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Title: GaAs-Schottky Diodes as Mixer between 700 GHz and 2500 GHz

Summary

The non-linearity of a GaAs-Schottky diode can be used as a mixer at room temperature in the submillimeter range (300 GHz to 3000 GHz). The best device at high frequencies up to now has been a 250 μm x 250 μm x 100 μm chip. Pt-Au-dots with 0.5 μm diameter and 1.5 μm spacing and insulated by SiO_2 are grown on a GaAs active layer ($N = 4 \times 10^{17}$ cm^{-3}). Each dot forms a Schottky contact. By alligning the tip of a special whisker wire perpendicular to the chip surface one single contact is chosen. D.C. characteristics of these diodes are: series resistance $R = 33\ \Omega$, capacitance $C = 0.5$ fF. The plasma frequency of about 6 THz is assumed to limit the application for higher frequency.
We use an optically pumped gas laser as a local oscillator (LO) for heterodyning. The LO and the signal radiation are coupled into the biased diode with the whisker wire acting as a long wire antenna. The system-noise-temperatures were measured as a function of bias current and LO power. Eccosorb material at 300 K/77 K was used as hot/cold source. The optimum LO power (lowest system-noise-temperature) at 118 μm (5 mW) was ten times the optimum power necessary at 214 μm, the optimum bias current were 950 μA and 300 μA, respectively. The system-noise-temperature varied only by a factor of two (12,000 K SSB at 214 μm, 24,000 K at 118 μm).
A possible explanation will be given for the mixing process as an interaction between LO photons and electrons flowing through the diode. With one laser as LO and another laser as signal ($P_{LO} \gg P_{SIG}$), the signal power P_{IF} was measured directly with a spectrum analyzer.
First, the fundamental mixing product $\nu_{IF} = |\nu_{LO} - \nu_{SIG}| = 1$ MHz was generated. Both lasers operated at 214 μm, but shifted slightly in frequency. Second, a higher harmonic signal at 11 GHz $= |2\nu_{LO} - \nu_{SIG}|$ with $\nu_{LO} =$ 693 GHz and $\nu_{SIG} = 1397$ GHz was generated. Third, the function of the lasers as LO and signal were changed. We were able to detect the subharmonic mixing product $|\nu_{LO} - 2\nu_{SIG}|$.
We measured all these mixing products with several diodes of different doping and geometry as a function of bias current. The mixing signals with the exception of the fundamental mixing product showed a strong dependance on the bias current. The extreme case was a sharp dip in the IF signal of more than 20 dB and a 3 dB width of only 30 μA.