The Effect of Oxygen Flow on the Transition Temperature of Hg0.75Pb0.25Sr2-yBayCa2Cu3O8+ δ Superconductors

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Abstract. In this paper, there are three different high temperature superconductors which are Hg0.75Pb0.25Sr2-yBayCa2Cu3O8+δ with different weight fractions y = 0.10, 0.20 and 0.25 that have been prepared successfully by solid state reaction and the samples have been equipped with/without O2 flow. The optimum calcinations is 1073 K and the sintering process that has been achieved within 1128-1133 K. Transition temperature Tc has been found by using four probe technique through electrical resistivity measurements. The greatest Tc that has been found for Hg0.75Pb0.25Sr1.75Ba0.25Ca2Cu3O8.31 is 115 oK. Oxygen content (O2) flow exhibits high-phased superconductors that is similar to the samples prepared without O2. Investigation of X-ray diffraction (XRD) is revealed (tetragonal structure) by the c-axis lattice parameter increasing of the samples substituted with Ba. It has been established, from the calculated results, that the Ba variation concentrations of all samples products a modification in the density (ρm), (c/a) and volume fraction (VPh(2223)).

1. Introduction
Many magnificent attempts have been achieved recently to develop the constancy of the Hg-1223 phase. Much efforts have been practiced in the production of Hg-Base high Temperature Superconductor (HTSC) phases manner, because of their sensitivity excess towards polluting from humidity and carbon dioxide. HgBa2Ca (n-1)CuO2n+2+δ phases synthesize is not so stable as the other HTSC phases of cuprate oxide group [1-3]. The majority effective method to advance the stability of the Hg-1223 phase is doing appropriate cationic exchange for Hg, which has oxidation states upper than that of Hg+2. Various substituted cationic like, Tl+3, Sn+4, Bi+3, Pb+4, Mo+4, Re+4, etc have made an effort [4-7]. The effect of this cationic replacements on the superconducting possessions are different. Furthermore, they lead to superior chemical stability [8, 9]. By (Ba) substituting to the (Sr) lesser cation in Hg0.8Tl0.2Ba2Ca2Cu3O8+δ which supply reservoir clog conduct to reduce the reaching between the superconductivity CuO2 blocks, that may improve the interlayer pair strength and cause a modification to irreversible line to higher fields [10,11]. They gain extra oxygen in the oxygen lacking HgOδ layer.
conducing to phase stability. In this paper, it has been substituted the Ba at the Sr site in the oxygen deficient Sr-O layer of Hg0.75Pb0.25Sr2Ca2Cu3O8+ δ superconductor, which is synthesized by solid state reaction technique.

2. Experimental Setup
The synthesis of Hg0.75Pb0.25Sr2-yBayCa2Cu3O8+δ HTSC phases (y = 0.10, 0.20 and 0.25) have been composed in a solid state reaction technique by three steps, suitable weights of started material (99.998% from May & Baker LTD Dagenham England). Each reaction that has been weighted of, HgO, Pb2O3, SrNO3, BaCO3, CaCO3 and CuO as powders by utilizing a sensitive balance. The powders of (BaCO3, SrNO3, CaCO3 and CuO), in the first stage are mixed collectively by utilizing agate mortar, the procedure of crushing take about (30-50) minute to homogeneous. Then, product mixture that is dehydrated by an oven at 473 °K. The mixture is placed in (programmable tube furnace) and exposed to 1073 °K temperature for about three hours with a rate of 473 °K/hr, then exposed to room temperature (RT) ambient by the similar heating amount of calcinations. This process is achieved to eliminate NO3 and CO2 gas from the prepared mixture.

The Sr2-yBayCa2Cu3O7 precursor of the second step is mixed with HgO and Pb2O3 to get the insignificant compositions Hg0.75Pb0.25Sr2-yBayCa2Cu3O8+δ. After that, powders is pressed into disc-designed pellets of (1.3 cm) diameter, and (0.2-0.3 cm) thickness, employing hydraulic press of type (Specac) underneath a pressure of 8 ton/cm2. The acquired pellets are presintered in air ambience with a rate of 473 oK/hr for twenty hours at 1128-1133 oK, then cooled down to RT by similar heating proportion.

The final step, pellets are re-pulverized, re-pressed and re-sintered in air and oxygen (oxygen rate 0.6 L/min) at the equivalent range of temperature for (24 hours) and then cooled at 773 oK, after that is annealed under oxygen for (4 hours) and then exposed to cool at room temperature by similar rate of heating. The examination of the (resistivity corresponding temperature), the excess of oxygen δ (O2) Δ (O2), in addition to measured transition temp. Tc, lattice paramètres (a, b, c and c/a) and mass density ρM have been described elsewhere [12-14]. The prepared specimens structure is identified by utilizing (X-ray diffractometer (XRD) - Philips) which have the following specifications, the source of Cuκα, current of (20 mA), voltage of (40 KV) and wave length (1.5405 A0).

3. Results and discussion
The quality diffusion coefficient of oxygen has been carefully determined which is critical grandness in optimizing the amply dense of polycrystalline samples [15-18]. Figure1 shows the resistivity as function of temperature for all Hg0.75Pb0.25Sr2-yBayCa2Cu3O8+δ samples prepared with or without oxygen treatments. The samples with oxygen treatments demonstrated a good high temperature superconductor while the samples that are without oxygen given lower Tc, because Tc increases with the increasing of δ [19, 20]. The zero-resistivity critical temperature Tc(0) increases systematically with increasing in concentration of Sr. The results of transition temperature Tc(0) for gaining Hg0.75Pb0.25Sr1.9Ba0.1Ca2Cu3O8.141, Hg0.75Pb0.25Sr1.8Ba0.2Ca2Cu3O8.191, Hg0.75Pb0.25Sr1.75Ba0.25Ca2Cu3O8.310, phases are 95, 98 and 117 °K, respectively. The data of Tc1 without O2 flow and Tc2 with flow of O2 are enumerated in the (table 1).

Table 1: Transition temperature (K) for the different Hg0.75Pb0.25Sr2-yBayCa2Cu3O8+δ samples.

| Sample        | Tc1 | Tc2 |
|---------------|-----|-----|
| Hg0.75Pb0.25Sr1.9Ba0.1Ca2Cu3O8.141 | 95  | 117 |
| Hg0.75Pb0.25Sr1.8Ba0.2Ca2Cu3O8.191 | 98  | 117 |
| Hg0.75Pb0.25Sr1.75Ba0.25Ca2Cu3O8.310 | 95  | 117 |
Figure 1. Dependence of temperature with resistivity for $\text{Hg}_{0.75}\text{Pb}_{0.25}\text{Sr}_2\text{Ba}_y\text{Ca}_2\text{Cu}_3\text{O}_{8+\delta}$ at indicated values of $y$ ($y = 0.10$, $y = 0.20$, $y = 0.25$).

Employing of flow rate with oxygen higher than 0.3 L/min produces deformed samples. Which is assigned the dropping of melting point, as indicated by Koyama et al. [18]. The oxygen stoichiometry Bi-based and Hg-based superconductors of $\delta=0$ are unbalanced [19], but the structure can be stabilized by interpolating of extra oxygen, which will produce greater cavities in the CuO$_2$ layers. The increasing of the cavities concentrations in the high-T$_c$ phase will conduct the development of the T$_{c1}$ and T$_{c2}$ [21, 22]. In this work all the synthesized samples are applied to whole structural identifications via X-ray diffraction. The resulted data of XRD for samples having various Ba concentrations are entirely polycrystalline and agree to Hg (Pb)-1223 phases. The results of XRD also show some impureness phases by tiny concentrations. The illustration XRD pattern is revealed in ‘figure 2’.
Obviously, it can be noticed through the XRD spectra that there are two essential phases in all production specimens of high Tc phase (1223), low Tc phase (1212) and a little amount of impureness phases of (Ca, Sr)$_2$CuO$_3$, CaPbO$_4$ and CuO. The presence of other than two phases can be related to the (stacking faults) along the c-axis. In all samples of Hg$_{0.75}$Pb$_{0.25}$Sr$_{2-y}$Ba$_y$Ca$_2$Cu$_3$O$_{8+δ}$ systems, the high phases augmented by Ba increasing. It has been observed that many following reflections that are ordering the cations and/or displacing of an ion or oxygen defects (the oxygen deficiency increases when Ba is replaced by Sr which has lesser ionic radius compared to Ba). This is similar to the result of a heterogeneous structure which causes the deformation of the c-parameter rising. The distortion of the structure is always reflected as the cause of the great conduction in the perovskite multi-layer state which proposes rising to several type of polarization at sufficient high-Tc, this polarization will allow holes or electrons to move along distance without undergoing scattering progression.

Table 1. Tc1 without oxygen flow, Tc2 with oxygen flow, oxygen content, $δ$(O2) with O2 flow, $Δ$(O2) without O2 flow, lattice parameters (a, b, and c) and mass density $ρ_M$ for different composition of Hg$_{0.75}$Pb$_{0.25}$Sr$_{2-y}$Ba$_y$Ca$_2$Cu$_3$O$_{8+δ}$

| y  | Tc1(K) | Tc2(K) | $δ$(O2) | $Δ$(O2) | a(A₀) | b(A₀) | c(A₀) | c/a | $ρ_M$ (g/cm³) |
|----|--------|--------|---------|---------|-------|-------|-------|-----|----------------|
| 0.10 | ----- | 95 | 0.141 | 0.071 | 3.829 | 3.829 | 15.41 | 4.0245 | 5.7547 |
| 0.20 | ----- | 98 | 0.191 | 0.086 | 3.830 | 3.831 | 15.43 | 4.0287 | 5.7617 |
| 0.25 | 103 | 117 | 0.310 | 0.207 | 3.833 | 3.834 | 15.44 | 4.0281 | 5.8041 |
4. Conclusions
Hg$_{0.75}$Pb$_{0.25}$Sr$_{2-y}$Ba$_y$Ca$_2$Cu$_3$O$_{8+y}$ high-Tc superconducting compounds ($y = 0.10$, 0.20 and 0.25) without/with oxygen treatment, have been synthesized by utilizing three-steps of solid state reaction technique successfully. Special significant of correlation between superconducting characterizations and the observed microstructural has been investigated by way of effect the coincident doping of Ba at Sr site for Sr-O$_2$ layer...
in Hg$_{0.75}$Pb$_{0.25}$Sr$_2$Ca$_2$Cu$_3$O$_{8+\delta}$. The results of XRD data conducted from various composed samples show that they are wholly polycrystalline and agree to Hg(Pb)-1223 phase. Critical transition temperature Tc (offset) of the Sr doped Hg (Pb)-1223 compounds range between 93-115 °K. Obtained results are yelled Tc increasing with the increases of $\delta$ (oxygen content). Furthermore the change of Ba concentrations for all composed samples gives a modification in the density $\rho_m$, c/a and volume fraction $V_{Ph(2223)}$.

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