Signatures of Weyl Fermions in Magnetotransport of Topological Semimetal α-Sn

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Topological semimetals have emerged as an attractive platform for both applied and fundamental research. This has been stimulated by their unique electronic properties, namely the presence of topological surface states (TSSs) and a linear, Dirac-like band structure in the bulk. Among the many compounds studied, α-Sn (grey tin) is of particular interest as a rare example of an elementary material with an inverted band structure. Nominally a zero-gap semiconductor, it can be turned into both Dirac semimetal (DSM) and topological insulator (TI) phases by strain [1]. Despite its rich topological phase diagram, most of reports focus on the properties of TSSs in the TI phase of grey tin.

Successful molecular beam epitaxy (MBE) on a hybrid, insulating CdTe/GaAs(001) substrates allows us to address a weakly explored part of the grey tin topological phase diagram of gray tin. With film thicknesses up to 200 nm and compressive in-plane strain introduced by the substrate, we ensure that our α-Sn layers are in the DSM phase. Here we will present the results of a thorough magnetotransport studies of our structures, focusing on signatures of 3D Dirac and Weyl fermions.

The π-Berry phase of Shubnikov-de Haas oscillations is found in magnetic fields both perpendicular (B_{perp}) and parallel (B_{paral}) to the current, which is a signature of the 3D nature of the observed carriers and their non-trivial topology. The low effective mass derived from the temperature-dependent amplitude of the oscillations, $m^* \approx m_0$, is consistent with previous reports. Importantly, we perform a detailed study of the negative longitudinal magnetoresistance (NLMR), present in B_{paral} up to 30 T. By ruling out alternative sources of NLMR, we are able to relate it to the chiral anomaly – a phenomenon expected for Dirac and Weyl semimetals. Finally, we analyse the anisotropic magnetoresistance (AMR) and the planar Hall effect (PHE), observed when the sample is rotated in a constant, in-plane magnetic field. We show that these effects exhibit an angular dependence consistent with anomaly-related magnetoresistance. Altogether, our work establishes the electronic properties of α-Sn as consistent with the 3D DSM phase, confirming previous theoretical predictions [1] and laying a solid foundation for further research.

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