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The structure and oxidation mechanism of $Pb_{1-x}Sn_xTe$ nanowires grown by MBE method

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In these research we present results of Transmission Electron Microscope (TEM) studies of Molecular Beam Epitaxy (MBE)-grown IV-VI nanowires (NWs). $Pb_{1-x}Sn_xTe$ as well as SnTe NWs were grown on both (100)- and (111)-oriented silicon substrates. Contrary to square cross-section observed for binary IV-VI NWs, ternary $Pb_{1-x}Sn_xTe$ possess 5-fold twinned cross-section independently on the presence of catalyst. Using HRTEM and HRSTEM, the whole NWs transferred onto holey carbon film, were separately investigated. Specimens sectioned by perpendicular cross-section with Focused Ion Beam (FIB) were investigated using X- Ray Energy Dispersive Spectroscopy (XEDS) profiles and maps to obtain semiquantitative atomic distribution. The atomic structure of epitaxial [110]||[110] heterointerface between (zinc blend) CdTe and (rock-salt) $Pb_{1-x}Sn_xTe$ was investigated by HRSTEM and aberration corrected HRTEM.

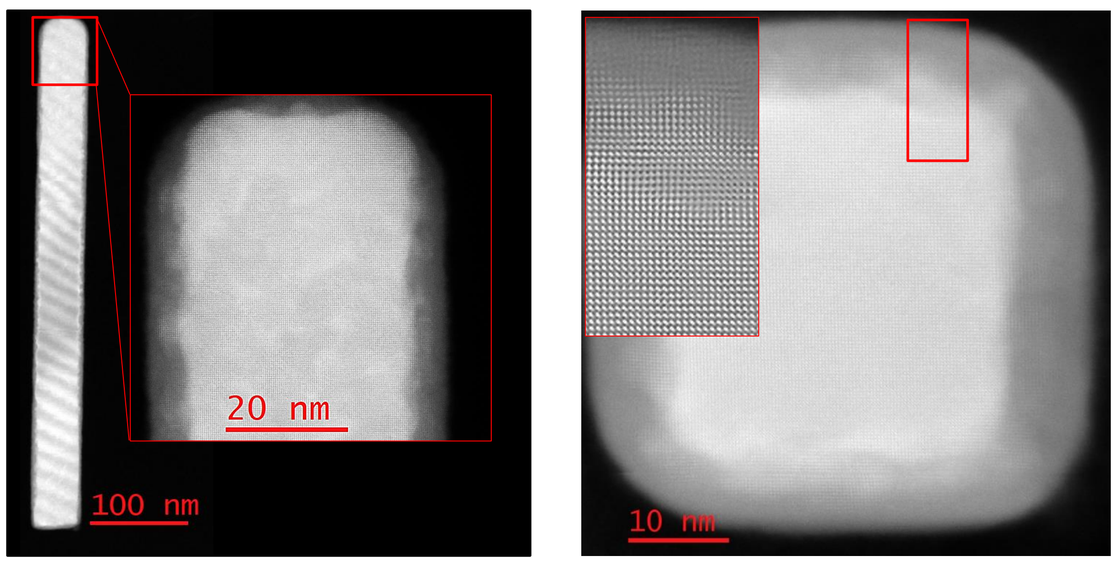


Fig. 1. STEM images of 4-fold SnTe NWs catalyzed with Pb: planarly view on the left, and the cross-section with extracted rock- salt structure on the right.

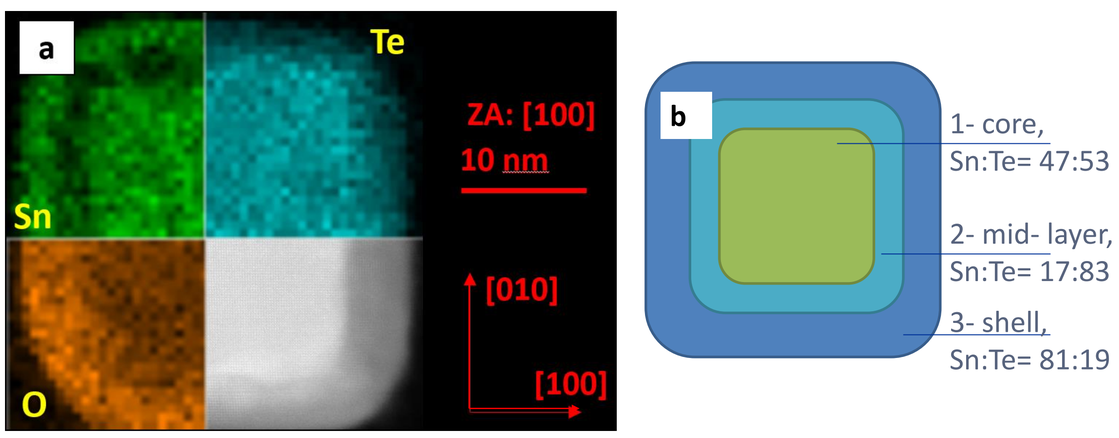


Fig. 2. (a) mixed STEM image of 4-fold SnTe NW with the EDS elemental maps that clearly shows specific distribution of the elements in intentionally homogeneous structure; **(b)** simple schematic image of the cross- section of the structure with Sn to Te ratio in each layer.

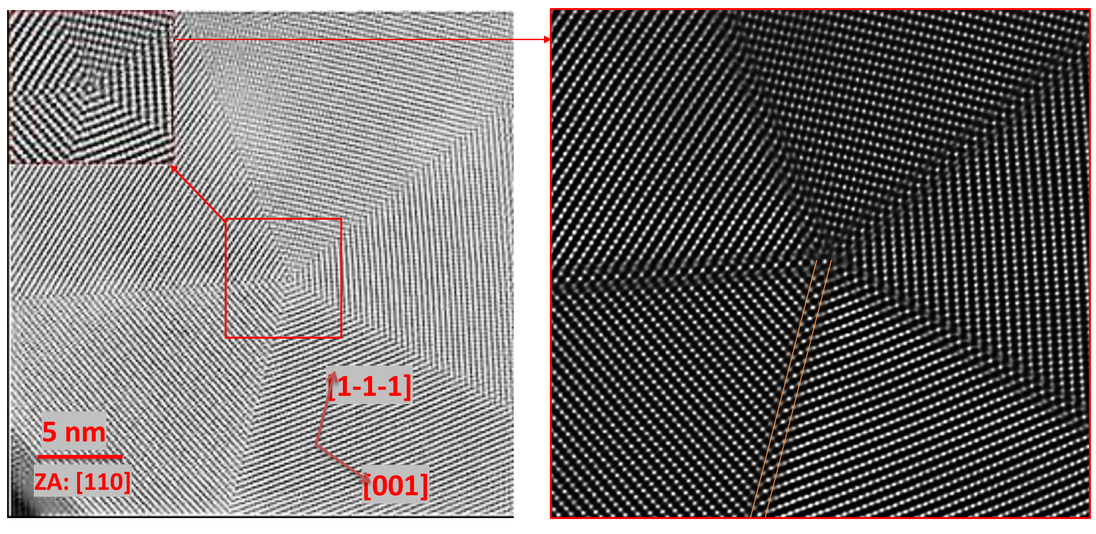
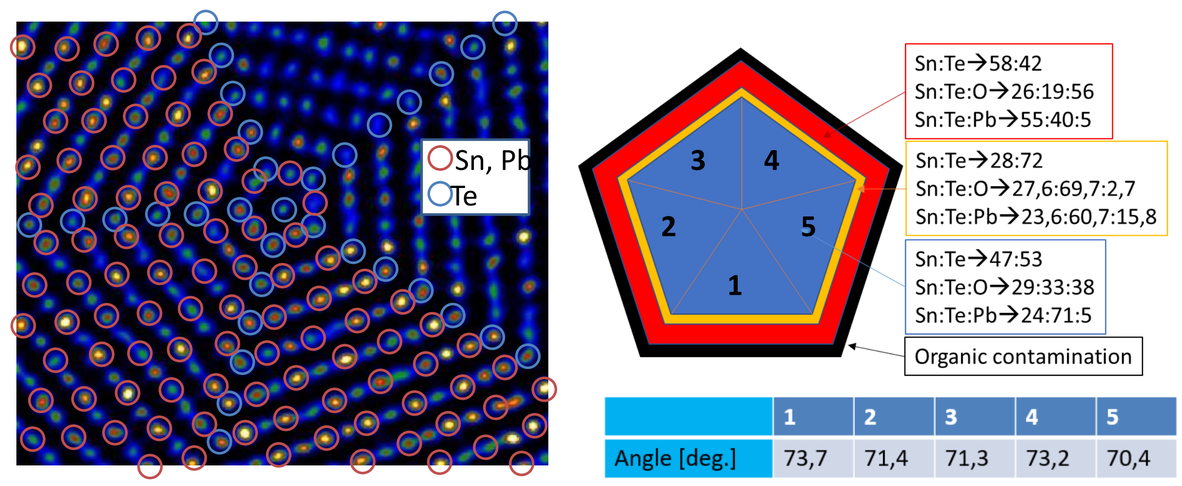


Fig. 3. STEM image of 5-fold (Pb,Sn)Te nanowire **(left)** with extracted and filtered image of the zoom of the central point on the **right.** Telluride {111} grain plane marked with orange lines. The central atom of the whole structure is also Te.



	1	2	3	4	5
Angle [deg.]	73,7	71,4	71,3	73,2	70,4

Fig. 4. (left) Color coded intensity image of 5- fold $Pb_{1-x}Sn_xTe$ NW with identified Sn/Pb or Te atoms. **(right)** schematic picture of the cross- section of the structure with marked elemental ratios, and labeled measured angle of each from 5 blocks. Crystallographic angle is 70,53° and the label shows- the blocks are strained.

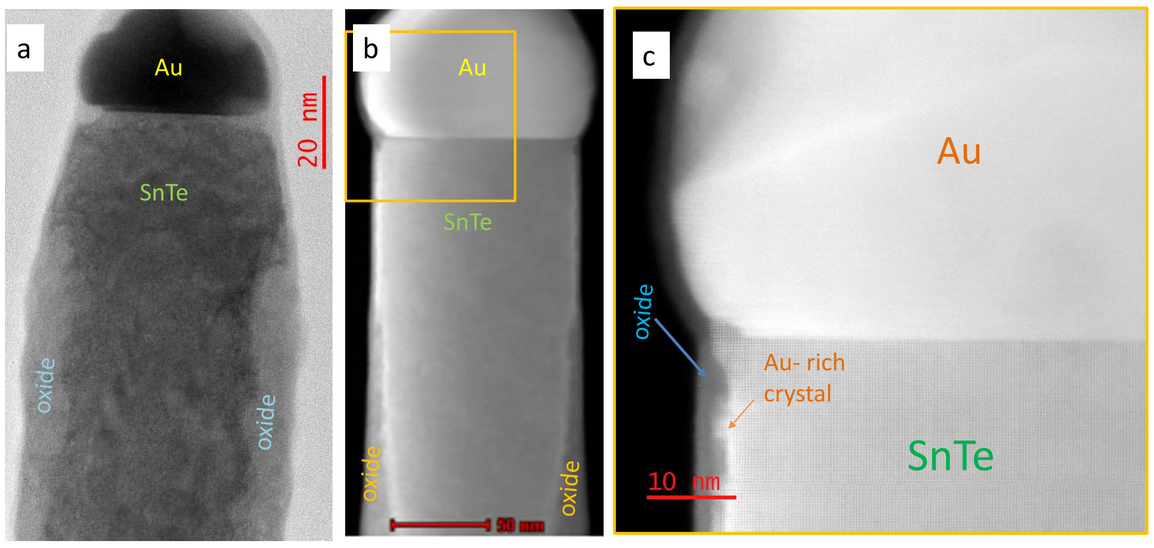


Fig. 5. (a) HRTEM **(b)** STEM image of the SnTe nanowire with gold catalyst droplet on the top, **(c)** enlarged region marked on (b) image with orange square. The protective properties of the Au droplet, and Au- sidewalls layer can be seen.

Summary:

The 4- fold SnTe NWs with the rock- salt structure were investigated. Specific distribution of O, Sn, and Te was found on the XEDS elemental maps, and that clearly shows **reactive diffusion mechanism** of the surface oxidation.

The cross-sectional TEM images shows that the growth direction was along [001] crystal axis in NWs with 4-fold symmetry, and [110] for each 5-fold $Pb_{1-x}Sn_xTe$ symmetry block.

These blocks forms {111} planes twin boundaries with Te atoms on the interfaces and in the center of the pentagon. The gold- doped crystal that appears in the sidewalls of the NWs (Fig. 5c) can prevent the significant amorphous oxide layer creation.

Young Session