Non-ohmic electrical transport in the Peierls-Mott state of deuterated copper-DCNQI systems

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Abstract

Electric-field-dependent measurements are reported in the low-temperature state of the organic conductors Cu[2,5(CH3)2-DCNQI]2 and Cu[(2,5(CH3)2)-DCNQI]0.70(2,5(CH3)2-DCNQI)0.30]2 with N=3 commensurate CDW. We correlate observed features of the electric conduction below and above threshold field with the temperature evolution of the N=3 CDW order as detected by the low-frequency dielectric measurements.

Keywords: Transport measurements, Metal-insulator phase transitions, Organic conductors

We have used DC electrical transport measurements in order to investigate N=3 CDW in the Peierls-Mott insulating state of two systems: (a) the fully deuterated system Cu[2,5(CH3)2-DCNQI]2 (abbreviated as d8) and (b) the partially deuterated system, that is, the alloy Cu[(2,5(CH3)2)-DCNQI]0.70(2,5(CH3)2-DCNQI)0.30]2 (abbreviated as h8/d8 70%-30%). We have already reported the low-frequency dielectric response of these materials. Our results gave a clear evidence of a collective mode contribution to the dielectric properties in the insulating state [1].

Nonlinear conductivity measurements were made at increasing temperatures until T_{C1\text{Warm}} was reached, after the sample was cooled from 100 K through the M-I transition at T_{C1\text{Cool}} down to 35 K (see Fig. 1). T_{C1\text{Warm}} ≈ 80 K and 55.6 K and T_{C1\text{Cool}} ≈ 77 K and 47 K for the d8 and the h8/d8 70%-30% system, respectively. The respective hysteretic regions, in which cooling and warming R vs. T traces differ, are situated between 70 K - T_{C1\text{Warm}} and 40 K - T_{C1\text{Warm}}, respectively. In Fig. 2, we show the ohmic conductivity and non-ohmic conductivity at twice the threshold field, for the d8 system. The preferred choice for the fit (full lines) was Mott’s variable range hopping (VRH) formula, which applies when the dominant conduction mechanism becomes the conduction by the carriers localized on impurities. This behavior and the T-independent behavior of the mean relax-

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Fig. 1. Normalized resistance vs. temperature for both systems.
55 K and 75 K and starts to increase at lower temperature (Fig. 4(a)). For the $d_{x^2}$ system the same behavior in commensurate SDW of $\kappa$-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Cl [2]. A common aspect of these two systems is a domain structure of DW ground state [3]. On the other hand, for a DW in an incommensurate structure a rise of $E_T$ followed by a disappearance of the nonlinear effect, once the free-electron screening becomes ineffective, would be expected. Indeed, we have observed such a behavior in N=4 CDW of DCNQI-Li system [4].

References