On-chip cell loading by a micro-robot had a suction mechanism

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超小型無索ナノピペットロボットで細胞を吸引して素早く運ぶ！

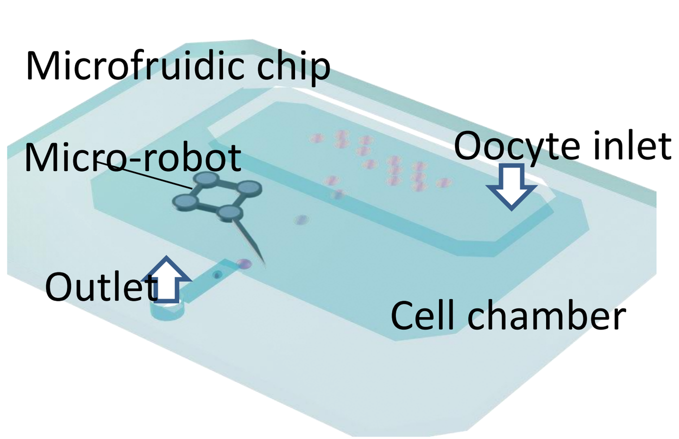
1. Background

Cell analysis using Micro-fluidic chip and micro-robot.

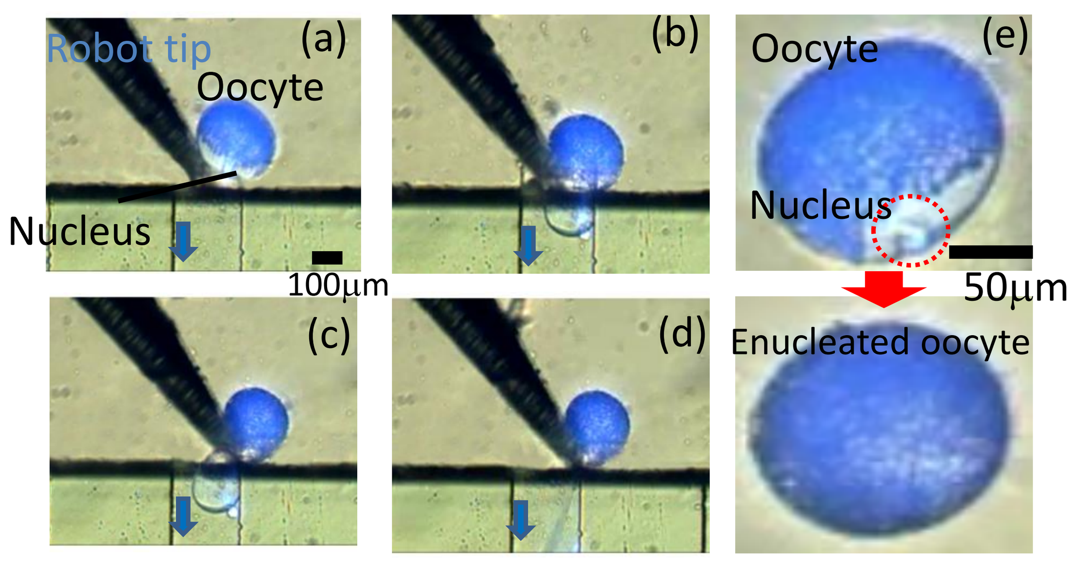
Advantage: Cell manipulation with high resolution and high speed,

Low contamination, Low turbulence

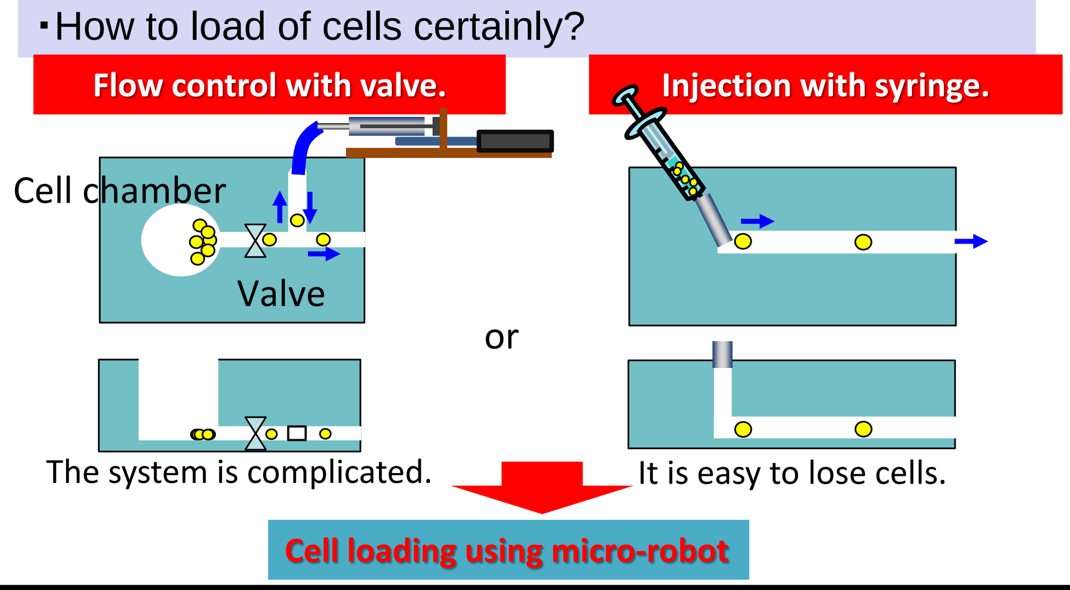
Enucleation using micro-robot and micro-fluidic chip



M. Hagiwara, F. Arai, et. al. MEMS2012

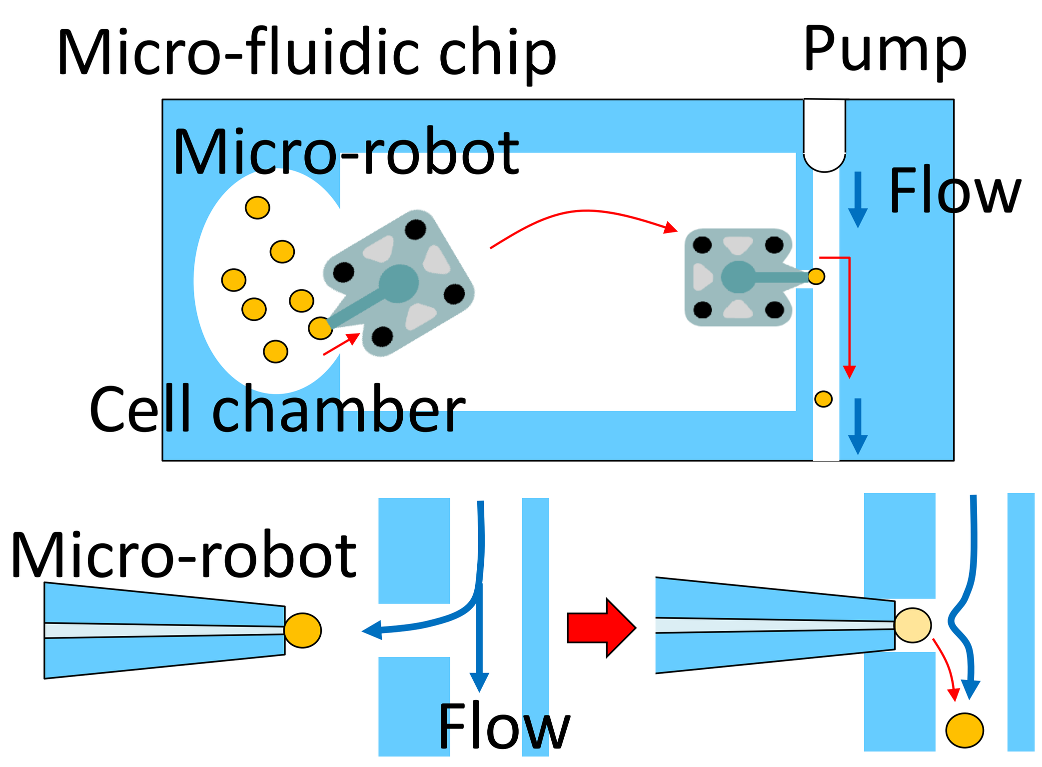


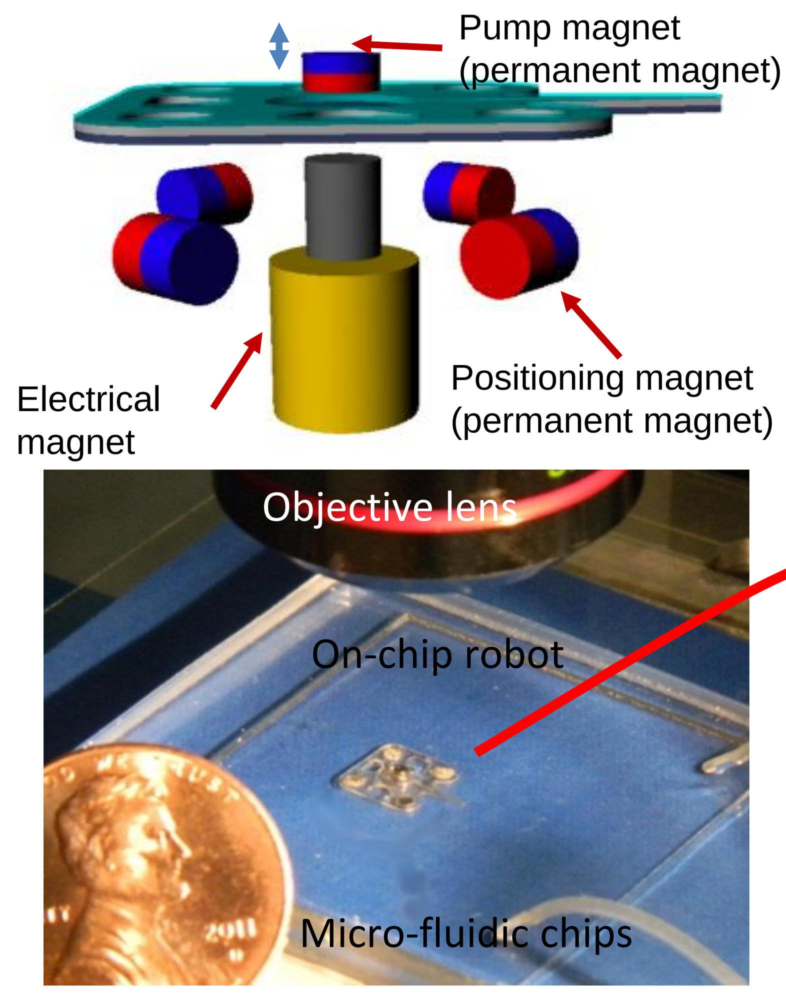
Problem of cell manipulation in Micro-fluidic chip.
・How to load of cells certainly?

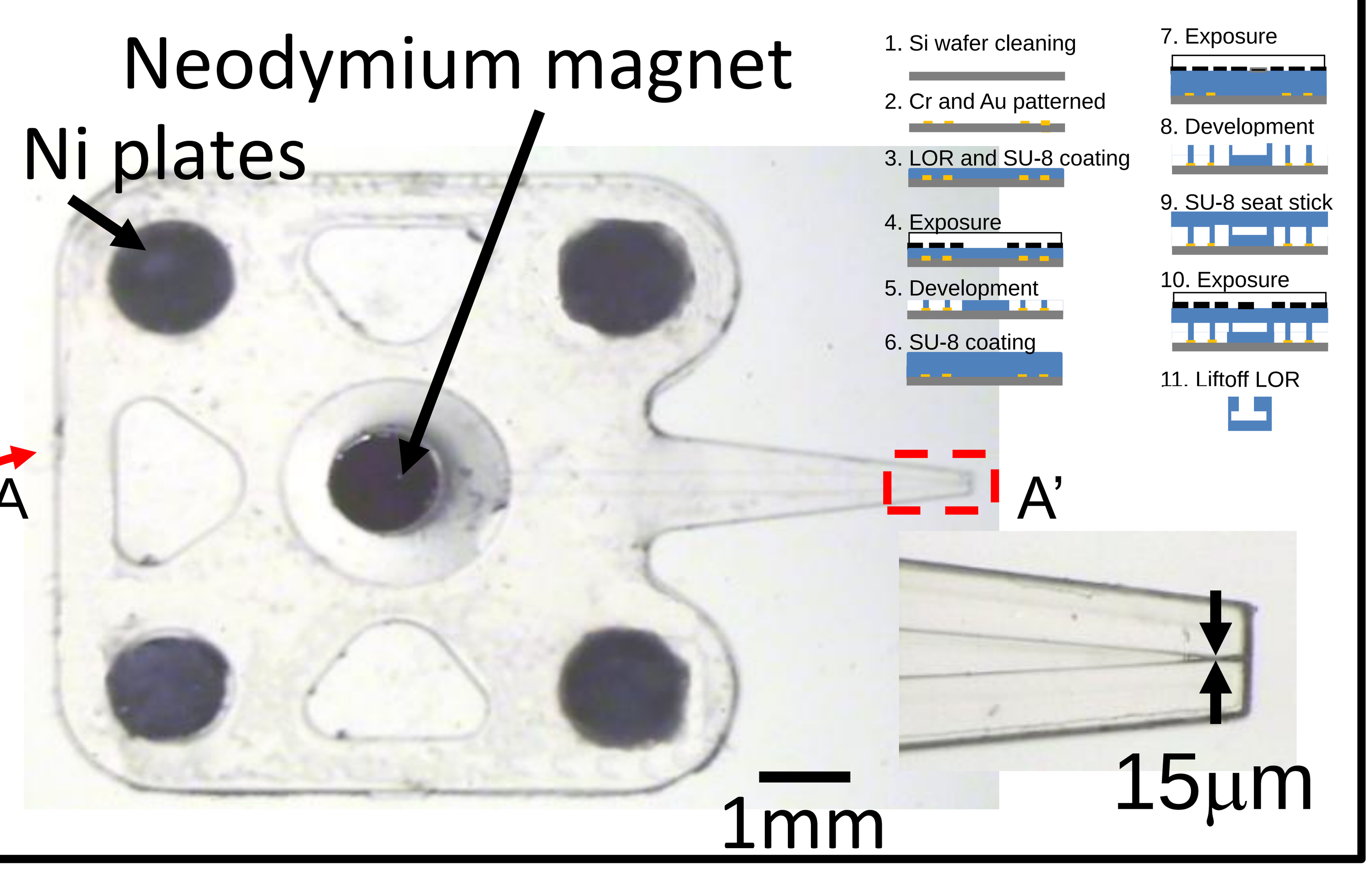


2. Concept & Fabrication

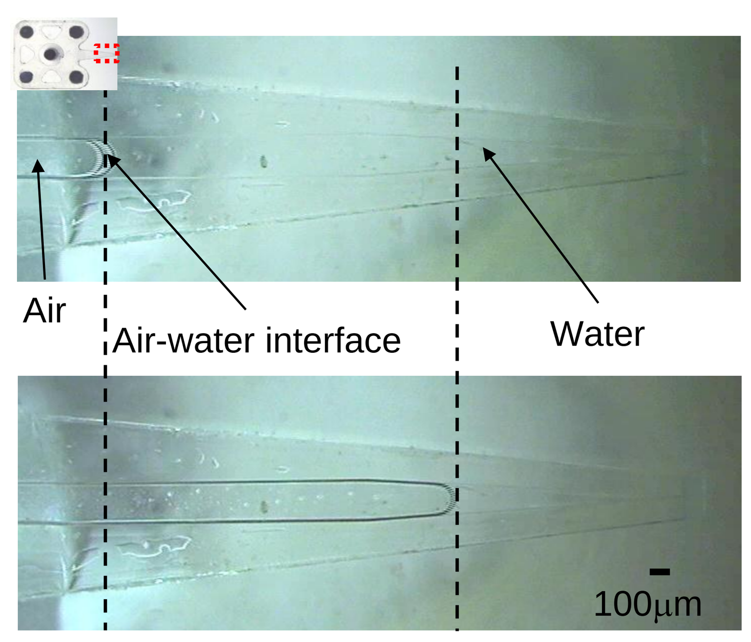
Cell loading using on-chip micro-robot.
High precision, High speed, Low contamination

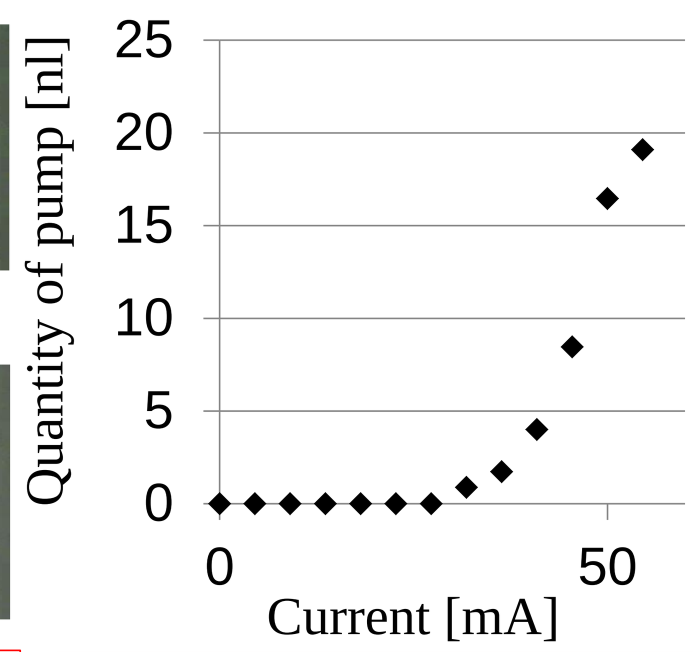






3. Aspiration force





Pumping quantity: Q_{pump}

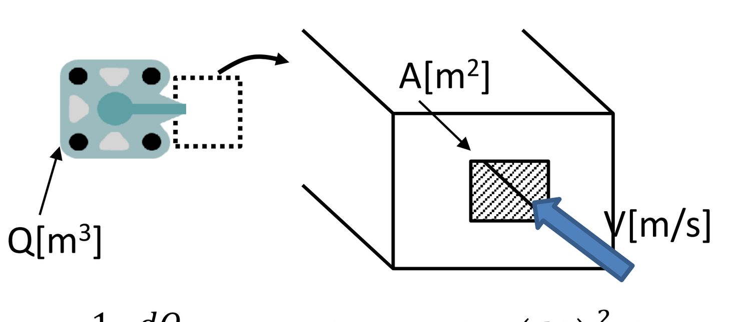
$Q_{pump} = N_{pixel} \times A_{pixel}$[μm²/pixeles] x 50[μm]

N_{pixel} :Number of pixels of moved water.

A_{pixel} :Area of the one pixel.

The maximum pumping quantity is 19.2 nl.

Estimate aspiration force



$$V = \frac{1}{A} \cdot \frac{dQ}{dt} \qquad P = \frac{1}{2}\rho V^2 = \frac{1}{2}\rho\left(\frac{dQ}{dt}\right)^2 \frac{1}{A^2}$$

$$F = P \cdot A = \frac{1}{2}\frac{\rho}{A}\left(\frac{dQ}{dt}\right)^2$$

When ρ is 995.76 kg/m³, A is 7.5 × 10^{-10} m²,(15μm x 50 μm), Q is 19.2 ×10^{-9} l, and t is 1.0 sec,

F = 3.26 μN.

Comparison of the aspiration force F and fluid resistance F_s .

$$F_s = 6\pi\eta a V_s$$

F_s :Force of the fluid resistance

η: fluid viscosity

V_s :Moving velocity of the cell

a :Radius of the cell

When η is 0.01 Ns/m², a is 100 μm, and V_s is 1 mm/s,

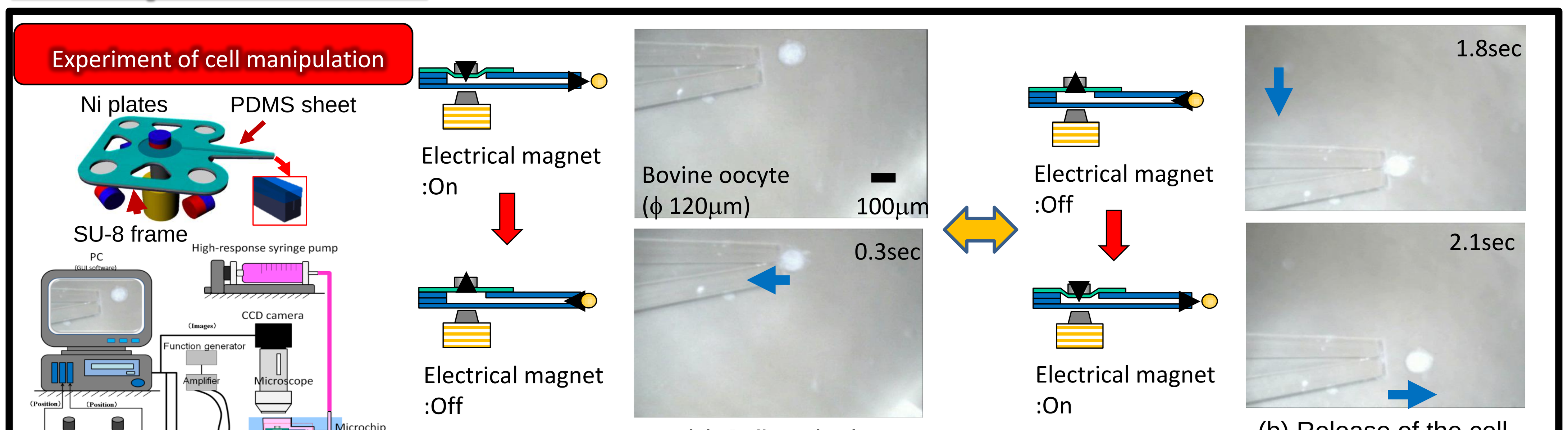
F_s = 1.89 nN.

$$F > F_s$$

The aspiration force F is enough high for manipulation in liquid.

4. Experiments

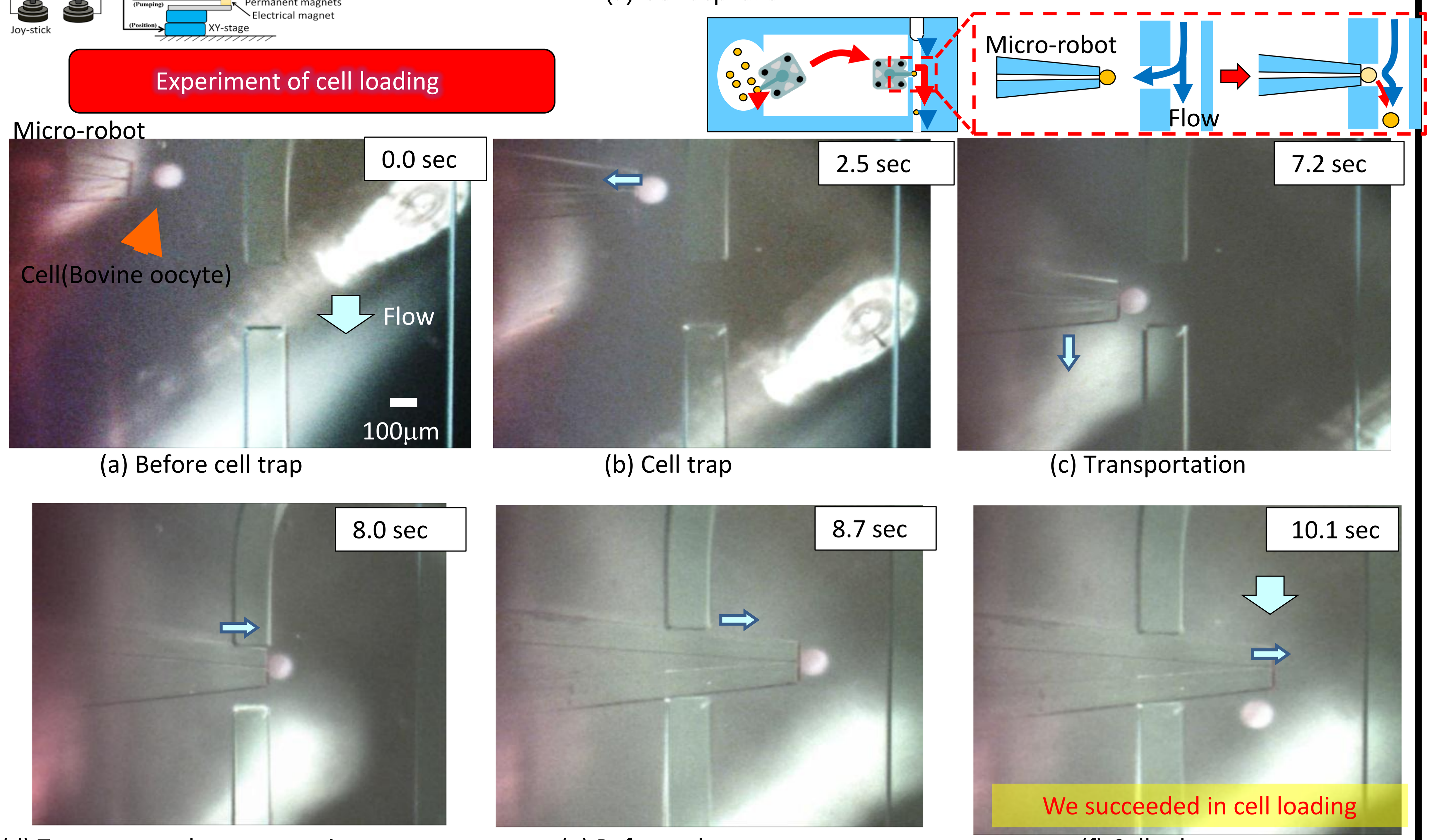
Experiment of cell manipulation



(a) Cell aspiration

(b) Release of the cell

Experiment of cell loading



(a) Before cell trap

(b) Cell trap

(c) Transportation

(d) Transport to the cross section

(e) Before release

(f) Cell release

5. Conclusions and future work

1. We developed an on-chip micro-robot with suction pump and evaluated an aspiration force of the robot.
2. We succeeded in cell loading using an on-chip micro-robot and micro-fluidic chip.
3. We design the tip of the micro-robot to improve the success ration of the loading of cells.

6. References

1. M. Hagiwara, et.al., "On-chip magnetically actuated robot with ultrasonic vibration for single cell manipulations", Lab on a Chip, issue12, pp.2049-2054, 2011
2. A. Ichikawa, F. Arai, "On-chip Noncontact Actuation of a Micro-pipette Driven by Permanent Magnets", MEMS2012, pp. 1081-1084, (2012)

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