# Mechanism of the Voltage Occurrence in BSCCO Superconductor for Neutron Irradiation

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**Abstract**

*Magnetic characteristics observed in BiSrCaCuO superconductor were studied. In the measurement of differential conductance, it was cleared that the mechanism of magnetic memory effect couldn't be explained by using conventional flux flow model. 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 characteristics arose from the interaction between the trapped magnetic flux and weak link of the filament formed in the superconducting bulk.*

**Keywords : Electromagnetic effect, Flux, Pininng, Magnetic property, Neutron Irradiation**

## 1. Introduction

When a sufficiently strong current greater than the critical current, passes through a type Ⅱ superconductor in the mixed state the Lorentz force between the flux line and moving charge exceeds the pinning force then the core lattice is set in motion against viscous drag force inducing a voltage drops in the sample. The early works of Kim et al showed that the voltage drop in the type Ⅱ superconductor in the mixed state, the flux flow resistivity remains zero up to the critical current, above which the voltage increases with current with increasing slope, dV/di until the liner flux flow region is attained [1]. The flux flow resistivity $\rho_f$ is given as $\rho_f = E/J = (=(\Phi_0/\eta c^2)B \propto dV/di$, where E is the electric field induced by the motion of flux lines, J is the transport current, $\Phi_0$ is the flux quantum contained in the vortex line, $B = N\Phi_0 \fallingdotseq H$ and $\eta$ is the viscous drag coefficient of superconductor[2-6]. The electromagnetic effects in Bi system have been experimentally studided. The electrical resistance of the superconductor is increased by the application of the external magnetic field. But the increase in the electrical resistance continues even after the removal of the magnetic field. The reason is as follows ; the magnetic flux due to the external magnetic field penetrates through the superconductor and the penetrated magnetic flux is trapped after the removal of the magnetic field. Some portion of the superconductor is changed to the normal state by the trapped magnetic flux. The appearance of the normal state yields to the increase in the electrical resistance. The electromagnetic effects are very interesting phenomena because they can be applied in many applications, for example it may be used to be a magnetic detector for magnetic tape or floppy disk. In order to investigate these phenomena, the mechanism of electromagnetic effect must be studied. In the present work, the application of magnetic effect for superconducting devices was examined and a possibility of using the superconducting device to be a high sensitive magnetometer was described.

## 2. Experimental and Results

Samples were made by the conventional solid state method using $Bi_2O_3$, PbO, $SrCO_3$, $CaCO_3$, and CuO powders of 99.9 % purity. The molar ratio of the starting materials was 1.84 : 0.34 : 1.91 : 2.03 :3.06 respectively for Bi : Pb : Sr : Ca : Cu and the powder mixture was calcined in an alumina crucible at 810℃ for 24h in air. After grinding the calcined cake, the precursor powder was mixed with $Ag_2O$ powder of 99.9% purity. The powder mixtures were pressed into pellets under 300kg/cm$^2$, followed by sintering at 830-850℃ for various time periods up to 120 h. The disk sample with a diameter of 8mm and thickness of 1mm weighed 0.3g.

In Fig.1, the current-voltage characteristics of U shaped YBaCuO, the curve (A) and (C) were obtained at B=0T, the curve (B) at B-0.15T at 77K and the curve (D) at B=0T and room temperature. The curve (B) at 77K 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, V-I characteristics shows as curve (C). This means that sample is in memorized state.

The symbols $V_{MAG}$ and $V_{MEM}$ in Fig.2 are the voltage appeared across the HTS sample after the removal of the external magnetic field and the memorized voltage of the sample after the remove of the external magnetic field, respectively. The curve $V_{MAG}$ and $V_{MEM}$ versus B was obtained in external magnetic field. The curve of $V_{MEM}$ versus B was measured after the removal of the magnetic field. The voltage drop across the field cooled superconducting magnetic sensor varied with the disfance of N and S pole of permanent magnet is shown in Fig.3. The Positive △V and negative △V are the increment and the decrement of voltage drop across the memorized HTS sample from the initial voltage Vo respectively. The upper horizontal axis Vo=3.35mV shows the density of magnetic flux corresponded to the distance in the lower horizontal axis.

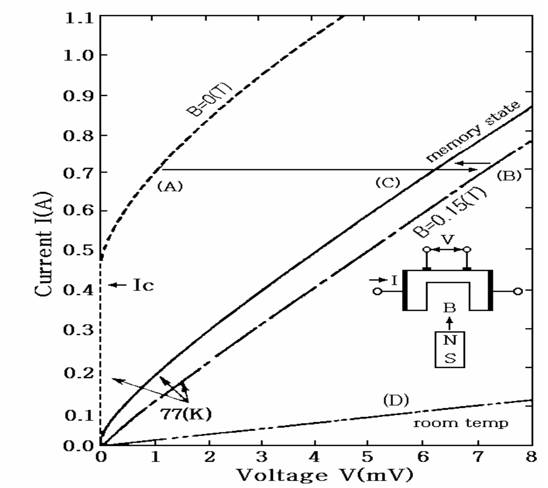


**Fig. 1. Current-Voltage characteristics of the BSCCO.**

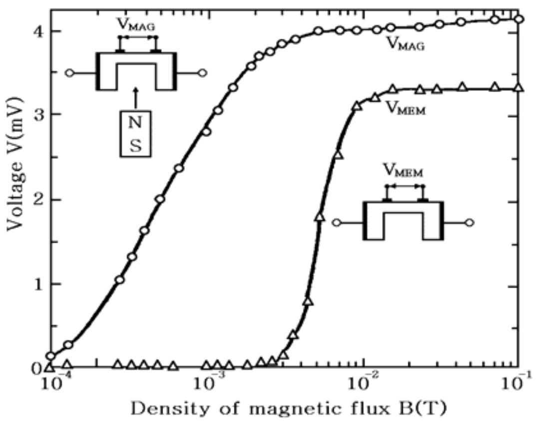


**Fig. 2. Dependence of the voltage V on externally applied magnetic flux B at 77K. .**

The upper horizontal axis Vo=3.35mV shows the density of magnetic flux corresponded to the distance in the lower horizontal axis. is counterclockwise, so that, the direction of trapped magnetic flux by north pole is upward direction as represented by an arrow sign indicated in this figure. This trapped magnetic flux will destroy some super conduction part which causes the appearance of the voltage drop across the sample ($V_{MEM}$) at each value of current I. Because the superconducting material is diamagnetic material, it will induce some magnetic flux with the opposite direction against the applied external magnetic flux. This is caused by the induced surface diamagnetic current with the clockwise direction as shown by dashed circle. Due to two kinds of current with the opposite direction, the total magnetic fluxes which pass through the superconductor are decreased. Since the destroyed normal regions of super conduction part will be also decreased, the decrease in the voltage drop across the sample at same value of current I, is observed.

## 3. Summary

The magnetic properties in BiPbSrCaCuO superconductor was studied. In the measurement of current-voltage characteristics, a voltage across the superconducting sample was observed on applying an external magnetic field. The voltage continues to appear the removal of the magnetic field. The appearance of the voltage is ascribed to the trapping of magnetic flux. Depending on the direction of applied magnetic flux less than $2.5\times10^{-5}$ T, the voltage in the magnetized sample increases or decreases. The possibility that the superconducting sample can be used for magnetic sensor has been examined. From the experiments, it has been found that the memorized superconductor can detect both magnitude and polarity of the coming magnetic flux. The knowledge from this principle of magnetic effect shows that the same polarity of the coming external magnetic flux and the memorized magnetic flux will cause to decrease the resistance of the superconductor, that is, the voltage across the superconductor is decreased.

## 4. Acknowledgment

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## 5. References

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