Texture Evolution in Ni Substrate Prepared by Powder Metallurgy and Casting Methods

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Abstract

Cube textured Ni substrate were fabricated for YBCO coated conductors from the initial specimens prepared by powder metallurgy (P/M) and casting and the effects of annealing temperature and reduction ratio on texture formation and microstructural evolution were evaluated. The initial specimens were rolled and then annealed in the temperature at 600 ℃ ~1200 ℃.

A strong cube texture formed for P/M substrate, and the degree of texture did not significantly vary with annealing temperature of 600 ℃~1100 ℃. On the other hand, the texture of casting substrate was more dependent on the annealing temperature and twin texture and several minor texture components started to form at 1000 ℃.

Keywords : Casting, Cube texture, powder metallurgy, substrate, YBCO

1. Introduction

In YBCO coated conductors (CC) process, multi-buffers and YBCO layer should be epitaxially deposited on substrate, thus, the formation of the substrate texture is critical to improve the critical current.

Two different approaches were used to fabricate textured metal in terms of preparation of initial specimens, i.e., casting and powder metallurgy (P/M). The casting method is simpler and provides denser and larger ingots than the P/M method. Most of the published researches deal with the casting method rather than with P/M[1]. By contrast, the P/M method has the advantages of forming a high purity microstructure without columnar or dendrite structure and of ease in making alloys with uniformly distributed elements. While it is well known that the texture depend on the annealing temperature and total reduction ratio, the texture components and their variation in the Ni substrate prepared by the P/M method were not widely studied.

In this work, we fabricated Ni substrates by P/M and casting methods. To characterize the effects of the two methods, the initial specimens were made of the same size and subjected to the same rolling conditions. Subsequently, the effects of annealing temperature and reduction ratio on the texture and grain morphology were evaluated.

2. Experimental and Results

Ni substrates were fabricated by P/M and casting via plasma arc melting(PAM) methods. To evaluate the effects of the two methods, the initial specimens were of the same size and subjected to the same rolling conditions. In the P/M method, the Ni powder was loaded into a mold, and isostatic pressure of 200 MPa was applied to form a rod-type compact(13 mm diameter and 120 mm length). The compacts were sintered at 1100℃ for 6 h in an atmosphere of 96% Ar and 4% H_2. For the casting method, 99.99% Ni chips were melted by plasma arc furnace in a reduced atmosphere of 1 x 10^{-3} torr and then formed into a rod-type ingot(13 mm diameter and 120 mm length).

The Ni rods were then cold-rolled into thin tape by a two-high rolling mill. Each rolling step reduced the thickness by less than 5%, and total reduction of 98.6% and 99.2% were incorporated to evaluate variation of texture with total reduction. Recrystallization annealing was performed at 600℃-1200℃ for 30 min. in an atmosphere of 96% Ar and 4% H_2..

Microstructures were examined by optical microscopy. The texture of the substrate was measured by four incomplete pole figures.

In order to evaluate the dependence of texture on the initial specimens and on the total reduction, a detailed analysis of ODFs of the rolled tapes was done. For the P/M-tape, the observed texture was mainly composed of Cu({112}<111>), Bs({110}<112>), and S({123}<634>) components. On the other hand, texture of the casting-tape consisted of Cu, Bs, S, and {013}<100> component as the major texture component and {110}<113>, {012}<121>, {012}<112>, and {001}<110> as minor one. The ODF of the P/M-tape with total reduction of 99.2%(hereafter, denoted P/M(99.2%)-tape) showed different texture patterns, compared with that of 98.6%. The major texture components were observed to be β-fiber texture, {001}<110>, and Goss ({011}<100>) components, and the intensity of β-fiber texture decreased. Low intensity of β-fiber and the presence of other components can have a detrimental effect on the formation of cube texture during recrystallization annealing.

Figs. 1 (a) and (d) show the pole figures of the P/M- and casting-substrates, respectively, annealed at 800℃, showing that a sharp cube texture ({001}<100>) developed and four (111) poles were symmetric. At the annealing temperature of 1000℃, the cube texture in both substrates began to degrade, but the degree and patterns of the texture were different. For the P/M-substrate, the homogeneous cube texture and symmetry of the poles were maintained. On the other hand, the pole symmetry and cube texture of the casting-substrate were considerably degraded. Several minor texture components were also observed, which became stronger as the annealing temperature increased further to 1200℃. Similar minor components began to form at 1200℃ for the P/M-substrate as shown in Fig. 1 (c). This indicates that the P/M-substrate has a wider and higher annealing temperature range within which the cube texture become stable, compared to that of the casting-substrate.

Fig. 1 (f) is a pole figure of the P/M(99.2%)-substrate after annealing at 800℃. The cube texture was poor and several minor texture components formed.

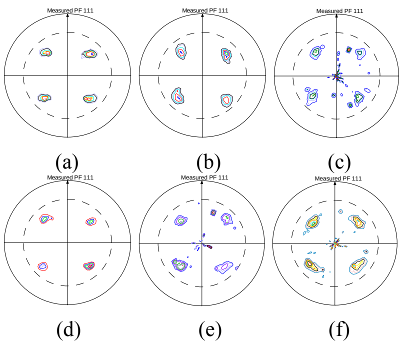

Fig. 1. (111) Pole figures of the P/M-substrates annealed at (a) 800℃, (b) 1000℃, (c) 1200℃, and the casting- substrates at (d) 800℃, (e) 1000℃ with reduction ratio of 98.6%, and (f) the P/M(99.2%) -substrate at 800℃

The microstructures of the substrates annealed at 800℃ and 1000℃ are shown in Fig. 2. We observed that, for both substrates, the grain is almost equiaxed and the grain size increases as the annealing temperature increases. The P/M-substrate grains were smaller than those of the casting-substrate, with the average grain size for the P/M-substrate being 28.12 ㎛ and 44.19 ㎛ at annealing temperatures of 800℃ and 1000℃, respectively, and the corresponding grain sizes for the casting-substrate being 50.86 ㎛ and 102.51 ㎛. The smaller grain size in the P/M-substrate can be explained by the "variation inhibition theory"[2].

In addition, annealing twins appeared at 1000℃ for the P/M-substrate and at 800℃ for the casting-substrate. These annealing twins became significant as the temperature increased, and more twins developed for the casting-substrate than for the P/M-substrate at a given temperature. The presence of twins would be expected to deteriorate the surface roughness and inhibit the formation of a sharp cube texture.

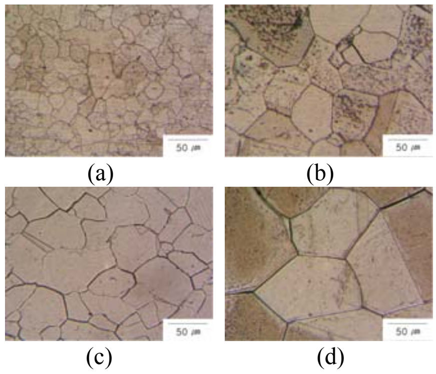

Fig. 2. Micrographs of top view of the P/M-substrate annealed at (a) 800℃, (b) 1000℃, and the casting-substrate at corresponding temperature (c)-(d)

3. Summary

Ni substrates were fabricated from the initial specimens prepared by the casting and P/M and the effects of annealing temperature and reduction ratio on texture and microstructural evolution were evaluated. We observed that a strong cube texture formed for the P/M-substrate at annealing temperature of 600℃~1100℃. It is to be noted that the P/M-substrate had a wider and higher annealing temperature range in which the cube texture become stable, compared to the range for the casting-substrate. We also observed that, for both substrates, the grain is almost equiaxed, and the grain size increases as the annealing temperature increases. The P/M-substrate grains were smaller than those of the casting-substrate.

4. References

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