テラヘルツ分光法を用いたリチウムイオン材料の電気伝導の測定及び解析

Terahertz spectroscopy of the electrical conductivity in lithium-ion materials

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Lithium-ion-based batteries are crucial components in portable electronic devices, electric vehicles and new energy systems. The design of high-performance batteries requires a deep understanding of the instinctive electronic properties of lithium-ion nanomaterials. However, because lithium-ion materials are usually powder-based materials, it is difficult to have a direct measurement of the electronic conductivity by conventional probing methods.

In this research, we have performed terahertz spectroscopy[1] for lithium-ion materials to estimate their electrical conductivities. We have mixed lithium-ion material (LCO) with conductive additive carbon powder (AB) and adhesive additive PVDF, and then coated the mixed powder on high-resistivity silicon wafers, as schematically shown in Fig. 1(a). The transmission spectra of the samples were measured with a THz time-domain spectrometer. Figure 1(b) shows the measured transmission averaging in the 0.1 to 0.5 THz band for samples with various AB component. The transmittance at the low-frequency band (0.1-0.5 THz) decreases with the increasing AB component, which is explained by the free electron absorption in the AB material. The black curve in Fig. 1(b) shows the transmission calculated using Drude model by assuming the AB component adds a conductivity of 220 S/mg to the sample. Figure 1(c) shows the measured reflectance spectra for samples of various compositions. As can be seen, LCO has a characteristic reflection peak at the high-frequency band (above >~3 THz), indicating that LCO functions as a dielectric material that causes resonant absorption at the high-frequency band. The obtained results would be useful for understanding the electrical properties of LCO materials.

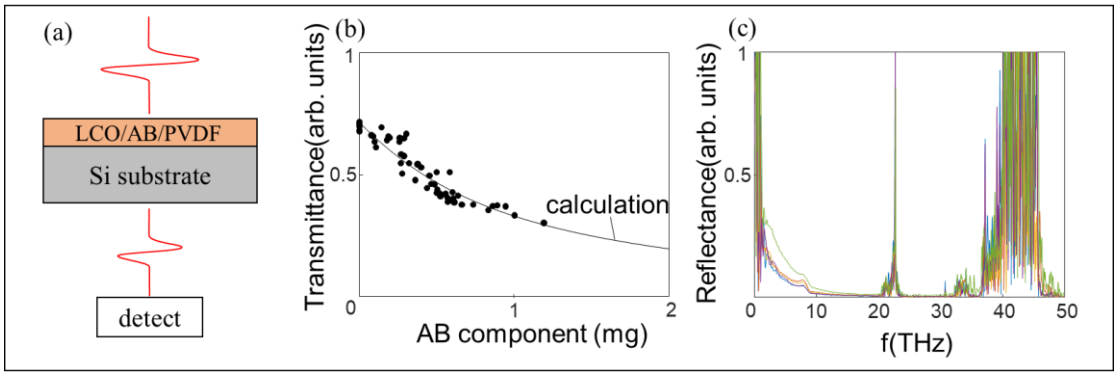

Fig.1:(a) The Sample Schematic Diagram. We have mixed lithium-ion material (LCO) with conductive additive carbon powder (AB) and adhesive additive PVDF, and then coated the mixed powder on high-resistivity silicon wafers. (b) measured transmittance averages in the 0.1 to 0.5 THz band for samples with various AB content and calculated transmittance using conductivity obtained using Drude model. (c) the measured reflectance spectra for samples.

Ref. [1] Lloyd-Hughes, J., Jeon, TI. A Review of the Terahertz Conductivity of Bulk and Nano-Materials. J Infrared Milli Terahz Waves 33, 871–925 (2012).