Surface dependent doping efficiency in Te:Cd_3As_2 Thin films

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Cd_3As_2 is a prototypical Dirac semi-metal, a class of materials with gapless topologically protected electronic states. In this system, these topological electronic states are close to the intrinsic Fermi level and are well isolated from non-trivial bands. Additionally, this system is air stable and compatible with molecular beam epitaxy, including lattice matching to III-Sb and II-Te layers, and similar elements to conventional semiconductors. These materials could play a role in a large number of applications, including transistors, spintronics, photodetectors, and thermoelectrics. To do this, however, significant progress must be made on achieving tunability of these materials. In particular, routes to altering its typical n-type carrier concentration must be developed.

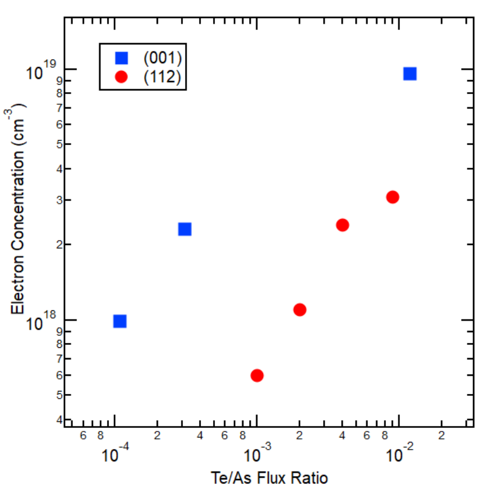

Figure 1. Electron concentration vs dopant flux ratio in Cd_3As_2 thin films of two different orientations

Previous attempts to dope $Cd_3As_2(112)$ with group VI elements, including Te and Se, were successful, allowing for increases of n_{3d} from 5e17 cm^{-3} up to slightly over 3e18 cm^{-3} [1]. Concentration vs mobility relationships appeared similar to doping in convention semiconductors, with mobility decreasing with increased ionized impurities. Attempts to increase doping beyond this level by using increased group VI fluxes resulted in lower measured Hall concentrations and even larger decreases in mobility, a sign that compensating defects are forming. When similar doping is attempted on the (001) surface, however, doping beyond 1e19 cm^{-3} is possible. Furthermore, an order of magnitude smaller Te fluxes are required to achieve similar doping levels. Finally, smaller unintentionally doped carrier concentrations are achievable on this surface. This work highlights the role of surface kinetics in defect incorporation in topological semi-metals.

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