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A Modified QMG method of High J_c YBCO Preparation.

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Abstract

A number of improvements of QMG method was offered to prepare large scale YBCO materials.

1. Introduction

Since the discovery of HTSCs the highest values of critical current densities Jc ≈10^4-10^5 A/cm^2 have been achieved on bulk YBCO materials by means of the melt process. However, only small samples (less than 1 cm in most cases) are characterized by these Jc values. For practical application large dimension materials are really attractive. The situation is complicated by poor mechanical properties of bulk HTSCs ($YBa_2Cu_3O_x$ especially) and some peculiarities of their microstructure. It is common for all melt techniques to use very slow cooling rates under the crystallization (V=1-10°C/h). As a result samples with poorly linked, huge crystallites are formed.

The present work is aimed to modification of melt processes to produce YBCO materials with more perfect microstructure. One of the most perspective "melt" method - Quench and Melt Growth (QMG) - was chosen to research [1].

2. Experiment

In the work different precursors were used to obtain YBCO materials such as mixtures of oxides (sample *A*) and $YBa_2Cu_3O_x$ powders. To form $YBa_2Cu_3O_x$ powder ceramic method (sample *B*) and freeze (or spray) drying [2] (sample *C*) were applied. Moreover stoichiometric and Y-riched (≈20wt.%) compositions were prepared. A common QMG scheme [1] was a base of thermal treatment in the experiments. At the same time cooling (and heating) rates and oxygen partial pressure were varied.

The sample obtained were investigated by chemical, X-ray and thermal analyses. Scanning and transmission electron microscopy analysis, critical current density measurements were also carried out.

3.Results and discussion

3.1. Powder prehistory

At the first step of our research correlation between precursors prehistory and distribution parameters of solid phases in the melt (Y_2O_3 at 1450°C and then Y_2BaCuO_5 at 1100°C) was found out (Tabl. 1). The finest and uniformly distributed particles of Y_2O_3 (and Y_2BaCuO_5 respectively) are formed from spray (or freeze) -drying $YBa_2Cu_3O_x$ powders. It was noted

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Table 1. Distribution characteristics of Y_2O_3 and Y_2BaCuO_5 particles in the melts (1450 and 1100°C respectively) of different precursors

Sample	Y_2O_3		Y_2BaCuO_5	
	d, μm	s, μm	d, μm	s, μm
A	10.0	10.0	2.5	2.0
B	6.0	5.0	2.0	1.5
C	3.0	2.0	1.0	0.5

(d) - Average size and (s) - average size dispersion of the particles.

earlier [3] that such organization of heterogeneous system is quite necessary for successful proceeding of QMG process. Therefore in order to optimize other stages this requirement was taken into consideration. Obviously, to prevent Y_2BaCuO_5 growth high temperature treatments should be limited.

3.2. Heating

To perform the former requirement heating quenched samples up to 1100°C was as fast as possible. Unfortunately in this case fast elimination of oxygen during the melting follows the oxidation of $BaCu_2O_2$ in quenched materials. It leads to irreversible changes of sample size and shape and formation of numerous pores in the bulk; so density is decreased strongly. We found out that use of inert atmosphere at this stage is very effective.

3.3. Crystallization

Relationsheep between cooling rate of the melts (in 1000-900°C range) and J_c values for samples with different linear sizes is shown in Fig. 1.

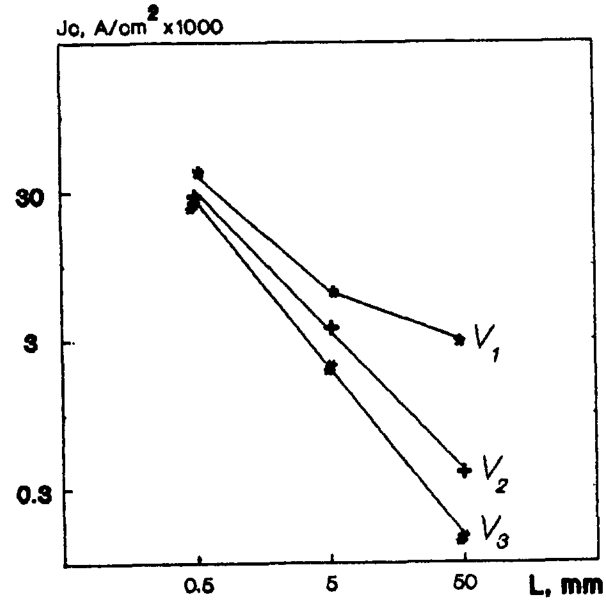

Figure 1. Dependence of critical current density (Jc) on linear sizes (L) of samples. Cooling rates V_1, V_2, V_3 in temperature range 1000 - 900°C are 100, 10 and 1 °C/h respectively.

One can see that larger samples have lower J_c values. However $J_c(H)$ measurements demonstrates that relatively low J_c values are not connected with "weak links" formation. A main reason of J_c decreasing consists in cracking of grains and poor intergranular contacts.

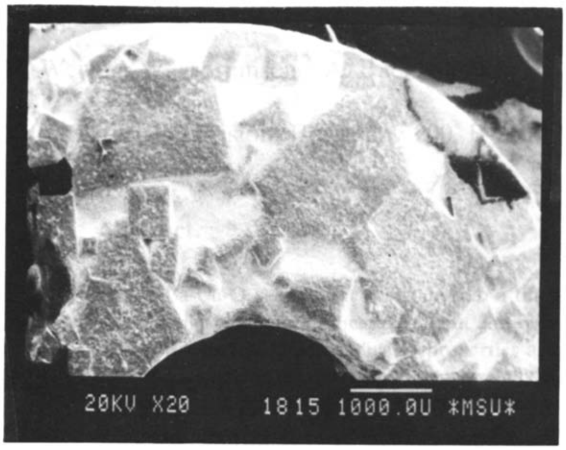

Figure 2. Microstructure of a sample prepared by slow cooling (V=1°C/h) in temperature range 1000 - 900°C.

Data obtained confirm the fact that fine-crystallites large scale samples obtained by fast cooling in 1000-900°C temperature range possess higher J_c values in comparison with coarse-crystallites ones.

4. Conclusions

We believe, that YBCO materials with high J_c values and satisfactory mechanical characteristics can be provided by increasing the cooling rate in a temperature range ≈ 1000-900°C. In this case possibility of completing the reverse peritectic reaction is to be determined by presence of fine and uniformly distributed particles of Y_2BaCuO_5 in the melt. It becomes possible if dispersed and homogeneous precursors are used, high temperature treatment is limited and oxygen exchange between samples and atmosphere is canceled.

Benefit of using Y-riched compositions due to relaxation of internal stresses near "$YBa_2Cu_3O_x$ - Y_2BaCuO_5" interfaces was also demonstrated.

References

1. M.Murakami Jap. J. Appl. Phys., 28 (1989), 1189.
2. S.M.Johnson Adv. Ceram. Mater., 2 (1987), 337.
3. M.Murakami IEEE Trans. on Magn., 27 (1991), 1479.