ABSTRACT

The surprising and at the same time puzzling superconducting properties of the ceramic superconductors , in particular, their the high transition temperatures - T_C, attracted global attention to these exotic materials. In addition to their unique superconducting properties, the understanding of the normal state properties also offers great challenge to the scientists. Since 1986 numerous studies have been undertaken to clarify the superconducting as well as normal state transport properties with the expectation that they will shed light on the mechanism of superconductivity in HTSCs. Their strange normal state properties are most vividly displayed in the transport properties like electrical resistivity, Hall effect, thermoelectric power. But these probes become ineffective in superconducting state and hence thermal conductivity becomes an effective probe to study the superconducting state behaviour. In order to investigate both the normal and superconducting state properties, in the present programme a study of temperature dependence of thermal conductivity and thermoelectric power of several (Bi,Pb) superconducting cuprates have been undertaken.

Temperature dependence of thermal conductivity of vanadium/nickel substituted polycrystalline 2223 (Bi,Pb) superconducting cuprates has been investigated on a series of samples. Samples are prepared by usual ceramic route and are characterised by X-ray diffraction indices, scanning electron microscopy (SEM). Substitutions by vanadium/nickel effectively suppress T_{CO}. The magnitude of thermal conductivity is also seen to be influenced significantly by above substitutions in the entire temperature range of measurement. However, this effect is more drastic in case of Ni substitution. The observed

profile of temperature variation of thermal conductivity of these samples can be explained well in terms of Tewordt and Wölkhausen formula. Analysis of the data also confirms the dominant role of phonon-defect scattering near K_{max}, while phonon-electron interaction becomes important near T_{CO} and above. Similar behaviour is also observed for (Bi,Pb) superconducting cuprates with different Pb content, where T_C is seen to decrease with decreasing Pb content. The electron-phonon coupling strength λ has been estimated from our measured K - T data. Further, detailed analysis of the slope of lattice thermal conductivity indicates strong coupling for some of the carriers in these systems.

Temperature dependence of thermoelectric power of vanadium substituted (Bi,Pb) superconducting cuprates, (Bi,Pb) superconducting cuprates of different Pb content, and (Bi,Pb) superconducting cuprates subjected to various degrees of deoxygenation have been investigated. Thermoelectric power in all cases is found to be positive and increases approximately linearly with decrease of temperature up to about 120K, before falling to zero at T_{CO}. The measured data have been analysed on the basis of different relevant models and it has been established that a modified two band model (Gottwick et al. and Forro et al.) with a narrow peak in the density of states near the Fermi level gives an excellent description (within 1%) of our measured data. We further suggested the p-orbitals of oxygen and d-orbital of copper may be responsible for the origin of the above two band picture.

Mixed state thermoelectric power of pure and vanadium substituted 2223 (Bi,Pb) superconducting cuprates have also been investigated in presence of two different magnetic fields. Pronounced broadening of transition both in electrical resistivity and thermoelectric power have been observe below $(T_C)_{onset}$. Experimental results on mixed state Seebeck effect have been discussed by attributing the observed dissipation to normal quasi particle excitations. However, for lower temperatures, typically below 0.8 T_C, the fluctuations of the order parameter across the internal weak links appears to be an important mechanism for dissipation inducing substantial Seebeck voltage.

Keywords: Thermal conductivity, Thermoelectric power, Mixed state thermoelecric power, High T_C superconductors, Temperature dependence, BiPbSrCaCuO pellets, Vanadium/Nickel substitution, Various Pb content, Deoxygenation, Strong coupling, Quasiparticle, Weak links.