Antenna-embedded wireless QCM sensor fabricated by a MEMS process.

Tomoyuki Nonaka[1], Akimi Uchida[1], Fumihito Kato[2], and Hirotsugu Ogi[3]
[1]Samco Inc, Kyoto, Japan; [2]Dept. Mech. Eng., Nippon Inst. of Tech., Saitama, Japan;
[3]Grad. School of Eng., Osaka Univ., Osaka, Japan

Background, Motivation and Objective

We developed a wireless MEMS quartz crystal microbalance (QCM) device using an ultra-thin quartz crystal resonator.
QCM is a mass sensitive sensor, whose mass sensitivity is inversely proportional to the square of the thickness of the resonator.
By using the MEMS technology, it is possible to realize an ultra-sensitivity QCM sensor by thinning the crystal and making it wireless.
However, by making the wireless (non-contacting) operation, the energy transfer efficiency significantly deteriorates and a high-power RF amplifier is needed, which increases the instrument cost and size.
Therefore, in order to make an ultra-high sensitivity QCM, we propose a new chip structure that makes the quartz crystal and antennas as close as possible.

Statement of Contribution/Methods

Figure 1 illustrates the cross-section view of the ultra-high-frequency MEMS QCM sensor that we succeeded in fabricating. The quartz crystal resonator of 3-μm-thick bare AT-cut quartz is packaged in the microchannel without being fixed; it is lightly supported by many metal coated micropillars for achieving a large Q value. The gap between the micropillars is 5 μm.
Through thin metallic wires, which are embedded in the SiO_2 wafer, the antennas for the non-contact excitation and detection of the shear vibration are formed on the inner walls of the microchannel, improving the transduction efficiency significantly.
The AT-cut quartz wafer on the substrate was first polished to 3 μm thick and after the substrate was removed, it was fixed to the microchannel with the sacrifice layer until the package was finished.
Finally, the quartz resonator was separated from the channel and isolated by removing the sacrifice layer.

Results/Discussion

Figure 2 shows the resonant spectrum measured in air. We established the wafer-base MEMS process and succeeded in creating QCM sensors with Q value of 22000 at the fundamental resonance frequency of 547 MHz with a very thin quartz crystal. Because the quartz resonator is fabricated by the gas-etching process, it is possible to make arbitrary-shape resonators, including ellipse and streamline shapes.
We will develop QCM devices to the biosensor for direct detection of biomarkers such as C-receptor protein. In addition, we also consider their application as gas sensors.

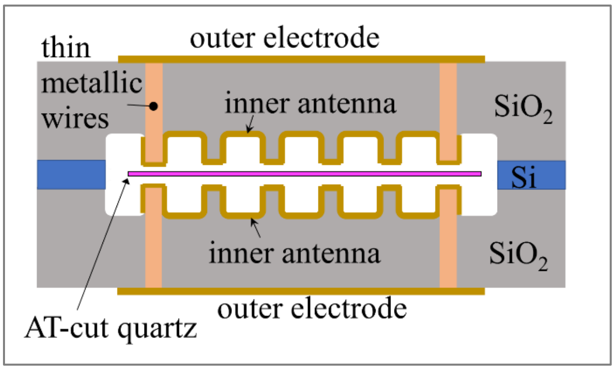

Figure 1

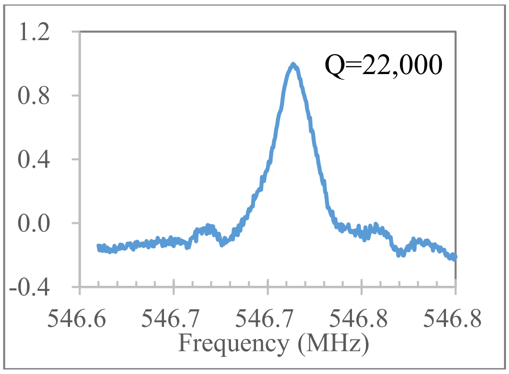

Figure 2