§11. Current Transport Properties and Stability in High T_c Superconductors

Kiss, T., Vysotsky, V.S., Takeo, M. (Dept. Electrical & Electronic Sys. Eng. Kyushu Univ.), Mito, T.

Based on a simulation study in a random pin medium, we have proposed a new method [1] to describe current transport properties in high T_c superconductors (HTS). The theoretical results are compared with measured electric field (E) vs. current density (J) curves in a YBCO film under magnetic fields up to 12 T.

It has been shown that the nonlinear E-J curves can be characterized by a power function $[(J-J_{cm})/J_0]^m$ with three parameters, i.e., the minimum value of critical current density (J_c) denoted by J_{cm}, the variance of the distribution, J_0, and the exponent, m, which determines the shape of J_c distribution. Magnetic field (B) and temperature (T) dependencies of the E-J curves can be attributed to the thermodynamic properties of J_{cm} and the typical value of J_c denoted by $J_k(\cong J_{cm}+J_0)$ through the corresponding macroscopic pinning force densities $J_{cm}B$ and J_kB, respectively, as in the similar form in low T_c superconductors.

The present method allows us to estimate the statistic J_c distribution from E-J curves. Moreover, B- and T-dependencies of the E-J curves can be predicted in a wide (B, T)-plane based on the scaling properties of the pinning force densities. The results obtained in a YBCO film was shown in Fig. 1.

These results are useful not only to estimate critical current properties in HTS materials, but also to design HTS based devices by taking into account operation conditions such as B, T and power dissipation. As an example, we studied the quench dynamics in a YBCO HTS film as well as in a Bi-based small HTS coil. It has been shown that the nonlinear transport properties are crucial to determine the quench properties in HTS. While the stability margin of HTS against a local disturbance was very large, quench current was limited by a catastrophic temperature rise originated from the nonlinear characteristic of Joule heating in HTS. Using the theoretical expression of E-J characteristics mentioned above and the heat balance equation, we can calculate the dynamic characteristics of the quench and the value of the quench current.[2] Results for a Bi-based HTS coil was shown in Fig. 2.

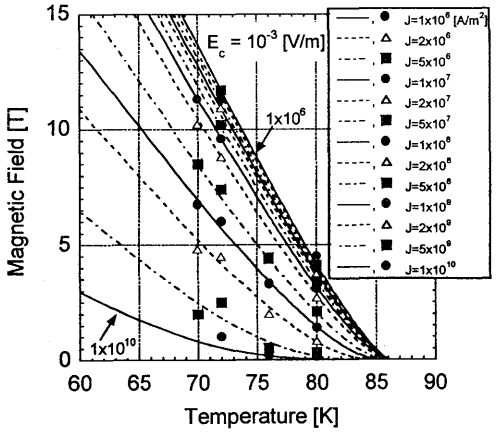

Fig. 1 Iso-J lines defined by E=10^{-3} V/m. The lines are the analysis based on the statistic model whereas the points are measured results.

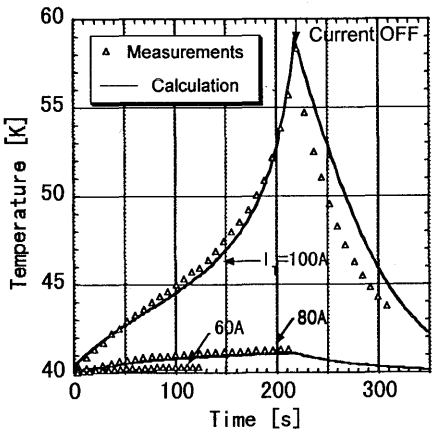

Fig. 2 Temperature rise for different bias currents in a Bi-based HTS coil.

Reference

1) Kiss, T. et al., ICEC17 (IOP Publishing Ltd, London, UK 1998) 427

2) Kiss, T. et al., Physica C **310**, (1998) 372