Multipolar Terahertz Antennas

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***Abstract*— Continuous-wave photonics-based THz sources present limited output power due to the restricted input optical power accepted by photomixers. Here, we investigate multipolar antenna design to increase the available THz output power by increasing the number of photomixers. Simulations of 4 to 8 dipole arms antennas are conducted, showing an improvement of antenna gain in comparison to standard dipole antennas, additionally to a potential increase of the THz power for photo-mixing applications.**

THE recent progress on THz communications accelerated by photonic technologies [1] lead to a possible integration of THz devices in the next-generation communication systems (6G). However, as photonic-based Continuous-Wave (CW) THz sources are concerned, the output power is limited [2] and the coherence (spatial, temporal and polarization) is not sufficient to ensure sufficient signal-to-noise at reception for successful high-data-rate communications.

Among the possible coherent sources, we proposed the use of a Dual-Frequency Vertical-external-Cavity Surface-Emitting Laser (VeCSEL) based on the coexistence of two transverse modes operating around 1064 nm [3], and demonstrated coherent and tunable THz emission using two kinds of photomixers, either a commercial Uni-Travelling Carrier Photodiodes [4] or a plasmonic-based photoconductive antenna [5].

In this work, we propose a solution to improve the THz output power by taking advantage of the transverse structuration of the laser modes described in [3]. The idea is to collect all the optical beating spots available in the transverse Laguerre-Gauss modes of the dual-frequency VeCSEL based on dual transverse modes operation.

To this end, we designed MultiPolar Antennas (MPA) at 100 GHz as a proof-of-concept, as proposed in [6] but with the objective to match with the specific dual-frequency VeCSEL optical excitation. Fig. 1 shows the design of 2 crossed dipoles on a conventional high-resistivity Si-lens, showing that adaptation can be achieved thanks to simulations realized using CST Studio suite. We will show how adaptation becomes challenging as the number of dipole arms increases, and show the effect of the polarity of each dipole arms. Indeed, polarity should alternate between each neighboring arm to match with the situation of optical transverse mode excitation.

The far-field and corresponding gain were calculated for the different configurations, showing that a higher gain can be obtained in comparison to standard dipole antennas (8 dBi versus 2.2 dBi). We will discuss about the possible compromises in terms of adaptation, gain and bandwidth of different kinds of multipolar antenna designs using 2 to 4 dipoles, for various possible excitation polarities.

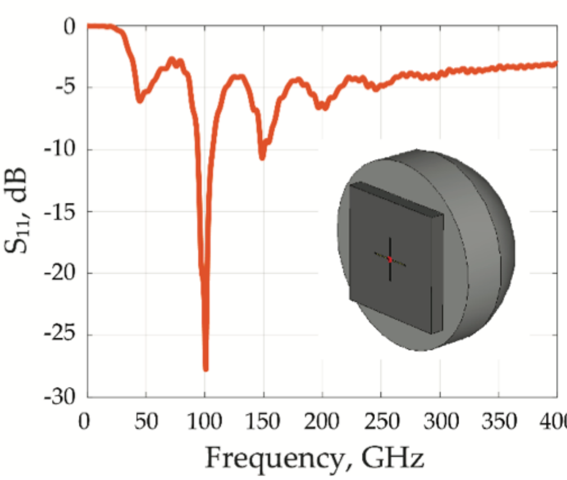

Fig. 1. Multipolar antenna based on 2 crossed dipoles designed at 100 GHz. Simulated S_{11} parameters shows that antenna adaptation can be verified for adequate antenna design. The inset shows an overview of the design the antenna mounted on a high-resistivity-Silicon Hyper-hemispherical lens.

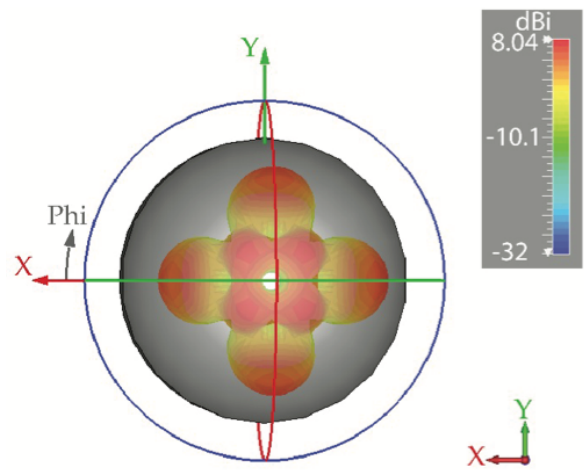

Fig. 2. Far-field pattern simulation for the multipolar antenna based on 2 crossed dipoles designed at 100 GHz. The maximum realized gain is 8 dBi.

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