Polarization-Sensitive Terahertz Detection with Microfabricated Photoconductive Antenna

Dmitry S. Bulgarevich[1], Makoto Watanabe[1], and Mitsuharu Shiwa[1],
Gudrun Niehues[2], Seizi Nishizawa[2,3], and Masahiko Tani[2]

[1]National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki, 305-0047, Japan
[2]Research Center for Development of Far-Infrared Region, 3-9-1 Bunkyo, Fukui 910-8507, Japan
[3]IHI Corporation, 1 Shin-nakahara-cho, Isogo-ku, Yokohama, Japan
DMITRY.Bulgarevich@nims.go.jp

Abstract

Polarization-sensitive terahertz (THz) time-domain spectroscopy (TDS) is a powerful tool for non-destructive evaluation (NDE) of optically anisotropic micro-/nanostructured materials. However, with typical dipole THz-TDS emitter/detector pair, only one component of the electric field (E) vector is measured. This makes it difficult to interpret the obtained images due to the possible transmission and reflection anisotropy of the incident light polarization. Therefore, the ability to detect arbitrary polarization directly is very desirable. Consequently, the THz devices with high sensitivity and straightforward data acquisition/analysis are in need. For this aim, the polarization-sensitive THz photoconductive detector was computer modeled, microfabricated, and tested for its performance as shown in Figs. 1 and 2 [1]. The good results and agreements between simulations and experiments were achieved. With appropriate experimental optical alignments, the angular response of our four-contact detector (4-CD) was very similar to the ideal one (see Fig 2), i.e. it had linear response ($\arctan\left(|E_x|^2/|E_y|^2\right) = \alpha - \phi$) on incident polarization angle (α) of the E. Simple data analysis was also a key point with 4-CD. In principle, such detectors could be used with any THz-TDS system for the NDE of stress, damage, or production-induced optical anisotropy in plastic, fibrous, and crystal materials as well as for the NDE of magneto-optic phenomena in semiconductors.

References

[1] M. Watanabe, D. S. Bulgarevich, and M. Shiwa, Japan Patent Pending 13-MS-044 (2013).

Figures

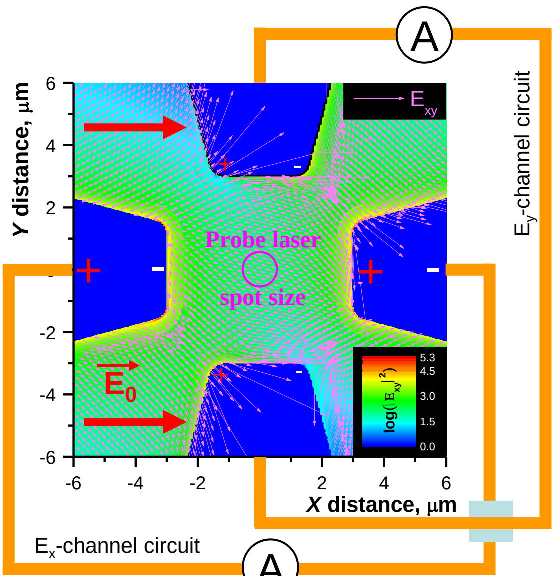

Fig. 1. FDTD simulation results of the source-normalized electric field intensity and vector distributions at the very center of the 4-CD. The broadband THz source with linearly polarized output is behind the picture plane. The schematic instantaneous charges on bowie-tie antenna tips (in blue color), which are generated by incident electric field (red arrows), are also shown to explain the detection principle with two electric circuits.

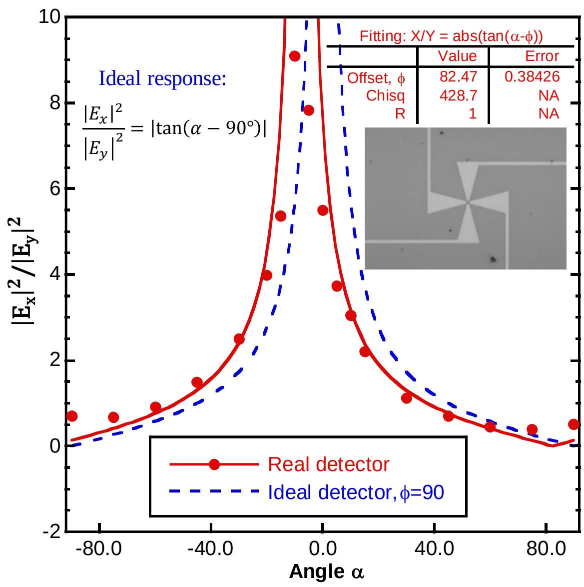

Fig. 2. Comparison between ideal linear angular response and real experimental one with 4-CD. Insert shows the photo of the microfabricated 4-CD on LT-GaAs surface with 70 μm metal bowie-tie flares and lead line electrodes.