Modeling and Optimization of THz Photoconductive Antenna

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Abstract

Terahertz (THz) technology has been receiving expanding interest in the recent years due to its rich scientific and potential application. For instance, a variety of semiconductor phonons resonate in the THz range; macro-biomolecules have unique fingerprint lines in the THz range; less radioactive and non ionizing; provide better temporal resolution compared with RF/microwave and have larger penetration depth compared to IR/visible light, which bears the advantages in the applications of imaging and nondestructive inspection. It has been observed that the output power level of the conventional RF/microwave techniques and optical methods drops sharply down to 10 μW at 1 THz. Therefore, the design of efficient antennas for terahertz wave transmission and receiving become an important concern of the day. Accordingly, the terahertz antenna optimization for maximum conversion into radiation for a specific terahertz antenna design is essential. Here, we simulated the photoconductive antenna (Strip Dipole Antenna, Hertzian Antenna) in terahertz range (0.1-10 THz) and optimize the geometry for the maximum efficiency.
Optimization code: Proposed antenna structure has been optimized using the RF Module of COMSOL Multiphysics®. PCA of gold on superstrate LT-GaAs with Si ball lens is used such that the multi-reflection between the substrate and the lens is minimum and the material for the lens is so chosen that the refractive index of the lens (n~3.4 for Si) is almost the same as that of the substrate. Antenna is excited simply using lumped element and optimized for various parameters. PCA is simulated for a far field domain by applying a perfectly matched layer (thickness ~ n*l_antenna) in the surrounded air sphere with an impedance matching condition on antenna. A user define free tetrahedral mesh with swept in pml is used, where various domains are assigned with different maximum mesh element size, varying from Si ball lens (~ 17.54 μm) to antenna (~ 5 μm). A blue bump appeared in the radiation pattern for optimized structure which shows that the radiation is also emitted across the PCA towards the Si ball lens, in the form of narrow beam. This allows the femtosecond pulse to incident on front side and emit THz pulse on back side of the PCA which reduced the complexity in the THz systems.
Further Study:
The proposed THz antenna design has been verified using Wave Optics Module for the radiation pattern obtained using RF Module. For this optimized geometry, we will look into the dynamics of generated photo-carriers resulting the terahertz radiation pattern.

Figures used in the abstract

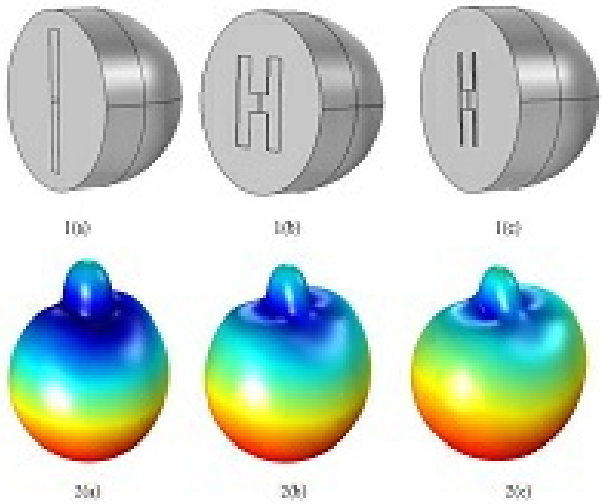

Figure 1: Dipole antenna design (a) Strip dipole antenna, (b) Hertzian dipole antenna structure A in 1(b) & structure B in 1(c). [first row] Corresponding 3d far field radiation pattern [second row, 2(a, b, c)].