ELSEVIER

Physica C 341–348 (2000) 2657–2658

PHYSICA C

www.elsevier.nl/locate/physc

Surface Resistance of Single Domain YBCO

[a]D. Qu, [a]Donglu Shi, [d]H. A. Blackstead, [b]Altan Ferendeci, and [c]David Mast

[a]Department of Materials Science & Engineering
[b]Department of Electrical & Computer Engineering, & Computer Science
[c]Department of Physics
University of Cincinnati
Cincinnati, OH 45220, USA

[d]Physics Department
University of Notre Dame
Notre Dame, IN 46556, USA

Abstract: *c*-axis single domain YBCO crystals have been grown by using the seeded melt growth (SMG) method. Surface resistance has been measured at 12.95 GHz and 77 K in magnetic fields up to 1.5 T. The Pippard scaling behavior has been found in the well-oxygenated crystal indicating the high-quality of the single domain YBCO and similar loss mechanism compared to conventional superconductors.

1. INTRODUCTION

Low surface resistance, R_S, is a key parameter of the conductors in *rf* devices. To achieve low surface resistance, the current approaches in processing HTS are thin film technologies, which can produce epitaxially grown films with low surface resistance.[1] In this work, we have utilized a single-crystal like, single-domain YBCO as an alternative but equally effective material that can be used to develop *rf* devices in telecommunications. In this paper, we present experimental data on the surface resistance of single domain YBCO samples.

2. EXPERIMENTAL DETAILS

The single domain materials used in this study were processed by the seeded melt growth (SMG) method which has been previously reported.[2] The sample was annealed in flowing oxygen at 400°C for 48 hours.

Surface resistance was measured in a rectangular resonator cavity (TE_{101} mode). As *rf* dissipation changed in the sample, this changed the losses in the cavity, and the cavity's quality factor (Q value). In turn, this changed the impedance match of the waveguide to the cavity and the power reflected from the cavity. Changes in the reflected power were detected as changes in the dc diode voltage.

3. RESULTS AND DISCUSSION

To characterize the bulk properties of these annealed samples, we conducted *ac* susceptibility measurements at different applied fields. Figure 1 shows the *ac* susceptibility versus temperature at different *ac* magnetic fields for a fully oxygenated YBCO sample. As can be seen, the sample exhibits extremely sharp superconducting transition comparable to the behavior of the best single crystals of YBCO reported. We note here that the *ac* susceptibility data reflect a bulk behavior of the material.

The surface resistance measurements in this work have shown similar behaviors compared to the *ac* susceptibility measurements. The measurements of surface resistance (R_s) have been carried out under different applied *dc* magnetic fields. In Figure 2, we show $\Delta R_s = R_s(B)-R_s(B=0)$ of the sample plotted as the function of temperature and magnetic field (B)

0921-4534/00/$ – see front matter
PII S0921-4534(00)01442-8

for the field applied parallel to the *c*-axis of the crystal. As can seen from this figure, the sample exhibits sharp transitions at all fields. To further analyze the data we have normalized ΔR_s, which allows us to see the scaling behavior in the magnetic field. Figure 3 shows the normalized R_s versus tempearture for *B*//*c*. As can be seen in this figure, normalization has resulted in a good scaling at all magnetic fields for this configuration. This has suggested a common *rf* dissipation mechanism for the temperature dependence of the surface resistance. According to Pippard, the temperature dependence of R_s can be expressed as

$$Rs = f(\omega)\, t^{\alpha}(1-t^2)/(1-t^4)^2,$$

where $t = T/T_c$.[3] The fitting of these curves in the superconducting state has resulted in a power-law behavior as shown in Figure 3 with $\alpha = 2$. As can be seen in this figure, the Pippard model, which describes the behavior of a conventional superconductor, has fitted the R_s data of the single domain YBCO quite well. The excellent agreement between the model and experimental data indicates that (1) an exceptionally high-quality single-crystal like superconductor and (2) the basic microwave behavior observed in the single-domain YBCO is similar to those conventional superconductors. However, a physical model will have to be established to further explain the loss mechanisms in the single-domain YBCO including the interaction between vortices and *rf* currents. This modeling work is currently under investigation.

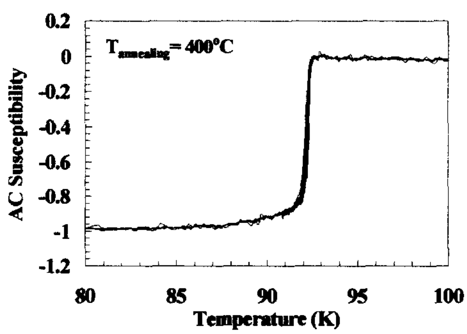

Figure 1. χ vs. T at fields: left to right: 2.2, 1.5, 1.0, 0.5, 0.25, 0.1 Oe.

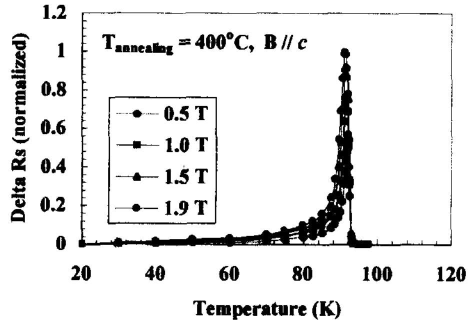

Figure 2. ΔR_s vs. T for the sample annealed at 400°C. The applied field, from left to right, is 1.9 T, 1.5 T, 1.0 T, 0.5 T.

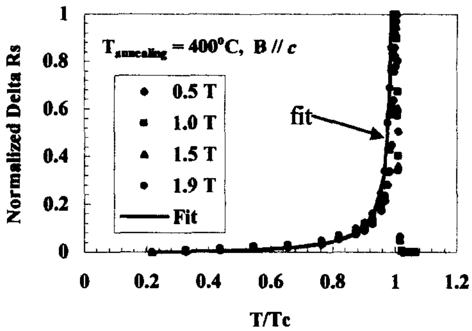

Figure 3. Normalized ΔRs with the fitting.

ACKNOWLEDGMENT

This work was supported by a grant from National Science Foundation under contract number ECS-9802281.

REFERENCES

1. C. Dubourdieu, J. P. Senateur, O. Thomas, F. Weiss, S. Hensen, G. Muller, "Correlation between the microwave surface resistance and the volumic fraction of *a*-axis grains in $YBa_2Cu_3O_{7-x}$ films," *Physica C* 308 1998 p.16.
2. D. Qu, Donglu Shi, S. L. Lu, A. M. Ferendeci, D. Mast, Net-shape processing of single-domain $YBa_2Cu_3O_x$ for a novel high-*Q* millimeter wave resonator, *Physica C* 315 1999 p.36.
3. T.Van Duzer and C.W. Turner, "Principles of Superconductive Devices and Circuits," Elsevier, New York (1981) p.130