Frequency tunability and mode switching of quantum cascade lasers operating at 2.5 THz

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Quantum cascade lasers (QCLs) are promising devices for local oscillators in terahertz heterodyne receivers. The lasing mechanism is based on intersubband transitions in the conduction band of heterostructures, most commonly made from GaAs/AlGaAs. A key issue for application in a heterodyne receiver is the frequency stability and tunability. Linear continuous frequency tuning is not straightforwardly obtained. We have investigated two QCLs. They are designed for an operation frequency at about 2.5 THz. One of the lasers has a Fabry-Perot resonator while the other laser is a distributed feedback (DFB) laser. The active medium of both lasers is based on a GaAs/AlGaAs superlattice. The design follows the so-called bound-to-continuum approach with a rather uniformly chirped superlattice and no marked distinction between the injection and lasing regions. Detailed high-resolution spectra of the laser emission as a function of temperature and current have been obtained by self-beating of the laser modes (only laser with Fabry-Perot resonator) as well as by mixing with the emission of a THz gas laser. We report on some spectral features, such as nonlinear dependences of the laser emission frequency on the current and singularities due to mode switching. The analysis shows frequency- and current-dependent nonlinearities of the frequency tuning for both lasers. The multi-mode QCL shows larger variations of the output power of a particular mode as well as larger frequency instabilities at the current values related to the mode switching. Less-expressed power variations have been found for the single mode DFB QCL. The results of the homodyne mixing indicate large variations of the effective refractive index in the active medium caused by the drive current. The implications for the use of the QCL as local oscillator in a heterodyne receiver will be discussed.