LIST OF FIGURES

Fig. 1.1 History of superconducting critical temperatures in metals, non oxide ceramics, alloys, oxide ceramics.(Ref. Wikipedia) 2

Fig.1.2 On passing below the transition temperature the magnetic lines of force are expelled, showing Meissner Oschenfeld effect 4

Fig.1.3 The behaviour of Type I superconductor in an applied magnetic field 7

Fig.1.4 The superconducting magnetisation curve of Type II superconductor 7

Fig.1.5 Crystal structure of YBCO (a) tetragonal phase (δ=1), (b) Orthorhombic phase (δ=0) 15

Fig.1.6 Temperature dependence of the resistivity for orthorhombic and tetragonal phase in YBCO 15

Fig.1.7 Dependence of Tc on oxygen content (7- δ) in YBCO 16

Fig.1.8 Calculated oxygen content in Y-123 compared with experimental data (open squares) [19] at various temperature and oxygen pressures [18]. Broken line indicates the solid phase orthorhombic to tetragonal phase transition 17

Fig.1.9 Dependence of RE-(III) ionic radius on lattice constant and peritectic temperature in RE-123. The RE-(III) ionic radii used for coordination number of eight 18

Fig.1.10 Schematic illustration of magnetic flux lines repelled by a superconductor with pinning centers 22

Fig.1.11 lattice constant vs. Temp. for Y-123 phase and for various substrates 23

Fig. 2.1 Schematic diagram of four- probe Tc measurement setup 35

Fig.2.1a Sample holder with samples affixed for four probe Tc measurement 35

Fig.2.2 A schematic drawing of Cold isostatic press 38

Fig.2.3 Schematic drawing of the various interactions of electron beam 41
Fig. 2.4 Schematic diagram of an SEM
Fig. 2.5 Schematic of EPMA system
Fig. 2.6 Schematic of Proportional counter detector of EPMA unit
Fig. 2.7 The schematic diagram of a transmission electron microscope
Fig. 2.8 Schematic of OIM
Fig. 2.9 Typical setup of EBSD with Kikuchi bands
Fig. 2.10 Kikuchi bands and corresponding indexing patterns
Fig. 2.11 Inverse pole figure mapping
Fig. 2.13 Magnetic measurement in SQUID
Fig. 2.14 Trapped magnetic field and levitation force measurement system
Fig. 2.15 Magnetising system
Fig. 2.16 Schematic of trapped magnetic and levitation force measurement system
Fig. 2.17 Data collection mapping of trapped magnetic field by hall probe of MTG samples
Fig. 2.18 Hysteresis loops at 77K for (a) a sintered Y-123 and (b) a zone melt textured Y-123 showing the increase in magnetization due to texturing.
Fig. 3.1 Flow sheet of synthesis (solid state route) Y-211 & Y-123
Fig. 3.2 Flow sheet of synthesis (nitrate decomposition route) of Y-123
Fig. 3.3 Y-123 powder in a alumina boat
Fig. 3.4 Y-211 powder in a alumina boat
Fig. 3.5 Particle size distribution of Y-211 powder (a) synthesised by solid state route (b) nitrate decomposition route
Fig. 3.6 XRD of Y-211 powder synthesized by solid state route
Fig. 3.7 XRD of Y-211 synthesized by nitrate decomposition route
Fig. 3.8 XRD of Y-123 powder synthesized by solid state route
Fig. 3.9 R vs T of sintered Y-123 pellet
Fig. 3.10 SEM image of fractured surface sintered Y-123 pellet
Fig. 3.11 High temperature XRD of sintered Y-123 powder
Fig. 3.12 R Vs T plot of Y-123 samples quenched from different Temperatures to liq.N2
Fig. 3.13 Tc as a function of oxygen content in Y-123
Fig. 4.1 XRD of sintered Y-123 powder
Fig. 4.2 XRD of composite B, (B1) - as mixed powder, (B2) - sintered powder, (B3) – Quenched powder
Fig. 4.3 XRD of composite C, (C1) as mixed powder, (C2) sintered powder, (C3) Quenched powder
Fig. 4.4 XRD of composite D, (D1) as mixed powder, (D2) sintered powder, (D3) Quenched powder
Fig. 4.5 SEM micrograph of fractured surface of sintered pure Y-123 pellet
Fig. 4.6 SEM micrograph of fractured surface of sintered pellet of composite A
Fig. 4.6a SEM micrograph of fractured surface of sintered pellet of composite B
Fig. 4.7 SEM micrograph of fractured surface of sintered pellet of composite C
Fig. 4.8 SEM micrograph of fractured surface of sintered pellet of composite D
Fig. 4.9 SEM micrograph of fractured surface of quenched pellet of composite B
Fig. 4.10 SEM micrograph of fractured surface of quenched pellet of composite C
Fig. 4.11 SEM micrograph of fractured surface of quenched pellet of composite D
Fig. 4.12 BSE image and corresponding X-ray mapping of sintered composite B
Fig. 4.13 BSE image and corresponding X-ray mapping of sintered composite C
Fig. 4.14 BSE image and corresponding X-ray mapping of sintered composite D

Fig. 5.1 Section of the Y-123 ternary phase diagram

Fig. 5.2 Mechanism of Y-211 diffusion to solid Y-123 front growth in MTG tech.

Fig. 5.3 Picture of moulds for fabricating components: (1) Mould for hollow cylinder 1, (2) Mould for plates, (3) Moulds for PINS, (4) Moulds for hollow cylinder 2, (5) Mould for hollow cylinder 3.

Fig. 5.4 Typical picture of mould and filling composite powder in mould with vibrating

Fig. 5.5 Typical thermal schedule for fabricating MTG components

Fig. 5.6 Flow chart of typical MTG technique

Fig. 5.7 Picture of cylinder during stages of fabrication using mould size hollow cylinder: (1) Compacted cylinder, (2) Sintered cylinder, (3) MTG cylinder

Fig. 5.8 Pictures of plate during various stages of fabrication using mould size plate 1: (1) Compacted plates, (2) Sintered plates, (3) TSMTG plates

Fig. 5.9 Pictures of pin during various stages of fabrication using mould size pin 1: (1) Compacted pin, (2) Sintered pin, (3) MTG pin

Fig. 5.10 Pictures of cylinder during various stages of fabrication using mould size hollow cylinder 2: (1) Compacted cylinder, (2) Sintered cylinder, (3) TSMTG cylinder

Fig. 5.11 Machined TSMTG cylinders

Fig. 5.12 Machined TSMTG plates

Fig. 5.13 Machined TSMTG pins using composite B (NDR-PI-1)

Fig. 5.14 Picture of rubber mould used to fabricate MTG components

Fig. 6.1 Critical transition temperature R Vs T plot of sintered & TSMTG SSR-PL-1 plate

Fig. 6.2 XRD of sintered pellet
Fig. 6.3 XRD of MTG NDR-PL-2 plate

Fig. 6.4 SEM and EDS of TSMTG SSR-PL-1 plate

Fig. 6.5 BSE and corresponding X-ray mapping of sintered MTG SSR-PL-1 plate

Fig. 6.6 SEM image of TSMTG SSR-PL-1 and corresponding elemental line profile

Fig. 6.7 OIM image of SSR-PL-1 plate

Fig. 6.8 TSMTG SSR-PL-1 plate was cut as shown in figure, the cut black portion was used for measuring for trapped magnetic field (a) and graph shows plot of SSR-PL-1 plate (b)

Fig. 6.9 Levitation force measurement of SSR-PL-1 plate

Fig. 6.10 Critical current density of SSR-CY-1 TSMTG hollow cylinder

Fig. 6.10a XRD pattern of TSMTG NDR-PL-2 plate

Fig. 6.11 SEM micrograph of NDR-PL-1 plate

Fig. 6.12 OIM image of TSMTG NDR-PL-2 plate

Fig. 6.13 HRTEM image of sintered Y-123 powder

Fig. 6.14 HRTEM image TSMTG NDR-PL-2 powder

Fig. 6.15 Trapped magnetic field measurement of TSMTG NDR-PL-1 plate

Fig. 6.16 Levitation force of NDR-PL-1 plate

Fig. 6.17 SQUID plot of NDR-PL-2 plate

Fig. 6.18 J_c measurement of NDR-CY-2 cylinder

Fig. 6.18a J_c measurement of MTG hollow cylinder NDR-CY-2 fabricated using composite –B with similar process used as in TSMTG NDR-CY-2 cylinder

Fig. 6.19 J_c of top portion of NDR-Cy-3 cylinder

Fig. 6.20 J_c of bottom portion of NDR-CY-3 cylinder

Fig. 6.21 SEM and corresponding EDS of Pt-CY-5 TSMTG sample
Fig. 6.22 BSE and corresponding X-ray mapping of sintered SSR-PL-1 plate

Fig. 6.23 $J_c$ measurement of TSMTG Pt-Cy-5 cylinder

Fig. 6.24 SEM and EDS spectrum of TSMTG Ce-CY-6 plate

Fig. 6.25 EPMA of TSMTG Ce-CY-6 plate

Fig. 6.26 $J_c$ measurement TSMTG of Ce-CY-6 cylinder

Fig. A.1 Levitation force measured at a distance of 1mm from magnet and pins for 7 pins bunched was found to be 17 N

Fig. A.2 Levitation force measured at a distance of 1mm from magnet and pins for 19 pins bunched was found to be 34 N

Fig. A.3 (A) Schematic drawing of rotor, (B) parts of rotor with HTSC plates, (C) assembled plate type rotor

Fig. A.4 (a) Schematic drawing of rotor, (b) parts of rotor with HTSC pins, (c) assembled pin type rotor

Fig. A.5 HTSC hollow cylinder fixed inside the rotor and assembly of hollow cylinder type rotor

Fig. A.6 HTSC motor assembly

Fig. A-7 Levitating magnet on TSMTG pellet
## LIST OF TABLES

Table 1.1 Characteristics of metallic and oxide superconductors  
Table 1.2 Application of HTSC materials  
Table 1.3 Progress and necessary factors for high $J_c$ HTSC materials  
Table 3.1 Oxygen content, $T_c$ and lattice parameters of Y-123, quenched from various temperature to liquid nitrogen  
Table 5.1 Required final dimensions of MTG components  
Table 5.2 Various moulds with shapes and sizes designed for fabricating components with corresponding photographs  
Table 5.3 Components fabricated using composites in rubber moulds  
Table 5.4 Shrinkage in size of the compacts while pressing, after sintering and after subjected to MTG  
Table 6.1 Critical current density of TSMTG hollow cylinders  
Table 6.2 Comparison of magnetic properties of TSMTG plates
Publications

Journal

1) Experimental Analysis of Different Type HTS Rings in Fault Current limiter
A.Gyore, I. Vajda, M R Gonal, K. P. Muthe, S C Kashyap, and D K Pandya.

2) Bulk High Temperature Superconductors Prepared by Melt Textured Growth
Technique- Effect of Y$_2$BaCuO$_5$ Particle Size
M. R. Gonal, R.C. Hubli and A.K. Tyagi

3) Study of Superconducting Properties in Melt Textured YBCO samples
M. R. Gonal, K.G.Bhushan, S Ramanathan, R.C. Hubli, A.K. Tyagi, and
G.P.Kothiyal
AIP Conf. Proc. 1447, 911

4) The Effect of Addition of Y-211 with two Different Particle Sizes on the
Properties of Melt Processed YBa$_2$Cu$_3$O$_{7-δ}$ (YBCO) Bulk Superconductors
Vajda
IEEE transactions on Applied Superconductivity (Communicated)

Symposium

1) Characterisation of Bulk High Temperature Superconductors Prepared by
Melt Textured Growth Technique
M. R. Gonal, R.C. Hubli and A.K. Tyagi†