1.3 THz HEB Mixer for APEX Telescope Facility Receiver

Denis Meledin, Vincent Desmaris, Sven-Erik Ferm, Mathias Fredrixon, Douglas Henke, Igor Lapkin, Olle Nyström, Alexey Pavolotsky, Magnus Strandberg, Erik Sundin, and Victor Belitsky
Group for Advanced Receiver Development (GARD),
Chalmers University of Technology, SE-412 96, Gothenburg, Sweden.

We will report on the development, tests and on-telescope verification for a THz waveguide Hot Electron Bolometer (HEB) balanced receiver for the Atacama Pathfinder EXperiment (APEX) telescope. The receiver covers the frequency range of 1250-1387 GHz (Band T2), and is part of a multi-channel receiver SHeFI (Swedish Heterodyne Facility Instrument) built by GARD [V. Belitsky, et al., Proceedings of joint 32nd Int. Conf. on IR-and MM Waves and 15th Int. Conf. on THz Electronics, Sept. 3-7, 2007, Cardiff, Wales, UK, 326-328]. Employing a balanced receiver design allows for an effective use of available LO power without the necessity of mechanical tuning, and has the advantage of suppressing LO additive noise and thus improving the stability of the HEB receiver. In addition, the waveguide design of the mixer limits the RF passband of the mixer and consequently minimizes the effect of direct detection and saturation in the HEB mixer.

The APEX Band T2 band uses HEB mixers, and its balanced scheme consists of an input 3 dB 90-degree waveguide RF hybrid with a 180-degree IF hybrid. The two HEB mixers are made of 4-5 nm thick NbN film deposited on crystalline quartz substrates with an MgO buffer layer [NbN films deposition and mixer patterning have been provided by B. Voronov and G. Goltsman, Moscow State Pedagogical University, Moscow, Russia]. The mixer RF hybrid part was built using split-block technique while the mixer chips are mounted in a back-piece layout with the waveguides dimensions of 90 μm x 180 μm. For precise fabrication of the RF hybrid and the back-piece with its substrate channels, we use a novel micromachining technology [V. Desmaris, et al., J. Micromech. and Microeng., 18, 095004 (6pp), 2008]. This technology allows the manufacturing of 2.5 D "all-copper" THz waveguide components with a 1 μm dimension accuracy and surface roughness better than 100 nm.

This mixer was installed at the APEX telescope as part of the SHeFI instrument with cooling provided by a close-cycle refrigerator. The receiver demonstrates good stability with a spectroscopic Allan time about 200 s, and the best DSB noise temperature of about 1000 K.

At the meeting, we will present details on the mixer and system design, results of the mixer characterization, and the first astronomical measurements with the APEX T2 receiver.