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STUDY OF THE STRUCTURAL AND ELECTRICAL EFFECTS OF THE $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+\delta}$ SUPERCONDUCTING WITH PARTIAL REPLACEMENT OF SILVER WITH THALLIUM

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Abstract

In this manuscript, the partial substitution of thallium by silver and its effect on the superconducting properties of $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+\delta}$ is studied with x = 0, 0.15 and 0.25. The samples were prepared by the solid state reaction method. The electrical conductivity was examined using the four probes technique to determine the critical temperature Tc. It was found that increasing the proportions of silver for all produced samples increases the critical temperature. It was also found that the best compensation ratio for x is 0.25, which gives the highest critical temperature, Tc. The ultrastructural properties of the samples were studied using X-ray diffraction. X-ray diffraction study showed that all the prepared samples had a tetragonal structure, with a clear change in the lattice constants. The results also showed that the samples were clearly affected by the replacement of silver with thallium. It was shown that the partial replacement of Tl with Ag promoted the formation of the superconducting 2223 phase.

Keywords: *Thallium, Silver, Superconducting Properties, Solid State Reaction Method, Electrical Conductivity And Tetragonal Structure.*

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Introduction

When materials are cooled to a specific temperature, known as the critical temperature Tc, they become superconducting, allowing electric current to flow without resistance and with no magnetic flux at all. This property is crucial for many applications in electronics, connectivity, and medical equipment. [1,2]. After the discovery of some ceramic materials with a temperature of more than 90 K, which were referred to as high-temperature superconductors, superconductors entered a new stage. The ability to use liquid nitrogen for cooling [3] and liquid nitrogen at a temperature of (77 K), which can be obtained readily and at an affordable price [4, 5], and the discovery of these materials have mad. When materials are cooled to a specific temperature, known as the critical temperature Tc, they become superconducting, allowing electric current to flow without resistance and with no magnetic flux at all. This property is crucial for many applications in electronics, connectivity, and medical equipment. [6,7]. After the discovery of some ceramic materials with a temperature of more than 90 K, which were referred to as high-temperature superconductors, superconductors entered a new stage. This discovery is extremely significant because liquid nitrogen at a temperature of (77 K), which is readily available and reasonably priced [8, 9], may now be used for cooling [10].

The discovery of these materials has facilitated numerous experiments and applications. Research is still going on to find superconducting materials with higher critical temperatures so that the applications are more readily available. Liquid nitrogen at a temperature (77 K), which can be obtained easily and at an appropriate cost [4, 5], is another option. Tl-1223 was discovered to have two configurations in general: A pure compound is TlBa2Ca2Cu3O9 [6].

A pure compound (Tl1xAgx) Sr2Ca2Cu3O9, where A is Pb, Hg, Sb, or Bi, is known as TlBa2Ca2Cu3O9 investigated the impact of doping in the Tl-1223 phase and discovered that while all samples' structures remained tetragonal [11], their respective lattice constants a and c grew as the transition temperatures grew. just a little. Copper oxide is present in one or more layers in superconducting ceramics with high critical temperatures [12]. According to one of them, the addition of in lowers the transition temperature from 122 to 100 K whereas a tiny quantity of Hg raises the critical temperature from 122 to 131 K. Additionally, (Tl0.5Pb0.5) Sr2Ca2Cu3O9 can be enhanced by partially substituting Pb and Bi for Ba + 2 at the Sr + 2 and Tl sites [8, 9]. These modifications enhance both Tl-1223's superconducting characteristics and its formation. In this study, we synthesize superconducting samples of a Tl1-xAgxBa2Ca2Cu3O9 complex with x = 0, 0.15, and 0.25 by quantitatively substituting thallium silver in the Tl-1223 phase under solid-state conditions, taking advantage of the excellent control of the resulting reaction under low O2 pressure, allowing the formation of pure (Tl)-1223.

The molecular weights of these materials relative to the weight of the element in each of the base material and the compound (sample) to be generated were used to calculate the weight ratios of the materials that contribute to the creation of the $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+d}$ compound.

1. Preparation

The molecular weights of these materials relative to the weight of the element in each of the base material and the compound (sample) to be generated were used to calculate the weight ratios of the materials that contribute to the creation of the $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+d}$ compound.

The oxides and carbonates are weighed out, combined, and then put into granules. These materials are then ground finely for 30 minutes using an agate grinder so that the mixture becomes homogeneous. An isopropanol solution is added during the grinding process to prevent falling or losing powder during the grinding process. The isopropanol alcohol is then removed from the grinder by placing it in an electric oven set between (50°C, 60°C).

These powders are put in a convection oven, which is heated to 850°C and heated at a pace of 120°C per hour in an air-saturated environment. This form is kept at (850 C) for (12) hours before being lowered to allow it to cool to a specific temperature. The model is taken out of the furnace at room temperature with a cooling rate of 30°C/hr and temperature control using a thermocouple. To prevent vaporization and loss, the powder is then combined and continuously processed for another 30 minutes. The ester of is solution is then added. 50˚C, 60˚C).

The powder is then manufactured under pressure (8 Ton/cm) in the form of tablets. These tablets had (12 mm) diameters and ranged in thickness from (0.8 mm) to (1.2 mm). 9. These discs are put in an electric oven, where the temperature is progressively increased to (850 °C) at a pace of (120 °C/hr) and held there for 12 hours before being gradually lowered at a rate of (30 °C). After acquiring the samples that were made in the shape of tablets from the previous sentence, the process of heating and cooling takes place in an atmosphere that is saturated with oxygen until it reaches room temperature. This process is known as sintering. The prepared samples are obtained as tablets, which are then placed in an electric oven and heated to (600 °C) at a rate of (120 °C/hr) from room temperature. The sample is then kept at this temperature for (12) hours before the temperature is raised. The oven heats up to 850 degrees Celsius at a rate of 120 degrees Celsius per hour, where it stays for 24 hours in an oxygen-rich environment. The model then cools to 600 degrees Celsius at a rate of 30 degrees Celsius per hour, where it stays for another 12 hours before being cooled to room temperature at a rate of 60 degrees Celsius per hour to room temperature. Tablet-shaped samples are obtained, and after being processed, they will be examined using an X-ray diffraction instrument to determine their structural characteristics and to look at their electrical properties with the four probes method.

2. Results and discussion

When the element Ag is partially substituted for the element Tl in the compound $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+\delta}$ compound, with x=0,0.15,0.25, the structural properties of the compound have been studied. However, the structural properties of the compound $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+d}$, which was prepared at an annealing temperature of 850 and under a hydrostatic pressure of 8 tons/cm 2 are different. When creating the models with the X-ray device and putting the value of x = 0.0.15 into the compound, the X-ray diffraction investigation of these samples revealed. The regularity of the crystalline structure and the appearance of distinct peaks are noticed as shown in figure 1.

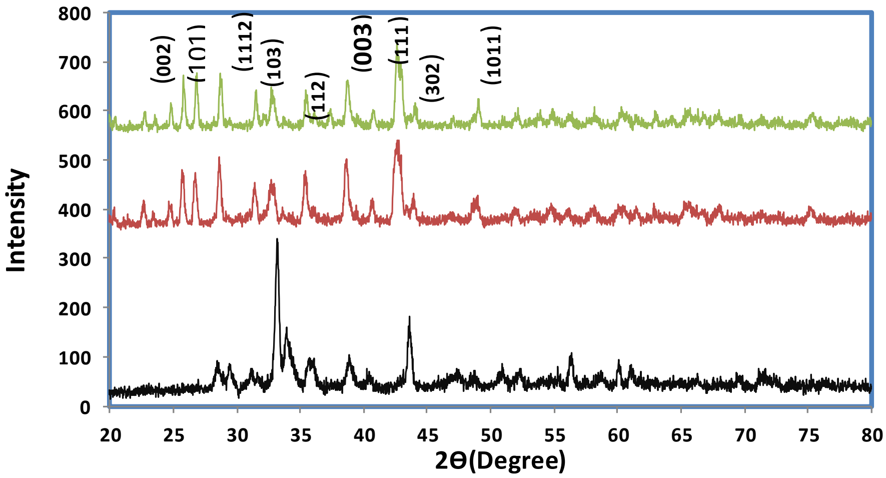

Figure (1): The diagram shows X-ray diffraction of $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+d}$ compound as function of 2Θ, with indicated values of x=0,0.15,0.25

Miller coefficients hkl are then discovered, and using a particular BASIC software, the values of the unit cell's dimensions are discovered. a = b = 5.24 A^0 and, c = 33.35 A^0 for x= 0, where: a = b = 5.34 A^0, c = 32. 89 A^0 for x= 15, a = b = 5.46 A^0 and, c = 32.125 A^0 for x= 25, as shown in Table 1. The results of X-ray diffraction revealed that the crystalline structure retained of the tetragonal type [13,14], with a visible decrease in the length of the c axis when the compensation ratio was raised to x = 0.25.

Using the four-probe approach, the electrical characteristics of the compound were investigated in order to determine critical temperature $T_{c(onset)}$ and $T_{c(offset)}$ for calculated the electrical resistivity as a function of temperature after the element Ag was partially substituted in the TI element of the $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+d}$ compound.

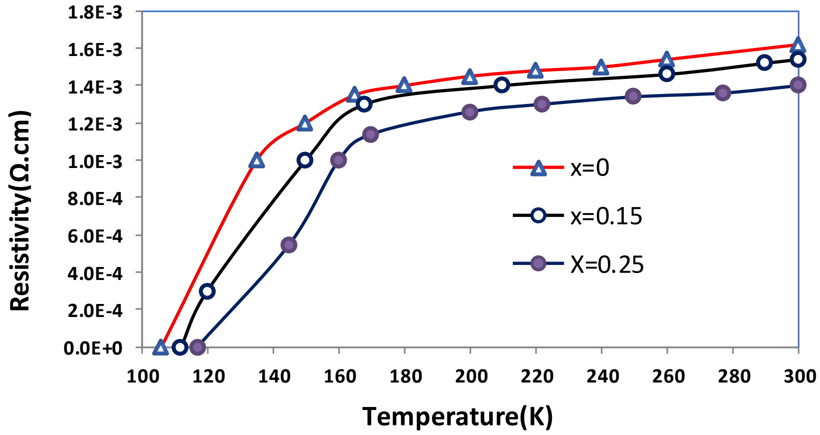

Figure (1): The diagram shows Resistivity of $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+\delta}$ compound as function of Ag, with indicated values of x=0,0.15,0.25

According to the study, the critical temperature $T_{c(onset)}$ and $T_{c(offset)}$ of the samples prepared when the compensation ratio was x= 0 ranged from 107, 132 K, and when the concentration ratio of Ag was increased to x = 0.15, the critical temperature rose from 113,139 K. When the concentration ratio of Ag was increased to x = 0.25, the critical temperature rose from 118, 143 K, respectively. Is was found that the critical temperature increased with increasing Ag concentration as shown in figure 1 and table 1 [15]. This result can be explained by the compound playing the perfect role in the crystal structure [16,17], and this percentage of compensation caused the critical temperature to rise as a result of an increase in the high phase 2223 with an increase in the silver concentration in the samples.

Table (1): Values axes a,c $T_{c(onset)}$, ΔT and $T_{c(offset)}$ of of $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+\delta}$ compound as function of Ag, with indicated values of x=0,0.15,0.25

x	**a** A⁰	**c** A⁰	$T_{c(OFF)}$(K)	$T_{c(ON)}$ (K)	ΔT_c(K)
0	5.24	33.35	107	131	24
0.15	5.34	32. 89	113	139	16
0.25	5.46	32.125	118	143	25

3. Conclusion

The effect of partial thallium replacement with silver on the superconducting characteristics of $T_{2-x}Ag_xBa_2Ca_2Cu_3O_{10+\delta}$ is examined in this publication with x = 0, 0.15, and 0.25. The solid state reaction approach was used to prepare the samples. The four probe method was used to evaluate the electrical conductivity in order to calculate the critical temperature Tc. The critical temperature was observed to rise as the quantities of silver in all produced samples increased. The optimal compensation ratio for x was also discovered to be 0.25, which results in the highest critical temperature, Tc. X-ray diffraction was used to examine the samples' ultrastructural characteristics. All of the prepared samples had a tetragonal structure, with a distinct change in the lattice constants, according to an X-ray diffraction investigation.

The ideal role that the compound played in the crystal structure can be utilized to explain this result. This percentage of compensation led to an increase in the critical temperature and an increase in the high phase 2223 with an increase in the silver concentration in the samples.

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