The Mixed-State Hall Effect in $\text{YBa}_2\text{Cu}_3\text{O}_7$ / $\text{PrBa}_2\text{Cu}_3\text{O}_7$ Multilayers

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Hall coefficient and longitudinal (ρ_{xx}) resistivities were examined to study the vortex dynamics in the $\text{YBa}_2\text{Cu}_3\text{O}_7/\text{PrBa}_2\text{Cu}_3\text{O}_7$ (YBCO/PBCO) multilayers. We find that the sign reversal of the Hall coefficient R_H diminishes with a decreasing thickness of the individual YBCO layer or a increasing thickness of the individual PBCO layer. These effects suggest a strong correlation between the mechanism of the mixed-state Hall voltage and the coupling strength between the layers.

1. INTRODUCTION

Anomalous Hall effect in the mixed-state has been observed in various high- T_c superconductors [1-3]. One of the most striking features of mixed-state Hall effect is the Hall resistivity undergo a sign reversal from the normal state. There is a large effort to study the sign change both theoretically [4-6] and experimentally [3,5,7], and this behavior is believed to be attributed to an intrinsic property of vortex motion in these materials. In this paper we present the results of the sign anomaly in the $\text{YBa}_2\text{Cu}_3\text{O}_7/\text{PrBa}_2\text{Cu}_3\text{O}_7$ (YBCO/PBCO) systems in which the vortex dynamics is changed by the spatial variation of the vortices structure.

2. EXPERIMENTAL

The c-axis oriented YBCO films and YBCO/PBCO multilayers were prepared by the rf sputtering onto $\text{SrTiO}_3(001)$ substrates. All the multilayers were sputtered onto a 960 Å thick PBCO buffer layer. On top of the buffer, a stack

consisting of n cells - YBCO / m cells - PBCO is deposited N times alternatively with N between 10 and 16, where a unit cell thickness $\approx 12\text{Å}$. The satellite peaks have been observed in the x-ray diffraction pattern indicating a superlattice structure and a Hall geometry was patterned for transport measurements. The Hall voltage was taken in field parallel to the c axis up to 4T and at a dc current density $J \sim 10^3 \text{ A/cm}^2 - 10^4 \text{ A/cm}^2$.

3. DISCUSSIONS OF RESULTS

The temperature dependence of the longitudinal resistivity ρ_{xx} and Hall coefficient in magnetic fields at 1T for YBCO/PBCO (60Å/60Å), (60Å/36 Å) multilayers and a YBCO film (1650Å) are displayed in figure 1(a). As shown by many authors, the resistive transition becomes broader at a high magnetic field and exhibits a strong depression of T_c with an increasing of decoupling between the superconducting layers. As for the Hall coefficients presented in figure 1(a), the peak value of negative Hall coefficient diminishes in magnitude for (60Å

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/36Å) multilayer while negative Hall coefficient disappears for (60Å/60Å) multilayer.

Figure 1. Temperature dependence of Hall coefficient R_H for (a) YBCO, (60Å/36Å) and (60Å/60Å) multilayers in field of 1T and (b) YBCO, (120Å/60Å), (60Å/60Å) and (36Å/60Å) multilayers in field of 4T, and the resistive transition as shown in the insets.

Moreover, a contrasted result for (120Å/60Å), (60Å/60Å) and (36Å/60Å) multilayers are shown in figure 1(b). For a fixed 60Å separation between YBCO layers, the peak value of negative Hall coefficient decreases for a (120Å/60Å) multilayer and a positive Hall coefficient is observed for both (60Å/60Å) and (36Å/60Å) multilayers. These

results imply that the change of the thickness of the individual YBCO layer in the multilayers will result in a variation of the coupling between YBCO layers. When the YBCO layer gets thinner or the PBCO layer becomes thicker, the vortex dynamic in multilayers will have a tendency to reveal a 2D-like behavior. According to Harries et al. [8], if the flux motion dominated by the downstream pancake-like vortices, the negative Hall voltage will diminish or return to positive in the mixed-state.

4. SUMMARY

In summary, we have measured both the longitudinal resistivities and Hall coefficient in the mixed state for a YBCO film and YBCO/PBCO multilayers. The negative Hall coefficient diminishes as one decreases the thickness of the individual YBCO layer or enlarges the thickness of the PBCO layer. These results indicate that the coupling between the YBCO layers affects the Hall coefficient in the mixed-state.

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