Compact, wavelength-on-demand Quantum Cascade Laser chip created

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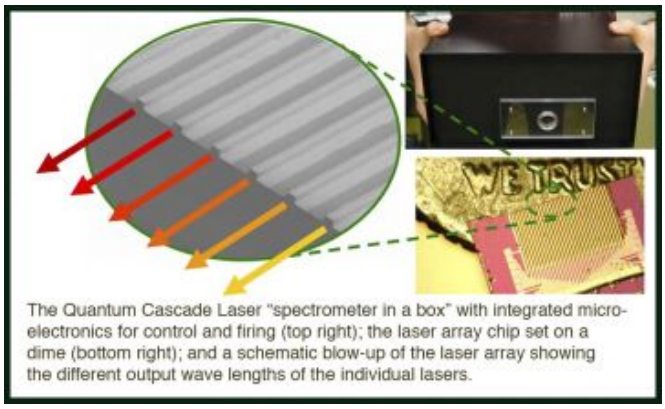

The Quantum Cascade Laser "spectrometer in a box" with integrated micro-electronics for control and firing (top right); the laser array chip set on a dime (bottom right); and a schematic blow-up of the laser array showing the different output wave lengths of the individual lasers.

Engineers at Harvard's School of Engineering and Applied Sciences have demonstrated a highly versatile, compact and portable Quantum Cascade Laser sensor for the fast detection of a large number of chemicals, ranging from infinitesimal traces of gases to liquids, by broad tuning of the emission wavelength. The potential range of applications is huge, including homeland security, medical diagnostics such as breadth analysis, pollution monitoring, and environmental sensing of the greenhouse gases responsible for global warming.

The team, which reported its findings in the Dec. 3 issue of *Applied Physics Letters*, was headed by Federico Capasso, the Robert L. Wallace Professor of Applied Physics and Vinton Hayes Senior Research Fellow in Electrical Engineering, and includes graduate student Benjamin Lee, researchers Mikhail Belkin and Jim MacArthur, and undergraduate Ross Audet, all of Harvard's School of Engineering and Applied Sciences. The researchers have also filed for U.S. patents covering this new class of laser chips.

The broad emission spectrum of the Quantum Cascade Laser material, grown by a commercial reactor used for the mass production of semiconductor lasers, is designed using state-of-the-art nanotechnology by controlling the size of nanometric thin quantum wells in the active region.

An array of 32 lasers, each designed to emit at a specific wavelength, is then fabricated on a single chip by standard semiconductor processing techniques to have a size of less than one-fourth of a dime. A microcomputer individually fires up and tunes each laser in the array in any desired sequence. This generates a broad and continuously tunable wavelength spectrum that can be used to detect a large number of chemical compounds.

"Our versatile laser spectrometer currently emits any wavelengths between 8.7 and 9.4 microns, in the so-called 'molecular fingerprint region' where most molecules have their telltale absorption features which uniquely identify them," Belkin says. "This ability to design a broad laser spectrum anywhere in the fingerprint region holds the promise of replacing the bulky and large infrared spectrometers currently used for chemical analysis and sensing."

The tunability of the laser chip can be extended up to 10-fold and several widely spaced absorption features can be targeted with the same chip, which will enable the detection in parallel of an extremely large number of trace gases in concentrations of parts per billion in volume. A portable compact spectrometer with this capability would revolutionize chemical sensing.

"These millimeter-size laser chips exploit the inherent enormous wavelength agility of state-of-the-art Quantum Cascade Lasers," says Capasso, who co-invented them in 1994 at Bell Labs. "As a first application we have shown that these widely tunable and extremely compact sensors can measure the spectrum of liquids with the same

accuracy and reproducibility of state-of-the-art infrared spectrometers, but with inherently greater spectral resolution."

Source: Harvard University