New sensor detects gaseous chemical weapon surrogates in 45 seconds

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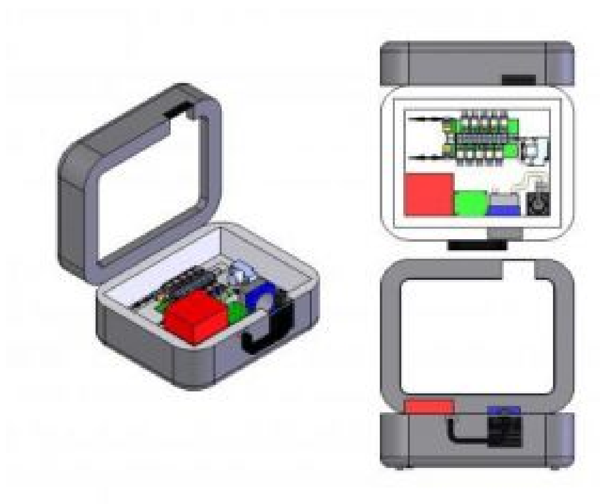

A conceptual prototype of Pacific Northwest National Laboratory's Quartz Vibrational Resonator Laser Photo-acoustic Sensing technology. The prototype includes 10 pairs of quantum cascade lasers and tuning forks in a box that is 12 inches long, 12 inches wide and 6 inches high. The full case would weigh less than 15 pounds. The technology can detect gaseous nerve agent surrogates, at the sub-part-per-billion level, in less than one minute. Credit: Pacific Northwest National Laboratory

Using lasers and tuning forks, researchers at Pacific Northwest National Laboratory have developed a chemical weapon agent sensing technique that promises to meet or exceed current and emerging defense and homeland security chemical detection requirements. The technique, called Quartz Laser Photo-Acoustic Sensing, or "QPAS," is now ready for prototyping and field testing.

PNNL, a Department of Energy national laboratory, has demonstrated QPAS's ability to detect gaseous nerve agent surrogates. In one test, researchers used diisopropyl methyl phosphonate (DIMP), which is a chemical compound that's similar to sarin. QPAS detected DIMP at the sub-part-per-billion level in less than one minute. The miniscule level is similar to letting one drop of liquid DIMP evaporate into a volume of air that would fill more than two Olympic-size swimming pools.

"QPAS is an extremely sensitive and selective chemical detection technique that can be miniaturized and yet is still practical to operate in field environments," said Michael Wojcik, a research scientist at PNNL. "The laser, tuning fork and other technology needed for QPAS are so simple, and yet robust, that further development is a low-risk investment, and we're eager to take it to the next level."

The instrument is based on Laser Photo-Acoustic Sensing, or LPAS, and infrared Quantum Cascade Lasers, or QCLs. LPAS is an exquisitely sensitive form of optical absorption spectroscopy, where a pulsed laser beam creates a brief absorption in a sample gas, which in turn creates a very small acoustic signal. A miniature quartz tuning fork acts as a "microphone" to record the resulting sound wave.

PNNL researchers paired multiple QCLs with the tuning forks, allowing simultaneous examination of a single sample at many infrared wavelengths. Nearly every molecule has unique optical properties at infrared wavelengths between three and 12 micrometers, and QCLs provide access to any wavelength in this region.

"Because of this access and the fact that QPAS is almost immune to acoustic interference, we have potential for extraordinary chemical sensitivity and selectivity," Wojcik said.

QPAS's small components represent a major advance over previous LPAS measurement methods. Historically, LPAS instruments were physically large, often measuring a meter or more in length. The entire arrangement was cumbersome, power-hungry and prone to interference from external sound and vibration.

In the QPAS technique, several QCLs can fit on a 3 x 3 millimeter chip. And the tuning forks are identical to the kind used in wristwatches, measuring only 4 millimeters long, 2 millimeters wide and 0.3 millimeter thick. A conceptual design for a battery-operated, prototype QPAS sensor, which includes 10 pairs of QCLs and tuning forks, would fit into a briefcase that is 12 inches long, 12 inches wide and 6 inches high – and the entire thing would weigh less than 15 pounds. In addition, the instrument can operate unattended for long periods of time.

QPAS is currently at Technology Readiness Level "five," meaning that while the technical components exist and initial testing is complete, the system still must be converted to a prototype.

Source: Pacific Northwest National Laboratory

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