QCL peak power record smashed

EVANSTON, Ill. – Only a year ago, the peak output power of a quantum cascade laser (QCL) was 34 W. Today, thanks to researchers at the Center for Quantum Devices at Northwestern University, peak power of 120 W from a single device at room temperature has been achieved. However, this extremely high peak power is only the first step in making such lasers ready for system integration.

The research was led by Manijeh Razeghi, Walter P. Murphy professor of electrical engineering and computer science at the university's McCormick School of Engineering and Applied Science, and the director and founder of the center.

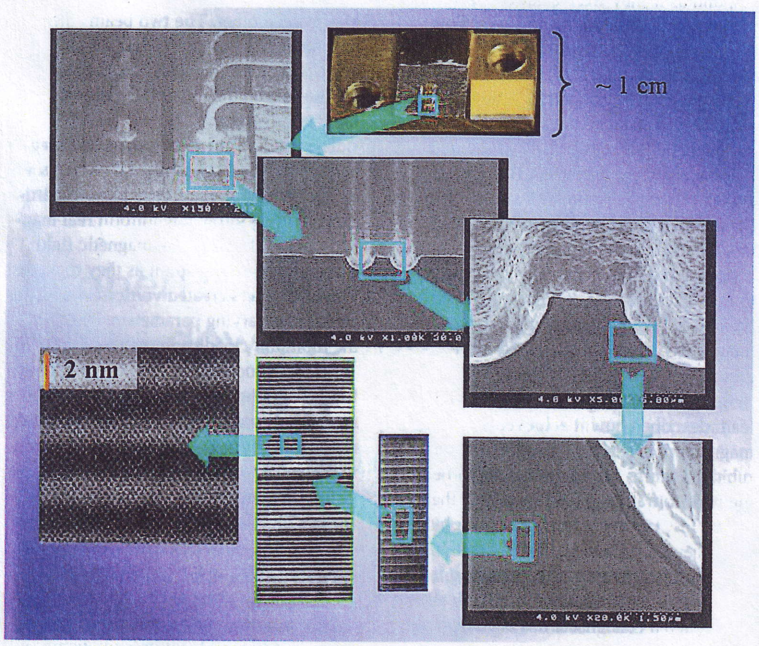
"The breakthrough is particularly attractive for sensing chemicals at a distance and for infrared countermeasures," Razeghi said, "because power is a luxury that defines range, speed and sensitivity for targeting remote applications such as misguiding incoming missiles."

The same research into high peak power also confirmed that the QCL is resistant to filamentation, which limits the beam quality of conventional broad-area semiconductor lasers as they get wider.

The researchers demonstrated that the ridge width of a broad-area QCL can be increased up to 400 μm without suffering from filamentation effects, as evidenced by a stable, well-defined output beam profile, nearly identical for all widths tested. Currently, although stable, the laser is not operating in the highest-quality mode.

"One future direction is to improve the beam quality," Razeghi said. "The current demonstration has a broad output beam, which makes the light harder to utilize fully. Some research into spatial mode filtering is warranted to combat this problem."

Unlike diode lasers, the QCL requires only electrons to operate, giving it unique properties that a conventional laser lacks.



Shown are size scales relevant to the quantum cascade laser. At the top is a packaged device. In the middle is the waveguide cross section as imaged by a scanning electron microscope. On the lower left are some of the individual layers of the injector region as imaged by a transmission electron microscope. Courtesy of Manijeh Razeghi/McCormick School of Engineering and Applied Science at Northwestern University.

One feature is that its linewidth enhancement factor is close to zero, compared with two to five for a conventional laser. The researchers believe that this difference has serious implications for power scaling with broad-area devices.

"Other wavelengths also need to be developed. Besides the 120 watts at shorter wavelengths, we have demonstrated up to 25 watts at a wavelength of 10.3 microns," she explained. "At present, this work is also unfunded, but we have confidence that similar power levels can be demonstrated throughout the three- to 12-micron wavelength range."

Razeghi said that, once this is achieved, another direction will be to improve the spectral characteristics.

"The current laser, like most broad-area lasers, shows many emission lines which span approximately 100 nanometers around a wavelength of 4.4 microns. For remote chemical sensing, a much narrower, single-mode emission is desired, which would require spectrally selective feedback. In addition, some moderate tunability of this wavelength would also be advantageous," she explained.

"A final research area is to scale average power delivery. While peak power is useful when fast detectors are available, use of these lasers for infrared countermeasures requires a more sustained power delivery. Thermal management makes this a significant challenge, limited by the overall power conversion efficiency of the laser. As such, both are subjects of current and future research."

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