Fermi-level managed barrier diodes for ultra-wideband THz-mixing

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Recently, the development of compact and cost-effective integrated circuits (ICs) has become attractive for a variety of THz applications ranging from communications to radar and spectroscopy [1]. In order to down-convert the THz signal into an intermediate frequency (IF) for further processing, Schottky barrier diodes (SBDs) are commonly employed as mixers on the receiver side. For low conversion loss (CL), pumping with local oscillator (LO) power levels of at least 1.6 mW in case of GaAs-based SBDs or 0.18 mW for low-barrier SBDs are required [2, 3]. Achieving sufficient LO power levels in the THz range remains challenging for chip-level sources, due to the limited selection of materials for reducing the barrier height or power requirement of SBDs. Fermi-level managed barrier diodes (FMBDs) enable more flexibility by employing a hetero junction and optimizing the barrier height with the doping concentration [4]. With the reduced switching power requirements, this facilitates ultra-wideband operation of novel integrated THz mixers.

In this work, coplanar waveguide (CPW) integrated InGaAsP Q1.25 based FMBDs are fabricated and characterized regarding their pumping power requirements. Figure 1 a) shows the diode characteristic of an FMBD with an area of 3x4 µm² fabricated using reactive ion etching. The corresponding responsivity is measured and simulated until 110 GHz indicating a first order roll-off after a 3 dB cut-off frequency of 65 GHz and a maximum responsivity of 340 V/W (s. Fig. 1 b)). The CL is investigated using harmonic mixing for different LO power levels at 20 GHz in Figure 1 c) keeping a fixed RF power of -30 dBm at 21 GHz.

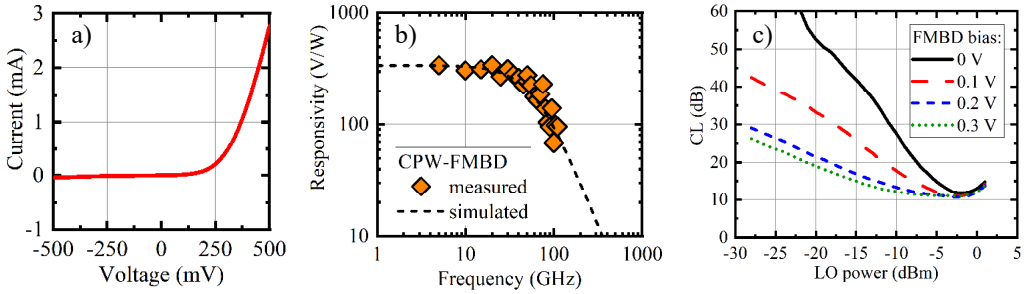

Figure 1. Measurements of a CPW-integrated FMBD showing the DC characteristic in a), the responsivity up to 110 GHz with simulation (dashed line) in b), and CL behavior in c).

Furthermore, several bias voltages were applied leading to a significant improvement of the CL slope, which itself reveals an almost linear trend depending on the LO power. In combination with broadband sources, such as photodiodes, tunable mixers can be realized for ultra-wideband frequency ranges. For future designs, optimization of the FMBD barrier has to be applied for optimal operation at zero bias condition.

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