Design of a dual-resonant TeraFET detector for sub-harmonic heterodyne detection

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For a number of emerging applications of THz photonics, e.g. holographic imaging [1], environmental monitoring, radar-like ranging and future communication (6G, 7G…), coherent detection is either mandatory, because it provides phase information, or at least desirable because of the better sensitivity compared with direct detection. However, the system cost increases and the systems become more complicated as a (usually powerful) reference signal is necessary. Furthermore, implementing coherent receiver arrays remains to be a tremendous technical difficulty.

Working with coherent detection in the sub-1-THz frequency range, one of the challenges is that the radiation power provided by the available sources usually decreases with increasing frequency. It is hence often advantageous to work in a sub-harmonic mixer configuration, where the frequency of the reference beam (local oscillator (LO) beam) is a unit fraction of the frequency of the signal beam. But then, the detector should be optimized for both the signal and the LO frequency. Here, we present a Si CMOS-based TeraFET detector with an on-chip antenna, which operates with high responsivity at two frequency bands, around 300 GHz for the LO and 600 GHz for the signal. The detector's antenna is a combination of a 600-GHz monopole slot antenna and a 300-GHz patch antenna. This mixed antenna design allows the signal and LO beams to be coupled onto the detector from different sides, which in return results in a more compact measurement setup since a beam combiner is avoided. Fig. 1 shows the simulated performances of detectors optimized for 590 GHz, 600 GHz and 614 GHz. An improvement of the responsivity by 7 dB, respectively of the NEP by 21 dB over a bow-tie antenna is found.

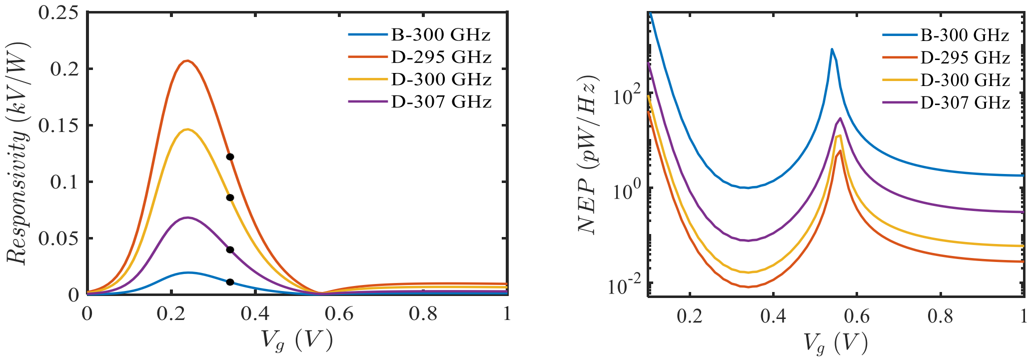

Figure 1: Comparison of responsivity and NEP achieved with TeraFETs with the novel dual-resonant antenna (marked by "D") in comparison with a standard bow-tie antenna (marked by B"). The dots in the left plot mark the gate voltage V_g where the NEP value is minimal.

Reference:

[1] G. Valušis, A. Lisauskas, H. Yuan, W. Knap and H. G. Roskos, *Roadmap of terahertz imaging 2021*, Sensors **21**, 4092 (2021).