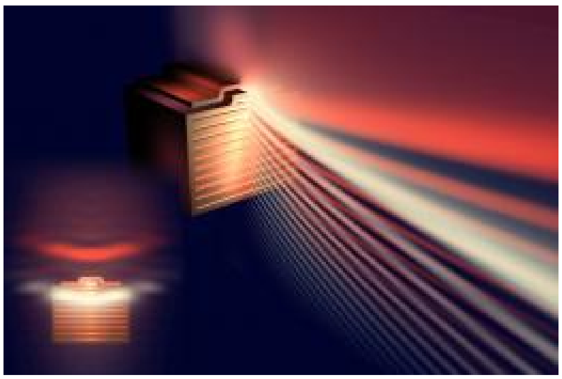
Building a more versatile laser

November 16 2009, By Miranda Marquit



The special grating directs laser beams. Illustration by Nanfang Yu, simulation results from the computer modeling and 3D illustration software.

(PhysOrg.com) -- One of the drawbacks associated with using semiconductor lasers is that many of them can only produce a beam of a single wavelength, and can only send that beam in one direction at a time. There have been efforts to tune lasers so that different wavelengths can be achieved, but these lasers still emit light only in one direction, and one wavelength at a given time. All that could change, though. Harvard University scientists Federico Capasso and Nanfang Yu , in Cambridge, Massachusetts, have been working with an international team to develop a laser that offers multibeam emission.

“Usually semiconductor lasers can only emit a single wavelength. Our design, though, allows us to emit beams in different directions, as well as beams of different wavelengths,” Capasso tells *PhysOrg.com*. Capasso believes that this work with fellow scientists at Harvard, and from the Institute of Quantum Electronics in Zurich, Switzerland, as well as Hamamatsu Photonics K.K. in Hamamatsu, Japan, will lead to a number of uses in a variety of applications in the future. He refers to the group's efforts as "beam engineering." The results of the latest simulations and experiments the group has done with multibeam lasers can be seen in *Applied Physics Letters*: "Multi-beam multi-wavelength semiconductor lasers."

The secret to the success of these lasers, Capasso explains, is the specially designed collimator used to direct the beams. "We realized that by designing a special collimator with two different gratings, we could create a beam that comes out to you at a certain angle, and another beam that comes out at a different angle. This essential allows us to use diffraction and interference to design beams to our specifications."

Previously, Capasso and his peers had shown how a plasmonic structure with aperture grating on a laser facet could collimate the beam that emerged. Taking this principle, the international team decided to split the beam of a quantum cascade laser into two different beams by using successive plasmonic gratings to define different lengths and periods on the laser's facet. The result was that it was possible to create two different beams - of different wavelengths and heading in different directions - with the same laser.

"We have created a multi-functional laser," Capasso insists, "that has a lot of potential. Not only can this add to the functionality of lasers as we have them already, but there is also the possibility of new applications in the future. This beam engineering will make lasers more efficient, since it requires more focus on designing the facet, rather than having to build an entire laser for each application." Some of the possible applications include fiber optic communications, interferometry, spectroscopy, holography, and LiDAR (light detection and ranging).

Capasso hopes that this work can be continued in the future. “We want to be able to steer the beam in real time, rather than having to set it ahead of time. Real time beam steering has been done by using multiple lasers in complicated maneuvers, but we hope to be able to use beam engineering to do it with a single laser.”

More information: Nanfang Yu, et. al., “Multi-beam multi-wavelength semiconductor lasers,” *Applied Physics Letters* (2009). Available online: link.aip.org/link/?APPLAB/95/161108/1