Research Highlights

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Subject Categories: **Lasers, LEDs and light sources** (/nphoton/archive/nphoton_s1_current_archive.html) | **Terahertz optics** (/nphoton/archive/nphoton_s16_current_archive.html)

Terahertz quantum-cascade laser: Going sideways

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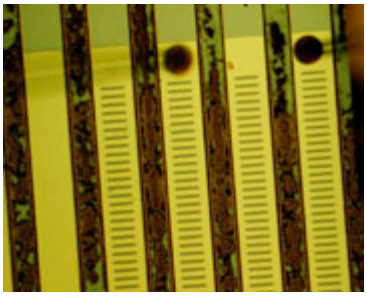
Surface-emitting terahertz quantum-cascade lasers offer better slope efficiencies than their edge-emitting counterparts



Owing to their ability to generate terahertz radiation at relatively high temperatures, strong interest has been shown in developing quantum-cascade lasers for imaging and spectroscopy applications. Unlike conventional semiconductor lasers, the operation of this type of device is not based on the characteristics of the conduction and valence bands, but relies on transitions between the electronic sub-bands in quantum wells, making emission possible in a frequency range of 2–5 THz. Until very recently most of the reported terahertz quantum-cascade lasers have been edge emitters. However, small out-coupling of the light results in a strongly divergent beam and hence poor slope efficiency. This is the problem that researchers from Harvard University in the USA and the University of Leeds in the UK have teamed up to investigate[1] (/nphoton/reshigh/2006/1206/full/nphoton.2006.72.html#B1).

The approach they take is to fabricate double-metal waveguide quantum-cascade lasers — placing cladding on both sides of the active region. Previous surface-emitting structures have used single-metal waveguides, but these cannot provide the same level of light confinement. The key to the new design is the incorporation of second-order diffraction gratings: first-order diffraction is perpendicular to the plane leading to surface emission, whereas second-order diffraction is in-plane and provides the required feedback. The researchers observe output powers comparable to edge-emitting lasers but with twice the slope efficiency. The device also shows single-mode behaviour and only a small (~6 degrees) beam divergence along the laser ridge. The team also predict that the double-metal waveguides could find a use in future terahertz sources that use difference-frequency generation between two mid-infrared laser modes.

REFERENCES

1. Fan, J. A. *et al.* Surface emitting terahertz quantum cascade laser with a double-metal waveguide. *Opt. Express* **14,** 11672–11680 (2006).