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Upper critical field of $Bi_{1\cdot5}$–$Pb_{0\cdot5}$–Ca_2–Sr_2–Cu_3–O_x superconductor

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Abstract. The high T_c superconductor of nominal composition $Bi_{1\cdot5}$–$Pb_{0\cdot5}$–Ca_2–Sr_2–Cu_3–O_x was prepared by solid-state reaction method. The upper critical field H_{c2} of the material with a zero-resistance transition at 110 K was investigated by observing variations in resistance with temperature down to 90 K and with a magnetic field up to $7T$. The slope of H_{c2} with temperature was about $-0{\cdot}41\ T/K$ for zero resistance transition and $-6{\cdot}86\ T/K$ for onset of superconductivity. H_{c2} values at 0 K were estimated to be $31{\cdot}3\ T$ and $563\ T$ for zero-resistance transition and onset of superconductivity respectively.

Keywords. Upper critical field; zero resistance transition.

1. Introduction

After the discovery of the new high temperature superconductors of Bi–Ca–Sr–Cu–O by Maeda *et al* (1988) efforts are on to increase the T_c in these compounds. The increase of T_c by the partial substitution of Pb was reported by Green *et al* (1988) and also a relatively higher T_c was reported by Sb substitution by Liu *et al* (1989). In this paper we report the preparation of 110 K phase $Bi_{1\cdot5}$–$Pb_{0\cdot5}$–Ca_2–Sr_2–Cu_3–O_x superconductor and the upper critical field H_{c2} of the material near T_c in magnetic fields up to $7T$. From these results H_{c2} values at 0 K were estimated for zero-resistance transition and onset of superconductivity.

2. Preparation

The bulk samples of nominal composition $Bi_{1\cdot5}$–$Pb_{0\cdot5}$–Ca_2–Sr_2–Cu_3–O_x were prepared by solid-state reaction technique. The raw materials were Bi_2O_3, $Pb(No_3)_2$, $CaCO_3$, $Sr(No_3)_2$ and CuO. The powder was mixed and ground, then calcined in air at 800°C for 24 h followed by repeated grinding and heating at 820°C for another 24 h. The reground powder was made into disk shape pellets of size (10 mm dia, 2 mm thickness) at about 4 kbar. The pellets were sintered in air for 300 h at 850°C followed by quenching in liquid nitrogen.

3. Experimental details

The resistance was measured by the standard four-probe method with ohmic contacts using conducting silver preparation (1228 C Elteck Corpn.). A current of 10 mA was passed using Keithley constant current source (M220) and voltage was measured by Keithley DMM (193A). A transverse magnetic field was applied on the samples using a superconducting magnet cryostat (Janis Research Co.). The resistance vs temperature

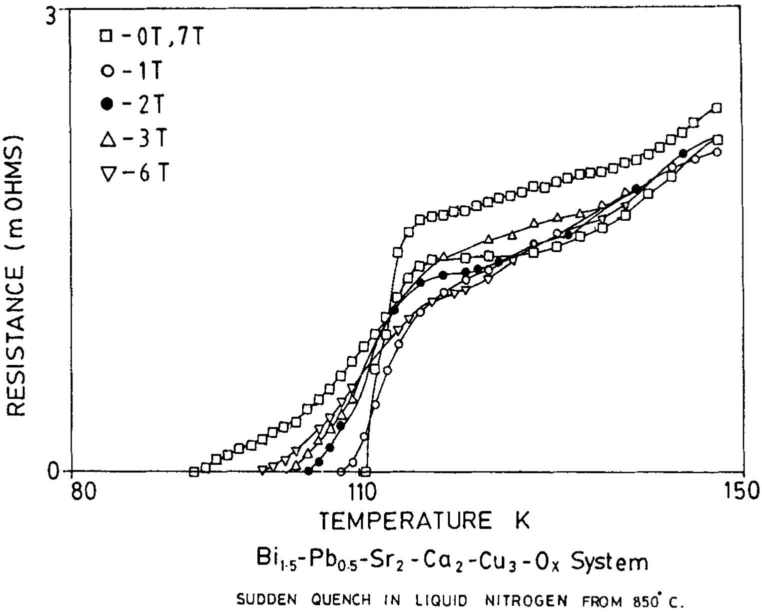

Figure 1. Resistance vs temperature of $Bi_{1.5}Pb_{0.5}Sr_2Ca_2Cu_3O_x$ system.

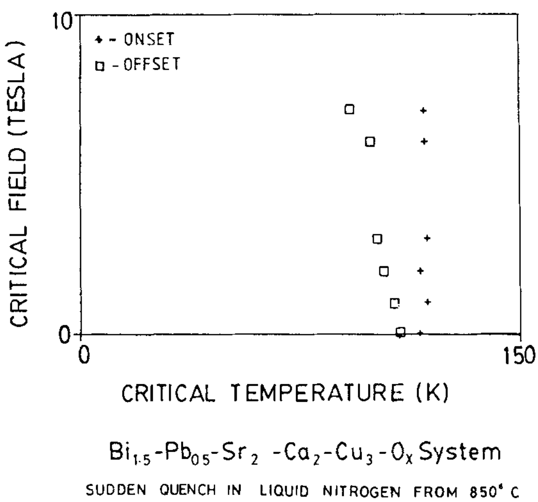

Figure 2. Critical temperature vs critical magnetic field curves of $Bi_{1.5}Pb_{0.5}Sr_2Ca_2Cu_3O_x$ system.

curves at various magnetic fields are shown in figure 1. The critical temperature vs critical magnetic field curves for both offset and onset states are shown in figure 2.

4. Results

At zero field complete zero resistance transition occurred at 110 K with an onset of 116 K. As the applied field was increased the low temperature portion of the transition curve shifted to low temperature, resulting in a broad transition. The high temperature portion, on the other hand, was slightly influenced with increase of magnetic field. This may be due to the weak coupling of the superconducting grains and their ultimate destruction with increase of magnetic field. Similar behaviour was observed in other systems like Y–Ba–Cu–O (Aoki *et al* 1987; Kobayashi *et al* 1987a) and La–Sr–Cu–O (Kobayashi *et al* 1987b).

H_{c2} values were derived from the resistance vs temperature curves in figure 1. Two values of H_{c2} were plotted as a function of temperature for both onset and offset states. The slope of H_{c2} vs temperature curve (dH_{c2}/dT) was calculated from figure 2. This was about -0.41 T/K for zero-resistance transition and -6.86 T/K for onset of superconductivity. The upper critical field H_{c2} at 0 K was derived from the relation H_{c2} (0 K) $= -0.69\ T_c\ (dH_c/dT)_{T=T_c}$ according to the Werthamer–Helfand–Holenberg (WHH) theory of type-II superconductors in the dirty limit. The values were 31.3 T and 563 T for zero-resistance transition and onset of superconductivity respectively.

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