Growth and Characterization of Ultrathin Topological Insulator Sb_2Te_3 /Bi_2Te_3 heterostructures on Si(111) grown by means of Molecular Beam Epitaxy

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Due to recent studies of possible dissipationless surface transport, topological insulators (TI) attracted attention to the field of condensed matter physics[1]. These surface states are topologically protected by time reversal symmetry and offer interesting fields of research like spintronics or quantum computing[2]. Band structure calculations showed that Sb_2Te_3, Bi_2Te_3 or Bi_2Se_3, are very promising materials to realize a three-dimensional topological insulator[3]. It was experimentally found out that these materials have a large background doping (n_{3D}~$10^{19}\mathrm{cm}^{-3}$) caused by vacancies or anti-site defects[4]. In order to have access to the fascinating properties of the topological insulators, it is mandatory to move the Fermi energy into the band gap to eliminate the bulk carrier transport. One approach is to use ternary[5] alloys, e.g. $BiSbTe_3$, and make use of compensation between p- and n-type doping.

Here, we follow a different approach, rather than employing an alloy we realized a p-n junction formed by a p-doped topological insulator layer on top of an n-doped one. We fabricated topological insulating Sb_2Te_3/Bi_2Te_3 p-n heterostructures by means of molecular beam epitaxy and characterized the topography of the films by scanning tunneling microscopy. Due to the van der Waals growth mode of the layered Te compounds, x-ray diffraction measurements show that the heterostructure is fully relaxed on the Si(111) substrate. Furthermore, scanning transmission electron microscopy measurements unveil the crystalline structure of the p-n interface. Energy dispersive x-ray spectroscopy and atom probe tomography enable the mapping of the chemical element distribution. We conclude that a diffusion of Sb and Bi during growth causes the formation of a ternary gradient. Transport measurements prove the tunability of the carrier concentration via composition of the p-n heterostructure.

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