Low-Cost Wearable Mass-Sensitive and Capacitive Bio/Chemical Multi-Sensor (#8269)

For embedded bio/chemical sensing applications

This wearable device utilizes microelectromechanical systems (MEMS)-based batch-fabricated resonant sensors that can be combined with off-the-shelf electronics components to create a robust embedded bio/chemical sensing system. The resulting low-cost embedded/wearable system has a wide variety of potential biological and chemical sensing applications. The transduction element consists of a MEMS resonator that can be coated with a variety of sensing materials, allowing for the detection of numerous gas-phase and liquid-phase analytes. The micromachined gravimetric sensors will detect whatever molecules can be bound or adsorbed using the surface chemistry that is applied to the device.

To detect gas-phase contaminants, resonators are coated with specific polymeric sensing films that absorb chemicals from the environment. Each resonator acts as a second-order system, where the frequency of its vibration is dependent on both its mass and stiffness. The increase in mass caused by the chemical loading within the sensitive film causes the resonant frequency of the sensor to drop. Tracking the resonant frequency allows one to quantitatively measure chemicals or biological agents present in the surrounding environment. A capacitive sensor fabricated on the resonator surface detects dielectric property changes in the in the polymeric film, adding another degree of freedom to the embedded system, simultaneously sensing mass and dielectric property changes in the polymeric sensing film.

The sensing system employs commercial-off-the-shelf (COTS) electronics components to operate the resonators in an amplifying feedback loop. An embedded field programmable gate array (FPGA)-based counter is used to read the sensor signal.

Benefits/Advantages

- **Versatile**: Customizes MEMS chemical sensors, compatible with a variety of sensing materials, allowing for the detection of numerous gas-phase analytes
- **Easy to manufacture**: Uses batch-fabricated sensors compatible with COTS electronics
- **Highly sensitive**: Offers sub parts-per-million detection limits for volatile organic compounds
- **Selective**: Use of two sensing principles improves ability of the sensor to distinguish between analytes

Potential Commercial Applications

- Environmental monitoring
- Exposure threshold monitoring
- Chemical threat detection

- Medical diagnostics

Background/Context for This Invention

Environmental monitoring often requires collecting samples in the field and sending them to a laboratory for analysis using gas chromatography and mass spectrometry (GC-MS). While these analytical methods are selective and highly sensitive, they are also expensive and time consuming, and they do not provide real-time results.

For sensing applications that require large numbers of sensors with the ability to provide real-time data, batch-fabricated microsensors based on MEMS technologies are appealing. They can be fabricated in large numbers and integrated with existing processes and integrated circuits.

Georgia Tech's mass-sensitive chemical sensors uniquely combine a resonator, the required electronics for sensor operation, and an embedded counter to read the sensor output in real time.

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More Information

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Publications

In-Plane Vibration of Hammerhead Resonators for Chemical Sensing Applications, ACS Sensors, Dec. 16, 2019

Micromachined Mass-Sensitive and Capacitive Chemical Multisensor Using Single Polymeric Sensing Film, 2020 IEEE 33rd International Conference on Micro Electro Mechanical Systems (MEMS) January 18-22, 2020, April 6, 2020

For more information about this technology, please visit:
https://licensing.research.gatech.edu/technology/low-cost-wearable-mass-sensitive-and-capacitive-biochemical-multi-sensor

Images:

The automated sequential delivery of multiple fluids. A varying number of delay gates imprinted in the branches are shown in the figure.

COVID-19 and flu saliva test on paper: (A) The automatic sequential delivery of multiple reagents required for virus test; (B) Water pouring into the device triggers the virus assay, allowing the presence of SARS-CoV-2 and influenza A & B viruses to be visually identified by the color changes in the corresponding detection spot