Sci. J. Fac. Sci. Menoufia Univ. Vol. V (1991). 1 - 8

THE EFFECT OF GAMMA RADIATION ON THE CRITICAL TEMPERATURE OF THE HIGH TEMPERATURE SUPERCONDUCTOR $Tl_2Ba_2CaCu_3O_{10+x}$

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ABSTRACT

The high temperature superconductor of a composition Tl_2 Ba_2 Ca_2 Cu_3O_{10+x} was preparerd and irradiated by γ- radiation using a ^{60}Co source with doses up to 48 M rad. Measurements of the D.C. resistance before and after irradiation shows that the effect of radiation on the resistance behaviour and the critical temerature is almost negligible. The x-ray diffraction of the samples before and after irradiation confirms our results.

INTROUDUCTION

Since the great achievement by Bednorz and Muller (1) of superconductivity at 30-40 k in alkaline earth doped La_2CuO_4, thousands of articles have been puplished related to that subject, and intensive work have been carried out to study the mechanisms involved in the phenomenon of high temperature superconductivity. As a quick

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result of that work, the critical temperature Tc has suddenly moved up to = 90 k for $Y_1Ba_2Cu_3O_{7-x}$ system (2,3), then soon after an even higher Tc of the order 125 k was reached for T1BaCaCuo system (4,5), and made the expression High Temperature Superconductivity meaningful. Although the rate of progress in that field has become lower, but the search for more stable materials are still going on, as well as the explanation of the conduction mechanisms.

The study of the effect of high enegy ionizing particles and radiations on those materials is highly important since they have interesting applications in satellites and other systems operating in the environment of outer space, however, relatively little work was published in that field (6, 7, 8). In this work we have prepared samples of the composition $Tl_2Ba_2Ca_2Cu_3O_{10+x}$ and they were subjected to high doese of γ- irradiation up to 48 M rad, to study the effect on the D.C resistance and on the critical temperature T_c. Our results showed very little effect of irradiation on both parameters which confirmed the stability of this material under those large doses of γ irradiation.

Preparation :

A bulk material of the composition $Tl_2Ba_2Ca_2Cu_3O_{10+x}$ was prepared, the preparation details were mentioned elsewhere (9,10,11), then four samples with dimensions 2x3x12 mm were cut from the same bulk. The samples were exposed to ^{60}Co γ-irradiation doses ranging between 16 M rad and 48 Mrad as shown in table (1).The rate of irradiation is 1 Mrad / 2h.The x-ray diffraction examination of the samples before and after irradiation showed that the dominant phase is $Tl_2Ba_2Ca_2Cu_2O_{10+x}$ and that no phase change due to irradiation even for the higher doses takes place.

Table (1)

Sample	Irradiation dose Mard	Tc before irradiation (K)	Tc after irradiation (K)
S 1	16	103.0	104.0
S 2	24	102.5	95.5
S 3	32	104.5	102.2
S 4	48	102.0	101.5

Measurements :

The D.C. resistance of the samples was measured before and after irradiation against temperature from room temperature down to 80 K, the normalised resistance R/R_0 for the four samples are shown against temperature in figures (1 to 4) were R_0 is the resistance at room temperature. The standard four probe method was employed to measure the D.C.R esistance, the passing current was ± 10 m A supplied by keithley 220 A constant current source, and the voltoge drop accross the sample was measured using keithley 181 Nanovoltmeter. The temperature was detected usig platinum resistance thermometer pt 100, the detailed method of setting the temperature is discussed elsewhere(8).

RESULTS

Figures 1 to 4 show that the normalized resistance decreases to about 40% of the room temperature values at about 100-120 k then the resistance falls of to zero with T_c ranging between 102 k and 104 k.

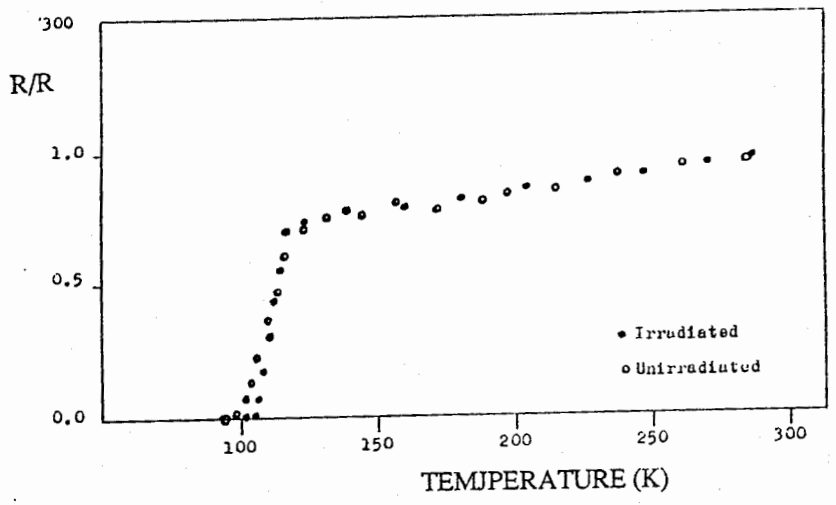

Fig. (1): The resistance-temperature characteristic of the sample s1.

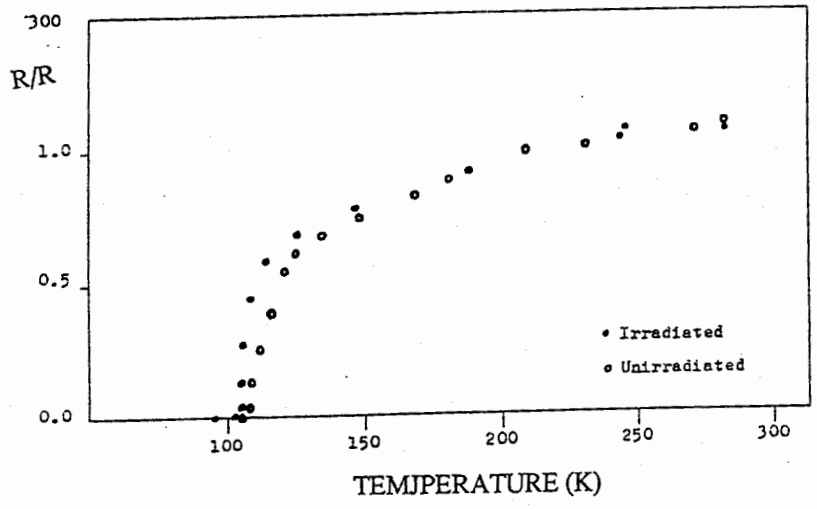

Fig. (2): The resistance-temperature characteristic of the sample s2.

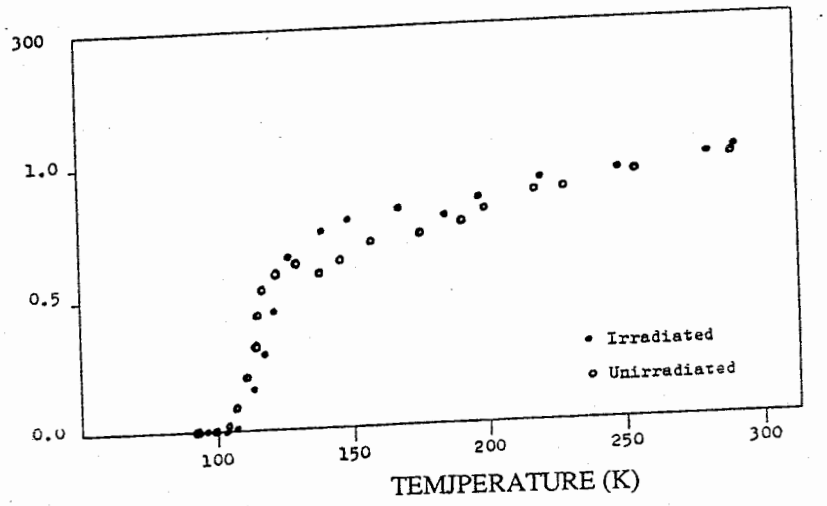

Fig. (3): The resistance-temperature characteristic of the sample s3.

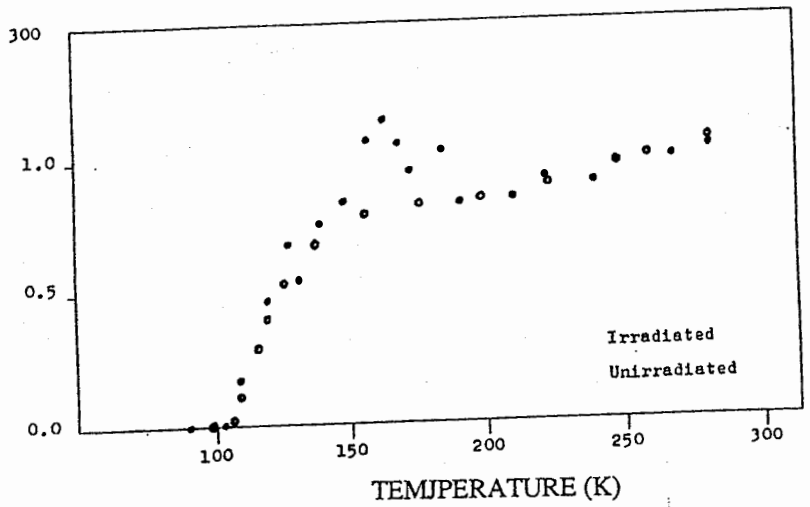

Fig. (4) : The resistance-temperature characteristic of the sample s4.

In general the results reflect the very little effect of the gamma irradiation even at higher doses on the D.C. resistance of the superconducting material and also on the critical temperature Tc.

CONCLUSION

Therefore we can conclude that the superconducting material $Tl_2Ba_2Ca_2Cu_3O_{10+x}$ and its superconducting properties appears to be nearly unaffected by the very high doses of γ-irradiation up to 48 M rad. This remarkable result was expected at lower doses but the extention of that stability to that range of dose of irradiation gives potential application in satellites and other systems operating in the environment of outer space.That stability of the superconducting properties after irradiation could be due to the fact that any substantial electronic excitations that could have produced are more likely to return to their original energy levels after the irradiation ceases as long as no ion displacement will take place. But on the other hand, bombardment by particles or lower quantum energy electromoagnetic radiation is more likely to produce damaging ion displacements because these radiations can more readily satisfy the momentum transfer conditions required to displace individual ions. Although shielding can limit the effects of these radiations even at that relatively high dose of up to 48 M rad the study of this problem more depply would throw more light on the superconducting mechanisms involved in this process.

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الملخص العربى

تم تحضير عينات من مواد فائقة التوصيل الكهربى لها درجة حرجة عالية تنتمى إلى النظام ثا٢ با٢ كا٢ نح٣ أ. ١+س .

وتم تعريضها لأشعة جاما بواسطة مصدر مشع للكوبلت ٦٠ بجرعات مختلفة حتى ٤٨ مليون راد .

إن التغير فى سلوك القياسات الكهربية قبل وبعد الإشعاع يكاد يكون معدوم وقد تم تأكيد هذه النتيجة بواسطة أشعة اكس قبل وبعد الإشعاع لهذه العينات .