Tiny lasers plug the 'green gap'

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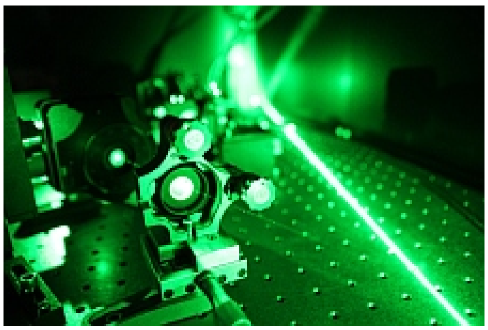

Optically pumped VECSELs - a kind of semiconductor laser. Provided by NATAL

(PhysOrg.com) -- Compact lasers which can work in formerly inaccessible parts of the spectrum and are suitable for mass production are now within reach.

Digital projectors use a variety of technologies to throw an image on to a screen. But existing projectors are bulky and there is a growing commercial interest in using new laser technology to make a projector small enough to build into a laptop computer or even a mobile phone.

“Such devices would have extremely high market potential,” says Mircea Guina of Tampere University’s Optoelectronics Research Centre. “But so far the development has been technologically hindered by the ‘green gap’ - the lack of green laser diodes.”

Laser diodes are very compact, mass producible and relatively cheap. They are widely used in such common devices as barcode readers, CD players and laser pointers. The standard approach uses so-called 'edge-emitting' diodes that offer a restricted range of visible wavelengths, which has proven to be technologically difficult to expand. They are also unsuitable where high brightness is required. Digital projectors require powerful sources of red, green and blue light. Without a novel green laser, in particular, compact projectors are not yet practicable.

"Using traditional laser diode technology it is still difficult to produce high-brightness radiation at the wavelengths preferred for laser projection applications," Guina says. "In particular, the emission from typical direct-emitting red laser diodes is limited to about 640-650 nanometres while the eye is most sensitive to 620-640 nanometres. They are also affected by changes in temperature and require high working voltages. Even worse, there is still no suitable commercial solution for the green colour."

Novel nanomaterials

Guina was project manager of the EU-funded NATAL project, which set out to develop new laser technologies that would not only plug the green gap but also make possible a host of other applications that require high-brightness miniature lasers tuned to very specific wavelengths.

The breakthrough results of the project closely relate to developments in novel semiconductor gain materials and the demonstration of new lasers. "The key technology is the optically pumped VECSEL, which resembles the geometry of a solid-state laser while retaining the wavelength versatility offered by semiconductor gain media," says Guina.

A VECSEL (vertical external-cavity surface emitting laser) is a kind of semiconductor laser that produces a high-quality beam of light perpendicular to the surface of the chip. The geometry also makes it easier to dissipate waste heat and so work at higher power.

Research in NATAL has focused on producing red, green and blue wavelengths by developing new nanomaterials to provide gain in a VECSEL - including ‘quantum dot’ structures that have not been used in a VECSEL before - and using ‘frequency doubling’.

Among the highlights from the project are high-power VECSELs operating directly in red light and frequency doubled infrared VECSELs that can emit in the sought-after green gap, as well as in the amber-orange-red part of the spectrum. The red lasers can themselves be frequency doubled to emit ultraviolet light.

Numerous applications

“One of the partners, the Institute of Photonics at the University of Strathclyde, has for the first time demonstrated direct-emission red VECSELs pumped with commercially available blue diode lasers,” Guina adds. “Another significant outcome of the project was a full 3D VECSEL simulation software that takes into account the laser geometry as well as optical and thermal properties of the laser.”

Industrial uses for compact, mass-produced lasers are likely to be numerous. Two NATAL partners, OSRAM Opto Semiconductors and EpiCrystals, are in the midst of developing the green laser for projection technologies.

The third industrial partner, TOPTICA Photonics, is working on scientific applications. “Using all semiconductor VECSEL technology we have new opportunities for customised and wavelength-tailored solutions in the near infrared,” says Wilhelm Kaenders, president of TOPTICA Photonics and NATAL project dissemination manager.

"Combining this with our established frequency conversion modules we can finally plug the spectral niche between green and red. We can now supply spectroscopists with diode-based single frequency, fixed frequency and tunable lasers from 375 to 3000 nanometres."

Artificial stars

Many other applications of the new lasers are possible, such as materials processing, UV lithography and in medicine. The amber-orange-red lasers, for example, could be used for photodynamic therapy and to make artificial guide stars for telescopes by exciting sodium atoms high in the atmosphere, supporting long-term goals of the European astronomical community.

There are also a number of scientific and medical applications where compact, reasonably high-power visible and UV lasers would be preferred over the existing high-cost, high-maintenance gas and ion lasers.

NATAL, which was funded through the EU's Sixth Framework Programme for research, ended in August 2008 but the work is being carried on in several other projects. Some of these aim to develop VECSELs emitting at longer infrared wavelengths which could be used in distance sensing, environmental monitoring of gases and tissue-welding in surgery. Lasers emitting ultra-short optical pulses are also in development.

"NATAL has helped to generate a significant amount of knowledge and new technologies in this field," Guina says. "Much of what we have done with VECSELs is now regarded as state of the art in the world."

The work on quantum-dot VECSELs is being continued in the FastDot project funded under the EU's Seventh Framework Programme. Other spin-out projects are expected to be generated in due course.

More information: www.orc.tut.fi/natal.html

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