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Computational Modeling of Terahertz Photoconductive Antennas Using Finite Element Method.

Mohammad Esmaeil Daraei[1]*, Mehdi Abedi-Varaki[2], and Ignas Nevinskas[1]

[1]Department of Optoelectronics, Center for Physical Sciences and Technology, Saulėtekio av. 3, LT-10257 Vilnius, Lithuania.

[2]Department of Laser Technologies, Center for Physical Sciences and Technology, Savanoriu av. 231, LT-02300 Vilnius, Lithuania.

*Email: esmaeil.daraei@ftmc.lt.

Terahertz (THz) frequencies refer to the region between the microwave (MW) and infrared (IR) bands in the electromagnetic (EM) spectrum, typically between 0.1 to 10 THz [1]. Photoconductive antennas (PCAs) are currently utilized as THz emitters and detectors [2]. A PCA consists of a photo-absorbing substrate (low temperature grown Gallium Arsenide (LT-GaAs) in this study) and a metallic dipole antenna biased with a direct current (DC) voltage that efficiently radiates THz waves. When a short pulse laser is illuminated on the PCA, photons are absorbed in the semiconducting substrates, resulting in electron-hole pairs generation. The electric field, established by an external DC bias between the electrodes, separates the photo-generated electrons and holes. The resulting photocurrent pulse is fed into the antenna, and the electromagnetic pulse radiates into free space. In this study, the finite element method is utilized to address Maxwell's wave equations in conjunction with the coupled drift-diffusion and Poisson's equations. A femtosecond optical pump is applied to activate the photoconductive antenna. The generation of pulsed broadband THz radiation from PCA is achieved by converting the sub-picosecond optical pulse into a transient current within the photoconductive antenna. The parameters for the setup include an incident wavelength of 800 nm, a 5 µm gap between the anode and cathode, a 1 µm air layer above the LT-GaAs, and an anode and cathode thickness of 100 nm each.

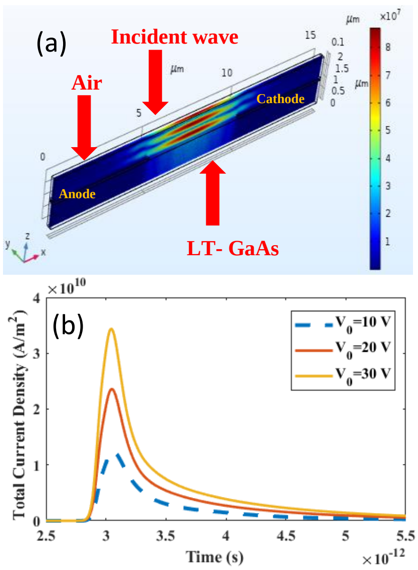

Fig.1. (a) Electric Field, (b) Total current density (A/m^2).

The computational modeling is divided into two steps: (1) calculating the optical response by determining the spatial distribution of the optical field using the frequency-domain form of the electromagnetic wave equation; and (2) determining the electronic response by solving the time-domain forms of the coupled drift-diffusion and Poisson's equations, using carrier generation derived from the optical field obtained in the first step. Simulations are performed for three different bias voltages, and the results are shown in Figure 1.

REFERENCES

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