Effect of Epitaxial Compression on Structural and Electrical Transport Properties of 3D Topological Dirac Semimetal Cd3As2

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Three-dimensional topological Dirac semimetals (3D-TDSMs) have unusually high mobility at room temperature due to their unique linear electronic band dispersion and nontrivial band topology. Devising a method to tune the band dispersion of 3D-TDSMs could revolutionize the field of electronics. This study aimed to determine if an epitaxial compression could alter the electronic transport properties of Cd3As2, a 3D-TDSM. Cd3As2 thin films were grown on (In(x)Ga(1-x))Sb buffer layers deposited on a GaAs substrate. The concentration of indium and gallium were varied to induce an epitaxial compression in the Cd3As2 thin film. The following four indium concentrations were each deposited onto its GaAs substrate: 0.76 In (lattice match), 0.74 In (0.195% lattice mismatch), 0.70 In (0.483% lattice mismatch), and 0.66 In (0.661% lattice mismatch). X-ray diffraction measurements were used to verify changes in the lattice parameter. Atomic force microscopy confirmed the surface morphology of the epitaxially compressed Cd3As2 thin films. Hall bars were prepared on the Cd3As2 thin film to measure electrical transport properties including sheet resistance, mobility, and sheet density at variable temperatures. The study found that the heteroepitaxial films exhibited differing electrical transport with the lattice match thin film having the highest mobility. The change in mobility, sheet resistance, and sheet density of the heteroepitaxial films suggests that the band dispersion of Cd3As2 had changed. Collectively, this study demonstrated that epitaxial compression can be used successfully to alter the electronic transport properties of 3D-TDSM thin films.

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