§11. Basic Research on the Oxide Superconductors for Fusion Reactors

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1. Introduction

To develop oxide superconducting magnets for fusion reactors, it is necessary to grasp the basic electromagnetic properties of oxide superconducting wires in detail. Oxide superconducting wires are usually deformed into thin tapes and have the anisotropy in ac loss property. This year we investigated the field angular dependence of the ac loss in YBCO superconducting thin tapes theoretically and experimentally. We report the results.

2. Theoretical expression of the field angular dependence of the ac loss

We studied the field angular dependence of the ac loss in YBCO superconducting tapes on the basis of their electromagnetic properties and derived the following theoretical expression by which we can estimate the ac loss for any field angle θ by using the observed ac loss in a perpendicular magnetic field to the wide surface,

$$W(B_m, \theta, n) = \begin{cases} W(B_m \sin\theta, 90°, n) & \text{for} \quad B_m < B_{pe}' \\ W(B_m, 90°, n)\sin\theta & \text{for} \quad B_m \geq B_{pe}' \end{cases}$$

where B_m is the field amplitude and B_{pe}' is the effective penetration field and n is the number of stacked tapes.

3. Ac loss measurement

We measured the ac loss by using a saddle-shaped pickup coil as shown in Fig.1. We prepared a 6-tape stack. Sample YBCO tapes with a length of 60mm were inserted into the center of a pickup coil. Kapton sheets with a thickness of 50μm were inserted between the tapes for insulation. Magnetic field angle was changed by rotating the sample around its axis. The characteristics of sample YBCO tapes are listed in Table 1. They were fabricated by a IBAD-PLD technique. Ac loss measurement was carried out at 77K in LN_2.

Observed field amplitude dependencies of the ac losses are shown in Fig. 2 with a parameter of field angle θ. We can see that the ac loss decreases with decreasing field angle monotonically for any amplitude. The lines represent the theoretically estimated ac losses by using the observed ac losses in a perpendicular field, that is θ=90 deg.. You can see that the estimated ac losses agree with the experimental ones for the whole-range of field amplitude. The validity of the derived theoretical expression was verified.

Table 1 Characteristics of a YBCO sample wire

Width	10mm
Substrate	Hastelloy
Thickness of	
Silver layer	10 μm
YBCO layer	0.5 μm
Buffer layer	1 μm
Substrate	100 μm
Ic(77K, 0T)	48A

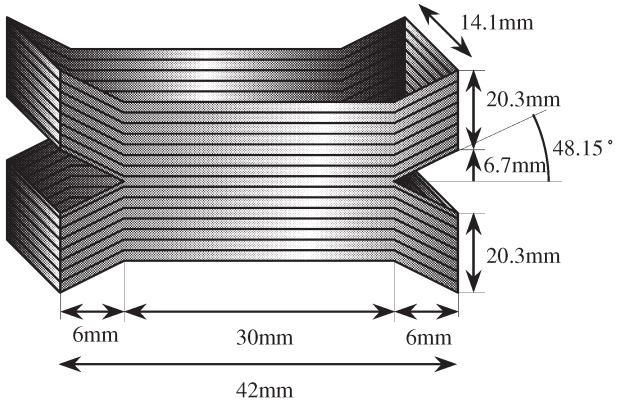

Fig.1 Dimensions of a saddle-shaped pickup coil.

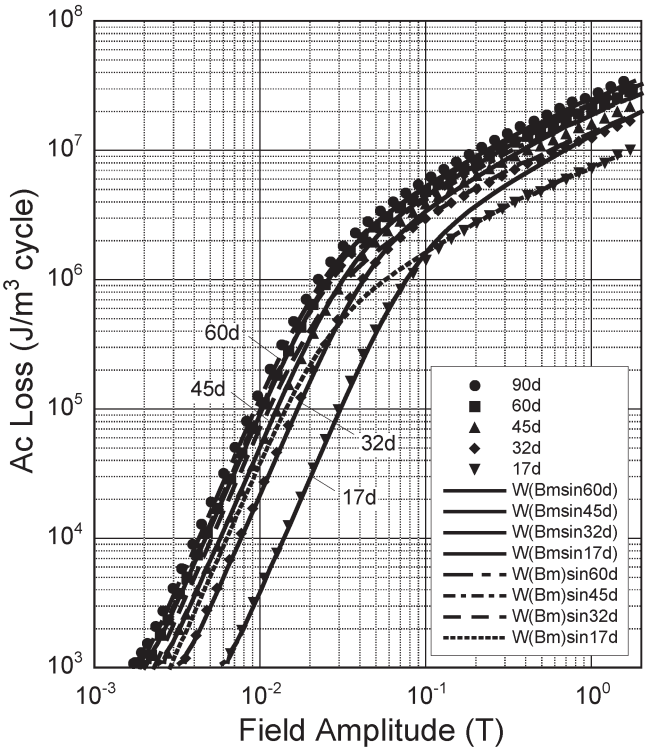

Fig.3 Amplitude dependencies of the ac losses in a YBCO 6-tape stack.