Spectroscopy around 245 GHz based on a SiGe Transmitter and Heterodyne Receiver

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Abstract— Terahertz/millimeter wave gas spectroscopy is an important tool for space exploration due to strong rotational transitions of many gases. We report on a tunable 245 GHz SiGe transmit/receive system based on SiGe technology. The system performance is demonstrated by high resolution gas spectroscopy.

The transmitter (TX) and receiver (RX) chips are fabricated in 0.13 µm BiCMOS SiGe technology at IHP [1]. Both, TX and RX have integrated antennas fabricated by localized backside etching (LBE). The heterodyne RX consists of a 120 GHz push-push voltage controlled oscillator (VCO), a 1/64 frequency divider for the fundamental frequency, a Gilbert-cell based subharmonic mixer, and a five-stage low noise amplifier. The TX is also based on a 120 GHz VCO. The tuning ranges of the TX and RX are 234 to 250 GHz and 237 to 254 GHz, respectively. The emitted output power of the TX is 1 dBm with an equivalent isotropically radiated power of 7 dBi.

For gas spectroscopy experiments, TX and RX are integrated in compact modules that provide e.g. the drive voltages, divider outputs, and input ports for the frequency control voltage. The modules are attached to a gas cell with a 1.9 m path length and plano-convex HDPE lenses as entrance windows for focusing of the radiation. The setup including TX, RX, the folded gas cell, and vacuum pumps is installed on a 45 cm by 75 cm ground pate [2].

The frequency tuning can be realized either by a phase-locked loop (PLL) or by directly applying a voltage to the VCO. For the latter setup, a voltage-frequency calibration was made by tuning the frequency with a PLL and reading out the corresponding voltage applied to the VCO. With respect to the calibration, a linear frequency scan can be performed by a nonlinear voltage ramp. By direct voltage frequency tuning a 2f spectrum of 12 Pa methanol from 238 to 251 GHz was measured. It exhibits a high SNR of 560 at an absorption line with an integrated absorption coefficient of $S = 4.8 \times 10^{-23}$ cm. The intermediate frequency (IF) was set to a constant value of 400 MHz and the power was detected by rectification with a Schottky diode. Measurements with higher IFs of up to 10 GHz were performed showing the potential of the RX for broadband heterodyne detection.

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