Terahertz laser source at room temperature

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"There is a growing interest in utilizing terahertz radiation, or T-rays, for a variety of applications," Mikhail Belkin, a scientist at Harvard University, tells *PhysOrg.com*. "The terahertz region is a part of the electromagnetic spectrum that lies between the radio waves and infrared/visible light."

Producing light in the terahertz range gets tricky, though: "Currently, the way to generate this radiation at room temperature involves solid state lasers that are bulky and energy consuming." In order to facilitate the creation of practical terahertz devices and systems, Belkin points out that "we want to create a compact electrically-pumped terahertz source, similar to semiconductor lasers in infrared and visible that you can fit in a laser pointer, and to be able to operate it at room temperature."

The applications for a laser device operating in the terahertz range include security screening, radio astronomy, biomedical imaging, and spectroscopy. "The main funding for our work comes from the security aspect," Belkin explains. "Terahertz rays can penetrate through cardboard, plastic, clothing, and many other materials, so that we can image a concealed weapon, or detect chemical and biological agents through sealed packages."

Along with colleagues at Texas A&M University and the Swiss Federal Institute of Technology, Zürich, Belkin believes a first step has been made in developing a practical room-temperature electrically-pumped semiconductor laser device that produces terahertz radiation. The key is to combine, in one device, a dual-wavelength infrared semiconductor laser and giant optical nonlinearity for difference-frequency mixing. Their current device produces approximately 300nW of 5THz radiation at room temperature. The findings are published in the article "Room temperature terahertz quantum cascade laser source based on intracavity difference-frequency generation" in the May 19 issue of *Applied Physics Letters.*

"We undertook an unusual approach to the problem, going around with a dual-wavelength quantum cascade laser operating at room-temperature in mid-infrared and utilizing a nonlinear optical process of difference-frequency generation inside the laser cavity to produce terahertz radiation," explains Belkin, expounding via email.

He continues: "In order to make the concept work, we needed to integrate giant optical nonlinearity inside the laser cavity. This has been done by growing a structure containing a stack of ultra-thin atomic layers of semiconductor materials on top of each other. This approach allowed us to adjust the energy levels in the structure to create an artificial medium with very large optical nonlinearity."

Right now, Belkin admits, the terahertz power output of their current devices is smaller that he and his colleagues would like. However, they have demonstrated the first room-temperature electrically-pumped semiconductor laser source of terahertz radiation. Additionally, the team is already making changes to the design to improve the terahertz power output. "We are confident that the power output of our devices can be improved several orders of magnitude when the structure is fully optimized," Belkin says.

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