§26. Development of Advanced Superconducting Conductors for Fusion Devices

Sumiyoshi, F., Kawabata, S., Kawagoe, A. (Kagoshima Univ.),
Matsushita, T., Otabe, E.S. (Kyushu Institute of Technology),
Iwakuma, M. (Kyushu Univ.),
Takahashi, M., Okada, M. (HITACHI),
Yanagi, N., Mito, T.

In order to develop the new superconducting conductors for fusion devices, the performance of MgB_2 wires is improved, and the investigation to assemble conductors and to fabricate the coils is carried out. In order to simultaneously attain both increase in critical currents and decrease in AC losses of MgB_2 wires, the MgB_2 tapes with high aspect ratio of cross-section have been proposed in this study. The proposed MgB_2 tapes are obtained by rolling the twisted MgB_2 multifilamentary round wires. The results of measurements of critical currents and coupling losses in the multifilamentary test tapes have been reported. In this time, measurements of both critical currents and magnetizations have been carried out on fine single filament wires and tapes which have been simulated a filament in multifilamentary wires and tapes, to clarify the effects of deformation to tape shape on the electromagnetic properties of MgB_2 filaments in maltifilamentary wires.

Nine samples have been prepared. In these samples, three samples are original round wires. Six tapes are obtained by rolling these original round wires. Diameters of the three original round wires are 0.807 mm, 0.585 mm and 0.455 mm, respectively. Each original round wire has been deformed to two tapes with different aspect ratio of cross-section 2 and 4, respectively.

Firstly, it is described on the results of critical current measurements. Critical currents have been measured by the four probe method at 4.2 K on the sample wires and tapes with 60 mm in length under transverse magnetic fields of 2 - 7 T. The directions of the magnetic fields applied tapes are two directions, one is parallel and the other is perpendicular to the flat face of the tapes. The ratios of critical current densities, J_c of tapes to that of original wires are shown in Fig. 1. Open symbols and closed ones represent results for parallel and perpendicular fields, respectively. It is found that critical current densities J_c in our tapes increase with increase in filament aspect ratio. The effect of deformations on J_c doesn't depend on the diameter of original round wires. In case of the tape with the aspect ratio of a filament of 9.2, its J_c for parallel field increase to 4.5 times as one of the original round wire. One of the possible reasons for the increase in J_c due to deformation from a round shape to a rectangular shape is the increase in electrical connectivity in the tapes.

Next, it is described on the result of magnetization measurements. The samples have been measured their magnetizations by pick-up coil method. These samples have been measured their critical current densities before measurements of magnetizations. In this experiment, magnetizations have been measured on samples under external magnetic fields of trapezoidal form with amplitude of 0.2 - 0.3 T superimposed on DC magnetic fields of 2 – 5 T. The ratio of effective thickness of tapes to that of original round wires is shown by Fig. 2. Effective thickness, t_{eff} is defined by $t_{eff} = 2\Delta M/J_c$. t_{eff} corresponds to magnitudes of hysteresis losses. It is found that hysteresis losses decrease with increase in aspect ratio of filaments. In case of the tape with the aspect ratio of 9.2, hysteresis losses decrease to 1/4 of the original round wire. Solid line represents a theoretical line. Measured data are closely to the theoretical line.

Consequently, it was confirmed that the forming into tapes from round wires has influences on the great increase in critical current densities and the great decrease in hysteresis losses.

(1) A. Kawagoe, et al., IEEE Trans. Appl. Supercond. Vol. 19, No. 2, in press.
(2) M. Kiuchi, T. Matsushita, TEION KOGAKU, Vol. 43, No. 8, 349, (2008)

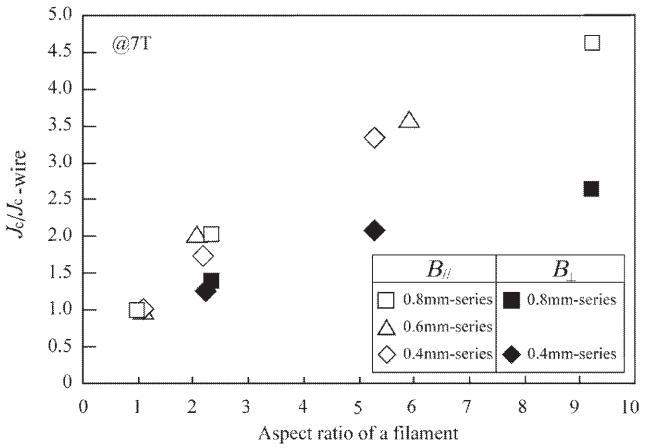

Fig.1 The effects of deformation into tape shape on critical current densities in MgB_2 filaments.

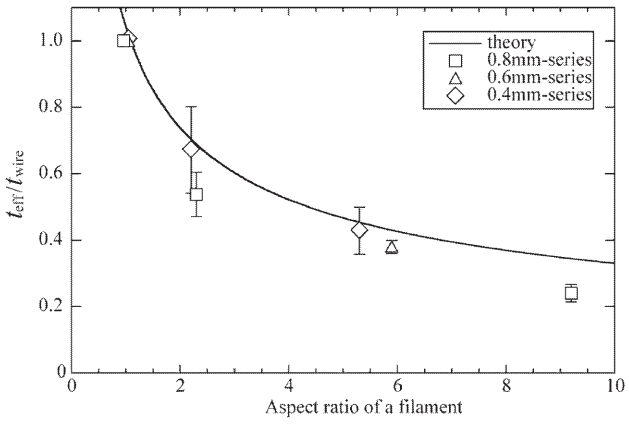

Fig. 2 Decrease in effective thickness in MgB_2 filaments