Researchers advance nano-scale electromechanical sensors

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Clemson physics professor Apparao Rao and his team are researching nano-scale cantilevers that have the potential to read and alert us to toxic chemicals or gases in the air. Put them into a small handheld device and the potential is there for real-time chemical alerts in battle, in industry, in health care and even at home.

"The ability to build extremely small devices to do this work has been something we've only seen so far in science-fiction movies," Rao said.

The width of a human hair or smaller, the micro- and nano-scale cantilevers look like tiny diving boards under an electron microscope. The researchers have advanced the method of oscillating cantilevers that vibrate much like a guitar string and measure amplitude and frequency under different conditions, creating highly reliable sensors that can relay a message that there's trouble in the air.

"The current way of sensing involves an optical method that uses a relatively bulky and expensive laser beam that doesn't translate well to use in nano-scale cantilevers. Our method is fully electrical and uses a small AC voltage to vibrate the cantilever and simple electronics to detect any changes in the vibration caused by gaseous chemical or biological agents," Rao said. "This method enables the development of handheld devices that would beep or flash as they read gas and chemical levels on site."

The potential applications are varied, he said. In addition to simultaneously reading multiple kinds of toxins in the environment, these electromechanical sensors have been shown to measure changes in humidity and temperature.

Preliminary results indicate that this fully electrical sensing scheme is so sensitive that it can differentiate between hydrogen and deuterium gas, very similar isotopes of the same element. Since the whole process is electrical, the size limitations that plague competing detection methods are not a problem here. The cantilevers can be shrunk down to the nano-scale and the operating electronics can be contained on a single tiny chip. Rao's research has shown that a single carbon nanotube can be used as a vibrating cantilever.

Rao credits Clemson Professor Emeritus of Physics Malcolm Skove, who discovered that measuring the resonant frequency of a cantilever at the second or higher harmonies would get rid of the so-called parasitic capacitance, an unwanted background that obscures the signal and has been a major stumbling block to the advancement of similar technology.

"When we operate at these higher harmonics of the resonant frequency, we get extremely clean signals. It makes a tremendous difference, and the National Institute for Standards and Technology is interested in promoting the Clemson method as one of the standard methods for measuring the stiffness of cantilevered beams," said Rao.

To view published papers on the research go to: people.clemson.edu/~arao/E-papers/HDR%20package.pdf .

Source: Clemson University

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