Broad-band molecular spectroscopy with a multimode terahertz quantum-cascade laser

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High-resolution molecular spectroscopy is a powerful tool for investigations of the structure and energy levels of molecules and atoms. In addition to scientific utilization, terahertz (THz) spectroscopy is of interest for detection and identification of gases in safety and security applications. While for frequencies below 2 THz many different methods have been developed, spectroscopy above 2 THz is hampered by the lack of frequency-tunable, continuous-wave, powerful, and narrow-linewidth radiation sources. For this frequency range, THz quantum-cascade lasers (QCLs) are promising radiation sources. We report on a THz absorption spectrometer, which combines a grating monochromator, a QCL, and a microbolometer camera. The QCL used for these experiments is based on a single-plasmon waveguide and a Fabry-Pérot cavity with both facets uncoated and is optimized for a low electrical pump power. It operates on several modes centered around 3.4 THz. The laser is mounted in a compact air-cooled cryocooler (model K535 from Ricor). The emitted beam is focused with a TPX lens and guided through a 27 cm long absorption cell onto the monochromator, which spectrally resolves the laser modes. The modes are imaged onto the microbolometer camera. The absorption spectrum of methanol around 3.4 THz is measured by detecting simultaneously the signal of each of the laser modes as a function of the laser driving current.