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The effect of the initial BSCCO 2212 grain size on the final grain size and the formation of BSCCO 2223

Jae-Woong Ko*[a], Jaimoo Yoo[a], Myoung-Je Park[a], Hai-Doo Kim[a] and Hyungsik Chung[b]

[a]Ceramic Materials Group, Korea Institute of Machinery & Materials
66, Sangnam-dong, Changwon-si, Kyungnam-do, 641-010, Korea
[b]Division of Mechanical and Industrial Engineering, Ajou University
San5, Wonchon-dong, Paldal-gu, Suwon, 442-749, Korea

Abstract

The effect of the initial BSCCO 2212 grain size on the final gain size and the formation of the BSCCO 2223 was studied using a powder precursor synthesized by two-powder method. 2212 and $CaCuO_2$ tapes were prepared by dip coating and joined by pressing and then followed by the repeated thermo mechanical treatment. The samples were characterized by XRD and SEM analysis. The formation and grain size of the BSCCO 2223 depended on the initial BSCCO 2212 grain size.

Keywords : 2212, grain size, 2223, two powder method

I. Introduction

The relations between the different phase of the system Bi-Pb-Sr-Ca-Cu-O are very complex, due to the presence of a large number of elements. Several BSCCO-2223 reaction mechanisms have been proposed; i) an intercalation process in which the pre-existing 2212 crystals transform directly into 2223 plates via the insertion of CuO_2/Ca bi-layers into the CuO_2/Ca/CuO_2 blocks of 2212 [1-5]; ii) a two-dimensional growth with decreasing nucleation rate. A liquid phase generated in the powder reacts with the 2212 matrix via the diffusion of Ca, Cu and Pb ions, resulting in the nucleation of the 2223, which diffuses into he 2212 matrix, maintaining the outline of the original crystal shape [6-11]. Relatively texturing of 2212 phase is more important for the former case than the latter, but the particle size and texturing of pre-existing 2212 phase are important factors on 2223 phase formation and grain growth. Heat-treating precursor powder at higher calcination temperature for particle size control of 2212 phase result in consuming liquid phase which gives driving force for grain growth of 2223 phase. In the original two-powder process, 2223 phase was made by mixing of 2212 phase obtained by solid-state reaction and other phases. However, in this work, 2212 phase has heat-treated at around its partial melting temperature and we called it modified two-powder process. In this work, 2223 phase was formed from different starting 2212 particle size and relationship between the size of 2212 particles and 2223 phase formation and grain growth were studied.

II. Experimental

To produce precursor powder using the two-powder process, lead doped 2212 and other phases were prepared as separate intermediate phases from spray drying of metal nitrate solution. Two different types of 2212 were made for 2223 formation. One

[1] *Corresponding author. Fax: +82 55 280 3342
e-mail: kjw1572@kmail.kimm.re.kr

was heat-treated at around its partial melting temperature for 2212. The other was prepared by partial melting and slow cooling process. The other precursor powder, which was mixture of Ca and Cu salts, was heat-treated at 710°C. The assemblage, with the overall composition 2223, was made by combining the appropriate amount of 2212 and other phases. Finally, the assemblages were sintered at 840°C in air for different times. The microstructures were observed by SEM. The XRD, DTA and EDS were performed to identify and characterize the samples. Detailed experimental procedures are shown schematically in Fig 1.

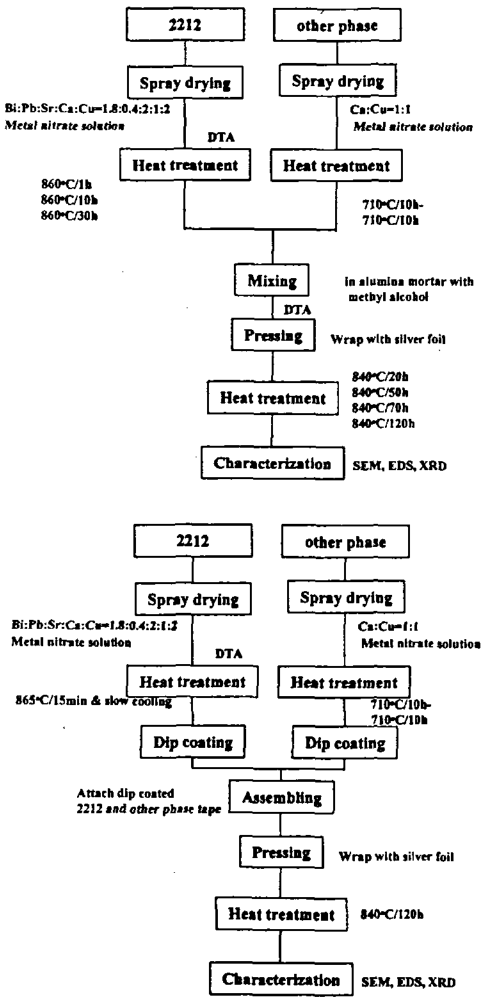

Fig. 1. Flow chart for the experiment

III. Results and discussion

2212 was synthesized with different particle size by heat-treating at 860°C for 1h, 10h, 30h and by partial melting and slow cooling. 2212 particles were plate-like grains and grown well with increasing heat-treating times. The average particle sizes are 2 m, 4 m, 10 m and ~100m (well aligned elongated grain (Fig. 2 and Fig.3)). Other powder heat-treated at 710°C for 10 hrs twice was consisted of $CaCuO_2$, CuO and CaO. The DTA traces (Fig. 4) for the powder mixture of 2212 and other phases show the onset temperatures of main endothermic peak were influenced by starting 2212 particle size.

Fig. 5 is the SEM image of the fracture surface of the oxide core fully heat-treated at 840°C for 20 and 70 hrs. These results suggest the final microstructure can be controlled by starting 2212 grain size at given heat-treating temperature. The precursor powder, which has larger 2212 particles, was less reactive than that which has small 2212 particles. This tendency can be clearly seen in combining of DTA traces (Fig. 4) and SEM results (Fig. 5).

The plot of the XRD data for 2223 formation was analyzed using Abrami equation [12], assuming nucleation and growth transformation mechanism. It shows that 2223 phase, from a mixture of 2212 phase which have different starting particle size and other phases, was formed by a diffusion-controlled two-dimensional nucleation and growth process, of which Abrami exponent is ~1.0.

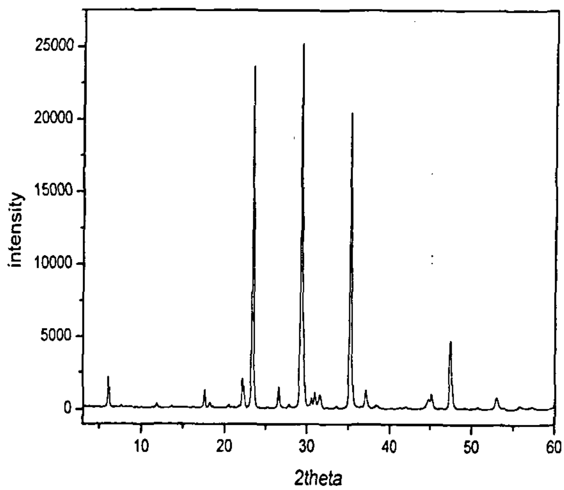

Fig. 2. XRD patterns for the well aligned Bi(Pb)2212

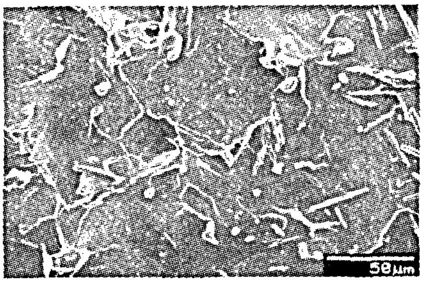

Fig. 3. SEM photos for the well aligned Bi(Pb)2212

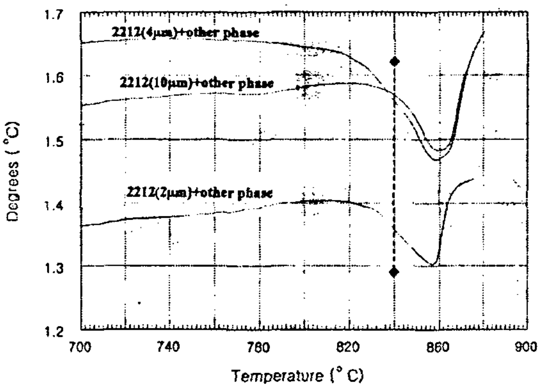

Fig. 4. DTA curves for the BSCCO-2212 and other phase mixture powder

IV. Summary

We have synthesized BSCCO-2223 by modified two-powder process and investigated effect of 2212 on 2223 phase formation and grain growth by control of 2212 grain size. Phase evolution of a 2223 and reactivity were remarkably sensitive to the size of 2212 particles and liquid phase. Larger size of 2212 particles has an influence on liquid formation temperature of the system. The Avrami relation was well suited for describing the kinetics of grain growth in 2223.

Acknowledgments

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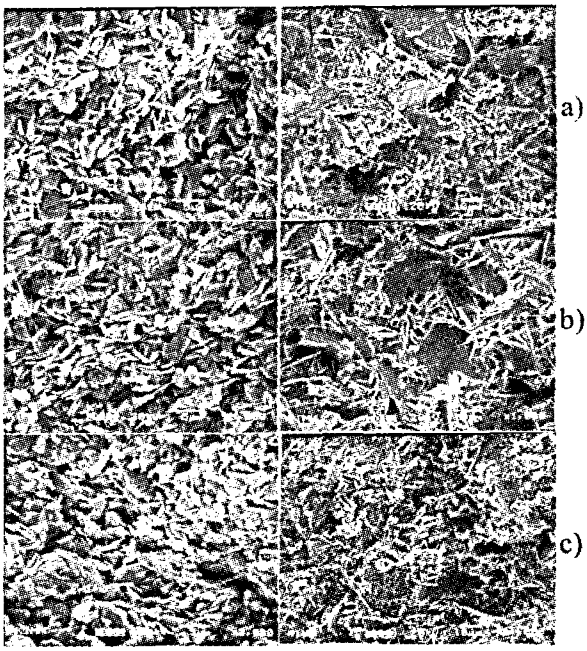

Fig. 5 SEM photos for the fracture surface of specimens
a) 2212(2 m)+ other phase mixture
b) 2212(4 m)+ other phase mixture
c) 2212(10 m)+ other phase mixture

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