). The positioning accuracy of dispensing droplet was ±5 μm (the distance between the nozzle and the target plate was 20 mm). The automation of spotting and patterning of droplets was successfully carried out by using X-Y stage as shown in the Figure 5. The 50 μm polystyrene beads laden droplet was also successfully injected because the position of particles can be fixed by the laminar sheath flow when it was ejected.

CONCLUSIONS

We succeeded in dispensing particle laden micro-droplet by a disposable on-chip inkjet mechanism. A glass bonded PDMS structure provided leaf spring structure to dispense droplets. Based on this achievement, we can extend this system to the automation of spotting on a microarray to culture cells in incubator systematically.

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