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Title: **Electrical and Thermal behaviour of doped cuprate and magnesium diboride superconductors.**

SYNOPSIS

Electrical and thermal properties of the Mn doped $GdBa_2Cu_3O_{7-\delta}$ superconductors have been investigated. Such materials show a metallic behaviour in their normal state. Resistivity increases monotonically with the dopant concentration; however, a drastic increase in resistivity is observed for $GdBa_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$ with x = 0.01 due to Mn inducing strong fluctuations near the transition temperature T_c. Thermal conductivity shows a hump below T_c for all samples. Except for x = 0.01 sample, peak height of the hump decreases with Mn. We have compared the Gd-based system with Y-based system. In Gd-based cuprates the peak height is reduced to about one-fourth of the value for Y-based samples. Thermoelectric power of Gd-based samples turns from e-like to hole-like even at x=0.005 while for Y-based samples it is e-like (upto 140K) for x=0.0, 0.005 and 0.0075 samples. On the basis of the structure of the *K*-data, and the electron or hole-like nature of S it has been argued that up to x=0.0075 Mn produces qualitatively the same effect in $YBa_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$ as Gd in $GdBa_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$. By analyzing thermal

conductivity data in terms of lattice theory, and thermoelectric power data in terms of a narrow –band picture a qualitative study of the role of Mn is made. In particular, the boundary scattering, point defects and sheet-like faults from the thermal conductivity data analysis, and chemical potential for the TEP analysis support different role of Mn for $x \leq 0.0075$ and $x > 0.0075$. Detailed specific heat measurements carried out on pure and Mn-doped samples of GdBaCuO indicate that the jump in specific heat at T_c depends on the extent of doping. In fact it is seen that the jump decreases with dopant. Specific heat does not show noticeable jump for $x \geq 0.01$. However, there is a clear evidence of superconducting energy gap at zero temperature from K data for all values of x. This feature suggests the presence of strong fluctuations in the specific heat near T_c.

In addition of these measurements resistivity and low-field ac susceptibility measurements of the co-doped system of $Y_{0.95}Pr_{0.05}Ba_2(Cu_{1-x}Mn_x)_3O_y$ ($0 \leq x \leq 2\%$) have been also carried out. Residual resistivity $\rho_{0,Pr\text{-}Mn}$ has been found to increase non-linearly with Mn content violating the Matthiesen's rule. In order to examine the role of Pr in this behaviour we have compared $\rho_{0,Pr\text{-}Mn}$ with resistivity $\rho_{0,Mn}$ of Y-123 without Pr which suggests that Pr plays a major role in determining $\rho_{0,Pr\text{-}Mn}$ upto x = 0.01. Difference of $\rho_{0,Pr\text{-}Mn}$ and $\rho_{0,Mn}$ is termed through the parameter $\Delta\rho_0$. Trend reversal of $\Delta\rho_0$ is attributed to a crossover from minor role of the potential scattering at and below $x = 0.01$ to a major role above $x = 0.01$.

Low field a.c.susceptibility measurements on $Y_{0.95}Pr_{0.05}Ba_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$ ($x \leq 0.02$) samples have been performed to investigate the intergrain regions. It is also found that the lower value of superconducting volume fraction f_g(= 0.12) for pristine sample (x=0) is possibly due to the presence of Pr. Lowest value of f_g =0.03 is found for x

= 0.005 sample. A correlation between f_g and the average grain size R_g is worked out and is found to favour growth of highly anisotropic grains. Average grain size is estimated from SEM micrographs of the $Y_{0.95}Pr_{0.05}Ba_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$ ($x \leq 0.02$) samples.

Further, superconducting and electronic properties of Fe substituted $Mg_{1-x}Fe_xB_2$ samples with x = 0, 0.003, 0.006, 0.012, and 0.03 viz. electrical resistivity ρ, thermal conductivity K, and Seebeck coefficient S have been measured from 10-300 K. T_C decreases rather linearly as a function of Fe upto x = 0.012, beyond which the solubility limit of Fe in MgB_2 lattice was noticed. The two-band model provides an excellent description of ρ data in terms of the Bloch-Grueneisen model. The coupling of carriers with defects/impurity increases with Fe substitution non-monotonically between 0.22 and 0.3. Thermal conductivity of the pristine material is seen to be the highest and exhibits a shoulder near 110 K, gradually fading out with increasing x. The overall coupling of phonons with defects/impurities as signified by the lattice thermal conductivity decreases with increasing Fe content. It has been found that the room-temperature S as well as the its slope in linear region (from T_C to about 150 K) show little change with respect to Fe substitution, indicating that the DOS near the Fermi level remains nearly unaffected in these $Mg_{1-x}Fe_xB_2$ alloys. Conclusions from the present results on the Fe substituted $Mg_{1-x}Fe_xB_2$ alloys, a modest T_C depression rate when compared with Mn, a much pronounced T_C depression rate when compared with other elements like Al, and nearly unaffected DOS rules out the possibility of spin flip scattering and/or reduction of DOS as well as disorder as a cause for the observed variations in T_C and place the role of Fe in MgB_2 lattice as a distinct one.