ISSN : 0974 - 7486 Volume 10 Issue 3

Materials Science

An Indian Journal

Full Paper

MSAIJ, 10(3), 2014 [95-98]

Influence of gamma irradiation on the superconductin properties of $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ ceramic

Kareem Ali Jasim[1], Mohammed Abdul-Nebi[1], Sawsan Abdul Hussein Mahdi[1], Tariq J.Alwan[2]*

[1]University of Baghdad, College of Education Ibn Al-Haitham, Department of Physics, Baghdad, (IRAQ)

[2]The University of Mustansiriyah, College of Education, Physics Department, Baghdad, (IRAQ)

E-mail : tariqjaffer2000@yahoo.com

ABSTRACT

We have studied the influence of gamma irradiation on the superconducting behavior of the $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ compound. Bulk polycrystalline samples have been prepared by the solid state reaction process. Superconducting properties and x-ray diffraction (XRD) have studied before and after gamma irradiation. X-ray diffraction analysis showed that $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ compound has tetragonal structure correspond to the high-T_c phase (1223) and low- T_c phase(1212) with decreasing of the c-axis lattice constant, the mass density, the ratio c/a and volume fraction V_{Ph} $_{(1223)}$ by increasing the dose of gamma irradiation. The electrical resistivity, by using the four probe technique, have showed decreasing the transition temperature $T_{c(off)}$ and $T_{c(on)}$ from 118 to 114 K and 131 to 130.5 K, respectively due to increasing irradiation dose.

KEYWORDS

Gamma irradiation;
Superconducting properties and x-ray diffraction.

INTRODACTION

Superconductivity has been discovered in the Tl-Ba-Ca-Cu-O system with a variety of transition temperatures and compositions[1-4].One of the problems in studying the superconducting behavior of these materials is the difficulty of obtaining single phase compound. Partial replacement of Tl^{+2} in an oxygen deficient Tl-O_δ layer by cations having higher oxidation states than Pb^{+4}, Bi^{+3}, Sb^{+4} in order to improve the stability and to make the synthesis of single phase material readily feasible[5-9]. Irradiation techniques are a powerful tool for assessing the influence of defects on superconductors, because they allow one to investigate the same sample prior to and after the irradiation, which excludes problems the variations of the sample. In this study, we have test the effect of gamma irradiation on the superconducting properties for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ compound, at room temperature by using ^{137}Cs source with different irradiated dose namely, 5 MRad and 10 MRad.

EXPERMENTAL

The samples were prepared by standard solid state reaction from the starting materials Tl_2O_3, Cd_2O_3, $BaCO_3$, $CaCO_3$ and CuO by two steps. In the first stepthe powder were mixed and ground in an agate mortar then calcined at 800 ˚C for 4 hours in a furnace to remove CO_2 gases from the mixture.The calcined powder was reground again, then pressed to pellets

Full Paper

with (1.2cm) in diameter under a hydrostatic pressure about (11 tons/cm^2). The pellets were then put in a furnace which has a programmable controller for sintering, and were presintered in air at 855–860 æ%C for 12 hours with a rate of 60 ˚C /h, and then were cooled to room temperature by same rate of heating. In the second step the pellets were reground, repressed, and resintered in the oxygen (oxygen rate 0.3 L/min) at the same range of temperature for further heating (12 hours).Finally,some samples have been irradiated by gamma ray at room temperature by using ^{137}Cs source with different irradiated dose for obtaining three samples. The sample A without irradiation, the sample B irradiated with dose 5MRad and the sample C irradiated with dose 10MRad. The ρ –T (resistivity vs. temperature) characteristics of these samples were measured by means of a standard d.c four-probe technique for measuring the critical temperatures to investigate their superconducting state. The structure of the prepared samples was obtained by using X-ray diffraction (XRD) in a range from 20 to 60 degrees. A computer program was established to calculate the lattice parameters a and c based on Cohen·s least square method[13]. The volume fraction for each phase (V_{phase}) has been determined[6]. The excess of oxygen content (δ) in all samples has determined by idometric titration method[10].

RESULT AND DISCUSSION

TABLE (1) shows experimental values of $T_{c(OFF)}$,$T_{c(ON)}$, $\delta(o_2)$,$a(A^0)$, $c(A^0)$, C/a, ρ_M, $V_{Ph-1223}$ for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ superconductor as a function of gamma irradiation dose. A plot of the normalized resistivity verses temperature (ρ –*T*) behavior for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ compound before and after gamma irradiation is shown in Figure (1). As a result one can observe

from Figure (2) that the transition temperatures $T_{c(offset)}$ and $T_{c(onset)}$ decrease from 118 to 114 K and 131 to 130.5 K, respectively due to increasing irradiation dose.

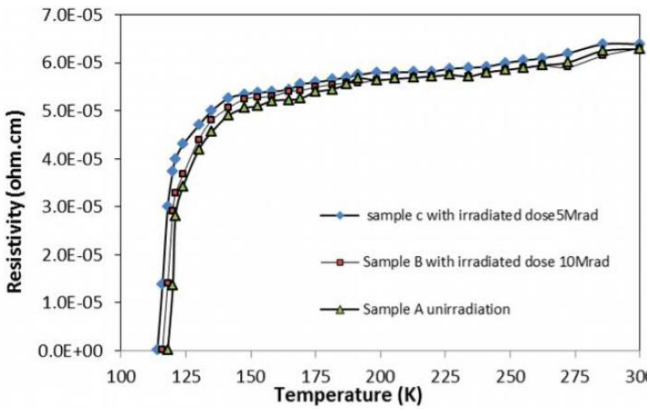

Figure 1 : The resistivity vs. temperature for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ at different irradiation dose

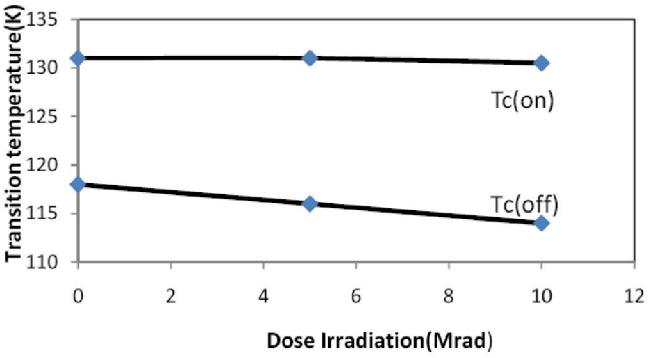

Figure 2 : transition temperature as a function of irradiation dose for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$.

Figure (3) shows XRD patterns for the samples A, B and C. It shows that all the samples consisted of a major high-T_c phase (1223) peaks H, minor low –T_c phase (1212) peaks L, and very small amounts of secondary phases. In addition the volume fraction $V_{Ph(1223)}$,the mass density and the ratio c/a decrease with increasing irradiation dose as shown in Figures.(4,5,6) respectively. From the values of excess oxygen δ shown in the TABLE (1) and Figure (7) we noted that the values of oxygen content of the specimens after irradiation decrease because it acts on the decompose the bonds in the CuO planes and increasing of defects,

TABLE 1 : Values of $T_{c(OFF)}$,$T_{c(ON)}$, $\delta(o_2)$,$a(A^0)$, $c(A^0)$, C/a, ρ_M, $V_{Ph-1223}$ for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ as a function of gamma irradiation dose.

Irradiation dose(Mrad)	$T_{c(OFF)}$(K)	$T_{c(ON)}$ (K)	$\delta(o_2)$	$a(A^0)$	$c(A^0)$	C/a	ρ_M (g/cm^3)
0	118	131	0.229	3.82	15.83	4.1434	5.584
5	116	131	0.237	3.87	15.80	4.082	5.579
10	114	130.5	0.248	3.89	15.79	4.059	5.571

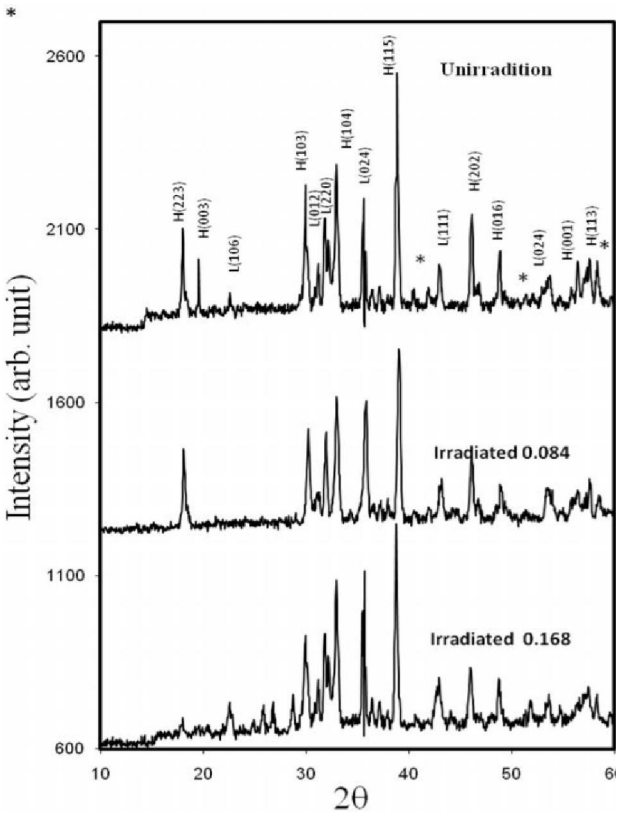

Figure 3 : XRD patterns of $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ at different irradiation dose

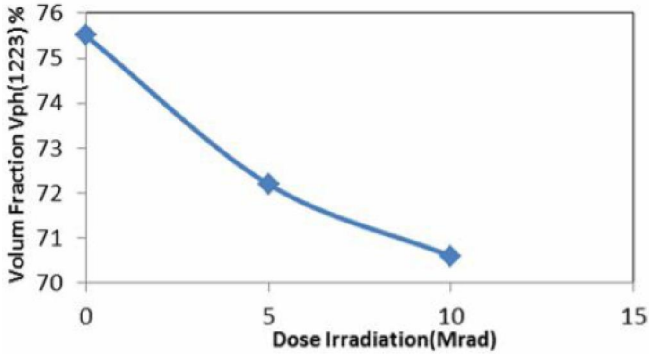

Figure 4 : $V_{ph(1223)}$ as a function of irradiation dose for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$

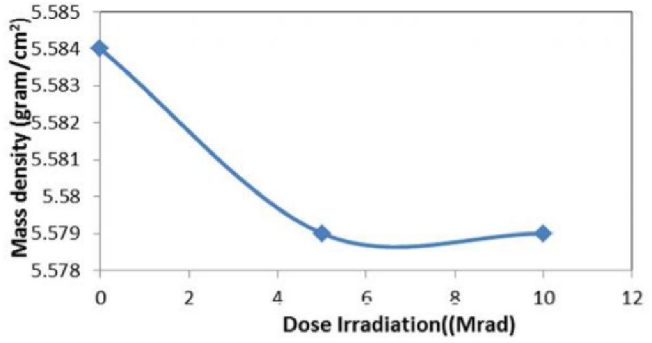

Figure 5 : Mass density as a function of irradiation dose for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$

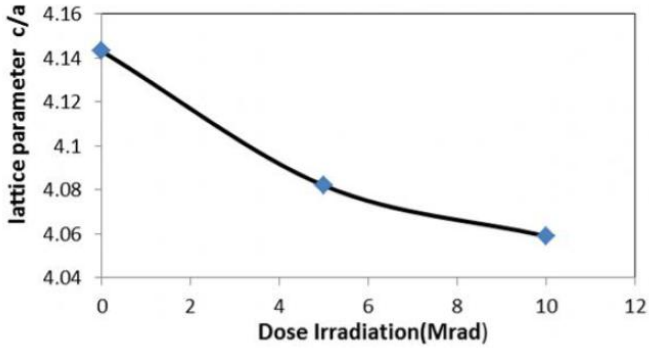

Figure 6 : Ratio c/a as a function of irradiation dose for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$

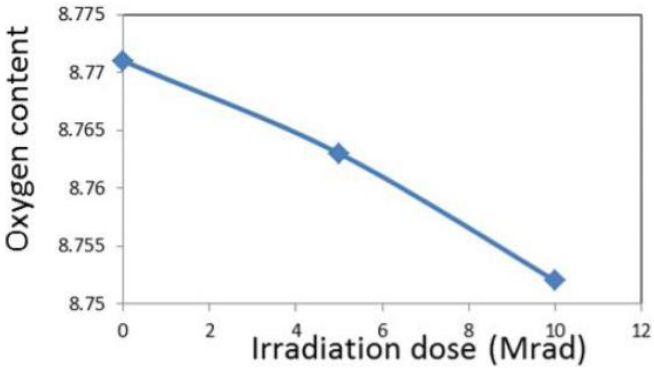

Figure 7 : Oxygen content as a function of irradiation dose for $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$

which decreases the number of holes in the lattice that account for decreasing critical transition temperature T_c [11].

CONCLUSIONS

In the present study, we have investigated the effect of gamma irradiation on the superconducting properties of $Tl_{0.72}Cd_{0.28}Ba_2Ca_2Cu_3O_{9-\delta}$ superconductor, synthesized by the solid state reaction method. Where noted from the experimental results that The transition temperatures of samples $T_{c(off)}$ and $T_{c(on)}$ decrease from 118 to 114 K and 131 to 130.5 K, respectively with increasing irradiation dose. This means that superconductors sensitive to the gamma irradiation, therefore we must caution when use the superconductor in the airspace.

REFERENCES

[1] Z.Z.Sheng, A.M.Hermann, A.El Ali, C.Almasan, J.Estrada, T.Datta, R.J.Matson; Physical Review Letters, **60**, 937 **(1988)**.

Full Paper

[2] R.M Hazen, L.W.Finger, R.J.Angel, C.T.Prewitt, C.G.Hadidiacos, P.J.Heaney, A.M.Hermann; Physical Review Letters, **60**, 1657 **(1988)**.

[3] C.C.Torardi, M.A.Subramanian, J.C.Calabrese, J.Gopolakrishnan, K.J.Morrissey, T.Askew, U.Chowdhry, A.Sleight; Science, **240**, 631 **(1988)**.

[4] M.A.Subramanian, J.C.Calabrese, C.C.Torardi, J.Gopolakrishnan, T.R.Askew, R.B.Flippen, U.Chowdhry, A.W.Sleight; Nature, **332**, 420 **(1988)**.

[5] K.A.Jasim; Ibn Al-Haitham Journal for pure and applied sciences, **3**, 38 **(2008)**.

[6] K.A.Jasim, Tariq J.Alwan, J.Supercond; Nov.Magn, **22**, 861 **(2009)**.

[7] K.A.Jasim; Journal of college of education, **84**, 806-812, **(2009)**.

[8] K.A.Jasim, T.J.Alwan; Materials Science & Technology Conference and Exhibition (MS&T'09), **14**, **(2009)**.

[9] M.Werner, F.M.Sauerzopf, A.Wisniewski; Phys.Rev.B, **61** 14795 **(2000)**.

[10] I.F.Ferguson, A.H.Rogerson; Comput.Phys.Commun., **32**, 95, **(1984)**.

[11] V.Sandu, S.Popa, D.Digioacchino, P.Tripodi; Journal of Optecalelctronics and advanced materials, **8**, 391–395 **(2006)**.