Fabrication and Characteristics of Superconducting Magnetometer

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The relation between electrical properties of YBaCuO ceramic superconductor and externally applied magnetic field was studied. Electrical characteristics of the superconductor with trapped magnetic fluxes are extremely sensitive to the external magnetic field and show the different responses which depend on the direction of the magnetic field. Considering these properties of the superconductor with trapped magnetic fluxes, a magnetic sensor is fabricated. This sensor is able to detect simultaneously both the intensity and the direction of the magnetic field. The sensitivity of the sensor is less than 10^{-4} T.

Keywords : YBaCuO, Magnetometer, Magnetic flux

1. INTRODUCTION

Major advantages of the superconductor are higher magnetic field attainable than conventional sensor and their simple fabrication[1,2]. The electromagnetic effects in YBaCuO system have been experimentally studied. 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 filed. 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 superconducting devices for magnetic sensor based on the electromagnetic effect is examined and a possibility of using the superconducting device to be a high sensitive magnetometer for the both magnitude and polarity is described.

2. EXPERIMENTAL PROCEDURE

Sample was made by the conventional solid state method using Y_2O_3, $BaCO_3$, and CuO powders of 99.9 % purity. The powder mixture was calcined in an alumina crucible at 950 °C for 24 h 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 300 kg/cm^2, followed by sintering at 950 °C for 24 h. The disk sample with a diameter of 8mm and thickness of 1mm weighed 0.3 g.

3. RESULTS AND DISCUSSION

The idea for the improvement is the using of two memorized superconducting device, by a different pole of magnet, in the wheatstone bridge circuit as is shown in Fig. 1. In this circuit, the superconducting device which is connected to point No. 2 is memorized by north pole of magnet while the another superconducting device is memorized by the south pole of magnet and is connected to point No. 1. Furthermore, a volt-meter is connected between point No. 1 and No .2 at which the positive terminal (+) of a volt-meter is connected to the point No. 2.

Before using of this circuit in the measurement, the wheatstone bridge circuit must be balanced by adjusting the R_1 or R_2, so that, the voltage difference between point No. 1 and point No. 2 is zero. Thus the volt-meter will show 0 volt, too. When applied magnetic flux from the south pole of magnet is measured, the wheatstone bridge circuit will be unbalanced, which is caused by the increasing of the resistance value of the memorized super-

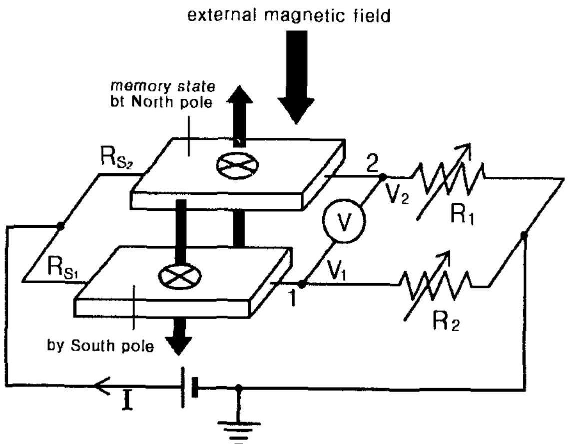

Fig. 1. Schematically represented principle of magnetometer.

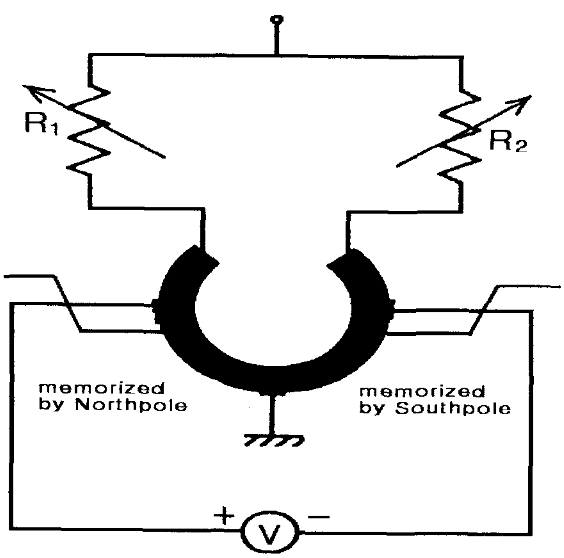

Fig. 2. Wheastone bridge including magnetometer.

conducting device by north pole ($Rs_2 \rightarrow Rs_2^+$) and the decreasing of the resistance value of the memorized superconducting device by south pole ($Rs_1 \rightarrow Rs_1^+$). In this case, the volt-meter will show a positive value of different voltage (+V). On the contrary, the volt-meter will show a negative value of different voltage (-V) due to the effect of external magnetic flux from the north pole of magnet.

Practically, a superconducting device with memorized by both kinds of magnetic north pole and south pole, is used the wheatstone bridge circuit which is shown in Fig. 2. By this simplfied circuit, the characteristics of magnetometer can be graphically shown as in Fig. 3 in order to show the relation between external magnetic flux(H) and output voltage of the sensor(V). From these

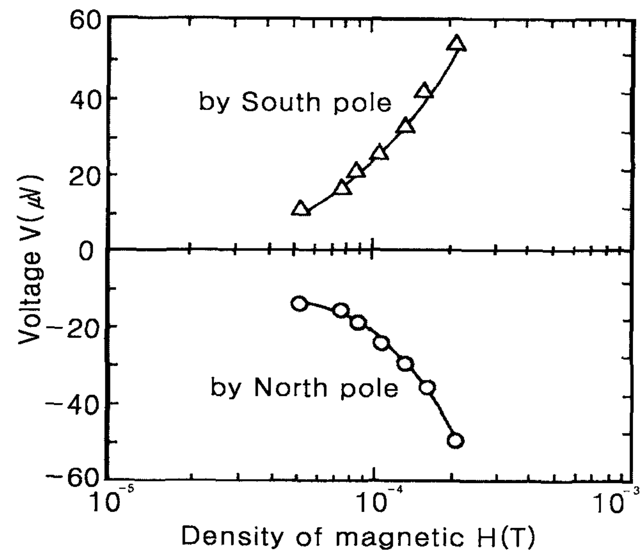

Fig. 3. Relation between external magnetic field and output voltage of magnetometer which appears when wheatstone bridge becomes in balance. The upper curve (lower curve) is obtained when the S-pole (N-pole) of magnet approaches to sensor.

characteristics, it is found that this sensor can detect both magnitude and polarity of the external magnetic flux of the value less than 1×10^{-4} T and it can respond to the magnetic flux from south pole as well as north pole.

4. CONCLUSION

The possibility that the superconducting device can be used for magnetometer has been examined. From the experiments, it has been found that the memorized superconducting device can detect both magnitude and polarity of the coming magnetic flux. The knowledge from this principle of magnetometer shows that the same polarity of the coming external magnetic flux and the memorized magnetic flux will cause to decrease the resistance of the superconducting device, that is, the voltage across the superconducting device is decreased. Furthermore, the different polarity of the coming external magnetic flux and the memorized magnetic flux will cause to increase the resistance value of the superconducting device, that is, the increasing of voltage across the superconducting device. To avoid the sufferance of measurement on the application of magnitude polarity detector, the two superconducting devices memorized by a different pole of magnet were employed in the wheatstone bridge circuit. The simplified circuit with the memory state of both kind of magnetic pole in a superconducting device has been proposed. By this simplified circuit, the V-H characteristics of this sensor were obtained. These results confirm a validity and agreement of the possibility of using the memorized superconducting device to be an magnetometer.

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