Investigating of the topological phase transition in $Pb_{1-x}Sn_xTe$ topological crystalline insulators by using nonlinear Hall effect measurements

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The linear Hall conductivity occurs in the systems, which have broken time-reversal symmetry either by the intrinsic or external magnetic field. However, recently predicted nonlinear Hall effect (NLHE) preserves time-reversal symmetry but it breaks inversion symmetry [1]. NLHE appears from the anomalous velocity of the Bloch electrons due to Berry curvature. Therefore, topological crystalline insulators and the Weyl semimetals are the potential candidates for NLHE due to a Berry curvature dipole [1-3]. The surface of topological crystalline insulators hosts massless Dirac fermions protected by mirror symmetries [2]. At low temperatures, ferroelectric transition caused one of the mirror symmetries to be broken. In the case of thin film, the small mismatch of the lattice parameter can also break the mirror symmetry. The present study reports a NLHE in the $Pb_{1-x}Sn_xTe$ topological crystalline insulator thin films with varying Sn composition. The thin film samples of $Pb_{1-x}Sn_xTe$ with compositions x=0.35 and x=0.42 were grown by molecular beam epitaxy (MBE) on (100) oriented CdTe (4 µm) // GaAs substrates. The nonlinear Hall signal appeared only when the AC excitation was applied along the mirror axis i.e. [110] in our case. The measurements of a nonlinear Hall voltage follows the same geometry as used in ordinary Hall effect, but the transverse voltage is measured at double-frequency, $V_2\omega$ and zero-frequency (DC) V_0 by using lock-in amplifiers. Both voltages quadratically depend on the perpendicular driving current and decrease when reaching transition from topological to trivial band ordering with rising temperature. The observed phenomenon opens the possibility of exploring topological phase transition as a function of temperature, composition and hydrostatic pressure in topological crystalline insulators.

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