Standard Project

Experimental Report template

Proposal title: **Mechanical properties of single Fe nanowires studied by in situ three-points bending tests combined with µLaue diffraction**		**Proposal number:** 32-02 805
Beamline: BM32	**Date(s) of experiment:** from: 23/11/2017 to: 28/11/2017	**Date of report:** 23/02/21
Shifts: 12	**Local contact(s):** J.-S, Micha, S. Tardiff	*Date of submission:*

Objective & expected results (less than 10 lines):

The goal of this experiment was the study of the nano-mechancical properties of single BCC Fe nanowires by *in situ* three-point bending tests combining the *in situ* AFM "SFINX" and Laue microdiffraction. While the mechanical behvior of FCC nanostructures are well investigated, works on BCC nano-objects are scarce.

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

Iron nanowires with a diameter of 100 to 200 nm and a length of up to 10 µm were grown by vapor phase deposition on carbon coated tungsten substrates. Individual nanowires were harvested and placed across 2 µm wide Si micro-trenches using micro-manipulators in a scanning electron microscope, thus forming suspended nano-bridges. The nanowires were thoroughly attached at both ends by electron beam induced deposition of Pt using a precursor gas in a SEM. A scanning electron micrograph of such a Fe nanowires is presented in Fig. 1(a). For the intended *in situ* three-point bending experiments, SFINX was installed at the BM32 beamline. The nanowires were located by measuring the yield of the Fe-K_α fluorescence.

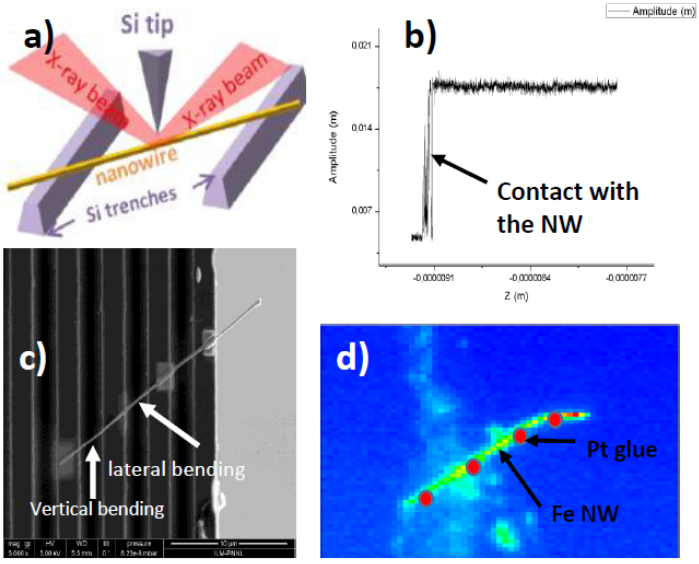


Fig. 1: a) Schematic of the *in situ* mechanical and µLaue measurements. b) Approach-retract curve of the AFM. c) Scanning electron micrograph and d) X-ray fluorescence map for a suspended Fe nanowire glued by Pt deposition.

During mechanical loading with the AFM-tip Laue microdiffraction patterns were recorded. The nanowires were deformed by two different methods, either vertical or lateral bending, using the AFM-tip. At pre-defined loads, the complete profile of the mechanically deformed nanowire was measured by scanning the focused X-ray beam along the nanowire using the KB scanning method. Integrated Laue microdiffraction patterns of the Fe 220 Laue spot for a nanowire at different loading stages is presented in Fig. 2(a) and (b).

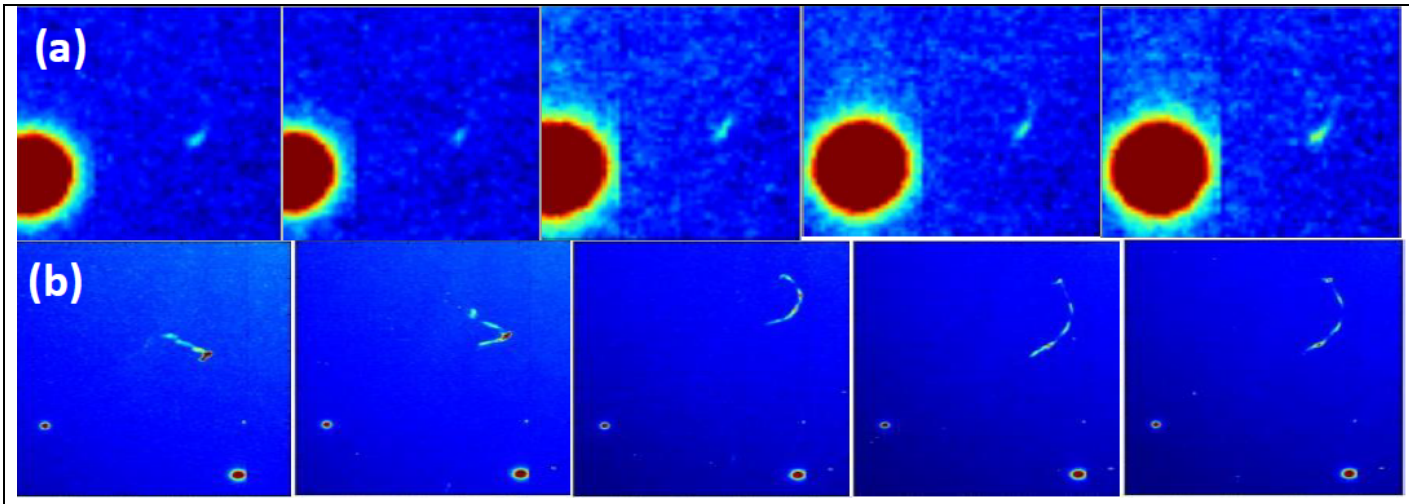
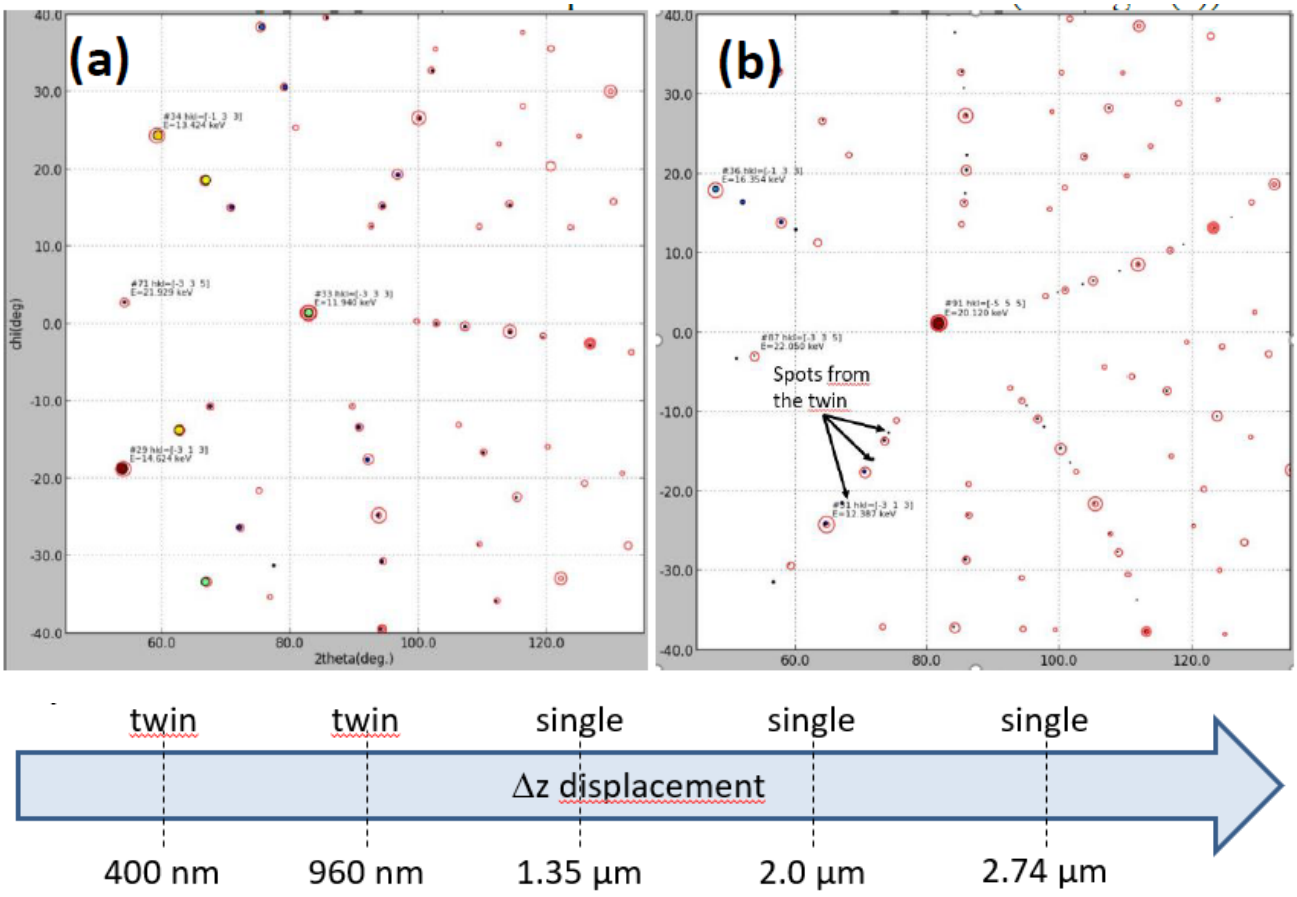


Fig. 2: Image sequence of a Fe and a Si Laue spots during a) vertical bending and (b) lateral bending using the AFM-tip.

In addition to the intended *in situ* three-point bending test on Fe nanowires, we performed *in situ* nano-indentation experiments on individual Au crystals using the same setup as before. The Au crystals were prepared by dewetting a 45 nm thin magnetron sputtered Au film on a sapphire substrate. Laue microdiffraction evidenced that some of the Au crystals contain a twin boundary parallel to the crystal-substrate interface (see Fig. 3(a)). *In situ* nano-indentation revealed that the Au crystals containing a twin boundary exhibit a lower maximal sustainable load before massive plastic deformation occured.



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

We successfully performed three-point bending tests on suspended Fe nanowires as well as in-situ nano-indentation on Au crystals.

Publication(s):

F. Lauraux, S. Labat, S. Yehya, J.-S. Micha, O. Robach, O. Kovalenko, E. Rabkin, O. Thomas, T.W. Cornelius, *In-situ force measurement during nano-indentation combined with Laue microdiffraction*, Nano Select 2 (2021) 99 – 106