Terahertz intersubband electroluminescence from n-type germanium quantum wells

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The Quantum Cascade Laser (QCL) has been demonstrated in polar III-V semiconductor materials employing transitions between conduction band states [1]. Harnessing intersubband transitions allows lasing at mid-infrared and far-infrared wavelengths. Buried InGaAs/InAlAs QCLs unlocked the mid-infrared application space, because they are operational at room-temperature and in continuous wave [2]. However, THz QCLs remain limited up to 250 K in pulsed operation with a large dissipation [3]. The quenching of the laser emission is related to thermally activated LO phonon emission in polar materials. Exploiting intersubband transitions in non-polar group IV materials with weaker electron-phonon interaction is an exciting approach to realize a Si-based THz QCL and to eventually elevate the operation temperature [4].

We report THz intersubband electroluminescence originating from n-type Ge/SiGe quantum cascade structures [5]. In Fig. 1 the electroluminescence spectra from three different structures (named 2307, 2306 and 2315) are shown. The structures are grown with ultra-high vacuum chemical vapour deposition and processed into deeply etched diffraction gratings. The nominally 4.2 um thick active regions consists of 50 periods of a single quantum well design. A line broadening of $\Delta f / f \approx 0.2$ is observed [5] and the spectral features agree with non-equilibriums Green's function calculations (see Fig. 1(c)) [4]. The Ge/SiGe emitters are benchmarked against a similar GaAs/AlGaAs struc-ture processed into the same device geometry [5]. The results pave the way towards the realization of a THz QCL on a silicon substrate.

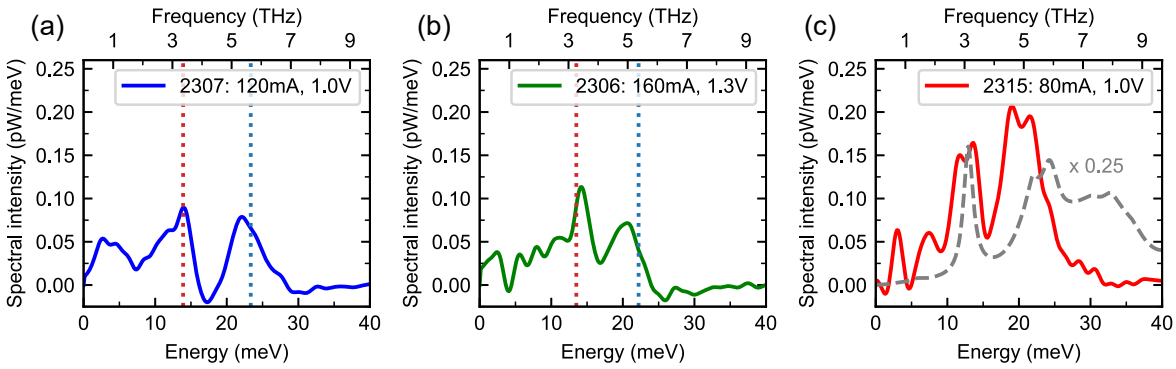

Fig. 1. Electroluminescence spectra from three different Ge/SiGe samples (a) (b) and (c). In (a) and (b) the simulated peak positions are indicated with the vertical dotted lines. In (c) the gray dashed line corresponds to the theoratical electroluminescence spectrum computed with *nextnano.NEGF*.

References

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