超小型水晶センサの作製

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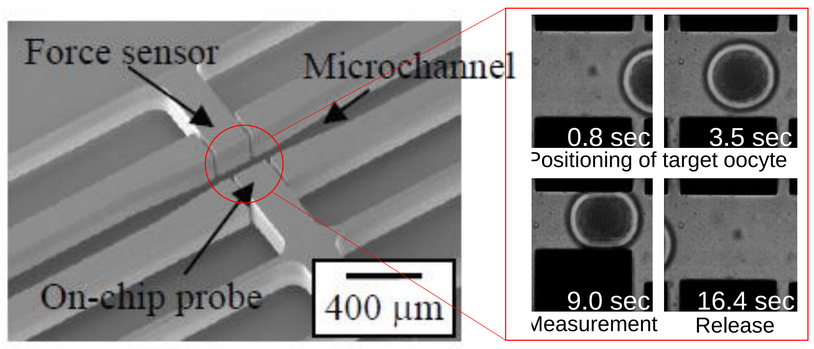
力センサの高剛性化・ワイドレンジ化・高感度化に挑む

Background

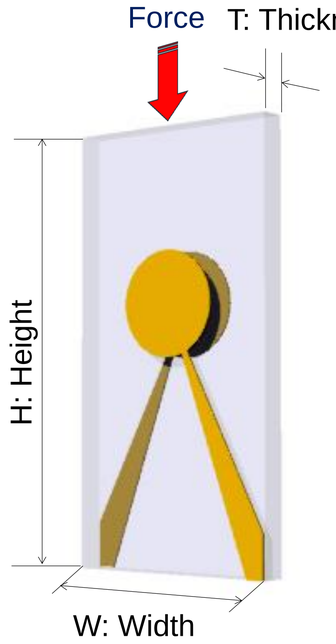
Previous research: Robochip

Mechanical characteristics ⇕ Quality, Cell state, Response, etc…



Features
- High-throughput
- Closed space
- Stable environment

Requirements
- Low-rigidity of force sensor
- Complicated system



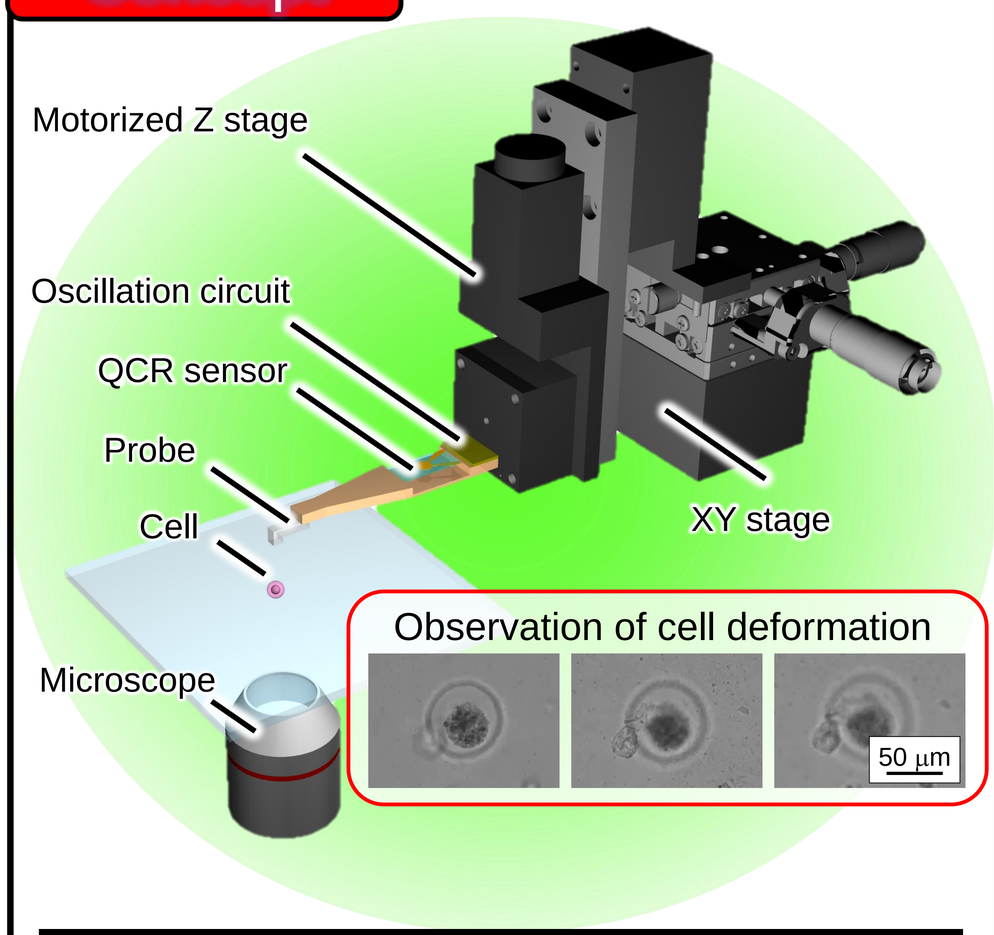
Quartz Crystal Resonator(QCR) sensor

Features of QCR sensor
- ☐ High rigidity & high sensitivity
- ☐ Highly stable resonant frequency
- ☐ Stress-dependent resonant frequency

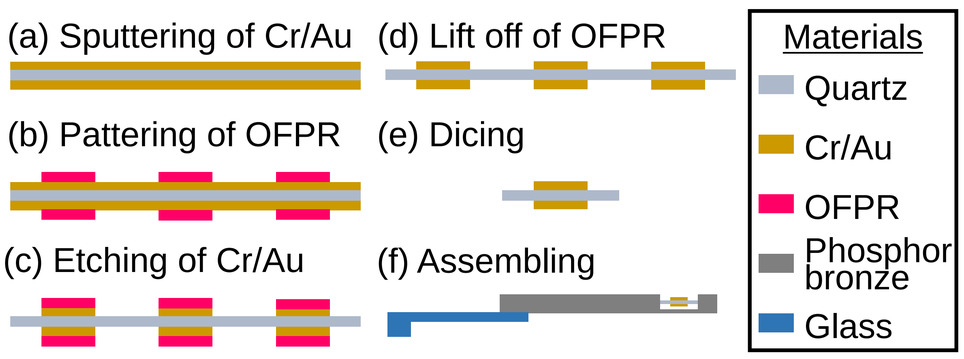
$$\Delta f = S_s \times \Delta P$$
$$S_s = \frac{S_0}{W} \times \left(\frac{1.67}{T}\right)^2$$

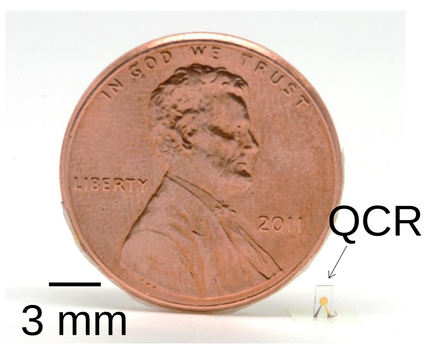
Δf:Frequency shift, S_s:Sensor sensitivity, ΔP:Applied force, S_0:Stress sensitivity

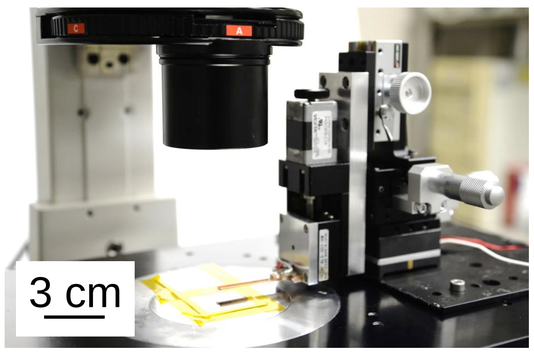
Concept



Fabrication process

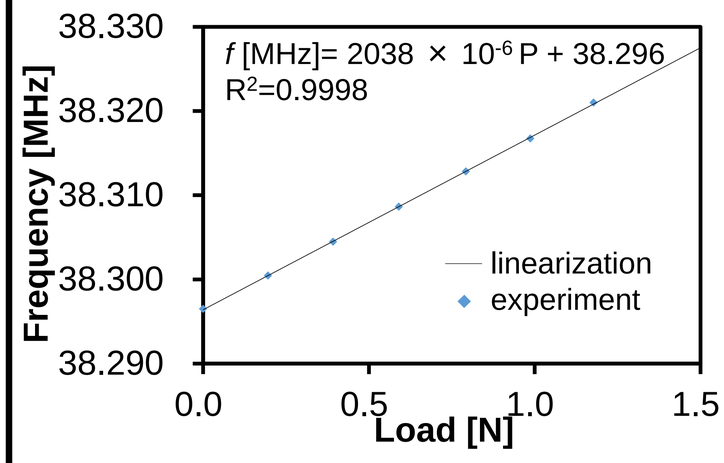






Experiment

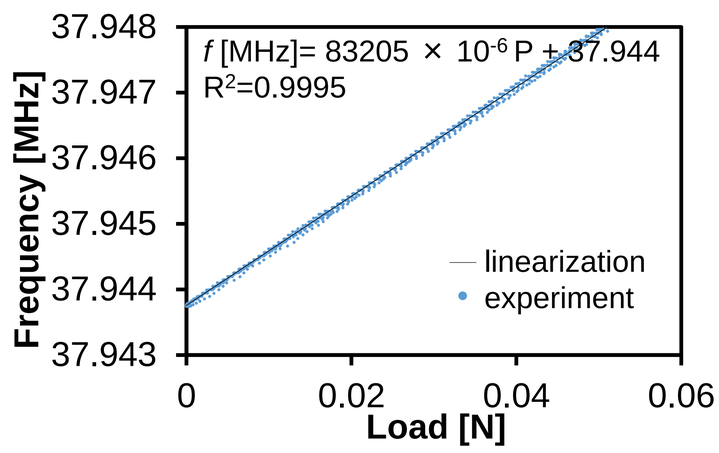
Calibration of QCR sensor



- ☐ High linearity
  R^2=0.9996[1] ⇨ **R^2=0.9998**
- ☐ Sensitivity
  1,458 Hz/N[1] ⇨ **20,378 Hz/N**

Resolution: **4.91 μN (estimated)**

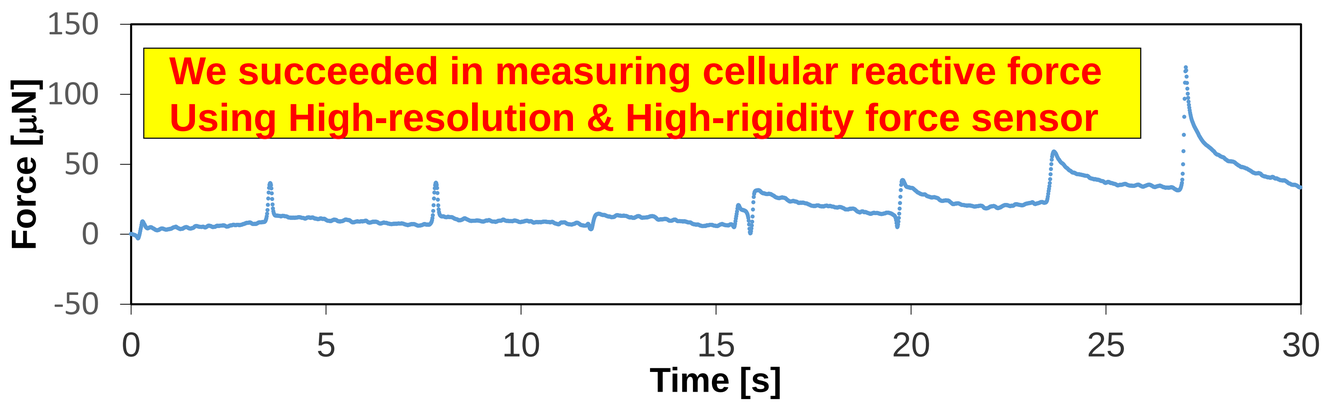
Calibration of Jig + QCR sensor



- ☐ High linearity
  R^2=0.9998 ⇨ **R^2=0.9995**
- ☐ Sensitivity
  1,458 Hz/N[1] ⇨ **83,205 Hz/N**

Resolution: **1.21 μN (estimated)**

Experimental result

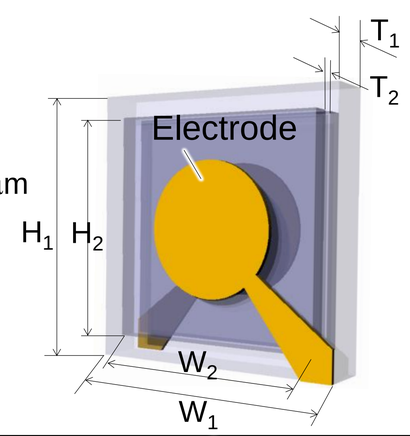


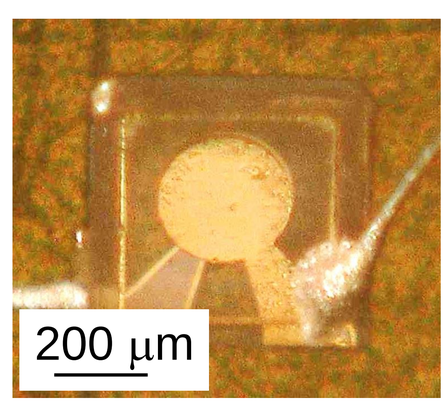
Future works

- ☐ Improvement the sensitivity
  - ✓ T_2: 40 μm→ 20 μm
  - ✓ W_1,H_1:1.3 μm,2.5 μm→ 600 μm,600 μm
  - ✓ W_2,H_2:500 μm,500 μm
- ☐ Sensitivity (theoretically)

1,458 Hz/N[1] ⇨ 157,464 Hz/N
+Jig ⇨ 708,588 Hz/N

Resolution: **0.1 μN (estimated)**





Reference

[1] Yuichi Murozaki, et al, "Miniaturized load sensor using quartz crystal resonator constructed through microfabrication and bonding." ROBOMECH Journal 1.1 (2014): 1-7.

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