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Peak effect in surface resistance at microwave frequencies in Dy-123 thin films

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Abstract. A pronounced peak in the microwave (at frequency 9.55 GHz) surface resistance, R_s vs. T plot (where T is the temperature) has been observed in epitaxial $DyBa_2Cu_3O_{7-y}$ superconducting thin films in magnetic fields (parallel to c-axis) in the range 2 to 8 kOe, and temperatures close to the superconducting transition temperature $T_c(H)$. Our data suggest that the nature of peaks observed in the two films is different, thereby indicating different defect structures in the films.

Keywords. Peak effect; flux line lattice; microwave surface resistance.

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1. Introduction

The peak-effect (PE) phenomenon basically focuses on the order–disorder transition [1] in the flux line lattice (FLL) of type II superconductors in its mixed state and can be explained with Larkin–Ovchinnikov [2] scenario $BJ_c(H) = (n_p\langle f^2\rangle/V_c)^{1/2}$ where n_p is the density of pinning sites, f the elementary pinning force parameter, B the magnetic induction and V_c the Larkin volume over which the vortex lattice retains its spatial order.

During the past few years the ac susceptibility measurements [3,4] at frequencies ranging from few tens of Hz to few MHz have been extensively carried out to study the PE phenomenon. Recently we have reported the observation of PE at microwave frequencies [5] and explained the scenario using Gittleman and Rosenblum [6] vortex motion equation. In this paper we report the comparison of PE at microwave frequencies in two different $DyBa_2Cu_3O_{7-\delta}$ (DBCO) superconducting thin films.

2. Experimental

Two DBCO films S_1 and S_2 (2500 Å), with $T_c \approx 89 \pm 0.2$ K were grown by pulsed laser deposition in different runs on single crystalline $LaAlO_3$ substrates. The films were subsequently patterned into linear microstrip resonators with a width of 175 μm and length 9 mm. The microwave measurements in dc magnetic field (0.2 to 0.8 T) were performed using microstrip resonator technique, as described elsewhere [5]. All microwave measurements for both samples were carried out with microwave power 10 dBm in zero field-cooled condition.

3. Results and discussion

Figure 1 shows that at zero field both films do not show any peak in R_s whereas at the higher field (0.4 T) it starts to appear near transition temperature. Also it is observed that

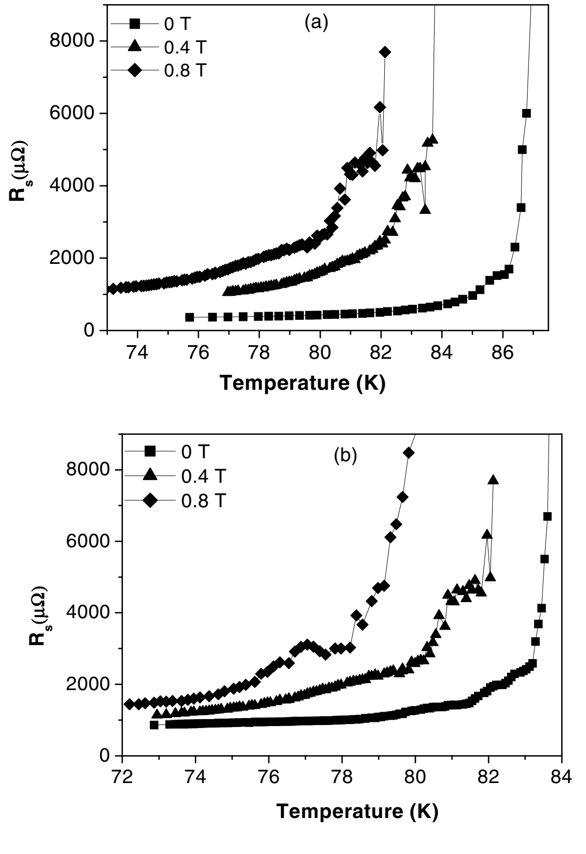

Figure 1. Plot of R_s vs. temperature at different applied magnetic fields at frequency 4.88 GHz, where (**a**) and (**b**) are for samples S_1 and S_2 respectively.

the plots shift towards lower temperature as we increase the field. In figure 2 a pronounced peak observed near transition temperature in both films at frequency 9.55 GHz is shown. As we increase the magnetic field, peak position shifts towards lower temperature. In the measurements at both frequencies the induced microwave current was always less than the critical current of the films. The reason for observation of this peak effect in these films has been explained in our earlier publication [5].

Comparing figures 1 and 2, it is observed that the peaks in sample S_1 are broader and more prominent than S_2. The occurrence of secondary peaks at all fields in the case of sample S_2 and the absence of the same in sample S_1 indicates that sample S_2 has higher defect density as compared to sample S_1. This is also clear from the fact that the surface resistance of S_2 measured at frequency 4.88 GHz in zero field and at 77 K is higher (441 $\mu\Omega$) than that of S_1 (300 $\mu\Omega$). The origins of secondary peaks in sample S_2 could be due to different defect structures present in the sample such as twin boundaries. In high T_c superconductor thin films twin boundaries are generally present. The depinning frequencies for all such defects could be different. The observation of multiple peak structures as shown in figure 2 suggests that there are two different types of defects present in this sample corresponding

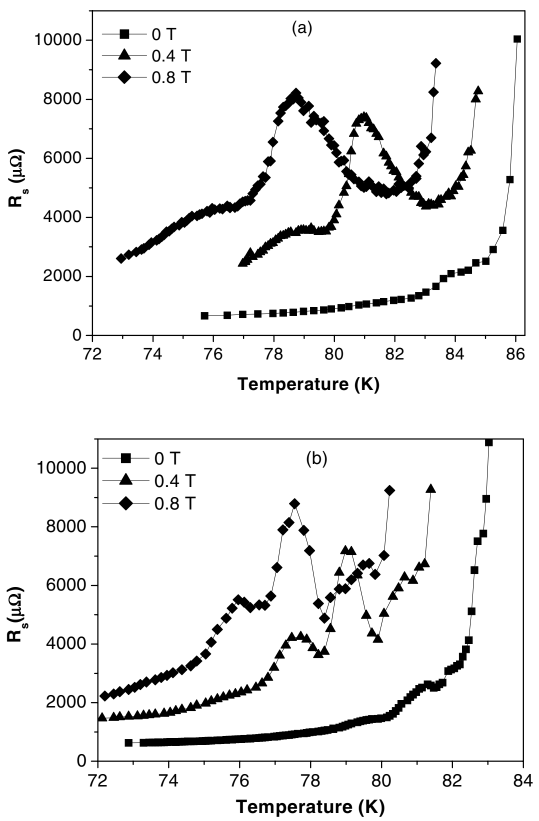

Figure 2. Plot of R_s vs. temperature at different applied magnetic fields at frequency 9.55 GHz, where (**a**) and (**b**) are for samples S_1 and S_2 respectively.

to different depinning frequencies (a few GHz to tens of GHz). From literature, the depinning frequencies for RE 123 material vary between 5–40 GHz [7]. Depinning of the vortex lines from defect structures, such as twin planes and defect clusters, having different pinning potentials (or different sets of pinning potentials) could be the possible cause for multiple peaks in $R_s(T)$ at the measurement frequency of 9.55 GHz.

4. Conclusion

In conclusion, peak effect in surface resistance is observed in two $DyBa_2Cu_3O_{7-\delta}$ thin films at subcritical currents at 4.88 and 9.55 GHz microwave frequencies in dc magnetic fields in the range 0.2–0.8 T. Comparison of the PE phenomenon observed in two different samples shows that the nature of the peak depends on the density of pinning centers, pinning potential, and hence, on the defect structure in the DBCO samples.

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