Flux-Flow Hall coefficient in $\text{YBa}_2\text{Cu}_3\text{O}_y$ Films with Proton Irradiation

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We have measured magnetic hysteresis loops, Hall coefficients R_H and resistivities of $\text{YBa}_2\text{Cu}_3\text{O}_y$ (YBCO) films with and without H^+ irradiation to examine the effects of H^+ irradiation on Hall coefficients. The fluence, ϕt , was up to $3 \times 10^{13} \text{ cm}^{-2}$. The incident energy of H^+ -ions was 3 MeV. Negative Hall coefficients and the pinning energy of YBCO films were affected by H^+ irradiation. The results are presented.

Radiation damages to high- T_c superconductors¹⁻⁴ have been of current interest to investigate the effects of defects on the flux pinning. In this work we report the effects of H^+ irradiation on the flux pinning and Hall coefficients R_H of $\text{YBa}_2\text{Cu}_3\text{O}_y$ (YBCO) films.

YBCO films used in this work were prepared in an off-axis rf magnetron sputtering system. A detailed description of the sample preparation has been reported in reference 5. The as grown films on $\text{SrTiO}_3(001)$ show a preferred orientation with the crystal c-axis perpendicular to the plane of the substrate. YBCO films were patterned to a five-leads Hall geometry and Hall coefficients of YBCO films were measured with and without H^+ irradiation in magnetic fields up to 6 T. The incident energy of H^+ -ions was 3 MeV and the fluence, ϕt , was up to $3 \times 10^{13} \text{ cm}^{-2}$.

Figure 1 shows typically resistivity as a function of temperature for a YBCO film (sample a) with and without H^+ irradiation. The fluence was at $\phi t = 3 \times 10^{13} \text{ cm}^{-2}$. There was a decrease of T_c ($T_{c, \text{zero}}$ decreases from 87.5 to

Figure 1 ρ as a function of T for sample a at $\phi t = 0$ and $3 \times 10^{13} \text{ cm}^{-2}$. ρ versus T for sample a near T_c is shown in the inset.

86.2 K as shown in the inset of Figure 1 and the normal state resistivity increased after H^+ irradiation. Hall coefficient as a function of temperature measured in a magnetic field of 4 T near T_c was shown in Figure 2. Negative Hall coefficient was observed for sample a at $\phi t = 0$. However, negative Hall coefficient disappears for sample a at $\phi t = 3 \times 10^{13} \text{ cm}^{-2}$.

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Figure 2 R_H as a function of T for sample a under $\phi t = 0$ and $3 \times 10^{13} \text{ cm}^{-2}$; the applied field was 4 T.

Figure 3 shows hysteresis loops for a YBCO film (170 nm thick) under different H^+ fluences at $\phi t = 0, 2 \times 10^{13}$, and $3 \times 10^{13} \text{ cm}^{-2}$ at $T = 5 \text{ K}$. One finds that $\Delta M = M_+ - M_-$ of a irradiated YBCO film was reduced at those fluences. ΔM

Figure 3 Magnetic hysteresis loops of a YBCO film with H^+ fluences at $\phi t = 0, 2 \times 10^{13}$, and $3 \times 10^{13} \text{ cm}^{-2}$.

decreased by about 30 % at $\phi t = 3 \times 10^{13} \text{ cm}^{-2}$ in a magnetic field of 1 T. J_c enhancement was not observed at those fluences and measured magnetic fields. The pinning energy U derived from the flux creep resistivity of Anderson-Kim⁶ given by:

$$\rho = \rho_0 \exp(-U/k_B T), \quad (1)$$

showed a decrease in U for sample a at $\phi t = 1 \times 10^{13}$, and $3 \times 10^{13} \text{ cm}^{-2}$ compared with that of sample a without H^+ irradiation. So negative Hall coefficient was affected by the flux pinning ability of YBCO films.

In summary, R_H and the flux pinning for YBCO films under different H^+ irradiation have been examined. The resistivity of irradiated YBCO films increased and T_c decreased. R_H in the superconducting mixed state was found to be affected by the flux pinning of YBCO films.

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