New Mid-Infrared Lasers Show Doubled Efficiency

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Researchers at the Center for Quantum Devices at the McCormick School of Engineering at Northwestern University have recently doubled the efficiency of infrared lasers under the U.S. Defense Advanced Research Projects Agency's Efficient Mid-wave Infrared Lasers (EMIL) program.

As these types of lasers become more efficient, they could be used in next-generation laser-based defense systems to fool incoming missile attacks or detect explosives or toxins in the atmosphere. Such lasers could also be used in commercial applications like trace chemical analysis, pollution monitoring, and free space communication.

But first, researchers must find the right laser sources at the right wavelengths. The mid-infrared wavelength range (3 to 5 microns) is especially useful for defense-based applications, and laser technology in this range has been targeted by the U.S. Defense Advanced Research Projects Agency (DARPA) as a strategic technology. The agency created the EMIL program to develop high efficiency, compact semiconductor laser sources with the hopes of demonstrating both high power (~1 W) and high power efficiency (50 percent) from an individual laser at room temperature. Besides demonstrating a significant energy savings over currently available sources, this technology (the quantum cascade laser) will also be more compact than any other laser technology for this wavelength range and operating temperature, with an active volume that is smaller than a human hair.

When the EMIL program started in March 2007, state-of-the-art mid-infrared semiconductor lasers, developed at Northwestern University, boasted power efficiencies on the order of five to 10 percent at room temperature. Over the past year, researchers at the Center for Quantum Devices, led by Manijeh Razeghi, Walter P. Murphy Professor of Electrical Engineering and Computer Science, have gradually improved this figure of merit through changes to material quality, design and fabrication. Currently a record power efficiency of 22 percent has been realized at room temperature (25 degrees Celsius). In other words, for the same power output, two to four times less input power is required. Furthermore, when cooled, the power efficiency increases to 34 percent at 160 degrees Kelvin (-113 degrees Celsius), which is also a record for this type of device. Along with high efficiencies, high output powers have also been demonstrated, with multi-watt output powers up to room temperature. This work is as yet unpublished, but recent intermediate accomplishments have recently been made public in the March 10, 2008 issue of *Applied Physics Letters*.

With up to two more years remaining in this EMIL project, there is still a lot additional research and development to be done. At present, this remains basic research, and individual lasers are quite expensive. Once developed, however, this type of laser is a strong candidate for mass production like the shorter wavelength semiconductor lasers used in CD and DVD players. This will bring down the cost significantly and allow penetration of this laser and its' applications to the commercial sector.

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