SHUBNIKOV-DE HAAS OSCILLATIONS OF THE QUASI-TWO-DIMENSIONAL ORGANIC CONDUCTOR β–(BEDT-TTF)$_2$I$_3$

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Introduction

Organic superconductor (BEDT-TTF)$_2$I$_3$ in the β_H-state is famous for its remarkably clean electronic structure as evidenced with giant quantum oscillations [1]. Recently, Hanasaki *et al.* carried out successfully the angular magnetoresistance (AMR) study for the β_H-state of -(BEDT-TTF)$_2$I$_3$ under a pressure of 5 kbar and at 1.6 K [2]. Considering that the AMR and the Shubnikov-de Haas (SdH) oscillations are mutually complementary, we launched the study of the SdH oscillations of the β_H-state under pressure by extending the temperature and the magnetic field range from those of Ref. [2]. Under a pressure of 7 kbar, well developed SdH oscillations were observed in the magnetoresistance of the β_H-state of (BEDT-TTF)$_2$I$_3$.

Experimental

Electrical contacts were made with the carbon paste in such a way that the interlayer resistance can be measured. Standard four-probe ac method with a lock-in amplifier was used. Hydrostatic pressure was generated in a miniaturized BeCu clamp cell with the Daphne 7373 oil as pressure medium. Pressure was calibrated to be 7 kbar at low temperature from the shift of superconducting transition temperature of a pure Sn wire. Experiments were performed either in a vacuum loaded He-3 refrigerator (Ewha W. U.) or in a pumped He-3 bath (SCM-2, NHMFL).

Results and Discussion

Figure 1 shows the SdH oscillations of β_H-state of (BEDT-TTF)$_2$I$_3$ in the interlayer resistance under 7 kbar. Two closely placed oscillation of the frequencies 3933 and 3998 T give modulations over a wide range of temperature. The mean frequency of the SdH oscillations increased from 3730 T at 1 bar to 3966 T at 7 kbar, or 6.3 %. But half the separation between the two frequencies decreased from 37 T to 32.8 T, resulting in substantial increase of the ratio, H_0/H_1. The former reflects the compressibility under pressure while the latter suggests that the third dimensional warping is reduced by pressure. Mass plot suggests that the effective mass along the interlayer direction is reduced substantially under pressure while the Dingle temperature is kept low even under pressure. SdH oscillations are dramatically enhanced at the Yamaji magic angles. The fundamental frequency has inverse cosine dependence [3].

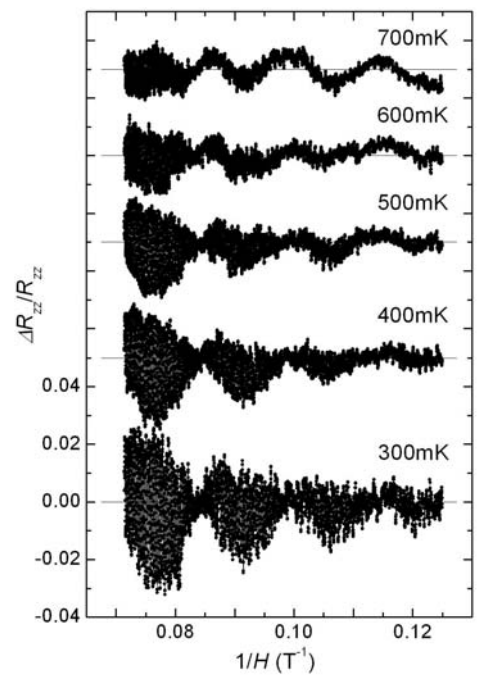

Fig. 1 Normalized oscillatory part of the interlayer magnetoresistance of β-(BEDT-TTF)$_2$I$_3$ at various temperature values. Data are vertically offset for clarity. Between two nodes, there are about 60 fast oscillations.

Conclusions

SdH oscillations can be observed only at temperatures lower than that used in the previous AMR study, 1.6 K [2]. SdH frequency, hence the cross sectional area of the FS increases by 6.3 %, but the warping amplitude decreases by 11 %. The pressure does not only increase the FS cross section but also decrease the interlayer charge transfer integral rendering the electron system more two-dimensional. We confirm once more that the Yamaji oscillations persist to higher temperature where all the SdH oscillations attenuate completely. The Q2D nature of the FS remains intact at least until 7 kbar, but the warping along the interlayer direction is significantly reduced with pressure.

References

[1] Kang, W., *et al*., Phys. Rev. Lett., **62**, 2559-2562 (1989).
[2] Hanasaki, N., *et al*., Phys. Rev. B, 57, 1336 (1998).
[3] Kang, W., *et al*., J. Korean Phys. Soc., to be published.