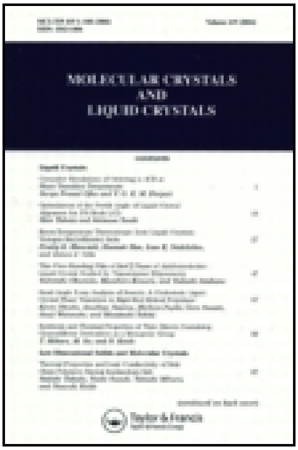

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Current Oscillations In Pure And W Doped TaS_3 Samples

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CURRENT OSCILLATIONS IN PURE AND W DOPED TaS_3 SAMPLES

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Abstract Current pulses modulated by quasiperiodic oscillations of MHz frequencies were directly observed on the oscilloscope in pure and W doped TaS_3 samples. The stable modulation with an initial phase determined by the onset of the pulses was observed in short samples which were previously treated with very high voltage pulses ($V_H > 100\ V_T$) of short duration. This treatment was more effective in the doped samples in which the threshold field for the onset of the nonlinear conductivity regime was lower than in the pure samples.

INTRODUCTION

The current oscillations of MHz frequencies observed in the nonohmic conductivity regime of CDW bearing chain compounds are regarded as the most direct evidence for the occurrence of the sliding CDW conductivity. In $NbSe_3$ the current modulation was observed both in the time domain[1] and by spectral analysis of the narrow band noise riding on the d.c. current.[2] Until now such oscillations were observed in TaS_3 only by the second method [3,4] and their amplitude was much smaller[3] than in $NbSe_3$. The observation of stable oscillations riding on current pulses applied on pure and W doped TaS_3 samples was recently reported.[5] The method by which this effect was obtained is described here in detail.

EXPERIMENTAL METHOD AND RESULTS

The stable oscillations were first observed in W-doped TaS_3 samples but later they were observed also in some pure orthorhombic TaS_3 samples. The concentration of the constituents in the growth batch of the doped samples corresponds to the atomic ratio [W]/[W+Ta] = 0.1, but Auger analysis of several samples of this

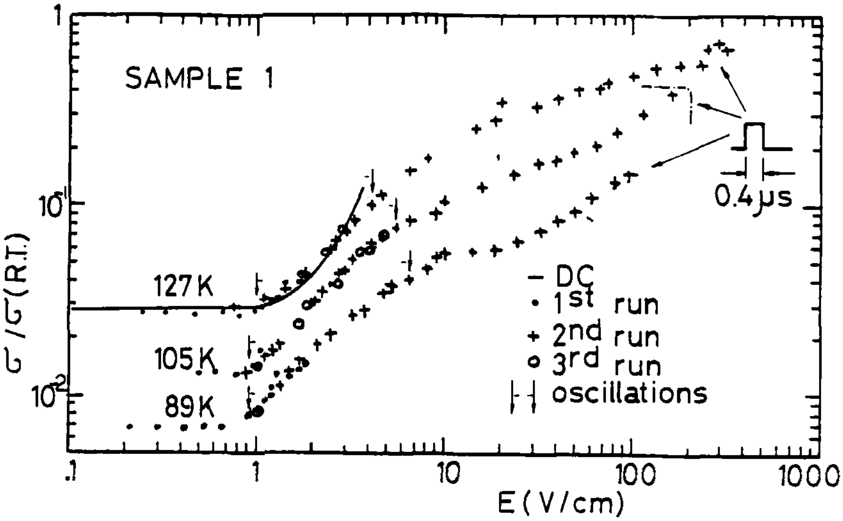

FIGURE 1 Conductance normalized to the value at room temperature vs. electric field for three temperatures. Sample dimensions 1.2 mm x 7 x 13 μm^2.

type, showed (after sputtering of about 1000 Å) that this ratio is closer to 0.04. These samples seemed more perfect than the pure samples. Their transition temperature is apparently unchanged, but the activation energy of their conductivity around 150 K is smaller by about 30% than in the pure samples. The threshold field E_T for non-linear conductivity is 1 V/cm or lower.

Fig. 1 is a typical plot of the conductivity versus electric field in the doped samples. The measurements were done by applying pulses with low repetition rate, and durations long enough such that the current and voltage could be measured in a flat position of the traces beyond the charging time constant of the circuit. At high fields the duration of the pulses could be reduced to less than 0.5 μsec. During the first runs the current and voltage traces were smooth in a large range of applied fields. At fields of about 300 V/cm the traces became unstable. The conductance of the samples was poorly determined in this regime, but its estimate is comparable, though smaller than its maximal ohmic value measured above the transition. Further increase of the applied field caused the samples to burn. It is believed that at such high field self heating plays an important role even for very short times and good thermal contact. The samples that survived this treatment showed stable current oscillations when the field was reduced to values within one order of magnitude above E_T and the duration of the pulses was expanded. The new property acquired by the treated samples is persistent even after they have been cycled through a large range of fields and temperatures. Within the experimental error the measured conductance of the samples (ohmic and non-ohmic) was not affected by the treatment (see Fig. 1). A typical set of current traces modulated by current oscillations is shown in Fig. 2 for a sample of W doped TaS_3. Similar traces have been obtained also for a few samples of pure TaS_3 though in a narrow range of fields and temperatures. The pure samples seem to require higher conditioning pulses and very few of them survive the treatment.

The most remarkable property of these oscillations is their reproducibility in a long train of applied pulses. This property indicates that the oscillations have a fixed source in the sample, probably at the contacts, and that the source is activated by the applied pulses. The role of the high conditioning pulses is probably in preparing the source.

From traces such as those shown in Fig. 2 the average frequency of the modulation - f_m was measured as a function of the excess current ΔI. These measurements were done at several temperatures. The plots of f_m versus ΔJ (the excess current density) for three W-doped TaS_3 samples are shown in Fig. 3 of reference 5. The ratio $\Delta J/f_m$ in the linear portions of the plots ranges between 22-50A/MHz cm^2. The lowest value was obtained for the thickest sample. The value of $\Delta J/f_m$ measured from the spectral analysis of the narrow band noise[4] in TaS_3 is 38A/MH_z cm^2.

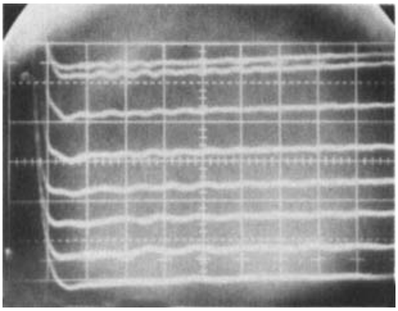

FIGURE 2 Stable current oscillations for a series of constant voltage pulses. Vertical 2 μA/div. Horizontal 0.5 μsec/div. Lowest trace corresponds to $I = 12$ μA. Sample dimensions: 0.6 mm x 3 x 3 μm^2.

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REFERENCES

1. John Bardeen, E. Ben-Jacob, A. Zettl and G. Gruner, Phys. Rev. Lett. 49, 493 (1982); R. Fleming, Solid State Comm. 43, 167 (1982).
2. J. Richard, P. Monceau and M. Renare, Phys. Rev. B25, 948 (1982).
3. A. Zettl and G. Gruner, Phys. Rev. B28, 2091 (1983).
4. P. Monceau, M. Renard, J. Richard, M.C. Saint-Lager, H. Salva, Z.Z. Wang, Phys. Rev. B28, 1646 (1983).
5. B. Fisher (to be published).