

Evidence of Charge Density Wave transverse pinning by x-ray micro-diffraction

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At low temperature, some metals have an incommensurate Charge Density Wave (CDW) transition where a periodic lattice distortion appears and opens a gap at the Fermi energy. When applying a large electrical current to a CDW material, a non-linear collective current is measured and is interpreted as the periodic creation of charged topological solitons at the electrical contacts [1,2]. We studied the CDW deformation under current in NbSe₃ using the micro-diffraction setup at ID01 beamline of the ESRF synchrotron [3]. The sample was prepared with a Focused Ion Beam (FIB) cut in a «L» shape as shown in Figure 1a. Therefore, the current could only flow in the upper region and we could compare on the same sample a CDW region with current with one without current. As shown in Figure 1b, a Fresnel Zone Plate focused the beam on a 200nmx300nm area allowing us to scan the CDW satellite peak (0 1 0)+q_{cdw} over the red region of Figure 1a with steps of 1μm. At each beam position on the sample, we measure the diffracted peak on a 2D detector and perform a rocking curve. Each map has a size of 0.6 TeraBytes and takes 45 minutes to measure due to the CDW satellite low diffracted intensity. From these map averaged along the horizontal axis, we could reconstruct the CDW phase Φ shown in Figure 1c. Below the FIB cut, where there's no current, Φ is constant at every current while in the upper region (where current is flowing) an unexpected shear deformation was measured. This transverse evolution has been interpreted as a surface pinning effect since Φ comes to the same value $((-10 \pm 5) * 2\pi)$ at the sample upper border ($z=37$) for every current. This transverse pinning can explain the dependence of the threshold current on the sample cross-section [4].

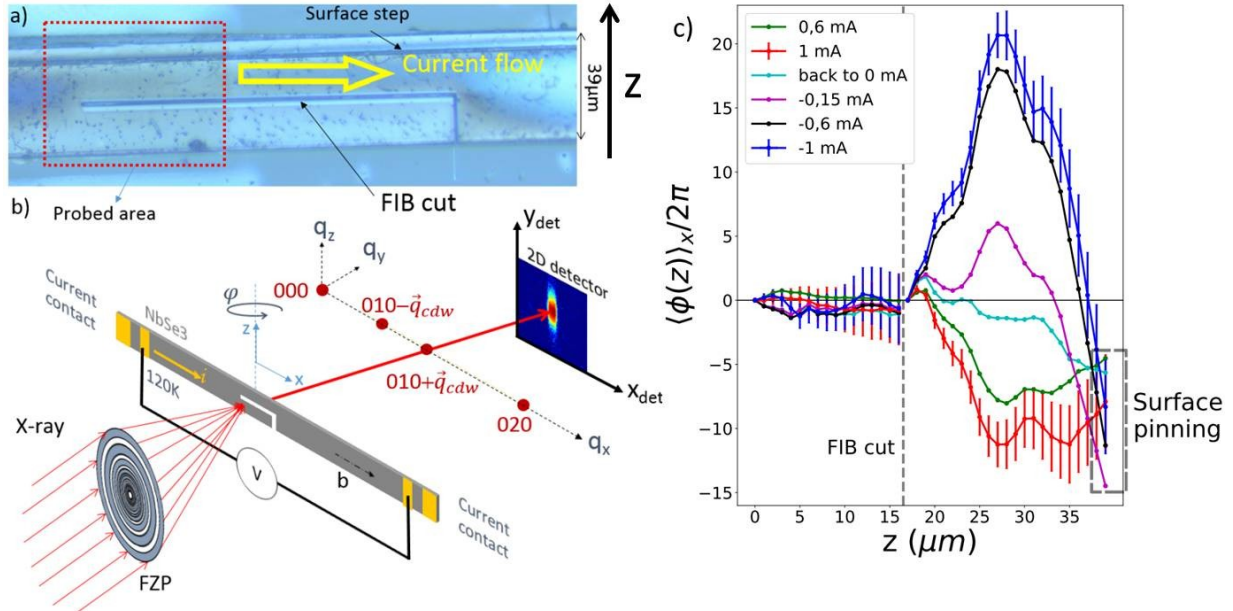


Figure 1: a) NbSe₃ sample prepared with a FIB cut. The current can only flow in the upper region. b) A Fresnel Zone Plate focused the X-ray beam on the sample, allowing to scan the CDW deformation as a function of position. c) Reconstructed CDW phase shear deformation along z . A surface pinning effect is observed at the sample upper border.

References

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