Negative Magnetoresistance and Magnetic-Field-Induced Insulator-Metal Transition in λ-Type BETS Salts

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The Mott transition has been one of the important research subjects in condensed matter physics because various attractive phenomena emerge in the vicinity of the Mott boundary. In some organic conductors, the Mott transition is induced by applying pressure or chemical substitution. On the other hand, magnetic field effects on the Mott transition have also been of interest. It has been suggested that the effects of the magnetic field on the Mott transition are closely related to the magnetism of the adjacent insulating state.

λ-$(BETS)_2GaCl_4$, where BETS is bis(ethylenedithio)tetraselenafulvalene, is a quasi-two-dimensional organic conductor which shows a superconducting transition at 5.5 K. In the donor layers, two BETS molecules form a dimer structure, and the π electron system forms an effective half-filled electronic state. By exchanging Cl atoms in the anion for Br atoms [λ-$(BETS)_2GaBr_xCl_{4-x}$], the ground state changes to an insulating state at around $x \sim 0.75$ due to the negative chemical pressure effect suggesting that the Mott boundary exists around $x \sim 0.75$ [1]. Because magnetic susceptibility and NMR measurements indicated that the magnetic insulating state adjacent to the Mott boundary is not a conventional antiferromagnetic state, unconventional magnetic field effects on the Mott transition may appear in λ-$(BETS)_2GaBr_xCl_{4-x}$ [1,2].

To explore the magnetic field effects on the Mott transition, we measured the magnetic field dependence of the electrical resistance of λ-$(BETS)_2GaBr_xCl_{4-x}$ ($0.65 \leq x \leq 0.9$) which is situated near the Mott boundary up to 50 T using pulse magnetic fields. Figure 1(a) shows the temperature dependence of the electrical resistance of λ-$(BETS)_2GaBr_{0.75}Cl_{3.25}$. The electrical resistance shows an abrupt drop in a narrow temperature range around 20 K, suggesting that λ-$(BETS)_2GaBr_{0.75}Cl_{3.25}$ crosses the Mott boundary. Figure 1(b) shows the magnetic field dependence of the electrical resistance. A large negative magnetoresistance is observed below 30 K where the electronic state is close to the Mott boundary. Furthermore, a discontinuous decrease in magnetoresistance is observed at low temperatures (indicated by arrows). These results suggest that the magnetic field stabilizes the metallic state and induces an insulator-to-metal-type Mott transition. In the symposium, we will discuss the magnetic field effects on the Mott transition in λ-$(BETS)_2GaBr_xCl_{4-x}$ in detail, presenting the results of magnetoresistance measurements performed over a wide Br content range.

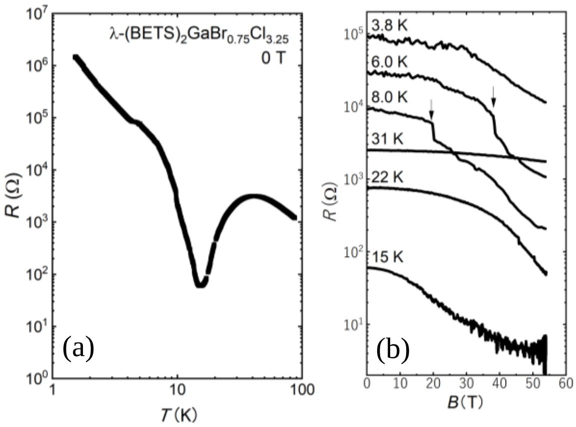

Fig. 1. (a) Temperature and (b) magnetic field dependence of the electrical resistance of λ-$(BETS)_2GaBr_{0.75}Cl_{3.25}$.

References

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