TEM analysis of the near- surface reactions in SnTe Nanowires

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Introduction

In this research the cubic rock- salt SnTe nanowires were analyzed using TEM. NWs were grown with two different methods: PVD, and MBE. The growth direction was among [001], and both (100) and (111)- oriented silicon substrates in case of MBE, and (100) in PVD were used. For TEM investigations, NWs were transferred to a mesh with holey carbon film and individually observed after orientation to the zone axis. In intentionally homogeneous nanowires, core/shell like structure was observed. Specimens were also fabricated by perpendicular cross-section with FIB, and EDS maps and profiles confirmed unusual elemental migration of tin atoms, as well as oxygen. The influence of metals, used for contact layers in magneto-transport measurements on the oxidation process was also investigated.

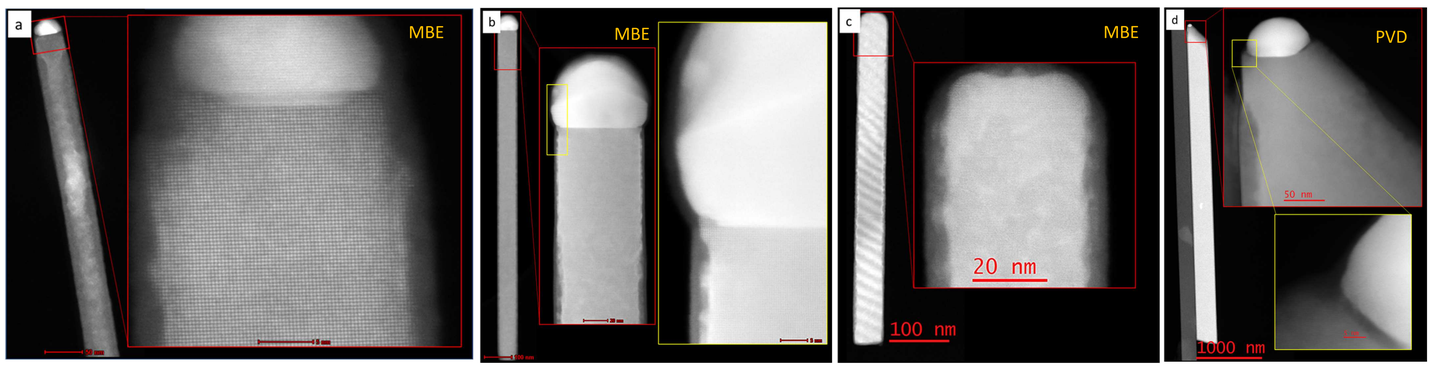

Figure 1.: STEM image of nanowires observed on the EM Cu mesh supported by the holey carbon film, of the (a) MBE made Au- catalyzed, (b) MBE made Au- catalyzed, (c) MBE made Pb- catalyzed, and (d) PVD made NWs. In case of those structures, that were catalyzed with gold, the Au- rich droplet on the top is clearly visible. ZA: [001], ↑ [010], → [100].

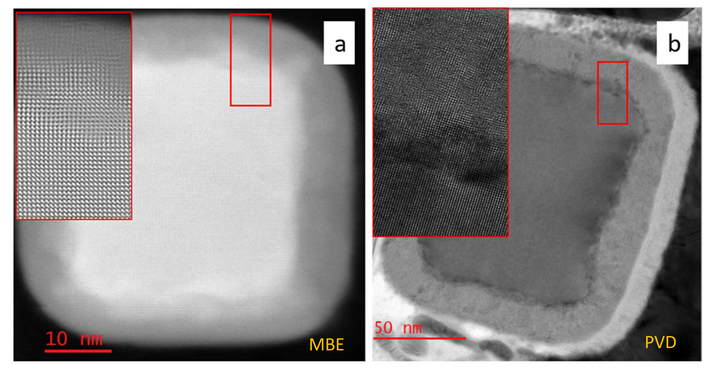

Figure 2.: Above: Images of cross- sectioned NWs with their extracted structure for (a) STEM MBE and (b) HRTEM PVD grown structures. Table: Comparison of the core composition, (spectra line L).

% at.	Sn	Te	O
MBE	49.99	46.69	3.32
PVD	43.11	51.79	5.1

MBE made nanowires' cross-section

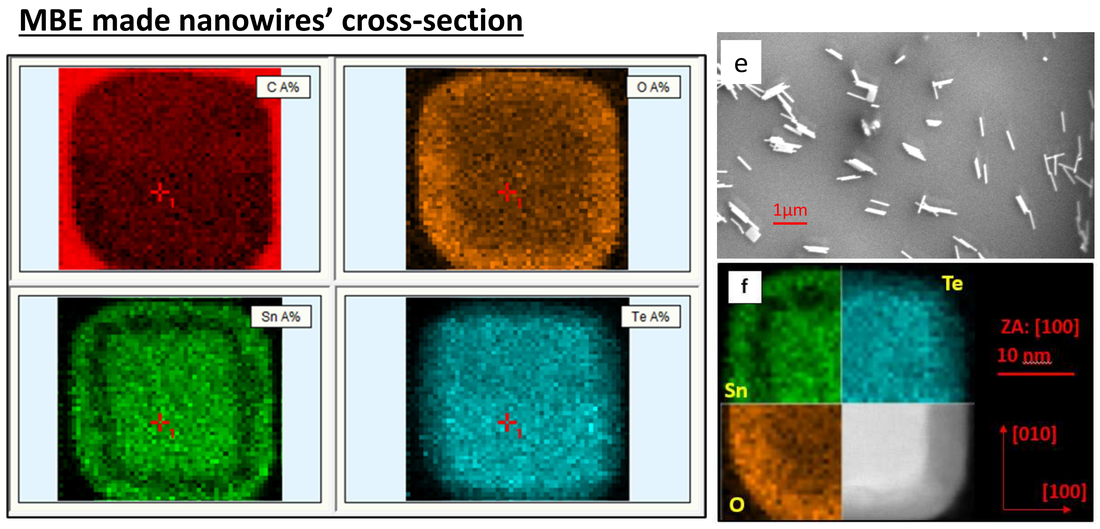

Figure 3.: (a-d) Elemental composition of the crossectioned NWs SnTe on the EDS maps, and (e) SEM image of sample's surface with nanowires, (f) EDS maps of Sn, Te, O, (g) schematic illustration of layers in MBE made NW.

PVD made nanowires' cross-section

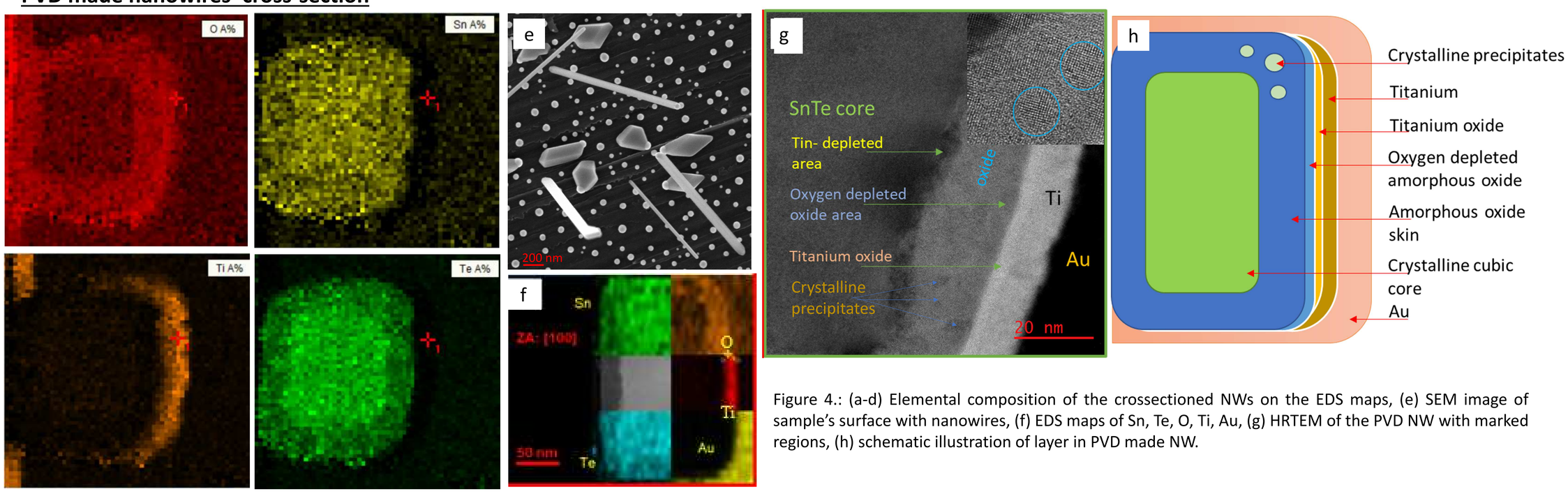

Figure 4.: (a-d) Elemental composition of the crossectioned NWs on the EDS maps, (e) SEM image of sample's surface with nanowires, (f) EDS maps of Sn, Te, O, Ti, Au, (g) HRTEM of the PVD NW with marked regions, (h) schematic illustration of layer in PVD made NW.

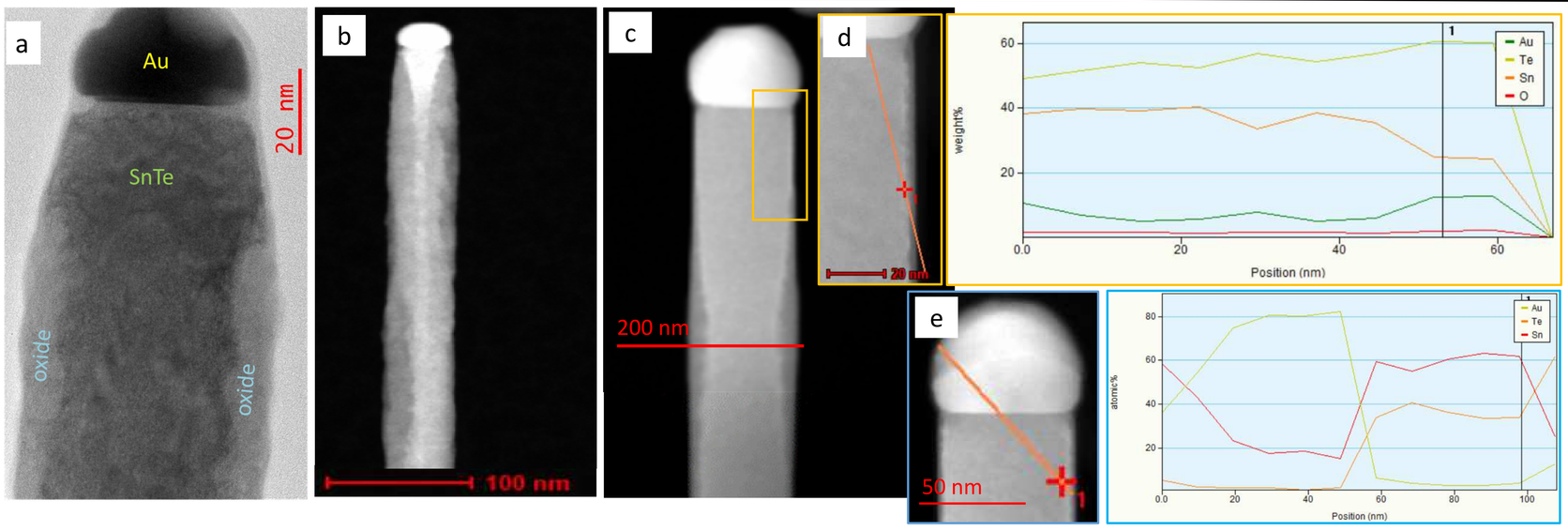

Figure 5.: (a) HRTEM (b) STEM image of the SnTe nanowire with gold catalyst droplet on the top, with visible advanced oxidation, (c) SnTe NW with golden droplet on the top, and with Au incorporated in the NW's sidewalls. The protective properties of the Au droplet, and Au- sidewalls layer can be seen, (d) Spectrum profile of the orange marked region from (c), (e) Spektrum profile of the NW with gold in the droplet and sidewalls.

Summary

The 4- fold SnTe NWs, made with two different methods, with the rock- salt structure were investigated. The cross-sectional TEM images shows that the growth direction was along [001] crystal axis. Specific distribution of consisting elements was found on the EDS elemental maps of both groups, and that clearly shows **reactive diffusion mechanism** of the surface oxidation. Additionally in PVD made nanowires can be seen migration of not only Sn to the surface, and O to the interior, but also formation of titanium oxide, or oxygen depleted oxide area, or even crystallites that formed during oxidation process, that corresponds with oxygen migration through the structure. Gold in form of droplets or incorporated in sidewalls of NWs provides protection against oxidation of SnTe.

Poster made for The 50th International School & Conference on the Physics of Semiconductors „Jaszowiec 2022”

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