Scientists demonstrate highly directional semiconductor lasers

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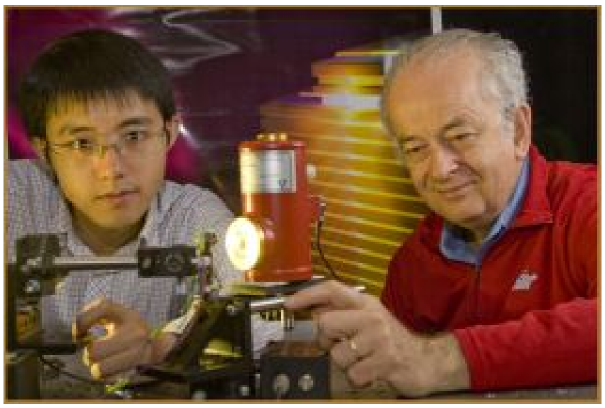

Graduate student Nanfang Yu and Professor Federico Capasso. Photo by Eliza Grinnell/SEAS

Applied scientists at Harvard collaborating with researchers at Hamamatsu Photonics in Hamamatsu City, Japan, have demonstrated, for the first time, highly directional semiconductor lasers with a much smaller beam divergence than conventional ones.

The innovation opens the door to a wide range of applications in photonics and communications. Harvard University has also filed a broad patent on the invention.

Spearheaded by graduate student Nanfang Yu and Federico Capasso, Robert L. Wallace Professor of Applied Physics and Vinton Hayes

Senior Research Fellow in Electrical Engineering, all of Harvard's School of Engineering and Applied Sciences (SEAS), and by a team at Hamamatsu Photonics headed by Dr. Hirofumi Kan, General Manager of the Laser Group, the findings were published online in the July 28th issue of *Nature Photonics* and will appear in the September print issue.

"Our innovation is applicable to edge-emitting as well as surface-emitting semiconductor lasers operating at any wavelength—all the way from visible to telecom ones and beyond," said Capasso. "It is an important first step towards beam engineering of lasers with unprecedented flexibility, tailored for specific applications. In the future, we envision being able to achieve total control of the spatial emission pattern of semiconductor lasers such as a fully collimated beam, small divergence beams in multiple directions, and beams that can be steered over a wide angle."

While semiconductor lasers are widely used in everyday products such as communication devices, optical recording technologies, and laser printers, they suffer from poor directionality. Divergent beams from semiconductor lasers are focused or collimated with lenses that typically require meticulous optical alignment—and in some cases bulky optics.

To get around such conventional limitations, the researchers sculpted a metallic structure, dubbed a plasmonic collimator, consisting of an aperture and a periodic pattern of sub-wavelength grooves, directly on the facet of a quantum cascade laser emitting at a wavelength of ten microns, in the invisible part of the spectrum known as the mid-infrared where the atmosphere is transparent. In so doing, the team was able to dramatically reduce the divergence angle of the beam emerging from the laser from a factor of twenty-five down to just a few degrees in the vertical direction. The laser maintained a high output optical power and could be used for long range chemical sensing in the atmosphere, including homeland security and environmental monitoring, without requiring bulky collimating optics.

"Such an advance could also lead to a wide range of applications at the shorter wavelengths used for optical communications. A very narrow angular spread of the laser beam can greatly reduce the complexity and cost of optical systems by eliminating the need for the lenses to couple light into optical fibers and waveguides," said Dr. Kan.

Source: Harvard University

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