Discrete Vernier tuning with constant output power in terahertz quantum cascade lasers using coupled cavities

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Terahertz-frequency quantum cascade lasers (THz QCLs) are compact solid-state sources of coherent radiation in the 1–5 THz region of the electromagnetic spectrum [1]. THz QCLs typically exhibit multiple longitudinal modes characteristic of Fabry–Pérot cavities. However, widely-tunable (single-mode) THz QCLs would be ideally suited to many THz-applications, such as atmospheric observations [2], and security screening [3]. Here we demonstrate discrete Vernier tuning using a simple two-section coupled-cavity geometry comprising of a '*lasing* section', which is electrically driven above the lasing threshold, and a '*tuning* section', which is driven below threshold. Our THz QCLs, based on a bound-to-continuum design [4], were processed into 150-μm-wide single–metal waveguides with lengths 4.5–4.8 mm. Devices were etched after packaging using a focused ion beam milling system to sculpt a14-μm–wide and 12-μm-deep air gap to form the two-section cavity [Fig. 1 (a)]. Devices were cooled in a continuous-flow helium cryostat and emission spectra measured using a Fourier-transform infrared spectrometer. The tuning section of the laser was heated below threshold using a train of 10-μs-long current pulses at a repetition rate of 8.21 kHz. The lasing section was driven with a single 500-ns-long pulses above threshold. Both the pulse trains were trigerred using a 600-Hz reference frequency. Discrete tuning with a blue shift in frequency was observed over bandwidths of 50 and 85 GHz from two devices with mode spacing of 15 GHz and 30 GHz respectively [Fig. 1 (b, c)]. A red shift in frequency over 30 GHz was also observed in device 2 by simply swapping the function of the lasing and tuning sections [Fig. 1 (c) Inset]. Negligible degradation in output power was observed with tuning current.

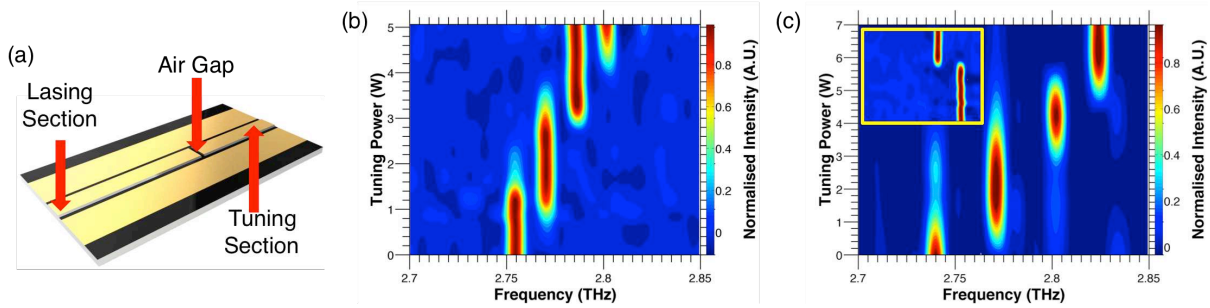

Fig. 1: (a) Illustration of a coupled cavity device. Blue shift of frequency obtained from two devices over bandwidths of (b) 50 and (c) 85 GHz, with tuning power applied to the short tuning section. Inset: Red-shift in frequency observed over same frequency and tuning power by swapping the lasing and tuning sections.

References

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