ENGINEERING NEWS

RESEARCH

New Design Results in Compact, Highly Efficient Frequency Comb

Device could be used to detect dangerous chemical agents

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Northwestern Engineering researchers have designed a quantum cascade laser (QCL) frequency comb that is dramatically more efficient than previous iterations.

Led by **Manijeh Razeghi (http://www.mccormick.northwestern.edu/research-faculty/directory/profiles/razeghi-manijeh.html)** , researchers in Northwestern's **Center for Quantum Devices**

Manijeh Razeghi

(http://cqd.eecs.northwestern.edu/research/research.php) theoretically designed and experimentally synthesized a new, strain-engineered emitter material. Made with the new material, the compact QCL frequency comb is one order of magnitude more efficient and emits more than four times the output power than all previous demonstrations.

Razeghi's QCL frequency comb operates in the infrared spectral region, which is useful for detecting many different kinds of chemicals, including industrial emissions, explosives, and chemical warfare agents.

"We are seeing the beginning of a true revolution in compact gas sensor technology," said Razeghi, Walter P. Murphy Professor of Electrical Engineering and Computer Science in Northwestern's McCormick School of Engineering. "Imagine a handheld system that can detect trace amounts of hazardous chemicals in a fraction of a second."

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A revolutionary player in fundamental science, a frequency comb is a light source that emits a spectrum containing a series of discrete, equally spaced frequency lines. The exact spacing of frequencies is key to manipulating light for various applications and has led to new technologies in diverse fields, including medicine, communications, and astronomy. Today, frequency combs span vast frequencies of light from terahertz to visible to extreme ultraviolet.

“Since the direct frequency comb was generated by using a mode-locked femtosecond laser in the 1990s, various techniques have been used to produce frequency combs,” Razeghi said. “But each of these techniques requires multiple optical components. This is neither compact nor convenient.”

Razeghi’s work has made it possible to generate a frequency comb from a single optoelectronic component just a few millimeters in length. The resulting QCL frequency comb is incredibly compact and emits more than 300 equally spaced frequency lines, spanning a range of 130 centimeters.

“The system is based on a mass producible component with no moving parts,” Razeghi said, “which is attractive in terms of both cost and durability.”

Razeghi’s group is currently looking for ways to increase further the spectral range of its QCL frequency combs. This includes searching for ways to make a chip-scale, room temperature, terahertz frequency comb, which would enable new applications in non-destructive package evaluation and biomedical imaging.