

On-Chip Force Sensor for Mechanical Properties Measurement of *Synechocystis* sp. PCC 6803



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Stiffness Measurement of a 2 μm Cell Using On-chip Force Sensor

Background & Purpose

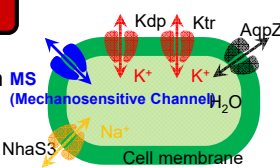
Synechocystis sp. PCC6803

Floating unicellular cyanobacterium MS (Mechanosensitive Channel) H_2O

Size: 2 μm

Model microorganism for the study of photosynthesis, biofuel and acclimation to environmental changes.

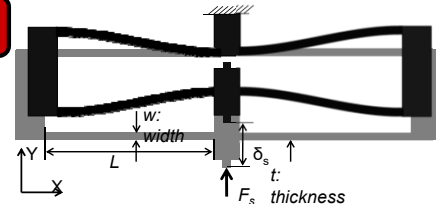
Purpose : Evaluate the mechanical properties of wild type and mutant type cell in response to osmotic shock.



Displacement measurement

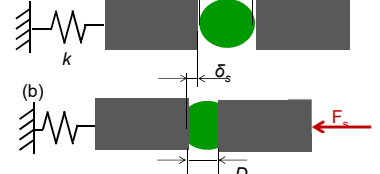
Force sensor

$$F_{res} = k_{sens} \delta_{res} = \frac{w^3 t E}{L^3} \delta_{res}$$



Cell Compression

(a) Sensor probe D_0 Pushing probe



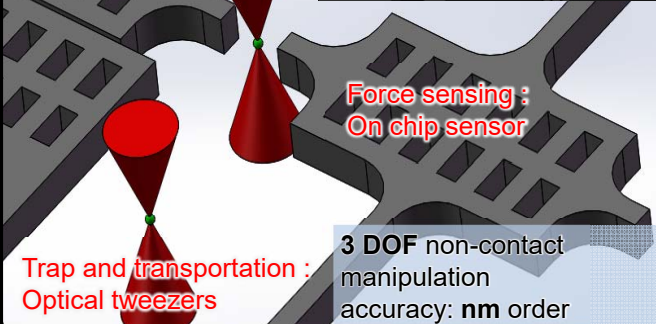
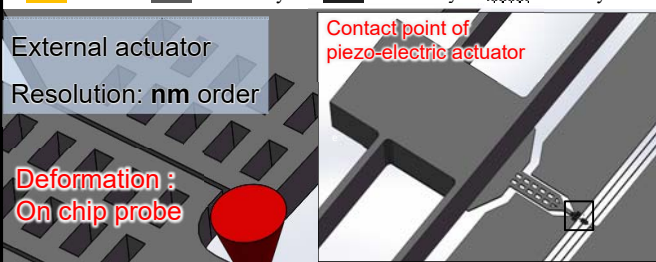
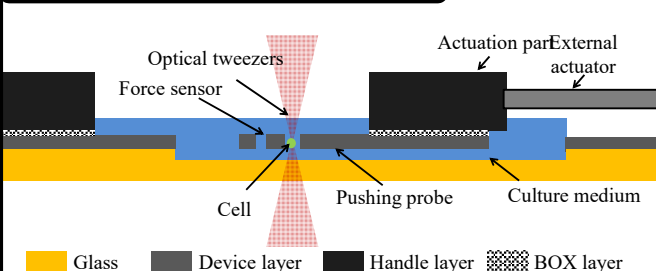
Hertzian contact theory

$$F_s = \frac{E_c \epsilon^{3/2}}{3(1-\nu^2)} D_0^2$$

$$\epsilon = (D_0 - D) / D_0$$

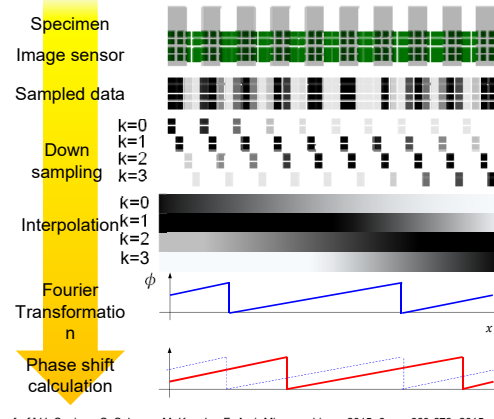
E_c : Young's modulus of single cell
 ν : Poisson's ratio
 F_s : Force
 D_0 : the original size of the cell
 D : the deformed size of the cell
 ϵ : deformation rate of the cell

Concept of Microfluidic chip

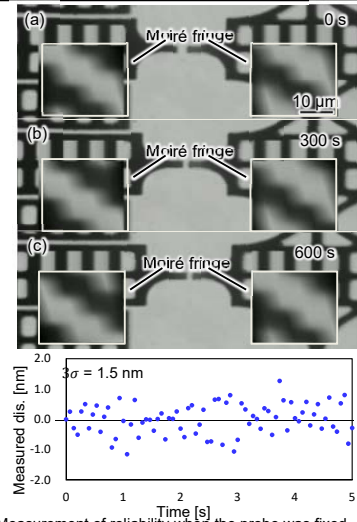


Displacement measurement

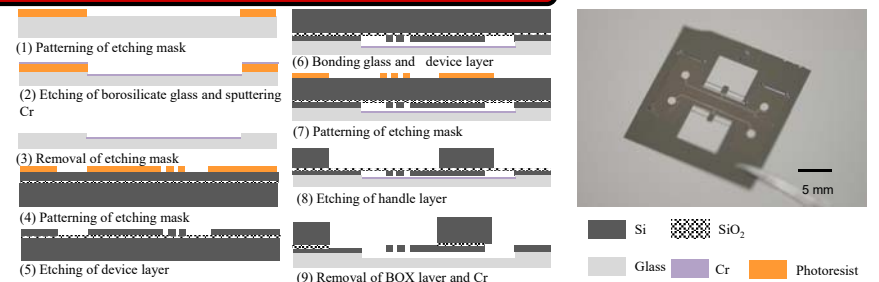
Sampling Moiré Method



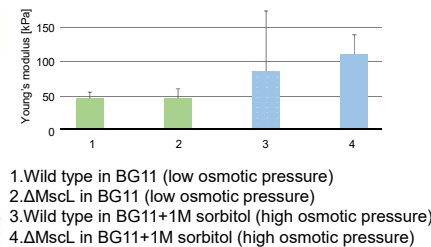
[ref.] H. Sugiura, S. Sakuma, M. Kaneko, F. Arai, Micromachines, 2015, 6, pp. 660-673, 2015



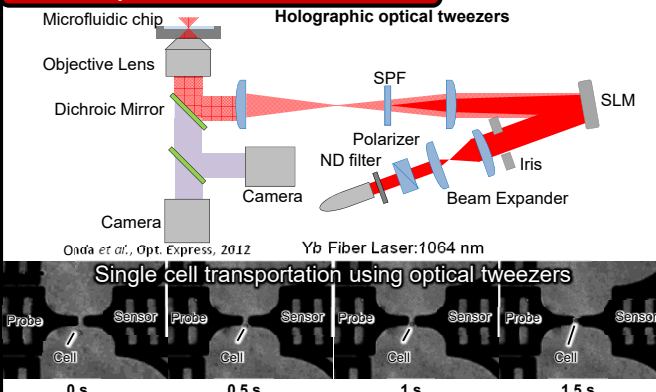
Fabrication process



Experiment



Transportation of the Cell



Reference

·Mechanical characterization system of cyanobacteria using a robot integrated microfluidic chip. Takayuki Hasegawa, Shinya Sakuma, Kei Nanatani, Nobuyuki Uozumi and Fumihito Arai. Intelligent Robots and Systems (IROS), 2015 IEEE/RSJ International Conference on. IEEE, 2015: 6033-6038.
·On-Chip Force Sensor for Mechanical Properties Measurement of *Synechocystis* sp. PCC 6803. Di Chang, Shinya Sakuma, Takayuki Hasegawa, Nobuyuki Uozumi, No.16-2 Proceedings of the 2016 JSME Conference on Robotics and Mechatronics(ROBOMECH), Yokohama, Japan, June 8-11, 2016, 2a2-18b7(1)-2a2-18b7(4).

Abstract: Mechanosensitive (MS) channels on the cell membrane of *Synechocystis* sense the surface tension within the membrane caused by intracellular pressure. Therefore, we investigate the relationship between mechanical properties such as stiffness of the cell and its osmoadaptation mechanism. In this paper we describe the design an on-chip force sensor which is able to measure reaction force of a single *Synechocystis* sp. PCC 6803 cell when it is compressed. We fabricate the robot integrated microfluidic chip including an on-chip sensor and an on-chip probe and evaluate the mechanical properties of single *Synechocystis* cell using this chip.

