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Texture hardening in PIT method and its effect on texture formation during annealing

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In present study the influence of several factors on the texture of Bi-based superconductor prepared by powder in tube (PIT) method has been studied. The grain growth of 2212 and 2223 phases during the heat-treatment process leads to obvious improvement of their texture degrees. The texture of mother phase 2212 is well beneficial to improving these texture degrees. These results are analyzed based on the mechanism of the minimum interface energy texture formation that was raised in the early works.

1. INTRODUCTION

The high texture microstructure in Bi-2223/Ag superconducting tape made by PIT(Powder In Tube) method, is the most important factor of getting high critical current density for large scale practical application. The PIT method includes combination of the materials, heat-treatment process and mechanic deformation. As many research works[1-5] on texture formation showed, the texture microstructure is formed in two procedures: the mechanical deformation and the heat-treatment processes, and many factors influence the texture formation. Therefore, investigation on which role these factors will play in the texture microstructure formation is very meaningful.

2. EXPERIMENTAL

According to the nominal composition of $Bi_{1.8}Pb_{0.4}Sr_2Ca_{2.2}Cu_3O_x$, the precursor powder with 2212 as main phase was fabricated by the traditional solid reaction method. The powder was filled into a Ag tube, and the tube was drawn and rolled into the two long tapes, one with 0.13 mm thickness and the other 0.5 mm. Then the thinner one was cut into short tapes, the short tapes were pressed at the pressures of 4.5, 9, 18, 36 and 56 T/cm^2. The thicker one was cut into several segments, which were rolled directly into tapes with 0.4, 0.33, 0.24, 0.1, and 0.11 mm in thickness respectively. All of the pressed and rolled tapes were annealed at 835℃ for 54 h, then cooled down to room temperature in air. The deformation rate is denoted by the ratio of the sample thickness difference before and after deformation to the original thickness. Two methods are used to measure the texture degree. One is the method introduced by Lotgering[6] to determine the texture degree P. The other is the tilting X-ray experimental to determine the texture degree Q. The detailed processes can be seen in [5].

3. RESULTS AND DISCUSSION

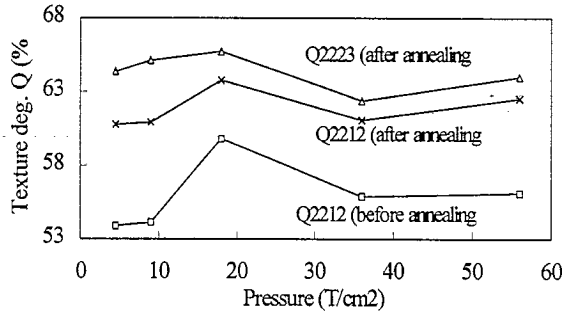

Fig.1 The dependence of the texture degree Q of the pressed samples on the pressure

According to the x-ray diffraction patterns and an early study[5], all the pressed and rolled samples before annealing are composed mainly of 2212 phase and others with small grain size. After annealing, a lot of 2223 phase was transformed, and both 2212 and 2223 phases were in the shape of sheet with large grain size. Since the results are consistent in the

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above two texture-measuring methods, one of the two series data is provided to discuss in the present paper. Figure 1 shows the relationship of texture degree Q with the pressure. For the samples before annealing, the dependence is complex. With the growth of pressure, the texture degree of 2212 phase increases while the pressure is small, reaches the maximum at pressure of 18 T/cm^2, then slightly decreases over 18 T/cm^2, and fluctuates in the range of higher pressure. There is an obvious phenomenon-hardening[1,2].

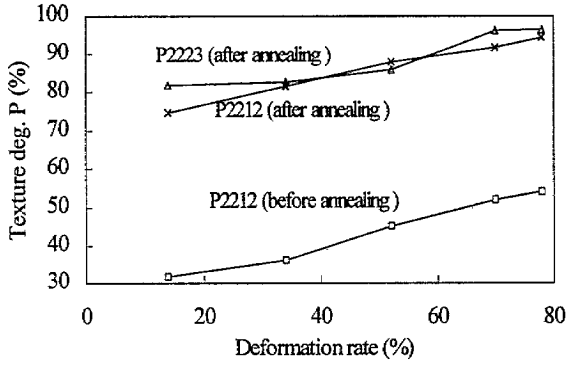

Fig.2 The dependence of the texture degree P of the rolled sample on the deformation rate

The effect of deformation rate during the rolling process on the texture degree P is indicated in Figure 2. With increasing the deformation rate, the texture degree of 2212 phase increase monotonously for sample before annealing. This result is different from that of research on the rolling deformation of 2223 single phase[2], which shows that the texture hardening occurs at 50 % deformation rate. It is considered that this difference results from the original microstructures. It is well known that grains of both 2212 and 2223 tend to be in the shape of layers. The grain size of the single 2223 phase must be large because of the preparation method. In the experiment here, the size of 2212 grains is small, and therefore the rotation deformation is easier to happen.

As shown in figures 1 and 2, the texture degrees of 2212 and 2223 phases after annealing increase obviously in all samples. Meanwhile, the texture degrees of two phases in the annealed sample are parallel to the texture degrees of 2212 phase in the sample before annealing regardless of the existence of the texture hardening phenomenon. On the base of the minimum interface energy texture formation mechanism[5], the grain growth in this case has made the texture higher. Moreover, the higher the texture degree in the original 2212 phase, not only the higher texture degrees of the nucleus of new phases 2212 and 2223, but also the easier formation of texture at the crystal growing stage, and these factors are very beneficial to the texture formation. For the rolling deformation, with the increase of the deformation rate, the texture degree of original 2212 phase increase monotonously, and the texture degrees of the two phases in the annealed samples increase monotonously. For the pressing deformation, the sample with the highest texture degree of original 2212 phase is the one pressed at the pressure of 18 T/cm^2 due to the texture hardening phenomenon, and its texture degrees of the two phases after annealing are also the highest.

4. CONCLUSION

In summary, during the PIT process, the deformation manner, rate and the microstructure of the original sample play important roles. When the Ag sheathed sample is composed of small 2212 grains, there is a texture hardening phenomenon in the pressing process, but not in the rolling process. In the annealing process, the grain growing of 2212 and 2223 phases improves its texture degrees, which are parallel to that of the original 2212 phase.

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