§19. Effective Resistivity of HTS Tapes with Shielding Currents

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In some high-temperature superconducting (HTS) coils operated in persistent current mode, the current decay rate is found to be shorter than the expected value. Figure 1 shows the electric field along the coil cable observed in a persistent current operation of the magnetically levitated floating coil of the Mini-RT device[1]. The electric field increases by triple power of the coil current, which is far from the expected curve based on the n-value model. Mechanical damage during the winding process should be accountable for this degradation, however, we consider that there might also be some electromagnetic effects, since large shielding current is supposed to be induced among non-twisted filaments in the present silver-sheathed Bi-2223 tape. Thus, interaction between the transport current and shielding current is being examined by experiments and numerical calculations.

A sample coil was wound with an Ag-sheathed Bi-2223 tape (width/thickness: 4.1/0.305 mm, critical current at 77 K, self-field: 126 A). The outer diameter of the single pancake coil is 150 mm and the tape length is 14.7 m. A photograph and a cross-sectional view are shown in Fig. 2. A uniform magnetic field was applied in the perpendicular direction of the tape surface and the magnetic field was measured with two Hall probes[2]. Figure 3 (a) shows the waveforms of the measured magnetic field when the coil temperature was kept at 40 K. It is seen that the magnetic field just above the cable continues to increase even after the external magnetic field reaches to a flat-top. This might be due to the decay of the shielding currents which are supposed to be induced by the application of the external magnetic field. The amplitude of the shielding current can be evaluated by the magnetic field and it is confirmed to be as large as the critical current. The field change can be well simulated by a simple calculation using the n-value of the cable, critical current and inductance of the shielding current path.

It has also been found that the temporal change of the magnetization is mitigated by reducing the coil temperature (Fig. 3 (b)) or by externally reducing the magnetic field. This suggests that the amount of shielding currents can be controlled by choosing an appropriate excitation procedure. On the other hand, the field change was found to become more rapid by applying a transport current. We consider that loss generation is also increased by adding transport current to shielding currents.

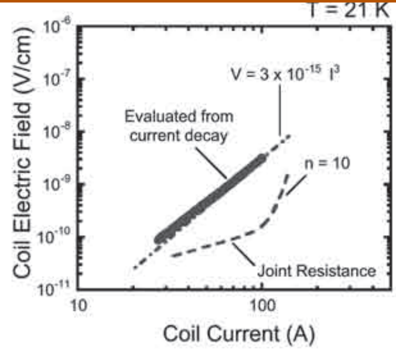

Fig. 1 Dependence of the electric field on the coil current measured in the floating coil of Mini-RT.

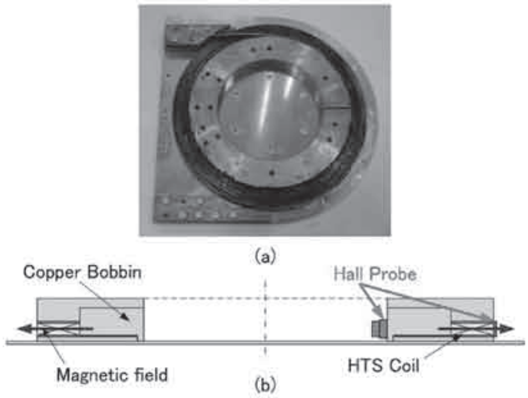

Fig. 2 Photograph and illustration of an HTS sample coil.

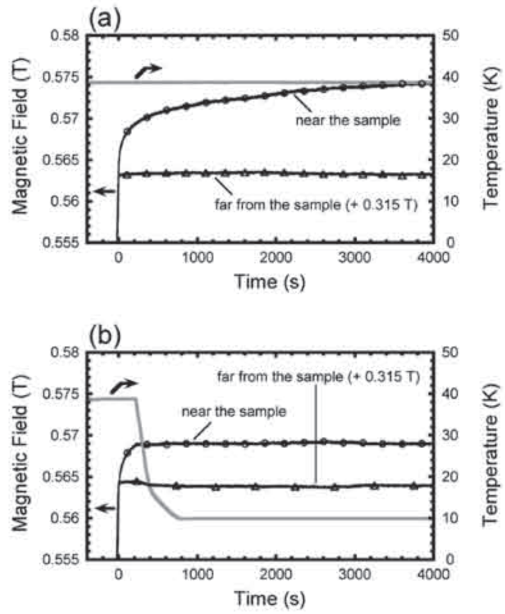

Fig. 2 Magnetic field measured by Hall probes with (a) temperature fixed at 40 K and (b) reduced to 10 K.

References
1) Yanagi, N., Hemmi, T., et al., IEEE Trans. Appl. Supercond. 15 (2005) pp.1399-1402.
2) Hemmi, T., Yanagi, N., et al., IEEE Trans. Appl. Supercond. 15 (2005) pp.1711-1714.