Spectral Characterization of a 2.5 THz Multi-Mode Quantum Cascade Laser

S. G. Pavlov, H.-W. Hübers, H. Richter, and A. D. Semenov
German Aerospace Center (DLR)
Rutherfordstr. 2, 12489 Berlin, Germany

A. Tredicucci, R. Köhler, and L. Mahler
NEST CNR-INFM and Scuola Normale Superiore
Piazza dei Cavalieri 7, 56126 Pisa, Italy

H. E. Beere and D. A. Ritchie
Cavendish Laboratory, University of Cambridge, Madingley Road, Cambridge CB3 0HE, United Kingdom

Recently, terahertz-range semiconductor quantum cascade lasers (QCL) have attracted attention as potential local oscillators in heterodyne receivers. The basic characterization of the lasers, such as beam profiles, frequency and power stability as well as temperature and current-related frequency tunability has been carried out. Precise spectral analysis is required if the device is going to be used for applications requiring very accurate absolute frequency, spectral purity and fine frequency tunability, such as in heterodyne spectroscopy. By combination of Fourier transform spectroscopy with heterodyne and homodyne mixing measurements it is possible to create a complete picture of the QCL spectral output. We will report on the characterization of a 2.5 THz multi-mode QCL with respect to mechanisms determining the laser emission frequency and mode spectrum. The laser mechanism is based on a bound-to-continuum laser design. Laser emission spectra at different drive currents and heat sink temperatures have been measured by homodyne (QCL-QCL) and heterodyne (QCL-THz gas laser) mixing experiments. The analysis shows that variations of the laser frequency and modifications of the mode spectra are caused by fast processes which apparently control the gain of the device. The emission frequencies of the QCL based on a bound-to-continuum design can be described by a formalism similar to a Fabry-Perot-type cavity with additional corrections, depending on the QCL frequency and drive current. The detailed study of the spectral characteristics provides basic data about the direction, magnitude, and range of the frequency tunability of QCLs of this family/design. The data are necessary for implementation of the laser in a THz heterodyne receiver for example on board of SOFIA.