AC susceptibilites in Ag-based composites of Hg(Pb,Bi)-1223 superonductors

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Abstract

Compounds of the $Hg_{1-x}Pb_xBa_2CaCu_3O_{8+\delta}$ ($x = 0.1$ and 0.2) and $Ag_y(HgBa_{1.9}Bi_{0.1}Ca_2Cu_3O_{8+\delta})_{1-y}$ ($y = 0.1$ and 0.2) were synthesized directly from the metal oxides without using a precursor. The structural and morphological properties were investigated. AC susceptibilities and DC magnetizations were measured using a SQUID magnetometer and a PPMS susceptometer. From the magnetic data, the critical temperatures are 134 K in Hg(Pb)1223 composites and 131 K in Ag-Hg1223. The estimated superconducting volume in the Ag-Hg1223 reduces when Ag content increases. AC losses estimated from the imaginary part of the AC susceptibilities χ'' and pinning potentials evaluated from the relaxation of the magnetization are compared and discussed in both samples.

Key words: Hg(Pb)1223; AC susceptibility; reversible motion; loss

1. Introduction

The bulk composite samples of the compositions $Ag_y(HgBa_{1.9}Bi_{0.1}Ca_2Cu_3O_{8+\delta})_{1-y}$ were synthesized directly from the metal oxides by powder metallurgy. AC susceptibilities and DC magnetizations were measured to estimate critical current densities and AC losses of both samples. The small peak value of the imaginary part of the AC susceptibilities χ'' less than $(3/4\pi)$ indicates the probable reversible fluxoid motions in a pinning potential in $Hg_{1-x}Pb_xBa_2CaCu_3O_{8+\delta}(x = 0.1$ and $0.2)$ [1]. AC losses were estimated from χ'' and discussed using the critical state model and compared with the Hg(Pb)1223 sample reported in the preceding paper [2].

2. Experimental

The bulk composite samples of the compositions (1) $Ag_{0.1}(HgBa_{1.9}Bi_{0.1}Ca_2Cu_3O_{8+\delta})_{0.9}$ (denoted as Ag-01) and (2) $Ag_{0.2}(HgBa_{1.9}Bi_{0.1}Ca_2Cu_3O_{8+\delta})_{0.8}$ (denoted as Ag-02) were synthesized directly from the metal oxides Ag_2O, HgO, BaO, Bi_2O_3, CaO and CuO by powder metallurgy e.g. pressing tablets and given heat treatments without any precursor preparation [3,4]. The morphology and chemical composition were investigated by scanning electron microscopy and Energy Dispersive X-ray Analysis. The structural investigations were made by X-ray diffraction using CuKa radiation. The samples consist of 1223-phase (tetragonal) and Ag. The lattice parameters of the tetragonal phase are $a = 0.38558 \pm 0.00182$ nm; $c= 1.58248 \pm 0.01730$ nm for sample Ag-01 and $a= 0.38487 \pm 0.00212$ nm ; $c= 1.62430 \pm 0.02951$ nm for sample Ag-02.

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3. Results and discussion

The superconducting volume were estimated from the temperature dependence of the Meissner magnetization slopes. The ratio between the volume estimated from Meissner magnetization and the volume computed from the weights and chemical compositions in the Ag-Hg1223 are smaller values of 0.41-0.45 compared with 0.61-0.64 in Hg(Pb)1223. The superconducting volume fraction of Ag-based Hg1223 reduces when Ag content increases. Observed AC susceptibilites of sample Ag-01 are shown in Fig. 1 together with those of Hg(Pb)1223 which clearly shows a high susceptibilities in Ag-Hg1223. The values of χ'' smaller than $3/4\pi$ should be ascribed to the reversible motion of the fluxoids [5].

From the measured AC susceptibilities the loss energy during a cycle w_p is given as $\chi''\pi b_0^2/\mu_0$ and is shown in Fig. 2 as a function of the AC amplitude b_0 at $B = 0.2$ T and at temperatures $T = 30, 40, 60,$ and 80 K. All data points tend to increase with the 2nd power of b_0 different from the 1st or 3rd dependence of the critical state model, which should originate from the reversible nature.

Magnetic relaxation under the constant magnetic field were observed by a SQUID magnetometer. Relaxation rate gives the well known apparent pinning potentials U_0^*. Pinning potential U_0^* of Ag-Hg1223 and Hg(Pb)1223 are shown in Fig. 3. Ag-based Hg1223 clearly indicates the high U_0^* values at high temperature region.

Ag-based Hg1223 superconductors shows a relatively small superconducting volume fractions compared with the Pb substituted Hg1223. AC susceptibilities and pinning potential of the Ag-based Hg1223 are shown to be higher.

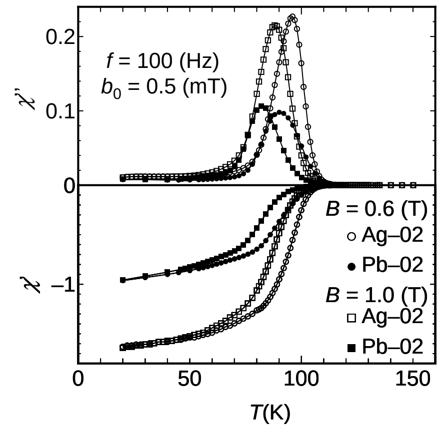

Fig. 1. AC susceptibilities of Ag-Hg1223 and Hg(Pb)1223.

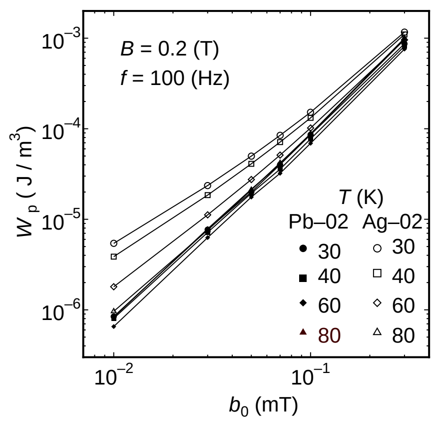

Fig. 2. Loss energies w_p of Ag-based Hg1223 and Hg(Pb)1223 (x=0.2) at dc field B=0.2 T. w_p increases as 2nd order of the AC field b_0.

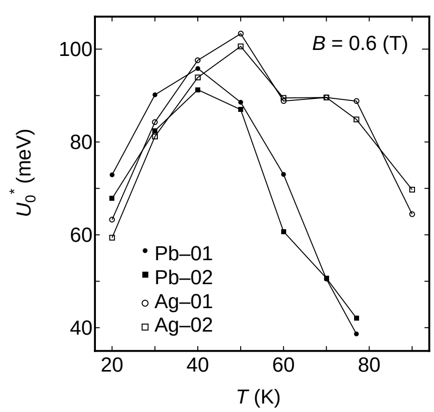

Fig. 3. Temperature dependence of apparent pinning potentials U_0^* estimated from relaxation rates of Ag-Hg1223 and Hg(Pb)1223.

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