ESRF	**Experiment title: Measurement of the dislocation nucleation rate in sliding charge density waves.**	**Experiment number:** HS-1730
Beamline: ID10A	**Date of experiment:** from: 6 march 2002 to: 13 march 2002	**Date of report:** 27/08/2002
Shifts: 21	**Local contact(s):** Gerhard Grübel	*Received at ESRF:*

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Report:

Incommensurate charge density waves (CDWs) in quasi-one-dimensional conductors are a prototype of collective transport in disordered systems. A CDW consists of a charge condensate with a spatial modulation of the electron charge density and a distortion of the underlying crystal lattice with same periodicity. Below the Peierls temperature, the system exhibits a super-structure: satellite peaks appear near Bragg peaks. Application of an electric field, beyond a threshold value E_T, can depin the CDW from the crystal impurities. Then, an additional current J_c due to the CDW motion appears and induces a non-linearity in the conductivity.

The free electrons of the crystal are converted into the CDW condensate in the vicinity of the injection electrode. This conversion takes place by nucleation and lateral motion of phase dislocation loops, each loop allowing the CDW phase to advance by 2π. It is possible to study this phenomenon, so-called phase slippage, by the way of high resolution synchrotron X-ray diffraction. The conversion near current electrodes has for consequence to shift the satellite peaks in reciprocal space.

A recent theory of the carrier conversion process has been developed by Brazovskii *et al.*: this theory connects the gradient of the CDW current density, $J_c(x)$, to the dislocation loop nucleation rate $R(q, J_c)$, itself related to the satellite shift $q(x)$: $dJ_c(x)/dx = 2eR[q(x), J_c(x)]$. The relationship between $q(x)$ and $R(x)$ is however unknown.

The aim of this experiment was to determine the phase-dislocation rate, $R(q, J_c)$, by combining two independent measurements on the same sample under the same conditions: measurements of the satellite shift $q(x)$ by high resolution X-ray diffraction technique, as provided on ID10A, and electrical measurements of the CDW current density $J_c(x)$.

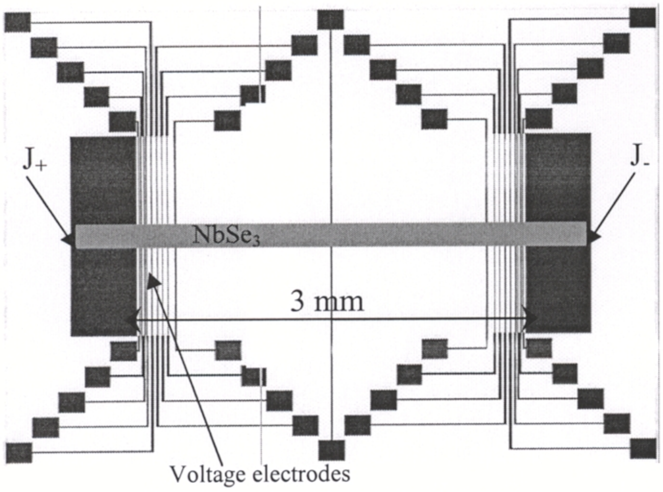

Fig. 1 : Measurement geometry showing the the two 500 µm-wide current electrodes and the nineteen 2 µm-wide voltage electrodes.

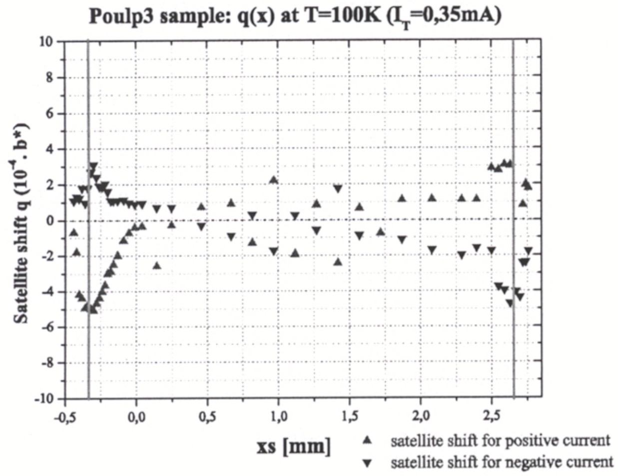

Fig. 2 : X-ray determination of the spatial dependence of the shift q(x) of the CDW satellite as a function of the X-ray beam position between current electrodes (vertical solid lines) at T = 100 K.

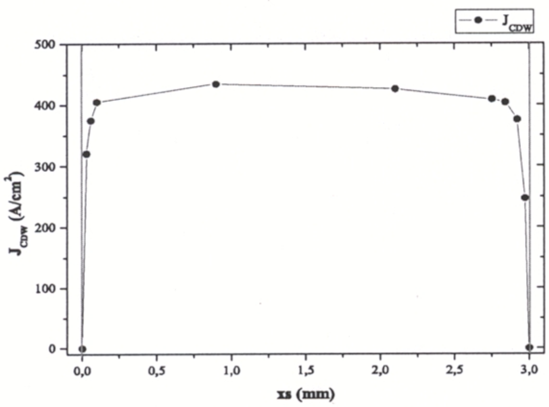

Fig. 3 : Preliminary J_{CDW} measurements for J_{tot} = 2500 A/cm^2 at T = 100 K. The CDW current density is zero at the current electrodes (vertical lines) and the maximum value is in the middle of the sample.

The $NbSe_3$ whisker was mounted on a 60 µm-thick silicon substrate equipped with twenty-one buried gold contacts (two current electrodes and nineteen voltage electrodes) . This technique is used to obtain electrical contacts without step at the substrate surface (in order not to distort the crystal). The sketch of the micro-electrodes is shown in Fig. 1: it was made by photolithography using the CRTBT (CNRS/ Grenoble) cleanroom equipements. The distance between the two current electrodes is 3 mm, 20 µm for the first four voltage electrodes, 40 µm for the four following ones and 60 µm for the last two. An additional voltage electrode is located in the middle of the sample.

The total current density J_{tot} was applie between contacts J_+ and J_-, potential differences were measured across the remaining pairs of adjacent contacts. The CDW current density is calculated from the following relation: $J_{CDW} = J_{tot} - J_N$, where J_N is the current density of the normal carriers measured in the Ohmic regime.

Measurements of the shift q(x) were performed at T = 100 K (see Fig. 2) and also at T = 80 K.

The *in situ* J_{CDW} measurements could not be performed during the X-ray measurements because the number of electric leads required could not be implemented on the ID10A displex.

The electrical measurements on the sample on which q(x) has been determined, have not yet been totally carried out at CRTBT. The reason is that, after removing the sample from the displex at ID10A, a large number of electrical contacts were lost, not because of broken wires, but due to the thermal cycling of the collodion film deposited on the crystal to improve the quality of the electrical connection. Now, we are presently in the process of restoring the electrical contacts and in order to measure $J_c(x)$ at T = 100 K and T = 80 K.

A rapid test of $J_c(x)$ performed before the X-ray measurements using only eight voltage electrodes is shown in Fig. 3 (T = 100 K, total current density J_{tot} = 2500 A/cm^2).

[1] S. Brazovskii, N. Kirova, H. Requardt, F. Ya. Nad, P. Monceau, R. Currat, J. E. Lorenzo, G. Grübel and Ch. Vettier, Phys. Rev. B, **61**, 10640 (2000).