The Study of RF-Stimulated Magneto-Conductivity in 20% Pr-doped HTS Y_{123}

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The HTS Y_{123} were synthesized anal doped with 20% Pr using conventional solid state reaction method The electrical conductivity as well as magneto-conduction processes were studied under radio frequency perturbations at room temperature on the compressed pellets endowed with 4-probe Hall geometry. The variations of Hall Potential V_H with magnetic field H as well as frequency reveal the Interesting features of superconducting switching inwards further high temperature side.

Keywords: High Temperature Superconductors (HTS), Doping, Superconductivity.

1. INTRODUCTION

The electrical as well as the magneto conduction process in HTS, ion conducting doped crystals, poly crystals, amorphous semiconductors, ion conducting polymers and glasses are presently the major field of research [1,2,3]. At low frequencies the electrical conduction is frequeny independent. However, around hopping frequency the ac conduction seems to obey power law $\sigma'(f) \propto (f)^n$ and BNN power relation in nono crystalline solids

$$\sigma'(f) = \sigma_{dc} \, [\, 1+(f/f_{max})^n]$$

where f is excitation frequency, f_{max} is relaxation frequency and n is the dimensionless frequency exponent normally lying in the range $0<n<1$ [4,5,6]. The nonlinear and chaotic oscillations in these materials and semiconductors under the influence of a transverse magnetic field called dynamic Hall effect has been employed to impart a comprehensive account given for the theoretical derivatives of nonlinear dynamic magneto transport in HTS Y_{123} under RF stimulations [7,8]. In the present study, the ac conductivity and its scaling behaviour in 20%, Pr-doped HTS Y_{123} had been interpretated using random free energy barrier mode. The transverse ohmic (V_y) and magneto potential (V_y'), Hall voltage V_H, the longitudinal i_x and the transverse i_y current components had been recorded under MRF excitations [9].

2. EXPERIMENTAL STUDY AND ANALYSIS

The HTS samples were employed in 4-probe Hall geometry and air drying silver paste (paste was formed of isoamil acetate, which is in liquid form) was used for making electrical contacts on the samples. The sample temperature was monitored within an accuracy of ±0.1K using a standard 100

Ohm platinum sensor in conjunction with the Keithley 224 programmable constant current source and Keithley 181 nanovoltmeter [10,11].

The x-terminal dc-voltage application on Hall probe of 20% Pr-doped HTS Y_{123} under magneto (H_z = 6KG) radio frequency (1-7MHz) excitations at 45° x-y plain yield the following results depicted in Figures 1-5.

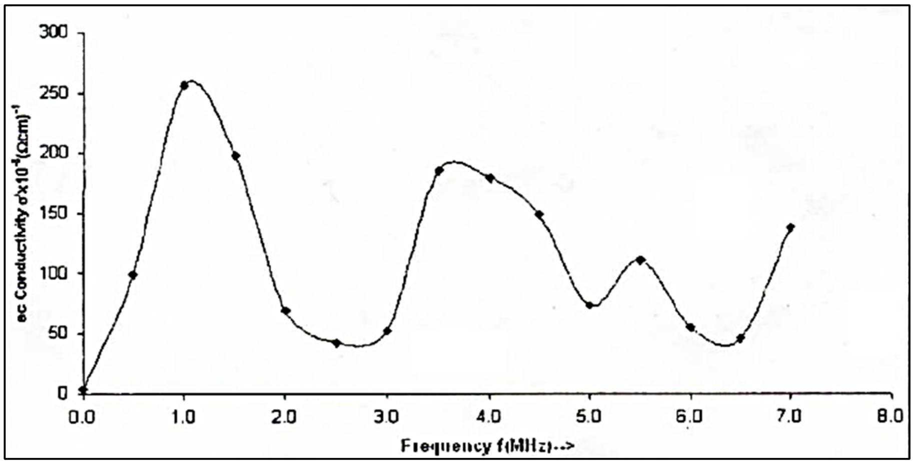

Fig. 1: The RF stimulated ac conductivity in 20% Pr-doped HTS Y_{123}.

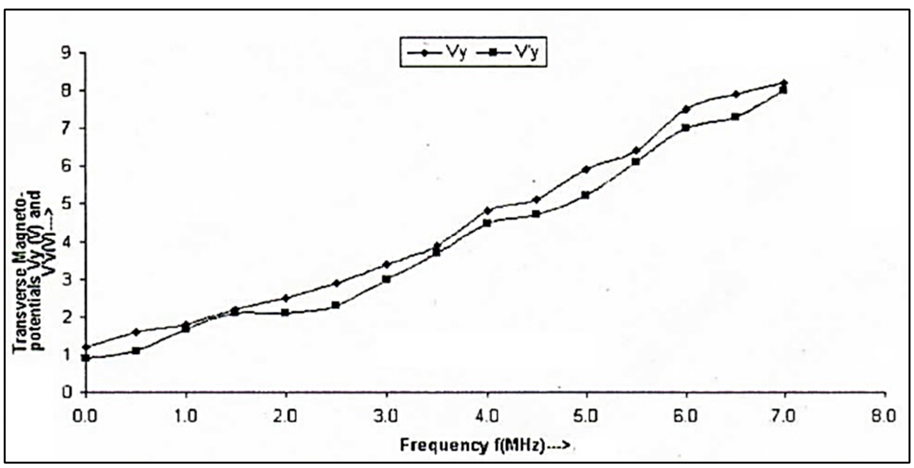

Fig. 2: The magneto splitting of transverse potential in 20% Pr-doped Y_{123}, V_x = 2V, H_z = 6KG.

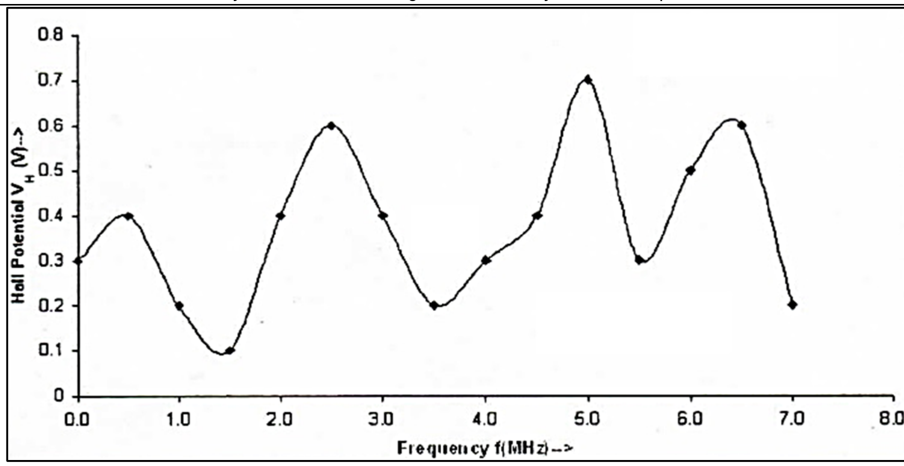

Fig. 3: The RF stimulated Hall voltage in 20% Pr-doped Y_{123}, V_x = 2V, H_z = 6KG.

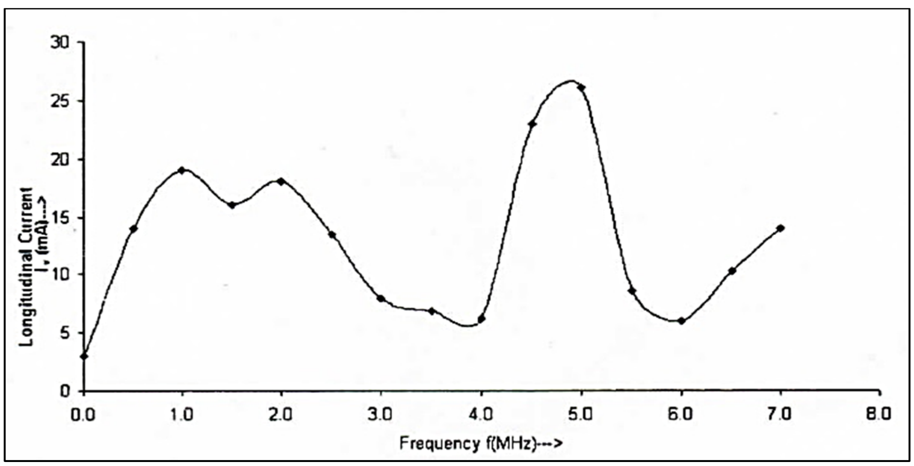

Fig. 4: The frequency dependent current component I_y in 20% Pr-doped Y_{123}, V_x = 2V, H_z = 6KG.

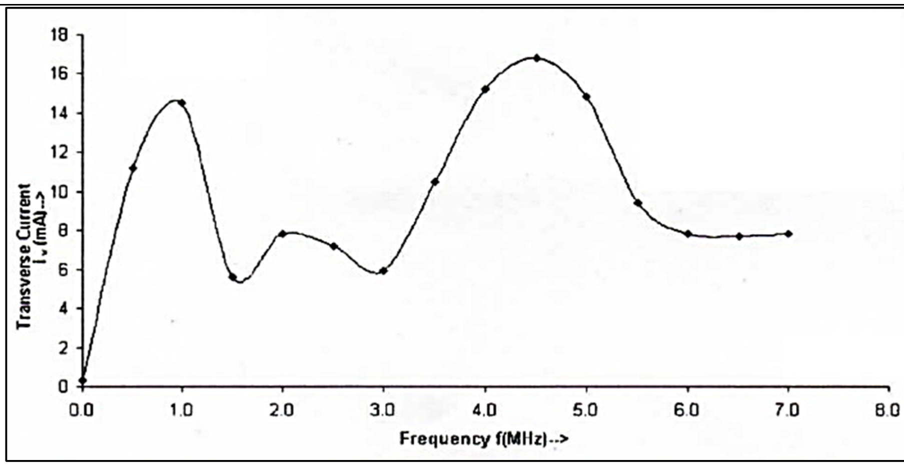

Fig. 5: The frequency dependent current component I_x in 20% Pr-doped Y_{123}, V_x = 2V, H_z = 6KG.

3. RESULTS, DISCUSSION & CONCLUSION

The AC conductivity σ'(f) variation with frequency has been depicted in Figure 1, i.e. fast rise for f between 0-0.5MHz than slow spontaneous oscillatory rise reaching upto 2.561×10^{-6} $(\text{Ohm-cm})^{-1}$ revealing semiconducting range. The transverse potentials both ohmic and magneto recorded at room temperature under RF excitations had been shown in Figure 2. It may be noted that a sharp rise from 3.9V for ohmic & 1.6V for magneto transverse voltage. The Hall potential record had been shown in Figure 3 which have periodicity 1.8MHz and amplitude of oscillation ranging from 0.7 volt to 0.1 volt. In 20% Pr-doped HTS Y_{123} in the i_x stepped development at first saturating value 19mA with frequency rise 0.5 MHz from initial f = 0MHz and then a slow rise approximately linear in nature reaching upto 26mA at f = 5 MHz had been shown in Figure 4. The i_y-f characteristic curve is oscillatory as shown in Figure 5. The current amplitudes varying between (0.3-16.8)mA maximum at f = 4.5MHz reaching a saturation value 8.5 mA after f = 6.0MHz

REFERENCES

[1] A. Ghosh and A. Pan; "Scaling of the Conductivity Spectra in Ionic Glasses: Dependence on the Structure", Phys. Rev. Lett., Vol. 84(10), pp. 2188, 2000. DOI:https://doi.org/10.1103/PhysRevLett.84.2188

[2] R. Swarup, B. Singh, M.P. Singh and Y. Singh; "The characteristics of conducting polymer bis (dithizonate) Ti(IV) isopropanalate $[(HDz)_2\ Ti(OP)_2]$", Synthetic Metal, Vol. 55(2-3), pp. 809-814, Elsevier Sequsia, Switzerland, 1993.

[3] B. Singh, H.K. Sharma, S.P.S. Jadon, M.P. Singh and R. Swarup; "Properties of Si(IV) conducting polymeric crystals The characteristics of EPR-hyperfine peaks in Si(IV) polymeric-crystals", Synthetic Metals, Vol. 56(1), pp. 1884-1889, Elsevier Sequsia, Switzerland, 1993.

[4] J.C. Dyre and T.B. Schroder; “Universality of ac conduction in disordered solids”, Rev. Mod. Physics, Vol.72, pp. 873, 2000. DOI:https://doi.org/10.1103/RevModPhys.72.873.

[5] J.C. Dyre; “The random free-energy barrier model for ac conduction in disordered solids”, J. Appl. Phys., Vol. 64(5), pp. 2456-2468, 1988.

[6] W.K. Lee, J.F. Liu and A.S. Nowick; “Limiting behavior of ac conductivity in ionically conducting crystals and glasses: A new universality”, Phys. Rev. Lett., Vol. 67, pp. 1559, 1991. DOI:https://doi.org/10.1103/PhysRevLett.67.1559

[7] R. Swarup, Pawan Kumar and Dharvendra Singh; “The RF stimulated Magneto-conductivity in HTS”, Proc. Of 44th DAE Solid state Physics Symp. (DAE – SSPS 2001), 103, 11 BARC, Mumbai Dec. 26-30, 2001.

[8] R. Swarup, Pawan Kumar and S.K. Agarwal; “The Magneto-Resistivity Anisotropy in HTS (Bi_{2212} and Y_{123})”, Proc. of 46th DAE solid state Physics Symp. (DAE-SSPS 2003/8), Jiwaj Univ. Gwalior, Dec. 26-30, 2003.

[9] P.C.E. Stamp, L. Forro and C. Ayacha, "Kosterlitz-Thouless transition of fluxless solitons in superconducting $YBa_2Cu_3O_{7-\delta}$ single crystals", Phys. Rev. B, Vol. 38(4), pp. 2847-2850, 1988.

[10] J.L.Tallon and J.W. Loram; "The doping dependence of T* - what is the real high-T_c phase diagram?", Physica C: Superconductivity and its applications, Vol. 349(1), pp. 53-68, 2001.

[11] J.C.S. Devis; "Impurity atoms on view in cuprates", Material Today, Vol. 5(4), pp. 24-33, 2002.