The High Temperature Superconductor Electronics

Pawan Kumar
Associate Prof., Department of Physics, A.S. (P.G.) College, Sikandrabad, India

The high temperature superconductivity (HTS) is setting a record breaking mile stone in the recent condensed matter physics. Where the microscopic mechanisms leading to pairing at unprecedently high temperatures our hopes lie on superconductivity of cuperates require the review of fundamental principles of the choice of new materials. The reported superconductivity in La-Ba-Cu-O had been retrospected in the electrolytic liquid mixtures in Hall geometry even at room temperatures.

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

1. INTRODUCTION

The substitutions studies at cation sites in $YBa_2Cu_3O_y$ (y=1,2,3) without completely destroying superconductivity along with the ion size, formal valence, electron structure and the magnetic moment influences this phenomenon [1]. The normal valence of the Cu ions between +2 and +3 in these high -T_c superconducting oxide materials is related to the oxygen content monitored by suitable choice of the annealing conditions. The Cu-valence can also be monitored by non-isovalent substitution on the Y or Ba sites. The superconducting T_c of $YBa_2Cu_3O_y$ (y=1,2,3) materials depends upon the concentrations of mobile materials, or effective Cu valence in the CuO_2 planes. The non linear fashion of oxygen content controlled 'p' is observable as the carriers are distributed in both the planes and the Cu-O chains. The cations doping at Y-site or Ba-site also change 'p' and thus affecting many characteristics. Several isovalent & aliovalent substitutions have been made for the Y^{3+} or Ba^{2+} ions to investigate the structure property relationships in these materials [2,3,4,5]. The substitution of La^{3+} for Ba^{2+} in $Y\,Ba_{2-x}\,La_x\,Cu_3Y_3$ introduces extra oxygen which leads to oxygen content y >7. The doping of higher valent La^{3+} for divalent Ba^{2+} taps out two mobile holes per excess oxygen from the Cu^xO_2-Y-Cu(2) O_2, layers. We are hereby employing the superconductivity study of Cu-S-O_4-(H-H-O)$_n$, multilayered and ionically regulated due to magnetodynomic stimulation. Another orthorhombic-tetragonal phase transformation has also been observed in the recent studies and the superconducting $La_{2-x}Ba_x\,CuO_4$ systems [6,7,8].

Insulating cooperates model magnets (Cu-O model magnets) with other elements (La, Si, Ca) extended into s=1/2 chains and s=1/2 spin ladder creatively synthesized due to solid state chemistry approach enables several CuO_2 chains linked with several ladders. The ground state of ladders depends upon the number of coupled chains i.e. the number of legs of the ladder. The ground state being non-magnetic for an even number of legs and magnetic for odd number of legs. The dynamics of holes introduced into these Cu-O chains and ladders is governed by the nature of highly correlated electronic system leading to elementary excitations far different from ordinary metals i.e. a criteria of weekly interacting quasi-particles [9].

Received: 22.04.2016, Accepted: 2.05.2016

2. THE VORTEX STATE AND THE SUPERCONDUCTIVITY

In the presence of an interned magnetic file HTS (Layered outactes) reveals electronic anisotropy & pronounced vortex state where as in traditional isotropic low T superconductors H-T phase diagram has the familiar form of a Meissner phase for low Hand a mixed phase with a 'vortex lattice' state upto the upper critical field beyond which the normal state is recovered "Vortex lattices, vortex liquid, vortex glass, polymer glass are the consequences of melting of the flux lines lattices appeared as the breaking-up into short segments or pancakes (evaporation) imposing a phase transition causing the latent heat and a first order drop in the resistivity. The non-equilibrium vortices state experiences a driving force i.e. current depending upon their mutual movements (forces between vortices, degrees of disorder and the elasticity of an individual vortex line) breaking away vortices from the pinning sites and move, creating dissipation at currents well above the critical value J_c. At low currents the bunches of vortices can move across energy barriers assigned by thermal fluctuations characterizing the height of these barriers depending upon current driving force and resulting in highly non linear velocity and force relationship (exponential dependence). Strong vortex pinning develops the high current carrying capability where as it is more difficult to pin the Soft vortices. The magnetodynomically regulated 3D-like ionics seems to impose the strongest coupling between pancake vortices with the desired flux lattice melting. The electrical resistance in the layered superconductors does not fall to zero untill the temperature is lowered to well below T_c and the resistance is not due to very small upper critical field Hc_2, which is very high because $Hc_2 \propto \frac{1}{\xi^2}\, C.L.(\xi)$. Clearly indicating that their microscopic origin i.e. the larger electronic/ionic anisotropy compounds exhibit this dissipated process in a more pronounced way than less anisotropic materials [10,11].

3. EXPERIMENTAL ANALYSIS

The transport properties along the multilayers and perpendicular to them need to be formulated which are strongly affected by the chemical nature of the charge reservoir layers. Cuperates being electronically highly anisotropic reveal a highly coherent electrical transport along the Cu-O layers and incoherent perpendicular to these layers Le the transverse resistivity is upto 5 orders of magnitude higher than that in planes. However, the normal state properties such as spin and charge dynamics are essentially independent of crystal structure but primarily depends upon the carrier (hole) concentrations.

The characteristic (V-I) curves of $Cu(SO)_4.(H_2O)_n$, $FeCl_3.(H_2O)_n$ and $KMnO_4.(H_2O)_n$, representing electrical resistivity behaviors at different temperatures have been depicted in Figures (1), (2) & (3) respectively. The normal and magnetoresistance (MR) graphs Figures (4) & (5) yielding the MR ratio [12] $\Delta\rho/\ \rho$ in these samples at first increasing in region I and then becoming constant in region II indicating induced domain wall pining. The oscillatory behavior of all these curves is a clear cut indicator of superconductivity trend even at room temperatures.

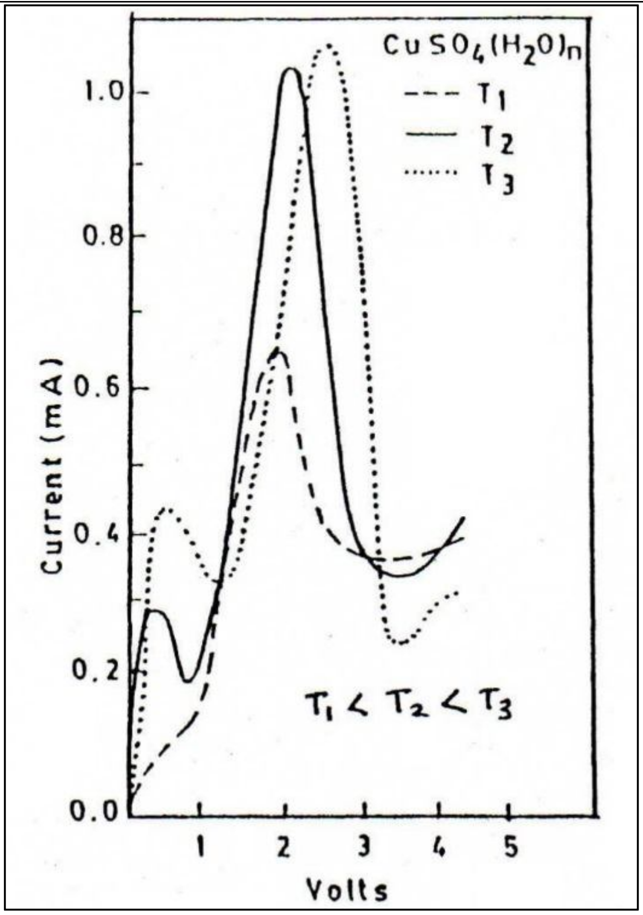

Fig. 1: Electrical resistivity behaviors at different temperatures for $CuSO_4.(H_2O)_n$.

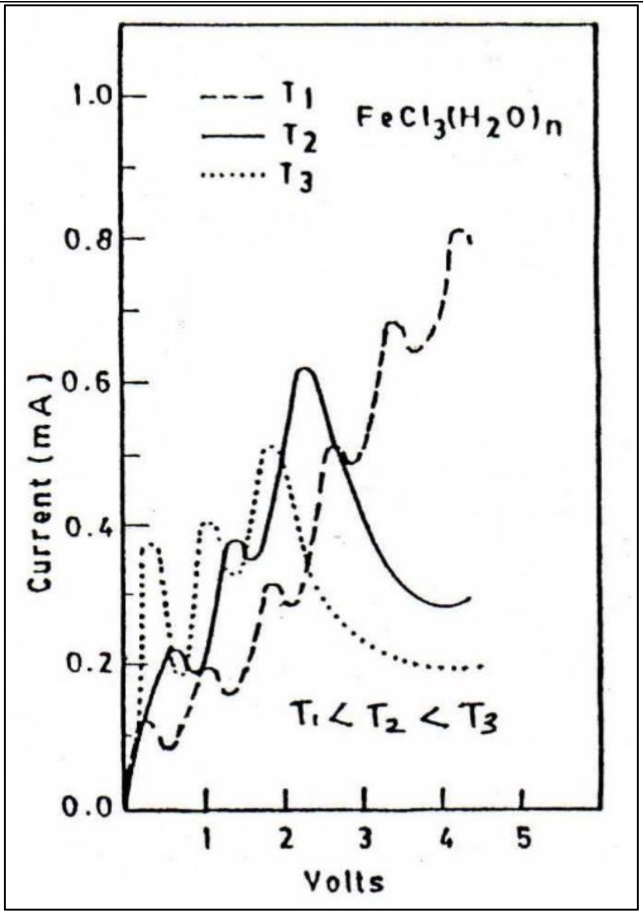

Fig. 2: Electrical resistivity behaviours at different temperatures for $FeCl_3.(H_2O)_n$.

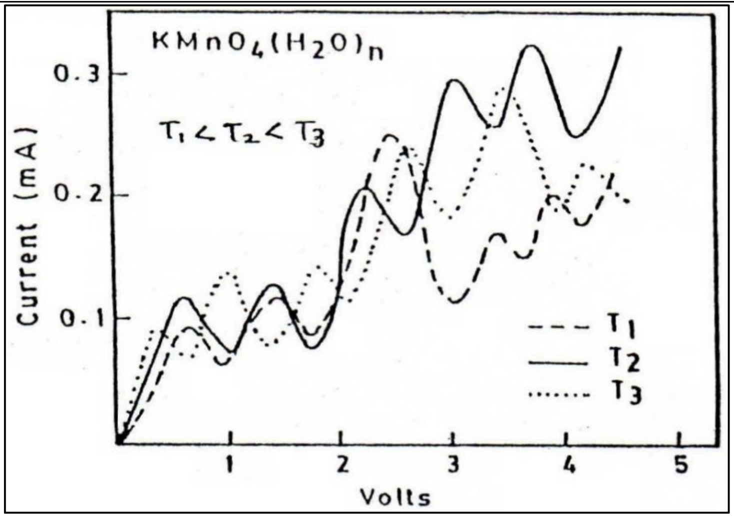

Fig. 3: Electrical resistivity behaviours at different temperatures for $KMnO_4.(H_2O)_n$.

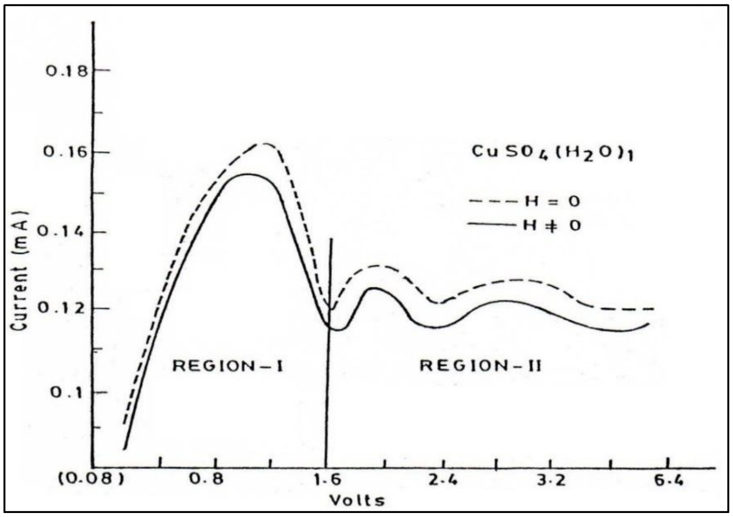

Fig. 4: Magneto-resistance behavior of $CuSO_4.(H_2O)_1$.

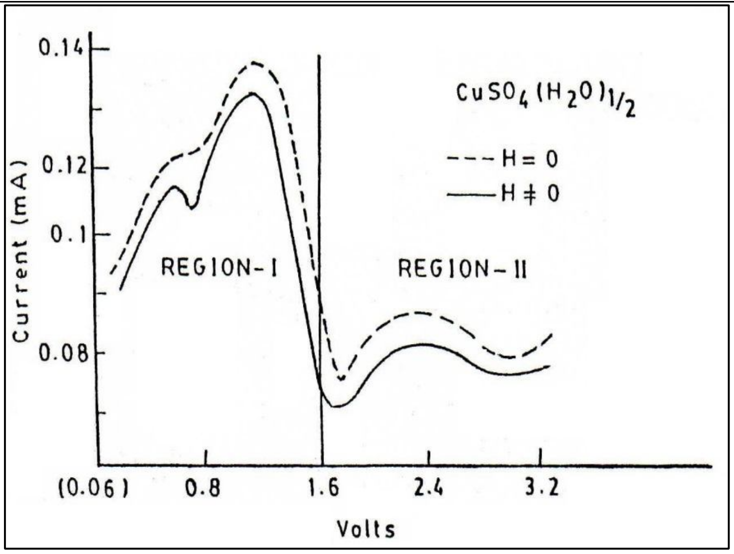

Fig. 5: Magneto resistance behavior of $CuSO_4.(H_2O)_{1/2}$.

3. RESULTS, DISCUSSION & CONCLUSIONS

Another interesting aspect follows from the excitation spectra of ^{1}D antiferromagnetic Heisenberg chain, that can be realized in cuperates. As a result of one dimension the elementary excitations are 'spinons' and 'holons', reflecting and decoupling of the spin and charge degrees of freedom of an electron/ion. The energy scales for the holon dispersion is given by the transfer integral 't', that for the spinon dispersion by the coupling constant 'J'. The spectra obtained from angle-resolved photoelectron spectroscopy are in good agreent with model calculations using independently measured values for 't' and 'J'.

The presence of external magnetic field imposes vortex state, even if two grains meet without an intervening chemical barrier. The microscopic aspect of the superconducting wave function based on the Josephson relation between the super current density and the phase difference between two weakly, coupled superconductors: superconducting crystal is Josephson Junction connected around a corner by a conventional s-wave superconductor. The tunneling spectroscopy results reveals that the consequences of order parameter symmetry due to the sign change of the dx^2-y^2 pair wave function along with k_y=k_x direction. Zero energy bound surface states can develop as the result of interference of reflected electrons and holes via the Andrecy effect. Further consequence of symmetry is the suppression of the critical current density at grains boundaries is the slight crystallographic misalignments (creating weak links), the symmetry of the order parameter leads to a reduced wave function overlap, further aggravated by the very short coherent length a diminished critical current, influencing the 'vortex state'.

REFERENCES

[1] Y. Tokura, J.B. Torrance, T.C. Huang and A.I. Nazzal; "Broader perspective on the high-temperature superconducting $YBa_2Cu_3O_y$ system: The real role of the oxygen content", Phys. Rev. B., Vol. 38(10), pp. 7156-7159, 1988**.**

[2] "Chemistry of oxide supercunductors", Edited by CNR Rao, Blackwell Science, U.K., 1988. ISBN 0632023023

[3] Y. Singh, M.P. Singh and R. Swarup; "Synthesis & spectral characteristics of dicyclopentadienyl bis (dithizonate) titanium (IV) [Cp_2Ti $(HD)_z)_2$] crystals", Synthetic Metal, Vol. 56(1), pp. 1878-1883, Elsevier Sequsia, Switzerland, 1993.

[4] 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.

[5] D.V. Singh, V.P. Gupta, R. Swarup; "The characteristics of rare earth chalcogenides & oxides", Synthetic Metal, Vol. 57(1), pp. 3617-3622, Elsevier Sequsia, Switzerland, 1993.

[6] M. Chaudhari, Kunal B. Modi, K.M. Jadhav and G.K. Bichile; "Structural phase transition in substituted La_2CuO_4 and Pr_2CuO_{4-y}", Pramana, J. Phys., Vol. 48(4), pp. 883-890, 1997.

[7] J.G. Bednorz, M. Takashige and K.A. Mullar; "Preparation and characterization of alkaline-earth substituted superconducting La_2CuO_4", Mater. Res. Bull., Vol. 22(6), pp. 819-827, 1987.

[8] J.G. Bednorz and K.A. Muller; "Possible high T_c superconductivity in the Ba−La−Cu−O system", Phys B-Condensed matter, Vol. 64, pp. 189-193, 1986.

[9] Bertram Batlogg; "Cuprate superconductors: Science beyond high T_c", Solid state communications, Vol. 107(11), pp. 639-47, 1998.

[10] "Physical properties of High Temperature Superconductors", Vol. IV, Edited by Donald M. Ginsberg, World Scientific, Singapore, 1989-96. ISBN:978-981-02-1637-5

[11] M.G. Cottam and D.R. Tilley; "Introduction to surface and superlattice excitations", Cambridge university press, Cambridge, 2004. ISBN 9780750305884

[12] G. Choe and M. Steinback; "Surface roughness effects on magnetoresistive and magnetic properties of NiFe thin films", J. Appl. Phys., Vol. 85(8), pp. 5777, 1999.