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Electron and spin properties of topological crystalline insulator (Pb,Sn)Se[1]

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Topological crystalline insulators (TCIs) constitute a new class of quantum materials with the Dirac-like metallic surface states that cross the bulk semiconductor band gap and are topologically protected by crystalline mirror plane symmetry. The TCI states have recently been experimentally observed in (Pb,Sn)Se, SnTe, and (Pb,Sn)Te for both (001) and (111) crystal surfaces. These IV-VI semiconductors undergo (at a specific tin content, temperature, and pressure) a band structure inversion driven by strong relativistic effects. The investigations of the surface electronic states by angle- and spin-resolved photoemission spectroscopy will be presented for bulk (Pb,Sn)Se monocrystals with tin content up to 37 at. %, also doped with magnetic Mn 2+ ions. In the inverted band structure regime we found the Dirac-like topological in-gap states in the vicinity of four X points of the (001) surface Brillouin zone and observe a temperature-driven topological phase transition from a trivial insulator to a TCI state below the band inversion point. In crystals with Mn ions we demonstrate very efficient tuning of the topological transition temperature by band gap engineering effect. The spin-resolved ARPES experiments revealed a characteristic vortical electron spin polarization texture at the Dirac points. Based on spectroscopic observation we construct the composition - temperature topological phase diagram of (Pb,Sn)Se and compare it with tight-binding band structure calculations. P. Dziawa et al., Nat. Mat. 11, 1023 (2012); B.M. Wojek et al., Phys. Rev. B 87, 115106 (2013); C.M. Polley et al., Phys. Rev. B 89, 075317 (2014); B.M. Wojek et al., Phys. Rev. B 90, 161202 (R) (2014).

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