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Magnetic and Thermal Properties of Pr in $La_{1-x}Pr_xBaCaCu_3O_7$ System with 0.0

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

Session GS
SUPERCONDUCTIVITY II (POSTER SESSION)

Mike Osofsky, Chair
Naval Research Laboratory, Code 6344, Washington, DC 20375

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.

*Work supported by the Spanish CICYT and CSIC
[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.

*Research sponsored by: Australian Research Council.

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 ΔS=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

to La:123. These results strengthen the contention of extended Pr-4f hybridization with Cu-O conduction band and therefore unusually high T_N of Pr and no superconductivity in the Pr:123 like system.

*Research sponsored by: Australian Research Council.

GS-04. MAGNETIC PROPERTIES OF $YBa_2Cu_3O_3/SrRuO_3$ MULTILAYERS. H. C. Yang, C. Y. Lin, L. M. Wang (Natl. Taiwan Univ., Dept. of Phys., Taipei, 106 Taiwan), and H. E. Horng (Natl. Taiwan Normal Univ., Dept. of Phys., Taipei, 117 Taiwan)

The magnetic susceptibility of $YBa_2Cu_3O_3/SrRuO_3$ (YBCO/SRO) multilayers was measured to study the effects of the layer coupling on the superconducting transition and ferromagnetic order. The YBCO and SRO films were prepared by the pulse laser ablation. The $CaRuO_3$ thin film reveals a ferromagnetic order at T~160 K while YBCO film is superconducting at T~90 K. The superconducting transition was reduced owing to the presence of the SRO layers. On the other hand, the presence of the YBCO layer effects the ferromagnetic ordering. The results are discussed.

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GS-05. MAGNETIC PROPERTIES OF Pb2Sr2PrCu3O8 STUDIED USING AC SUSCEPTIBILITY. S. Y. Wu, W.-H. Li, K. C. Lee (Dept. of Phys., Natl. Central Univ., Chung-Li, Taiwan 32054, ROC), J. H. Shieh, and H. C. Ku (Dept. of Phys., Natl. Tsing Hua Univ. Hsinchu, Taiwan 300, ROC)

The magnetic response of $Pb_2Sr_2PrCu_3O_8$ to the applied magnetic field has been studied by ac magnetic susceptibility measurements. Both the in-phase component χ' and the out-of-phase component χ'' of the ac susceptibility reveal superconductivity below 60 K and Pr ordering with $T_N \approx 7$ K. A dc magnetic field of strength 0.5 kOe destroys 50% of the Meissner diamagnetic response, which however persists up to a strength of 10 kOe. The effect of the applied dc field on the diamagnetic screening of the superconducting state may be well described using the pair breaking mechanism. Below ~15 K, both χ' and χ'' may be decomposed into two components: one of superconductivity and the other of magnetic ordering of the Pr spins. The latter was found to be sensitive to the frequency as well as to the strength of the driving field, while the former was found not. The correlated Pr spins respond "better" to a driving field of lower frequency or lower strength, indicating a relative long spin relaxation time for the correlated Pr spins. These behaviors are similar to what have been observed in the spin glass systems.

GS-06. SYNTHESIS AND TRANSPORT PROPERTIES OF $Pr_2Ba_4Cu_7O_{15-\delta}$ SINGLE CRYSTALS. Yuh Yamada[1], Akiyuki Matsushita[2], Shigeru Horii[3], Jinhua Ye[2], Yasuji Yamada[4], and Izumi Hirabayashi[4] ([1]Dept. of Material Sci. Shimane Univ., Matsue 690, Japan, [2]Nat'l. Res. Inst. for Metals, Tsukuba 305, Japan, [3]Dept. of Crystal. Mater. Sci., Nagoya Univ., Nagoya 464-01, Japan, [4]Div. VIII, Superconductivity Res. Lab., ISTEC, Nagoya 456, Japan)

We reported to synthesize the polycrystalline $PrBa_2Cu_4O_8$ (Pr124) and $Pr_2Ba_4Cu_7O_{15-\delta}$ (Pr247) by using the high oxygen pressure technique and the electrical resistivity of the Pr124 and Pr247 was found to exhibits a metallic temperature dependence below 180K.[1,2] This behavior provides an interesting contrast to the semiconducting one of $PrBa_2Cu_3O_{7-\delta}$ (Pr123). From the results of pressure effects on the electrical resistivities of these systems, we have attributed the metallic behavior to the conduction through the double chains.[2] Therefore it is interesting to synthesis the single crystal and study these systems for the direction dependence of the electrical resistivities. In this work we report that the single crystal Pr247 oxides was synthesized for the first time by using the Flux method under high oxygen pressure and measured the direction dependence of the electrical resistivities.

[1]Y. Yamada *et al.*, Phisica C 231 (1994) 131.
[2]A. Matsushita, *et al.*, Phisica C 242 (1994) 381.

GS-07. SPECIFIC HEAT, MAGNETIZATION AND C-ISOTOPE EFFECT OF $Y_2C_2(I,Br)_2$ SUPERCONDUCTORS. Walter Schnelle, Rüdiger W. Henn, Thomas Gulden, and Reinhard K. Kremer (Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany)

The specific heat $c_p(T)$ and the magnetization $M(H,T)$ of polycrystalline samples of the layered superconductors $Y_2C_2I_2$ (Ref. 1) and $Y_2{}^{13}C_2I_2$ ($T_c \approx$ 10 K), $Y_2C_2Br_2$ ($T_c \approx$ 5 K)[1] and of the mixed crystals $Y_2C_2I_{1.5}Br_{0.5}$ ($T_c \approx$ 11.6 K) were measured from 1.5–80 K and magnetic fields up to 10 T. All samples exhibit sharp phase transitions in zero field. The jump $\Delta c_p = r\gamma T_c(H)$ at T_c is drastically reduced in amplitude and broadens significantly with magnetic fields, similar to the high-T_c cuprates. The temperature dependence of $\Delta c_p(T)$ and of $H_c(T)$ is analyzed in the framework of the α-model and is consistent with strong electron-phonon coupling with $2\Delta/k_BT_c = 4.3(2)$ and $\kappa_{GL} = 60(5)$ for $Y_2C_2I_2$. The $^{13}C/^{12}C$ isotope effect of $Y_2C_2I_2$ is found to be near zero. In contrast to this the 3-dimensional parent compound YC_2 shows textbook-like BCS behavior with C-isotope effect +0.51(7).[2] We discuss the thermodynamic parameters of these new layered superconductors and compare them with those of YC_2.

[1]R. W. Henn *et al. Phys. Rev. Lett.* **77**, 374 (1996).
[2]Th. Gulden *et al. Submitted to Phys. Rev. B*, May 1997.

GS-08. H-T-PHASE DIAGRAM FOR THE GIANT MAGNETIC FLUX JUMPS IN LTSC AND HTSC, THE ROLE OF REMAGNETIZATION PROCESS. V. V. Chabanenko, A. I. D'yachenko, A. V. Chabanenko (Physico-Tech. Inst., Natl. Acad. of Sci. , ul. R. Luxemburg, 72, 340114, Donetsk, Ukraine), H. Szymczak, S. Piechota, A. Nabialek, and N. D. Dung (Inst. of Phys., PAS, Al. Lotnikov 32/46, 02-668 Warsaw, Poland szymh@ifpan.edu.pl)

An influence of a magnetic prehistory on the flux jumps connected with the thermomagnetic instability was investigated both theoretically and experimentally. We have measured the magnetostriction and the magnetization of $La_{2-x}Sr_xCuO_4$ and $Ba_{1-x}K_xBiO$ single crystals, as well as of melt-textured YBaCuO in magnetic fields up to 12 T using a strain gauge technique and VSM. Remagnetization loops were calculated using the criterion of the thermomagnetic instability[1] employing three models of the critical state: the original Bean model, the Kim-Anderson model and the exponential model. These results and data[2] are used for computer simulations both of magnetostriction and magnetization loops with flux jumps. The loops are constructed in a wide range of experimental parameters. Different features of the hysteresis loops are discussed. The field and temperature ranges where the flux jumps occur were determined (fig.a,b).