ABSTRACT
This work presents a simple device for trapping and making an array of 1μm-sized objects. Although a lot of methods for trapping and arraying small particles have been reported [1] [2], there still remain difficulties to manipulate numbers of 1μm-sized objects in a short time. Here, we describe a microfluidic device with nanochannels: this device is applicable to trap and array 1μm-sized objects by hydrodynamic force through the nanochannels. We successfully applied this dynamic microfluidic device for φ1 μm fluorescent beads and living Escherichia coli (E. coli).

KEYWORDS: Microarray, Nanochannel, E. coli, Dynamic microfluidic device

INTRODUCTION
In cellomics studies, drug screening and detection/diagnostic applications, there is great demand for micro devices that enable to trap small particles such as microbeads coated with proteins or living cells. We have reported on a dynamic microfluidic device to trap and release microbeads in a short time in Micro Electro Mechanical Systems (MEMS) 2008 [3]. This device, however, was not able to trap 1μm-sized particles since trapping 1 μm particles needs fluidic channels smaller than 1 μm; this width is difficult to be fabricated by conventional photolithography. Here we demonstrate a dynamic microfluidic device embedded with nanochannels formed by etching glass substrate using CHF₃ plasma.

Figure 1 shows the concept of our dynamic microfluidic device. This device consists of two parts; cover Polydimethylsiloxane (PDMS) microchannels and glass substrate with nanochannels. When we introduce 1μm-sized particles, they are trapped at the nanochannels by the hydrodynamic force through the nanochannels. After certain numbers of particles are trapped, the hydrodynamic resistance increases and the following particles are no longer trapped at the filled nanochannels.

Figure 1. Concept of trapping particles by hydrodynamic force through nanochannel
FABRICATION

Figure 2 shows the fabrication process of this device. First, we fabricated cover PDMS by basic photolithography process using S1818 positive resist (Figure 2(a-e)). Then, we deposited aluminum on the glass substrate as a mask for glass etching. Then, we etched the glass by CHF$_3$ plasma for about an hour (Figure 2(f-l)).

Figure 2. Fabrication process of microfluidic device with nanochannel

Figure 3(a) is the image of the surface of the etched glass. The white box indicates the scanned area by Atomic Force Microscope (AFM) and Figure 3(b) shows the scanned AFM image. The dashed line $\alpha - \beta$ in Figure 3(a) indicates the measured area shown in Figure 3(c). Measured depth of the nanochannels is 400-450 nm. Finally, we bonded the cover PDMS with microchannel and the etched glass substrate by O$_2$ plasma (Figure 2(m)).

Figure 3. AFM image of etched glass substrate
EXPERIMENTAL RESULTS
We conducted two experiments using this device. First, we trapped $\phi 1 \, \mu m$ fluorescent beads and made an array of them. Figure 4(a) shows the array of fluorescent beads. 5-10 beads are trapped at each nanochannel and we could observe the blue fluorescence around the nanochannels. Next, we introduced *E. coli* and made an array of them. Figure 4(b) shows the trapped *E. coli*. We observed that 2-3 *E. coli* were trapped at each nanochannel. These results demonstrate that our microfluidic device is useful for trapping 1$\mu m$-sized objects and making an array of them.

![Figure 4](image)

*Figure 4. Trapped 1$\mu m$ beads and E. coli*

CONCLUSIONS
We have succeeded in fabricating dynamic microfluidic device with nanochannels in depth of 400-450 nm. This device allows us to trap 1$\mu m$-sized beads and polymorphic microbes, and make an array of them only by introducing them into the device. We believe that our device is useful for rapid screening of bacterial phenotypes.

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REFERENCES