Compact THz spectrometer based on 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 the scientific interest, terahertz (THz) spectroscopy is also of interest for the 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 in these experiments contains a single-plasmon waveguide and a Fabry-Pérot cavity with both facets uncoated. It is optimized for low electrical pumping powers an emits several modes centered around 3.4 THz. The laser is mounted in a compact air-cooled cryocooler (model K535 from Ricor) [1]. 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 [2]. By this means, frequency multiplexing is achieved.

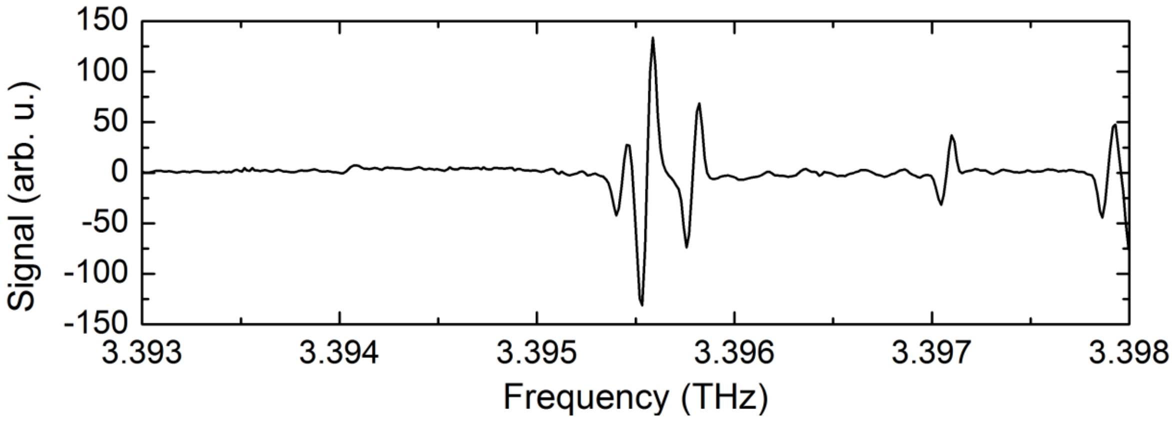

Fig. 1: Absorption signal of $^{12}CH_3OH$ at 1 hPa measured with the microbolometer array for a single QCL mode.

[1] H. Richter, M. Greiner-Bär, S. G.Pavlov, A. D. Semenov, M. Wienold, L. Schrottke, M. Giehler, R. Hey, H. T. Grahn, and H.-W. Hübers, “A compact, continuous-wave terahertz source based on a quantum cascade laser and a miniature cryocooler”, Optics Express 18, 10177–10187 (2010)

[2] R. Eichholz, H. Richter, S. G. Pavlov, M.Wienold, L. Schrottke, R. Hey, H. T. Grahn, and H.-W. Hübers, “Multi-channel terahertz grating spectrometer with quantum-cascade laser and microbolometer array”, Applied Physics Letters 99, 141112 (2011)