Standard Project

Experimental Report

Proposal title: Strain mapping and defect distribution along mechanically deformed Cu nanowires by μLaue diffraction		**Proposal number:** 32-02-744
Beamline: BM32	**Date(s) of experiment:** from: 14/11/2012 to: 17/11/2012	**Date of report:** 15/02/2013
Shifts: 9	**Local contact(s):** J.-S. Micha	*Date of submission:* *02/2012*

Objective & expected results (less than 10 lines):

Our goal was to study the mechanical properties of individual nanostructures and the influence of size effects using μLaue diffraction. For this purpose, we randomly dispersed Cu nanowires oriented along the <110> direction on a Si substrate and we plastically deformed them ex situ to different strain states. While the orientation of the wires was apriori unknown due to their radial symmetry μLaue diffraction gives direct access to their orientation on the surface. The microfocused white beam was scanned along the deformed wires to record the strain distribution in the nanostructures.

Results and the conclusions of the study (main part):

The nanowires were visually located by means of the optical microscope at the BM32 beamline. During the experiment we recorded μLaue diffraction patterns at several points along plastically deformed single nanowires of different diameters:100, 200 and 500 nm. The μLaue diffraction data is analyzed using the LaueTools software developed at the BM32 beamline.The most interesting results were obtained for a 200-nm-diameter wire. The SEM image of this nanowire is shown in figure 1 and the scan direction is indicated by the red arrow. The Laue pattern collected at one position along the wire is depicted in figure 2. Here we recognize the signals from the substrate and the ones from the Cu wire that was found to be (111) oriented with respect to the substrate with 2 grains in Σ3 orientation relationship. The shape of the various Bragg peaks contains information of both strain and defects in the specimen. Thus, μLaue diffraction mapping gives access to both the complete map of the plastic strain gradient and the defect distribution within a single nanostructure. In figure 3 the evolution of the 222 peak along the wire is shown. The spot moves on the detector as effect of a twisted/bent structure. In addition, the presence of both strain and extended defects results in an elongation of the Laue spot. The deviatoric strain calculated (in the laboratory coordinates system) for this wire at the position #30 is:

Deviatoric strain (%)
[[-0.674631 0.511971 -0.632441]
 [0.511971 0.814427 0.454147]
 [-0.632441 0.454147 -0.139795]]

Further analysis will allow us to obtain the two rotation matrix associated to the bending and twisting of the investigated Cu nanowire for a better interpretation of experimental data.

Justification and comments about the use of beam time (5 lines max.):

For studying single wires the white beam at BM32 was focused down to 300 x 500 nm2 employing the recently commissioned KB mirror system. Thanks to the fluorescence detector and the MARCCD present at the beamline the Cu-K radiation and the diffraction signal of the wires was recorded simultaneously allowing for location unambiguously the different nanowires while translating the sample through the beam

Publication(s):

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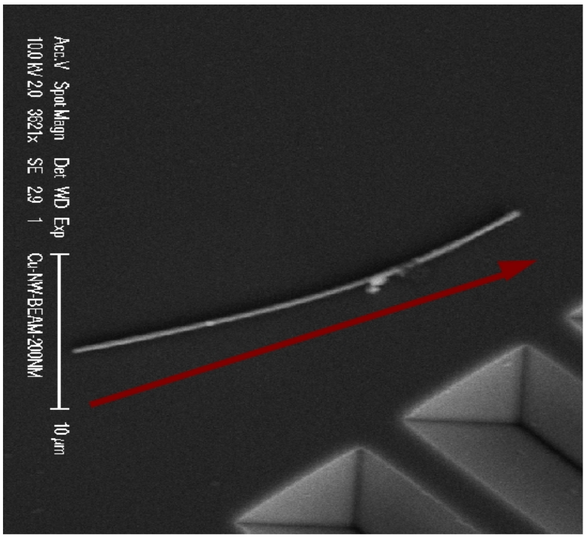

Figure 1: SEM image of the investigated nanowire. The scan direction is indicated by the red arrow

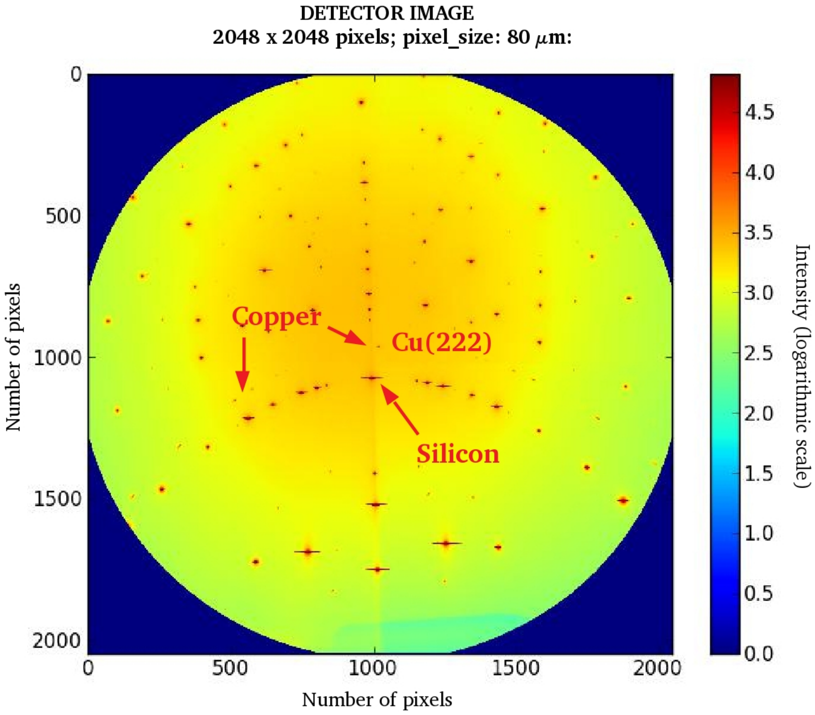

Figure 2: Laue pattern collected at one position along the wire

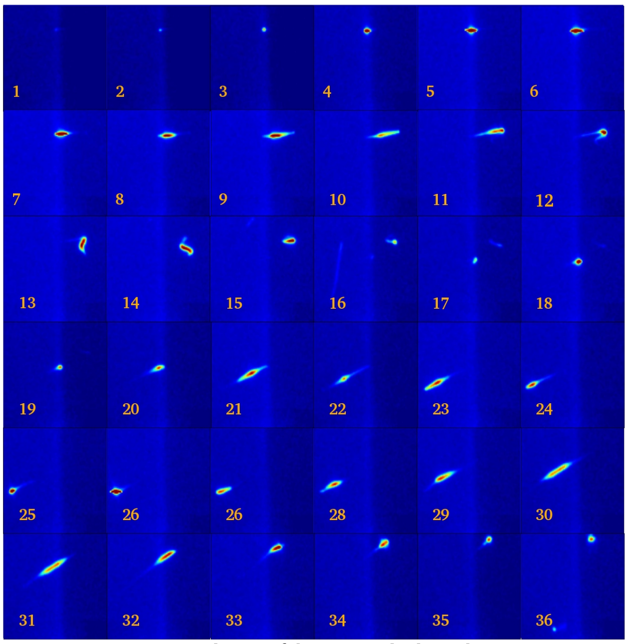

Figure 3: Evolution of the 222 peak along the wire