| ESRF | **Experiment title:** *XPCS study of Charge Density Wave current conversion in $NbSe_3$* | **Experiment number**: HS3290 |
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| **Beamline** : ID20 | **Date of experiment**: from: 14/03/07 to: 21/03/07 | **Date of report**: 13/09/07 |
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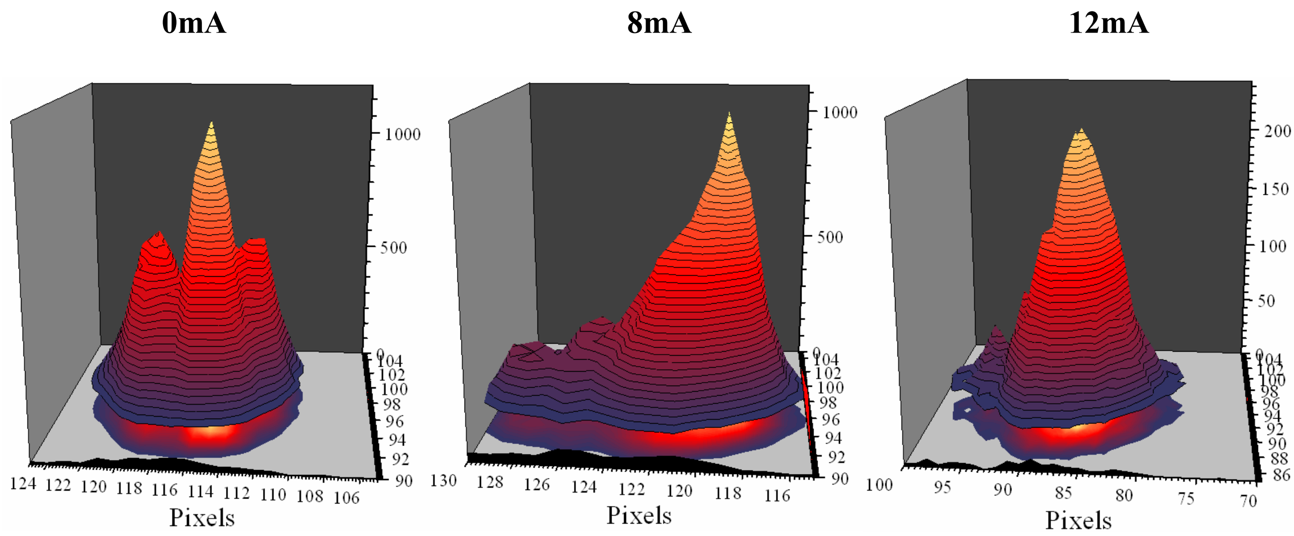
## Report:

The goal of this experiment was to measure the sliding motion of a Charge Density Wave under an external electric current by using coherent diffraction. CDW are found in quasi-one-dimensional (1D) metallic compounds, and consist in the simultaneous modulation of the lattice and the charge density of the conducting electron at twice the Fermi wave vector $2k_F$. The lattice modulation gives rise to pairs of satellite reflections flanking the fundamental Bragg peaks at $\pm 2k_F$ in the x-ray spectra, the shape of the satellite reflections being related to the CDW phase-phase correlation function. Upon an electric field larger than a threshold, the CDW slides as a whole, transporting a non-ohmic current. Prototypical CDW systems are the blue bronze $K_{0.3}MoO_3$ and $NbSe_3$, in which a CDW state is stabilized below 180 K and 145 K respectively. However, the blue bronze is an insulator in the CDW state, while $NbSe_3$ still exhibits metallic properties. As the CDW can be considered as an electronic crystal, the presence of conducting electrons that can screen CDW excitations, make the two systems different and extremely interesting to compare.

After having studied the blue bronze[1] under a coherent beam (see reports HE1284 and HS2402), we present here the results on NbSe3, with the same experimental conditions as for our experiment HE2053. The sample was mounted inside a He orange cryostat, with its (H0L) plane perpendicular to the horizontal diffraction plane. It was cooled down to 90K to be well inside the CDW state. The (0 1.241 0) incommensurate satellite reflection has been measured with a direct illumination CCD camera, with 20µm pixel size. This experiment has been devoted to the measurement of the superstrucure reflection versus the external current, for different beam positions on the sample, especially near the electrical contacts, in order to probe the current conversion[2]. One purpose was to follow the satellite reflection in a presence of defects, and to observe its evolution when current is applied, until reaching the threshold current value necessary for the CDW to slide.




*This figure shows the CDW reflection at the same position on the sample for three different current values: 0mA, 8mA and 12mA. The nice speckle pattern existing at 0mA progressively disappears when the current is applied stepwise, until disappearing completely when the threshold current value of 12mA is reached.*

**Results:**

We used two samples during this experiment, and their satellite reflections had a different shape. The first one was very elongated along a perpendicular direction, whereas the other one was thin in that direction. We supect the directions perpendicular to the b* axis to be different in the two samples. This is going to be checked with Laue measurements in our laboratory.

We show the results corresponding the a $NbSe_3$ single crystal that was 3.1mm long, 20µm large and 2µm thick. It was lying on a Sapphire substrat (300µm thick) that wore a hole. The initial sample resistance was 13.8Ω at 90K and the threshold value was 12mA at this temperature.

We worked with a beam energy of 8keV, and pinholes allowed us to get a 10µmx10µm beam size. The CCD camera was located at 1,80m from the sample. A rough estimate of the transverse coherence length gives $\xi_T \approx 2.5\mu m$, and $\xi_L \approx 1.05\mu m$ for the longitudinal one.

On figure 1, the diffraction pattern of the (0,1.241,0) CDW reflection is displayed. The three images are taken on the same position on the sample, but at different currents. When no current is applied, the satellite reflection is splitted into three speckles. When the current is raised up to 8mA, the pattern changes a lot and begins to disappear. In the sliding regime, when the threshold current value is reached (I=12mA), the speckle pattern is totally smooth out. We interpret this evolution as an time averaging of the speckle pattern due to the sliding CDW. Note that the position of the satellite reflection is slightly shifted from an image to the other, but this is attributed to beam instabilities.

Finally, we have also made XPCS measurement in order to observe the dynamics of defects in the vicinity of contacts. These data are still under process.

**References**

[1] D. Le Bolloc'h, S. Ravy, J. Dumas, J. Marcus, F. Livet, F. Yakhou, C. Detlefs, L. Paolasini PRL 2005
[2] H. Requardt, F. Ya. Nad, P. Monceau, R. Currat, J. E. Lorenzo, S. Brazovskii, N. Kirova, G. Grübel, and Ch. Vettier, Phys. Rev. Lett. 80, 5631-5634 (1998); 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, 10640-10650 (2000)

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