Electrically-controlled frequency tuning of terahertz quantum cascade lasers over 190 GHz using a coupled cavity with integrated photonic lattice

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Terahertz (THz) frequency quantum cascade lasers (QCLs) are compact unipolar semiconductor sources of THz radiation, in which photons are generated through intersubband electron transitions [1]. THz QCLs typically use ridge waveguides, and emit multiple frequencies characteristic of Fabry–Pérot cavities. However, several THz applications, such as trace gas detection, spectroscopy, feedback-interferometry-based imaging, atmospheric observations, and security screening, require a widely frequency tuneable and single-mode THz source. Moreover, the current and temperature tuning of THz QCLs are only ~–5 MHz/mA and –34 to –100 MHz/K, respectively [2]. As such, development of an electrically-controlled frequency tuneable THz QCL is still a technological challenge.

We previously demonstrated electrically-controlled discrete, and quasi-continuous Vernier frequency tuning of THz QCLs using an optically coupled cavity (CC) approach, comprising a lasing (active) cavity and a tuning (passive) cavity [3, 4]. We have also demonstrated continuous tuning of a CC mode without any degradation of output power by integrating a finite-defect-site photonic lattice (PL) into the lasing cavity [4]. We recently improved our PL design and have engineered spectral emission, and frequency tuning from such PL-QCLs [5]. Here, we report the progress made towards improving the spectral coverage from our next generation of electrically-controlled frequency tuenable THz CC-PL-QCLs.

Frequency emission in our previous CC-QCLs was controlled only through localised electrical Joule heating of the tuning cavity (driven sub-threshold). Here, we have additionally driven our tuning cavity above threshold, and exploited mutual coupling and cavity pulling effects to enhance continuous frequency tuning [6]. Furthermore, we have also integrated a PL into the lasing cavity, allowing discrete tuning of CC modes. Through a combination of the discrete tuning and cavity pulling effect, in conjunction with thermal effects, we have recorded frequency tuning over 190 GHz (side mode suppression 20–40dB), including a ~100 GHz quasi-continuous tuning from ~3.47–3.57 THz [Fig. 1] from a THz CC PL QCL based on an active region reported in Ref. [7].

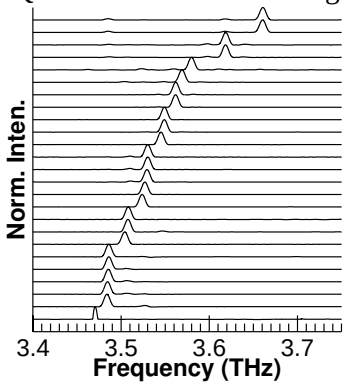

Fig. 1. Normalised emission spectra (offset and rearranged) showing tuneable frequency emission from a THz CC PL QCL over a bandwidth of 190 GHz, for a range of driving currents, and temperatures.

References

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