§26. Interaction between the Transport Current and Shielding Currents in Bi-2223/Ag HTS Tapes

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Electromagnetic properties and loss generation in high temperature superconducting (HTS) cable is an important issue to be clarified so that HTS cables and coils can be applied for many applications including fusion research[1]. As there is no twist among filaments in the present Ag-sheathed Bi-2223 cable, a relatively large amount of shielding current is supposed to be generated by applying external magnetic field especially in the perpendicular direction to the tape surface. In this respect, we investigate the magnetization characteristics and loss generation of a single pancake HTS coil using a special apparatus with which a uniform perpendicular magnetic field can be applied to a coil sample also with a temperature control[2]. Figure 1 shows an example of the measured waveforms of the electric field and magnetic field when the transport current is applied under the external magnetic field. As is shown in Fig. 1, the magnetic field just above the cable surface keeps increasing after the external magnetic field becomes constant (at ~770 s), which is due to the decay of the shielding currents. When the transport current is applied, the field increases even more rapidly, and at the same time, the terminal voltage of the sample coil shows a relatively high value than that expected from the n-value model. Thus, we observe that there is an increase of loss generation due to the interaction between the transport current and shielding currents.

Numerical calculations have also been performed in order to examine the experimentally observed results. A new finite element analysis (FEM) code has been developed by assuming the cross-section of the HTS filaments as a single oval-shaped core (Fig. 2). A pancake coil structure is dealt with a three-dimensional axisymmetrical configuration and fundamental equations are derived from Maxwell's equations and Kirchhoff's law. The magnetic vector potential and electrical potential are solved using the nonlinear properties of the HTS cable, such as the E-J characteristics given by the n-value model. The magnetic field change observed with a sample coil can be well simulated by the present calculation and the interaction between the transport current and shielding currents has been confirmed as the current distribution in Fig. 3 indicates. The current decay rate in the case of persistent current operation is also being examined.

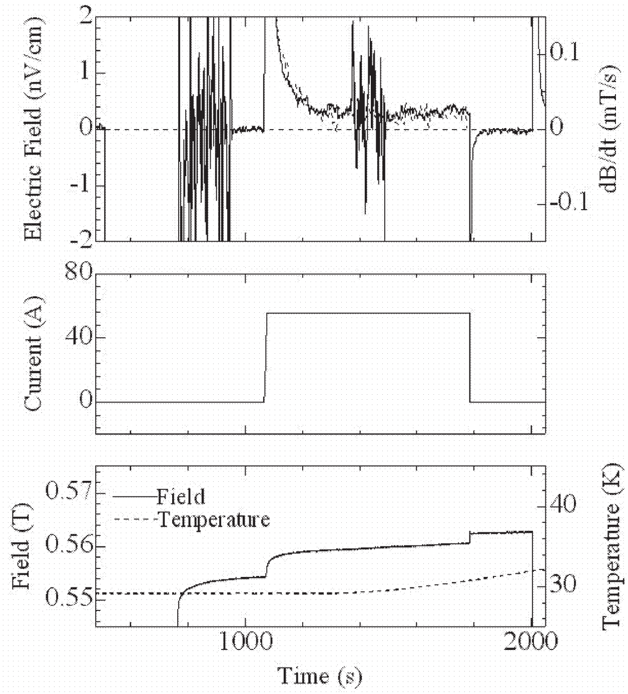

Fig. 1 Electric field and magnetic field measured with a sample coil.

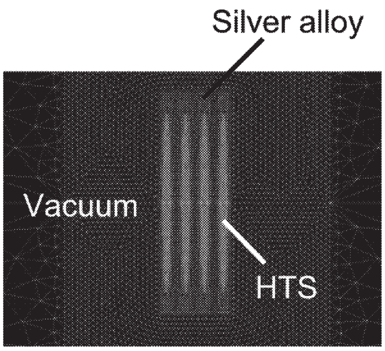

Fig. 2 Model for FEM calculation.

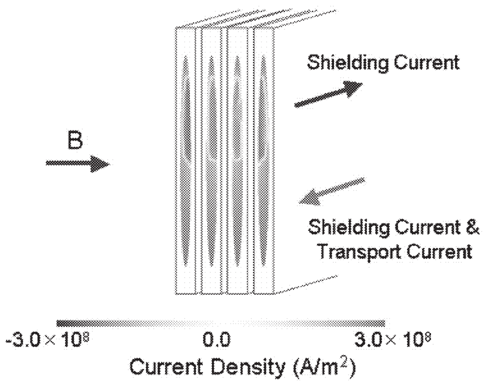

Fig. 3 Example of current distribution obtained by FEM.

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.