Operation of a Monolithic Planar Schottky Receiver Using a THz Quantum Cascade Laser

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Terahertz heterodyne receivers using Schottky diode mixers are desirable because they require no cryogenic cooling, have intermediate frequency (IF) bandwidths ≥ 20 GHz, and can deliver usefully low noise performance. However, to achieve optimal conversion gain and noise temperature, Schottky receivers operating in the THz range require at least several milliwatts of continuous local oscillator (LO) power. For this reason, the most common THz LO source used for Schottky receivers is the CO_2-pumped molecular gas laser. Of clear interest is the possibility of replacing the tube-based molecular gas laser with a solid-state THz LO source capable of pumping a Schottky mixer. To date the only solid-state source capable of producing > 1 mW of continuous wave power above ~ 2 THz is the quantum cascade laser (QCL). THz QCLs have been shown to work as good LO sources for superconducting HEB mixers, [1] which require significantly less LO power than Schottky mixers. Frequency down-conversion has also been accomplished using two QCL lines and a point-contact Schottky diode.[2]

We will report on the operation of a monolithic planar Schottky diode receiver using a THz QCL. The Schottky mixer consists of a Ti/Pt/Au anode contacting a GaAs membrane and is packaged into a waveguide block with an integral horn antenna. The details of the mixer design, construction, and packaging are described in Refs. 3 and 4. At 2.5 THz, the minimum noise temperature of the packaged receiver was about 11,000 K. Although the design of the receiver was optimized for 2.5 THz, good responsivity and measurable noise temperature were obtained for this receiver at frequencies up to 3.1 THz. Using the 2.9 THz deuterated methanol line from a molecular gas laser, the receiver showed a noise temperature of ~ 30,000 K, using 6 mW of LO power in a 25 mm diameter Gaussian beam coupled to the receiver input mirror.

Preliminary measurements using a 2.8 THz surface-plasmon guided QCL in place of a molecular gas laser have been made. The QCL emitted a total power of ~ 2 mW in a non-Gaussian divergent beam. After collecting and collimating this beam using an off-axis paraboloid mirror, there was insufficient LO power coupled to the receiver input mirror to generate a measurable noise temperature. However, the receiver did show that when the QCL was driven past a threshold current bias, its output split into two modes spaced 12.8 GHz apart, generating a clear 12.8 GHz IF signal in the receiver. The width of this IF signal indicated that the linewidth of the free-running QCL emission was ≤ 10 kHz. We will present further studies on receiver operation with better coupling of QCL light and higher power QCLs.

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