Nonlinear I-V characteristics in α-(BEDT-TTF)$_2$I$_3$

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A two-dimensional (2D) organic conductor α-(BEDT-TTF)$_2$I$_3$ is well known as a charge ordered (CO) system. In a few two dimensional CO systems, strong non-linear I-V characteristics (power law behavior $I \sim V^{\alpha}$) have been observed in high voltage regions.[1] In order to investigate the universal I-V behavior in 2D CO systems, we have measured I-V characteristics at various temperatures in a wide electric field region for α-(BEDT-TTF)$_2$I$_3$. The temperature dependence of the inplane resistance in α-(BEDT-TTF)$_2$I$_3$ shows thermal activation type $\sigma=\sigma_0\exp(-\Delta/2k_BT)$ with Δ=660 K below 70 K for low bias voltage (in linear I-V region). The carriers are expected to be thermally excited electron-hole pairs. When the electrical flux between the excited hole and electron is well confined in the 2D layer, the Coulomb potential between them is approximately given by $U_o\ln(r/a)$, where r is the electron-hole distance, and a is the minimum length, which should be comparable to the size of BEDT-TTF molecule. In a large r region, we assume constant potential $U_o\ln(\lambda/a)$ for $r>\lambda$, where λ is the cut-off length. The factor U_0 depends on the dielectric constants of the BEDT-TTF and I$_3$ layers. Since the maximum Coulomb potential between the excited electron and hole is written as $\Delta(E)=U_o[\ln(U_o/aeE)-1]$ for high electric field E, we get the power law $I \sim E^{\alpha}$ and $\alpha=U_o/2k_BT+1$ whereas $\alpha=1$ for low E. Figure 1 shows the experimental results and the simulations. We see power law behavior in the high V region at low temperatures. The simulations are made for $U_o/2k_B$=165 K, a=0.5nm, λ=120nm and the voltage contact spacing d=40 μm. The experimental results are well reproduced except for T=15 and 20 K. It may be due to quantum tunneling effect. The magnetic field effect on the nonlinear I-V characteristics will be also presented.

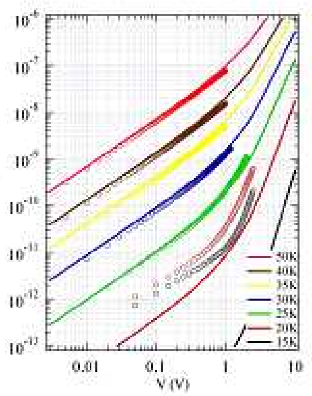

Fig. 1. Experimental results (circles) and simulations (solid curves) of I-V characteristics.

[1] Y. Takahide *et al.*, Phys. Rev. Lett. **96** (2006) 136602