Terahertz responsivity enhancement of silicon CMOS transistor-based detectors using a current bias

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***Abstract*— We report on a responsivity enhancement of silicon CMOS transistor-based detectors for terahertz radiation by the application of a source-to-drain bias current.**

I. Introduction and Background

The prospect of terahertz (THz) technologies to be widely used in practical applications strongly depends on the availability of sensitive and cost-efficient detectors operable at room-temperature. It has been reported that rectification of THz radiation by plasma waves excited in the channel of field effect transistor [1,2] presents basis for a new family of practical detectors.

Based entirely on field effect, the operation principle allows efficient detection at frequencies well above the transistor cut-off frequency. Recently, we have shown that rectification in non-resonant approximation ($\omega\cdot\tau \ll 1$) can be understood as distributed resistive self-mixing allowing a rational design of transistor detectors, using common circuit design tools even without rigorous treatment of plasma-wave-related physics in the transistor channel [3].

II. Results

The transistor-based THz detectors were fabricated at IHP Microelectronics GmbH, Frankfurt (Oder), Germany, using the CMOS part of the 0.25 µm BiCMOS SG25H technology. The characterization and application of the FPA to multipixel imaging has recently been reported for both direct detection [4,5] and heterodyne dectection [6]. The detectors were also characterized as voltage or current detector regimes.

Here, we discuss the enhancement of the detector responsivity by applying a DC current across the transistor channel. The literature reports such enhancement in high-electron-mobility transistors (HEMTs) where the current bias was explained to realize the resonant conditions for carrier density oscillations [7]. In Fig. 1 we provide experimental data for our Si CMOS devices showing, that current biasing also results in a substantial increase in detector responsivity even for transistors where plasmonic resonances are ruled out due to the comparatively long channel length and low carrier mobility. We show that, almost independent of the gate-to-source bias, the detector responsivity can be increased about tenfold. In the same way as for HEMTs [7], our results can be explained analytically using a hydrodynamic transistor channel model with appropriate boundary conditions. We also provide an analytical estimate of the nonequilibrium thermal noise showing that the minimum noise-equivalent-power (NEP) for Si-CMOS transistor detectors can be reduced by at least a factor of three compared with the unbiased detectors. Experimental noise characterization measurements are undergoing and will be presented at the conference.

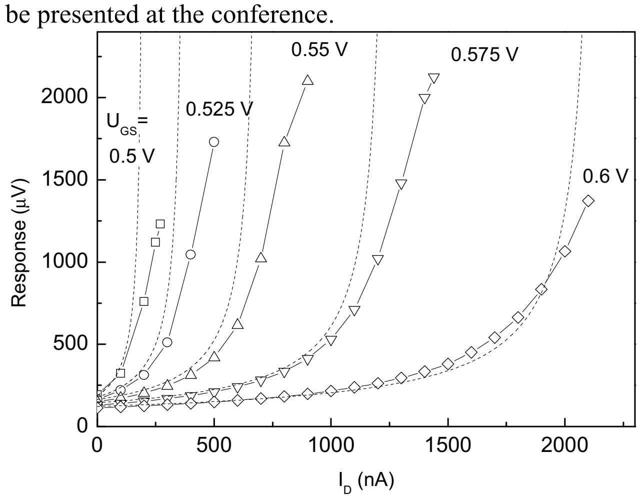

Fig. 1. Experimental data (symbols) showing current bias dependent response to 600 GHz radiation. The dashed lines result from analytic calculations.

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