§ 27. Stress/Strain Characteristics of PIT MgB₂ Tapes with Nickel Sheath — Effect of Indium Addition to the Core —

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MgB₂ superconductors fabricated by the powder-in-tube (PIT) process are expected to be less expensive superconducting conductors because simple and low cost fabrication procedures are applicable. The transport critical current density, J_c , of the core in the PIT MgB₂ conductors, which depends on the raw powder quality, sheath material, fabrication procedure, heat treatment condition and so on, is in the range of 10^4 – 10^5 A/cm² at 4.2 K and 0 T. In order to improve the J_c , addition of metal powders, such as silver, nickel, copper, indium and tin, to MgB₂ core has been tried by some of the present authors.¹⁾ Among them, it has been shown that the 10 vol% indium addition and annealing at 473 K for 10 hours enhances J_c by a factor of five. The addition of indium was assumed to contribute for the improvement of weak MgB₂ grain linkage. For practical applications, it is important to study the stress/strain characteristics of the conductor. The tape with the indium powder in the core is expected to have better stress/strain characteristics than that without indium. In this study, the effect of the indium addition to the MgB₂ core on the stress/strain characteristics is investigated.

Two nickel sheathed mono-core PIT tapes with 10 vol% indium addition in the core and without it, for reference, were prepared. The MgB₂ powder with or without 10 vol% indium powder was encased in a nickel tube with an outer/inner diameter of 8/6 mm to form a sheath/core composite. The final tape width and thickness after rolling were 4 mm and 0.3 mm, respectively. The nickel/MgB₂ ratio was estimated to be about 1.3 by the SEM photographs. Then, only the tape with 10 vol% indium addition was annealed at 473 K for 10 hours in flowing argon/5 vol% hydrogen gas. The details of the MgB₂ tapes are found in Ref. 1). The stress/strain characteristics evaluation of the tapes at 4.2 K and 2 T was conducted. The detailed description of the apparatus is available in Ref. 2). Both ends of the specimen were soldered to each copper terminal. The specimen can be contracted freely during cool down, so that we do not have to consider the pre-strain caused by the difference of thermal contraction between the specimen and the apparatus. The I_c was evaluated with the criterion of $1\mu\text{V/cm}$.

Fig. 1(a) shows the stress–strain curves of the tapes. Square symbols represent the points on unloading. They are almost linear excepting for high and low stress region.

Although some discrepancy is seen in the initial region of straining, the stress-strain curves for two tapes are almost comparable within the accuracy of the strain measurement, 0.05 %. Fig. 1(b) shows the strain dependence of I_c for the two tapes. The I_c is normalized by I_{c0} , I_c at 0 % external strain. The tapes with and without indium addition have I_{c0} of 87 A and 31 A, respectively. In the case of indium added tape, I_c is constant, within the accuracy of measurement, irrespective of applied strain and then suddenly degraded beyond 0.5 % strain. On the other hand, the I_c of the tape without indium increased very slightly up to 0.2% with the external strain and then gradually decreased until 0.25% where it begins to decrease steeply. After the degradation, I_c could not reversibly recovered on unloading. The compressive strain levels of the cores of MgB₂ subjected from Ni sheath for indium added tape and that without it appear almost the same. The increase in the strain for the irreversible degradation onset by indium addition will be ascribed to the improved connectivity of MgB₂ grains as evidenced by the increase in the I_c before straining mentioned above. The mechanisms how the indium addition suppresses the slight increase in I_c with strain is not known at present.

Fig.1. Stress-strain curves (a) and strain dependence of I_c (b) for nickel sheath /MgB₂ tapes with and without 10 vol% indium addition.

References

- 1) Tachikawa, K., et al., *Physica C* **382**, (2002) 108.
- 2) Katagiri, K., et al., *Adv. Cryog. Eng.* **36**, (1990) 69.