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Measurement of Internal Friction of $Bi_2Sr_2Ca_2Cu_3O_x$/Ag Composite Tapes by Vibrating Reed Technique

振動リード法による $Bi_2Sr_2Ca_2Cu_3O_x$ 超電導テープの内部摩擦測定

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1. Introduction

The powder-in-tube technique to produce metal/superconductor composites has proved to be an attractive route for producing superconductor tapes[1]. It has been established that preparation of the powder, mechanical formation, and heat treatment are responsible for the improvement in critical current density of Ag-sheathed Bi-based superconductor tapes[2]. The sausaging morphology of the powder and the undulating interface between the silver and powder is commonly observed after the mechanical deformation. In order to improve the critical current density it is necessary to character and decrease the internal friction of the superconductor tape due to thermal activation or mechanical formation around transition temperature T_c. As a typical superconducting material, Bi2223/Ag tape needs high-critical current density, which is influenced by imperfects such as point defects, dislocations and other defects at the interface between the powder and silver.

In this study, we measured the temperature dependence of internal friction of the Bi2223/Ag composite tapes in temperature range from 90 K to 400 K. Three thermally activated prossces were observaed. The thermal activation mechansms will be discussed.

2. Experimental

The Bi2223/Ag composite tape, DI-BSCCO type H, was supplied by Sumitomo Electric Industries, Ltd. The reeds of the tape have dimensions of $4.3 \times 0.23 \times l$ mm^3, where l is 27, 29, 31, 35 and 39 mm corresponding to resonance frequencies of 164, 139, 124, 96 and 80 Hz at room temperature, respectively. The reeds were fixed in a copper box in a vacuum chamber with residual gas pressure below 3×10^{-4} Pa. One end of the reed was fixed on ground electrode, and an alternating voltage was applied on other end of the reed without contact, free end, to vibrate them. The displacement of the free end was measured using a laser/CCD camera displacement sensor with accuracy of 10 nm. Temperature of the reed set in the copper box was changed from 90 K to 300 K in steps of 5 K. The amplitude A of the vibration decreased approximately exponentially with time t,

$$A = A_0 e^{-\alpha t}.$$

The internal friction Q^{-1} was determined from the constant α of the decay curve of vibrating reed.

$$Q^{-1} = \alpha / \pi f,$$

where f is resonance frequency.

3. Results and Discussion

Figure 1 shows a photograph of the cross section of the Bi2223/Ag composite tape. The yellow area is silver and black area is the Bi2223 powder. The undulating interface between silver and powder can be observed and the thickness of the tape is about 0.23 mm. Figure 2 shows the temperature dependences of resonance frequencies of the tapes at various reed lengths. The resonant frequencies decrease with increasing temperature. The temperature dependences of internal friction of the tapes at various reed lengths are shown in Fig. 3. The internal frictions increase with temperature and frequency. Also several peaks are observed on the

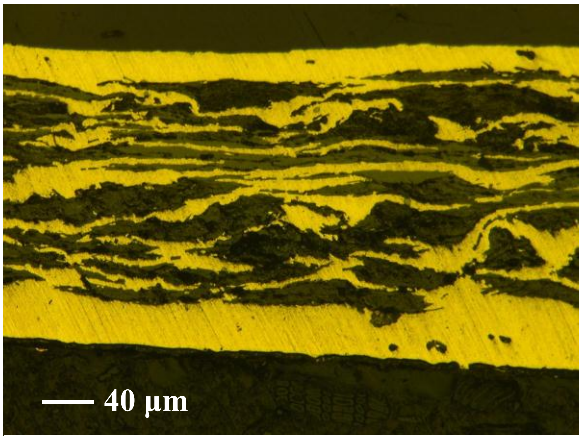

Fig. 1 Photograph of the cross section of the Bi2223/Ag composite tape.

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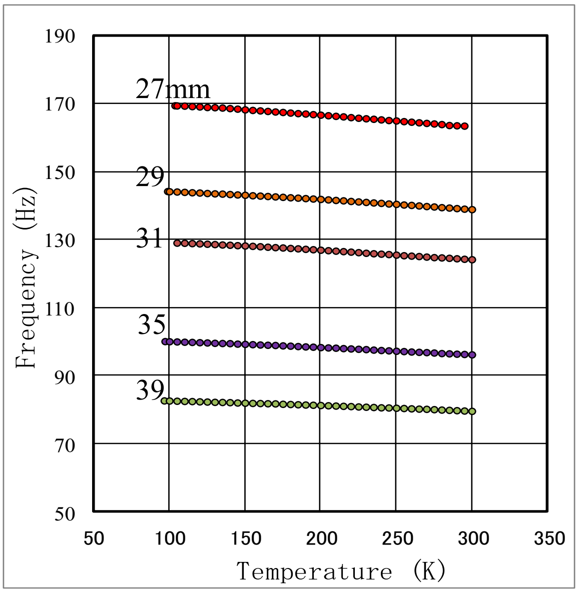

Fig. 2 Temperature dependences of resonant frequencies of the Bi2223/Ag tapes at various reed lengths.

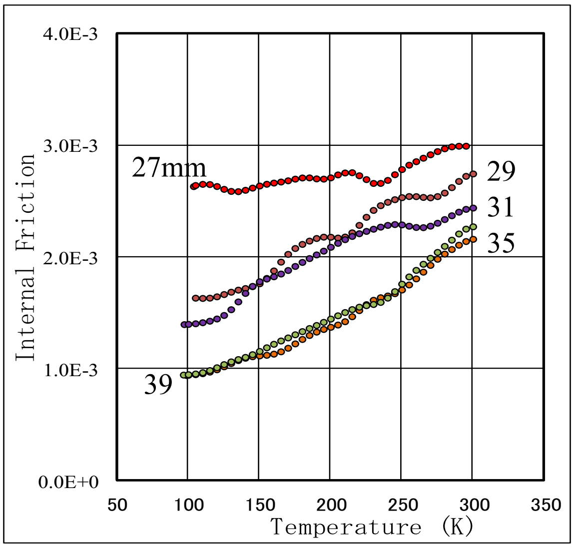

Fig.3 Temperature dependences of the internal friction of the Bi2223/Ag tapes at various resonant frequencies.

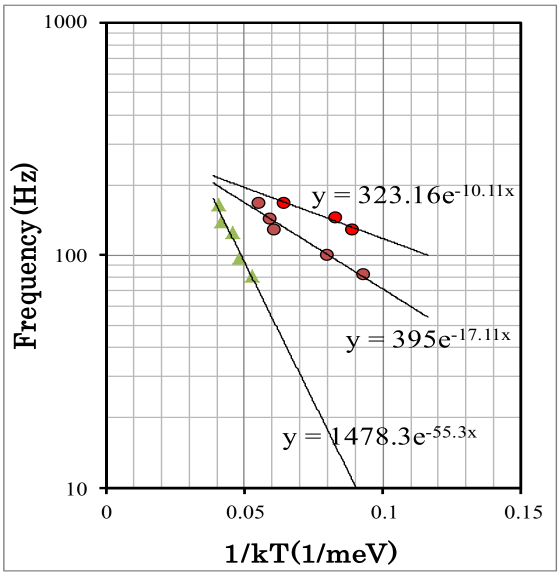

Fig. 4 Peak frequencies of internal friction of the Bi2223/Ag tapes vs. inverse absolute temperature.

temperature dependences of the internal friction. It was confirmed that the peaks shift to higher temperatures with increasing frequency. The results suggest that there are thermal activation processes of the internal friction in the Bi2223/Ag tapes. The activation energies are obtained by Arrhenius plot method. As is shown in Fig. 4, three thermal activation processes with activation energies of 10, 17 and 55 meV are observed. These activation processes may occur in the silver crystals because of the motion of point defects and/or dislocations at the interface between the Bi2223 crystals as well as in the Bi2223 crystals. In fact, a Bordoni type friction with activation energy of 9 meV has been observed in silver crystal[3], and the internal friction processes with activation energies from 200 to 400 meV due to motions of point defect and dislocation have also been observed in silver crystal at temperatures from 170 K to 200 K[4]. Also, in the BSCCO crystals a phase transition process with activation energy of 24±2 meV in the temperature range of 78−160 K has been reported[5].

4. Conclusion

We have studied temperature dependences of internal friction of the Bi2223/Ag composite tapes by using vibrating reed technique in the range of 90−300 K. Three thermally activated processes with activation energies of 10, 17 and 55 meV are observed. Influence of the processes on the critical current density properties of the Bi2223/Ag tapes will be studied.

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