Non-linear conductivity in SDW phase of $(TMTSF)_2ClO_4$

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In the quench-induced SDW phase of $(TMTSF)_2ClO_4$, increase of the longitudinal conductivity with the threshold and narrow band voltage noise in the non-ohmic regime are observed. The spin density wave slides and contributes to the electric conduction.

The SDW phase is induced below 6K, in $(TMTSF)_2ClO_4$ in zero magnetic field by rapid quenching through the anion ordering temperature 22K.[1] We measured the electrical conductance along the a-axis as functions of both electric field and temperature. Both dc and pulse methods were used. Samples were cooled in helium atmosphere down to 80K in 3-4 days to avoid micro-cracks and associated complicated problems of inhomogeneous electric field within the crystal. On further cooling, samples were quenched into liquid helium with the rate 100K/sec, after prolonged holding at 40K.

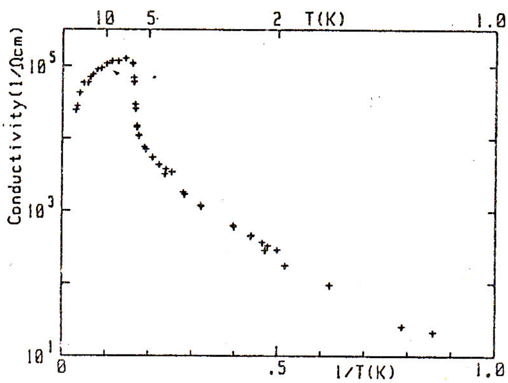

Fig.1 Ohmic conductance of $(TMTSF)_2ClO_4$

From the ohmic conductance shown in Fig.1, the SDW transition temperature T_N and the SDW gap 2<> are given as 5.7K and 17K, respectively. The ratio $2<>/T_N=3$ is close to the BCS value of 3.5; the one-dimensional fluctuation is hardly observed. The ratio R(300K)/R(4K)= 200 is smaller than 750 in $(TMTSF)_2NO_3$ [2], probably because of anion disorder.

Figure 2 shows the excess conductivity normalized by the ohmic value. The onset of the conductivity increase is sharp enough to determine the threshold field E_T. Only near 4K, the conductivity is slightly rounded. Figure 3 shows E_T as the fun

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ction of temperature. It shows the monotonous increase with temperature in the range $(1/4 - 3/4)/T_N$. Maki and Virosztek[3] pointed out that the phase fluctuation has little effect on the depinning of the SDW systems of low T_N and large coherence length and that E_T in SDW increases monotonously with temperature and is practically constant below $0.5T_N$. Qualitatively, our results are in agreement with their prediction and with experimental results by Tomic et al.[2], who found that E_T in $(TMTSF)_2NO_3$ is tempera ture independent at $T/T_N < 0.5$. On the other hand, we have obser ved that E_T shows gradual but significant decrease with lowering temperature even for $T/T_N < 0.5$.

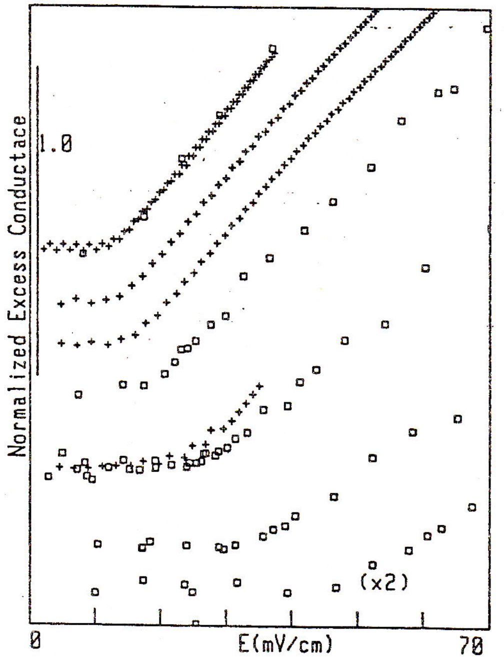

Fig.2 Normalized excess conductivity
Temperature(from the top): 1.5K, 1.7K, 1.9K, 2.5K, 3.0K, 3.5K, 4.2K

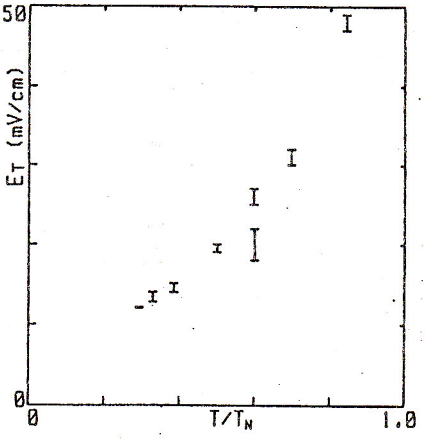

Fig.3 Threshold electric field for the conductivity (cross;DC, square;pulse)

Narrow band voltage noise was observed at 1.2K under DC current bias larger than the threshold value for non-ohmic condu ctivity. Figure 4 shows the voltage noise spectra.

The noise power of the narrow band component is much lower than that observed in typical CDW systems. No broad band noise has been detected. The noise frequency increases linearly with the excess current as shown in Fig.5. From its slope and assumption of the uniform current density, the characteristic length of the pinning potential much smaller than the SDW wave length is found; the SDW current density is highly non-uniform because of the large conductivity anisotropy. Though still qualitative, the observation of narrow band noise in the non-ohmic regime provides the concrete evidence that the SDW slides and contributes to the electric conduction.

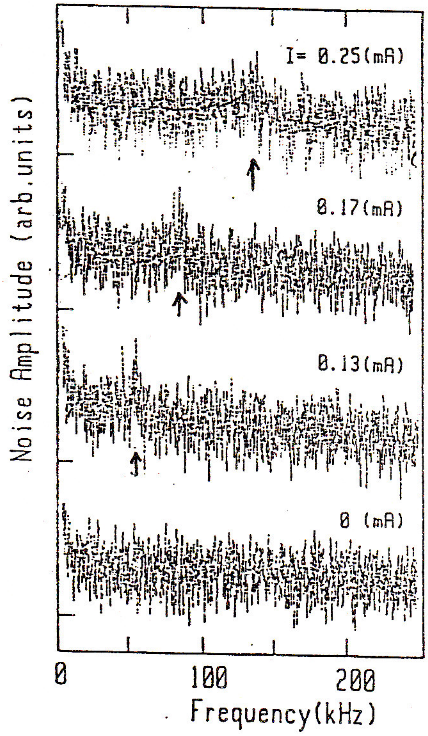

Fig.4 Voltage noise spectra

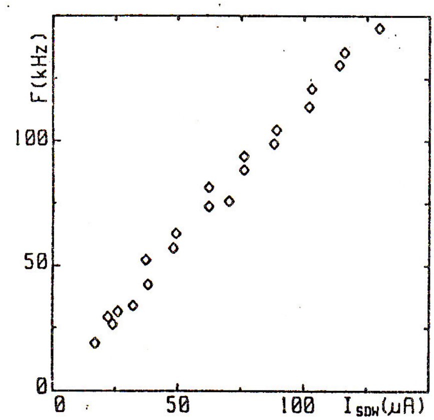

Fig.5 Noise frequency vs. excess current

At lower temperature below 2K, hysteresis and switching are observed in the current-voltage relation. Rich variety of pheno mena due to metastability are expected in the field of SDW as well as CDW dynamics.

Acknowledgment

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