フォトファブリケーションによるマイクロツールの製作とオンチップレーザ操作

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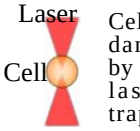
マイクロ流路にマイクロツールを局所投入するにはどうしたらよいか？

Abstract:

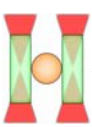
Laser tweezers are suitable for manipulation of a single microscopic object. Single cell manipulation is important for biological research works. We proposed indirect manipulation of cell with the laser trapped microtools to prevent heat damaged by direct lighting of laser at a cell. We succeeded in fixation and pinpoint injection of microtools in a microchip. ITO microelectrodes are patterned on the surface of the microchannel by photolithography. The microtools are fixed on the electrode with the gelatin layer beforehand. To release the fixed tools in water, these electrodes work as micro heaters to melt the gelatin layer. Then, the released tools are caught in the microchannel by dielectrophoretic force near the electrodes. These electrodes are used to generate electric field gradient near the tools. We have confirmed the effectiveness of the proposed method by experiments.

Background:

Why microtools are needed?

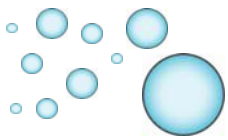


Cells are damaged by direct laser of trapping.

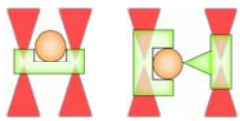


Cells are not damaged by indirect laser of trapping.

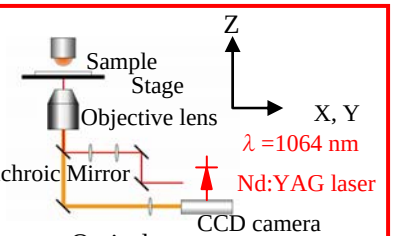
Microtools



The availabilities of wide range of commercial microtools are limited.

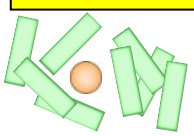


Various kind of microtools are made for dexterous manipulation.



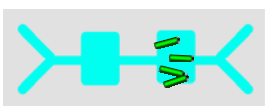
Optical arrangement

Why pinpoint injection of microtools is required?

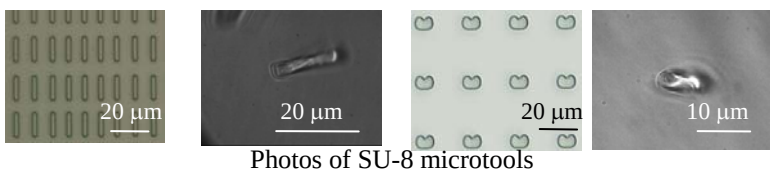


Interruption of manipulation

Number control

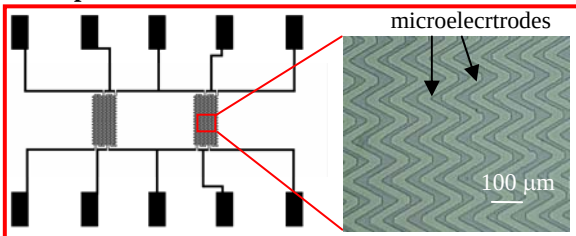


Location control



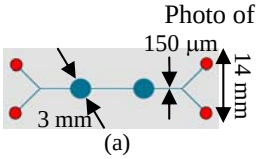
Photos of SU-8 microtools

Concept:



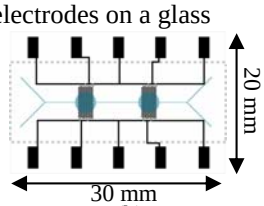
ITO thickness is 100 nm.

Photo of patterned ITO microelectrodes on a glass



(a)

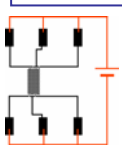
Channel's height was 45 μm and PDMS thickness was 5 mm.



(b)

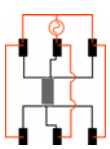
Dedsign of microchip
(a) PDMS channel (b) ITO microelectrodes

(a) Pinpoint injection by microheaters



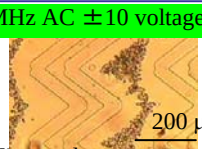
Microheaters used to melt gelatin (side view)
(a) Neutral (b) Gelatin melts by heating the electrode.

(b) Positioning of microtools by dielectrophoretic force



Trap image by dielectro-phoretic force (side view)

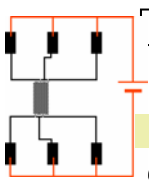
1 MHz AC ±10 voltage on



Microtools are arranged by dielectro-phoretic force with no water flow.

Experiment result:

(a) Pinpoint injection by microheaters



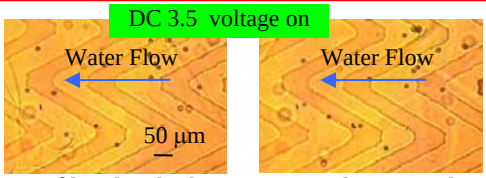
ohmic value: 1.57 kΩ

3.50 V

Joule's law

$$Q(cal) = 0.24 \times V \times I \times t = 1.87 \times 10^{-3} \times t$$

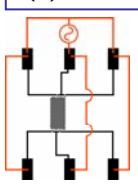
DC 3.5 voltage on



Photos of beads which were put in the microchannel

Beads were transported to the drain port and the speed was regulated by the syringe pump. After heating the electrode, gelatin was washed away by water. Without heating, beads didn't move. In photographs, beads were moved to left.

(b) Positioning of microtools by dielectrophoretic force



1 MHz ±10.0 V

1 MHz AC ±10 voltage on

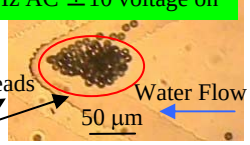
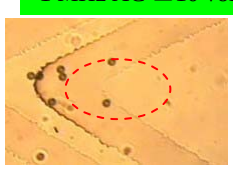


Photo of gathered beads

Many beads were flown using a syringe pomp, where flow rate was 60 μm/s. However, dielectrophoretic force by microelectrodes was strong enough to capture beads around the apex of a triangle.

1 MHz AC ±10 voltage off



After AC voltage was cut off, beads were flown to the drain port and hence, no beads were observed. Consequently, we could control the positions of microtools in the chip.

Photo of immediate aftermath of power off

Conclusions

- Micro electrodes are used for purpose of microheater and dielectrophoretic force control.
- We have confirmed pinpoint injection of microtools by using gelatin and microheater.
- Using dielectrophoretic force and pump, microtools were placed in the microchip.
- We have used laser tweezers with the microtools to prevent damage to the sensitive samples.