Local Oscillator for a 4.7-THz Multi-Pixel Heterodyne Receiver Based on a Quantum-Cascade Laser

H. Richter[1,*], N. Rothbart[1], M. Wienold[1,2], L. Schrottke[3], K. Biermann[3], H. T. Grahn[3], and H.-W. Hübers[1,2]

[1]*German Aerospace Center (DLR), Institute of Optical Sensor Systems, Rutherfordstr. 2, 12489 Berlin, Germany*
[2]*Humboldt-Universität zu Berlin, Department of Physics, Newtonstr. 15, 12489 Berlin, Germany*
[3]*Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e. V., Hausvogteiplatz 5−7, 10117 Berlin, Germany*
[*]Contact: Heiko.Richter@dlr.de

Abstract— We report on the design and performance of a 4.7-THz local oscillator (LO) for the seven-pixel heterodyne spectrometer upGREAT, which is the upgrade of the German Receiver for Astronomy at Terahertz Frequencies (GREAT). The upGREAT instrument has been developed for SOFIA, the Stratospheric Observatory for Infrared Astronomy. The LO is based on a quantum-cascade laser (QCL). The first operation took place in October 2016. During this measurement campaign the fine structure line of atomic oxygen has been observed in a variety of astronomical objects.

The LO combines a QCL with a compact, low-input-power Stirling cooler. The 4.7-THz QCL is based on a hybrid design and has been developed for continuous-wave operation, high output powers, and low electrical pump powers [1]. Efficient carrier injection is achieved by resonant longitudinal optical phonon scattering. This design allows for an operating voltage below 6 V. The amount of generated heat complies with the cooling capacity of the Stirling cooler of 7 W at 65 K with 240 W of electrical input power [2]. The QCL has a single-plasmon waveguide with a lateral distributed feedback (DFB) grating, which is optimized for 4.745 THz. This yields single mode emission over most of the driving current range of the laser through one of the end facets of the waveguide. The beam of the QCL is formed with dedicated optics into an almost Gaussian profile. The peak output power of the QCL is 2.5 mW. The frequency tunability ranges from about −1.5 GHz to +5 GHz around the OI rest frequency. The LO is a significant improvement over its predecessor, which has been in routine operation in the GREAT heterodyne spectrometer on SOFIA since 2014 [3].The design of the LO and its performance in terms of output power, frequency accuracy, frequency stability, and beam profile as well as its implementation in upGREAT will be presented.

[1] L. Schrottke, M. Wienold, R. Sharma, X. Lü, K. Biermann, R. Hey, A. Tahraoui, H. Richter, H.-W. Hübers, and H. T. Grahn, Semicond. Sci. Technol. vol. 28, 035011, 5 pages (2013).
[2] 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, Opt. Express vol. 18, pp. 10177–10187 (2010).
[3] H. Richter, M. Wienold, L. Schrottke, K. Biermann, H. T. Grahn, and H.-W. Hübers, IEEE Trans. Terahertz Sci. Technol. vol. 5, pp. 539–545 (2015).