

Attempts for Intermolecular Phonon Measurement of High Mobility Organic Semiconductors by Terahertz Absorption Spectroscopy

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Intramolecular and intermolecular vibrations are factors that reduce charge carrier mobility in organic semiconductors, and thus transport characteristics in the organic electronic devices are strongly affected by molecular vibrations. Therefore, understanding and controlling of the molecular vibrations are essential for highly efficient organic semiconductor devices. Our group previously elucidated intramolecular vibrational properties on the single crystal pentacene, which is known as a p-type organic semiconductor exhibiting considerable charge carrier mobility, in far- to mid-infrared range at BL6B, UVSOR [1-4]. In this study, we tried to identify intermolecular vibrations, which are predicted to appear in the THz region [5-7], by performing infrared absorption spectroscopy measurements in a lower wavenumber range on the single crystals of representative organic semiconductors dinaphthothienothiophene (DNTT), pentacene (Pn), and rubrene (Rub).

Single crystals of DNTT, Pn, and Rub were prepared by physical vapor transport and were fixed onto diamond substrates. Infrared absorption spectroscopy measurements were performed using a Si bolometer (General Purpose 4.2 K Bolometer, IRLabs, Inc.), a wire grid beam splitter capable of detecting in the 0 - 120 cm^{-1} measurement range, and in a transmission configuration in a high vacuum (10^{-5} Pa) chamber. Measurements were also performed on a diamond substrate without the molecular crystal as a reference sample. For the Fourier transform, the Blackman function was used to correct the integration range.

Figure 1 shows the IR signal intensity through each sample (diamond, DNTT/diamond, Pn/diamond, and Rub/diamond). The intensity dropped sharply below 20 cm^{-1} and above 100 cm^{-1} , indicating that the substantial region in these measurements was 20 – 100 cm^{-1} . From the data shown in Fig. 1, the absorbance of each molecular crystal sample was determined using the Lambert-Beer formula as shown in Fig. 2, where the light intensity transmitted through the diamond substrate without and with the molecular crystals was assigned to I_0 and I , respectively. No peaks were seen in the measured wavenumber region for any of the molecular samples, and thus intermolecular vibrations could not be identified. This may be ascribed to the insufficient transmittance of the THz photon through

the organic semiconductor single crystal samples relative to that through the diamond substrate. Another possible cause is the low intensity of the incident THz light itself.

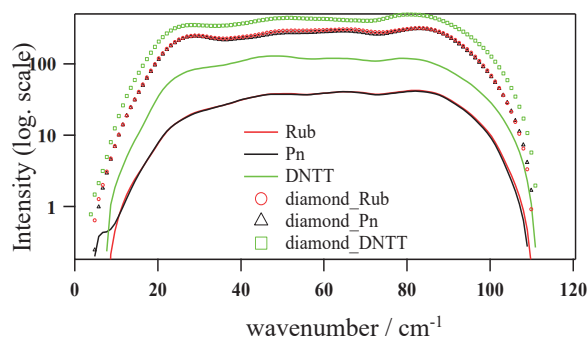


Fig. 1. THz transmission intensity of each sample.

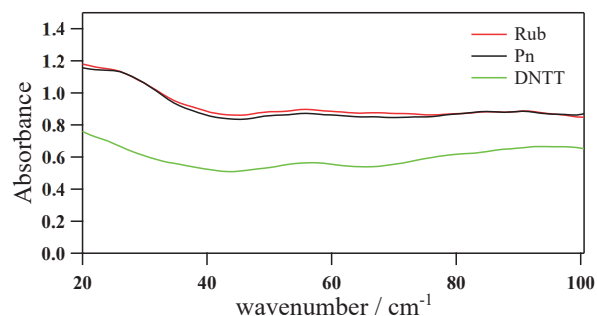


Fig. 2. THz absorbance of each molecular single crystal sample obtained using the Lambert-Beer formula for the transmission signals shown in Fig. 1.

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