Pressure Effect on Sliding CDW in $K_{0.3}MoO_3$

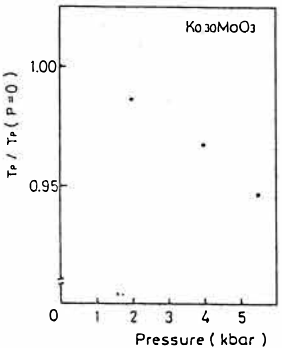
Kazushige Nomura, Ryūta Kohsaka and Takashi Sambongi
Department of Physics, Hokkaido University, Sapporo 060, JAPAN

Abstract-The Peierls transition temperature, the CDW gap and the threshold field for the CDW depinning were measured in $K_{0.3}MoO_3$ under hydrostatic pressure. Amplitudes of the transient voltage oscillation and the narrow band noise were also investigated and the increase of coherency of CDW motion was found under pressure.

The charge-density-wave (CDW) state in a quasi-one-dimensional conductor is described with the phase variable and the coherency of phase plays an important role in the behavior of CDW. Such a coherency is supposed to be modified by pressure through parameters such as the transfer integral. Recently the threshold field for the CDW depinning have been investigated under pressure in several CDW materials[1,2,3]. Here we report the pressure effect on the static and dynamic behavior of CDW and discuss the coherency of CDW state.

Transport measurements were done in a single crystal of $K_{0.3}MoO_3$ with a four probe configuration. Pressure was achieved in a beryllium-copper microbomb with 1:1 mixture of kerosene and transformer oil as pressure transmitting medium. The value of pressure was calibrated with the resistance of manganin wire.

We obtained the transition temperature T_P from the temperature dependent ohmic resistance. As shown in Fig. 1, T_P is suppressed by pressure with the



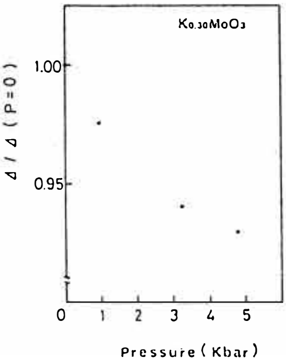


Fig. 1 Pressure dependence of the Peierls transition temperature T_P.

Fig. 2 Pressure dependence of the Peierls gap Δ.

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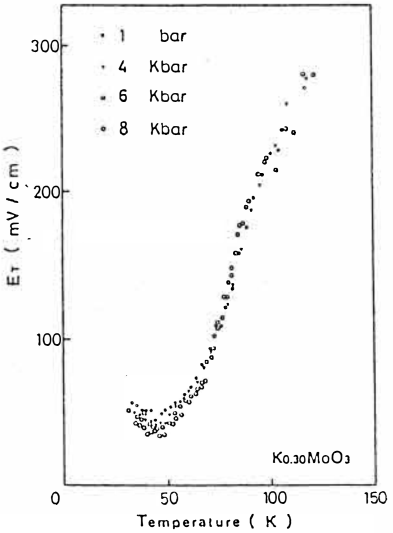
rate of 1 %/kbar. The CDW gap Δ, estimated from the slope of logR-1/T curve at $T_P/2$, decreases under pressure with the rate of 1.5 %/kbar as shown in Fig. 2. These rates are roughly consistent with those in recent experiments [2,3]. The decrease of Peierls gap is simply attributed to the decrease of the electron-phonon coupling parameter λ and the breaking of nesting condition of Fermi surface. The larger decreasing rate in Δ than T_P suggests that the one-dimensional fluctuation is somewhat suppressed under pressure.

The threshold field E_T was obtained from the non-linear dc transport. As shown in Fig. 3, E_T decreases under pressure in the low temperature region below 70 K and increases above 70 K, although the behavior is not clear above 100 K, due to the rounded I-V curve. In the weak pinning regime, E_T is expressed as, $E_T \propto K^{-3}\{\Delta/(n_{CDW}\lambda)\}^4$, where K and n_{CDW} are the elastic constant of phase deformation and the condensate density, respectively. The decrease of E_T is qualitatively explained with the increase of K and the decrease of Δ under pressure. These correspond to the increase of the Fukuyama-Lee-Rice length as a whole: The static coherency of CDW is enhanced under pressure. In the high temperature region, the variation of n_{CDW} is appreciable against the pressure, as shown in Fig. 4. It is understood that the decrease of n_{CDW} brings about the increase of E_T in the high temperature region, overcoming the mechanism effective in the low temperature.



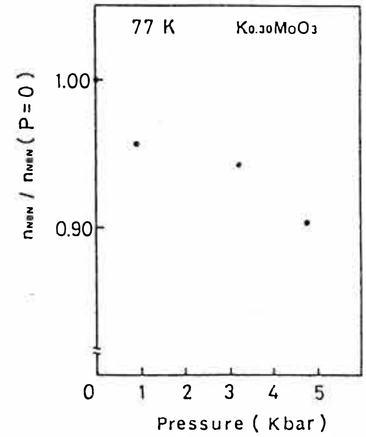
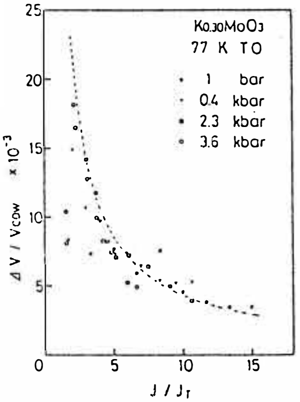


Fig. 3 Temperature dependence of the threshold field E_T.

Fig. 4 Pressure dependence of the CDW condensate density n_{NBN} obtained from the narrow band noise frequency.



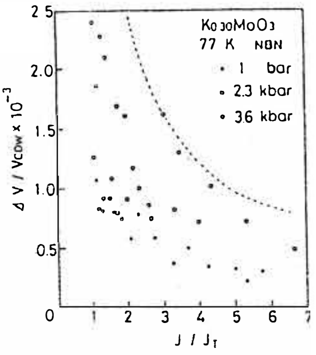


Fig. 5 Normalized amplitude of TO vs. current density.

Fig. 6 Normalized amplitude of NBN vs. current density.

We investigated amplitudes of the transient voltage oscillation (TO) and the fundamental narrow band noise (NBN) systematically. Their voltage amplitudes ΔV, normalized to the voltage drop V_{CDW} from the ohmic line, are shown in Fig. 5 and Fig. 6. Broken line denotes the relation expected from the rigid CDW model[4] as,

$$\Delta V/V_{CDW} \propto [(J/J_T)-\{(J/J_T)^2-1\}^{1/2}],$$

where J and J_T represent the current density and its threshold value, respectively. The amplitude of TO is nearly independent of the pressure and is roughly one order larger than that of NBN at the highest pressure (3.6 kbar). The current dependence of $\Delta V/V_{CDW}$ of TO is well fitted to the above relation. While, the NBN amplitude, which characterizes the stationary sliding state, is enhanced about 3 times under the pressure of 3.6 kbar. The latter is understood with the increase of the velocity coherent volume, in which the CDW is sliding coherently, under pressure in the stationally sliding. At the beginning of sliding, the coherency of sliding motion already reaches its upper limit and is not enhanced by pressure. The CDW behaves as a rigid one in the transient sliding.

References

1. D. Moses and R. M. Boysel, Phys. Rev. B31, 3202(1985).
2. G. Mihály and P. Canfield, (preprint).
3. L. Forró, (preprint).
4. G. Grüner, A. Zawadowski and P. M. Chaikin, Phys. Rev. Letters, 46, 511(1981).