# NANOSENSOR SNIFFS OUT GAS LEAKS IN SECONDS

A highly versatile and sensitive gas detector promises to OVERCOME THE LIMITATIONS OF CONVENTIONAL SENSORS.

**Industrial gas leaks could be detected in seconds** using a highly sensitive nanomechanical sensor. The device employs functional polymers to rapidly monitor for trace quantities of multiple target gases. By switching the polymers used, the device could also be readily adapted for sensing applications, ranging from quality control in food and beverage production and chemical processes, to non-invasive diagnosis of multiple health conditions through analysis of breath.

The multisensory device is the product of an ongoing collaboration between specialists in functional-polymer design at Japanese chemical company Mitsui Chemicals, Inc., and leaders in microelectromechanical systems (MEMS) device development at Tohoku University in Sendai, Japan.

"We collaborated very closely to design a highly sensitive sensor," says Takahito Ono a professor in the Graduate School of Engineering at Tohoku University. "Our device has a radically different design from those of other gas sensors."


▲ **A prototype of a compact gas sensor that has a radically different design from conventional sensors.**

At the heart of the device is a chip with four silicon frames featuring a comb-like array of slits. A different functional polymer is embedded in the slits of each frame. As the polymers absorb gas molecules from the air, they swell, generating stress in one side of the silicon frame. This, in turn, generates an electrical current by squeezing a component that converts mechanical pressure into electricity. This design ensures that most target gases can be detected at sub-parts-per-billion concentrations.

The four-polymer design also allows simultaneous sensing of multiple target gases. The unique swelling response of each polymer generates a characteristic pattern of electrical signals in the chip, which the device compares with a database to identify the gases present.

The specialized polymer expertise of scientists at Mitsui Chemicals has been key to the device's high performance. "We understand the interaction between gases and polymers very well, so we only need four channels for most combinations of target gases," explains Mai Kurihara Yamazaki from the company's R&D centre. "We can predict how each polymer reacts with a gas, so we can customize the device to detect different target gases." Both the type and amount of gas present can be determined.

Vithun Khamsong/Moment/Getty

▲ **A versatile gas sensor will be useful for detecting industrial gas leaks.**

The device offers several key advantages over rival technologies, Yamazaki adds. "Traditional gas chromatography can be highly sensitive, but it is relatively slow, must be performed by expert users, and it can be challenging to detect certain target gases such as amines and sulfides," she says. "Our multisensory MEMS device works in real time, doesn't require highly trained operators, and can process highly complex mixtures by using algorithms we've developed."

Crucially for many applications, the sensor can operate even under high-humidity conditions. "Conventional semiconductor sensors are highly sensitive to water," says Yamazaki. "If you try to use them under high humidity you might get an inaccurate reading, and it will shorten the lifetime of the device." To minimize the issue of humidity, one of the four polymers in the new device can be selected to monitor humidity levels, so that the device can automatically account for humidity fluctuations.

The partners are continuing to develop the device and improve performance, notes Ono, with a next-generation prototype due to be completed by the end of 2022. "Our expertise is very complementary," Yamazaki says. ■

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