Multiband charge conduction in the metallic valance bond state of $IrTe_2$

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Introduction

Multiple orbital degeneracy and its coupling to charge, spin, and lattice degrees of freedom often lead to intriguing electronic phases with various types of dimerization, which is often referred to as valence bond states. $IrTe_2$ is a recent candidate of valence bond solids, which uniquely shows metallicity and two different types of dimerization transitions at T_{s1}~ 280 K (1/5-type) and T_{s2} ~ 180 K (1/8-type). Due to these dimerization structures across the layers, a two-dimensional electronic system is induced across the layers, which has never been observed in other layered materials. Therefore, $IrTe_2$ offers a model system to investigate how itinerant electrons couple to the underlying complex dimer patterns and how such a coupling induces an intriguing electrical properties.

Experimental

Single crystals of $IrTe_2$ were grown by flux methods. X-ray diffraction and energy dispersive spectroscopy confirm the high crystallinity and also the right stoichiometry. The field dependent Hall resistivity was measured up to 14 T using PPMS at POSTECH and up to 18 T using a superconducting magnet at NHMFL, Tallahassee.

Results and Discussion

The abrupt change associated with the phase transitions are confirmed by field-dependent Hall resistivity, as shown in Fig. 1. With decreasing temperature, the absolute value of Hall resistivity shows weak temperature dependence, but the linear tendency is gradually bent. The pronounced non-linearity of $\rho_{xy}(H)$ suggests that electron-type carriers contribute significantly in the charge conduction, which is consistent with the fact that the appearance of electron pockets in the reconstructed Fermi surface. For quantitative analysis, we employed the two band model to fit the obtained $\rho_{xy}(H)$ data, which provide the temperature dependent densities and mobilities for both electron-type and hole-type carriers. We found that the hole carrier density near T_{s1} is significantly suppressed, while its mobility is enhanced. At T_{s2}, however, carrier densities for both electrons and holes remain unchanged, but the hole mobility drops suddenly. These contrasting behaviors at T_{s1}~ 280 K (1/5-type) and T_{s2} ~ 180 K (1/8-type) suggest different changes in the charge conduction.

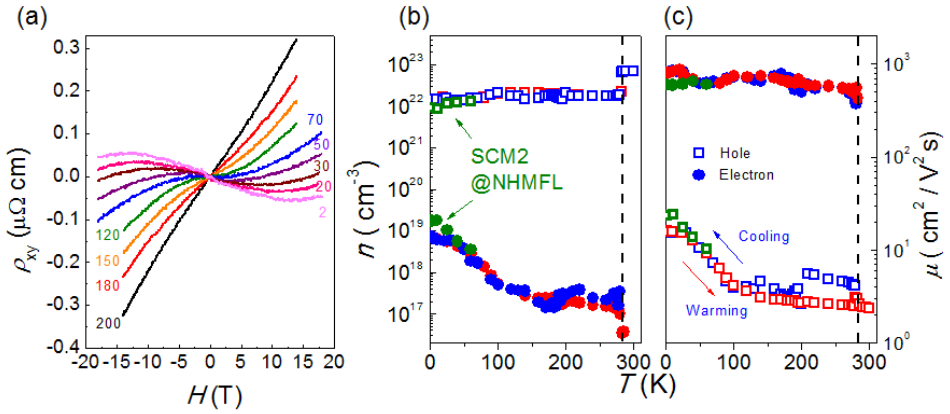

Fig.1 (a) Magnetic field dependent Hall resistivity below T_{S1}~280 K, Temperature dependent (b) densities and (c) mobilities for both electron-type and hole-type carriers.

Conclusions

Through the 1/5-type transition at T_{s1}, the Fermi surface reconstruction from a large 3D FS to many 2D FSs induces two band conductions. The enhanced hole mobility, in spite of occurrence of domain wall between two different stripe domains, is consistent with formation of the cross-layer metallic state. In contrast, for 1/8-type transition, the FS is reconstructed once again, still keeping 2D-states and two band character but with larger scattering across the domain wall. These results can be attributed to formation of mixed dimerization domains with different sequence as observed in scanning tunneling microscopy.

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