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# Structural and Magnetic Properties of $RSr_2Fe_3O_9$ (R=La, Y, Pr, and Gd)

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FRIDAY MORNING, JANUARY 9, 1998 CONCOURSE, 9:00 TO 12:00

# Session GS
# SUPERCONDUCTIVITY II (POSTER SESSION)

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## Contributed Papers

**GS-01. THE Re-DOPED HIGH $T_c$ SUPERCONDUCTOR $HgBa_2Ca_2Cu_3O_x$: MAGNETIC IRREVERSIBILITY VERSUS ANISOTROPY.** L. Fàbrega, B. Martínez, J. Fontcuberta, A. Sin, S. Piñol, and X. Obradors* (Institut de Ciència de Mater. (CSIC), Campus de la U.A.B., 08193 Bellaterra, Spain)

The copper oxide $HgBa_2Ca_2Cu_3O_x$ is the superconductor with highest $T_c$ ($\approx$135K). However, it had not received much attention until very recently, because of its difficult synthesis (requiring high pressure) and its reported high anisotropy. It is well known that superconducting copper oxides with extreme anisotropy have important handicaps for their use in applications, because magnetic flux moves very easily in them, and therefore they are unable to carry high electrical currents, without dissipation, in most of their H-T phase diagram. An important step forward was realized when it was shown[1] that the partial substitution of Hg by Re stabilizes the phase, allowing its synthesis without application of high pressure. Furthermore, this substitution does not lower $T_c$ and rises the irreversibility line of the superconductor, i.e. broadens the non-dissipative region of its H-T phase diagram. These important issues—particularly the last result, which was soon attributed to a decrease of the anisotropy—have awakened the interest for this material. Indeed, from the above considerations the relevance of having a superconductor with very high critical temperature and reduced anisotropy may be clearly pressumed. To determine the anisotropic irreversibility line of this superconductor and establish the effect of the Re have become a matter of the greatest interest, and are the object of this paper. We report on magnetic measurements carried out on grain-aligned Re-doped $HgBa_2Ca_2Cu_3O_x$. From these data we extract the anisotropic critical currents of the material. We observe a rise of the irreversibility line, as compared to the unsubstituted superconductor; this effect is accompanied by a marked decrease of the anisotropy. We analyze the origin of magnetic irreversibility as a function of temperature and magnetic field, and find that bulk pinning determines it at low temperatures, whereas surface barrier effects dominate at higher temperatures. Finally, we try to assert the effects of Re-doping on these two contributions. Our results indicate that this substitution leads to (i) an enhancement of bulk pinning, due to the anisotropy reduction, and (ii) a possible increase of surface barriers, due to the accompanying metallization of the interlayers. The implications of these features with regard to potential applications of the superconductor will be also addressed.

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[1]Shimoyama *et al.*, Physica **C224**, 1 (1994).

**GS-02. STRUCTURAL AND MAGNETIC PROPERTIES OF $RSr_2Fe_3O_9$ (R=La, Y, Pr, and Gd).** V. P. S. Awana, S. X. Dou (Universisty of Wollongong, Ctr. for Superconducting and Electron. Mater., Wollongong, NSW 2522, Australia), I. Felner, I. Nowik (The Hebrew Univ., Racah Inst. of Phys., Jerusalem 91904, Israel), S. K. Malik (Tata Inst. of Fundamental Res., Homi Bhabha Rd., Bombay 400005, India), Apurva Mehta (SSRL/SLAC, Stanford, CA 94309), Rajvir Singh, A. V. Narlikar (Nat'l. Phys. Lab., K.S. Krishnan Marg, New Delhi 110012, India), and W. B. Yelon (Univ. of Missouri, Reseach Reactor Facility, Columbia, MO 65211)

We have investigated the $RSr_2Fe_3O_9$ (R=La, Y, Pr, and Gd) materials by several experimental techniques, including X-ray and neutron diffraction, magnetic susceptibility and Mossbauer spectroscopy measurements. All materials studies are single phase and crystallize in the hexagonal perovskite structure. Magnetic susceptibility studies reveal that for R=La and Pr, the Fe ions order antiferromagnetically at about $Y_N$=190 K. Short range magnetic correlations are observed up to 250 K. For R=La and Pr. Mossbauer studies reveal two in equivalent magnetic sextets, below 190 K, with the area ratio 2:1. Above $Y_N$ one singlet is observed, with an isomer shift value typical to $Fe^{4+}$. $Y_N$ is extremely sensitive to oxygen concentration. For R=Y and Gd the magnetization curves do not lend themselves to easy determination of the magnetic transition due to an extra magnetic phase which exists up to 350 K. This phase is a result of deficiency of oxygen. The Mossbauer spectra at 300 K indicates two superimposed singlet lines, and contain a small magnetic sextet. There is no indication that the R sublattice in $RSr_2Fe_3O_9$ (R=Pr, and Gd) order magnetically down to 1.5 K.

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**GS-03. MAGNETIC AND THERMAL PROPERTIES OF Pr IN $La_{1-x}Pr_xBaCaCu_3O_7$ SYSTEM WITH $0.0 \leq x \leq 1.0$.** V. P. S. Awana,* S. X. Dou (Univ. of Wollongong, Ctr. for Superconducting and Electron. Mater., Wollongong NSW 2522, Australia), Rajvir Singh, A. V. Narlikar (Natl. Physical Lab., K. S. Krishnan Marg, New Delhi 110012, India), S. K. Malik (Tata Inst. of Fundamental Res., Homi Bhabha Rd., Bombay 400005, India), S. Uma, E. Gmelin (Max-Planck-Inst. fuer Festforperfoerschung, Heisenbergstrasse, D-70569 Stuttgart, Germany), and W. B. Yelon (Univ. of Missouri Res. Reactor Facility, Columbia, MO 65211)

The results on structural aspects, superconductivity, magnet and thermal properties of $La_{1-x}Pr_xBaCaCu_3O_7$ system are to be presented. Both X-ray and neutron diffraction studies reveal that Pr substitutes isostructurally in the tetragonal $LaBaCaCu_3O_7$ (La:1113) system until the complete replacement of La by Pr. The c-lattice parameter of the substituted system decreases with an increase in $x$, indicating successful substitution of bigger ion $La^{3+}$ by comparatively smaller $Pr^{3+/4+}$. The superconducting transition temperature, $T_c$, determined from AC susceptibility measurements decreases with $x$. The relative $T_c$ depression due to Pr in the $LaBaCaCu_3O_7$ superconductor is less in comparison to that found for La-site Pr substituted $LaBa_2Cu_3O_7$ (La:123). While the critical concentration of Pr to completely suppress the superconductivity of former is around 70 at.% of Pr at La-site, for later the same is reported only 30 at.%. For non-superconducting samples, i.e., for $x$=0.70 and 1.0, possible antiferromagnetic ordering temperature $T_N$, of 4 K and 8 K, respectively, are observed from both DC magnetic and heat capacity measurements. Interestingly, in $La_{1-x}Pr_x$:1113 system the $x_{cr}$ of Pr is 0.70, with a $T_N$ of 8 K, for $La_{1-x}Pr_x$:123 system, while $x_{cr}$ is half the $T_N$ is nearly two times. The related entropy change for $x$=1.0 sample near $T_N$ amounts to $\Delta S$=3.5 J/Mol.K. The results are explained on the basis of distribution of Pr at both RE and Ba sites in the RE:1113 structure. This leads to a lower $T_N$ and a less deleterious effect of Pr on the superconductivity of La:1113 compared