Microstructures of High-$J_c$ Melt-Textured YBa$_2$Cu$_3$O$_{7-x}$/Ag Superconductors

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Received 30 July 1993

Silver has been previously added to the melt-textured YBa$_2$Cu$_3$O$_{7-x}$ in order to increase the critical current density ($J_c$) of these materials. However, the effect of this addition on the $J_c$ is presently unclear. The purpose of this study is to investigate the effect of silver on both critical current density and the microstructure of the melt-textured YBa$_2$Cu$_3$O$_{7-x}$ superconductors by means of X-ray diffraction, optical polarized microscopy, and transmission electron microscopy (TEM). The $J_c$ of the MTG YBCO/Ag samples is more than $10^4$ A/cm$^2$ under the 5 kOe magnetic field. It has been shown that as the concentration of silver increases, the fraction of the $211$ phase dispersed within the $123$ matrix decreases. Therefore, the $J_c$ slightly decreases. These results, together with the effect of the $211$ phase, dislocations, and other structure defects on flux pinning, are described in this paper.

KEY WORDS: Critical current density; Ag addition; grain alignment; flux pinning; defect structure; YBCO; melt-texturing.

1. INTRODUCTION

The melt-textured growth (MTG) process has been developed [1–3] to produce high critical current density, $J_c$, superconductors by reducing weak links in sintered materials, which result in very low critical current densities. In contrast to sintered materials, the $J_c$ of the MTG materials is much larger and their degradation under a magnetic field is much less due to the significant elimination of the current density-limiting weak links, and to the existence of many effective flux pinning centres within the MTG processed material. In order to further increase the $J_c$ of the MTG superconductors, silver doping has been used to increase the flux pinning strength and reduce the number of microcracks. However, for the YBCO/Ag MTG superconductors, the effect of silver...
doping on $J_c$ is not clear since some contradictory results have been reported. Some authors claim that silver doping in MTG 123 materials can enhance the $J_c$ in the MTG processed materials [4]. In contrast, other studies have indicated that Ag doping has detrimental effects on the $J_c$ of 123 [5,6].

In this study, a series of YBa$_2$Cu$_3$O$_y$/Ag superconductors was fabricated using the MTG process. Following processing the magnetic critical current densities were calculated. The effect of the silver dopant on YBCO superconductors was investigated by examination of microstructures of these materials using various methods. The effect of structural defects on flux pinning is also discussed.

2. EXPERIMENTAL

Samples were prepared by a conventional solid-state reaction followed by the MTG processing as we mentioned before [8]. The magnetic properties of the samples were measured using a superconducting quantum interference device (SQUID) magnetometer. The microstructure was characterized using a LEITZ MM6 metallographic microscope, a SIEMENS D5000 X-ray diffractometer and a JEOL-2000FX transmission electron microscope (TEM).

3. RESULTS AND DISCUSSION

The X-ray diffraction patterns of the samples have shown that crystals are preferentially aligned, and the cleavage plane is the $a$-$b$ plane of the 123 phase.

The $J_c$ values of the samples were calculated using a modified Bean critical state model [7]. Plots of $J_c$ as a function of magnetic field $H$ up to 30 kOe at 77 K with the magnetic field perpendicular to the