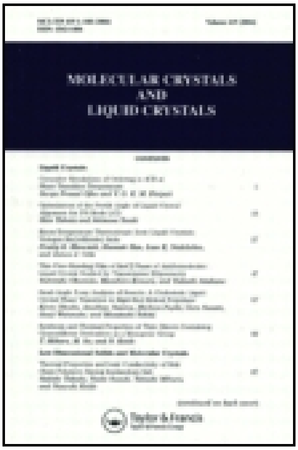

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Hysteresis And Charge Density Wave Transport In The Blue Bronzes

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HYSTERESIS AND CHARGE DENSITY WAVE TRANSPORT IN THE BLUE BRONZES

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Abstract We report the observation of a dependence of the low field resistance of blue bronzes on the electrical and thermal history of the samples. We suggest that these phenomena are related to the motion of charge-density wave domains boundaries coupled to defects.

INTRODUCTION

$K_{0.30}MoO_3$ and $Rb_{0.30}MoO_3$ undergo a Peierls distortion towards a semiconducting incommensurate charge-density wave (CDW) state at 180 K.[1] In the low temperature phase, non linear conductivity due to the motion of electrons condensed in the CDW state is well established.[2] We have previously reported that the current carrying state was metastable involving long time scales (hours).[3] Metastability phenomena with shorter time scales (ms) have also been found.[4,5] We have recently observed low frequency (~ 1 Hz) coherent voltage fluctuations in the non linear state on samples quenched from 300 to 77 K with an applied dc current.[6] We report here the effect of the thermal and electrical history of the samples on the low field resistance.

EXPERIMENTAL RESULTS

The samples used in this study are single crystals electrolytically grown. Electrical contacts were made by evaporating indium on freshly cleaved crystals. To avoid any Joule heating, the experiments were performed by immersing the samples in liquid nitrogen.

Figure 1 shows the differential resistance obtained by ac lock-in detection as a function of the driving current for $Rb_{0.30}MoO_3$. A hysteresis in the Ohmic resistance is found when the current has been swept above the threshold current I_t up to a given value I_{max}. If we denote R_1 the low field resistance in the virgin state and R_2 the resistance found after the current has been swept above I_t, we can define a isothermal remanent resistance (IRR) as $\Delta R/R = (R_2-R_1)/R_1$. After a full cycle (2-5), the following cycles are nearly identical to the first one if one keeps the same value for I_{max}.

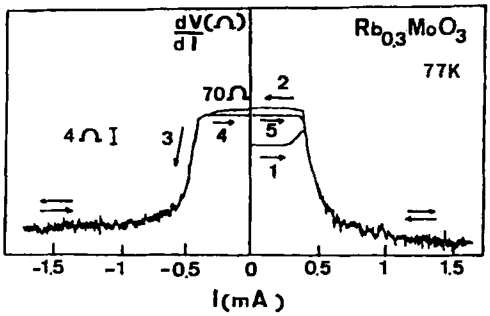

FIGURE 1 Differential resistance dV/dI as a function of the dc current for $Rb_{0.30}MoO_3$ at 77 K. 1 corresponds to the virgin state.

Figure 2 shows the effect of the thermal and electrical history of the sample on the low field resistance. When the sample is cooled from 300 to 77 K with an applied dc current, the Ohmic resistance R_{th} is found larger than the resistance R_1 obtained with a zero current cooling. We denote this increase $\Delta R/R = (R_{th}-R_1)/R_1$ the thermoremanent resistance (TRR). The TRR increases noticeably when the current applied during cooling is larger than the threshold current I_t at 77 K. Both the IRR and TRR increases near I_t. The TRR and IRR tend to saturate at comparable values for current larger than I_t. The TRR becomes vanishingly small near 130 K.

These results have some similarities with the remanent magnetizations of spin-glasses and also with the results obtained by Tsutsumi et al.[7] on $K_{0.30}MoO_3$ and by Hutiray et al. on TaS_3[8].

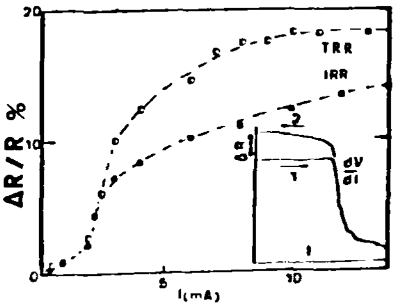

FIGURE 2 Thermoremanent (TRR) and isothermal remanent resistance (IRR) of $K_{0.30}MoO_3$ at 77 K. The threshold current I_t at 77 K is 2.2 mA. The inset shows the hysteresis in the differential resistance measurement (1 corresponds to the first sweeping from a virgin state). The horizontal axis corresponds to the current applied during cooling for the TRR and to I_{max} values for the IRR.

DISCUSSION

The predominant role of the metastability in the blue bronzes is well-established.[3,4] A possible source of metastability is the existence of crystals defects or impurities. In the case of the blue bronzes, the Ohmic resistivity is not intrinsic and has to be attributed to non-stoichiometry and/or impurity levels in the Peierls gap.[6] In the 'pure' samples, these levels may correspond to localized electrons on Mo^{5+} donor centers. These centers may be on the Mo sites labelled 2 and 3 in Ref. 9. After a cooling process, the electron population of the two corresponding levels would be metastable. If these defects are coupled to the CDW, the sliding motion of the CDW would induce a redistribution of the population on the two levels. These rearrangements may involve electron jumps on neibhoring Mo2 and Mo3 sites. One cannot exclude, however, some variable distorsion due to the CDW motion which would lead to some displacements of the levels in the Peierls gap.[10]

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