산소결핍 Y-Ba-Cu-O 결정의 자화특성

Magnetization characteristics of oxygen deficient Y-Ba-Cu-O crystal

한국원자력연구소: 김찬중, 김기백, 김우곤, 이호진, 원동연, 홍계원

I. Introduction

According to the magnetization result[1] for the 123 crystal grown from CuO-based flux, the oxygen deficiency acted as a strong flux pinning site for the applied magnetic field and it appeared as an anomalous second peak at an intermediate magnetic field. This phenomena was also observed in the melt-powder-melt-processed sample where different amount of 211 was externally added with an aim of improving critical current density (J_c).[2] The anomaly was more remarkable in the undoped 123 domain than in the domains with 211 addition. In spite of the prolonged oxygenation, the anomaly was still remained in the undoped 123 crystal.[1-3] This is due that the second phase addition enhanced the oxygen diffusion by creation of microdefects such as the interface area between 211 particles and 123 matrix and the platelet boundary and thus less oxygen vacancies were formed in the domain with 211 addition as compared to the undoped sample.

In this study, the effect of the oxygen deficiency on the magnetization hysteresis characteristics was investigated in the single crystalline 123 domain prepared by the melt-texture growth method. The observed anomalies in magnetization curves was described with microstructure related to oxygen diffusion.

II. Experimental Procedure

The 123 powder used in this experiment was commercially available product supplied by SSC, Inc. The particle size of 123 powder was stated to be 2-5 μm. The powder was uniaxially pressed into a pellet using a steel mold. The pellet was sintered at 940°C for 5 h in air and then air-cooled. The sintered pellet was placed on a (001) MgO single crystal substrate and heated rapidly to 1040°C where 123 phase is decomposed to 211 and Ba-Cu-O liquid phase, held for 0.5 h, cooled to 1010°C at a rate of 40°C/h, cooled again to 980°C at 1°C/h and then air-cooled. During the slow cooling stage, large 123 domains were formed by the peritectic reaction of 211 phase and the liquid phase. The melt-textured pellet was crushed in an alumina mortar so as to separate single crystalline 123 domains from the pellet. The domain samples were annealed in flowing oxygen at 450°C for 72 h. Magnetization curve was obtained from 20 K to 77 K for the 123 domain sample (dimension of 2.75 x 2.75 x 0.8 mm) and up to 2 T by using a vibration sample magnetometer. Microstructure of the melt-textured domain was investigated for a polished surface by using an optical polarized microscope.

III. Results and discussion

Figure 1 shows the magnetization curves of the melt-textured 123 domain measured at various temperatures (77 K, 60 K, 40 K and 20 K). The magnetization curves were obtained for the applied magnetic field (H) parallel to the c-axis because the anomaly was reported to be remarkable for this direction.[1,3] The domain was annealed in flowing oxygen at 450°C for 72 h. Although the oxygenation time varies with defect density within prepared samples, at least, a few hundreds hours are needed for full oxygenation of the melt-processed 123 sample.[1,2] The shorter oxygenation period for our sample was intentionally aimed to introduce oxygen deficiency in the domain. It can be seen in the magnetization curve at 77 K that the magnitude of the magnetization difference $\triangle M$ [= M - (-M)] initially decreases with increasing magnetic field up to 0.25 T, increases with increasing magnetic field, reached to maximum at 1 T and then decreases again. The value of $\triangle M$ at the peak point is similar to that at 0 T. The appearance of second peak point

at the intermediate magnetic field is anomalous and is comparable to the normal magnetization in which $\triangle M$ decreases gradually with increasing magnetic field. Such an anomalous magnetization was first reported in an oxygen deficient single 123 crystal grown from CuO flux.[1] Daeumling et al. proposed that the anomaly attributed to flux pinning induced by oxygen vacancies for the applied magnetic field. The observed anomaly in our sample also appears to be due to oxygen deficiency because the performed oxygenation time (72 h) is not enough for full oxygenation. As seen in Fig. 1(B), the anomalous magnetization behavior is also observed in the curve measured at 60 K while the overall shape of the magnetization is slightly different from that observed at 77 K. After the initial decrease, the magnitude of $\triangle M$ monotonically increased up to the magnetic field of 2 T. It is likely that the second peak will shift to the higher magnetic field if the magnetic field extends over 2 T. Similar magnetization behaviors are reported in the 123 crystal where the second peak shifted from 2 T to 5 T as temperature was lowered from 80 K to 70 K[1] and in the melt-processed 123 domain with Pr doping showing similar behavior[4] However, the values of magnetic field at which the anomalous peak occurred different from those of our samples. It appears to be due to the different amount of oxygen deficiency among the samples. On the other hand, the anomalous magnetization is not significant at the temperature of 40 K and 20 K in the range of the measured magnetic field. This means that the oxygen vacancy is not effective flux pinning sites at these temperatures.

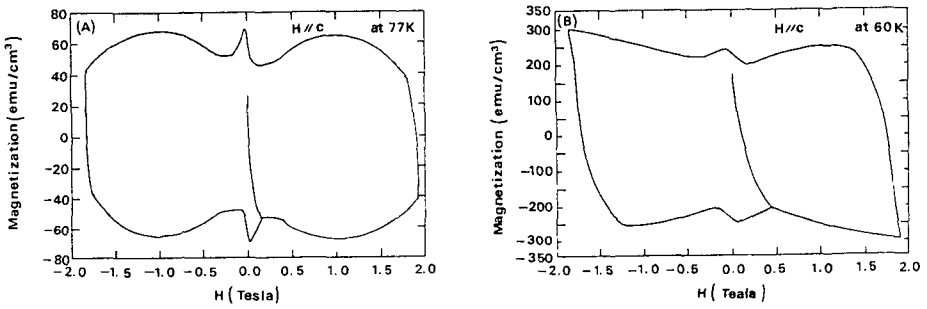

Fig. 1 Magnetization hysteresis curves measured at (A) 77 K and (B) 60 K of the melt-textured 123 domain

IV. Conclusion

In summary, magnetic hysteresis characteristics of oxygen-deficient Y-Ba-Cu-O domain, which was prepared melt-texture processing and followed subsequent annealing in flowing oxygen at 450°C for 72 h, was estimated at various temperatures (77K, 60K, 40 K and 20 K) and magnetic field up to 2 T. At 77 K, the anomalous magnetization, which seems to be due to the flux pinning by oxygen deficiency, is observed in the intermediate magnetic field near 1 T. The anomalous peak shifted to a higher magnetic field when the measuring temperature is lowered to 60 K. The anomaly is not observed at low temperature of 40 K and 20 K, which indicates that the oxygen deficiency is not effective flux pinning site at these temperature.

References

1. M. Daeumling, J. M. Seuntjens, and D. C. Larbalestier, Nature, **346** 332 (1990).
2. N. Nakamura, M. Murakami, H. Fujimoto, and N. Koshizuka, Cryogenics, **32** 94 (1992).
3. C. J. Kim and P. J. McGinn, Physica C 222 **177** (1994)
4. H. Hojaji, S. Hu, A Barkatt D. D. Davis and A. N. Thorpe, Physica C, **195** 135 (1992).