Numerical Simulation of Contactless Methods for Measuring j_C-Distribution of High-Temperature Superconducting Thin Film

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The critical current density j_C is one of the most important parameters of high-temperature superconductors (HTS). Although the standard four-probe method has been widely used for measuring j_C, it requires the heat-treat process of a HTS sample. This process may lead to the degradation of the HTS characteristics. For this reason, a contactless method has been desired for measuring the critical current density.

As the contactless measurement method of the critical current density j_C, Claassen *et al.* proposed the inductive method [1]. While an ac current $I(t) = I_0 \sin 2\pi f t$ is applied in an N-turn coil placed just above a HTS thin film, they measured the harmonic voltage induced in the coil. As a result, they found that the third-harmonic voltage suddenly develops when the coil current I_0 exceeds the threshold current I_T. In addition, they showed that j_C can be calculated from I_T. On the other hand, Ohshima *et al.* have proposed the permanent magnet method [2]. While moving a permanent magnet up and down above a HTS film, they measured the electromagnetic force acting on the film. As a result, they found that the maximum repulsive force F_M is roughly proportional to j_C. This result implies that j_C can be estimated from the measured value of F_M.

A numerical code has been developed for determining the time evolution of the shielding current density in a HTS thin film. By using the code, two kinds of the contactless methods are investigated numerically. The results of computations show that, in the inductive magnet, the third-harmonic voltage suddenly develops above a certain limit of the coil current I_0. This tendency qualitatively agrees with Claassen's experimental results. In addition, it is found that, even if the center of the magnet is located at the film edge, the maximum repulsive force F_M is almost proportional the critical current density j_C in the permanent magnet method (see Fig. 1). This means that the j_C-distribution can be determined from these relationships between j_C and F_M.

[1] J. H. Claassen *el al.*, Rev. Sci. Instrum. **62** (1991) 996.
[2] S. Ohshima *el al.*, IEEE Trans. Appl. Supercond. **15** (2005) 2911.

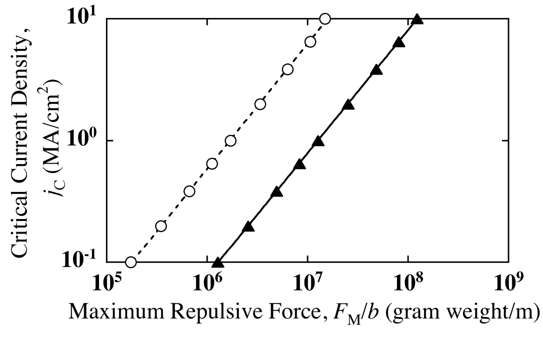

Fig. 1 Dependence of the critical current density on the maximum repulsive force. Here, b is the HTS thickness. In addition, ▲ : for the case where the magnet is just above the sample center, and ○ : for the case where it is above the sample edge.