Wireless and batteryless MEMS resonator sensors

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Abstract

The goal of this project is to establish a resonator sensor system that can be used not only for diagnosis but also for a wide range of applications such as gas sensing in inaccessible areas, health monitoring of infrastructures, and long-term biological signal monitoring in living animals, based on a new measurement concept of semi-permanent measurement.

Background & Results

Early diagnosis is extremely important for cancer, neurodegenerative diseases, and viral diseases, resulting in a huge reduction in medical costs. In addition, the realization of a carbon neutral society is highly expected, requiring the advancement of related technologies. The importance of hydrogen as a decarbonized energy source is well understood, but its explosive nature is also recognized, and it is particularly important to improve the performance of hydrogen gas sensors, especially for battery-free measurement in inaccessible locations such as nuclear power plants. In addition, aging of infrastructure has become a serious problem in many countries, and development of such a device that can remotely evaluate stresses inside structures without power supply will greatly contribute to monitoring the health of social infrastructure structures. Thus, a sensing technology that is highly sensitive, wireless, and batteryless is eagerly awaited in the realization of a safe, secure, and healthy society. We consider that only the resonator sensor will satisfy these demands.

The resonator sensor detects various properties through the change in the resonant frequency of the microbell (resonator) as shown in Fig. 1. Capturing target materials on the resonator surface increases the effective mass of the resonator system and decreases the resonant frequency. This principle can be used as a label-free biosensor (upper left). When the shape of the resonator is changed by an external force, the resonant frequency changes. This phenomenon can be used as a stress sensor (bottom left). If resonator's elastic constants are sensitive to temperature, it can be used as a temperature sensor because the resonance frequency changes with temperature change (upper right). When a target gas is adsorbed on the sensor film deposited on the resonator, bending deformation occurs due to the generation of the surface force, which also changes the resonance frequency. This principle can be used as a gas sensor (bottom right). For example, Figure 2 shows the response of originally developed MEMS resonator sensor for hydrogen-gas detection, which can detect hydrogen gas at extremely low concentrations of 1 ppm.

Significance of the research and Future perspective

Our original sensing technology makes it possible to achieve not only ultra-sensitive detection of targets, but also batteryless and long-distance sensing of various targets: It will conduct the semi-permanent measurement of hydrogen gas concentration at nuclear power plants and other locations where human access is difficult as well as the semi-permanent nondestructive evaluation of internal stress of infrastructures by embedding the sensors in them, contributing to a safe, secure, and healthy society.

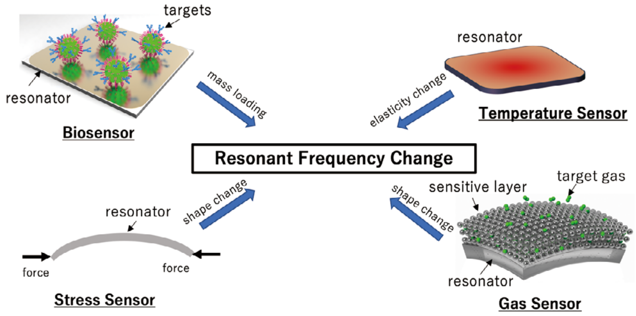

Figure 1 Applications of the oscillator sensor.

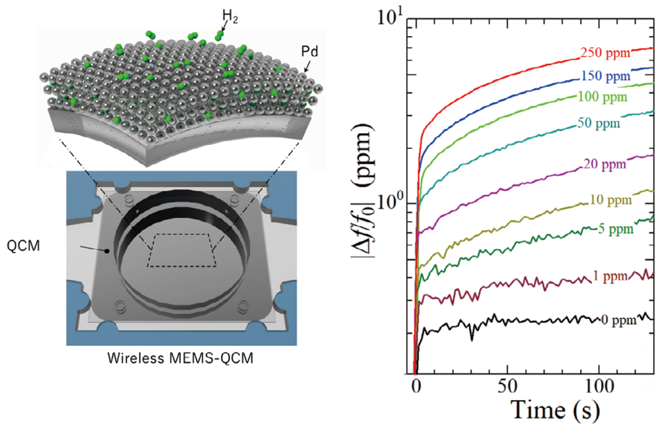

Figure 2 Hydrogen-gas detection by the MEMS oscillator sensor.

Patent: Japanese Patent No. 4981998, Japanese Unexamined Patent Publication No. 2021-131315, 2019-138628

Treatise:
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