SYNOPSIS

Ever since the discovery of superconductivity in cuprates it has been realized that defects in various forms and dimensions play a crucial role in controlling the superconductivity in these systems. The present thesis attempts to understand the defect controlled charge transfer phenomenon occurring on different length scales in the well studied $YBa_2Cu_3O_{7-y}$ system.

Chapter-I gives an introduction to the phenomenon of superconductivity and its chronological development. The salient features of the high Tc superconductors (HTSC) are briefly outlined with a special reference to the defect mediated mechanism and charge transport in these systems. A brief review of the literature existing in this area is presented in Chapter-II.

Chapter-III deals with the facilities developed in house for the preparation of HTSC samples in the form of bulk sinters and thick films and their characterization by various techniques. These include automatic data acquisition system for DC four probe resistivity, AC magnetic susceptibility measurement, current pulse technique for Jc measurement, and oxygen determination by idometric titration. A brief outline of the facility developed at the Nuclear Science Centre for simultaneous in-situ resistivity data acquisition of multiple samples during swift heavy ion (SHI) irradiation is also given here.

A crystallochemical analysis of oxygen deficient and tri/monovalent ion doped YBCO is presented in Chapter-IV. The analysis reveals the evolution of metastability in this system by way of coordination incompatibility and charge state instability in the charge reservoir layer. The importance of the metastable states in inducing charge and spin fluctuations in the cuprate structure, and hence for the very existence of superconductivity in the cuprates is discussed. The applicability of this analysis is examined in a series of Ag doped YBCO in

Chapter-V. Some of the controversies existing in the literature on the solubility limit of Ag in the YBCO lattice, effect of Ag doping on the structure and superconductivity and the reduced oxygen in/out diffusion in Ag doped YBCO systems are addressed and a possible explanations for the same is given based on our experimental data.

Analysis of the charge transfer process in granular HTSC's are under taken in Chapters-VI and VII. A detailed study of the temperature dependence of resistivity in a series of granular YBCO/Ag composite bulk and thick film samples with varying Ag content indicate that the global (macroscopic) charge transfer is strongly influenced by the details of local current distribution. Thus, a percolative current conduction model was used to quantify the granularity in our samples in terms of the parameters like the weak-link resistivity across grain boundaries and the current percolation factor arising from the misaligned grains and sample dependent defects such as voids and cracks. Evolution of these parameters, estimated from the temperature dependence of resistivity, with Ag content showed that Ag modifies the microstructure of the composites and influences the charge transfer process in them. The implication of the present study on the grain growth and narrowing of grain size distribution in the composites is discussed.

Chapter-VIII reports the response of granular sintered cuprates to SHI (120 MeV S and 250 MeV Ag) irradiation. We analyze the evolution of the temperature dependent resistivity characteristics of YBCO and YBCO/Ag composite thick films with irradiation fluence and probe into the inter and intragranular modifications induced by these ions. In particular, we show that SHI irradiation can effect grain alignment in an otherwise randomly oriented granular superconductor and can cause a Tc suppression in the grains due to secondary electrons emitted during ion irradiation.

The important findings of the present work are outlined in Chapter IX.