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Laser Sets Records in Power and Energy Efficiency

EVANSTON, Ill. --- The rise in global terrorism in recent years has brought significant attention to the needs for more advanced sensors and defense technologies to protect civilians and soldiers.

Next-generation laser-based defense systems are now being designed for this need, including the use of infrared countermeasures to protect aircraft from heat-seeking missiles and highly sensitive chemical detectors for reliable early detection of trace explosives and other toxins at a safe distance for personnel.

Since practical systems must be easily portable by a soldier, aircraft or unmanned vehicle, they must be lightweight, compact and power efficient. In addition, such systems also would need to be widely deployable and available to all soldiers, airplanes and public facilities, which requires a low production and operating cost. While several types of lasers exist today that can emit at the desired infrared wavelengths, none of these lasers meet the above requirements because they are either too expensive, not mass-producible, too fragile or require power-hungry and inefficient cryogenic refrigeration.

A new type of semiconductor-based laser, called the Quantum Cascade Laser (QCL), may soon change this situation. Like their computer chip cousins, semiconductors lasers are inherently compact and suitable for mass production, which has led to their widespread and low-cost use in everyday products, including CD and DVD players.

The Center for Quantum Devices (CQD) at Northwestern University, led by Manijeh Razeghi, Walter P. Murphy Professor of Electrical Engineering and Computer Science at the McCormick School of Engineering and Applied Science, has recently made great strides in laser design, material growth and laser fabrication that have greatly increased the output power and wall-plug efficiency (the ability to change electrical power into light) of QCLs.

The CQD now has demonstrated individual lasers, 300 of which can easily fit on a penny, emitting at wavelengths of 4.5 microns, capable of producing over 700 milli-Watts of continuous output power at room temperature and more than one Watt of output power at lower temperatures. Furthermore, these lasers are extremely efficient in converting electricity to light, having a 10 percent wall-plug efficiency at room temperature and more than 18 percent wall-plug efficiency at lower temperatures. This represents a factor of two increase in laser performance, which is far superior to any competing laser technology at this wavelength.

These results have been submitted for publication, and Razeghi presented similar results at the Conference on Indium Phosphide and Related Materials, which took place in Japan this past May.

Razeghi's research work received funding in March from the Defense Advanced Research Projects Agency (DARPA) through the Efficient Mid-Wave Infrared Lasers (EMIL) program, which is overseen by Henryk Temkin and Mark Rosker from DARPA and Mihal Gross of the Office of Naval Research (ONR). The work is also partially funded by the Navy and Army Research Office (ARO) through separate contracts, which are overseen by Jerry Meyer from the Naval Research Laboratory and Michael Gerhold from ARO, respectively.