Low power consumption quantum cascade lasers at 2.7 THz for compact and sensitive heterodyne detectors

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Terahertz (THz) technology is demonstrating more and more attractive applications in different fields, from astronomy, medicine and biology to material science and security. Superconducting heterodyne THz receivers combine very high spectral resolutions with sensitivity approaching the quantum noise limit. HEB (Hot Electron Bolometers) mixers are currently the most sensitive for operating frequencies beyond the THz and QCL (quantum cascade lasers) sources offer a great potential as local oscillators for heterodyne detection in the THz range.

In order to realize compact and sensitive heterodyne THz receivers combing superconducting HEB mixers and QCLs, currently the most promising and optimal receiver configuration for frequencies beyond 2 THz, we have undertaken the development of the QCL operating around 2.7 THz with the following specifications : single mode emission at a specified target frequency, low power consumption and near Gaussian beam emission.

We have chosen the distributed-feedback (DFB) architecture, in particular the 3rd-order DFB approach that can provide single mode emission as well as small beam divergence [1]. The DFB is implemented by introducing a deeply-etched lateral corrugation along the laser ridge that provides the necessary distributed feedback.

To obtain single mode operation at the desired frequency we have fabricated several devices with different grating periods and/or grating duty cycle. Based upon electro-optical characterizations of the lasers, the devices that best suit the application can be selected. During the electromagnetic modelling and simulation for the design of the lasers, special care has been taken to reduce the overall size as much as possible in order to minimize the power dissipation. We obtained devices with electrical consumption lower than 100 mW, which is very interesting for integrating QCLs to HEB mixers for embedded applications.

We have studied different quasi-optical configurations to reshape the QCL's output beam into a Gaussian beam for an efficient coupling with the HEB mixer. In particular, systems using Pyrex dielectric hollow waveguides [2] [3] and parabolic mirrors with short focal length have been studied with the aim of building a fully integrated heterodyne receiver. We'll present the simulation and experimental results.