PROPERTIES OF *Bi-2223* SUPERCONDUCTORS FOR SUBSTITUTION OF *Cu* BY MAGNETIC TRANSITION ELEMENTS

Nguyen Huy Sinh
Faculty of Physics
College of Natural Sciences, Hanoi National University

abstract *The effects of the substitution of some magnetic impurities (Fe, Co, Ni) f in Bi-2223 superconductor have been studied. It is found that the T_c and a, b pa ters are monotonically decreased as a function of the doping impurities. The disinte temperatures of superconducting phases have been changed by magnetic elements cc tration. The weight-loss of the samples linearly decreased by ratio of impurity per Cu. is correlated with the release of oxygen in bulk of samples. The influence of the ma impurities on the superconducting characterization concerning with BCS - theory wh impurity atoms replaced into Cu(2) sites in CuO_2 planes has been discussed.*

I. INTRODUCTION

The substitution of the 3d atoms for Cu is expected to provide important inf tion concerning with the mechanism of high-T_c superconductivity. In the Bi-supercon the CuO_2 - planes are the structure element only containing Cu site in the unit c Cu is replaced by 3d-atoms which enter to Cu(2) sites, thus this substitution affec rectly the CuO_2 -planes. The incorporation of magnetic atoms as the Fe, Co and the crystal structure may be one of the reasons to suppress T_c with increasing ma impurity concentration. This paper presents the experimental results for the substi of Cu by 3d-atoms in $Bi_2Sr_2Ca_2(Cu_{1-x}$ (Fe, Co, $Ni)_x)_3O_y$ with $x = 0.00 - 0.10$. suppression of T_c and variation of superconducting properties in this system are disc by the influence of magnetic moment effects on basis of BCS - theory.

Nominal composition of samples of $Bi_0Sr_2Ca_{n-1}$(Fe, Co, $Ni)_x)_nO_y$ (n = 3 and 0.00 - 0.10) was calculated by WEIGHT program and were prepared using the solid reaction method. The resistivity curves have indicated that the (2223) phase var at x > 0.04 for Fe, Co -doped and at $x > 0.05$ for the Ni-doped samples. On the hand, there is transition from metallic to semiconducting behavior at x > 0.06 for Fe Co-doped and at $x > 0.08$ for Ni-doped samples. The temperatures of zero resistivity to be decreased, but the resistivity curves do not go to zero even at 60K. This ind that by increasing 3d-concentration not all of these samples are superconducting. It that all samples with $0.00 < x < 0.05$ are metallic in the normal state with incr

ing concentration x, the metallic characterization reduced and then the transition n metallic to semiconducting state appears at higher doping. The values of transition peratures as function of Fe, Co and Ni doping are given in figure 1. This indicated for the higher doping concentration (at x > 0.05) important changes are noted in the acteristics of sample.

The suppression of T_c in this em can be explained on the ba- f BCS-theory for contribution of netic impurities in CuO_2 planes. pairing of carriers in the planes CuO_2 is responsible for high-T_c erconductivity in all copper-oxide mics, it is of interest to alter the tronic structure, as well as intro- magnetic-impurities into Cu(2) s in the CuO_2 planes. There is lence given by Sequeim et al [1] n neutron and Rao et al [2] from NES diffraction experiments that 3d-atoms substitute into Cu site CuO_2 planes. The suppression of by the substitution of $3d$-transition als for Cu has been attributed he magnetic- impurities incorpo- d in the crystal structure con- ing the interaction of the mag- c moments and electron spins. one electron has a spin up (↑) ciated with the other electron ch has a spin down (↓) to form Cooper-pairs.

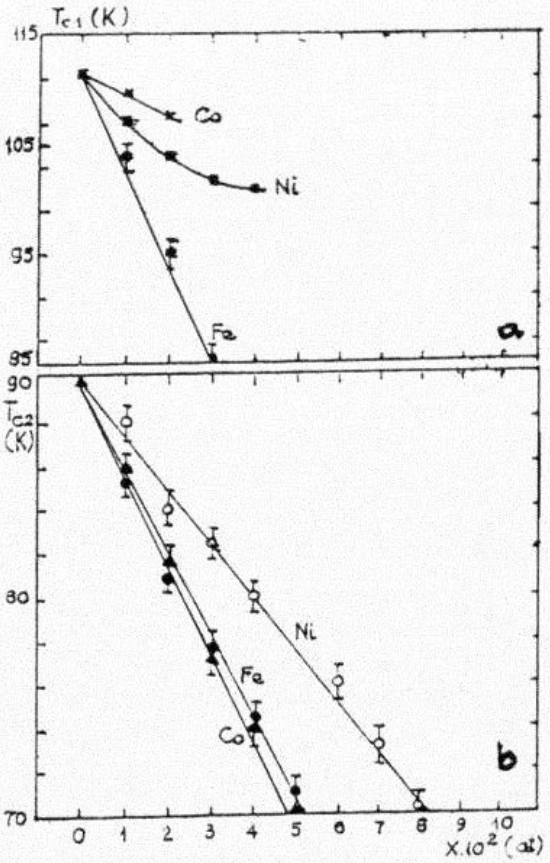

Figure 1. Suppression of T_{c1} (a) and T_{c2} (b) by doping concentration (x) in $Bi_2Sr_2Ca_2$ $(Cu_{1-x}$ (Fe, Co, Ni)$_x)_3O_y$ compounds (x = 0.00 - 0.10)

The Cooper - pairs must follow the conservation of laws for the spins, number - es (k) and impulses (p) in superconducting state.

The interaction between the electrons and the doping impurity atoms lead to vi- ing the conservation's of mentioned laws. By increasing of doping concentration (x), magnetic moments tend to decrease the possibility of formation of Cooper-pairs in su- conducting state. Thus the interaction between electron spins and magnetic moments mpurity prevents the appearance of the superconducting behavior and hence cause a rease in T_c. Apart from this, Fukuda et al. [3] showed that this substitution causes rder effect in the crystal structure also. We suppose the suppression of T_c concluding latter reason.

XPD patterns showed that some weak impurity reflections are observed indica that the limited doping concentrations are incorporated into the crystalline structure. figures 2 (a,b) demonstrated the change of lattice parameters and volume of unit cell v doping concentrations. It shows lattice parameters a, b are slightly decreased and c aln unchanged by increasing the concentration of x. The limited doping concentration of Fe, Co and Ni magnetic atoms have occupied the sites of Cu(2) in CuO_2 planes. causes the suppression of superconducting behavior as well as of T_c, but does not ca the change of crystalline structure. It is quite different in the similar doping case of Y-(123) superconductors [4].

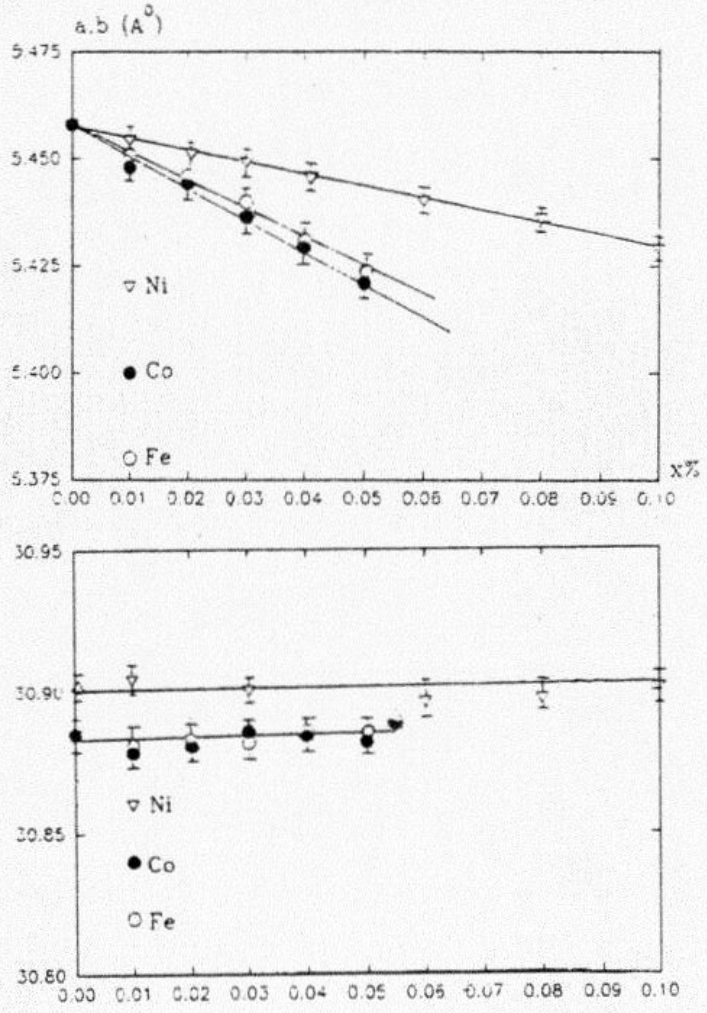

Figure 2. Variation of lattice parameters a, b and c in $Bi_2Sr_2Ca_2(Cu_{1-x}$ (Fe, Co, Ni)$_x)_3O_y$ $(x = 0.0 - 0.10)$.

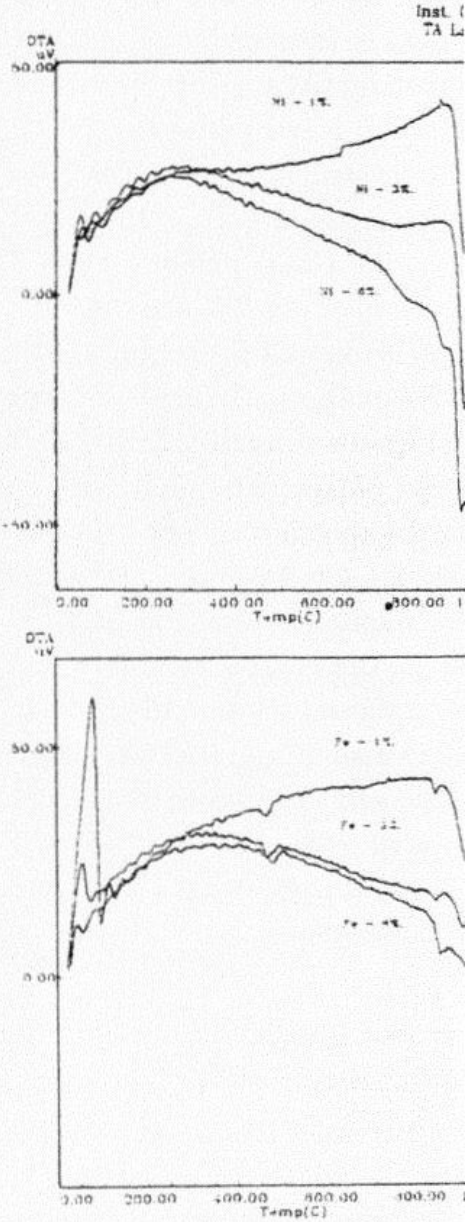

Figure 3. DTA data for Bi_2 Sr_2 Ca_2 (Cu Ni)$_x)_3$ O_y (x = 0.0 - 0.10). (a). For (b). For Ni .

The volume of unit cell is nearly linearly decreasing with increasing doped concen- ation. This possibility corresponds to the fact that the ionic radii of Fe, Co, Ni is less an that of Cu . The susceptibility measurement also indicated that for the same amount doping concentration in samples, *Co* strongly suppresses the superconducting behav- r more than Fe and Ni. At the higher doping concentration, amount of (2212) phase creases and quickly denigrates to that of (2223) phase. Furthermore, with increasing x ncentration, the superconductivity is going to vanish for the both of (2212) and (2223) ıases. This is in agreement with the observed results from XPD and electrical resistivity easurements.

The figures 3 show the DTA traces of Bi_2 $Sr_2Ca_2(Cu_{1-x}$ $(Fe,Ni)_x)_3O_y$ (x =)0 – 0.10) for the case of Fe and Ni-doping. (The similar behavior is seen in Co-)ping case). These indicate that below 500^0C, all samples take up oxygen and then lease of oxygen at the higher temperatures indicated by the transition from exothermic endothermic behavior in the DTA traces. The endothermic at about $800 - 930^0$C is tributable to incongruent melting. It is clear from the thermogravimetric curves that e amount of oxygen increase rapidly with the Fe, Co, Ni doping transition elements. GA measurement indicated that the weight-loss increases with increasing doping concen- ation and that of the Fe doping samples have less than that of the other samples. The fference of DTA and TGA in the process of absorption and desorption oxygen between ıdoping and doping samples become more pronounced at higher temperature.

The SEM photographs show the differences for the structure on the surface of sam- es with various substituted elements and difference doping concentration. The variation the sharp, the dimension and border of grains were observed on surface of all samples. may be prove that the magnetic elements (Fe, Co, Ni) have been incorporated in these mpounds.

ı conclusion: the obtained results give evidence of the coexistence of (2212) and (2223) perconducting phases and the amount of the (2212) phase increasing and that of the 223) phase simultaneously degenerating with increasing doping concentration. The su- rconductivity slightly vanished at higher doping concentration of magnetic impurity. can be confirmed that the limited doping concentrations of Fe, Co, Ni impurity have en substituted into Cu(2) sites and incorporated in the crystal structure. This concerns ith the variation of the sharp and the dimension of grains which observed on the surface samples. The interaction between electron spins and magnetic moments of Fe, Co, i impurities due to these doping compounds seems to give the one ability of explana- on for the suppression of superconducting transition temperatures T_c. This paper is pported by National Subject Nr. 435/1998- 2000.

REFERENCES

[1] A.Sequiem. *Structural aspects of hight-T_c Superconductors from neutron profile refinement studies. Phys.* **B 174**(1991) 311.

[2] K.V.R.Rao, K.B.Garg, S.K.Agarwal, V.P.S.Awana A.V.Narlikar. *Cu - K - edge*

X-ray absorption study of Fe - doped Bi2Sr2Ca1Cu2Oy superconductors. Phys. **192**(1992) 419.

[3] Y.Fukuda, N.Sanada, T.Nakadaira, M.Nagoshi, Y.Syono and M.Tachiki. *Effe of substitution of Fe and Co for Cu in* $Bi_2Sr_{1.8}Ca_{1.2}Cu_2O_y$ *on electronic sta studies by photoemission. Phys.* **C 190**(1991) 73.

[4] Nguyen Huy Sinh, Nguyen Thi Thu Phuong. Phase transition in high tempe ture superconductor $YBa_2(Cu_{1-x}M_x)_3O_{7-y}$ and $Bi_2Sr_2Ca_2(Cu_{1-x}M_x)3O_y$ s tems ($M = Fe, Co, Ni, x = 0.00 - 0.10$). *The second National Solid State Phy Conference in Doson, Haiphong* (1997). To be Published.

TẠP CHÍ KHOA HỌC ĐHQGHN, KHTN, t.XVI, n^{0}4 - 2000

TÍNH CHẤT CỦA CHẤT SIÊU DẪN Bi - 2223 KHI THAY Cu BẰNG CÁC KIM LOẠI CHUYỂN TIẾP TỪ

Nguyễn Huy Sinh

Phòng thí nghiệm Vật lý Nhiệt độ thấp

Đại học KH Tự nhiên - ĐHQG Hà Nội

Một số hiệu ứng thay thế các tạp chất từ (Fe, Co, Ni) cho Cu trong siêu dẫn -2223 đã được nghiên cứu. Nhận thấy rằng: Nhiệt độ chuyển pha siêu dẫn T_c và hằng số mạng a, b giảm theo hàm của nồng độ tạp chất. Nhiệt độ phân rã các pha s dẫn thay đổi theo nồng độ các kim loại chuyển tiếp từ. Độ mất trọng lượng của các n giảm tuyến tính theo tỷ lệ các kim loại chuyển tiếp pha tạp và Cu . Vấn đề này có l quan đến sự giải phóng oxy trong mẫu. Một trong những cách lý giải ảnh hưởng của chất từ lên đặc tính siêu dẫn của hệ này đưa trên lý thuyết BCS khi các nguyên tử k loại chuyển tiếp từ thay thế vào vị trí Cu(2) trong các mặt Cu_2O.