Epitaxial Growth and Band Structure of Lead Tin Chalcogenide Topological Crystalline Insulators

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Topological crystalline insulators (TCI), where topological surface states (TSS) are protected by crystal symmetry, have been recently theoretically predicted [1] and experimentally realized for (001) cleaved bulk samples of SnTe and solid solutions of $Pb_{1-x}Sn_xTe$ and $Pb_{1-x}Sn_xSe$ [2-4]. TSS have been indeed observed by angle resolved photoemission spectroscopy (ARPES). Existence of TSS and studies of topological nature of other surfaces are certainly of interest but the growth of bulk single crystals in other orientations remains challenging [5]. Moreover simultaneous observation of conduction and valence band surface states by ARPES in TCIs based on SnTe is difficult due to highly p-type doping nature of these materials.

In this work, molecular beam epitaxy (MBE) of (111) oriented $Pb_{1-x}Sn_xTe$ and $Pb_{1-x}Sn_xSe$ heteroepitaxial layers grown on BaF_2 substrates is demonstrated and their structural and electronic properties investigated. By control of the growth conditions, high quality epilayers with different Sn concentration were obtained. The carrier concentration and thus, the position of the Fermi level is controlled by Bi-doping. Hall effect measurements performed at low temperatures confirmed excellent quality of the samples and mobility of order of 10000 $cm^2V^{-1}s^{-1}$ was achieved that makes further investigations of transport and magneto-optical properties of the samples very perspective.

ARPES studies were performed at the PGM-1 synchortron beameline at BESSY II. Temperature and Sn content dependent E ($k_{//}$) maps recorded around the Γ-point. For certain temperatures and Sn concentrations, formation of TSS and band gap closing were observed. In addition, a giant Rashba splitting is observed for $Pb_{1-x}Sn_xTe$ samples which can be controlled by Bi doping. The value of Rashba parameter

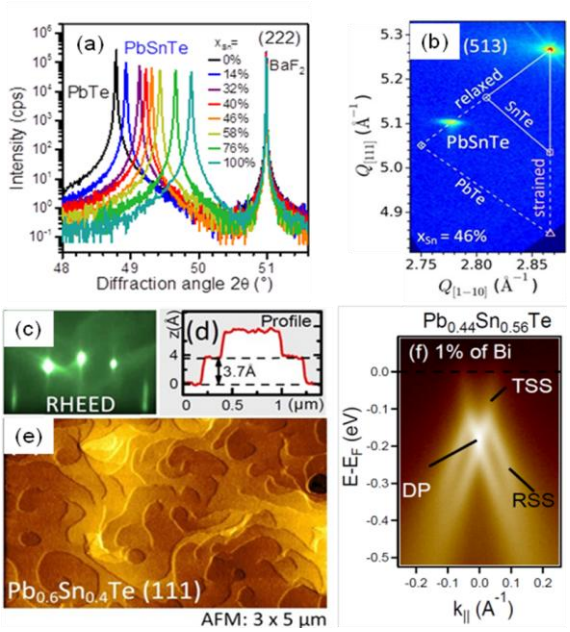

Fig. 1: (a) XRD pattern, (b) reciprocal space map around the asymmetric (513) reflection, (c) RHEED pattern, (e) AFM image with (d) line profile and (f) ARPES spectrum for (111) $Pb_{1-x}Sn_xTe$ epilayer with x_{Sn}= 0.46.

as large as α_R=3.5 eVÅ can be achieved for our samples, which comparable to the values reported for other giant Rashba splitted systems.

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