Electron transport signatures of bulk band inversion in $Pb_{1-x}Sn_xSe$ topological crystalline insulators

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Topological insulators are a new class of quantum materials in which time-reversal symmetry and relativistic (spin-orbit) effects and inverted band structure result in electronic metallic states on the surface of bulk crystals. These states exhibit Dirac-like energy dispersion across bulk band-gap and are topologically protected against disorder. Theoretical proposals show that topological insulator states can also be induced in new materials by specific crystalline symmetries [1]. The first material that has been theoretically identified as topological crystalline insulator is SnTe [2]. In subsequent research it has been demonstrated that $Pb_{1-x}Sn_xSe$ and $Pb_{1-x}Sn_xTe$ solid solutions exhibiting inverted band structure belong to the same class of topological crystalline insulators family [3,4,5].

Here we report on electric and thermoelectric transport characteristics of topological crystalline insulator samples made of bulk $Pb_{1-x}Sn_xSe$ monocrystals grown by self-selective vapour growth with composition (x) ranging from 0.19 to 0.30. A set of measurements of resistivity as well as Hall, Seebeck and transverse Nernst-Ettingshausen effects were performed for each sample. The PbSe sample served us as a trivial insulator (non-topological) reference. All the samples are highly degenerate with electron concentration on the order $10^{18}cm^{-3}$. Even though the resistivity, Hall and Seebeck coefficients display some broad features in the vicinity of band inversion temperature, its the precise determination requires detailed model of band structure parameters over whole range of compositions. Likely, it occurred that Nernst-Ettingshausen coefficient changes sign, while passing through point where bulk bands interchange their order. The transition temperature obtained this way agrees well with that determined from angle resolved photoemission spectroscopy studies [3]. Furthermore, the non-topological reference sample does not exhibit such a sing change. Consequently, we propose transverse Nernst-Ettingshausen coefficient to be a good experimental signature of transition to topological crystalline insulator state.

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