MICROMANIPULATION OF MICROTOOLS
MADE OF SU-8
BY INTEGRATED OPTICAL TWEEZERS
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ABSTRACT
We propose a novel cell manipulation method of Integrated Optical Tweezers (IOT) with microtools made of negative photoresist, SU-8 (MicroChem). This microtool is made by photolithography and hence it has complex shape. IOT is a novel optical tweezers integrating Time-Shared Scanning (TSS) [1] for high speed manipulation of a few objects and Generalized Phase Contrast (GPC) [2] for trapping a lot of objects. Here we propose IOT as the combined manipulation method and demonstrate manipulation of SU-8 microtools. This proposed noncontact manipulation method worked well as we expected.

KEYWORDS: Optical Tweezers, Scanning, Generalized Phase Contrast, Microtool

INTRODUCTION
Optical tweezers is useful for noncontact cell manipulation, however, direct irradiation of the focused laser is harmful to the cells. So we have proposed indirect cell manipulation by using laser manipulated microtools. The shape of conventional tools is sphere and manipulability is not good [3]. Therefore, we need to use microtools with well-suited shape for dexterous cell manipulation. Here we made microtools by photolithography using negative photoresist, SU-8 (MicroChem). And for using complex shape microtools, we need Multi-trap Optical Tweezers (MOT) which can manipulate multiple objects. Time-Shared Scanning (TSS) [1] and Generalized Phase Contrast (GPC) [2] are known as MOT and each method has own advantage. TSS is suitable to manipulate a few objects in high speed. GPC is suitable to manipulate a lot of objects, however the manipulation speed is slow compared with TSS. In this paper, we developed IOT by integrating TSS and GPC and demonstrate manipulation of SU-8 microtools.

EXPERIMENTAL
Figure 1 shows the concept of IOT which is integrated TSS and GPC. With the advantage of each method in mind, TSS is primarily used to manipulate objects dynamically and GPC is primarily used to manipulate objects statically in IOT. Figure 2 shows a novel cell manipulation method using microtools manipulated by IOT. In this method, microtools have the circular root and the allow-shaped edge to grasp a cell securely. GPC traps the root of the microtool for support of rotation (not move) and TSS manipulates the edge of the microtool for rotation (move). With this movement like robot hands, we can achieve complicated dexterous cell manipulation.
To manipulate the microtools, we developed IOT which can manipulate them fast and securely. We designed and fabricated microtools with SU-8 of which the shape is suitable for IOT. We can manipulate cells stably since it has plane contact surface. SU-8 is useful for the chemical resistance and its refraction index (1.575) is higher than that of water. Hence it is trapped by laser in water. We fabricated them with photolithography for mass productivity. Figure 3 shows the fabrication steps of the microtools made of SU-8. Figure 4 shows mass-produced microtools which were patterned on the sacrificial layer with photolithography.

RESULTS AND DISCUSSION

We demonstrated IOT performance by trapping polystyrene beads (3 μm diameter: Duke Scientific) shown in Figure 5. The inner five beads (large number) were trapped and rotated with GPC of which speed was $1/5\pi$ rad/sec (slow). The outer two beads (small number) were trapped and rotated with TSS of which speed was $1/2\pi$ rad/sec (fast). From these results, we checked it works as we expected.
Figure 6 shows manipulation of a SU-8 microtool with IOT. The root of the microtool was trapped and fixed with GPC and the edge was trapped and rotated with TSS in high speed. The experiments showed good performance of manipulation.

CONCLUSIONS
In this paper, we developed a new cell manipulation method; IOT which can manipulate microtools stably and securely. We fabricated SU-8 microtools of which shape is suitable for IOT, and manipulated the microtool with IOT. The proposed method can be used for cell manipulation and force measurement of a grasped cell in the microchannel.

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REFERENCES