Strain mapping of nano-twinned axial ZnTe/CdTe hetero-nanowires

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The aim: The development of a method for precise high-resolution strain mapping of highly strained hetero-nanowires (NWs) with twin boundaries and high thickness gradient

Object: CdTe/ZnTe hetero-nanowires fabricated by molecular beam epitaxy (MBE) with the use of Au nano-catalysts

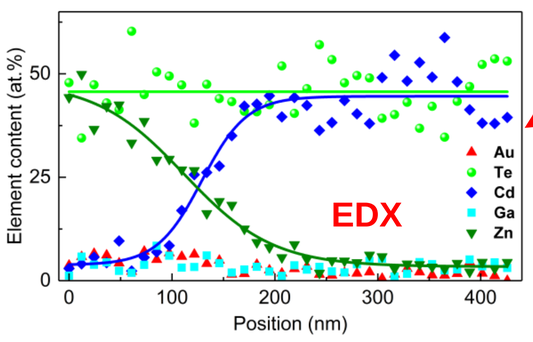
Instrument: Transmission electron microscope Titan Cubed 80–300 operating at 300 kV

The main challenges in ZnTe/CdTe NW strain mapping:
- high thickness gradient
- nano-twinning (for non-centrosymmetric zone axis)

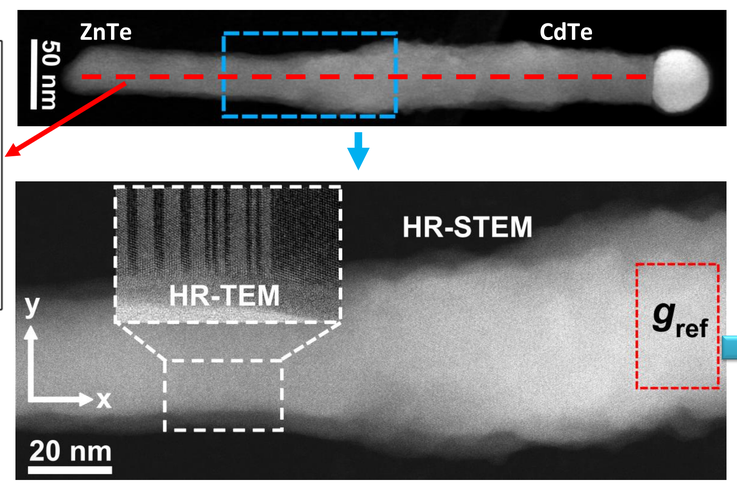
Geometric Phase Analysis (GPA) nano-twinned axial ZnTe/CdTe hetero-nanowire

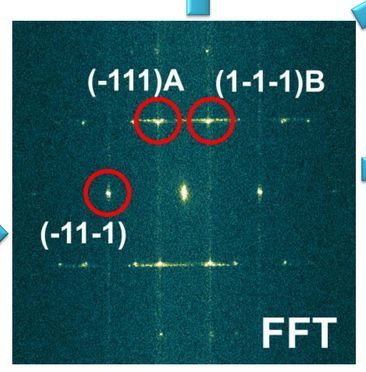
Require:
- thin specimen
- perfect zone axis orientation

Limited field of view (FOV)
Difficult analysis in the case of nano-twinning

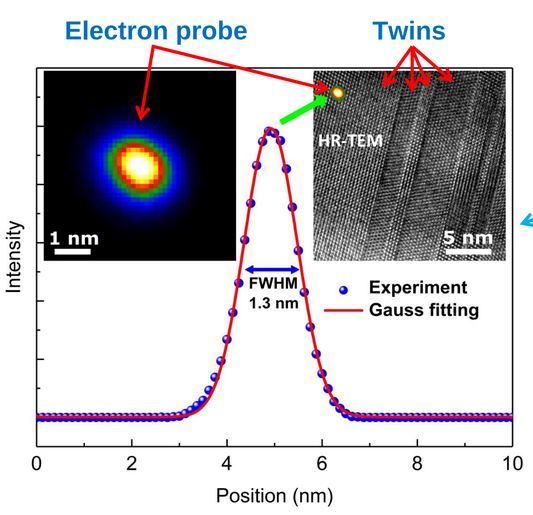


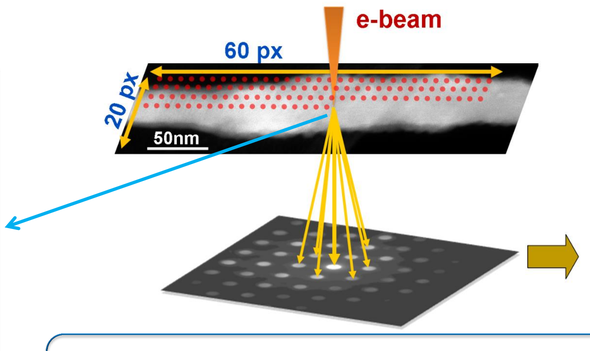
Energy dispersive X-ray spectroscopy (EDX) integrated elements distribution profile along the NW

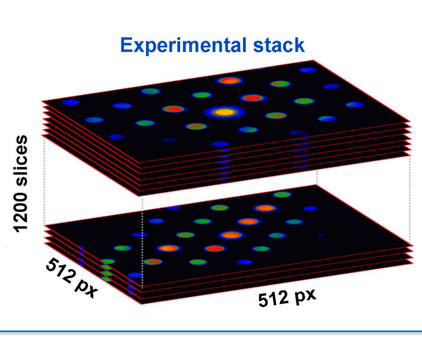




Nano-beam electron diffraction (NBED)

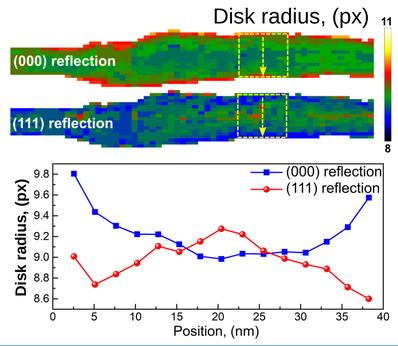




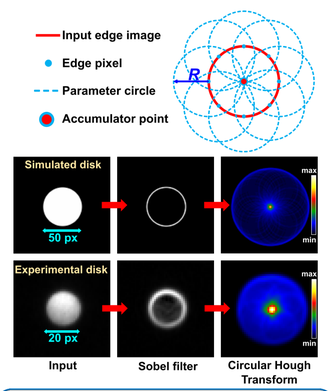


The NBED strain mapping is based on processing of series diffraction patterns acquired during scanning of the specimen by nano-focused electron beam. The measurements of the length of reciprocal lattice vector ***g*** for a particular reflection allows the determination of lattice spacing.

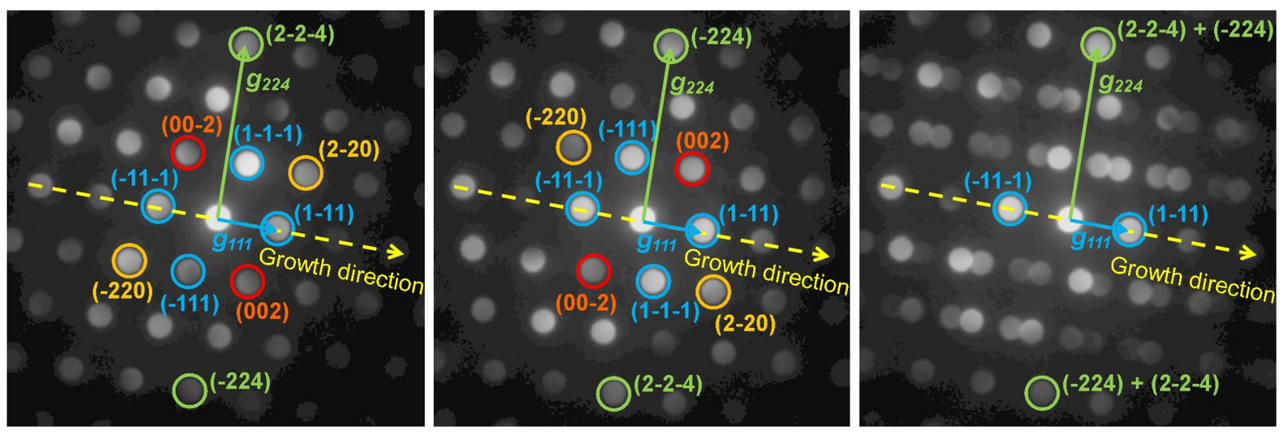
$$|g_{hkl}| \sim \frac{1}{d_{hkl}}$$



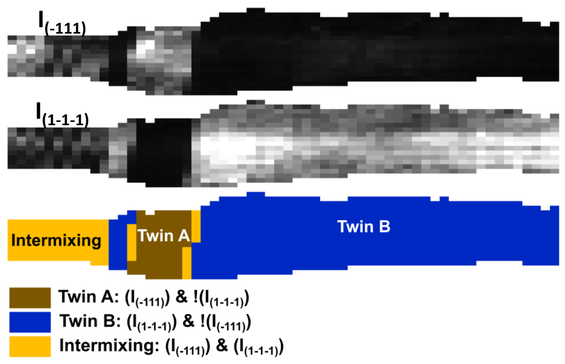
The thickness gradient in NW affect on diffracted beams intensities. This may lead variation of diffracted disk radius.



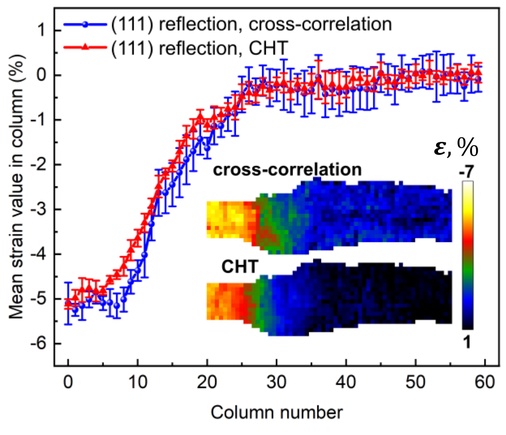
Circular Hough transform (CHT) with variable radius solves the problem of the variation of the disk radius



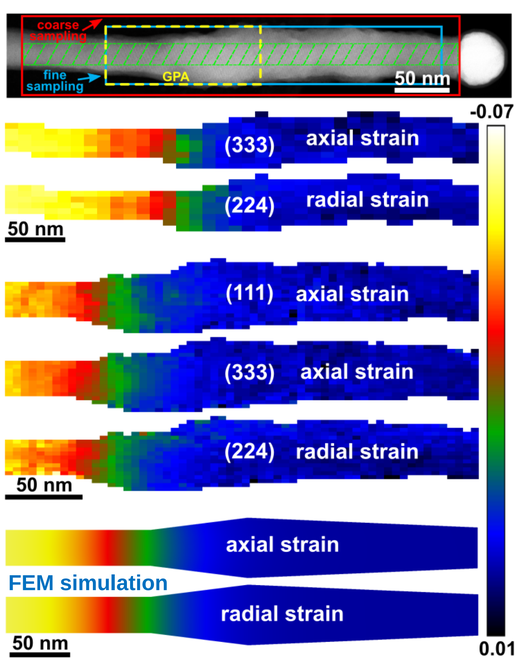
Twin A | Twin B | Twin A + Twin B

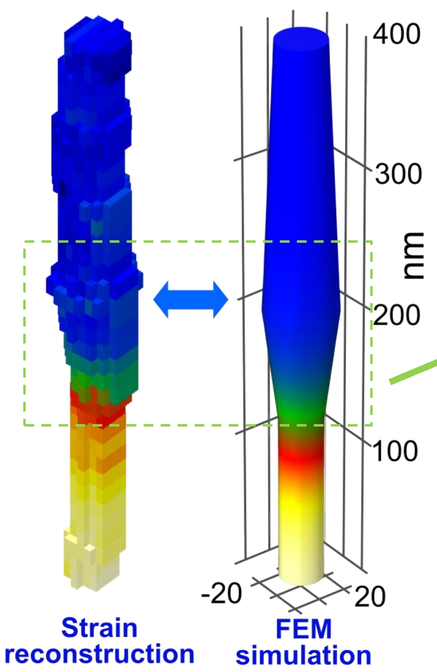


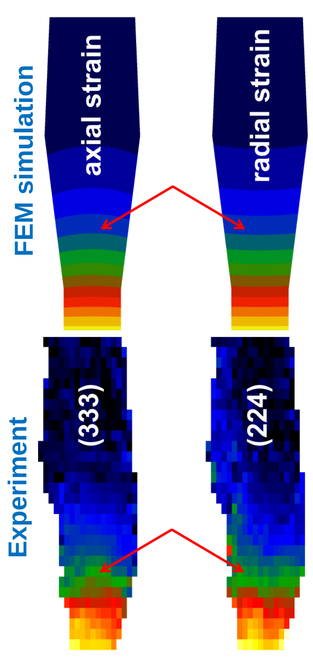
Relatively thin twin domain leads to simultaneous illumination of different crystallographic twins and, as results, overlapping the diffraction.



Comparison CHT and cross-correlation

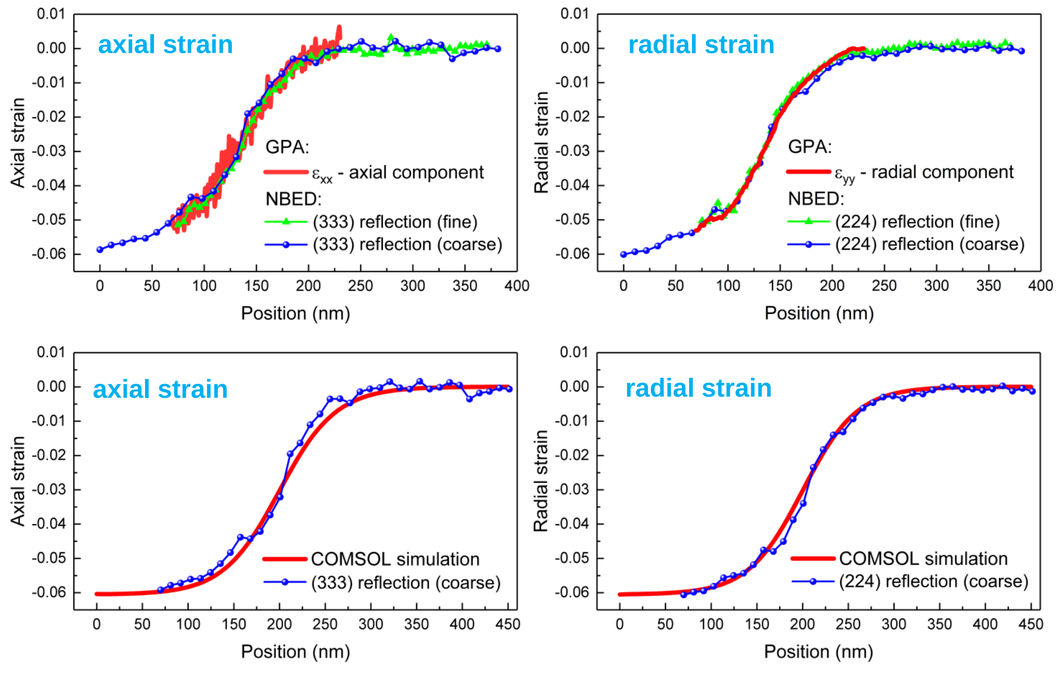






Experimental and projected maps of relative strain obtained by COMSOL simulation

Fine features of the strain behavior!



The comparison of FEM simulated and experimental strain profiles

- We improved algorithm for the detection of the centers of diffraction disks based on the Sobel filtering and Hough transform.
- Proposed methodology of NBED strain mapping for NW which is characterized by a high gradient of thickness and composition.
- We show that it is possible to determine the 3D strain distribution in elastically strained axial NW based on the experimental 2D maps of the lattice distortion and 3D FEM simulations (with assumption the radial symmetry of NW).

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S. Kryvyi, S. Kret and P. Wojnar, Precise strain mapping of nano-twinned axial ZnTe/CdTe hetero-nanowires by scanning nanobeam electron diffraction. *Nanotechnology*, **33**(19), 195704, (2022)