DISCLOSURE OF THE PSEUDOGAP TEMPERATURE IN $Nd_{2-x}Ce_xCuO_4$ BY RESISTIVITY MEASUREMENT IN HIGH MAGNETIC FIELDS

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Introduction

One of the key issues in understanding the mechanism of high T_c superconductivity is its relation to the unusual normal-state properties above the superconducting dome. The high temperature normal-state resistivity of HTSC´s is linear with temperature. By cooling a system below a temperature T*, a deviation from such metallic-like behavior is observed. The anomaly in resistivity is also accompanied by changes in other properties of the system, such as NMR, ARPES, optical conductivity, etc... These phenomena are usually attributed to the formation of a pseudogap, the origin of which is a matter of investigation to this day. Nevertheless, it is reasonable to assume that some features of the pseudogap are closely related to the magnetic correlations (very likely for the electron-doped side) and also to the Cooper pairing of the electrons. To distinguish between those effects and the effects related to intrinsic disorder and to crystal imperfections, we measured the c-axis magnetoresistivity of two sets of Nd_2CuO_4-based samples. In the first set, the electron concentration was controlled by varying Ce concentration whereas the second set involved the induction of isovalent extrinsic disorder by the substitution of Cu by Ni.

Experimental

Single crystals of $Nd_{2-x}Ce_xCuO_{4-\delta}$ (NCCO, x= 0.125, 0.1375, 0.15) and $Nd_{1.85}Ce_{0.15}Cu_{1-y}Ni_yO_{4-\delta}$ (y= 0.005, 0.010, 0.015) were grown by the traveling solvent floating-zone method. A standardized oxygen reduction procedure was followed to regulate the oxygen stoichiometry, presumably resulting in the same δ for all samples. The crystals were cut by a wire saw to obtain smaller samples, with a typical size of 1x1x1 mm^3. Sample quality was verified by measuring the magnetic susceptibility with SQUID over the temperature range of 4 to 30K (T_C for the optimally doped samples is 25K). The typical transition width is ~1.5K indicating high crystal quality. Resistivity is measured in a conventional four-wire c-axis configuration with two annular contacts on either surface of the crystal. To achieve low contact resistance, gold pads were sputtered and the gold wires were attached to them by silver paint. The resistivity was measured with the help of lock-in to reduce the noise to signal ratio. The temperature was then varied from 4 to 300 K and, by the use of the 33T high field magnet system located in the Cell 12, the magnetic field was varied from 0 to 32.7 T.

Results, Discussion and Conclusions

The out-of-pane $\rho_c(H,T)$ magetotransport on a series of Nd_2CuO_4-based single crystals allows us to determine the temperature, field and,. in particular, the previously unstudied doping and disorder dependences of the pseudogap, critical field (H_{c2}) and position of the maximum in resistivity. A preliminary analysis of the results measured on optimally doped NCCO (x=0.15) samples shows a good agreement with results reported for similar systems close to the optimal doping (e.g. $Sm_{2-x}Ce_xCuO_4$ [1] or $Pr_{1.85}Ce_{0.15}CuO_4$ [2]). A detailed analysis of the results is underway in an effort to connect the results on the optimally doped samples with those obtained on the underdoped and disordered samples. This is interesting not only in view of mapping the low energy scales in the phase diagram of electron-doped superconductors but also in the light of our recent neutron work on the same set of samples[3]. It is expected that complementary information will be extracted from the current magnetoresistivity work, which should provide additional information about the reported magnetic quantum critical point (at x=0.134) and clarify some issues related to the suggested interpretation of the pseudogap.

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References

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