MgB_2 초전도 선재 제조 및 자장하에서의 임계전류특성

고재웅, 유재무, 김영국, 오개희[a], 최승주[a], 정형식[b], H. Kumakura[c], K.Togano[c]
한국기계연구원, [a]일진전기(주), [b]아주대학교, [c]NIMS

The Fabrication of MgB_2 superconducting tape and its transport critical current property under magnetic field

J-W. Ko, J.M. Yoo, Y.K. Kim, K-H. Oh[a], S.J. Choi[a], H.S. Chung[b], H. Kumakura[c] and K.Togano[c]
KIMM, [a]Iljin Electric Co., Ltd., [b]Ajou Univ., [c]NIMS

kjw1572@kmail.kimm.re.kr

Abstract - The stainless steel sheathed MgB_2 tapes with Cu addition were fabricated by PIT method without heat treatment. The J_c value of 5,600 A/cm^2 and 16,000 A/cm^2 at 4.2 K and 5 T were obtained for the MgB_2 tape and 10 vol % of Cu added MgB_2 tape respectively. The J_c-B curve shows enhancement in J_c under magnetic field, which suggests enhancement in flux pinning property with Cu addition.

1. Introduction

Since the discovery of superconductivity at 39 K in MgB_2 compound by Akimitsu *et al.*[1], many research groups in the world have been studied to find out new possibilities of practical application. Experiments in MgB_2 bulk and tape indicate that MgB_2 system shows no weak coupling of grains and that grain alignment is not necessary conditions for obtaining large current transfer across grains[2]-[3]. Recently, MgB_2 tapes with high transport currents using Ni, Cu and stainless steel sheath were obtained without any heat treatment[4]-[6]. These are very advantageous for practical application compared to high T_c superconductors. Considering superconductivity at 39 K, one of possible applications of MgB_2 compound is a crycooler cooled magnet operated at 20 K. In view of practical applications, superconducting parameters such as upper critical field, H_{c2}, critical current density, J_c, and irreversibility field, H_{irr}, are very important factors. The upper critical field, H_{c2} of MgB_2 at 20 K was about 12 T, which was higher than that of Nb-Ti wire at 4.2 K[7]. However, J_c under magnetic field at 20 K of MgB_2 is still low, which does not reach to the practical level. Furthermore, H_{irr} at 20 K is also not high enough for magnet application. In this paper, we report I_c of Cu added MgB_2 tape under magnetic field at liquid helium temperature and propose the possibility of enhancement in transport properties under magnetic field.

2. Experimental

Commercially available MgB_2 powder with various amounts of Cu powder was packed into stainless steel tubes. These tubes were rolled into rectangular rods using groove rolling and then cold rolled into tapes. The final size of tapes was about 4 mm in width and about 0.6 mm in thickness. These tapes were cut into short pieces with a length 4-5 cm, and current leads and voltage taps were directly soldered to the sheath materials of the tapes. A magnetic field was applied parallel to the tape surface. The critical current I_c was measured by a standard four-probe resistive method at 4.2 K in magnetic fields with a 1 μ V/cm criterion.

3. Results and Discussion

Figure 1 shows the typical cross section of the stainless steel sheathed MgB_2 tape. Densified microstructure was obtained without any heat treatment. Figure 2 shows J_c versus magnetic field curves of Cu added MgB_2 tapes. The J_c values of Cu added MgB_2 tapes were much higher than that of the MgB_2 tape under magnetic field. The J_c value in 5 T of MgB_2 was about 5,600 A/cm^2 and 16,000 A/cm^2 for 10 vol % of Cu added MgB_2 tape. Enhancement in J_c under magnetic field for Cu added MgB_2 tape can be explained by the high packing density of MgB_2 with Cu addition associated with the hard sheath material.

Figure 3 shows the abnormal behavior in voltage versus current curve at 6 T. That shows a possibility in enhancement of flux pinning property with Cu addition. The introduction of pinning centers is required to obtain substantial increase of J_c. The introduction of pinning centers is also effective in reducing the sensitivity of J_c to the magnetic field.

4. Summary

We fabricated MgB_2 tape and Cu added MgB_2 tapes by PIT method without any heat treatment. The J_c value of 5,600 A/cm^2 and 16,000 A/cm^2 at 4.2 K and 5 T were obtained for the MgB_2 tape and 10 vol % of Cu added MgB_2 tape respectively. The J_c-B curve shows enhancement in J_c under magnetic field, which suggests enhancement in flux pinning property with Cu addition.

Acknowledgement

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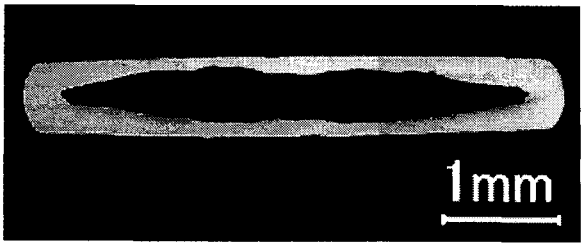

Fig.1. Optical micrograph of Cross section for MgB_2 tape

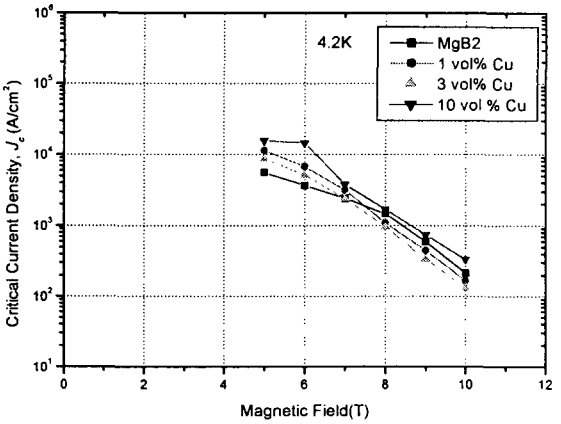

Fig.2. J_c-B characteristics at 4.2K of MgB_3 tapes with different amounts of Cu

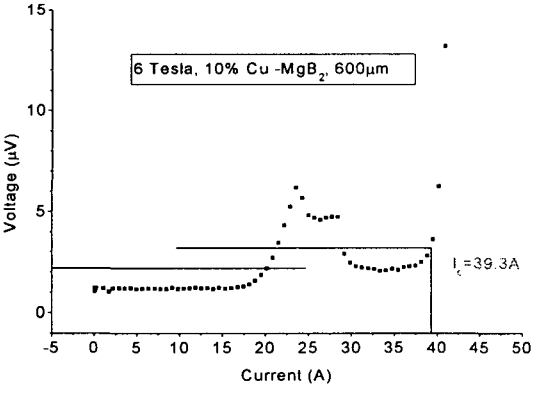

Fig.3. V-I characteristic at 4.2K and 6T of 10 vol% Cu added MgB_2 tape