Area of Research

- **Preparation and electrical & magnetic characterization of high T_C Superconductors**
- **Vortex phase diagram in high Tc Superconductors**
- **Simulation of I-V characteristic of Josephson junctions arrays**
- **Carbon Nano Tube**

Summary of Present Research Work

Studying the vortex phase diagram in BSCCO single crystals and the effect of intrinsic pinning on vortex motion and localization in layered HTSC

High T_c Superconductors (HTSC) are highly anisotropic layered compound consisting of weakly coupled Cu-O planes separated by buffer layers that serve as charge reservoirs. The magnetic and transport properties of HTSC , for a large range of angles α between applied magnetic field and Cu-O planes can be understood within the frame work of 3D anisotropic Ginzberg –Landau model. However this description fails when the field is closely aligned with superconducting layers (α<0.5°). In this case the vortices become confined between Cu-O layers. As a result of such confinement, the pinning strength of the vortex system is strongly dependent up on the relation between the vortex lattice spacing (s) and distance between the Cu-O planes (d). With increasing s/d the pinning strength changes periodically, having local maxima where the ratio s/d is integer (commensurate states). In the experiment when the magnetic field is increased the critical current should show oscillation with a period which is proportional to $B^{-1/2}$. These commensurate states have been studied in YBCO and are understood up to certain extent. While these studies in BSCCO have not been done in details. Due to high anisotropy of the BSCCO the phase diagram of it especially for B ab has not been understood well. We are studying transport and magnetisation of BSCCO single crystals as function of α.

In addition to above we are starting the fabrication and transport measurement of Carbon Nano Tube (CNT).

Summary of Previous Research Work

I have been working on HTSC materials since 1987. My doctoral thesis is on ***Electron Paramagnetic resonance (EPR) and Low Field Dependent Microwave Absorption in High Tc Cuprate Superconductors (HTCS) and I did following studies.***

Ac susceptibility and STM studies on BSCCO single crystals irradiated with heavy ion Beam .

A good quality of the single crystals of BSCCO 2212 was grown by self-flux method. Three BSCCO single crystal were irradiated with 250 MeV Ag^{+17} ions with respective dose of 2.5, 5.0, $10.0x10^{10}$ ions/cm^2 to create columnar defect in them. The defect structure was characterized at nano level using scanning tunneling microscope (STM) technique. Low ac field (B_{ac}) magnetic susceptibility measurements in a frequency range of 0.016 – 1kHz and field range of 0.01 – 10 Gauss were performed on the crystals before and after irradiation. Considerable frequency dependence of the susceptibility transition is observed. Using an Arrhenius-like expression, flux creep activation barriers were determined which show B_{ac} dependence. Introduction of defects leads to a shift of susceptibility transitions to higher temperatures and an increase in activation barriers. The results show the dependence of Bulk pinning rather than surface/geometrical barriers in determining the flux line dynamics at low fields and temperature very near to critical temperature.

Substitution studies

We have also measured the resistivity and ac susceptibility of Zn doped $LaBaCaCu_3O_{7-d}$ systems having Zn content of .5%, 1.0%, !.5%,2.0%, 2.5% and 3.0% at wt. From above studies following conclusions have been drawn about the role of Zn in LBCCO samples. (1) The conduction mechanism of electrons appears to follow a crossover from the purely metallic regime to localization regime due to either weak localization or electron-electron interaction effects after about 1.5% Zn. (2) The superconducting transition as revealed by resistivity vs temperature curves or susceptibility vs temperature curves becomes sharper with zn-content increasing up to 1.0%. After 1.5% the resistive and ac susceptibility transition become broader with increasing Zn. (3) Tc depression up to Zn content of 1% seems due to direct suppression of the effective pairing interaction, while at and above 2.5% Zn Tc depression is expected due to disorder effects such as reduction of density of states at the fermi energy.

Simulation of I-V Characteristic of intrinsically stacked Josephson Junction arrays

We did the simulation of I-V curve of intrinsically stacked JJ arrays as a function of magnetic field taking noise into consideration on the basis of RCSJ Model. The simulated results show good agreement with experimental results.

EPR and Field Dependent Microwave Absorption Studies

EPR is a very sensitive tools to characterize the presence of impurity phases in HTCS and it also gives some clue about the localized charge on the copper atoms and their interaction with their environments.

As a probe of the material properties, a microwave measurement is a useful complement to low frequency susceptibility and resistivity measurements for at least two reasons. Firstly, it is contact less measurement. Secondly, it permits the study of the resistive behavior below super conducting transition temperature Tc

We prepared the polycrystalline samples YBCO by different methods and characterized them by resistivity measurements, XRD, EPR and SEM. LFDMA was studied in details in these well characterized samples as a function of temperature, modulation field, microwave power and grain size. All HTCS give intense LFDMA at and below T_c. The derivative signal of LFDMA shows peak and hysteresis. Peak position (H_m) of derivative signal of LFDMA gives the measure of grain size of HTSC materials.

The LFDMA signal arises due to the microwave loss in weak links forming Josephson junctions in granular superconductors. In polycrystalline samples there are a large number of inter-granular Josephson junctions (JJ) of different sizes and oriented randomly.

All these junctions can be approximated by a single representative resistively shunted JJ. Microwave loss was calculated in the single representative JJ on the basis of the RSJ model. The calculated results agree with that of the experimental results qualitatively. From this we conclude that microwave loss in the polycrystalline samples is due to the intergranular JJ.

We studied the field cooling (FC) and field exposure (FE) effect on the LFDMA in YBCO & TlBCCO. The measurement of hysteresis area under field cooling and field exposure gives the measure of lower critical field of inter granular junction (Hc1j) and that of grain (Hc1g). From above measurements it has been concluded that TlBCCO have lower pinning force than YBCO. Thus the above measurements gives the measure of relative pinning strength of the materials.

Other area of interest

In addition to above, I am also interested in t*he transport and magnetic properties of Carbon Nano Tube.*