Electrical Transport of Zn-doped Dirac Semimetal Cd_3As_2 Films

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Topological semimetals (TSMs) are emerging as materials with potential use in low powered electronics and spintronic devices [1-4]. In order to translate the useful properties of TSMs to device applications, studies focusing on reliable epitaxial growth, disorder, and the control of electronic states in TSM films are needed. Here, we focus on the use of alloying with Zn to modify the electronic structure and electrical transport of $(Cd_{1-x}Zn_x)_3As_2$ with x = 0-0.23.

Zn doping of Cd_3As_2 has been used to lower the carrier concentration and move the Fermi energy closer to the Dirac point. However, the addition of Zn is also expected to modify the band structure, causing a change in the electronic structure from Dirac semimetal to semiconductor [5]. By tuning the growth conditions to suppress native defects in our films [6] we are able to produce $(Cd_{1-x}Zn_x)_3As_2$ films with carrier concentrations a full order of magnitude smaller (as shown in Fig. 1b, ~10^{17} cm^{-3}) than other literature reports (>10^{18} cm^{-3}) [7]. Lowering the starting carrier concentration enables us to tune the Fermi energy with smaller amounts of Zn doping.

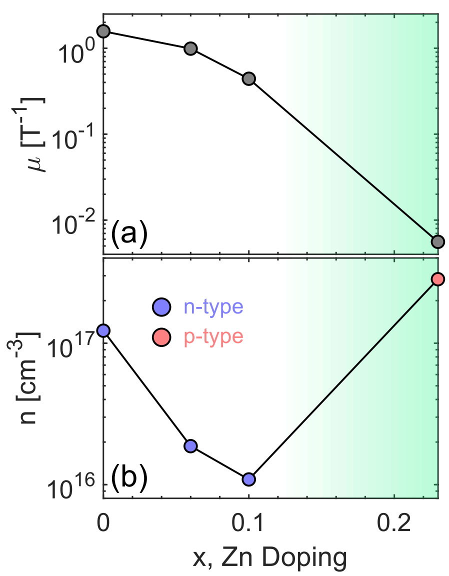

Figure 1: Zn doping dependence of (a) the low-field mobility and (b) carrier density. Low doping densities lower the electron-like carrier density while slightly reducing the mobility. Increasing above 10% Zn doping, the mobility drops by two orders of magnitude and the dominant carrier type switches from electron-like (blue) to hole-like (red). The green shaded region reflects Zn doping sufficient to alter the electronic structure.

Figure 1 shows the Zn doping dependence of the low-field mobility and the carrier density for our films. For x < 0.1, we observe a slight reduction in mobility with increasing x paired with an order of magnitude reduction in the carrier density. By x = 0.23, the dominant carrier switches from n-type to p-type accompanied by a 100x reduction of the carrier mobility, consistent with the transition from TSM Cd_3As_2 to semiconducting Zn_3As_2 behavior. We will present a careful analysis of the electrical transport properties to explore the low Zn doping regime where the n-type carrier densities reach their lowest values before the electronic structure is significantly altered.

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