Investigation of the influence of grain boundary on the magnetic properties of superconducting ceramics of Sm-123

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Abstract

Samples of $SmBa_2Cu_3O_{7-d}$ (Sm-123) were prepared by the technique of solid vapor reaction with three different procedures. The samples were subjected to preliminary heat treatment, whose level was 960 ° C for 24 hours, which was repeated 7 times for sample A. Then they were subjected to further heat treatment at 1060°C level at which the samples A and B had a synthesis time of 72 hours, and sample C of 30 minutes. Then, the samples were cooled naturally to 520°C for oxygenation process. All samples were characterized by XRD, SEM and ac magnetic susceptibility measurements. SEM's of different average sizes for each sample junction, which influenced the ac magnetic susceptibility measurements.

Keywords: superconductor, SmBaCuO, ceramic.

1. Introduction

The transport properties of polycrystalline superconductors are limited due to grain boundaries (intergrain regions) and defects within the grains (intragrain regions) such as point defects, dislocations, stacking faults, cracks, etc. Understanding and control of the microstructure are necessary to improve the physical properties of granular superconductors and their applications. With this aim in mind, some researchers have optimized synthesis route of samples as reported in Ref [1-5]. The results indicated an upgrade of development and quality control of Sm-123 ceramic. Moreover, this material exhibits high J_c under magnetic fields (peak effect) [1,2,5] which is important parameter for type inductive SFCL, motors and maglev transportation [3]. Because of the improvement on the properties of Sm-123, the replacement of $YBa_2Cu_3O_{7-d}$ (Y-123) by Sm-123 might drastically improve the performance in practical applications [1-3].

2. Synthesis of samples

Three samples of $SmBa_2Cu_3O_{7-d}$, labeled as A, B and C were prepared as described elsewhere [6]. It is important to emphasize that the precursor of sample A was heated 7 times while the others samples were treated only one time. Moreover, others parameters for synthesis also were as displayed in the Table 1.

Table 1: Parameter of synthesis of the ceramic samples.

Sample	Temperature	Time	Fluxo de O_2
A	1060°C	72h	30 bubbles /min
B	1060°C	72h	30 bubbles /min
C	1060ºC	0.5h	60 bubbles /min

3. Characterization of samples

All the samples were characterized by X ray powder diffraction. The phases identified were the orthorhombic and tetragonal structures of Sm-123 with some peaks associated to residual phase of $BaCuO_{2+x}$ as shown in Table 2.

Table 2: Global analysis of X-ray diffraction of the samples with different thermal treatments.

Fases	A	B	C
$\%_{massa}$Ortorrombic	74	91	89
$\%_{massa}$Tetragonal	10	6	7
$\%_{massa}BaCuO_{2+x}$	6	2	2
$\%_{massa}$Unidentified	10	1	2

These samples were also analysed by Scanning Electron Microscopy (SEM). Details of the grain morphology can be observed in the SEM image in Figures 1. Using this image of sample A, a histogram of the grain boundary size was done. This procedure was also used for samples B and C. These histograms were then analysed in the framework of gamma density distribution function:

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

where λ and η determine the distribution scale and distribution shape, respectively. This function is often used on models which describe physical quantities are taken positive values. The average junction size was carried out and it is shown in Table 3.

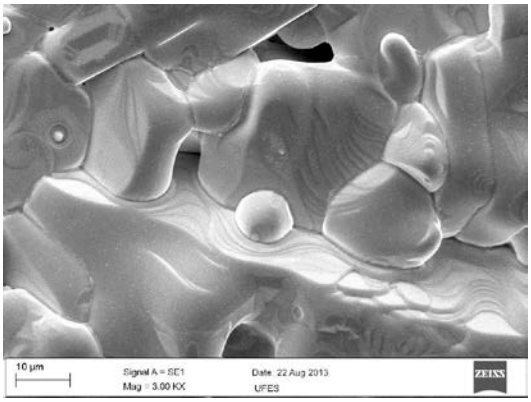

Figure 1: SEM image of sample A. A randomly oriented grain array, typical of a polycrystalline compound, is observed.

Table 3: Average size of the junction of each sample.

Sample	η	λ	$\mu\,(\mu m)$
A	4,1	0,4	$9,8 \pm 0,6$
B	3,53	1,72	$2,05 \pm 0,02$
C	3,83	2,57	$1,49 \pm 0,02$

The samples were also submitted to measurement of magnetic susceptibility ac (χ_{ac}), and results are displayed in Figure 4. T_c values were determined by criterion of the first derivative of the susceptibility. The results show that each sample has distinct magnetic shield, which may be related to the average grain size and homogeneity of oxygen content into the grain.

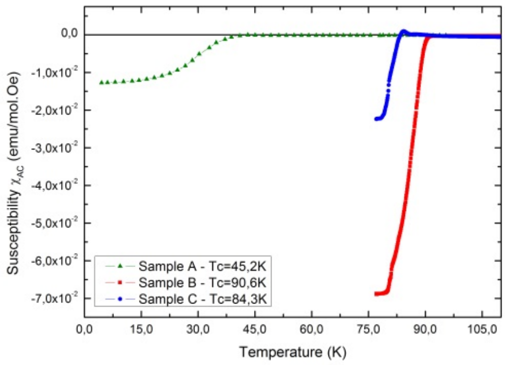

Figure 4: Measurement of ac magnetic susceptibility of samples A, B and C with magnetic field Ha = 8 A / m and v = 448 Hz.

In Figure 5, it is showed the transition width (ΔT_c) of the magnetic susceptibility measurements. It can observe that sample A presented largest ΔT_c as compared to the samples. This result suggests that the oxygen content is not homogeneous in grain of sample A. In our opinion, non-optimal oxygen content into the grain can suppressed magnetic shielding current and broaden superconducting transition as reported in Ref. [7].

4. Conclusions

Samples of SmBa2Cu3O7-d (Sm-123) were prepared with three different procedures. From these SEM images, the average junction sizes were determined, where the sample A presented larger junction size. But it had a broadened superconducting transitions and minor magnetic shielding signal.

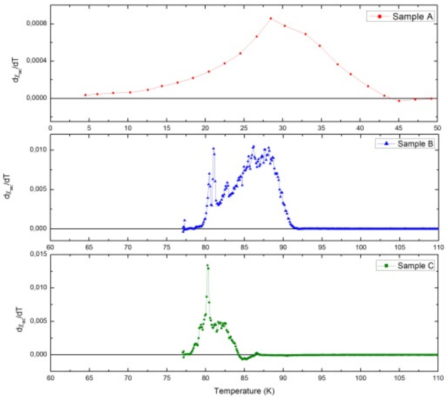

Figura 5: Curves of $\frac{d\chi_{ac}}{dT}$ as a function of the temperature for samples A, B e C.

In conclusion, the magnetic susceptibility ac results have indicated that the distribution of oxygen was not homogeneous in the grains during preparation of sample A. This result is in agreement with the X-ray diffraction analysis where it showed lower percentage of Sm-123 phase and higher amount of $BaCuO_{2+x}$ residues in this sample A. Therefore, the parameters of synthesis influenced the superconducting properties of our sample

5. Acknowledgement

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6. References

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