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Title of Thesis: **Synthesis and characterization of iron chalcogenide superconductors**

Abstract

Certain materials at low temperatures exhibit interesting property of superconductivity. Superconductors are metals or metallic compounds which when cooled below a certain temperature; lose their electrical resistance completely and exclude external magnetic fields due to formation of Cooper pairs. Thus, a superconductor acts as a perfect conductor and a perfect diamagnet.

Prior to the discovery of high temperature superconductors, the use of superconductors required liquid helium or liquid hydrogen as coolant. For superconductors with T_c 90 K, the cost effective liquid nitrogen was used as coolant. The superconducting transition temperature has become a major interest for the researchers worldwide. With the aim to develop a room temperature superconductors that will dramatically change energy requirements in terms of electricity production and transmission. The ultimate goal of world-wide investigations on various properties of superconductors is to understand the phenomenon of superconductivity that will help to design superconductors at room temperature.

In 2008 iron based superconductor drew great attention of the scientific community. These superconducting materials are yet to be investigated in detail both theoretically and experimentally in order to understand the mechanism behind superconductivity and physical property variation. The discovery of iron based superconductors (FBSs) laid the foundation of a new era in the field of superconductivity by replacing the Copper Age by Iron Age. The most fascinating property of these superconductors is an easy interplay between superconducting and magnetic properties, which is one of the important aspect for designing new materials of technological interest. Practically, the iron based superconductors seem to be even better candidates for applications in power generation and power transmission. Iron chalcogenides, the binary FeSe, FeTe and Ternary FeTeSe are the simplest structures among Fe based superconductors. Iron telluride is regarded as the parent compound of the "11"

family and is not a superconductor, but it can become superconductor when doped with oxygen or Se/S.

In this thesis we study the structural, electrical and magnetic properties of iron base superconductors. We prepared the samples through solid state reaction route and characterized them with XRD, SEM, Raman study, Resistivity, magnetic measurements and EXAFS study .The prepared samples show single phase with tetragonal structure with space group P4/nmn confirmed from Reitveld refinement using full proof programme and dense surface morphology has been seen from SEM images. The Raman spectra exhibit similar characteristics of XRD with variation of intensity, suggesting unconventional nature of superconductivity. Temperature (12 K $\leqslant$ T $\leqslant$ 300 K) dependent extended x-ray absorption fine structure (EXAFS) studies at the Fe K edge in $FeSe_{1-x}Te_x$ (x = 0, 0.5 and 1.0) on such compounds. The data for all three compounds exhibit a double peak structure in the range of 1.5 to 3 Å. Results show superconducting nature of FeSe which when doped with Te forms $FeSe_{0.5}Te_{0.5}$, also shows superconducting properties with enhanced T_c. On the other hand, FeTe is found to be non-superconductor although shows SDW around 78K and become superconductor via doping Se (0.50%).
The R(T,H) plot shows high upper critical fields and from (DC/AC) magnetic susceptibility measurements bulk superconductivity and, weak coupling between the grains has been confirmed. Besides isothermal M(H) loop in the first quadrant at 5K shows that lower critical field(H_{c1}) is around 100 Oe. Also thermally activated flux flow(TAFF) of Arsenic free $FeTe_{0.5}Se_{0.5}$ sample were analysed by using conventional Arrhenius relation and modified TAFF model and it was found that there is decreasing of activation energy by applying magnetic field and is attributed to the weak coupling grain boundary pinning. Influence of pressure enhances T_c from 12K to 25K on $FeTe_{0.5}Se_{0.5}$ sample indicating charge carriers are increased at Fermi surface. The interplay between superconductivity and magnetism on Fe-based superconductors has been explained through phase generic diagram their important applications have also been mentioned in this thesis.