



Superconducting mechanism of YBaCuO superconductors

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ABSTRACT

Electromagnetic properties of YBaCuO superconductor were measured on applying an external magnetic field to study non-volatile magnetic effect. The voltage increases with increase in applied magnetic flux, but it becomes constant at about 10^{-2} T. The appearance of the voltage is ascribed to the trapping of magnetic flux. By changing the density of external magnetic flux, changes in inductance of a coil in which a superconducting bar inserted were also measured. The results showed that the filament model was valid to explain the mechanism of the occurrence of a voltage in superconducting sample. It was concluded that the electromagnetic properties arose from the interaction between the trapped magnetic flux and weak link of the filament formed in the superconducting bulk.

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1. Introduction

YBa₂Cu₃O_{7-y} ceramic superconductor has revealed a variety of physical properties of this compound concerning superconductivity. The Lorentz force between the flux line and moving charge exceeds the pinning force when a sufficiently strong current greater than the critical current passes through a superconductor in the mixed state [1–3]. The core lattice is set in motion against viscous drag force to depend on inducing a voltage a sufficiently strong drops in the sample. The electromagnetic effect on high T_c superconductor (HTS) and its application were studied. However, the voltage occurrence of polycrystalline superconductor exists not only flux flow but also weak link of grains. It seems to depend on there is little information about the weak link. Hence, electromagnetic properties of a polycrystalline superconductor were measured to study an effect of weak link between grains in this paper.

2. Experimental

The superconducting YBa₂Cu₃O_{7-y} ceramic superconductor was prepared through the solid state reaction of the appropriate amounts of Y₂O₃, BaCO₃ and CuO powders of 99.99% purity powders. Proportioned powders were well mixed in an alumina mortar with a pestle, calcined at 950 °C for 20 h in air and then furnace cooled. The calcined cakes were crushed in an alumina mortar with a pestle, mixed with CeO₂ powder of 99.99% purity up to 5 wt%,

pressed isostatically into pellets. The pellets were sintered at 950 °C for 10 h in air, slowly cooled down to 400 °C, held for 24 h, and then furnace cooled. In order to transform the tetragonal phase to orthorhombic one, the pellets were cooled slowly down to 450 °C, held for 24 h and then air cooled. The current–voltage characteristics were measured by the four probe technique with indium electrodes. The magnetic flux trapped in the superconductors was polarized with a samarium cobalt rare earth permanent magnet of $B = 0.15$ T, 46 mm in length 10 mm in thickness.

3. Results and discussion

In Fig. 1, the current–voltage characteristics of U shaped YBaCuO, the curve (A) and (C) were obtained at $B = 0$ T, the curve (B) at 0.15 T at 77 K and the curve (D) at $B = 0$ T and room temperature. The curve (B) at 77 K gradually approaches the curve (C) and fixed after the removal of the external magnetic field. If the voltage is applied again after returning to zero voltage, I – V characteristics shows as curve (C). This means that sample is in memorized state. It is found from the results that, the range of magnetic flux less than 2×10^{-3} T, the voltage drop across the superconducting sample becomes to zero after the removal of magnetic field. To apply the filament model as the mechanism of electromagnetic effect, it is necessary to confirm the validity of filament model. This paper observed the validity by measuring inductance of coil that inserted YBaCuO superconductor and verified current.

Superconductor revealed the characteristics of normal magnetism above T_c and of anti magnetism below T_c . As a result, property of superconductor was recognized with measuring of inductance of coils that inserted YBaCuO superconductor. As the superconductor

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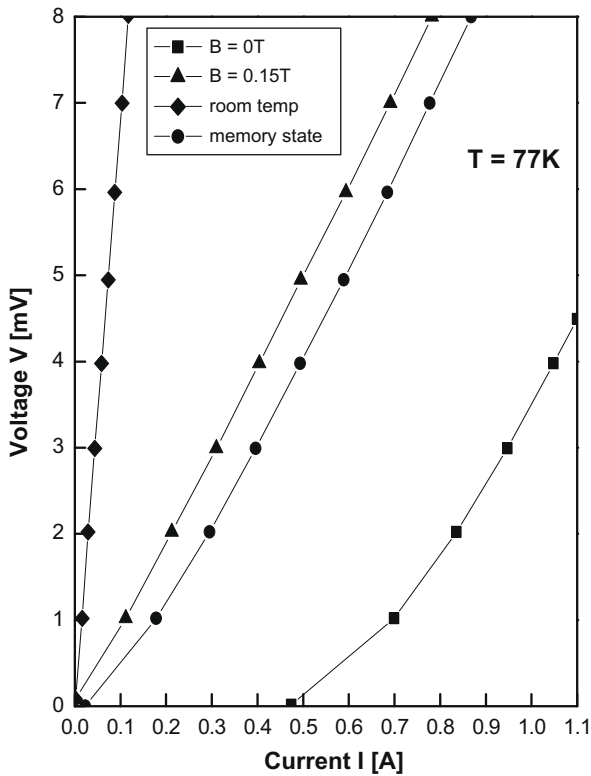


Fig. 1. Current–voltage characteristics of the superconductor.

above T_c was normal magnetism, the inductance of coils, L_0 , that inserted YBaCuO superconductor as follows:

$$L_0 = K_0 \pi a^2 n^2 \mu_0 / l \quad (1)$$

K_0 is the Nagaoka constant, l the length of coils, a the radius of superconductor, n the number of rolling coils, and μ_0 is the permeability.

The inductance of coils was indicated by susceptibility of substance inserted the coils. The magnetic flux, across the inside of superconductors, was removed due to anti magnetism of superconductor susceptibility below T_c . As a result, the inductance of coils inserted superconductors was declined. The YBaCuO superconductor, which is prepared by sintering method, shows the properties of a ceramic. Therefore, the material is considered to

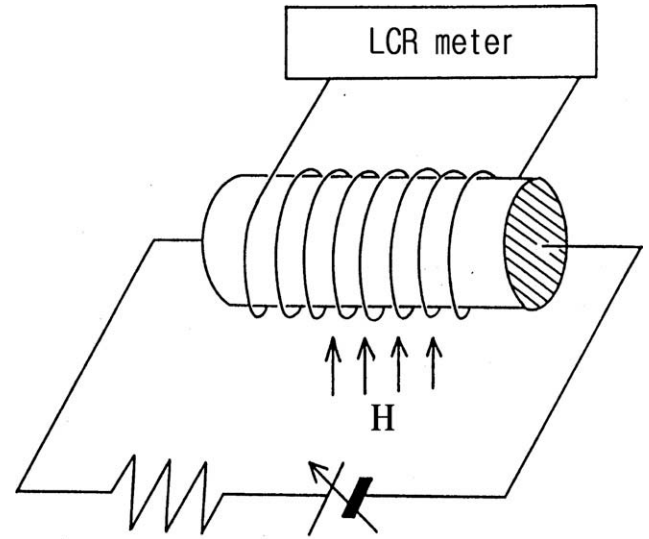


Fig. 3. Circuit to measure inductance of the coil which superconducting sample inserted.

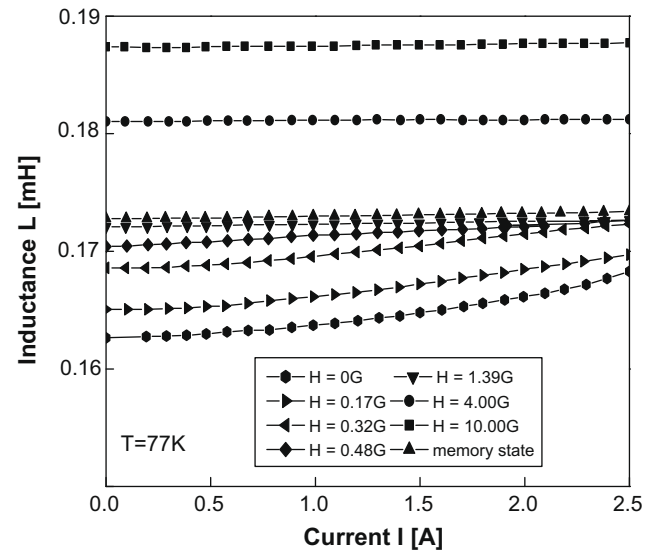


Fig. 4. Dependence of inductance on sample current density of external magnetic flux is taken as a parameter.

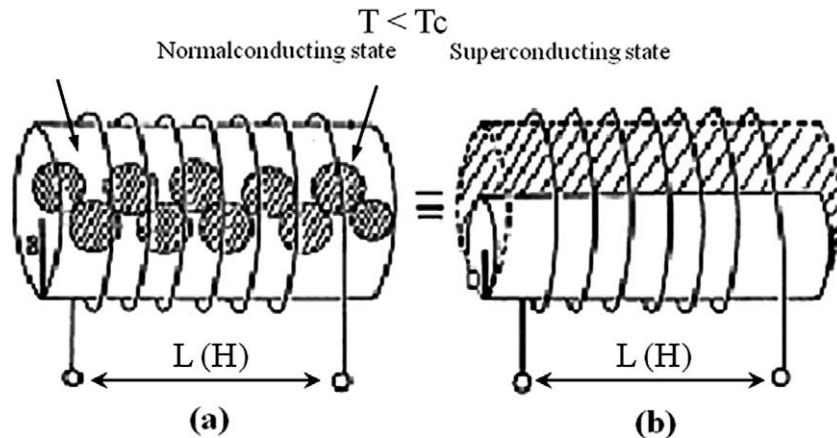


Fig. 2. Schematic of the superconducting sample inserted into a coil. Superconducting region is drawn by hatch. (a) Mixed state of superconducting region and normal conducting region. (b) Equivalent representation of (a).

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