Broadband quantum cascade laser

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Sensors for detection of gases and liquids have seen impressive progress over the last ten years boosted by a large number of applications. For example, increasing concerns about atmospheric pollutants responsible for global warming or connected to pulmonary diseases have fostered strong demand for very sensitive, portable, and selective gas detectors. Coverage of the mid-infrared region of the electromagnetic spectrum with broadly and quickly tunable light sources is of particular interest as most relevant gases have the strongest vibrational frequencies in this spectral range. Such sources – integrated in relatively small and portable systems – would greatly facilitate the optical chemical sensing of mixtures of gases or liquids. Recent improvements in room-temperature operation and wavelength coverage of quantum cascade lasers (QCLs) show the potential of these devices for the integration in such portable chemical sensing systems.

We developed broadly tunable InP-based QCLs with active regions optimized for large gain and benefitting from a new process to reduce losses and thermal resistance, as well as power consumption and threshold currents. In a first design, such lasers showed a tuning range over 25% of the central wavelength in pulsed mode. Integrated in an external cavity-QCL (EC-QCL) setup [1], we measured a coarse tuning range from 9.6 ⌠m to 8.0 ⌠m in cw operation at room temperature. This corresponds to 201 cm^{-1} tuning in wavenumbers with output powers in excess of 20 mW over 172 cm^{-1} at 18 °C and a side mode suppression ration of >35 dB. Our latest design of an EC-QCL with an active region specifically developed for broadband application shows a coarse tuning over almost 4 μm (more than 400 cm^{-1}) in pulsed mode, corresponding to 40% of the central wavelength. Peak optical power of 720 mW at the maximum of the gain curve (1200 cm^{-1}) was measured.

Work is in progress with strain-compensated materials to cover the lower mid-infrared range (4–7 μm).

1. R. Maulini, A. Mohan, M. Giovannini, J. Faist, and E. Gini, "External cavity quantum-cascade laser tunable from 8.2 to 10.4 μm using a gain element with a heterogeneous cascade", Appl. Phys. Lett. **88**, 201113 (2006).