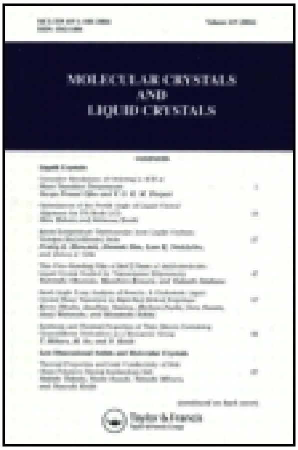

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Experimental Approach To Charge Density Wave Pinning: Irradiation Of Inorganic Quasi Id Conductors

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EXPERIMENTAL APPROACH TO CHARGE DENSITY WAVE PINNING: IRRADIATION OF INORGANIC QUASI 1D CONDUCTORS

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Abstract Controlled variation of defect concentration by irradiation adds a new dimension to the experimental investigation possibilities of pinned charge density waves. Some recent results are briefly reviewed.

INTRODUCTION

After several years of studies on materials presenting collective charge density wave (CDW) transport it is generally accepted that lattice defects have a most important role in the pinning of the CDW condensate. However, there have been only a few attempts to examine the effects of defects in any detail[1], probably due to experimental difficulties. In case of chemical substitution it is not easy to control the concentration and the homogeneity of the defect concentration at the level necessary for these studies.

Radiation damage is by far the most practical tool for this kind of investigations: working carefully it is possible to produce well controlled and homogeneous defect concentrations in a range of several orders of magnitude. Furthermore, this can be done "in situ", following the interesting properties on the same sample at varying defect concentrations. Irradiation experiments have been extensively used to investigate the properties of charge density waves in the presence of defects but only in compounds in which the interesting CDW dynamics have no important manifestations[2]. The recent findings of new materials presenting collective CDW transport permit a systematic study on the effects of irradiation induced defects on the CDW dynamics in continuation to the works done earlier on $NbSe_3$(ref.3). In this purpose we have started to irradiate the transition metal chain compounds TaS_3, $K_{0.3}MoO_3$ and $Rb_{0.3}MoO_3$, $(TaSe_4)_2I$. Some of the important results will be presented below.

CDW TRANSITION TEMPERATURE

The variation of the CDW transition temperature with defect concentration has been followed in detail for orthorhombic[4] and monoclinic[5] TaS_3 and for the blue bronzes[6]. A decrease is usually observed at higher doses, corresponding to $10^{-3}...10^{-2}$ atomic fraction of defects[7]. for both polytypes of TaS_3 this decrease of critical temperature is accompanied with a loss of transversal coherence of the CDW induced structural distortion[4,5]. However, very important effects on the CDW transport phenomena occur already long before any notable decrease is observed. This indicates that at low defect concentrations the average CDW amplitude remains practically constant even though the CDW becomes pinned.

THRESHOLD FIELD

Our results indicate that the threshold field of the non-linear CDW conduction increases linearly with irradiation dose, i.e. defect concentration. This behaviour is valid for all materials studied by us up to now, that is orthorhombic TaS_3(ref.4), the blue bronzes[6] and $(TaSe_4)_2I$ (ref.8). Such behaviour suggests that the irradiation induced defects are strong pinning centres[9], contrary to chemical impurities[1].

NOISE ASSOCIATED WITH THE SLIDING CDW

Observations on orthorhombic TaS_3 have revealed that the narrow band noise peaks broaden rapidly when the defect concentration increases[4]. At the same time the broad band noise level is amplified. However, there is no variation in the relation fundamental frequency vs. CDW-current. More detailed studies on the behaviour of the noise with defects might clarify the physical origin of the noise signal.

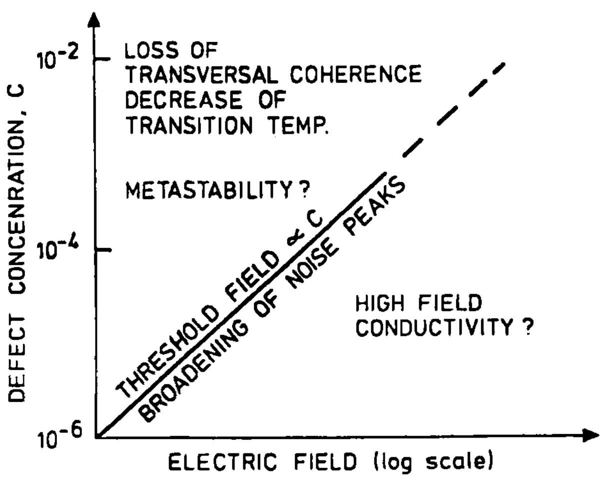
A NEW DIMENSION FOR THE PINNING PROBLEM

The fact that irradiation adds a new dimension to the experimental investigation of the pinned CDW is illustrated in the Figure 1. There we have sketched some important observations made on the electric field-defect concentration dependent phenomena. In addition to those already discussed we want to pay attention to two features that merit detailed studies.

The first is the metastability near the threshold and below it. This kind of phenomena are very prominent in the blue bronzes and our experiments have revealed surprising results. For example, the switching transition to the non-linear, sliding-CDW state can be induced by a slight irradiation of non switching samples[6]. Also the metastability of the low-field (single particle) resistivity can be greatly enhanced by irradiation[6].

Another interesting point is the CDW conductivity at the high field limit. The Grenoble group reported that irradiation defects can influence strongly this property[10], and the microwave conduct-

FIGURE 1 The irradiation induced defects influence many phenomena related to the pinning of the CDW.



ivity results[11] on irradiated samples suggest a similar conclusion (remembering that field and frequency dependence of the CDW transport are very similar[12]).

In conclusion, the observations made up to now encourage further studies of charge density waves pinned by irradiation induced defects.

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