Terahertz Array Beamforming Using Low-Voltage Graphene-Modulators

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Abstract:
The terahertz band (0.1-10 THz) is a vastly unused segment of the spectrum, set to be used by future 6G communications, for its super high transmission speeds. Not only that, but radiation in the below infra-red band is also finding more uses in various applications, such as sensing and medical, where THz may enable innovative solutions. However, technology for this part of the spectrum is still in its infant stages of development. From emitters, to receivers, signal generators, antennas, the devices aren't yet matured or even realized. In this work we present a 4x2 antenna array, whose diagram is controlled via graphene modulators, designed having in mind a fabrication process available for 8 inch wafers. Chemical potentials of 0.1 to 0.4 eV are used, which corresponds to maximum bias tensions of 5 V, that should be more easily implemented with conventional electronics. This allows a comprehensive diagram control, reaching 360 degrees of reach in Phi, and at least 15 degrees in theta (Figure 1). Theoretically, a plasmonic array with graphene modulators could use graphene radiators to achieve incredible size reduction. In practice, graphene will not have enough efficiency to serve as a useful radiator, and metallic radiators should serve as the main emitting elements (Figure 2). This means a compromise between array dimensions and radiation efficiency, as the metallic elements do not support the plasmonic phenomenon at 1 THz. Additionally, graphene on-chip electronics implementation in the micro and nanometer range presents several other challenges. Adding additional graphene elements besides the modulators may also not be feasible with current available fabrication processes and measuring capabilities, or even in a functional sense.
Some planned-for-fabrication devices are presented. Their architecture was designed to facilitate measurements in probe-less THz measurement ranges. The fabrication masks are ready, and the devices should be relatively simple to fabricate.
Keywords: antenna arrays, beamforming, graphene, nano-devices, THz measurements

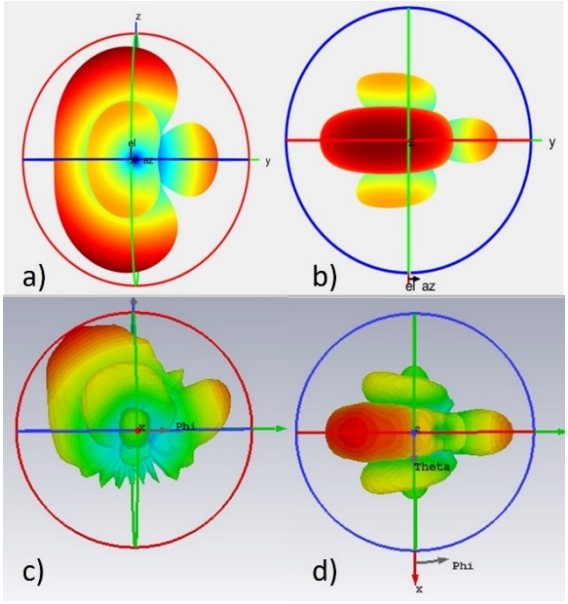

Figure 1: Array factor designed to point at Phi = 270 and Theta = 15, and the simulated results. A) and b) represent the array factor, while c) and d) are the corresponding simulated radiation diagrams.

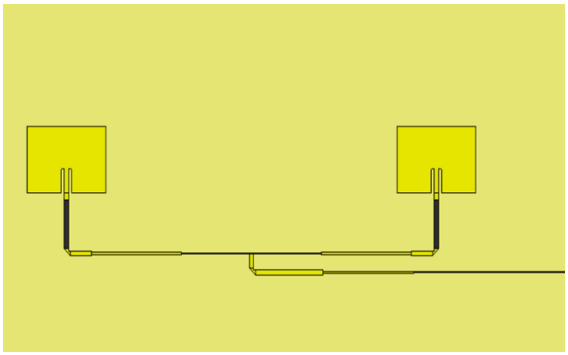

Figure 2: Possible array configuration, showing a feeding network, graphene modulators, and gold patches.

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