Electromagnetic Properties of Bi System Superconductor for Neutron Irradiation

Sang Heon Lee[1,a] Yong Choi[2]

[1] Department of Electronic Engineering, Sun Moon University,
[2] Department of Electronic Materials Engineering,
SunMoon University,
100 Kasan, Tangjeong, Asan, Chungnam 336-708 Korea
shlee@sunmoon.ac.kr

Abstract

Effects of Ag_2O doping on the electromagnetic properties in the BiSrCaCuO superconductors. The electromagnetic properties of Ag_2O doped and undoped BiSrCaCuO superconductor were evaluated to investigate the contribution of the pinning centers to the magnetic effect. It was confirmed experimentally that a large amount of magnetic flux was trapped in the Ag_2O doped sample than that in the undoped one, indicating that the pinning centers of magnetic flux are related closely to the occurrence of the magnetic effect. It is considered that the area where normal conduction takes place increases by adding Ag_2O and the magnetic flux penetrating through the sample increases. The results suggested that Ag acts to increase pinning centers of magnetic flux, contributing to the occurrence of the electromagnetic properties.

Keywords : Electromagnetic effect, Ag, Flux, Pininng, Magnetic property

1. Introduction

The response of the superconductor to magnetic field, is one of fundamental characteristics, in which magnetic flux is repelled (Meissner effect) and producing a levitating force. Superconductor levitation over a permanent magnet and vice verse has attracted many engineering attention because it offers a non-contact lubrication free and virtually friction free bearing systems, such as hybrid super-conducting magnetic levitation(HSMB) system by McMichael et al[1], ISTEC by Fukuyama et al[2], and superconductive magnetic levitation car(Maglev)[3]. Fly-wheel energy storage are the most prospective applications. In the present work, the effects of Ag_2O doping on the magnetism and superconductor levitation/suspension of BiPbSrCaCuO superconductor were investigated in view of flux pinning.

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. The magnetization characteristics of the Ag_2O doped and undoped BiPbSrCaCuO samples was examined by $\triangle M=M^+-M^-$ obtained from the hysteresis curves with 3×3×5mm specimen using a vibrating sample magnetometer(VSM) between 0 to 0.2T at 77K. The temperature dependence of DC susceptibility was measured using a magnetic balance at a static magnetic field of about 7×10^{-3} T. The toroidal magnet used in this study was a samarium cobalt rare earth, NEOMAX, B=0.15 T. The distribution of magnetic flux density along the axial direction was measured by using a gaussmeter, LakeShore INC.

Fig.1 shows an example stable superconductor levitation and suspension of 2% Ag_2O doped sample above and beneath a toroidal magnet. The floating height between in the bottom surface of the sample and the top surface of the toroidal magnet and the suspension distance between the top surface of the sample and the bottom surface of the toroidal magnet were 2mm and 3mm respectively. The 2% Ag_2O doped sample in suspension was field cooled condition, cooled to 77K, in the presence of magnetic field of the toroidal magnet of magnetic flux about 0.1T. The flux density is almost zero in the region located about 3mm from the lower surface of the toroidal magnet.

The difference in the magnetization, $\triangle M=M^+-M^-$, showed that the magnetization decreases with applied field due to the increase in the intrinsic pinning by normal conducting volume. $\triangle M$ increases with dopent, showing a maximum at 2% doping, and decreased with further doping 10 and 20% doping as in Fig.2. The magnetic flux is

generated by a vortex current which circulates around the vortex with a sense of rotation opposite to that of the diamagnetic screening surface current. The presence of Ag in the doped sample is attributed to the reduction of Ag_2O in oxide ceramics during reaction sintering, similar to those observed in the Ag_2O doped YBaCuO superconductor.

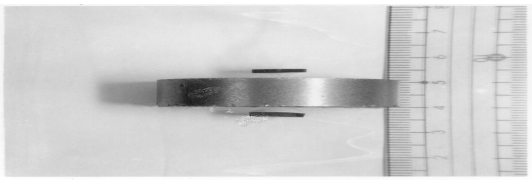

Fig. 1. 2% Ag_2O doped sample stable superconductor levitation and suspension above and beneath a toroidal magnet.

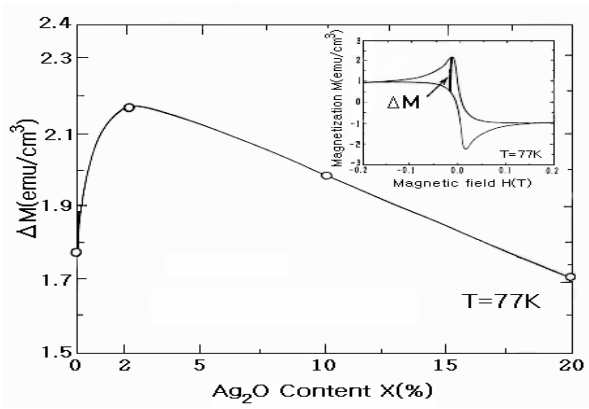

Fig. 2. △M dependence on Ag_2O addition from the characteristics of magnetization hysteresis.

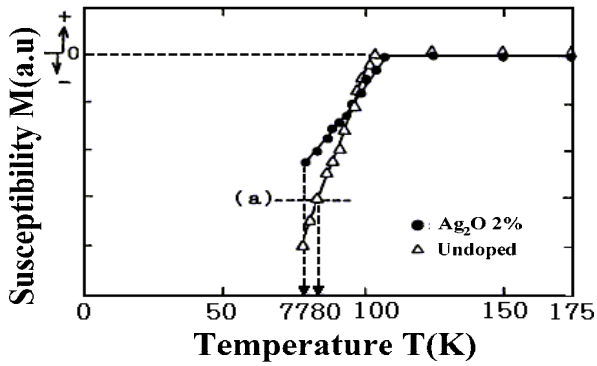

Fig. 3. Temperature dependence of dc susceptibility in BiPbSrCaCuO superconductor.

The temperature dependence of DC susceptibility measured between 77K and 175K was shown in Fig.3. The diamagnetic transition occurs nearly at the same temperature for both doped and undoped samples. However, the greater temperature dependence for the undoped sample, $(dx/dT)_{undoped} > (dx/dT)_{doped}$, indicates the greater diamagnetism for the undoped sample than doped sample in which 2% of normal conducting Ag_2O were doped. It is considered that the area where normal conduction takes place increases by adding Ag_2O and the magnetic flux penetrating through the sample increases. The results suggested that Ag acts to increase pinning centers of magnetic flux, contributing to the occurrence of the electromagnetic properties. The larger diamagnetism in the undoped superconductor repels externally applied magnetic field and creates an mirror image of external magnet producing levitation force.

3. Summary

Electromagnetic properties of Ag_2O doped and undoped BiPbSrCaCuO superconductors were evaluated to account for the magnetic suspension of a BiPbSrCaCuO superconductor under a toroidal permanent magnet. Since the diamagnetism effect at 77K is larger in the undoped sample than the Ag_2O doped sample, the invasion of the magnetic flux to the undoped sample is harder. That is, since the magnetic flux penetrating the undoped sample is smaller, the influence of the pinning center is weak and the suspension hardly takes place. On the other hand, in the Ag_2O doped sample, the diamagnetism is relatively weak at 77K and the magnetic flux easily penetrates the sample. Therefore, the influence of the pinning center is strong and the suspension is noticeable at 77K. The pinning center of magnetic flux is related to the suspension and that the Ag_2O acts as the pinning center to magnetic flux, thereby causing the magnetic suspension. In addition, the occurrence mechanism of the suspension was explained by using the qualitative model based on the relationship between the pinning center and the distribution of the magnetic flux from a toroidal permanent magnet.

Acknowledgment

This work was carried out with help of National Research Lab.(NRL) program of Korea Science and Engineering Foundation (KOSEF) and Ministry of Science and Technology, Korean government.

4. References

1.C.K.McMichael,K.B.Ma,M.A.Lamb,L.Chow, .H.Hor, .K. Chu: Appl.Phys.Lett. Vol.60 (1992) p.1893.

2.H.Fukuyama,K.Seki, T.Takizawa, S.Aihara, M.Murakami, H.Takaichi, and S.Tanaka : Proc. 4th Int. Symp. on Superconductivity Tokyo Springer, (1991) pp.279-2841.