Standard Project

Experimental Report template

Proposal title: **Flexoelectricity of single ZnO nanowires studied by *in situ* µLaue diffraction**		**Proposal number:** 32-02 780
Beamline: BM32	**Date(s) of experiment:** from: 11/02/2016 to: 16/02/2016	**Date of report:** 26/08/16
Shifts: 15	**Local contact(s):** O. Robach	*Date of submission:*

Objective & expected results (less than 10 lines):

The goal of this experiment was the study of the flexoelectric properties of single ZnO nanowires by combining the *in situ* AFM "SFINX" and Laue microdiffraction as well as electrical measurements. While flexoelectricity is negligible in bulk materials it becomes important at the nanoscale. By deforming single self-suspended ZnO nanowires in a three-point configuration using the AFM-tip and measuring simultaneously *I-V* curves as well as recording Laue microdiffraction patterns, we aimed on following the mechanical deformation and to correlate the induced strain gradients with changes in the *I-V* characteristics giving access to the flexoelectrically generated polarization. The experimental configuration is schematically displayed in Fig. 1(a).

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

ZnO nanowires with a diameter of 100 to 200 nm and a length of several micrometers were grown by chemical bath deposition. The wires were detached from their growth substrate and placed across aluminum electrodes deposited on a Si wafer. The wires were thoroughly attached at both ends also improving the electrical connectivity by electron beam induced deposition of Pt using a precursor gas in a SEM. A scanning electron micrograph of such an electrically connected ZnO nanowires is presented in Fig. 1(b). The *I-V* curve of such a ZnO nanowire is shown in Fig. 1(c) revealing that both contacts are Schottky contacts. For the intended in situ experiments, SFINX was installed at the BM32 beamline. The nanowires were located by measuring the yield of the Zn-K_α and the Pt-L_α fluorescence (see Fig. 1(d)).

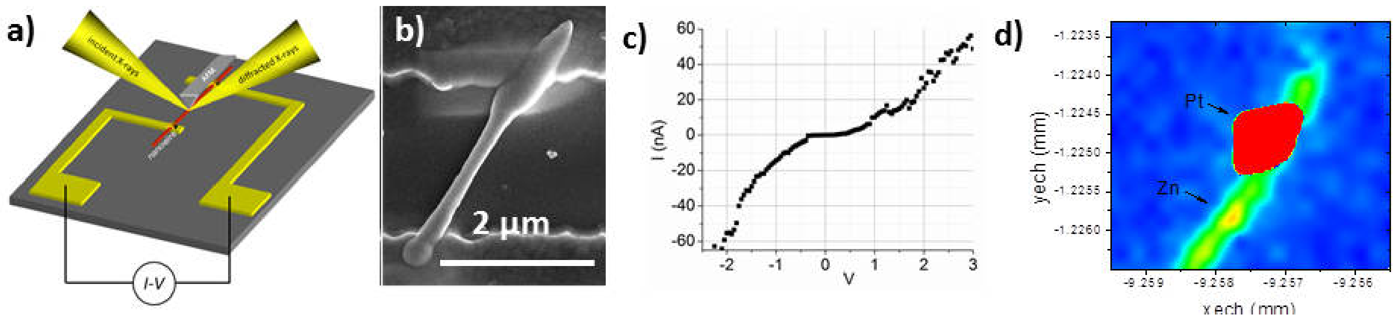

Fig. 1: a) Schematic of the *in situ* electrical and µLaue measurements. b) Scanning electron micrograph of a suspended ZnO nanowire between two Al contacts and glued by Pt deposition. c) *I-V* curve of the nanowire. d) Fluorescence map of a suspended and glued ZnO nanowire.

During mechanical loading with the AFM-tip Laue microdiffraction patterns were recorded. The evolution of a ZnO and a Si Laue spot during the mechanical deformation is shown in the image sequence presented in Fig. 2. While the Laue spot of the Si substrate is stationary, the ZnO diffraction peak moves on the detector indicating the bending of the nanowire. The blurring of the ZnO Laue spot may originate from the strain gradient in the bent nanowire. During the loading process the ZnO Laue spot suddenly jumps to a different position on the detector. This may be caused either by a breaking and relaxation of the nanowire or by slipping off the nanowire with AFM-tip and thus displacing the nanostructure.

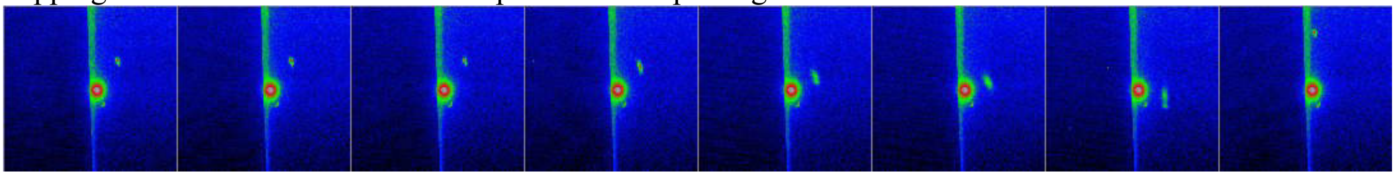

Fig. 2: Image sequence of a ZnO and a Si Laue spots during loading with the AFM-tip.

The aforementioned experiments were all performed on one single position along the self-suspended ZnO nanowires. In the future, the profile of the complete nanowire under load shall be measured using the newly developed KB scanning technique where the focused X-ray beam is scanned across the stationary sample.

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

While the electrical contacting by external probes worked well, the bonding of external wires did not succeed due to a burn-off of the ZnO nanowires. However, we could successfully demonstrate the *in situ* mechanical deformation of the ZnO nanowires as well as *ex situ I-V* measurements. The contacting problem is currently being taken care of paving the way for future simultaneous measurements of both the mechanical deformation by Laue microdiffraction and the *I-V* curves as a function of the mechanical load.

Publication(s):

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