Nondestructive Characterization of Carrier Density and Mobility in β-Ga_2O_3 Using Terahertz Waves

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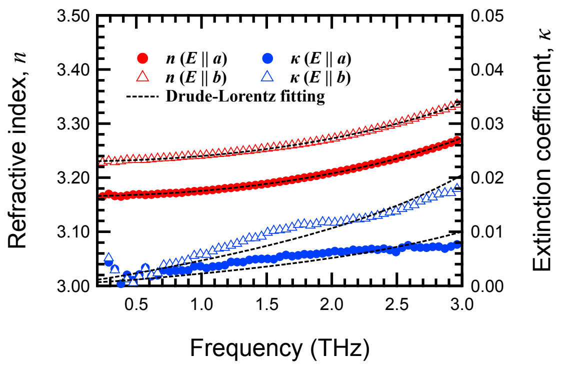
The β-Ga_2O_3 ultrawide-bandgap semiconductor is a promising material for next-generation high-power devices. For the rapid development of device applications, a nondestructive characterization method is highly beneficial. In this study, we employed terahertz time-domain spectroscopy (THz-TDS) to evaluate the electrical properties of a homoepitaxial Si-doped β-Ga_2O_3 film deposited on a semi-insulating c^*-oriented substrate [1]. Transmission THz measurements were performed on the bulk substrate and the epilayer, and their complex refractive index along the *a*- the *b*- axes were then obtained. Figure 1 shows the real (refractive index) and imaginary (extinction coefficient) parts of the complex refractive index of the bulk and the epilayer. For the bulk sample, the gradual increase of the complex refractive index with increasing frequency is attributed to phonons. For the epilayer sample, the rapid increase of the complex refractive index with decreasing frequency is attributed to free carriers. The Drude-Lorentz model is used to describe the optical response that is characterized by free carriers and phonon effects. Using this model, the carrier density and mobility of the epilayer are found to be ~4.6×10^{17} cm^{-3} and ~103 cm^2/Vs, respectively. These results are in good agreement with Hall measurements. But unlike electrical characterization methods, THz-TDS does not require the attachment of metal contacts that damage the sample surface. Therefore, THz-TDS is an attractive technique for the accurate and nondestructive characterization of wide-bandgap semiconductors which would benefit the development of device applications.



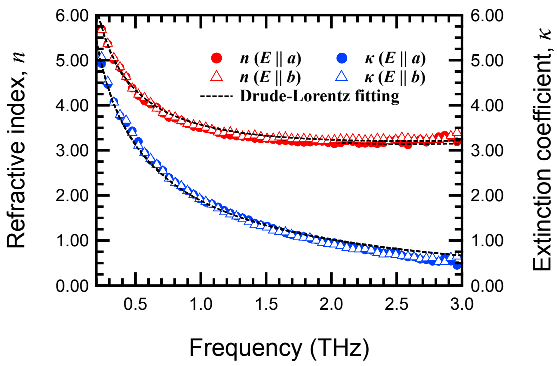


Figure 1. Complex refractive index spectra of β-Ga_2O_3 in the THz region: (left) semi-insulating bulk; (right) doped epilayer.

[1] V.C. Agulto *et al.*, Appl. Phys. Lett. **118** (2021) 042101.