

Ravi Chandra Gundakaram

International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI)

Balapur P.O., HYDERABAD 500 005, INDIA

Tel: +91-9490119636; e-mail: ravi.gundakaram@gmail.com

SUMMARY OF EXPERIENCE

- 32 years' post-Ph.D. research experience in the characterization and synthesis of materials, and 19 years' experience in R&D administration
- 20+ years' experience in setting up advanced facilities for characterization of materials, and in running the Centre for Materials Characterization and Testing at ARCI
- Guided three students for Ph.D. in Materials Engineering (two of them registered at SEST), and several students for M.Tech., M. Sc. and B. Tech. projects
- Skilled in microstructural studies using electron microscopy, in the measurement of mechanical, magnetic, transport and mechanical properties of materials, and in instrumentation
- 61 publications in international refereed journals, and three chapters in book series
- Referee for national and international journals

RESEARCH EXPERIENCE (Post-Ph.D.)

2004- INTERNATIONAL ADVANCED RESEARCH CENTRE FOR POWDER METALLURGY AND NEW MATERIALS (ARCI)

Hyderabad, INDIA

2018- *Scientist 'G' (Present position)*

2010-18 *Scientist 'F'*

2004-10 *Scientist 'E'*

**2005-10 *Team Leader, Centre for Mechanical and Microstructural
Characterization***

**2010- *Team Leader/Head, Centre for Materials Characterization
and Testing***

- Microstructural studies using electron microscopy (Electron Backscatter Diffraction, Focused Ion Beam Milling and Transmission Electron Microscopy)
- Structural studies by x-ray diffraction
- Microstructure-structure-property correlations in materials, with special focus on coatings and films

- Study of the mechanical properties of coatings at sub-micron length scales using Nanoindentation
- Synthesis and study of multicomponent alloys for refractory applications
- Establishing new facilities for microstructural, structural and chemical characterization and setting up of infrastructure for R&D
- Administration of a Centre consisting of Scientists, Technical Officers, Technical Assistants, Technicians and students

Established the following major imported facilities at ARCI as Indenting Officer:

1. Transmission electron microscope (TEM) with LaB₆ filament
2. Field emission scanning electron microscope (FE-SEM)
3. Focused ion beam (FIB) milling unit with gas injector system
4. Scanning electron microscope (Tungsten filament)
5. Non-contact optical profiler with sub-nanometre resolution
6. Ion beam etching and coating unit
7. Electropolishing unit
8. Optical microscope with image analyzer
9. Digital macrohardness and microhardness testers

As Team Leader/Head, was involved in the establishment of the following major facilities:

1. Small angle x-ray scattering (SAXS) unit
2. High flux x-ray diffraction unit with 9kW rotating anode generator, with low (77K) and medium (600K) temperature attachments
3. Inductively-Coupled Plasma Optical Emission Spectrometer (ICP-OES)
4. Field emission gun transmission electron microscope (FEG-TEM)

2002-04 ALFRED UNIVERSITY, Alfred, NY, U.S.A.

Research Scientist

- Electron Backscatter Diffraction studies on metals and alloys
- Study of chemical durability of glass systems using ICP-AES
- Study of dopant incorporation in ceramics

2000-01 MERCK-KANTO ADVANCED CHEMICAL LTD., Taipei, Taiwan

Process Development Specialist

- Synthesis of Bi-based High- T_c superconductors
- Study of phases and phase transformations in high- T_c superconductors
- Measurement of magnetic and transport properties
- XANES measurements with synchrotron radiation (at the synchrotron Radiation Research Center, Hsinchu, Taiwan)

1997-99 NATIONAL TAIWAN UNIVERSITY, Taipei, Taiwan

Post-Doctoral Fellow

- Synthesis of oxides showing colossal magnetoresistance (CMR) with the three-dimensional and layered structures
- Electron spin resonance (ESR) measurements and study of the spin dynamics in CMR oxides
- Magnetoresistance measurements in fields up to 10 Tesla
- Study of the effect of reduced dimensionality and the insulator-metal transition

**1994-97 INDIAN INSTITUTE OF SCIENCE AND JAWAHARLAL NEHRU
CENTRE FOR ADVANCED SCIENTIFIC RESEARCH, Bangalore, India**

Research Associate

- Synthesis of several families of transition metal oxides, especially CMR materials and High- T_c superconductors
- Magnetic measurements with a Faraday balance and study of magnetic exchange interactions in rare-earth manganates
- Low temperature resistivity and magnetization measurements up to 10 K

**1993 OSMANIA UNIVERSITY AND B.H.E.L. CORPORATE R&D CENTRE,
Hyderabad, India**

Research Fellow

- Fabrication of High- T_c superconducting tapes by the powder-in-tube method
- Resistivity and critical current density measurements on superconducting tapes

RESEARCH EXPERIENCE (Ph.D.)

Department of Physics, Osmania University, Hyderabad, India

- Synthesized High- T_c superconductors of the Bi-2223 and Bi-2212 systems and studied the effect of dopants on superconductivity
- Fabricated experimental setups for the measurement of transport and magnetic properties (electrical resistivity, magnetic susceptibility and critical current density)
- Automated measurements by interfacing the experimental setups to PCs and developed the necessary software
- Designed and constructed high-temperature resistive furnaces for synthesis of oxide ceramics
- Studied phase purity of samples by recording and analyzing x-ray diffraction patterns

EDUCATION

Ph.D.	Physics	1987 – 1992
	Osmania University, Hyderabad, India	
	Doctoral Dissertation: Effect of addition of Ag, Cd, In, Sn and Sb on the superconducting properties of the Bi-2223 system	
	Ph.D. Supervisor:	Prof.S.V.Suryanarayana
M.Sc.	Solid State Physics	1985 - 1987
	University of Hyderabad, India	
B.Sc.	Physics	1982 - 1985
	Nagarjuna University, India	

SKILLS

Computer related: Interfacing of equipment to computers for data collection and analysis

Languages: English, Telugu, Hindi, Tamil, Kannada, German, Spanish and Mandarin (elementary)

AWARDS

Fellow of the Electron Microscope Society of India (2020)

PUBLICATIONS IN JOURNALS

1. High-temperature oxidation behavior of $\text{Nb}_x(\text{MoTaW})_{(1-x)}$ ($x = 0.25, 0.4, 0.55, \text{ and } 0.7$) refractory multicomponent alloys
Anjali Kanchi, Koteswararao V. Rajulapati, Vijayaraghavan Ganesan,
Ravi C. Gundakaram
Intermetallics 177 (2025) 108604
2. Electrochemical corrosion behavior of $\text{Nb}_x(\text{MoTaW})_{(1-x)}$ ($x = 0.25, 0.4, 0.55, \text{ and } 0.7$) refractory multicomponent alloys
Anjali Kanchi, Koteswararao V. Rajulapati, A. Jyothirmayi,
Ravi C. Gundakaram
Materials Letters 377 (2024) 137472
3. Effect of Nb content on the mechanical properties of $\text{Nb}_x(\text{MoTaW})_{(1-x)}$ ($x = 0.4, 0.55, \text{ and } 0.7$) refractory multicomponent alloys
Anjali Kanchi, Koteswararao V. Rajulapati, D. Sivaprahasam, S.S. Satheesh Kumar,
I. Balasundar, Ravi C. Gundakaram
Intermetallics 172 (2024) 108379
4. Influence of Thermomechanical Processing on Microstructure and Mechanical Properties of MoNbTaW Refractory High-Entropy Alloy
Kanchi, A., Rajulapati, K.V., Rao, B.S., Sivaprahasam, D., Gundakaram, R.C.
Journal of Materials Engineering and Performance 31(10) (2022) 7964-7972
5. Tailoring the Microstructure and Mechanical Properties of Titanium Alloy Ti6Al4V Forgings with Different Combinations of Thermo-Mechanical Processing and Heat Treatment Cycles
Pravendra Pratap Singh, R. K. Gupta, V. Anil Kumar, Ravi C. Gundakaram and
Satish Kumar Singh
Transactions of the Indian National Academy of Engineering 6 (2021) 839
6. Room Temperature and 600°C Erosion Behaviour of Various Chromium Carbide Composite Coatings
L. Venkatesh, B. Venkataraman, Manish Tak, G. Sivakumar,
Ravi C. Gundakaram, S.V. Joshi, I. Samajdar
Wear 422-423 (2019) 44
7. Microstructural response of various chromium carbide based coatings to erosion and nano impact testing
L. Venkatesh, Suresh Babu Pitchuka, G. Sivakumar, Ravi C. Gundakaram,
S.V. Joshi, I. Samajdar
Wear 386–387 (2017) 72–79

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8. Morphology-Dependent Hardness of Cr₇C₃-Ni-Rich Alloy Composite vs Orientation Independent Hardness of Cr₇C₃ Primary Phase in a Laser Clad Microstructure
Venkatesh, L.N., Suresh Babu, P., **Gundakaram, R.C.**, Doherty, R.D., Joshi, S.V. and Samajdar, I
Metallurgical and Materials Transactions A: Physical Metallurgy and Materials Science 48(4) (2017) 1534-1539
 9. Single pass laser-arc hybrid welding of maraging steel thick sections
Subashini, L, Prabhakar, K.V.P., **Gundakaram, R.C.**, Ghosh, S and Padmanabham, G.
Materials and Manufacturing Processes 31(16) (2016) 2186-2198
 10. Microstructural studies of oxide dispersion strengthened austenitic steels
Suresh, K., Nagini, M., Vijay, R., Ramakrishna, M., **Ravi C. Gundakaram**, Reddy, A.V. and Sundararajan, G.
Materials and Design 110 (2016) 519-525
 11. Nanoindentation and tensile testing of human hair fibres
Mishra, S., Kunchi, C., Venkateshan, K., **Gundakaram, R.C.** and Asusumalli, R.B.
Journal of Materials Science (2016) 51 10191
 12. Microstructure and phase evolution in laser clad chromium carbide-NiCrMoNb
Venkatesh, L., Samajdar, I., Tak, M., Roger D. Doherty, **Ravi C. Gundakaram**, K. Satya Prasad and S.V. Joshi
Applied Surface Science 357 Part B (2015) 2391-2401
 13. Controllable crystallographic texture in copper foils exhibiting enhanced mechanical and electrical properties by pulse reverse electrodeposition
Chokkakula L.P. Pavithra, Bulusu V. Sarada, Koteswararao V. Rajulapati, M. Ramakrishna, **Ravi C. Gundakaram**, Tata N. Rao and G. Sundararajan
Crystal Growth and Design 15(9) (2015) 4448-4458
 14. Effect of microstructure and phase constitution on mechanical properties of Ti_{1-x}Al_xN coatings
Sai Pramod Pemmasani, Krishna Valleti, **Ravi C. Gundakaram**, Koteswararao V. Rajulapati, Ramakrishna Mantripragada, Suresh Koppoju and Shrikant V. Joshi
Applied Surface Science 313 (2014) 936-946
 15. Rapid consolidation of FeAl-Fe₃AlC_x ultrafine composites by mechanically activated field-assisted technique
Archana, M.S., **Gundakaram, R.C.**, Rao, Y.S., V.V.V.S. Srikanth, S.V. Joshi and J. Joardar
Materials Science and Engineering: A 611 (2014) 298-305

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16. Nanocrystalline phases during mechanically activated processing of an Iron (Fe) Aluminum (40 at% Al) alloy
M. S. Archana, M. Ramakrishna, **Ravi C. Gundakaram**, V.V.S.S. Srikanth, S.V. Joshi and J. Joardar
Materials and Manufacturing Processes 29 (2014) 864-869
 17. Characterization of multilayer nitride coatings by Electron Microscopy and Modulus mapping
Sai Pramod Pemmasani, K.V. Rajulapati, M. Ramakrishna, K. Valleti, **Ravi C. Gundakaram** and S.V. Joshi
Materials Characterization 81 (2013) 7
 18. Effect of addition of surface modified nanosilica into silica-zirconia hybrid solgel matrix
Sowntharya, L., **Gundakaram, R.C.**, Soma Raju, K.R.C. and Subasri R.
Ceramics International 39(4) 2013 4245-4252
 19. Characterization of coatings by SEM-based Microdiffraction
Gundakaram, R.C. and Pemmasani S.P.
Materials Science Forum vol. 702-3 (2012) 570-573
 20. Process parameter impact on microstructure and phase constitution of laser clad Inconel-chromium carbide layers
Venkatesh, L., Samajdar, I., Tak, M., **Gundakaram, R.C.** and Joshi, S.V.
Materials Science Forum vol. 702-3 (2012) 963-966
 21. Structure-property correlations in cathodic arc deposited TiAlN coatings
S.P. Pemmasani, Krishna Valleti, M. Ramakrishna, K.V. Rajulapati, **Ravi C. Gundakaram** and S.V. Joshi
Materials Science Forum vol. 702-3 (2012) 967-970
 22. Extensive nanotwinning: Origin of high current density to high fields in perform-optimized infiltration-growth-processed $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ superconductor
Devendra Kumar, N., Rajasekharan, T., **Gundakaram, R.C.** and Seshubai V.
IEEE Transactions on Applied Superconductivity 21(6) (2011) 3612-3620
 23. The tribological behaviour of detonation sprayed TiMO(CN) based cermet coatings
G. Sundararajan, G. Sivakumar, D. Sen, D. Srinivasa Rao and **G. Ravichandra**
Intl. J. of Refractory Metals and Hard Mater. 28(1) (2010) 71-81
 24. The influence of heat treatment on the microstructural, mechanical and corrosion behaviour of cold sprayed SS 316L coatings
G. Sundararajan, S.P. Phani, A. Jyotirmayi and **Ravi C. Gundakaram**
J. Mater. Sci 44 (2009) 2320

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25. Isostructurality, polymorphism and mechanical properties of some hexahalogenated benzenes: The nature of halogen ••• halogen interactions
Reddy C.M., Kirchner M.T., **Gundakaram R.C.**, Padmanabhan K.A., Desiraju G.R.
Chemistry: A European J. **12 (8)** (2006) 2222-2234
26. Structural basis for bending of organic crystals
Reddy C.M., **Gundakaram R.C.**, Basavoju S., Kirchner M.T., Padmanabhan K.A., Desiraju G.R.
Chem. Comm. 31 (2005) 3945-3947
27. Electrical and Magnetic Properties of $\text{NdTiO}_{3+\delta}$
E.J. Connolly, R.J.D. Tilley, A. Arulraj, **R. Gundakaram**, C.N.R. Rao
J. Alloys Compounds 388 (2005) 153
28. Electric dipolarization near the metal-insulator transition in $\text{La}_{1-x}\text{Sr}_x\text{MnO}_3$
Chern G., Liu Y.L., Tai M.F., **Gundakaram R.**, Lin J.G.
Chin. J. Phys. **43 (4)** (2005) 867-873
29. Tuning Pb content in high- T_c $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ superconductors studied by X-ray absorption near-edge structure spectroscopy
Chang S.C., **Gundakaram R.**, Chen J.M., Liu R.S.
J. Low Temp. Physics **131 (3-4)** (2003) 613-618
30. 'Maturization' of high- T_c precursor powders for use in superconducting tapes
R. S. Liu, **R. Gundakaram**, S. C. Chang, L. Woodall and M. Gerards
Physica C **372-376** (2002) 1167-1170
31. Chemical pressure induced phase transition in single and double perovskites with magnetoresistance effect
Liu, R.S., Shen, C.H., Chan, T.S., **Gundakaram, R.**, Hu, S.F., Lin, J.G. and Huang, C.Y.
Tamkang Journal of Science and Engineering 5(1) (2002) 59-61
32. Effect of secondary phases in the precursor powders on the transformation to the (Bi,Pb)-2223 phase
Gundakaram, R., Chang, S.C., Liu, R.S., Woodall, L. and Gerards, M.
MRS Symposium-Proceedings 689 (2002) 81-86
33. Absence of phase transformation at low temperature in Co-doped LiMn_2O_4 samples
Shen, C.-H., **Gundakaram, R.**, Liu, R.-S. and Sheu, H-S.
Journal of the Chemical Society, Dalton Transactions (1) (2001) 37-40

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34. Effect of Pb doping in high- T_c $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ superconductors studied by X-ray absorption near-edge structure spectroscopy
R.S. Liu, S.C. Chang, **R. Gundakaram**, J.M. Chen, L.Y. Jang, L. Woodall and M. Gerards
Physica C **364-365** (2001) 567
35. Evidence for electron-doped (n-type) superconductivity in the infinite-layer $(\text{Sr}_{0.9}\text{La}_{0.1})\text{CuO}_2$ compound by X-ray absorption near-edge spectroscopy
Liu RS, Chen JM, Nachimuthu P, **Gundakaram R**, Jung CU, Kim JY, Lee SI
Solid State Commun. 118 (7) (2001) 367-370
36. Crystal and electronic structures of inverse spinel-type LiNiVO_4 prepared by the sol-gel method
R. S. Liu, Y. C. Cheng, **R. Gundakaram** and L. Y. Jang
Mat. Res. Bull. **36** (2001) 1479
37. Effect of Co doping in LiMn_2O_4
C. H. Shen,, R. S. Liu , **R. Gundakaram**, J. M. Chen, S. M. Huang, S. Chen and C. M. Wang
J. Power Sources **102** (2001) 21
38. Chemical control of colossal magnetoresistance in manganites
C. H. Shen, R. S. Liu, **R. Gundakaram**, S. F. Hu, J. G. Lin, C. Y. Huang and C. M. Wang
Mat. Chem. Phys. **72** (2001) 281-285
39. Studies into the phase transformation of Bi-2223 precursor powders using X-ray diffraction and SQUID susceptibility measurements
R. Gundakaram, S.-C. Chang, R. S. Liu, L. Woodall and M. Gerards
IEEE Trans. Appl. Supercond. **11** (2001) 3182
40. Absence of phase transformation at low temperature in Co-doped LiMn_2O_4 samples
Chih-Hung Shen, **R. Gundakaram**, Ru-Shi Liu and Hwo-Shuenn Sheu
J. Chem. Soc., Dalton Trans. (2001) 37
41. Internal chemical pressure effect and magnetic properties of $\text{La}_{0.6}(\text{Sr}_{0.4-x}\text{Ca}_x)\text{MnO}_3$
C. H. Shen, C. C. Chen, R. S. Liu, **R. Gundakaram**, S. F. Hu and J. M. Chen
J. Solid State Chem. **156** (2001) 117
42. Effects of dimensionality in the rare-earth manganates
R. Gundakaram and C. Y. Huang
Int. J. Mod. Phys. B **13** (1999) 3792

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43. Cr doping in the $\text{La}_{1.2}\text{Sr}_{1.8}\text{Mn}_2\text{O}_7$ system
R. Gundakaram, J. G. Lin, C. H. Chen, R. S. Liu, F. Y. Lee, M. F Tai
and C. Y. Huang
J. Phys.: Condens. Matter. **11**(26) (1999) 5187
44. Electron spin resonance study on CMR oxides
R. Gundakaram, J. G. Lin, C. S. Lee, P. C. Kuo and C. Y. Huang
J. Magn. Soc. Japan **23** (1999) 531
45. Internal pressure effect on some manganite oxides
C. Y. Huang, **R. Gundakaram** and J. G. Lin
Int. J. Mod. Phys. B **12** (1998) 315
46. Size effect on the electron spin resonance of $\text{Pr}_{0.7}\text{Sr}_{0.3-x}\text{Ca}_x\text{MnO}_3$
R. Gundakaram, J.G. Lin and C. Y. Huang
Phys. Rev. **B58** (1998) 12247
47. Electron spin resonance study of $\text{Nd}_{0.7}\text{Sr}_{0.3-x}\text{Ca}_x\text{MnO}_3$
J.G.Lin, **R.Gundakaram**, J.B.Wu, R.S.Liu and C.Y.Huang
Chinese J. Phys. **36** (1998) 453
48. The nature of charge-ordered state in $\text{Y}_{0.5}\text{Ca}_{0.5}\text{MnO}_3$ with a very small average
radius of the A-site cations
Anthony Arulraj, **R.Gundakaram**, Amlan Biswas, N.Gayathri,
A.K.Raychaudhuri and C.N.R.Rao
J. Phys.: Condens. Matter **10** (1998) 4447
49. Electrical transport, magnetism and magnetoresistance in ferromagnetic
oxides with mixed exchange interactions: A study of the
 $\text{La}_{0.7}\text{Ca}_{0.3}\text{Mn}_{1-x}\text{Co}_x\text{O}_3$ system
N.Gayathri, A.K.Raychaudhuri, S.K.Tiwary, **R.Gundakaram**,
Anthony Arulraj and C.N.R.Rao
Phys. Rev. **B56** (1997) 1345
50. Effect of substitution of Cr^{3+} in place of Mn^{3+} in Rare-earth manganates
on the magnetism and magnetoresistance: Role of superexchange
interaction and lattice distortion in $\text{LnMn}_{1-x}\text{Cr}_x\text{O}_3$
R.Gundakaram, Anthony Arulraj, P.V.Vanitha, C.N.R.Rao, N.Gayathri,
A.K.Raychaudhuri and A.K.Cheetam
J. Solid State Chem. **127** (1996) 354
51. Unusual field dependence of the resistivity and magnetoresistance in
 $\text{Nd}_{0.5}\text{Ca}_{0.5}\text{MnO}_3$
R.Mahendiran, R.Mahesh, **R.Gundakaram**, A.K.Raychaudhuri and
C.N.R.Rao
J. Phys.: Condens. Matter **8** (1996) L455

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52. Magnetic properties of Rare-earth nickelates of the $\text{Ln}_2\text{BaNiO}_5$ family
R.Gundakaram, N.Y.Vasanthacharya, A.K.Ganguli and C.N.R.Rao
Eur. J. Solid State Inorg. Chem. **33** (1996) 41
53. Phosphate derivatives of 123 cuprates of the formula $\text{LnSr}_2\text{Cu}_3\text{O}_7$
(Ln = Gd, Dy and Ho)
R.Nagarajan, **R.Gundakaram** and C.N.R.Rao
Solid State Commun. **98** (1996) 761
54. Transformation of the oxygen-deficient 123 cuprates, $\text{LnBa}_2\text{Cu}_3\text{O}_{7-x}$
(Ln = Nd, Gd, Dy, Er : $0.3 \leq x \leq 0.4$) to a 124-type structure on low
temperature annealing
K.M.Bhat, **Ravichandra Gundakaram**, G.N.Subbanna and A.K.Ganguli
Solid State Commun. **95** (1995) 629
55. Potassium substitution in the $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ superconductor
B.Gopala Krishna, **G.Ravi Chandra** and S.V.Suryanarayana
Mat. Sci. Engg. **B25** (1994) 153
56. Tin addition to the superconducting Bi-2223 system
G.Ravi Chandra, B.Gopala Krishna and S.V.Suryanarayana
Mod. Phys. Lett. **B8** (1994) 1175
57. Effect of heat treatments and additives on the superconducting properties of
the Bi-2223 system
Ravichandra Gundakaram and S.V.Suryanarayana
Appl. Supercond. **1** (1993) 535
58. Effect of sodium substitution on superconductivity in Bi-based 2212 system
B.Gopala Krishna, **G.Ravi Chandra** and S.V.Suryanarayana
Physica C, **200** (1992) 425
59. Thermal expansion and superconductivity in alkali metal and silver doped
Bi-Sr-Ca-Cu-O System
B Gopala Krishna, **G.Ravi Chandra** and S.V.Suryanarayana
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60. Superconductivity in Na doped $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ system
S.V.Suryanarayana, B.Gopala Krishna, **Ravichandra Gundakaram** and
S.Venkat Reddy
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61. Effect of annealing and quenching on superconductivity in Pb and Sb doped
 $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_y$
S.V.Suryanarayana, **Ravichandra Gundakaram**, B.Gopala Krishna and
S.Venkat Reddy
Bull. Mater. Sci. **414** (1991) 327

BOOK CHAPTERS

1. Applications of EBSD in Materials Science

Ravi C. Gundakaram

“Microscopy Applied to Materials and Life Sciences”, Apple Academic Press (USA)
(2018) pp 227-256 ISBN 9781771886727

2. An introduction to the characterization of coatings

Ravi C. Gundakaram

“Surface Engineering”, D.S. Rao and S.V. Joshi, Eds., Daya Publishing House, Delhi,
2010, pp. 393-423

3. Highly reactive (Bi,Pb)-2223 precursor powders via process tuning

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“Studies of High Temperature Superconductors (Advances in Research and
Applications): The BSCCO System – II”, ed. A.V. Narlikar,
Nova Science Publishers, New York; vol. **36** (2000) 119-142