OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

FACT SHEET

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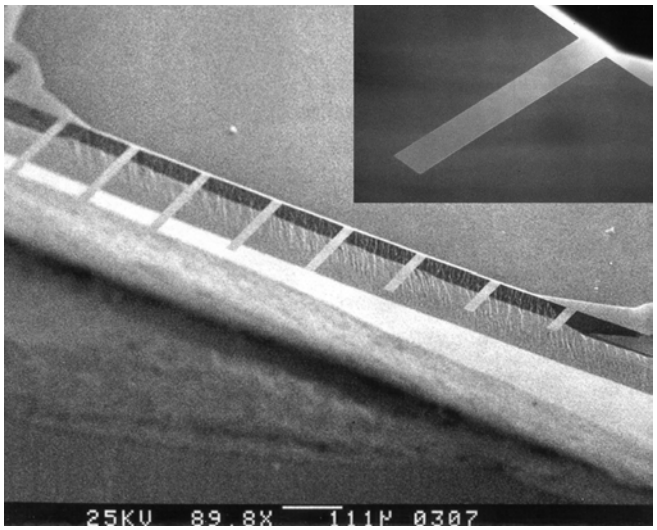
CMOS Cantilever Sensor Systems

The Department of Energy's (DOE's) Oak Ridge National Laboratory (ORNL) is developing sensor systems based on micro- and nano-electro-mechanical systems (MEMS and NEMS). Cantilever-based sensors systems utilize MEMS fabrication and custom CMOS readout. Cantilevers can be readily fabricated on silicon wafers and other materials. Miniature cantilevers, hanging off the edge of a support piece, deflect quite easily even under minuscule forces such as that due to adsorption of analyte molecules. In addition, the resonance frequency of the cantilever varies sensitivity due to added mass of the adsorbed molecules. Thus, two orthogonal signals (bending and resonance frequency variation) can be obtained in a single measurement. The dimensions of the cantilever determine the sensitivity while the selectivity is achieved by applying chemically selective coatings on the cantilever surface. The beauty of cantilever concept lies in its low power consumption, and the capability of high density arraying for simultaneous multiple sensor responses. In addition, cantilever sensors work with ease under solution conditions. Cantilever sensors can be used for detection of physical, chemical, and biological analytes with extremely high sensitivity and selectivity. Demonstrated applications for this technology include:

- Chemical vapors (including chem. warfare agents)
- Biological agents (medical as well as biowarfare agents)
- Contaminants in water
- Explosives (vapors of TNT, RDX, and PETN)
- Acoustics
- Vibration monitors
- Flow rate
- Viscosity and density
- Infrared and UV radiation
- Nuclear radiation
- Electric and magnetic fields
- Detection of DNA, antibody, and pathogens



ORNL is a multiprogram science and technology laboratory managed for the U.S. DOE by UT-Battelle, LLC. ORNL is a leader in research that includes neutron science, high performance computing, energy efficiency, complex biological systems, material science, and instrumentation science and technology. ORNL has extensive expertise in MEMS and NEMS technologies.

The objective is to integrate multiple analyte detection on a single sensor platform with digital signal processing for readout to create a unique sensor array that are small in size, highly reliable, and low cost.

Technical Concept

The concept behind cantilever sensor is simple. Molecular adsorption on cantilever surface results in changes in resonance response such as resonance frequency, amplitude, phase and Q-factor due to mass loading. When the molecular adsorption is confined to a single side, the cantilever undergoes bending due to changes in surface stress (surface free energy). The motion of the cantilever can be sensitively detected using a number of techniques such as optical beam deflection (similar to a CD

in piezoresistivity, piezoelectricity, capacitance, and tunneling current. Consequently, microcantilevers are a universal platform to base electro-mechanical sensors for measuring a multitude of physical, chemical, and even biochemical factors, depending upon the selection of the coating.

Detection limits have yet to be fully explored, but parts-per-billion to parts-per-trillion have been demonstrated in some cases. Advantages of the cantilever sensor platform include:

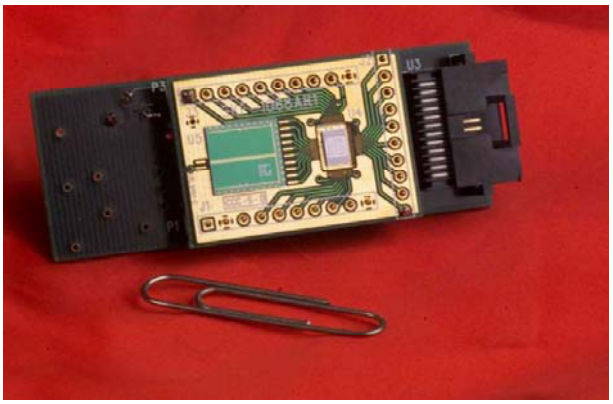
- Miniature size
- Multiple analyte detection using single platform
- Extreme high sensitivity
- Excellent selectivity due to arrayed readout
- Operation in air and under solution
- Common mode rejection for noise cancellation.
- Wide dynamic range
- Can be coupled to RF communications
- Low-power electronics, power management circuitry, and electrical self testing

ORNL has over 17 patents in cantilever sensor technology, with many pending patents

Development Activities

Chemical selective cantilevers that do not use chemical coatings (polymers or self- assembled monolayers)
Development of cantilever arrays and functionalized arrays
Detection of heavy metals in ground water
Develop front-end electronics (signal processing, power management, and data acquisition)
Prototype circuit board
Demonstration of multiple analyte detection in presence of interferents in laboratory conditions
Field demonstrations at DOE reservation for Hg in ground water

- Transfer technology



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