§38. Development of Advanced Superconducting Conductors for Fusion Devices

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In order to develop the new conductors for fusion devices, the performances of the MgB_2 wires are improved, and the investigation to assemble conductors and to fabricate the coils is carried out. In order to achieve both increase in critical currents and decrease in coupling losses of MgB_2 wires, the MgB_2 tapes with high aspect ratio of cross-section have been proposed in this study. The test tapes were fabricated. The results of measurements of critical currents and coupling losses in the tapes are reported.

The proposed MgB_2 tapes in this study are the tapes whose aspect ratios are increased by rolling the twisted MgB_2 multifilamentary round wires. These tapes are expected to have high performances as follows: (1) AC losses in the tape decrease under changing transverse magnetic fields oriented to parallel to its flat face. (2) The critical current densities of the tapes increase. In this study, three samples were prepared. Two of them are the tapes, which have been rolled the twisted multifilamentary round wire. One of them is the round wire before rolling. Three samples are named Wire, Tape3 and Tape7. These correspond to the round wire, tapes with aspect ratio of 3.3 and 6.6, respectively. Sample parameters are shown in Table 1. The round wire and tapes have 6 filaments with average diameter of 130 μm, and there are composed of CuNi/Nb/MgB_2.

Firstly, the results of the critical current measurements on these tapes and wire are described. The critical currents of the sample coils have been measured in these experiments. The diameters, length and turn number of the sample coils are 47 mm, 30mm and 10 turns, respectively. The critical currents of the samples under the external magnetic fields of 2-7T in direction of parallel to the coil axis, i.e. parallel to the flat face of the tapes, were measured by the four probe method.

Table 1 Parameters of MgB_2 samples

Name	dimension of cross-section	aspect ratio	cross-sectional area of filaments
Wire	ϕ1.02mm	1.0	8.01×10^{-8} mm^2
Tape3	1.64mm×0.497mm	3.3	8.04×10^{-8} mm^2
Tape7	2.25mm×0.342mm	6.6	7.02×10^{-8} mm^2

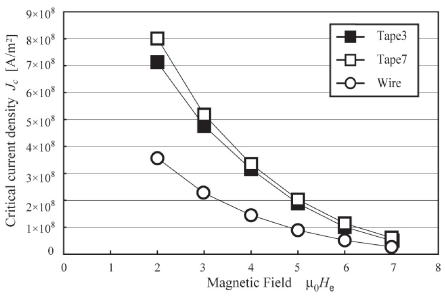

Fig.1 Critical current densities of the twisted MgB_2 multifilamentry round wire and tapes.

The electrical fields along sample axis were measured by voltage taps soldered to samples. The average critical currents of samples were measured by voltage taps mounted for both ends of the sample coils, whose length are 1480mm corresponding to 10 turns of sample coils.

From measured critical currents, the critical currents densities, J_c of MgB_2 filaments in each sample are calculated. The magnetic fields dependencies of J_c are shown by Fig. 1. The critical current densities of tapes have been are lager than about 2 times that of Wire.

Next, the results of the coupling loss measurements are described. In the measurements, short, straight samples with 20cm in length were used. Ten wires (or tapes) which were insulated from each other were impregnated by epoxy. Our original measuring system was used to measure the coupling losses. The measurements were carried out under the following conditions: the dc magnetic fields $\mu_0 H_{dc}$=0.5T, the ac magnetic fields $\mu_0 H_m$ =0.4-2.4mT, the frequency f=0.2-318Hz. The ac losses were measured by the magnetization methods under the condition that transverse magnetic fields were applied perpendicular (face-on, FO), and parallel (edge-on, EO), to the flat face of the tapes. The measured frequency dependencies of the coupling losses are shown by Fig. 2. Under the parallel magnetic fields to the flat faces of the tapes, coupling time-constants of Wire, Tape3 and Tape7 are 0.2ms, 0.05ms and 0.02 ms, respectively. These data agree well with theoretical values. The coupling losses in Tape7 are about 1/10 times that of Wire.

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

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(3)T. Matsushita, et al., Supercond. Sci. Technol. **21,** (2008) 015008
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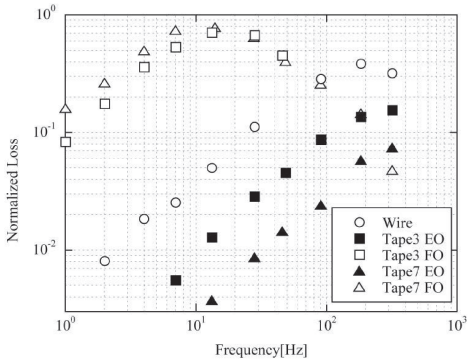

Fig. 2 Frequency dependences of coupling losses in the twisted MgB_2 multifilamentary wire and tapes.