Board-band Terahertz Birefringence of Fe-doped Gallium Oxide (Ga_2O_3)

Wang Ke[1], Hao Jiang[1], Chen Gong[1], Hironaru Murakami[1] and Masayoshi Tonouchi[1]
[1]Osaka University
Email: wang-k@ile.osaka-u.ac.jp

Introduction

Wild bandgap (Eg~4.8eV) enables Ga_2O_3 to be expected in applications of optoelectronic field, such as solar cells, transparent electrodes and photocatalysts[1]. In terahertz range, birefringence had been observed by using THz-GSE result[2]. By introducing THz-TDS, we have observed birefringence phenomenon in wilder THz-range. The refractive index of these two axes have shown large difference.

Experiment

In the experiment, our sample was 10×15 mm^2 β-Ga_2O_3(010) crystal, doped by Fe and made by Novel Crystal Technology, Inc. We applied a commercial THz-TDS system (Otsuka Electronics Co., Ltd), with its laser source at 780nm, to study this sample. The polarization of THz and the detector, are highly linear. With certain directions of radiation and detection, we rotated the sample holder for 30° each time and 360° for total. Note that the degree here is a relative degree between sample holder and THz polarization.

Results and discussion

Temporal waveform has separated into two peaks, and we attribute this to birefringence in the crystal. With the rotating of sample holder, amplitude of these two peaks increase and decrease as shown in Figure 1. In our results, we assumed data at 60° and 150° they contain one polarization direction only. By using these data, we have calculated the refractive index of two axes, as shown in Figure 2. For determining the thickness of the crystal, we applied the method proposed by L. Duvillaret et al[3]. Results of both two axes turned to be the same at 494 micrometers.

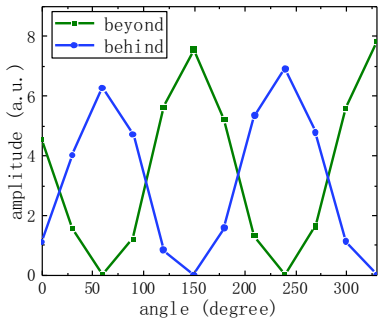

Figure 1. Azimuthal angle. The green line "beyond" means the former peak and the bule line "behind" means the subsequent peak of Ga_2O_3 temporal waveform.

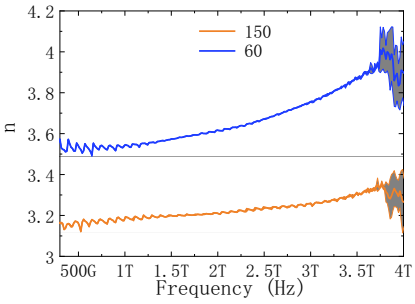

Figure 2. Refractive index of Fe-doped Ga_2O_3(010). The bule line is at 60° and the orange line is at 150°. Shadowed area stands for standard deviation.

Our data is wilder and data up to 3THz is reliable. With frequency increasing, there is a raise of refractive index. We currently attribute this phenomenon to phonon scattering.

Reference

[1]. S. J. Pearton, J. Yang, P. H. Cary, F. Ren, J. Kim, M. J. Tadjer, and M. A. Mastro, Applied Physics Reviews **5**, (2018).
[2]. A. Phys, S. Blair, S. Knight, A. Chanana, V. Darakchieva, M. Stokey, P. Ranga, K. Irmscher, and A. Michael, **252103**, (2020).
[3]. L. Duvillaret, F. Garet, and J.-L. Coutaz, Applied Optics **38**, 409 (1999)