Abstract:

The discovery of superconductivity by Heike Kamerlingh Onnes in 1911 is one of the major breakthroughs in the field of condensed matter physics. A number of superconducting materials such as intermetallics, cuprates, iron oxypnictides, bismuth chalcogenide, and transition metal dichalcogenide based systems have been extensively investigated in the last few decades. Recently, the area of superconductivity has been rejuvenated after the discovery of superconductivity in the noncentrosymmetric crystal structures. The absence of inversion symmetry introduces an antisymmetric spin-orbit coupling (ASOC) which lifts the original spin degeneracy at the Fermi level, splitting it into two spin-ordered sub-surfaces. This allows the admixture of spin-singlet and spin-triplet pairing states within the same orbital channel.

In this thesis, we have discussed the synthesis, characterization, and physical properties of rare earth chalcogenides La_3Se_4, $La_{2.75}Y_{0.25}Se_4$, and La_3SeTe_3. Polycrystalline chalcogenides were synthesized by solid state sealed tube technique. This thesis discussed the detail characterization of La_3Se_4 and its derivatives in the context of noncentrosymmetric superconductivity. All the systems crystallize in noncentrosymmetric cubic body-centered Th_3P_4-type structure with space group I-43d. We have discussed the superconducting properties of La_3Se_4 with superconducting transition temperature Tc ~ 8.5 K in detail by means of X-ray diffraction, electrical transport, magnetization, heat capacity measurements, and density functional theory calculations. The specific heat jump at Tc, $\Delta C/\gamma Tc \sim 2.04$, exceeds the value for weakly coupled BCS superconductor, suggesting superconductivity in La_3Se_4 is in the strong-coupling regime. From the density functional theory based first-principles studies, we observe that the number of states at the Fermi energy is dominated by *d* and *f* electrons of La, and is found to be highly sensitive to the La deficiency in La_3Se_4.

Superconductivity is found in $La_{2.75}Y_{0.25}Se_4$ below Tc ~ 7.4 K. Bulk superconductivity is confirmed by the jump at Tc of the specific heat with $\Delta C/\gamma Tc \sim 0.7$, and the value is much smaller than the isotropic weak coupling BCS value of 1.43. Therefore, $La_{2.75}Y_{0.25}Se_4$ is a weakly coupled superconductor. Detailed superconducting characteristic parameters have been estimated.

Superconducting transition below 2.3 K has been observed in La_3SeTe_3. From the temperature dependent DC susceptibility measurement, it has been observed that the onset of diamagnetism occurs at 2.4 K in ZFC measurement. Normal-state properties such as Sommerfeld coefficient, phonon specific heat coefficient, Debye temperature, electron-phonon coupling constant, and density of states have been discussed.