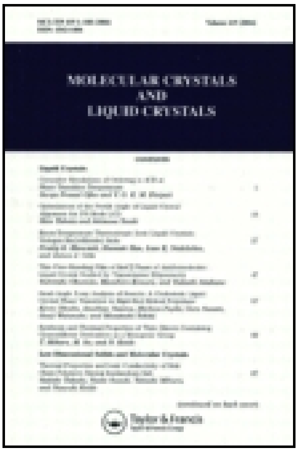

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Magnetic Shielding Using High-T_c Superconducting Films Prepared by a Tape Casting Method

Mamoru Ishii [a], Masasuke Takata [a], Tsutomu Yamashita [a] & Keizou Tsukamoto [b]

[a] Department of Electrical Engineering, Nagaoka University of Technology, Niigata, Japan

[b] Nihon Cement Co., Ltd., Tokyo, Japan

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MAGNETIC SHIELDING USING HIGH-T_c SUPERCONDUCTING FILMS PREPARED BY A TAPE CASTING METHOD

MAMORU ISHII, MASASUKE TAKATA and TSUTOMU YAMASHITA
Department of Electrical Engineering,
Nagaoka University of Technology, Niigata, Japan

KEIZOU TSUKAMOTO
Nihon Cement Co.,Ltd., Tokyo, Japan

Abstract A superconducting tube has been developed for a magnetic shielding. This tube was composed of 42 pieces of Bi(Pb)-Sr-Ca-Cu-O ring disks prepared by a tape casting method. As the magnetic field was applied parallel to the axis of the tube, the magnetic flux density was shielded up to 19 gauss by the tube.

INTRODUCTION

A magnetic shielding may be regarded as one of the important applications of high-T_c superconductors. Symko et.al. presented that the flux was shielded up to 20 gauss by the Y-Ba-Cu-O tube.[1] In our previous paper, it was reported that the flux started to penetrate from the perimeter of the Y-Ba-Cu-O superconductor at a magnetic flux density as low as 7 gauss.[2] Such magnetic shielding properties of the superconductors are of concern not only for practical applications, but also for a better understanding of the basic properties of these materials.[18]

The investigations concerning the magnetic shielding properties have been made mostly in Y-Ba-Cu-O system. In the present paper, we report the preparation of Bi(Pb)-Sr-Ca-Cu-O ring disks by a tape casting method and the measurements of the magnetic shielding properties of the tube composed of the superconducting ring disks.

EXPERIMENTAL

FABRICATION OF Bi(Pb)-Sr-Ca-Cu-O TUBE

Bi(Pb)-Sr-Ca-Cu-O superconducting ring disks were prepared by a tape casting method.[9,10] The prescribed amounts of Bi_2O_3, PbO, $SrCO_3$, $CaCO_3$ and CuO were mixed in the molecular ratio of $Bi_{1.8}Pb_{0.3}Sr_{1.9}Ca_{2.0}Cu_{3.0}O_x$ under acetone, calcined at 845°C for 12h. This product was pulverized and mixed with a binder formulation consisting of solvent, organic binder (polyvinyl butyral), dispersant and plasticizer. The resulting slurry was cast on polyethylene carrier sheets under an 80mm wide doctor blade. After drying for more than 24h, green films with a thickness of 100μm were obtained. The green films were cut into rings with an outer diameter of 20mm and an inner diameter of 8mm. Twenty sheets of the ring films were laminated and heated at 400°C to decompose and evaporate the organic binder and sintered at 845°C for 24h in air. The ring disks thus obtained were pressed at 2000kg/cm^2 and sintered again at 845°C for 24h in air in order to produce a highly oriented microstructure with improved density.[11,12] The critical temperature T_c and the critical current density J_c of each ring disk were 103K and 560A/cm^2 (at 77.3K), respectively.

The Bi(Pb)-Sr-Ca-Cu-O tube was composed of 42 pieces of the ring disks as shown in Fig.1.[13] The tube was with an outer diameter of 20mm, an inner diameter of 8mm and a length of 42mm.

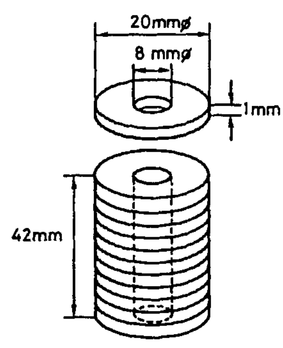

Figure 1 Superconducting tube for a magnetic shielding.

MEASUREMENT OF MAGNETIC SHIELDING PROPERTIES

The tube was mounted axially in a pair of helmholtz coils which generated a dc external magnetic field (an external magnetic flux density B_{ex}). The magnetic shielding properties of the tube were measured at 77.3K with a Bell model BHA-921 cryogenic hall probe. The probe measured the internal magnetic flux density B_{in} as the external magnetic flux density B_{ex} was applied. The sensitivity of the probe was 0.708mV/kgauss. The area of the sensitive part of the probe was $0.20mm^2$. The probe was moved from the center to the edge of the tube to measure the magnetic shielding properties at different positions inside the tube.

RESULTS AND DISCUSSIONS

After zero magnetic field cooling of the tube, B_{in} at the center of the tube was monitored. The magnetic shielding curve of B_{in} as a function of B_{ex} is shown in Fig.2. The dashed line indicates the data at the room temperature. When B_{ex} was increased from zero to 100 gauss, the flux was shielded up to 19 gauss. This value is refered to as a maximum shielding magnetic flux density B_m. With a further increase in B_m, the flux started to penetrate into the center of the tube. When B_{ex} was decreased from 100 to zero gauss, the residual magnetic flux density of 20 gauss was observed since the flux was trapped inside the tube.

Subsequently, B_m was measured at various positions from the center to the edge of the tube. Figure 3 shows the result. The value of B_m was decreased steeply by moving the measuring position. The result shows that the penetrating flux moved in from the edge of the tube as the magnetic field was increased. This occurs because the current density, which was induced to keep the magnetic flux density inside the tube constant, reached the critical value at the edge of the tube first. However, the steep decrease of B_m near the center of the tube can not be explained sufficiently, since B_m should be constant there in general. This problem is now under investigation.

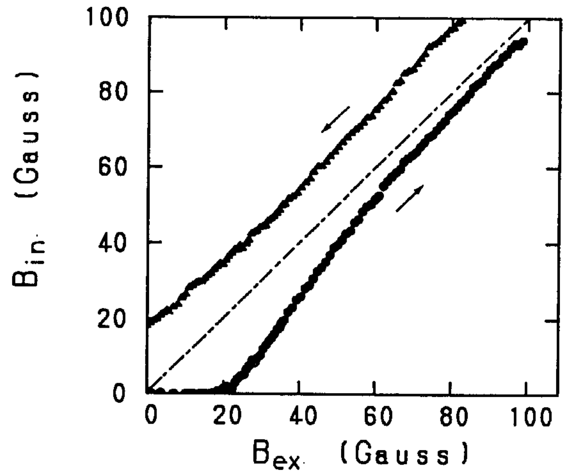

Figure 2 Magnetic shielding curve of B_{in} as a function of B_{ex} at the center of the tube.

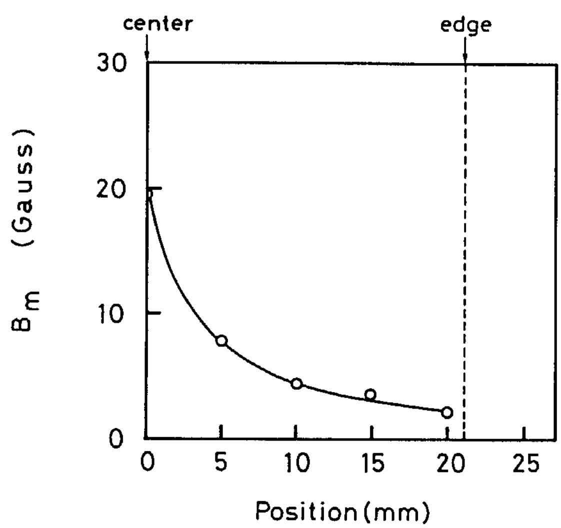

Figure 3 Axial dependence of B_m for the tube.

CONCLUSION

The superconducting tube has been developed for the magnetic shielding. This tube was composed of 42 pieces of Bi(Pb)-Sr-Ca-Cu-O ring disks prepared by a tape casting method. As the magnetic field was applied parallel to the axis of the tube, the magnetic flux density was shielded up to 19 gauss by the tube.

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