XPS measurements on single Bi_2Te_3 nanowires fabricated by electrodeposition in etched ion-track membranes*

J. Krieg[1,2], C. Chen[3], J. Avila[3], C. Trautmann[1,2], M.-C. Asensio[3], and M.E. Toimil-Molares[†1]

[1]GSI, Darmstadt, Germany; [2]Technische Universität, Darmstadt, Germany; [3]SOLEIL Synchrotron, Gif-sur-Yvette, France

Bi_2Te_3 belongs to a recently discovered new class of materials, called topological insulators (TI), which form conductive surface states while their bulk material is an ordinary band insulator. These exotic surface states are generated by strong spin-orbit coupling and feature spin-momentum locking of the charge carriers due to time reversal symmetry. For this reason TI materials are of high interest for future electronic applications like dissipationless transport and spintronics [1, 2]. The major challenge to address the surface states is the reduction of the concentration of residual bulk carriers dominating over the signal. Nanowires (NWs) of high surface-to-volume ratio combined with controllable geometric, crystallographic and morphologic properties are excellent model systems to investigate the TI surface states.

Here, we present x-ray photoelectron spectroscopy (XPS) studies with sub-micron resolution on individual 100 nm diameter Bi_2Te_3 NWs. The NWs are synthesized by electrodeposition in etched ion-track templates fabricated by irradiating 30 μm thick polycarbonate foils with GeV heavy ions at the UNILAC accelerator and selective chemical etching of the ion tracks in 6 M NaOH at 50 °C. Subsequently, NWs are electrodeposited within the channels at an applied potential of 0 V vs. SCE at 30 °C. Details on the fabrication and characterization are reported in [3].

After deposition, the NWs were released from the membrane and randomly distributed onto a silicon wafer. Figure 1 displays XPS spectra recorded with an unfocused beam, i.e. from the entire substrate, as prepared (red), after 15 s (blue) and 15 min (black) of Ar plasma cleaning in UHV. The O and C signals indicating contamination of the Bi_2Te_3 surface by i.e. oxidation, polymer residual, etc., decrease with increasing cleaning time. After surface preparation, single NWs were identified in the focused beam mode by scanning the area of interest and detecting only photoelectrons of a certain energy (corresponding to Bi or Te). A representative XPS map is presented in fig. 2 a evidencing the excellent spatial resolution achieved. Single NWs can be distinguished from bundles and analysed in more detail. Figures 2 b and c display two mappings of the single NW marked in fig.2 a (black frame) recorded using Te 55 eV (b) and Bi 68.5 eV (c), respectively. The Te signal is localized on the NW, while Bi signals are detected also at larger distances from the NW surface. Further measurements are required to understand the origin of these signals at 68.5 eV in the NW surroundings.

In conclusion, the first nano-XPS measurements on 100 nm diameter Bi_2Te_3 NWs were successfully performed. A cleaning protocol to obtain highest surface quality was established. Point XPS spectra along the NWs indicate that our NWs are of homogeneous elemental composition.

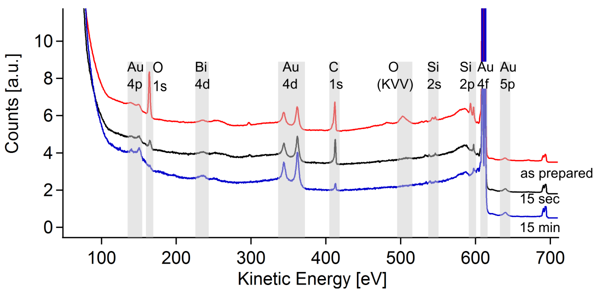

Figure 1: XPS spectra recorded in defocused mode as prepared, after 15 s and after 15 min of Ar plasma cleaning.

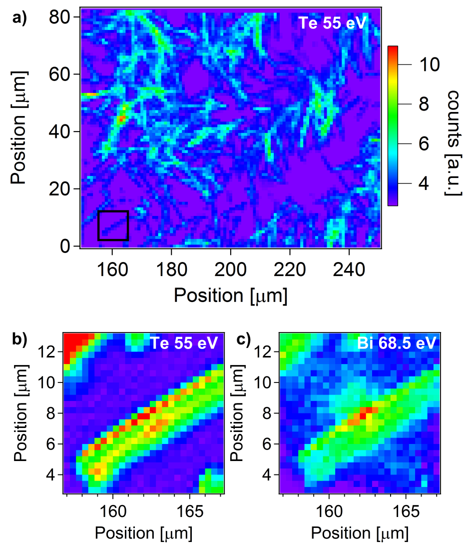

Figure 2: XPS mappings of Bi_2Te_3 NWs: overview (a), single NW recorded by analysing Te (b) and Bi (c) spectra.

References

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† M.E.ToimilMolares@gsi.de

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