MS42-O5 Random arrangement of the phase domains in single nanowires

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The distribution of rotational twins within single semiconductor nanowires (NWs) has been studied using the nanobeam x-ray diffraction setup at ID1 beamline at ESRF [1]. Stacking faults, and twins are the major defects in NWs. Coherent x-ray diffraction imaging (CDI) using a nano-beam synchrotron radiadion provides a non destructive method to investigate the defect structures in NWs. However, as x-rays probe intensity distributions in reciprocal space, and the phase information is lost during the experiment and can be retrieved using phase retrieval algorithms [2]. In case of a highly defective NW structure, this approach is challenging as the planar defects lead to a complex speckle pattern along certain directions in reciprocal space (fig 1a), whose inversion has up to now not been shown. Here, we present a novel approach how to retrieve the arrangement of twin domains within single GaAs nanowires along the NW growth axis. A combination of the phase retrieval algorithms and methods such as Error-Reduction (ER), Hybrid Input-Output (HIO) and Shrink Wrap (SW) [3] have been used to retrieve the lost phase information. Probing about 10^4 different trial phases the arrangement and the length of particular phase segments is different but the average number of phase changes is rather constant. This leads to the conclusion that one can determine the defect density by CDI but still not the detailed phase arrangement. In present case the calculated defect density is 0.240 defects/nm. Moreover, we have studied the effect of the certain range chosen in reciprocal space along the speckle rod pattern (by cutting a number of sub regions from Fig.1a) on the final result of the PR analysis, and found a correlation in between Δq_z, density of the speckles and number of phase switches. Finally we support the PR analysis by numerically simulating the NW with different possibilities of having ZB / TZB phase segments of completely random arrangement or in an arrangement of possible defect free segment length. These simulations come to confirm the PR result showing that in the case of random arrangement of the ZB and TZB simulated speckle patterns shows similar features compare to measured one.

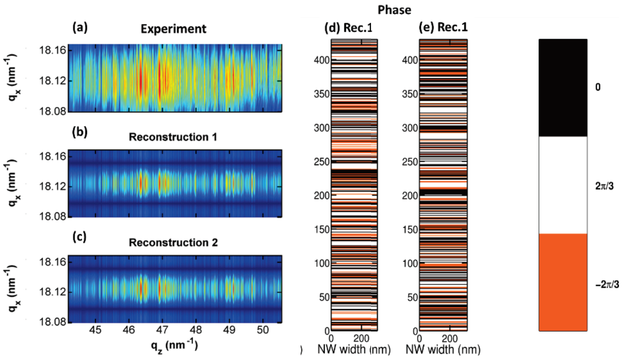

Figure 1. (a) Experimentally recorded (CDI) spackle pattern of the single GaAs NW. (b,c) Fourier transform of the reconstructed NW after the phase retrieval. (d,e) Retrieved phase of the NW for two different random phases as a starting phase in phase retrieval algorithm.

Keywords: Coherent X-Ray Diffraction Imaging, Phase Retreival