MS41-O3 Twin domain mapping in topological insulator Bi_2X_3 (X=Se,Te) by scanning XRD and electron backscattering diffraction

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3D topological insulators are a new kind of matter with inverted bulk band gap and Dirac cone-like surface states [1]. Bi_2X_3 with X=Se and Te are prime members of this material class and were shown to exhibit the predicted topological properties [2]. For electrical devices made from these materials large area high quality thin films are required which, however, commonly show the formation of twin defects as can be seen in Figure panel a. Horizontal (c-plane) twin defects were shown to influence the electronic properties [3] whereas little is known about vertical twin defects. We have investigated the horizontal and vertical twin defect formation in molecular beam epitaxy grown Bi_2Se_3 and Bi_2Te_3 thin films by scanning x-ray diffraction (SXRD) [4] and electron backscatter diffraction (EBSD). With EBSD we directly obtain the crystal orientation in the vicinity of the surface as shown in Figure panel b. Scanning x-ray diffraction probes the bulk of the thin films and thus complements the surface sensitive electron imaging techniques. For SXRD a focused x-ray beam (~150 nm diameter) is used and with the samples mounted on piezo-scanners the XRD intensity is mapped in real space. Performing measurements at the asymmetric (10-1.20) Bragg peak the XRD intensity (Figure panel c) therefore reveals that defects separating the two twin domains are not strictly vertical but that one twin domain might also overgrow another second one. Based on these results we are able to present a strategy to reduce the surface density of such defects which has important implications for the study of topological surface states.

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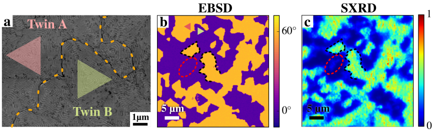

Figure 1. Twin formation in Bi_2Te_3 thin films. a) Scanning electron micrograph of a twin boundary (dashed line) separating two twinned areas. b) Electron backscatter diffraction (EBSD) inplane orientation map showing the twin domains in the very same area as bulk sensitive scanning XRD measurement c).

Keywords: scanning x-ray diffraction, electron backscatter diffraction, twin domain, topological insulators