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This is the author's version of a Proceedings Paper presented at the **UK Semiconductors conference 2012, Sheffield, UK**

Kundu, I, Dean, P, Li, LH, Valavanis, A, Khanna, SP, Cunningham, JE, Linfield, EH and Davies, AG *Terahertz quantum cascade lasers with externally biased photonic lattices for electronic tuning*. In: UNSPECIFIED UK Semiconductors 2012, Sheffield, UK.

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# Terahertz quantum cascade lasers with externally biased photonic lattices for electronic tuning

I. Kundu,<sup>a</sup> P. Dean, L. H. Li, A. Valavanis, S. P. Khanna, J. E. Cunningham, E. H. Linfield, A. G. Davies

School of Electronic and Electrical Engineering, University of Leeds, Leeds, LS2 9JT, UK

<sup>a</sup>Email: el09ik@leeds.ac.uk

Single-mode (SM) operation of terahertz (THz)-frequency quantum cascade lasers (QCLs) is essential for gas sensing [1] and for their use as local oscillators. Whilst such SM operation has been demonstrated previously using distributed feedback (DFB) gratings [2] and photonic lattices (PLs) [3], an ability to tune SM THz QCLs electronically would be highly desirable for many applications. We have fabricated THz QCLs with electronically-controlled PL gratings. Our THz QCLs, based on a bound-to-continuum design [4], were processed into 150- $\mu\text{m}$ -wide semi-insulating surface plasmon ridge waveguides with lengths 2.5–4.5 mm. The upper waveguide was then patterned into three sections. The outer sections were fully metallised. In the central 530- $\mu\text{m}$ -long section, however, the top  $n$ -doped layer was etched away and metallic PLs fabricated using electron-beam lithography, with grating pitch 14.60–15.65  $\mu\text{m}$ . In each device both the PL and the outer sections were bonded separately to allow independent biasing (Fig. 1(a)). Devices were cooled in a continuous-flow helium cryostat and emission spectra measured using a Fourier-transform infrared spectrometer. Standard (unpatterned) devices lased with multiple Fabry–Pérot modes in the range 2.70–2.83 THz, whilst single mode emission was observed for devices patterned with a PL. The emission spectra recorded from devices with PLs of different grating pitch showed stop-band behaviour [5], with the experimentally-determined stop-band bandwidth of around 25 GHz agreeing with the value of 23 GHz calculated using finite-element modelling. A bias of 2 V applied to the PL, then led to a change in the spectral features in a number of devices, an example of which is shown in Fig. 1 (b) and (c).

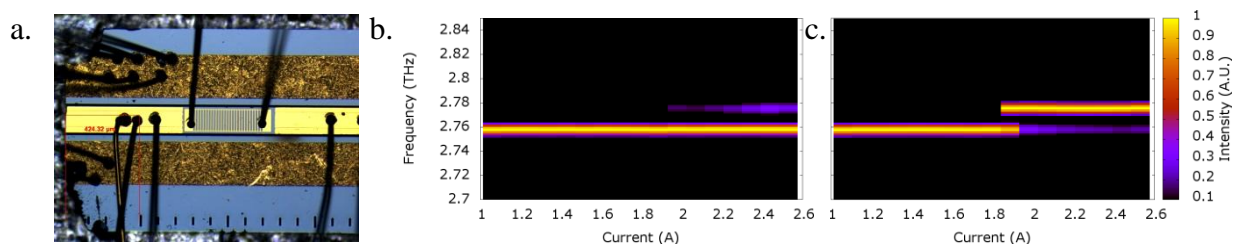


Figure 1: (a) Optical image of a fabricated device. Spectra obtained with (b) an unbiased PL and with (c) a 2 V bias applied to the PL.

## References

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