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Study the effect of gamma Irradiation on the Superconducting Properties of $HgBaSrCa_2Cu_3O_{8+\delta}$

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Abstract. In this work, goal is to study the effect of gamma irradiation on the properties of superconducting of the superconductor $HgBaSrCa_2Cu_3O_{8+\delta}$, at room temperature using a source of ^{137}Cs with a dose of 3. 6 and 9 MRad. The sample was prepared through solid state interaction. The properties of superconductor and XRD were studied before and after irradiation. It appears that our compound has a quadratic structure corresponding to the 1223 phase with a low c / a ratio due to gamma irradiation. Moreover, the transition temperature (Tc (on) & Tc (off)) decreased from 113 to 105 K and 119 to 114 K, respectively, when the dose increased from 0 to 9 Mrad.

1. Introduction

Superconductivity is a phenomenon that represent two states, an ideal conductivity ($\rho = 0$) and diamagnetic (χ= -1,$\mu < 1$), where this phenomenon occurs with certain substances under certain low temperatures called critical temperature and has a symbol of (T_c). The main aim of most papers in superconductor field is to rise the critical temperature to make it close to room temperature, thus the researchers try to change the preparation condition or replacement of some elements in compound by another. And how superconductivity is affected when exposed to electromagnetic and charged particles fields. Superconducting applications are widely used in the medical and engineering fields. These applications are used in radiometric examination, magnetic resonance imaging and in laser devices that need to be accurately used.

Hg –base superconductors are generally given by $HgBa_2Ca_{n-1}Cu_nO_{2n+3n}$-((n: the number of consecutive Cu-O layers). It is well known that three phases are $HgBa_2CuO_{5+\delta}$ ((n = 1, 1201 phase, T_c 86 K), $HgBa_2CaCu_2O_{6+\delta}$ ((n = 2, 1212 phase, T_c = 105 K) and $HgBa_2Ca_2Cu_3O6+\delta$ (n = 3, 1223 phase, T_c = 132K), which is formed by the traditional method of frying [1, 2]. The synthesis of the superconducting ceramic material base on the elements of Mercory, Barium, Copper and Oxygen was the beginning of the creation of a new porcelain of copper oxide - a higher critical temperature (T_c) of 70 Kelvin [3]. The oxides of bismuth, strontium, calcium and copper for the production of newly superconducting ceramic T_c ranged from 80-110 k [4]. Moreover, some properties of superconductors can be studied by radiation. Radiation mechanisms are a powerful tool for assessing the impact of defects on superconductors, because they allow one to investigate the same sample before and after irradiation, which excludes problems of differences in the sample [4-6]. Here, we report the study of gamma rays on superconducting transport in bulk polycrystalline samples of the $HgBaSrCa_2Cu_3O_{8+\delta}$ compound, at room temperature using a source of 137Cs with a dose of 0,3, 6 and 9 MRad.

2. Experimental

The synthesis of four samples (A, B, C and D) of $HgBaSrCa_2Cu_3O_{8+\delta}$ High Temperature Superconductors (HTSC) phases have been prepared by solid-state reaction process. The same initial chemical proportions prepared the specimens corresponding to the original mixtures, such that by the mixing of HgO, BaO, CaO and CuO, as a starting substance, according to the general chemical formula:

$HgO + BaO + SrO + 2CaO + 3CuO \rightarrow HgBa\mathit{Sr}Ca_2Cu_3O_{8+\delta}$

Sampling synthesis was performed through two precursors. In the first step, BaO, SrO, CaO and CuO powders were mixed together using a mortar paste to form the clay during the grinding process for a period of 40-60 minutes. The mixture was placed in a furnace for calcification. For this process, the powder was heated to 850 ° C for three hours at 200 ° C / hour and then cooled to the temperature of room at the same heating rate. In the second step, the precursors Ba $SrCa_2Cu_3O_7$ were mixed with HgO to obtain the $HgBaSrCa_2Cu_3O_{8+\delta}$ nominal structures. The powder was pressed in the form of pellets in the shape of a disk (1.5 cm) and diameter (0.25-0.3 cm) using hydraulic pressure under 5 ton / cm^2 pressure. The pellets prepared in the usual quartz tube were prepared on the basis of 855-860 ° C for 24 hours at a rate of 200 / h / h, then cooled to room temperature and filled for 4 hours and cooled to the temperature of room at the same heating rate. In order to make comparisons between samples A, B, C and D (sample A, which was prepared without irradiation, samples B, C and D were exposed to radiation, using a source of 137^{Cs} in doses 3, 6 and 9 MRad, respectively).

The properties of ρ -T (resistance to temperature) of these specimens were measured by a standard d.c probe technique to verify their superconductivity properties. Oxygen content can be determined using the method of chemical, the so-called iodometric calibration [7]. Methods for measuring critical temperatures and metatarsal parameters a and c as well as the volume fraction of any Vphase phase were described elsewhere [8].

3. Results and Discussion

From the curve of the resistance vs. temperature curves (ρ -T) shown in the figure, one can obtain the values of critical transition temperatures Tc (displacement) and TC (starter) before and after gamma irradiation using source 137^{Cs} with a dose of 0, 3, 6 and 9 MRad. These temperatures were 113 to 105 K and 119 to 114 K when the dose increased from 0 to 9 Mrad, respectively.

Figure. 1. shows measured resistance to temperature (ρ -T). The critical transition temperature (due to irradiation from 0 to 9 MRad) decreased from 113 to 105 K for $T_{c\ (offset)}$ and 119 to 114 K for $T_{c\ (onset)}$ increased from 0 to 9 Mrad, respectively. According to X-ray diffraction data, samples were found consisting of almost pure polyphase phase Hg-1223. However, very small amounts of Hg-1212. Very small quantities of secondary stages were detected in all specimens. Figure. 2. appearances the XRD patterns taken in non-irradiated granules of sample A and radioactive samples B, C and D with gamma irradiation currents of 3, 6 and 9 respectively. (1212 peaks), the higher phase reflections T_c for sample (A) have a higher density than samples B and C and D increase in the peaks of 1212 and a decrease in the 1223.

The lattice parameters were estimated using d values and h k l reflections of X-ray diffraction pattern observed by the program based on the least Cohen-s square method [10]. The values of the temperature parameters $T_{c(offset)}$,$T_{c(onset)}$, oxygen content, exess oxygen $\delta_{(O2)}$, a, c, c / a, and volume fraction $V_{ph\ (1223)}$. It is worth noting that experimental errors in the current results were estimated at (± 5%).

The oxygen values of as shown in Table 1 showed that the value of the oxygen content in the sample increases after the irradiation increase from 0 to 9 Mrad, because it decomposes the bonds in the CuO planes and increases the defects, The number of holes in the grid that cause the temperature drop is critical to T_c [9]. According to x-ray diffraction data shown in Figure. 2. For our samples we note that they have a tetragonal structure with a change of c / a ratio. In addition, they consist of high $HgBaSrCa_2Cu_3O_{8+\delta}$ high phase and increase very amounts of $HgBaSrCa_1Cu_2O_{6+\delta}$ phase.

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4. Conclusions

We have inspected the effect of gamma irradiation of HgBaSrCa2Cu3O8+δ superconductor which has been prepared under optimum conditions. X-ray diffraction analysis showed tetragonal structure with changing of the ratio c/a for the samples irradiation compared with that unirradiation. The transition temperature is found to be sensitive to gamma irradiation where the transition temperature Tc(off)and Tc(on)were decreased (due to irradiation from 0 to 9 MRad) from 113 to 105 K for Tc(offset) and 119 to 113K for Tc(onset) from irradiatiom increase 0 to 9 MRad.

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Table1. values of $T_{c(OFF)}$, $T_{c(ON)}$,$\delta(o_2)$, $a(A^0)$, $c(A^0)$, C/a , for $HgBaSrCa_2Cu_3O_{8+\delta}$ compound as functions of gamma irradiation dose.

Dose	**0**	**3**	**6**	**9**
$T_{c(OFF)}$**(K)**	**113**	**108**	**106**	**105**
$T_{c(ON)}$ **(K)**	**119**	**117**	**116**	**114**
$\delta(o_2)$	**0.111**	**0.221**	**0.244**	**0.253**
$a(A^0)$	**3.30**	**3.32**	**3.33**	**3.37**
$c(A^0)$	**15.483**	**15.772**	**15.857**	**15.441**
c/a	**4.691**	**4.750**	**4.476**	**4.581**

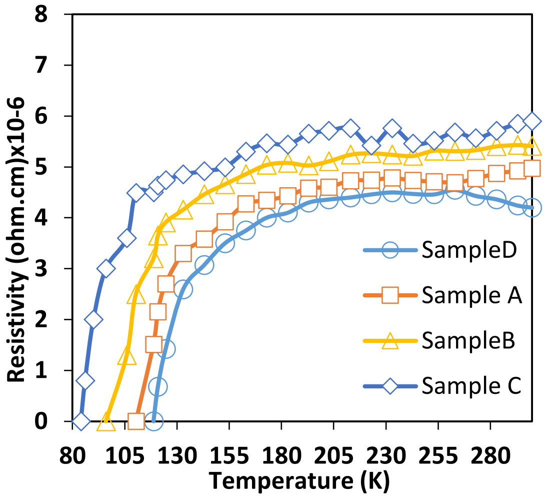

Figure1. The resistivity vs. temperature for sample A without irradiation, Samples B, C and D have been irradiated, by using ^{137}Cs source with dose 3, 6 and 9 MRad respectively.

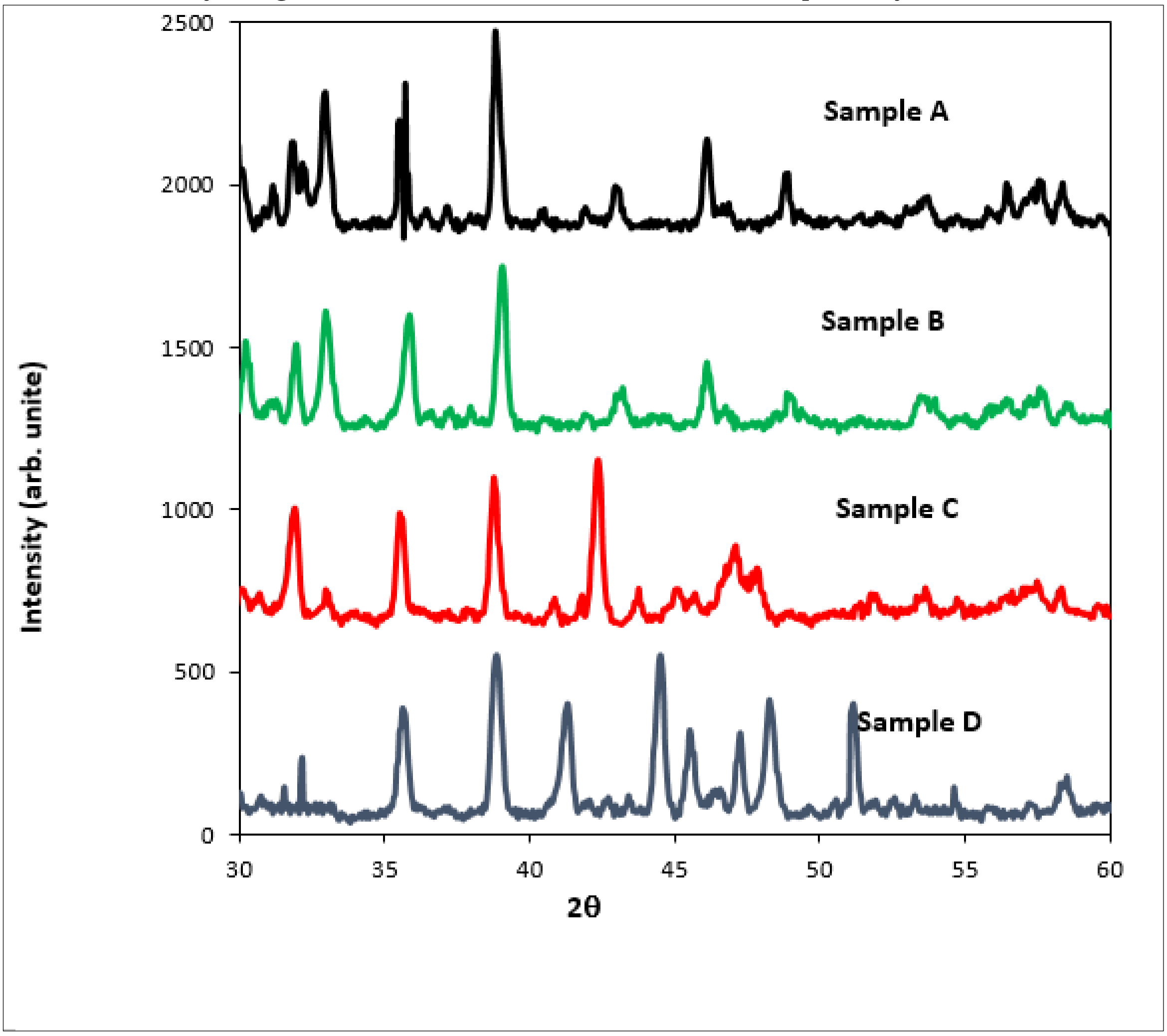

Figure2. XRD patterns for the $HgBaSrCa_2Cu_3O_{8+\delta}$ samples A, B, C and D.