ELSEVIER

Physica B 284–288 (2000) 905–906

PHYSICA B

www.elsevier.com/locate/physb

Orientation dependence of irreversible magnetic properties in Hg-based superconducting ceramics

C. Ecker[a,*], M. Baenitz[a], K. Lüders[a], E.S. Otabe[b], T. Matsushita[b], H.R. Khan[c], E.V. Antipov[d]

[a]Fachbereich Physik, Freie Universität Berlin, D-14195 Berlin, Germany
[b]Kyushu Institute of Technology, 680-4 Kawazu, Iizuka 820-8502, Japan
[c]FEM, Material Physics Department, D-73525 Schwäbisch Gmünd, Germany
[d]Moscow State University, 119899 Moscow, Russia

Abstract

Powder of (Hg,Pb)-1223 material was oriented and investigated by means of AC magnetization measurements. The irreversibility line was determined by several methods, up to fields of 9 T. In order to study the dimensionality of this material, the irreversible properties are compared for two field directions: parallel and perpendicular to the crystallographic *c*-axis. We found the orientation dependence to be influenced strongly by reversible flux motion. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: AC susceptibility; Irreversibility line; Reversible fluxoid motion

1. Introduction

Anisotropic superconducting materials usually show an enhanced pinning along their crystallographic *ab*-planes. The irreversible magnetic properties therefore depend on the angle of the applied magnetic field B_0. For example, in Bi-2212 the irreversibility fields are distinctively higher when the field B_0 is applied parallel to the *ab* direction.

In mercury compound superconductors the dimensionality is still under discussion. In this paper we examine the dimensionality of Hg-1223 by investigating the orientation dependence of the irreversibility line.

2. Experiment

Samples of $Hg_{0.7}Pb_{0.3}Ba_2Ca_2Cu_3O_{8+\delta}$ (Hg,Pb-1223) have been prepared, details can be found in Ref. [1]. The partial substitution of Hg by Pb helps to stabilize the phase and does not change the crystal structure. Investigations on pure Hg-1223 samples which come to similar results are not shown in this paper. The sample grains are disc shaped, with a diameter of about 15 μm and a height of 2 μm. Due to this strong shape anisotropy grains tend to orient in high magnetic fields. It was therefore possible to orient the sample by applying a 9 T magnetic field at room temperature. The grains were then fixed in paraffin.

3. Results and discussion

The temperature dependence of the AC susceptibility χ'' was measured for different magnetic fields B_0 up to 9 T. As an example of the data used to determine the irreversibility line, the measurements at $B_0 = 5$ T are shown in Fig. 1. To account for the demagnetization effect and the incomplete superconducting volume, the curves are multiplied by correction factors obtained from the Meissner state, which are 1.46 and 0.99 for B_0 in *c*- and in *ab*-direction, respectively.

The irreversibility temperatures were determined by multiple methods: from the peak maxima (1) and also from the peak onset, using different criteria to define the

* Corresponding author.

PII: S0921-4526(99)02221-8

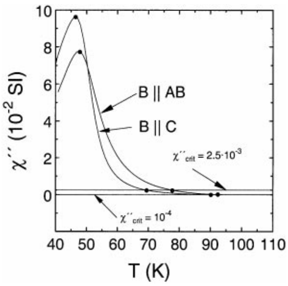

Fig. 1. Imaginary part of the complex susceptibility at $B_0 = 5$ T. The dots mark the resulting irreversibility Temperatures T_i^c and T_i^{ab} for different definitions. The discrepancy between the orientations depends on the criteria χ''_{crit} and ranges from less than 1 K (maxima) to 8.5 K.

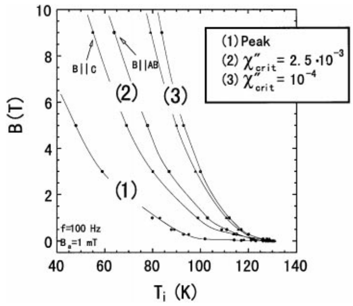

Fig. 2. Irreversibility lines for the two field orientations and several criteria. The straight lines are just for illustration.

point of the first deviation from zero (2 and 3). The resulting lines of irreversibility are shown in Fig. 2.

For both orientations the peak maxima occur at similar temperatures, therefore the so-called practical irreversibility line is nearly independent of orientation. A different picture arises when a criterion χ''_{crit} is used to define the irreversibility line. Due to the different peak shapes the temperatures where χ'' meets the criterion differ remarkably for both orientations.

To understand these results and to answer the question if the irreversibility line does depend on the orientation or not, one has to consider the effects which influence the signals. Noticeably, the peak heights of Fig. 1 differ from the value given by the Bean model (0.21 for cylinders). From studies of amplitude and frequency dependence we know that the data are strongly influenced by reversible fluxoid motion [2]. This effect causes a strong orientation dependence of the heights of χ'' but a small one for the peak temperatures. Due to this, method (1) gives more reliable results.

We therefore conclude that the pinning behavior of the material indicates a low dimensionality.

Acknowledgements

This work was supported by the Volkswagen-Stiftung, FR Germany, Grant No. 1/73680 and DFG, contract DFG-Khan 20/1-1.

References

[1] M. Baenitz, C. Ecker, K. Lüders, E.S. Otabe, T. Matsushita, H.R. Khan, Adv. Supercond. X (1997) 537.
[2] T. Matsushita, E.S. Otabe, B. Ni, Physica C 182 (1991) 95.