Electronic property of the conducting LB film of BEDO-TTF and stearic acid in high magnetic field

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Abstract

The transverse magnetoresistance was measured up to 15 T in the metallic LB films of BEDO-TTF and stearic acid. The negative magnetoresistance shows the existance of the weak localizaion in two-dimensional electronic system (2DES) in these LB films. The magnetoresistance increased linearly with the magnetic field above 3 T, and then exhibited a specific curve associated with 2DES.

Key words: BEDO-TTF; LB film; weak localization

1. Introduction

The Langmuir-Blodgett (LB) film of BEDO-TTF (BO) and fatty acid shows high dc conductivity up to 80 Scm^{-1} at 300 K and metallic temperature dependence down to about 100 K [1,2]. These molecules form a bilayer film at the air-water interface upon the isothermal compression process [3]. The upper and lower layers consist of fatty acid and BO. This bilayer films are deposited as Y-type LB film on the solid substrate with keeping the bilayer structure. The homogeneous conducting layers with closed-packed BO molecules are realized thank to the above mentioned bilayer structure.

The conducting LB film of BO and fatty acid showed the logarithmic temperature dependence of the conductance and the negative magnetoresistance below 20 K [1]. It gives an evidence of the weak localization in two-dimensional electronic system (2DES) in the organic LB film [1,2]. The Thouless length of the LB film is up to about 600 Å at 1.7 K [1].

High-magnetic field transport is interesting in such 2DES. In this paper, we report results of the magnetoresistance of the LB film made of BO and stearic acid (SA) under the magnetic field up to 15 T at different temperatures in transverse magnetoresistance geometry.

2. Experiment

In the preparation of LB films, each chloroform solution of BO and SA was mixed under the 1:1 molar ratio prior to being spread on the pure water surface. After the isothermal compression process, bilayer film of BO and SA is laid down on the sapphire substrate, according to the vertical deposition way with keeping a surface pressure at 20 mN/m. The four-probe method was applied to measure the magnetoresistance. Four gold electrodes separated by 0.5 mm gaps were made by evaporation and chemical etching procedure on the sapphire substrate prior to the deposition of the LB films. Magnetic field was applied perpendicular to the film plane up to 15 T. The measurements were performed using facilities of the Materials Design and Characterization Laboratory, Institute for Solid State Physics, University of Tokyo.

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3. Results and Discussion

Fig. 1 shows the transverse magnetoresistance $\Delta\rho/\rho_0 = [\rho(B) - \rho(0)]/\rho(0)$ at several temperatures. The negative magnetoresistance, coming from the quantum interference of carriers, was observed under 3 T. As shown in Fig. 1, the maximum of the negative magnetoresistance shifts toward lower-magnetic field as decreasing temperature. This behavior shows the formation of a weakly localized two-dimensional system (WL-2DES) [1].

Above 3 T, after the collapse of the quantum interference, the positive classical part increases linearly with increasing the applied field. With decreasing temperature, the magnetoresistance tends to deviate from the linear field dependence. The distinct change of the slope is observed around 8 T at 2.4 K. As shown in Fig. 2, the Thouless length is extended apparently associated with the formation of the 2DES [1]. Therefore, the temperature variation of the transverse magnetoresistance seems to be related to the 2DES. The similar temperature dependence of the magnetoresistance was observed in some BEDT-TTF based quasi-2D conductors [4]. For example, they show the low frequency Shubnikov-de Haas oscillation superposed with magnetic breakdown at high magnetic field. In the present LB film, we have obtained an inelastic scattering time $\tau = 2.6 \times 10^{-13}$ s at 5 K [1]. Following this calculation, we obtain $\omega_c\tau \approx 1$ around 10 T at 2.4 K by using the effective mass of BO compound [5]. According to the value of $\omega_c\tau$, the cyclotron motion may appear above 10 T. Hence, this specific curve at 2.4 K in Fig. 1 may be a precursor of the Shubnikov-de Haas oscillations. Further study will involve high-field magnetoresistance above 15 T at lower temperature.

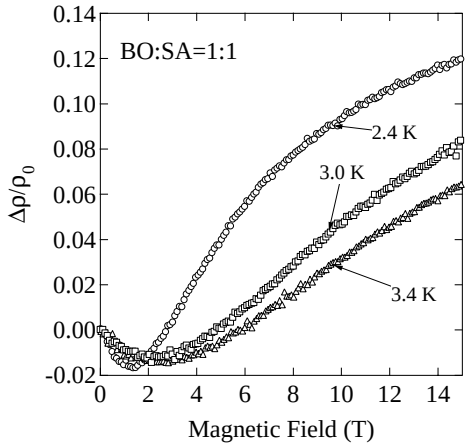

Fig. 1. Transverse magnetoresistance of the LB film of BEDO-TTF and stearic acid at several temperatures.

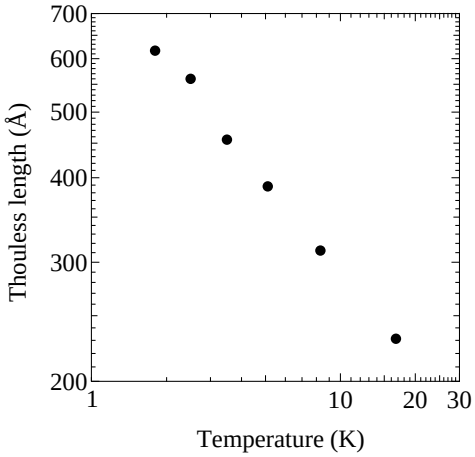

Fig. 2. Temperature dependence of the Thouless length of the LB film of BEDO-TTF and stearic acid at several temperatures.

4. Summary

We measured the transverse magnetoresistance up to 15 T in the metallic LB films of BEDO-TTF and stearic acid. The negative and linear positive magnetoresistance was observed under and above 3 T, respectively. The change was observed in the slope of the positive magnetoresistance, which may be a precursor of the Shubnikov-de Haas oscillations. However, more experiment is necessary to clarify high magnetic field carrier transport.

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