(111) Topological Crystalline Insulator Epilayers with Dirac-Rashba Surface States

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Semiconductors with large spin-orbit interactions exhibit physical properties that are of interest for potential spintronic applications [1]. Here we report on angle- and spin- resolved photoemission experiments of IV-VI topological crystalline insulator $Pb_{1-x}Sn_xSe$ and $Pb_{1-x}Sn_xTe$ epilayers grown by molecular beam epitaxy in (111) orientation. In these materials a giant Rashba splitting can be induced not only by bulk doping with Bi as shown previously for $Pb_{1-x}Sn_xTe$ [2] but also by surface doping with Sn. The latter experiments were carried out in-situ under UHV conditions at the UE112_PGM-2a-1^2 beamline at the BESSY II synchrotron. By ARPES measurements, we shown that the resulting Rashba parameter α_R can be tuned over a wide range from 0 to 3.8 eV·Å. In contrast to other topological insulator systems like Bi chalcogenides [3], where the Rashba surface state (RSS) are separated in energy and *k*-space from the topological surface states (TSS), in the IV-VI compounds investigated here, the branches of the RSS can be tuned in such a way that they overlap with the TSS such that Kramers and Dirac points coincide (see Fig. 1). This raises the fundamental question about the hybridization of these states and the modification of spin texture, the consequence of this will be discussed. Results will be compared with the theoretical surface spectral density of states obtained using a tight-binding approach and recursive Green's function method. In the calculations the observed Rashba effect was simulated by applying a potential described by Thomas-Fermi screening model.

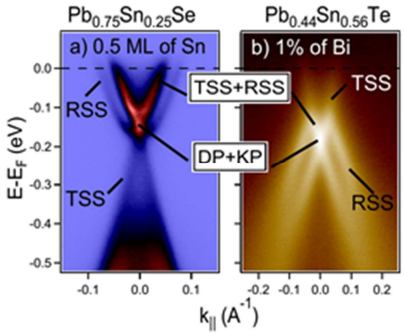

Fig. 1: ARPES spectra of $Pb_{0.75}Sn_{0.25}Se$ (a) and $Pb_{0.44}Sn_{0.56}Te$ (b) epilayers recorded at the point at 150K, demonstrating the superposition of the topological surface states with the Rashba bands. The Rashba splitting is invoked by deposition of 0.5 monolayer of Sn or bulk doping with 1% of Bi. The topological surface states, Rashba surface states, Dirac and Kramers points are indicated and marked as TSS, RSS, DP and KP, respectively.

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