تأثير استبدال السيلكون علي البنية والموصلية الفائقة للموصل الفائق $(0\leq x \leq 0.03)$ $(Cu_{1-x}Si_x)_3O_{7-\delta}$

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في هـــذا البحث تم تحضـــير العينات باستخدام تفاعل الحالة الصلبة مع التركيبة المبدئية للموصل ، فقد تمت دراســـة التباين في التغيرات الهيكلية للشبيكة , والتشـــوه المعيني , حيث $x= 0 , 0.01 , 0.02 , 0.03$. $(0\leq x \leq 0.03)$ ضمن نطاق تركـــيز السيلكون حيود الأشعة السينية باستخدام قياسات (l بمعاملات ميللر المتمثلة a , b , c)خلال هذا النطاق نستطيع معرفة مؤشرات (c) حيث إن المتغيرات الشبكية المعطاة تـــم حسابها مـــن خلية الوحدة والتي أظهرت أن اتجاه العينات هو المحـــور باستخدام لها خاصية انحدار أشعي سيني $a \neq b \neq c$ بتماثل معيني متناسق ، وبذلك المركب معيني , والعوامل الشبكية حيث نستطيع أن نـــرى مرحلة ارتفاع الشوائب لنظام $(Cu_{1-x}Si_x)_3O_{7-\delta}$ من المركب Cu-Kα إشعاع , ولكن لا تظهر أي $(Cu_{1-x}Si_x)_3O_{7-\delta}$ السيلكون المطعم .

وتـــم ملاحظة القمم التي تنتمي إلى الأطوار المختلفة تغيرات في سعة القمم في شكل السيلكون المطعم حيث تقل الموصلية الفائقة.

$(Cu_{1-x}Si_x)_3O_{7-\delta}$ من ناحية أخرى إن استبدال أو التطعيم بالسيلكون لا يوجد له تأثير في نظام المركب

Effect of Si substitution on the structure and superconductivity of $YBa_2(Cu_{1-x}Si_x)_3O_{7-\delta}$ superconductor $(0\leq x \leq 0.03)$

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Abstract

In this research, samples were prepared by using solid state reaction with starting composition YBa2 (Cu3-x Si x) O7-x for x= 0.00, 0.01, 0.02 and 0.03. . The variation of the structural changes of the lattice parameters orthorhombic distortion and strain of YBa2(Cu1-x Six)3O7-δprepared samples as a function of Si concentration (x) within the range of ($0 < x \leq 0.03$) were studied, using XRD measurements. Within this range, a, b and c by Miller indices (h k l) should know. the lattice parameters a, b and c are given in the (h, k, l) values calculated from unit cell parameters shows that samples has c-axis orientation and their structure has orthorhombic symmetry. that the structure is orthorhombic with lattice parameters $a \neq b \neq c$. X-ray powder diffraction pattern using Cu-Kα radiation of YBa2Cu3O7−δ (x=0.03) rise in impurity phases can be seen for the Si-doped system. Peaks that belong to different phases YBa2(Cu3-x Si x)O7-x were observed. But, any considerable changes in amplitude of the peaks are not seen in the figure. Si doping drives YBa2Cu3O7-x structure reduces superconductivity. On the other hand, the substitution of Si does not have considerable effect on YBa2Cu3O7-x system.

INTRODUCTION

There have been extensive efforts to synthesise high density Yba2 Cu3 O7-ʒ ever since its discovery. Many studies have investigated the behavior of transition metal dopants in the Yba2 Cu3 O7-ʒ “123” superconductor [1- 2].]. Much of this research has focused of metal ions such as Co, Fe, Zn, Ni when they are substituted for the copper ions at Cu (1) and Cu (2) sites, commonly referred to as the chain and plane sites, respectively. It is now widely recognized that superconductivity occurs in the Cu O2 planes and the role of the chains is to act as a hole carrier reservoir coupling the planes [3- 4]. The orthorhombicity of Y-123 i.e the measure of difference between the a and b lattice parameters is known to be due to the missing oxygen atoms sites along the a direction orthogonal to the Cu-O chains [5- 6].

Haneda et al. (1987) prepared single crystals of YBa2Cu3O7-δ and characterized it by the x-ray microscope analyzer and x-ray diffraction. The crystals of the T group have a semiconducting behavior and no critical temperature above 50 K. The O2 group shows sharp resistivity drops with an onset temperature between 72 and 92 K, and a zero resistivity between 70 and 90 K. Also, the O1 group exhibiting metallic behavior and has a zero resistivity temperature of about 60 K. They measured the electrical resistivity of these crystals and found that some of them were above 77K. Zhang et al. (2001) also studied two phase transitions in Zn-doped YBCO superconductor. The samples of YBa2Cu3-xZnxO7-δ (x=0.05, 0.10, 0.15, 0.20, and 0.25) was prepared by conventional solid state reaction technique. XRD patterns show that the samples were still single phases, but the crystalline parameters changed a little. The depression of Tc value by Zn-dopant has close relationship with changing amount of heat and weight at about 430°C and 800 °C. The work on the substution by Si with a larger ionic radius is rare in the laterature. [7]

Experimental Details:

Preparation of the Samples

Appropriate amounts of yttrium oxide, barium carbonate and copper oxide with starting composition YBa2Cu3O7-δ were mixed and ground in a marble mortar for one hour. The mixture was calcined in air at 910 °C for 24 hours, with several intermittent grinding followed by oven cooling at 40°C per hour. The powders were reground and then pressed into tablets of ~13 mm diameter and 4 mm thickness using SPECAC press. The tablets were sintered at 910 °C for 24 hours and slow cooled to room temperature at 40 oC per hour. Four samples were prepared by using solid state reaction with starting composition YBa2(Cu1-x Six)3O7-δ for x=0.0, 0.01, 0.02, 0.03. Sample were prepared by thoroughly mixing appropriate amounts of high purity (≥ 99.99%) powders of BaCO3, Y2O3, Si2O3, and CuO with starting compositions YBa2(Cu1-x Six)3 O7-δ for x=0, 0.01, 0.02, and 0.03. These powders were heated for 24 hours at 910 oC with several intermittent grindings and oven cooled. The powders were then pressed into pellets with approximately 13 mm diameter and 4 mm thick and heated at 910 oC in air for another 24 hours followed by furnace cooling to room temperature.

Calculations of YBa2 (Cu1-xSix) 3O7-δ

The chemical equation for sample preparation is given as below:

1/2 Y2O3 + 2BaCO3 + (1-x) CuO + (x) Si → YBa2 (Cu1-x Six) 3O7-δ +2CO2↑

X-ray Diffraction

XRD investigation of the prepared bulk material was carried out in order to verify the presence of the orthorhombic YBCO phase. The x-ray diffraction pattern confirms the formation of the "123"perovskite-like structure of the space group p4 mm with the general formula YBa2Cu3O7.

The X-ray-Diffraction (Siemens D 5000) diffractmeter with Cu-Kα source was used to determine the phase of the samples, the compound were ground into fine powder and characterized by using the X-ray diffraction (XRD) method. X-ray powder diffraction with CuKα radiation (λ = 1.4506 A0) at 30 kv, 40 mA0 was used to examine crystallography of the sintered samples. The diffraction angle, 2θ are from 5° to 60°. XRD data analysis shows the peaks, which are equivalent to certain Miller indices. The lattice parameters a, b and c could be determined from the following equation:

$$\frac{1}{d_{hkl}^2} = \frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2} \qquad (1)$$

(a, b , c) lattice parameter

The Bragg's low used to determined (d)

$$n\lambda = 2d\sin\theta \qquad (2)$$

where n = 1, 2, 3, d distance between the atoms, 2θ angle of Miller indices, and λ the wave length of CuKα.

Results and Discussion

X-ray diffraction (XRD) patterns for pure and substituted samples that have been sintered at 980℃ for 24 hours are discussed.

Figure (1) shown the normalized of x-ray diffraction patterns for pure and substitution samples sintered at 980℃ for 24 hours. The peaks of the diffraction pattern for the pure represent that of 123 phases.

Table(1) lattice parameter a, b and c for YBa2 (Cu3-x Si x) O7-x with different composition

SampleYBa2Cu3O7-x	a(***A***°)	b (***A***°)	c(***A***°)	Ratio c/b	volume A^3
0.00	3.816	3.875	11.653	3.884	172
0.01	3.818	3.862	11.668	3.889	172.0
0.02	3.815	3.899	11.667	3.889	173.5
0.03	3.823	3.898	11.657	3.885	177.1

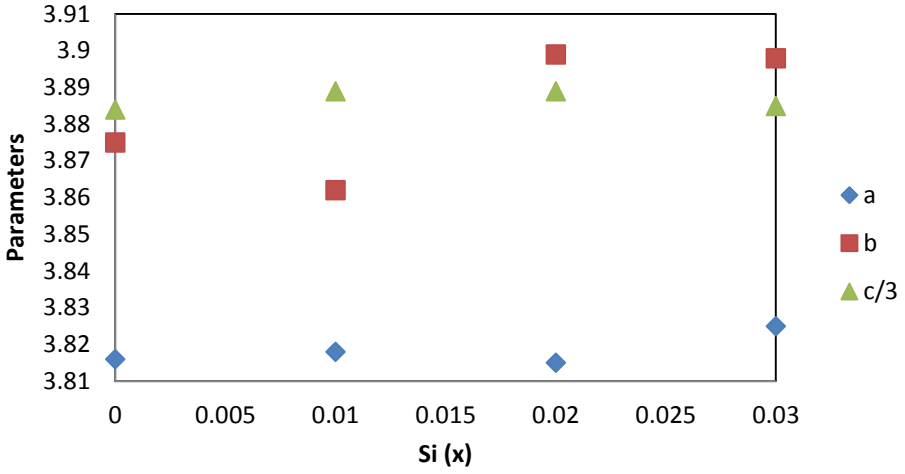


Figure (1) Lattice parameter a, b and c/3 versus composition (x)

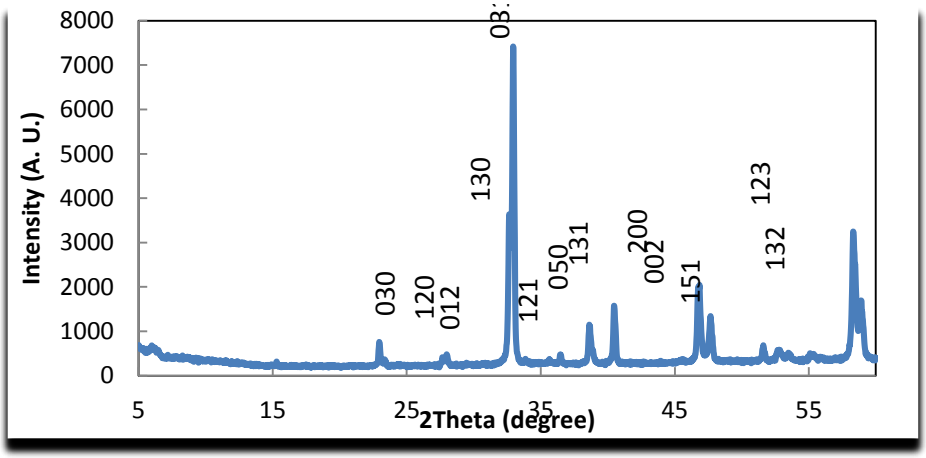
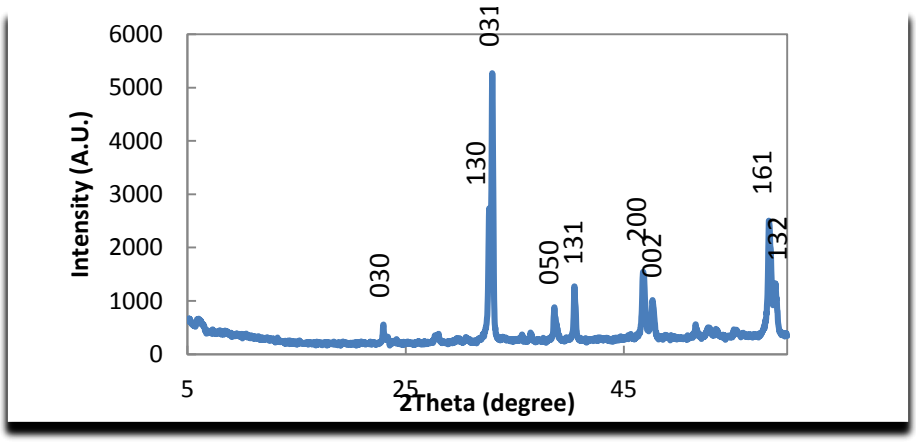


Figure (2) X-ray powder diffraction pattern using Cu-Kα radiation of YBa2CuO7−δ (x=0.00)



Figure(3) X-ray powder diffraction pattern using Cu-Kα radiation of YBa2Cu3O7−δ (x=0.01)

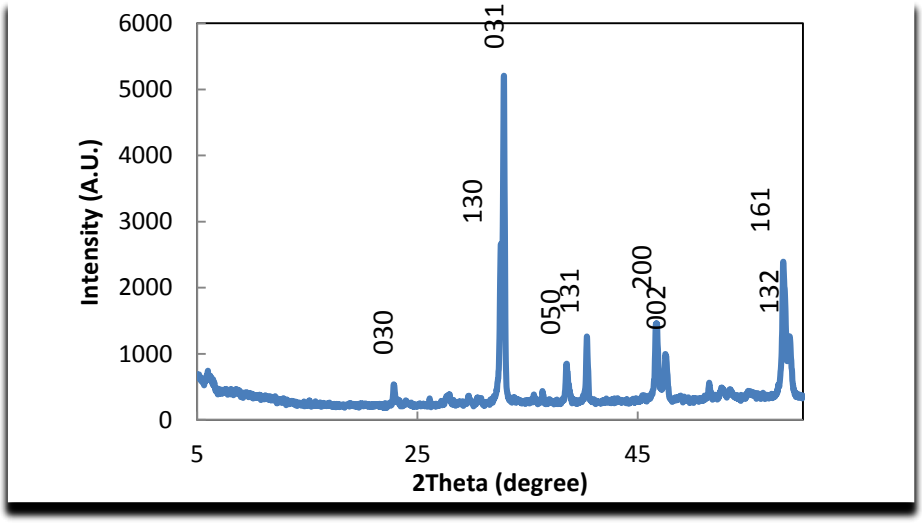


Figure (4) X-ray powder diffraction pattern using Cu-Kα radiation of YBa2Cu3O7−δ (x=0.02)

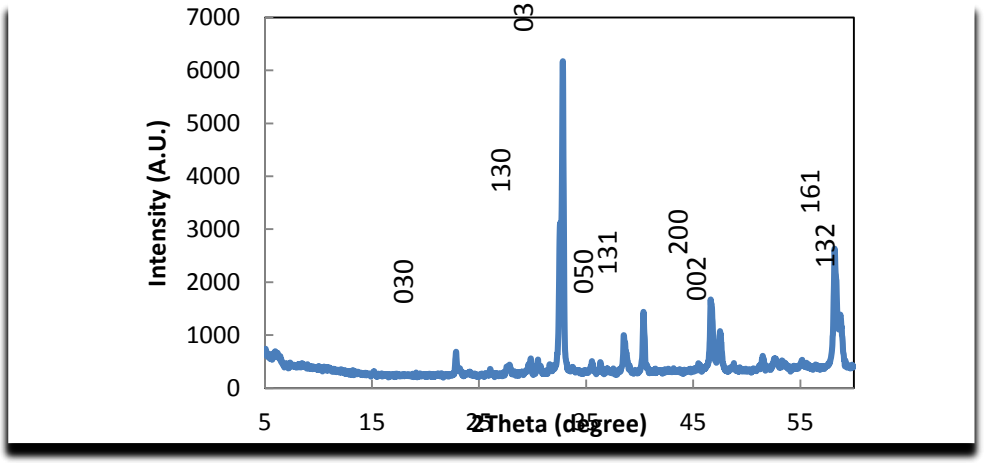


Figure (5) X-ray powder diffraction pattern using Cu-Kα radiation of YBa2Cu3O7−δ (x=0.03)

X-ray diffraction results for the YBa2(Cu3-x Si x)O7-x (x = 0.00, 0.01, 0.02 and 0.03) samples are illustrated in Figure 1. To obtain the parameters a, b and c by Miller indices (h k l) should know. Table 1. Showed the lattice parameters a, b and c are given in the (h, k, l) values calculated from unit cell parameters shows that samples has c-axis orientation and their structure has orthorhombic symmetry.

Samples showed that the structure is orthorhombic with lattice parameters $a \neq b \neq c$. In this Figure (5) rise in impurity phases can be seen for the Si-doped system. Peaks that belong to different phases YBa2(Cu3-x Si x)O7-x were observed. But, any considerable changes in amplitude of the peaks are not seen in the figure. Si doping drives YBa2Cu3O7-x structure reduces superconductivity. On the other hand, the substitution of Si does not have considerable effect on YBa2Cu3O7-x system.

The cell parameter c was found to increase linearly as Si concentration increase. Other lattice parameters also increased with increasing Si concentration. Therefore, there an increase in the volume of the unit cell as Si concentration increased. By calculating the lattice parameters, all the substituted samples are preserved as orthorhombic structure similar to that of the pure sample as indicated in Table (1)

CONCLUSION

The solid state technique was performed in the preparation of Si substitution YBa2Cu3O7-x polycrystalline ceramic superconductor. In this study, Cu site was separately subjected to Si substitution with composition ranging from x = 0.00 to x = 0.03. The superconducting properties of the samples have been investigated. The variation of the structural changes of the lattice parameters (a, b and c/3), orthorhombic distortion and strain of YBa2(Cu1-x Six)3O7-δ prepared samples as a function of Si concentration (x) within the range of ($0 < x \leq 0.03$) was studied, using XRD measurements. The results of x-ray diffraction (XRD) analysis of superconducting shows are single phase and orthorhombic structure for all samples with lattice parameter $a \neq b \neq c$. However, at higher concentration of Si substitution, some unknown peaks were observed. But, any considerable changes in amplitude of the peaks are not seen in the figure. Si doping drives YBa2Cu3O7-x structure reduces superconductivity

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