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Tiny laser may be weapon against terror

EVANSTON, Ill. --- The difficulty of detecting the presence of explosives and chemical warfare agents (CWAs) is once again all too apparent in the news about the London bombings.

In a significant breakthrough, researchers at Northwestern University's Center for Quantum Devices have demonstrated a specialized diode laser that holds promise as a weapon of defense in both civilian and military applications. Once optimized, the tiny laser could quickly detect explosives and CWAs early and warn against possible threats.

The Northwestern team, led by center director Manijeh Razeghi, became the first to create a quantum cascade laser (QCL) that can operate continuously at high power and at room temperature with an emission wavelength of 9.5 microns and a light output of greater than 100 milliwatts.

Existing standard diode lasers, such as those used to read compact discs or barcodes, do not operate effectively in the longer wavelengths that are required to detect CWAs. The challenge for researchers around the world has been to develop a portable laser that operates in the far-infrared (wavelengths of 8 to 12 microns). Every chemical has a unique "fingerprint" because it absorbs light of a specific frequency, and most CWAs fall in the 8 to 12 micron region.

"Our achievement is critical to building an extremely sensitive chemical detection system," said Razeghi, Walter P. Murphy Professor of Electrical and Computer Engineering. "One of the key elements in a successful system is the laser source. Both mid- and far-infrared diode lasers need to operate at room temperature, have high power -- greater than 100 milliwatts -- and be extremely small in order to keep the system portable. We have now demonstrated such a laser in the far-infrared wavelength range."

This research is part of a four-year program called Laser Photoacoustic Spectroscopy (LPAS) funded by the Defense Advanced Research Projects Agency (DARPA). The goal of the program is to develop a man-portable system that can warn against a large number of potential threats using mid- and far-infrared diode lasers. Once optimized, such lasers would be a very reliable means of detecting explosives and chemical warfare agents while distinguishing them from benign chemicals present in the atmosphere.

During the next two years Razeghi and her team will work to put together a detection system based on the center's far-infrared laser. The system will then be evaluated by DARPA for use by the military.

Northwestern is a world leader in high-power QCL research. The Center for Quantum Devices was the first university research lab in the world to successfully grow, fabricate and test quantum cascade lasers back in 1997. By utilizing quantum mechanical design principles and advanced crystal growth techniques, the QCL is able to demonstrate high-power and high-temperature operation.

After the initial demonstration of room-temperature pulsed lasers in 1997, the primary efforts of Razeghi and her colleagues over the past several years have been to increase the laser's operating temperature, power output and efficiency in order to achieve the continuous operation necessary for sensitive chemical analysis.

In 2003 the center was the first to demonstrate high-power mid-wavelength infrared continuous wave QCLs operating above room temperature. (Like the far infrared, standard diode lasers cannot access this mid-infrared range.) At present, individual devices with output powers of several hundred milliwatts have been demonstrated in the 3 to 5 microns wavelength range.

Razeghi's research is supported by the Defense Advanced Research Projects Agency, U.S. Air Force Office of Scientific Research, the Army Research Office and the Office of Naval Research.