Materials Science & Engineering Thesis Defense

Synthesis and Characterization of 2D Quantum Rare-earth-Tri-tellurides to analyze its CDW behavior.

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Abstract

In Rare-earth-Tri-telluride family, RTe3s [R=La, Ce, Nd, Sm, Gd, Tb, Dy, Er, Ho, Tm] the emergence of Charge Density Waves has been under investigation from a long time due to broadly tunable properties by either chemical substitution or pressure application. These quasi 2D Layered materials RTe3s undergo nesting of Fermi Surface leading to CDW instability. CDWs are electronic instabilities found in low-dimensional materials with highly anisotropic electronic structures. Since the CDW is predominantly driven by Fermi-surface (FS) nesting, it is especially sensitive to pressure-induced changes in the electronic structure. The FS of RTe3s is a function of p-orbitals of Tellurium atoms, which are arranged in two adjacent planes in the crystal structure. Although the FS and electronic structure possess a nearly four-fold symmetry, RTe3s form an incommensurate unidirectional CDW more favorably then bidirectional. The lighter RTe3s [La-Gd] possess single, incommensurate, unidirectional CDW transition, while the heavier RTe3s[Tb-Tm] possess a second CDW lower transition temperature, with an orthogonal in-plane wavevector. The orthorhombic crystal structure, with a and c-lattice vectors lie in Te-plane, constrains the wavevector of the high temperature transition along c-axis.This dissertation includes details for the crystal growth of various rare-earth-tri-tellurides, RTe3s by Chemical Vapor Transport including various precursors, transport agent, temperature gradient, and rate of the growth. After the growth, the crystals were confirmed by Raman, EDS; crystal structure and orientation was confirmed by XRD; topological images were taken by SEM. Magnetic phase was established by VSM measurement. Detailed CDW study was done on various RTe3s by Raman spectroscopy. Temperature dependent Raman study of RTe3s established the CDW transition temperature and Kohn anomaly, also known as Phonon softening. Angle resolved Raman data confirming the nearly four-fold symmetry. Thickness dependent Raman spectroscopy resulting in the conclusion that as thickness decreases CDW transition temperature increases. Electrical measurements like R vs T to compare CDW transition by different modes of excitation, photons and electric field. I-V measurements of Schottky junction with RTe3 as metal and Silicon as semiconductor, gave the idea of CDW transition at space charge region. CDW transition is analyzed as a function of alloying.

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