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Thermal Conductiviry in the ab-Plane of the Organic Conductor α-(BEDT-TTF)$_2$I$_3$

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In the previous note,[1] members of the present authors reported a jump of the in-plane thermal conductivity $\kappa(T)$ of α-(BEDT-TTF)$_2$I$_3$ observed at the metal-insulator (M-I) transition near 135 K. The authors (and also Henning *et al.*[2]) attributed the jump $\Delta\kappa$ directly to the electronic thermal conductivity component κ_e. In this addendum, we propose a more reasonable separation of the electron and phonon (κ_{ph}) components. The revised estimation of κ_{ph} clearly demonstrates that the phonon velocity v_{ph}, and accordingly the phonon spectrum remarkably change at the M-I transition of this system.

The Wiedemann-Franz law gives an estimation of κ_e as follows,

$$\kappa_e = L_0 \frac{T}{\rho} = 2.45 \times 10^{-8} (\text{Watt ohm/deg}^2) \times \frac{T}{\rho}. \quad (1)$$

In case that ρ is independent of temperature T, κ_e is proportional to T. The electrical resistivity and the thermal conductivity of the metallic phase α-(BEDT-TTF)$_2$I$_3$ in ref. 1 just correspond to this case. With already almost constant κ_{ph} above 80 K we can expect that κ_{ph} is also independent of temperature in the higher temperature metallic region. The κ_e should be estimated by extrapolating linear T dependence of κ to 0 K and $\kappa_e(T)$ is given by the difference between observed $\kappa(T)$ and the intercept of the extrapolated line with the coordinate (0* in Fig. 1) because 0* is the zero point of κ_e. This estimation gives $\kappa_e = 0.47$ mW/cmK and $\kappa_{ph} \cong 0.23$ mW/cmK at 140 K. Thus, in the metallic region, κ_{ph} is reduced to below 1/2 of that of the insulating phase ($\kappa_{ph} \cong 0.56$ mW/cmk). Two mechanisms may be responsible for this reduction of κ_{ph}. One is very strong phonon scattering by electrons in the metallic state and the other is the change of the phonon velocity v_{ph} at the M-I transition. In Fig. 1, we also plotted the κ data due to Henning *et al.*[2] The relatively large κ values of ref. 2 shows an enhancement of κ in metallic region, which suggests that the phonon scattering by electrons is not very strong in this compound. The reduction of $\kappa_{ph} = (1/3)Cv_{ph}^2\tau$ (C = phonon specific heat, τ = phonon scattering time) which is pointed out in this work should mainly be caused by the reduction of v_{ph} in the metallic phase.

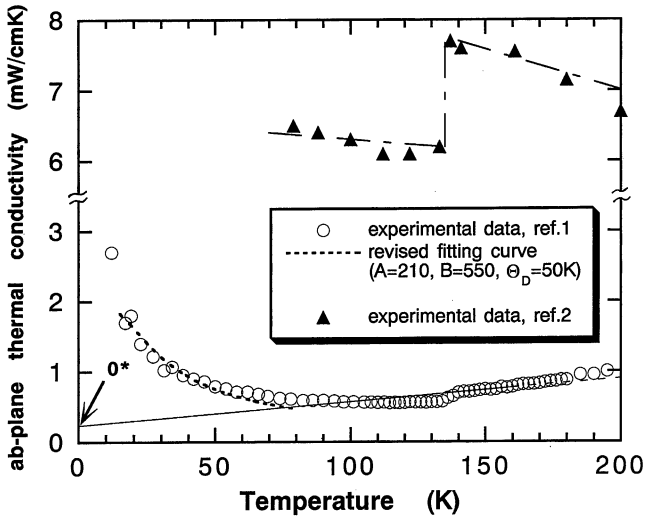

Fig. 1. Thermal conductivity vs. T.[1] Thin straight line is the linear extrapolation of κ from the metallic phase for the estimation of the electron component κ_e. The dotted curve is the revised fitting for the κ_{ph} in the insulator phase. The curve takes account of only the boundary scattering (τ_b^{-1}) and point defect scattering (BT^4x^4) for phonons in contrast to ref. 1. The proposed value of A (mW/cmK) of this work corresponds to the boundary scattering mean free path $\approx$2.5 mm,[3] which is consistent with the sample size ($\approx 2 \times 4$ mm^2 in cross section). The conductivity data of ref. 2 are also shown for comparison. The very strong point defect scattering (large BT^4x^4) for the sample of ref.1 explains the qualitative and quantitative difference of each $\kappa(T)$ behavior. The very small and almost constant κ of ref.1 above 80 K suggests that the phonon mean free path approaches the possible minimum l_{min} ($\approx$lattice spacing) at and above this temperature.

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