l/f noise peaks of $YBa_2Cu_3O_{7-\delta}$ thin films in a magnetic field

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Abstract: The magnetic field and temperature dependence of l/f noise has been measured in epitaxial $YBa_2Cu_3O_{7-\delta}$ thin films. In magnetic field two peaks were observed as temperature decreases; one at higher temperature was found to match the thermal fluctuation of the sample resistance and the other near the foot of the transition was found to be magnetic-field dependent and we have studied the voltage noise spectral density S_V(f, T, H) dependence on frequency f, applied magnetic field H and temperature T.

I. INTRODUCTION

Low frequency (f) noise, mostly l/f noise, of the high-temperature superconductors (HTS) near the superconducting transition temperature Tc, has been studied by several groups. One of the interesting properties of l/f noise in this region is the enhanced noise which was observed in various bulks and thin films of $YBa_2Cu_3O_{7-\delta}$ [l-5], Bi [6], and Ti based compounds [7]. Number of models has been suggested to explain the origins of l/f noise near Tc. Extremely large noise observed in the bulk samples of $YBa_2Cu_3O_{7-\delta}$ was explained as the noisy hopping processes across the inhomogeneous boundaries [8]. For polycrystalline thin films of $YBa_2Cu_3O_{7-\delta}$, Lee et al. [2] observed two noise peaks, one near the onset Tc and the other near the zero-resistance temperature. The noise peaks near the onset was magnetic field independent and well fitted to a thermal fluctuation effect, while the magnitude of the peak near the zero-resistance temperature decreased as applied field increased up to 50 gauss. They suggested the latter peaks due to flux flow. Rosenthal et al. [3] also observed enhanced noise near Tc in the polycrystalline films of $YBa_2Cu_3O_{7-\delta}$, but they concluded that this noise does not arise from thermal fluctuations. In addition, the spectral noise density S, decreased markedly as the microstructure of the films was improved. In this work, we present a study of l/f noise in c-axis oriented high-quality epitaxial films of $YBa_2Cu_3O_{7-\delta}$, in an attempt to understand the possible origin of flux flow noise in a magnetic field up to 14T. Our results show that two noise peaks were observed in a magnetic field as temperature decreases; one at higher temperature was found to match the thermal fluctuation of the sample resistance and the other near the foot of the transition was found to be magnetic field dependent.

II. EXPERIMENTS

C-axis oriented epitaxial $YBa_2Cu_3O_{7-\delta}$ films with a thickness of 400 nm and a width of 7.53 μm are deposited by the laser ablation method on the surface (100) of SrTiO3 substrate. The resistance vanished, in zero magnetic field, at Tc = 90 K. Electrodes of measurement are in gold and deposited on the surface of the sample in situ by evaporation. The distance between electrodes of power measurement is 135 μm. Contact resistances were less than 1 Ω. A direct current, perpendicular to the magnetic field, is applied on edges of the sample. The sample central region voltage signal goes through a low-noise transformer of report n = 100, then in a preamplifier of gain equal to 100 and finally in a RC filter. The signal is visualized on a programmable oscilloscope then recorded and analyzed by computer [11].

RESULTS & DISCUSSION

Figures 1 and 2 shows S_v as a function of temperature T in magnetic fields H= 5 and 14T applied parallel to the c-axis under a bias current I= 1nA

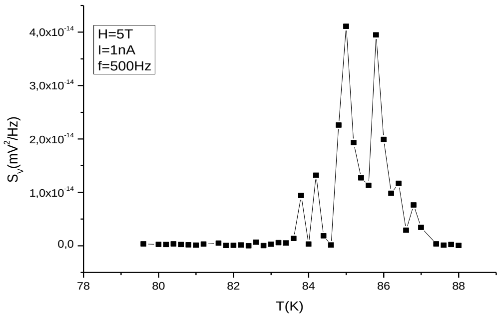

Figure 1: The temperature dependence of S_v at 500 Hz in YBCO films in magnetic fields 5T. Two peak are observed in a magnetic field

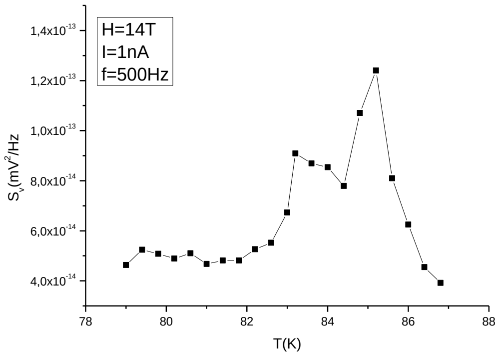

Figure 2: The temperature dependence of S_v at 500 Hz in YBCO films in magnetic fields, 14T. Two peaks are observed in a magnetic field.

The field dependence of two peaks is clearly different. The magnitude of T_2 peak decreases and the peak position moves to lower T as applied field increases, while those at T_1 remain unchanged. This field dependence of the noise peaks indicates that T_2 peaks are field induced, while T, peak is not related to magnetic fields. The upper peak at T_1, has been observed in polycrystalline samples by many groups, while their interpretations vary.
The main focus of this paper is to understand a possible origin of the noise peak at T_2 in a magnetic field and its field dependence. The qualitative explanation of the noise peak T_2 can be given in terms of flux motions. The details of flux motion under current flow are not simple [10], but main components of the forces exerting on the moving flux lines consist of the Lorentz force, the pinning force, and the viscous force etc. If the Lorentz force on a given flux line or bundle exceeds the pinning force, flux lines start to move. Thermal activation also can help flux lines out of their pinning centres. When they are out, flux lines move with a constant flux-flow velocity due to the viscous force. Moving flux lines can be pinned, at different locations or they keep moving to the edge of the sample and leave. Pinned ones can get in motion again some time later by the Lorentz force and thermal activation, repeating the same sequence until they reach the edge of the sample. During these processes, voltage pulses with various heights and duration arise. At sufficiently low temperatures where pinning is strong, most flux lines are pinned, thus flux-motion noise will vanish. Noise is also small when the pinning is negligible at high temperatures since flux lines drift without being disturbed by pinning potential. Between these two limiting regions of pinning, individual voltage pulses during the flux migration result in a noise peak.

CONCLUSION

The temperature and magnetic field dependence of l/f noise in epitaxial $YBa_2Cu_3O_{7-\delta}$ films exhibited two noise peaks. One at higher temperature was found to match the thermal fluctuation of the sample resistance and the other near the foot of the transition was found to be magnetic-field dependent. We showed that the field dependent noises are due to the thermally activated flux motion interacting with the pinning potential, and the peaks arise mainly from the competing effect of the increase of the flux bundle size and the decrease of the resistance as temperature decreases.

REFERENCES

1. J.A. Testa, Y. Song, X.D. Chen, J. GoIben, S.I. Lee, B.R. Patton, and R. Gaines, Phys. Rev. B38,2922 **(1988).**
2. J.H. Lee, ***S.C.*** Lee, and Z.G. Khim, Phys. Rev. B40, 6806 (1989).
3. **P.A.** Rosenthal, R.H. Hammond, M.R. Beasley, R. Leoni, Ph. Lerch, and J. Clarke, IEEE Trans. on Magnetics, ***25,*** 973 (1 989).
4. M.J. Ferrari, M. Johns03 F.C. Wellstood, J. Clarke, P.A. Rosenthal, R.H. Hammond, and M.R. Beasley, Appl. Phys. Lett. **53,** 695 (1988).
5. M.J. Ferrari, M: Johnson, F.C. Wellstood, J. Clarke, D. Mitzi, P.A. Rosenthal, C.B. Eom, T.H. Geballe, A. Kapituhik, and M.R. Beasley, Phys. Rev. Lett. 64, 72 (1989).
6. **A.** Maeda, Y. Kato, H. Watanabe, I. Terasaki, and K. Uchinokura, Physica B165&166, 1363 (1990).
7. Y. Song, A. Misra, Y. Cao, A. Querubin Jr., X. Chen, P.P. Crooker, and J.R. Gaines, Physica **C172,** 1 (1990).
8. F.N. Hooge, Phys. Lett. **29A,** 139 (1969); F.N. Hooge, T.G.M. Kleinpenning, and L.K.J. Vandamme, Rep. Prog. Phys. 44,479 (1981).
9. R. F. Voss and J. Clarke, Phys. Rev. B 13, 556 (1976).
10. for example, V.M. Vinokur, V.B. Geshkenbein, M.V. Feigel'man, and G. Blatter, Phys. Rev. Lett. **71,** 1242 (1993).

