UNIVERSITI PUTRA MALAYSIA

DOPING DEPENDENCE OF MAGNETIC SUSCEPTIBILITY AND ELECTRICAL PROPERTIES OF HIGH TEMPERATURE SUPERCONDUCTING CERAMICS

SYED ALI BEER MOHAMED

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1999

SPECIALLY DEDICATED
TO MY BELOVED
PARENTS
AND
WIFE

DOPING DEPENDENCE OF MAGNETIC SUSCEPTIBILITY AND ELECTRICAL PROPERTIES OF HIGH TEMPERATURE SUPERCONDUCTING CERAMICS

By

SYED ALI BEER MOHAMED

Dissertation Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in the Faculty of Science and Environmental Studies Universiti Putra Malaysia

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LIST OF SYMBOLS AND ABBREVIATIONS

T_c	Critical temperature
B_c , B_{c1}, B_{c2}	Critical magnetic field
BSCCO	Bi-Sr-Ca-Cu-O system
GL theory	Ginzburg-Landau theory
BCS theory	Bardeen, Cooper and Schrieffer theory
LBCO	La-Ba-Cu-O system
YBCO	Y-Ba-Cu-O system
Y123	Family member in $YBa_2Cu_3O_{7-x}$
Bi(2201)	Family member in $Bi_2Sr_2Ca_nCu_{n+1}O_{6+2n}$, n =0
Bi(2212)	Family member in $Bi_2Sr_2Ca_nCu_{n+1}O_{6+2n}$, n =1
Bi(2223)	Family member in $Bi_2Sr_2Ca_nCu_{n+1}O_{6+2n}$, n =2
BPSCCO	Bi-Pb-Sr-Ca-Cu-O
TBCCO	Tl-Ba-Ca-Cu-O system
T(2223)	Family member in $Tl_2Ba_2Ca_nCu_{n+1}O_{6+2n}$, n =2
HBCCO	Hg-Ba-Ca-Cu-O system
TGA	Thermogravimetric Analysis
DTA	Differential Thermal Analysis
Calcination	Heating process where the solid state reaction occur
Sintering	Heating process yielding for more compacting of the sample grains and improve its properties
Acetate Precursor	Metal acetate dissolved in suitable solvent

Citrate Precursor	Metal citrate dissolved in suitable solvent
Oxide technique	Solid state reaction method
G_s	Gibbs free energy per unit volume
G_n	Free -energy density of the normal state
H	Applied magnetic field
M	Magnetization
μ_0	Permeability of free space
ξ	Coherence length
λ_L	Penetration depth
ε_F	Fermi energy
θ_D	Debye temperature
v_F	Fermi velocity
k	Boltzman constant
h	Blanck constant
N_s	Superelectron density
$N(\varepsilon)$	Density of state
Δ_0	The zero-temperature energy gap
C_s	Specific heat
λ	Electron- phonon coupling constant
$D_{ph}(\omega)$	Phonon density of the state
$\alpha^2(\omega)$	The electron -phonon coupling strength

μ^*	Coulombic repulsion
a, b, c	Lattice parameters
J_c	Critical current density
MRI	Magnetic Resonance Image
SQUID	Superconducting Quantum Interference Device
$MO(R)_m$	Metals alkoxides
$M(OH)_m$	Metal hydroxides
χ	Susceptibility
AC	Alternating Current
V	Induced voltage
ζ	Filling factor
V	Sample volume
α	Calibration coefficient
f, ω	Frequency and angular frequency
XRD	X-ray diffraction
$\mathbf{d}_{hkl}$	Reciprocal d vector
hkl	Miller indices
SEM	Scanning Electron Microscope
IR	Infrared
$\bar{\nu}$	Wave number

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Chairman : Associate Professor Abdul Halim Shaari, Ph.D.

Faculty : Science and Environmental Studies

It has been well known that Bi-Sr-Ca-Cu-O system has three superconducting phases represented by general formula, $Bi_2Sr_2Ca_{n-1}Cu_nO_y$, referred to as 2201(n = 1,T_C ~ 10K), 2212 (n=2, T_C ~ 80K), and 2223 (n = 3, T_C ~ 110K) The role of calcium and copper seem to influence the formation of those phases This research work was focussed at the role played by calcium in the formation of 2223 phase by doping this site with different elements having different valences and ionic radius

Samples of $Bi_{2-x}Pb_xSr_2Ca_2Cu_3O_y$ (x = 0 1 to 0 6) and $Bi_2Pb_{0\ 6}Sr_2Ca_{2-x}M_xCu_3O_y$ (M = Ba, Y, V, Zn, Sn with x =0 02 to 0 10) were prepared using the conventional solid state reaction technique The samples were sintered at 855^{0}C for 150 hours and annealed at 830^{0}C for 30 hours The transport properties of the samples were measured using four-point probe resistance measurement, magnetic properties by using ac susceptibility, microstructure by scanning electron