Magnetic properties of ceramic composite using melt process

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ABSTRACT

The critical transition temperature and critical current density of YBaCuO single crystal bulk were measured after heat diffusion treatment in nano powder. The superconducting start temperature was found to be to high at 91.62K. It can be seen that the critical current density and the critical temperature of the superconducting sample was subjected to a thermal diffusion process that was higher than those of conventional superconducting samples. As a result of this study, it can be seen that the flux phase diffuses into the crystal grain boundaries through the oxygen diffusion path in the heat treatment process and the 211 phase is generated inside the superconducting wire, thereby improving the superconducting flux effect, the superconducting transition temperature and the critical current density. The diffusion heat treatment method of the flux material proposed in this study has the effect of improving the grain boundary state in the superconducting body by direct flux injection from the surface, thereby enhancing the flux pinning and increasing the superconducting transition temperature and the critical current density .

Keywords: superconductor, magnetic field, bulk

1 INTRODUCTION

As second generation high-temperature superconducting technology spreads, the practical use of superconducting devices is accelerating. Particularly, the application to high-efficiency power devices to minimizing loss from the viewpoint of energy efficiency has been actively carried out. It is expected that there will be a huge demand in the form of substitute demand for existing power system and application of superconducting power device to high efficiency new power system.

In order to cope with the future paradigm shift of electric power systems, development and application of superconductivity applied technologies are necessary. On the basis of superconductivity-related technological capabilities, continuous research on elemental technologies must be backed up in order to lead the future electric power market. Demand for superconducting bulk materials used for power related equipment (such as superconducting shielding apparatus, large capacity magnetism, accelerator magnets, etc.) with applied superconducting magnetic force by accelerating power application technology using superconductivity has been increasing.

It is necessary to develop superconducting bulk for superconducting magnets used in next generation energy sources such as superconducting shielding and nuclear fusion reactors. The high temperature superconducting bulk under development, is in the process of developing a wire using YBCO, but due to various disadvantages of YBCO superconductor (Anisotropic current flow), it will take a great deal of effort to develop a commercial superconducting bulk process.

Research is needed to improve the critical current of superconducting bulk at superconducting shielding operating temperature. By installing high-temperature superconducting bulk, bypassing the magnetic field of vertical components that the superconducting bulk receives in current conduction, it is possible to improve the critical current value of superconducting bulk and to increase superconducting current to englarge energy storage or to reduce the lecel of superconducting.

2 EXPERIMENTAL METHOD

Commercial YBaCuO superconductor and Y211 powders (Solvay LTD, Germany, 99.9%) were used to fabricate the Y123 compacts. The compact composition was stoichiometric $Y_{1.5}Ba_2Cu_3O_{7-y}$. Five grams of YBaCuO powder was pressed into compacts in a 12mm diameter steel mold and pressed isostatically. The seed YBaCuO was placed on a MgO single crystal substrate and positioned at the center of a box furnace. The samples were heated to 920℃ at a heating rate of 100℃/h and maintained at this temperature for 2 hour, heated again to 1040℃ and held at this temperature for 0.5h. To induced single $Y_{1.5}Ba_2Cu_3O_{7-y}$ grain growth, the samples were cooled from 1020℃ to 950℃at a cooling rate of 1℃/h and cooled again to room temperature at a rate of 100℃/h. The electromagnetic characteristics of the YBaCuO ceramic superconductor depend on the inner defects of the superconductor. The flux pinning center can be controlled during the thermal process. In this study, the YBaCuO bulk was blended with Sm_2O_3 powders at 900℃ for 2 hours to keep inducing samarium diffusion. Then, the superconducting properties of the heat-treated superconductors, such as the trapped magnetic flux, were determined. A microstructural investigation and property measurements were carried out at three different regions of the surface of the YBaCuO superconductor. The microstructure was analyzed by scanning electron microscopy (SEM). To understand the change in superconductivity caused by samarium diffusion, the temperature dependence of the magnetic moment and the Jc-B characteristics at 77K were estimated using a SQUID magnetometer. The Jc value was calculated from the magnetization loops using an extended Bean model for a rectangular sample.

3 RESULTS AND DISCUSSION

The YBCO superconductor is called a high-temperature superconductor and has a high critical temperature of 92 K. Therefore, it is possible to conduct experiments using liquid nitrogen rather than liquid helium, thereby significantly reducing the cost of expensive materials the the purchasing of liquid nitrogen.

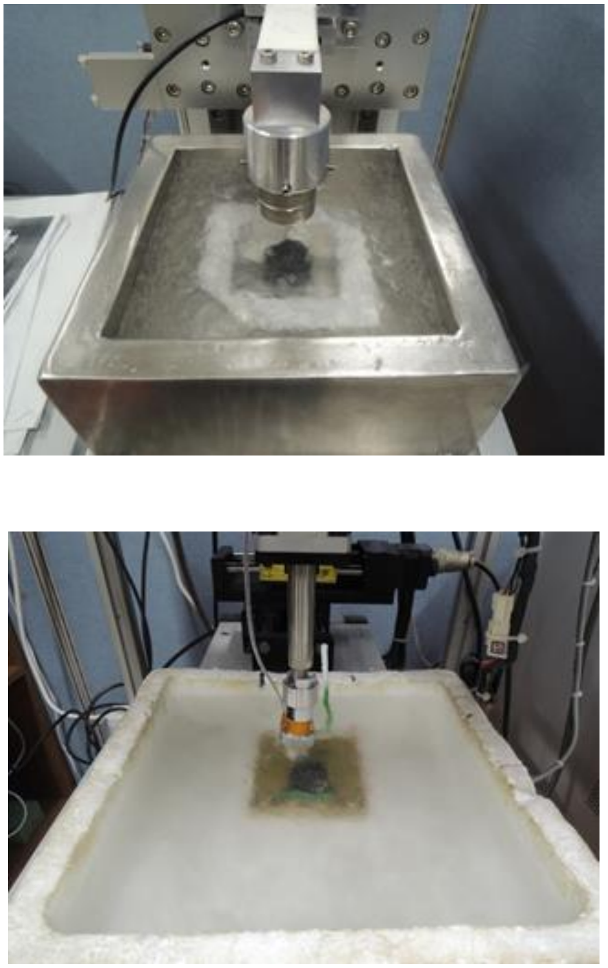

Figure 1: Measurement of magnetic properties for the trapped magnetic field of superconducting specimens

In the figure above, the ZFC (Zero Field Cooling) test was carried out and the specimen was tested under liquid nitrogen at a temperature of about 77 K, with a space of 1 mm from the specimen. After fixing the specimen under liquid nitrogen, wait until it becomes a superconducting state, then measure it with a permanent magnet suspended above it at a distance of 2 mm per second from the specimen at a height of 50 mm. The reciprocating experiment is carried out again with the magnet raised, the experiment for reproducibility is carried out, the measurements are carried out twice in the same section in one cycle. The rectangular metal containers on which the specimens are placed are highly affected by the temperature, so there is a high probability of affecting the superconductors. Therefore, it is important to consider lowering the temperature again to room temperature before measurement.

The (FM) Field Mapping test is carried out in the case of the lower part, however, the permanent magnet is placed on the specimen with no distance between the specimen unlike the above-mentioned magnetic levitation force measurement. Then, the specimen is fixed in a specific container. The magnetic field of the permanent magnet is put into the specimen, and the induced magnetic field is detected and 3d mapping is performed. The measurement range of 40x40 mm, which is the size of the specimen, is specified. The magnitude of the induced magnetic field can be measured in kG size. It is measured at intervals of 2 mm and by the size of the specimen. As the magnitude of the magnetic field is different for each section, when mapping is performed, the graph will be shaped like a round mountain. This means that the magnitude of the magnetic force captured at the central part of the specimen in which the seed grows is larger.

4 CONCLUSIONS

Superconducting bulk specimens were fabricated using YBCO calcined powder, and the environment for the seeds to grow well was created by making the entrance and exit of heat to the specimen in to a tunneling form. In order to overcome the disadvantages of the conventional superconducting bulk method by stacking and growing two specimens in the figure on the right, it is easy to manufacture specimens with high physical properties in a short period of time, thereby greatly increasing the throughput and introducing the above method to industrial industries. In addition, since the degree of failure in the specimen manufacturing process is reduced, the material consumed is relatively less, which can have a significant effect on the material cost reduction.

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