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# RADIATION RESISTANCE OF THE HIGH $T_c$ SUPERCONDUCTOR $Y_1Ba_2Cu_3O_{7-\delta}$ UP TO 16.25 Mrad

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## ABSTRACT

*The high temperature superconductor $Y_1Ba_2Cu_3O_{7-\delta}$ was exposed to $^{60}Co$ $\gamma$-irradiation up to 16.25 Mrad. Measurement of the D.C. resistance against temperature reflect the stability of the superconductor under radiation, and the absence of significant change of the $T_c$ due to $\gamma$-irradiationX-ray diffraction also shows no change before and after irradiation.*


## INTRODUCTION

The recent discoveries of high temperature superconductivity by Bednorz and Muller (1) in alkaline earth doped $La_2CuO4$ at 30-40 k, and by Chu (2) and Cava (3) in $Y_1Ba_2Cu_3O_7 - \delta$ (YBCO) above 90 k are of a great interst from the stand points of both basic science and potential applications. Those discoveries were soon followed by a flood of research work led to very fast progress in this field and soon after much higher critical temperature superconductor TlBaCaCuO, was discovered (4, 5) above 120K.


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Superisingly enough relatively little work was done to study the effect of radiation(6,7) on the stability of this class of materials, although it is highly desirable property of electronic circuit materials to be resistant to high energy ionizing particles and rediations. That is especially importatant for applications in satellites and other systems operating in the environment of outer space. Bombardment with ions accelerated by the earth's magnetic field has been shown to seriously degrades those superconductors (7). Ionizing radiation such as γ and x-rays is perhaps of an even more serious concern because such radiataion passes through protective shielding moer readily than dose particulate radiation. The effect of this radiation on those high Tc superconducting materials have not received much attention to our knowledge, it was shown (6) that the ceramic superconductor YBCO appears to be remarkably resistant to doses of γ irradiation up 1.3 M rad.

In this work we have extended this range to 16.25 Mrad and our results show that stability under γ irradiation extends to that higher dose of irradiation.

## *Sample preparation:*

our YBCO sample was prepared by the standard method of sintering finely ground and thoroughly mixed stoichiometric quantities of $BaCO_3$, $Y_2O_3$ and CuO at 700 °C in air.

Examination of the resulting powder by x-ray diffraction showed that it is to be almost primarily the $Y_1Ba_2Cu_3O_{7-\sigma}$ compound. This material was pressed into a disk and fired at 950°C in open air, then slowly cooled, the detailed preparation procedure was mentioned elsewhere (8-11). Five samples were irradiated with $^{60}$CO-γ-radiation at a rate of 1 M rad/2h. Radiation doses are shown in table (1).

## *Measurements*:

The samples were measured immedaitely after irradiation for D.C. resistance from R.T. down to $LN_2$. The standard four-probe method was employed to measure the resistance with gold electrodes pressed against the sample.The current was 10 mA supplied by kiethley 220 A constant current source. The potential difference was measured using kiethley 181 nanovoltmeter and the temperature was measured using platnum resistance thermometer pt-100. The temperature was controlled manually by dipping the sample & thermometer at different depths inside a $LN_2$ half filled dewar, the stability of temperature was ± 1 k.

**Table (1)**

| Sample | Irradiation Mrad | Tc (K) |
|---|---|---|
| S 1 | Unirradiated | 80.7 |
| S 2 | 4.25 | 82.0 |
| S 3 | 5.25 | 82.5 |
| S 4 | 6.75 | 81.2 |
| S 5 | 16.25 | 82.5 |

## RRESULTS AND DISCUSSION

Five samples were prepared and four of them were irradiated to rates shows in table (1). Figure 1 shows the normalized D.C. resistance against the temperature measured during cooling cycle from room temperature down to 78 k. In general the normalized resistance decreses slowly from 1.0 at R.T. down to 0.6 at 90 K then sharply to zero around $T_c = 81$ K. The value of Tc for each sample is shown in table (1). The results show very little change in the resistance dependence on temperature before and after irradiation, even at the highest dose (16.25 M rad.), also the effect of irradiation on the Tc is shown to be very little. x-ray examination of the samples before and after irradiation shows that the dominant phase is almost the $Y_1Ba_2Cu_3O_{7-s}$ phase with no phase change by irradiation as have been confirmed by the D.C resistance measurements.

## CONCLUSION

The ceramic material $Y_1$ $Ba_2Cu_3O_{7-s}$ and its superconducting properties appear to be virtually unaffected by high doses of $\gamma$ radiation.We suggest this is because this substance is primarily an ionic crystal with very strong ionic binding. Although the $\gamma$ irradiation certainly produces substantial electronic excitations it is much less likely to produce ion displacements, in the absence of which, the electrons will return to their original energy states after the irradiation ceases, and the structure and properties of the material will be unchanged. If this is the case, bombardment by heavy particles or lower quantum energy electromagnetic radiation is more likely to produce damaging ion displacements because these radiations can more readily satisfy the momentum transfer conditions requires to displace individual ions. Even though, as noted previously, shielding can limit the effects of these radiations, the types of radiation that can damage these superconductors, the damage mechanisms and defectes produced, are interesting both from practical stand and for the light they may shed on structure and superconducting mechanisms of these exceptionally interesting materials.

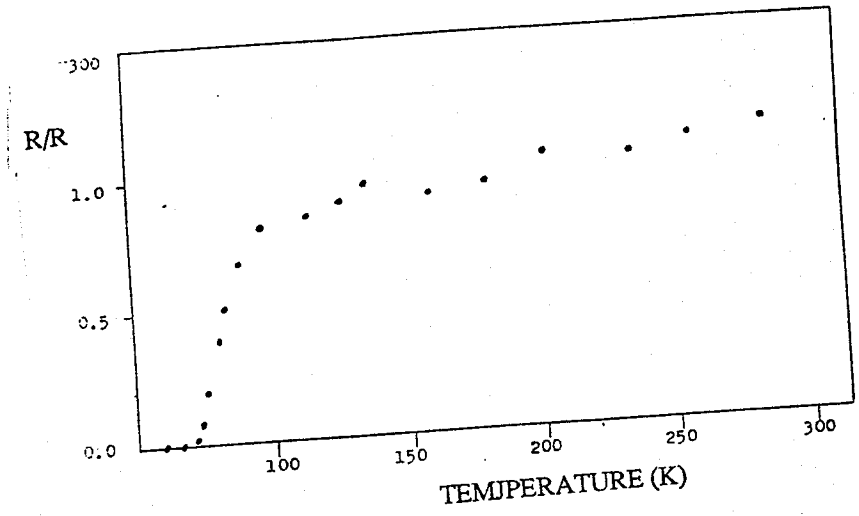


Fig . (1) : The resistance-temperature characteristic of the sample s1.

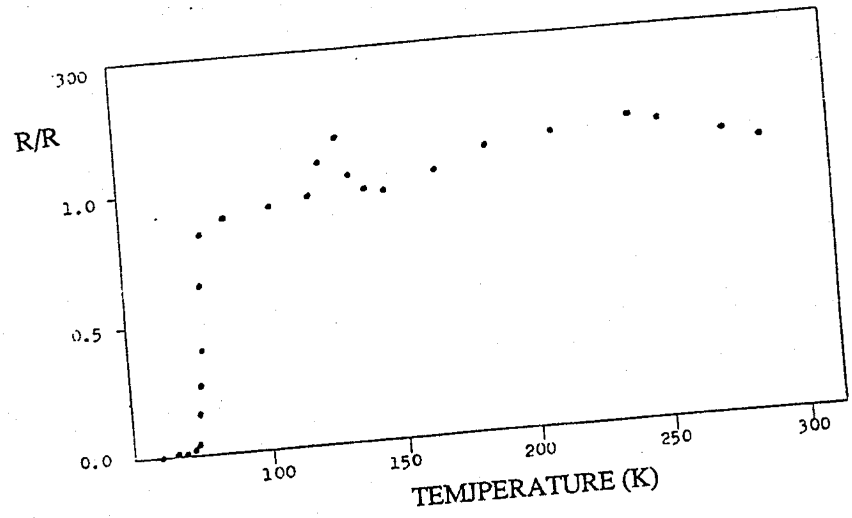


Fig. (2) : The resistance-temperature characterictic of the sample s2.

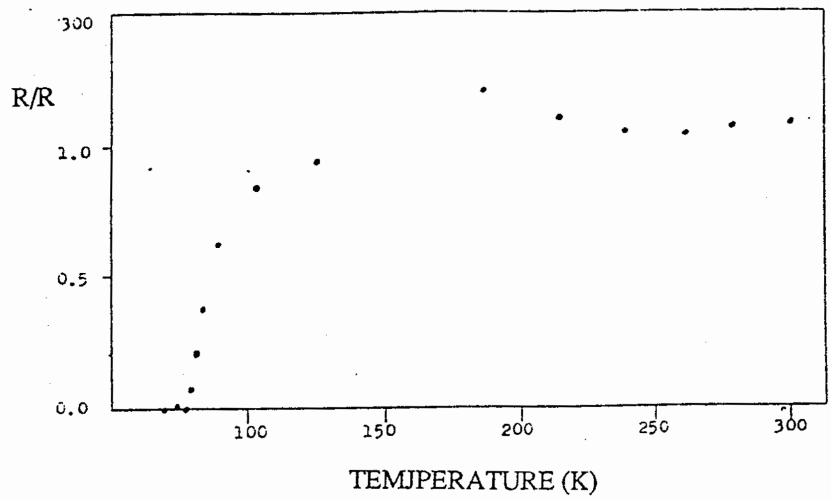


Fig. (3) : The resistance-temperature characteristic of the sample s3.

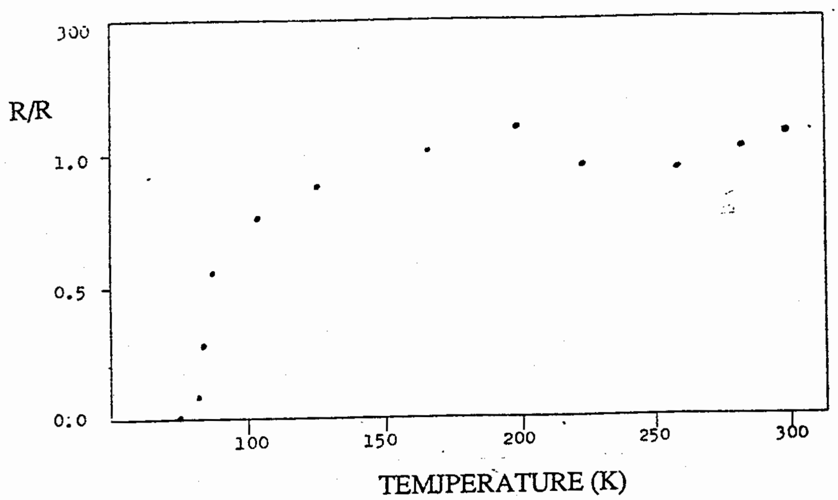


Fig. (4) : The resistance-temperature characteristic of the sample s4.

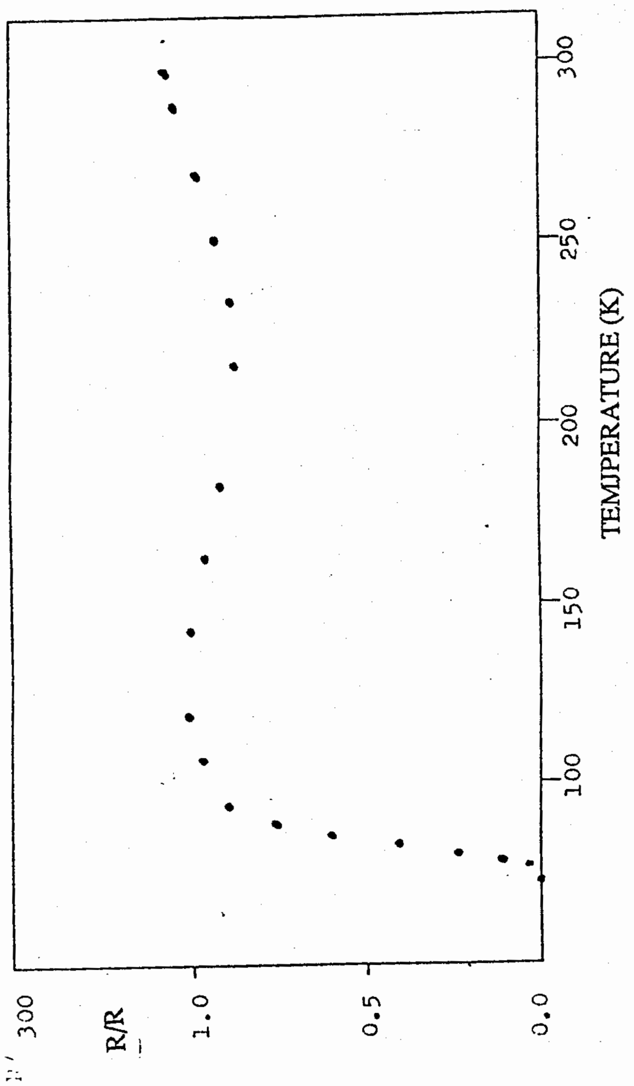


Fig. (5) : The resistance-temperature characteristic of the sample s5.

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## المقاومة الاشعاعية للمواد فائقة التوصيل المنتمية للنظام $Y_1Ba_2Cu_3O_{7-\delta}$

تم تحضير عينات من مواد فائقة التوصيل الكهربى والتى لها درجة حرجة عالية منتمية الى النظام اتر١ با٢ نح٣ ا٧ - س وتم تعريض لاشعة جاما من مصدر مشع كوبلت ٦٠ بجرعات مختلفة حتى ١٦,٢٥ مليون راد .

القياسات الكهربية التى اجريت على العينات التى تم تحضيرها أثبتت عدم تأثر هذه العينات لمثل هذا الإشعاع .