MBE growth and topological phases of α-Sn epilayers on insulating (001) CdTe/GaAs substrates

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α-Sn is a zero-gap semiconductor that under external perturbations can possess various topological phases [1]. Bulk α-Sn is only stable below 13.2 °C. However, the α-Sn phase can be stabilized above room temperature in a thin film form [2]. Recent experimental studies of this material have been mainly focused on α-Sn grown on narrow gap semiconducting substrates [3,4], which makes transport investigations problematic and limits potential applications of this material [4].

In this work, we experimentally show that under applied in-plane compressive strain Dirac semimetal (DSM) phase exists which further is transformed in the Weyl semimetal (WSM) phase under applying magnetic field. 30-200 nm thick films of α-Sn are prepared by the molecular beam epitaxy on (001) GaAs with CdTe buffer. Structural characterization performed by reflection high-energy electron diffraction (RHEED), atomic force and scanning electron microscopy as well as X-ray diffraction (XRD) proves high quality of obtained samples. XRD measurements revealed -0.14 % of in-plane compressive strains, the prerequisite for the DSM phase. The α-Sn band structure is studied by angle-resolved photoemission spectroscopy (ARPES) as a function of both temperature and film thickness. It is shown by ARPES that the prepared samples possess DSM phase in the temperature range 10-300 K. The presence of the WSM phase is further confirmed by magnetoresistance measurements. Negative longitudinal magnetoresistance (NLMR) is observed in a wide temperature range (1.6-90 K). Pronounced Shubnikov–de Haas oscillations confirm the structural perfection of prepared samples.

Our results provide an important platform for further reliable investigation of transport properties and possible application of α-Sn in spintronic devices.

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References

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