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Investigation of the influence of grain boundary on the magnetic and transport properties of superconducting ceramics $YBa_2Cu_3O_{7-\delta}$

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Abstract

$YBa_2Cu_3O_{7-\delta}$ polycrystalline ceramic samples were produced in order to study the thermal diffusivity. The samples were heat treated at different levels. These samples were characterized by XRD, ac magnetic susceptibility and scanning electron microscopy. The analyzes of the SEM image showed that the samples have different sizes of the junctions of grains. Samples A and B show Tc equal to 91.3 K and 91.3 K, respectively. EDS analyzes indicated the concentration of ions in the center of the grain and edge grain for each sample. The measurements of thermal diffusivity, performed by flash method, indicated that the sample has a larger grain size, sample A, also has higher thermal diffusivity. Sample A also showed better magnetic shielding in the ac magnetic susceptibility measurements.

Keywords: supercondutor, YBaCuO, cerâmica.

1. Introduction

This study aimed to the experimental study of the effect of the size of the joints in the magnetic and transport properties in polycrystalline system $YBa_2Cu_3O_{7-\delta}$.

2. Sample preparation and synthesis

Both samples used in this study were prepared by a solid state reaction by mixing 1/2 mol de Y_2O_3, 2 moles de $BaCO_3$ e 3 moles de CuO in powder form in a agate mortar. samples were uniaxially compacted at a pressure of 1.00 ton. Different thermal treatments were used.

Table 1: Description of the homogenization heat treatment of superconducting samples.

Heat Treatment			
Sample	Temperature	Time	Cooling
A	970°C	24h	48°C/h
B	950°C	24h	48°C/h

3. Characterization of samples

3.1 X-Ray Diffraction
Phases identified for the samples A and B indicate that the main phase is $YBa_2Cu_3O_{7-\delta}$.

3.2 Magnetic Susceptibility
The samples were subjected to measurement of ac magnetic susceptibility (χ_{ac}).
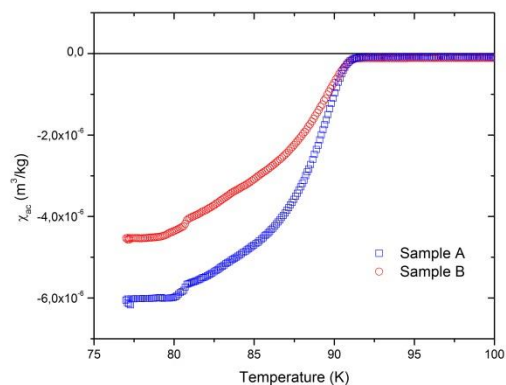The experimental apparatus is described for Passos [1].

Figure 1: Measurement of ac susceptibility of the samples A and B with magnetic field H_a = 5 A/m and ν = 4,23 kHz.

Measurements of T_c at ambient pressure for each sample are shown in Table 2.

Table 2: T_c values obtained for samples A and B.

Sample	T_c (K)
A	91,3
B	91,8

The difference in the magnetic shielding which at 77 K may be related to the grain size of each sample.

3.2 Scanning Electron Microscopy (SEM)
The micrographs taken from the secondary electron signal (SE - secondary electron) are arranged in Figures 2 and 3.
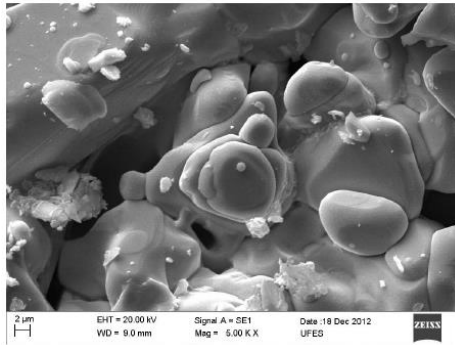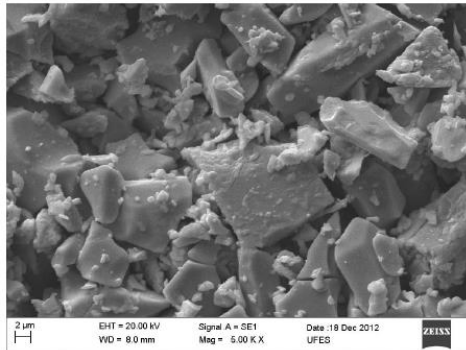
Figure 2: Image micrograph of sample A.

Figure 3: Image micrograph of sample B.

3.3 Average Size of Junctions

A quantitative analysis of the average grain size of the junctions was performed, based on the SEM images, with the aid of a density function of gamma distribution [2].

$$f(x) = \begin{cases} \dfrac{\lambda^{\eta}}{\Gamma(\eta)} x^{\eta-1} \exp(-\lambda x), & if \ x \geq 0 \\ 0, & otherwise \end{cases}$$

Parameters η and λ can be used to calculate the mean of the distribution μ. Measures of the various line segments characterizing a junction between two or more grains were made. The results were arranged in histograms and analyzed to obtain the parameters η e λ adjusted to the histogram data [3].

Table 3: Parameters of the distribution and the values of the average sizes of μ junctions with their uncertainties.

Sample	η	λ	$\mu \ (\mu m)$
A	4,22	0,74	$5,72 \pm 0,06$
B	3,30	2,22	$1,48 \pm 0,02$

According to the data shown in Table 3, the average grain size of sample A is larger.

3.4 Thermal Diffusivity

Flash method was used to obtain the thermal diffusivity [4], the experimental arrangement used to measure the thermal diffusivity is displayed in Figure 4.
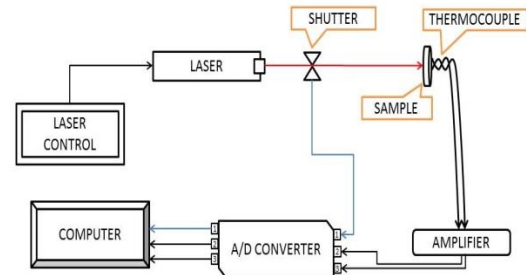

Figure 4: Experimental arrangement used to measure the diffusivity of the samples of YBaCuO.

A series of measurements of thermal diffusivity for samples A and B was performed, and the values that are presented in Table 4 are composed of the mean of each sample.

Table 4: Comparison between values of average size of μ junctions diffusivity α.

Sample	$\mu \ (\mu m)$	$\alpha \left(cm/s^2 \right) \times 10^{-4}$
A	$5,72 \pm 0,06$	$8,4 \pm 0,6$
B	$1,48 \pm 0,02$	$7,1 \pm 0,6$

4. Conclusions

A statistical analysis of SEM's showed that the sample A has a larger average size of the joints. Sample A also showed a higher thermal diffusivity than sample B, which means that it has less resistance to the transport of thermal energy and thus higher magnetic shielding found in the ac magnetic susceptibility measurements.

5. Acknowledgements

6. References

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