Shubnikov-de Haas Oscillations and Fermi Surface of τ-Phase Conductors

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Abstract

τ-phase organic quasi-two-dimensional conductors have a 4-fold single Fermi surface (FS) from band calculation. At low temperature, the resistivity turns into semiconducting, whereas Shubnikov-de Haas oscillations (SdH) have been observed. The SdH signal includes two frequencies that are inconsistent with the band calculation. Recently, we found the superstructure of this salt below 245 K by X-ray study. This result may explain the contradiction between observation and calculation for the FS.

Key words: Fermi surface; Shubnikov-de Haas oscillation; X-ray; superstructure

1. Introduction

Organic τ-phase conductor, τ-(EDO-*S,S*-DMEDT-TTF)$_2$(AuBr$_2$)$_{1+y}$ shows several remarkable phenomena in its transport property [1], and its optical, magnetic, and thermal properties were investigated to understand the ground state of this salt [2]. The conducting layers and insulating layers with the anion composition $y \sim 0.75$ stack along c-axis, alternately. The previous band calculation predicts the existence of the star shape FS for this salt (Inset of Fig.1) [3]. The temperature dependence of the resistivity of this salt is metallic down to about 50 K, and then turns into semiconducting. In spite of the semiconducting behavior in resistivity, we observed SdH oscillations in this salt [4]. The observed SdH oscillation includes two different frequencies that predict the existence of two FS's. They are inconsistent with the band calculation [3]. In this work, we study the high field magnetoresistance and crystal structure by X-ray to examine whether there is superstructure or not.

2. Results and Discussion

High field magnetoresistance was measured for three samples from three several batches. The electrical current and external magnetic field is almost perpendicular to the conducting ab plane. SdH oscillations were observed for all samples (Fig. 1). There are two frequencies in the SdH signal for each sample as previously reported. These are 48.8 T and 476 T (♯9701), 53.2 T and 455 T (♯0107), 50.0 T and 450 T (♯0003), respectively. The frequencies are almost the same for

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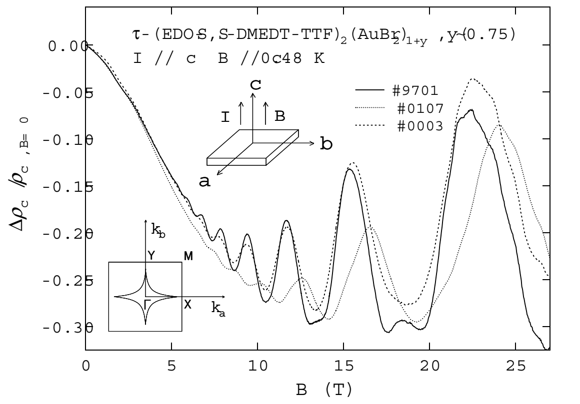

Fig. 1. Shubnikov-de Haas oscillations in τ-(EDO-S,S-DMEDT-TTF$)_2$($AuBr_2)_{1+y}$.

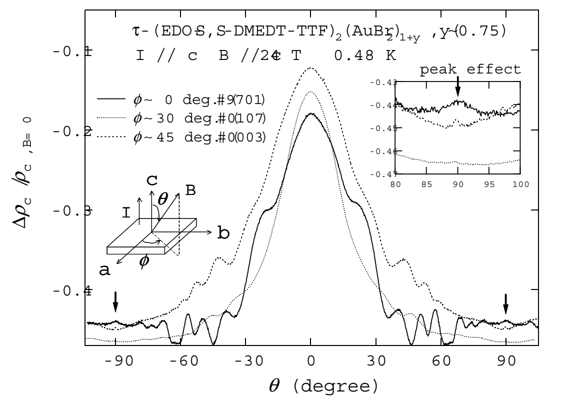

Fig. 2. Angular dependence of the magnetoresistance of τ-(EDO-S,S-DMEDT-TTF$)_2$($AuBr_2)_{1+y}$.

three samples, and small difference may come from the off angle of the sample.

Figure 2 shows the angular dependent magnetoresistance (AMRO) at 24 T. Magnetic field was rotated in three different plane as indicated in the inset of the Fig.2. Some oscillations are seen in the figure, but they are not Kajita-Yamaji oscillation because the peak position changes with the strength of the magnetic field. It is just a SdH oscillation that changes their frequency with the field rotation. For near $B \parallel ab$, peak effect was observed for all samples. On the contrary, other analogous τ-phase conductor, τ-(P-S,S-DMEDT-TTF$)_2$($AuBr_2)_{1+y}$ does not show the effect, that imply the incoherent transport along c-axis of this salt [5].

Recently, we study very high magnetic field magnetoresistance and Hall effect up to 60 T. We observed the beginning of the N=0-state (quantum limit), and flat structure in R_{xy} that reminds us of quantum Hall effect (not shown).

In the present X-ray study, we found the existence of

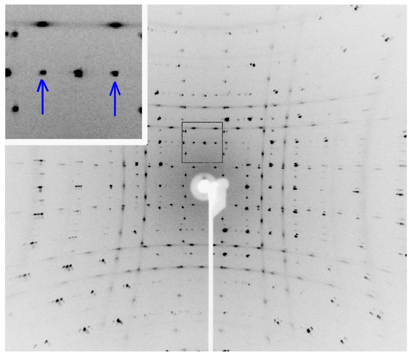

Fig. 3. Diffuse X-ray scattering pattern of τ-(EDO-S,S-DMEDT-TTF$)_2$($AuBr_2)_{1+y}$ at 90 K. Arrows denote the satellite reflections.

two types of two-fold domain consists of $AuBr_2$ anion in insulating layer which cross with 90 degree each other. Futermore, we found clear satellite reflections between the center of the Bragg spots below 245 K (Fig. 3). Because the intensity of the diffise spot from anion shows anomaly at this temperature, conducting layer is coupled with the anion layer. As a result, the lattice of the conducting layer may be considerd to also become two-fold domain, $a \times 2b$ and $2a \times b$. If this is the case, the first Brillouin zone is reconstructed to half, and two FS's will newly appear. This may explain the contradiction between observation and calculation for the FS.

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