Theory of I-V Characteristics for Two-Dimensional Charge-Ordered Electron Systems at Quarter Filling

Yasuhiro Tanaka[1] and Kenji Yonemitsu[1,2]
[1]*Institute for Molecular Science, Okazaki, Japan*
[2]*Graduate University for Advanced Studies, Okazaki, Japan*
Email: yasuhiro@ims.ac.jp

The current-voltage characteristics and charge distribution for two-dimensional quarter-filled charge-ordered electron systems under applied bias voltages (V) are investigated theoretically by using nonequilibrium Green's functions. Nonlinear conductions have recently been observed in organic conductors such as θ-(BEDT-TTF)$_2$CsCo(SCN)$_4$[1] and β-(*meso*-DMBEDT-TTF)$_2$PF$_6$[2]. In these compounds, charge-ordered high-resistive states switch into conductive ones by an electric field, which suggests current-induced melting of the charge-order.

In order to clarify the mechanism of the phenomena, we consider an extended Hubbard model with long-range Coulomb interactions mainly on the square lattice attached to metallic electrodes, the effects of which are incorporated into the self-energy. We apply the Hartree approximation to the model whose parameters are chosen so as to obtain a checkerboard charge order in the absence of bias V. In the self-consistent calculations with finite bias V, electron density and the scalar potential that satisfies the Poisson equation with a suitable boundary condition are obtained according to ref. [3].

It is found that there is a first-order transition from the charge-ordered high-resistive state to a conductive state with increasing bias V. In the former phase, charge distribution is almost unchanged compared with that of the equilibrium state, whereas it is essentially uniform in the latter phase. We will also consider the anisotropic triangular lattice in order to discuss the nonlinear conduction in θ-type organic conductors where different charge-orders compete with each other.

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