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A STUDY OF SOME PHYSICAL PROPERTIES OF HIGH TEMPERATURE SUPERCONDUCTORS

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ABSTRACT

In the field of high temperature superconductors (HTSc) the transition temperature T_c, the current density J_c and the pinning energy U_p are very important in characterizing such materials. It is well established now that such quantities are affected by the method of preparation, magnetic field and the temperature.

In this thesis, we have prepared two of the most common ceramic HTSc systems; $YBa_2Cu_3O_x$ (YBCO) with nominal critical temperature $T_c = 91$ K and $Bi_2Sr_2Ca_2Cu_3O_x$ (BSCO) with $T_c = 108$ K. Dynamics of vortices in the different pinning regimes were extensively studied through electrical measurements under zero field cooled (ZFC) and field cooled (FC) conditions, i.e. cooling the sample from about 300 K down to 12 K in zero magnetic field and cooling the sample in a constant magnetic field, respectively. The field cooled mechanism is known to prevent vortices from reaching an equilibrium configuration. So, the dimensionality of the movement of vortices, the activation energy as well as the critical current density were examined according to different models, such as,

flux creep, collective flux creep and vortex-glass model. Also two empirical formulae expressing the effect of the field cooled (FC) on the transition temperature T_c and the applied field H_a on the pinning energy U_p were also suggested.

Results of magnetoresistance for YBCO sample were analyzed using the vortex - glass model proposed by Fisher (1991). These results show sharp transition from vortex-lattice to vortex-glass phase with increasing the magnetic field from 10 mT to 200 mT.

The dependance of conductivity on temperature for BSCO sample was analyzed using the theory of fluctuation conductivity near T_c which was first introduced by Aslamazov and Larkin, AL, (1968). Also a power law dependence for the current-voltage characteristics (I-V) at 77 K with an exponent close to 1.5 which characterizes a two dimensional (2D) behavior as pointed out by Kess et. al. (1989) through his thermal assisted flux flow (TAFF) model was proposed.

CHAPTER 1

INTRODUCTION TO SUPERCONDUCTORS

1. INTRODUCTION TO SUPERCONDUCTORS

1.1 General Review

Physical properties of the high temperature superconductors (HTSC) have been of considerable interest over the last decade from both experimental and theoretical points of view. The resistivity measurements of these systems provide some information regarding the type of transition.

Since the discovery of superconductivity by Kamerlingh Onnes in 1911 [1] in Hg at 4 K, one of the primary objectives of superconductivity research has been to raise the transition temperature T_c at which the resistivity goes to zero value. It was found that half of the metallic elements and a number of alloys exhibit superconductivity when they are sufficiently cooled. Table (1.1) shows some of the superconducting elements and compounds and their transition temperatures T_c.

After the amazing discovery of Onnes, a lot of researches were carried out in order to investigate the properties of the newly discovered materials. Many of the properties of superconductors can be explained if it is supposed that below T_c the conduction electrons may be divided into two classes. Some behaving as "superelectrons" and referred to as

element/compound	T_c(K)	element/compound	T_c(K)
Aluminium	1.20	Niobium	9.30
Cadmium	0.25	$YBa_2Cu_3O_7$	92.00
Indium	3.40	$HgBa_2Cu_4O_x$	94.00
Mercury	4.20	$Bi_2Sr_2Ca_2Cu_3O_{10}$	110.00
Tin	3.70	$Tl_2Ba_2CaCu_2O_{8-y}$	120.00
Ta - Nb	6.30	Nb_3Sn	18.00
Pb - Bi	8.00	Nb_3Ge	23.00

Table 1.1 Superconducting Transition temperature of some elements and alloys.