HgO-added YBa$_2$Cu$_3$O$_{7-\delta}$ superconductors

MANGLESH DIXIT, SHOVIT BHATTACHARYA, RAJNEESH MOHAN, KIRAN SINGH, P S R KRISHNA*, VILAS SHELKE, N K GAUR and R K SINGH†

Department of Physics, Barkatullah University, Bhopal 462 026, India
*Solid State Physics Division, Bhabha Atomic Research Centre, Mumbai 400 085, India
†M.P. Bhoj Open University Bhopal 462 016, India
E-mail: mohanrajneesh1@rediffmail.com

Abstract. The HgO-added YBa$_2$Cu$_3$O$_{7-\delta}$ (YBCO) superconductor has been studied for its structural and superconducting properties. Polycrystalline YBCO samples were synthesized through solid-state reaction method by adding HgO in different concentrations without using oxygen annealing. All the samples showed a sharp superconducting transition temperature around 90 K. The X-ray diffraction patterns of all the samples revealed monophasic Y-123 nature. The structural studies were carried out by neutron scattering and Rietveld analysis. The neutron scattering revealed that Hg is not incorporated in the Y-123 system and has shown optimum oxygen concentration. The significant role played by the HgO is to provide oxygen ambient through its decomposition, thus changing the oxygen balance in favour of high Cu-valence state.

Keywords. Superconductivity; solid-state reaction method; HgO addition; neutron diffraction.

PACS Nos 74.72.Bk; 74.70.Vy

1. Introduction

It is widely known that the superconducting properties and structural stability of Y-123 compound depend strongly on the oxygen content. Moreover, these compounds exhibit superconductivity only when annealed in the oxygen ambient [1–4]. An alternative way to improve the oxygen content is the use of some internal source of oxygen [5–7]. In this respect the HgO can be considered as a potential material because of its lower decomposition temperature (476°C) and high oxygen ambient created during decomposition. It decomposes into mercury, which escapes from the matrix leaving the crystal unaltered and oxygen, which provide an excellent ambient for the formation of a stoichiometric oxide compound [8–14]. We have already reported the synthesis of YBa$_2$Cu$_3$O$_y$ with the addition of HgO [15–17]. In this paper we report the studies on the structural and the superconducting properties of HgO-added Y-123 compound.
2. Experimental

The polycrystalline samples of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ were synthesized by solid-state reaction method. A stoichiometric amount of $\text{Y}_2\text{O}_3$, $\text{BaCO}_3$ and $\text{CuO}$ was ground thoroughly. The calcinations were done twice at 925°C for 24h with intermediate grinding. $\text{HgO}$ was added to the calcined mass in the molar ratio $x = 0.4, 0.5, 0.6$ and 0.7 and were pressed to pellets. The pellets were sintered at 950°C for 24h, followed by furnace cooling.

The identification of the phases in the samples was done by X-ray powder diffraction technique at room temperature in which $\text{CuK}_\alpha$ radiation was employed in the range $10^\circ \leq 2\theta \leq 70^\circ$ using Shimadzu XRD 6000 diffractometer. The resistance as a function of temperature was measured by the standard four probe method. The neutron powder diffraction data were collected at room temperature for the sample with $x = 0.4$ on the powder diffractometer ($\lambda = 1.249$ Å) at Dhruva reactor, BARC. The data were analyzed in orthorhombic $\text{Pmmm}$ space group by using FullProf [18] to obtain structural parameters, including oxygen site occupancies for different oxygen sites.

3. Results and discussion

The X-ray diffractograms of all the samples synthesized with HgO addition are shown in figure 1. The diffraction peaks were compared with standard JCPDS data of $\text{YBa}_2\text{Cu}_3\text{O}_y$. It has been found that all the diffraction peaks correspond to Y-123 phase only, irrespective of the different $x$ ratio. No peak corresponding to impurity or mercury related phase was observed. This reveals the mono-phasic nature of all the samples.