

# CURRICULUM VITAE

## 1. Name, designation and address for communication:

DR. INDRANIL MANNA

*FNA, FNAE, FNASc, FASc, FIE(I), FIIM, FEMSI, PRS, PhD*

DIRECTOR

Central Glass and Ceramic Research Institute (CGCRI), A CSIR Laboratory

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Institute Homepage: [www.cgcri.res.in](http://www.cgcri.res.in); Personal Homepage: [www.imanna.org](http://www.imanna.org)

[**ON LIEN from:** Department of Metallurgical and Materials Engineering  
Indian Institute of Technology (IIT), KHARAGPUR; W.B. 721 302, INDIA]

## 2. Residential address:

Flat # 9A, Block I, SIRSA Campus, 59 Lake Road, Kolkata 700029 (Tel +91 33 24666696)

Permanent: P-10/250, KALYANI, NADIA, WB 741 235, INDIA (Tel: +91 33 6453 7138)

3. **Date and Place of Birth:** January 22, 1961; CALCUTTA

4. **Religion:** Hinduism

5. **Nationality:** Indian (Passport No.: G 4442056)  
Born in Calcutta, India

6. **Family Status:** Married with two children

## 7. Educational Qualifications:

DEGREE/EXAMINATION (TENURE)	INSTITUTION	MAJOR	PERFORMANCE
<i>Premchand Roychand Scholarship (PRS)</i> (1993-1998)	CALCUTTA UNIV. Calcutta - 700 071 <i>India</i>	Applied Physics (Metallurgy)	Thesis accepted & Mouat medal awarded (1999)
<i>Doctor of Philosophy (Ph.D.)</i> (1986-1990)	I.I.T., KHARAGPUR W.B.-721302 <i>India</i>	Engineering	No grade is awarded

<b><i>Master of Technology</i></b> <b>(M.Tech.)</b> (1983-1984)	<b>I.I.T., KANPUR</b> U.P.- 208016 <i>India</i>	Physical Metallurgy	<b>Topper</b> Cumulative Perform. Index = 9.6/10.0
<b><i>Bachelor of Engineering</i></b> <b>(B.E.)</b> (1979-1983)	<b>B. E. College</b> (Calcutta University) <i>India</i>	Metallurgy	Rank - 2 <sup>nd</sup> Class - I 79% in aggregate
<b><i>Higher Secondary</i></b> (Class-XII) (1977-1979)	<b>Pannalal Institution</b> Kalyani, W.B. (under W.B.C.H.S.E.)	Science	<b>1st Div.</b> 69% in aggregate
<b><i>Secondary Examination</i></b> (Class - X) (1971-1977)	<b>Pannalal Institution</b> Kalyani, W.B. (under W.B.B.S.E.)	General	<b>1st Div., Rank - 43rd</b> <b>Star Marks</b> 77% in aggregate

## 8. Professional (Research/Teaching) Experience:

- A. **Director**, Central Glass and Ceramic Research Institute (CGCRI), Jadavpur, Kolkata. A CSIR Laboratory (under the Ministry of Science and Technology, Government of India) – since March 1, 2010.

### Administrative responsibilities within CSIR:

- a) **Member, Governing Body and Society of CSIR** (highest body of CSIR)
  - b) **Member, Planning Commission Working Group of CSIR** for 12<sup>th</sup> five year plan
  - c) **Member, Planning Commission Working Group of DAE** (as DG-CSIR's representative) for 12<sup>th</sup> five year plan
  - d) **Member, Planning Commission Working Group of DST** for 12<sup>th</sup> five year plan
  - e) **Member, Senate, Academy of Scientific & Industrial Research (AcSIR)**
  - d) **Member, Management side, Joint Consultative Mechanism, CSIR**
  - e) **Member, Monitoring Committee**, NMITLI project on SOFC at CSIR-CGCRI
  - f) **Chairman, Steering Committee**, NMITLI Project on SOFC at CSIR-CGCRI
  - g) **Task Force Chairman**, CSIR Network Projects NWP 027, 028, 029, 035, 051
  - h) **Task Force Chairman**, CSIR Supra institutional Project SIP 023
  - i) **Member, Research Council** of CSIR-NML, CSIR-NPL, CSIR-CMERI, CSIR-AMPRI
  - j) **Member, Management Council** of CSIR-NML and CSIR-IICB
  - k) **Member, Advisory Committee**, CSIR Innovation Complexes at Chennai, Mumbai, and Kolkata (Baruipur and Salt Lake)
  - l) **Chairman**, CSIR Committee on Human Resource Development, Engineering Sciences (ENG-41)
  - m) **Chairman**, Bureau of Indian Standards, Ministry of Consumer Affairs, Standards Committee on Ceramics (CHD 09) [as Director, CSIR-CGCRI]
  - n) **Chairman**, Bureau of Indian Standards, Ministry of Consumer Affairs, Standards Committee on Glass and Glassware (CHD 10) [as Director, CSIR-CGCRI]
- B. At the IIT-Kharagpur:
- a) **INAE Visvesvaraya Chair Professor**, Department of Metallurgical & Materials Engineering, I.I.T., Kharagpur and CSIR-CGCRI Kolkata – April 2009 to March 2011. Usual teaching and research assignments
  - b) **Chairman**, Central Research Facility, I.I.T., Kharagpur – Dec. 2006 to Dec 2009 and **Vice-chairman**, 2004 to 2006 (for 3 years).

- Administrative position to run a central research facility that houses all the major analytical research instruments of the Institute (TEM, SEM, XRD, OES, DSC, MS, CD, FTIR, etc.)
- c) **Professor**, Department of Metallurgical & Materials Engineering, I.I.T., Kharagpur – Jun. 2003 onwards.  
Teaching in under- and post-graduate level, Independent research (Institute, Sponsored, Collaborative), Research guidance, Course-curriculum and laboratory development, Consultancy, Academic services to outside agencies, Organizing short-term courses, and Rendering administrative services
- d) **Coordinator**, Institute Mission Project on Nano Science and Technology – 2003 to 2009.
- e) **Associate Professor**, Dept. of Metallurgical & Materials Engineering, I.I.T., Kharagpur – Mar.1997 to Jun. 2003.  
Teaching in under- and post-graduate level, Independent research (Institute, Sponsored, Collaborative), Research guidance, Course-curriculum and laboratory development, Consultancy, Academic services to outside agencies, Organizing short-term courses, and Rendering administrative services.
- f) **Assistant Professor**, Dept. of Metallurgical & Materials Engineering, I.I.T., Kharagpur – Nov.1990 to Feb.1997.  
Teaching in under- and post-graduate level, Independent research (Institute, Sponsored, Collaborative), Research guidance, Course-curriculum and laboratory development, Consultancy, Academic services to outside agencies.
- g) **Lecturer**, Dept. of Metallurgical Engineering, I.I.T., Kharagpur, -Nov.1985 to Nov.1990.  
Teaching in under/post-graduate level, Independent research (Institute/Sponsored), Research guidance (B.Tech/M.Tech), Laboratory development, etc.

**C. Outside the IIT-Kharagpur (on leave):**

- a) **Visiting Scientist**, National Institute of Materials Science, Tsukuba, Japan – May-Jun 2009  
Independent research on structure of amorphous solids (~ 2 months)
- b) **Visiting Professor**, University of Ulm, GERMANY – May-July, 2007 (2 months)  
Independent research on phase transformation and deformation behavior of metallic glass
- c) **Visiting Professor**, Technical University of Clausthal, Germany – May'06 to July'06  
Collaborative research on ECAP consolidation of amorphous Al alloy powders (DFG project). Also, visited/lectured at the University of Chile, Santiago (June 12-20, 2006).
- d) **Visiting Professor**, University of Tennessee, Knoxville, USA – May'05 to June'05  
Collaborative research on laser surface amorphization (DST-NSF project). Also, visited and lectured at the University of British Columbia, Vancouver, Canada during July 1-9, 2005
- e) **Visiting Professor**, ENISE (National School of Engineering), Saint Etienne, FRANCE – May'04 to June'04  
Independent research in surface engineering and curriculum development
- f) **Humboldt Fellow**, University of Ulm, GERMANY – Jul'01-Jun'02, Dec'02, May-Jun'03  
Independent research on Amorphous Al-alloys and Phase Transition in nanocrystalline materials under severe plastic deformation
- g) **Senior Fellow**, School of Materials Engineering, Nanyang Technological University, SINGAPORE - Jul. 2000 to Jun. 2001.  
Visiting faculty position - teaching, research and administration. Entrusted to initiate a post-graduate course on thermodynamics for the first time, revise under-graduate curriculum and take up special projects.
- h) **Guest Scientist**, Max-Planck-Institut fuer Metallforschung, STUTTGART – Oct. 1999 (1 month), Jun.-Jul., 1998 (1 month), Jun.-Jul., 1997 (1 month), May-Jul., 1996 (2 months), Oct.-Nov., 1995 (2 months).  
Collaborative research.

- i) **Visiting Fellow**, Laser Lab., Mechanical Engg. Dept., University of Liverpool, U.K. - May-Jun., 1999 (1 month), May-Jun., 1998 (6 weeks), Mar.-Jul. 1995 (5 months).  
India-UK Collaborative Research Project; and Independent post-doctoral research as an Indian National Science Academy (INSA) - Royal Society Exchange Fellow.
- j) **Guest Scientist**, Technical Univ., CLAUSTHAL – May, 2000 (1 month), - Dec., 1999 (1 month), May-Jun. (1 month), 1997.  
Guidance of doctoral study and collaborative research.
- k) **Guest Scientist**, Technische Universitaet, BERLIN - Dec., 1995 (1 month).  
Independent research as a DAAD Re-invitation Fellow.
- l) **Guest Scientist/DAAD Fellow**, Max-Planck-Institute fuer Metallforschung, STUTTGART (1 year) - Mar.1989 to Mar.1990 (*on leave from the IIT-Kharagpur*).  
Independent post-doctoral research as a DAAD Fellow.
- m) **Engineer**, Forge shop, Mishra Dhatu Nigam (A Govt. of *India Integrated Superalloys plant*, Ministry of Defense), HYDERABAD, A.P. India - Dec.1984 to Nov.1985 (1 year).  
Supervision of the production schedule.
- n) **Teaching Assistant**, Dept. of Metallurgical Engg. I.I.T., KANPUR, India - Jan.1984 to Dec.1984 (1 year).  
Rendering assistance for checking answer scripts, holding laboratory, sessional & tutorial classes, etc. (awarded to the class topper in merit list).
- o) **Vacational Trainee**, Durgapur Steel Plant, Steel Authority of India, DURGAPUR, India – May’82 to Jul.’82.  
Summer Training in an industry as a part of the undergraduate degree program.
- p) **Vacational Trainee**, Andrew Yule Co., KALYANI, W.B., India – May 1981 to Jul. 1981.  
Summer Training in an industry as a part of the undergraduate degree program.

#### **ADMINISTRATIVE POSITIONS HELD IN IIT Kharagpur:**

- Acting Head, Department of Metallurgical & Materials Engineering (summer quarter, 2008)
- Chairman, Central Research Facility (2006 – 2009)
- Vice Chairman, Central Research Facility (2004-2006)
- Coordinator, Nano Science and Technology (2004 – 2010)
- Faculty adviser and Mentor to selected group of undergraduate students
- Professor-in-charge of X-ray diffraction and Heat Treatment Laboratories
- Professor-in-charge, FE-Scanning electron microscope and PLD laboratory (2006-2010)
- Professor-in-charge of Departmental Workshop (2004-2007)

## **9. Academic/Professional Awards and Recognition:**

### **a. Awards/Fellowships/Prizes:**

1. **J C Bose Fellowship** of DST, elected in June 2012
2. **Fellow (FEMSI)**, Electron Microscopy Society of India, elected in 2011.
3. **Fellow (FNA)**, Indian National Science Academy (INSA), New Delhi, elected in 2010.
4. **Fellow (FWAST)**, West Bengal Academy of Science & Technol (WAST), elected in 2010.
5. **Platinum Jubilee Medal Lecture**, 98<sup>th</sup> Indian Science Congress (held in Chennai, 2011).
6. **INAE Visvesvarya Chair Professor** (2009-2011) – Awarded by the Indian National Academy of Engineering, New Delhi.
7. **G D Birla Gold Medal, 2008**  
(Awarded by the Indian Institute of Metals for outstanding contributions in Materials Science and Engineering).

8. **Fellow (FASc)**, Indian Academy of Sciences (IAS), Bangalore, elected in 2008.
9. **Best Paper Award** at the Annual Technical Meeting of Indian Institute of Metals, 2008  
[For the paper: "Nano-intermetallic dispersed amorphous Al-alloy" by D Roy, I Manna]
10. **INAE-AICTE Distinguished Industry Professor** (2007-2009), awarded by the Indian National Academy of Engineering (INAE) jointly with Tata Steel, Jamshedpur.
11. **Fellow (FNASc)**, National Academy of Sciences, India (NASI), Allahabad, elected in 2005.
12. **Fellow (FNAE)**, Indian National Academy of Engineering (INAE), New Delhi, elected in 2005.
13. **Fellow (FIE)**, Institution of Engineers (India), Kolkata, 2005.
14. **Life Fellow (FIIM)**, Indian Institution of Metals, Kolkata, 2005
15. **Best Paper Award** for our work on 'Nanofluid' presented in:
  - (a) International Conference on Advanced Materials Design and Development (ICAMMD-06), December 14-17, 2005, Goa, India.
  - (b) International Conference on Nanoscience and Technology (ICONSAT-2006), March 16-18, 2005, New Delhi, India
  - (c) National Seminar on Advanced in Nano, Metallic and Ceramic Composite, February 23-24, 2006, Trivandrum, India
16. **Best Paper Award**, Metallurgical & Materials Engineering Division, 18<sup>th</sup> Indian Engineering Congress, (held in Lucknow, Dec. 19, 2003).  
(Awarded by the Institution of Engineers (India) for the best paper in their Journal).
17. **M.N.A.Sc., Member**, National Academy of Sciences, 2003  
(Elected Member of the National Academy of Sciences, Allahabad, U.P.)
18. **Metallurgist of the Year Award, 2002**  
(Awarded by the Ministry of Steel and Mines, Government of India through the Indian Institute of Metals).
19. **Alexander von Humboldt Fellowship**, Germany, 2001  
(Awarded by the AvH Foundation, Germany for independent research).
20. **Materials Research Society of India (MRSI) Medal**, 2000  
(Awarded by the Materials Research Society of India).
21. **Binani Gold Medal**, 1999  
(Awarded by the Indian Institute of Metals (IIM) to the co-author of the best paper published in the Transactions of the Indian Institute of Metals in a calendar year).
22. **Mouat Medal (Calcutta University) - 1999**  
(Awarded for the successful completion of the Premchand Roychand Studentship, a post-doctoral research scheme of the Calcutta University)
23. **Best Paper Award**, 51<sup>st</sup> Annual Technical Meeting of the I. I. M., 1997 (held at Jamshedpur).  
(Awarded by the Indian Institute of Metals for the best poster paper - as a co-author).
24. **DAAD Re-Invitation Fellowship**, 1995-1996  
(Awarded by the German Academic Exchange Service, Bonn, Germany).
25. **Career Award for Young Teachers**, 1995  
(Awarded by the All India Council of Technical Education, New Delhi).
26. **International Exchange and Scientific Collaboration Fellowship**, 1994  
(Awarded by Indian National Science Academy, New Delhi and Royal Society, London).
27. **INSA Medal for Young Scientist**, 1992  
(Awarded by the Indian National Science Academy, New Delhi).
28. **Premchand Roychand Scholarship (PRS)**, 1992  
(Awarded by the Calcutta University for post-doctoral research).
29. **Young Metallurgist Award**, 1991  
(Awarded by Ministry of Steel and Mines, Government of India through Ind. Inst. of Metals).
30. **Deutscher Akademischer Austauschdienst DAAD Fellowship**, 1988-90

- (Awarded by the German Academic Exchange Service for postdoctoral research).
31. **Rai Bahadur J. N. Ghosh Memorial Scholarship**, 1986  
(Awarded by the Calcutta University for higher research in overseas).
  32. **National Scholarship**, 1977.  
(Awarded by Ministry of Culture, Government of India for Securing **43rd** position in *Secondary Examination* among more than 120000 students in the state of West Bengal).
- b. Professional Recognition:**
33. **Editorial Board Member**, *High Temperature Materials and Processes* (Editor-in-Chief: Fukuyama, Hiroyuki); Publisher: DeGruyter, Germany [www.degruyter.com/page/Flavor](http://www.degruyter.com/page/Flavor) (2010-present).
  34. **Member, Editorial Board**, Indian Ceramic Society and Indian Institute of Ceramics (2012)
  35. **Vice President**, Millenium Institute of Engineering and Management (MIEEM), Kolkata
  36. **Member**, Research Board, H R Johnson Ltd. (Prism Cement Group), Mumbai, 2010-2012
  37. **Member, Senate, W.B. University of Technology**, 2010-2012
  38. **External Expert**, Study Circle, Department of Metallurgical Engineering, Jadavpur University, 2010-2012
  39. **Member**, Board of Studies, Dept of Metallurgy & Materials Engineering, Bengal Engineering & Science University (BESU), Shibpore, Howrah, W.B. 721103; 2010-2012
  40. **President, Materials Science Section, 97<sup>th</sup> Indian Science Congress** (held in Trivandrum, Jan. 3-7, 2010) of the Indian Science Congress Association, Kolkata
  41. **Associate Editor, Bulletin of Materials Science (Springer)** – 2010-2012, appointed by the Indian Academy of Sciences Bangalore.
  42. **Editorial Board Member**, *Lasers in Engineering*, *Published by* Old City Publishing Co. USA (2010).
  43. **Co-Chairman, 63<sup>rd</sup> Annual Technical Meeting of the Indian Institute of Metals (IIM)** held in Science City, Kolkata during Nov 13-17, 2009.
  44. **Key Reader, Metallurgical and Materials Transactions 2009-2012**  
(Appointed by the Metall. & Mater. Trans Board).
  45. **Member, National/International Advisory Committee**, ASIA STEEL 2009 (organized by POSTECH, South Korea); MATS-2008 and ISCS-2008 (organized by Tata Steel); ICAMT-2008, ICONSAT-2008 organized by IGCAR+INAE.
  46. **Member, Research Council**, NML, Jamshedpur (2007-2009 and 2010-2012); National Physical Laboratory (NPL) New Delhi (2010–2012), and Central Mechanical Engineering Research Institute (CMERI) Durgapur (2010-2012).
  47. **Member**, National Organizing Committee of the Annual Technical Meeting of the Indian Institute of Metals in 2005 (Chennai), 2006 (Jamshedpur), 2007 (Mumbai), 2008 (Jamshedpur), 2009 (Kolkata), 2010 (Bangalore), and 2011 (Hyderabad).
  48. **Member**, Editorial Board of STEEL TECH, a bi-monthly bulletin on Steel published by Tata Steel.
  49. **Honorary Advisor, DAAD** (German Academic Exchange Service) 2006-onwards.
  50. **Member, Program Advisory Board, NANO-2006** (An International Conference in Bangalore in Aug. 2006).
  51. **Guest Editor**, Special Issue on Nanoscience and Technology, Transactions of the Indian Institute of Metals [Vol. 58(6), 2005].
  52. **Deputy Managing Editor, Metal News**, A bi-monthly bulletin of the Indian Institute of Metals, Kolkata – 2005 to 2010.
  53. **Council Member, Indian Institute Of Metals** for 2004-05, 2005-06, 2006-07, 2007-08, 2008-09, 2009-10, 2010-11, 2011-12. Also, In-charge for IIM web site (www.iim-india.net)

54. **Member, Board of Editors, Computers, Materials and Continua** – A new *Tech Science Press* international journal (ISSN 1546-2218), California, USA.
55. **Member, Editorial Advisory Committee**, Transactions of the Indian Institute of Metals, 2003. Also, **Guest Editor** for the Special Issue of the Trans. IIM on ‘**NanoScience and Technology**’ scheduled for July 2004 issue.
56. **International Advisory Committee Member and Session Chair**, Interfaces in Advanced Materials (IAM-03), held in Chernogolovka, Russia during May 26-30, 2003 (an international conference on interfaces).
57. **Session Chair, Nano-2002 International Conference on Nanomaterials** (Held in Orlando, USA during Jun. 16-21, 2002).
58. **Session Chair, TMS Annual Meeting on Surface Engineering** (Held in Nashville, USA during Mar. 13-16, 2000).
59. **Outstanding Referee Citation and Prize of Acta Materialia 1999** (Awarded to 10 out of 900 referees for Acta/Scripta Materialia journals, Elsevier Science)
60. **Reviewer**, Acta/Scripta Mater, Surf Coat Technol, Appl Surf Sci, Langmuir, Mater Sci Engg A/B, Wear, Mater Chem Phy, Appl Phy Lett, J. Appl. Phy., J. Mater. Res, Philos Mag, Metall Mater Trans A, Trans Ind Inst Met, Bull Mater Sci
61. **Recorder, Materials Science Section, I.S.C.A., 1998-99 and 1999-2000.** (Elected by the Indian Science Congress Association, Calcutta).
62. **Key Note Addresses** in the 50<sup>th</sup> (1996) and 51<sup>st</sup> (1997) Annual Technical Meetings of the Indian Institute of Metals held in New Delhi and Jamshedpur.
63. **Research Grant, GTZ-Germany 1997-1999.** (Awarded by the Deutsche Gesellschaft fuer Zussamenarbeit (GTZ) GmbH).
64. **Member, Materials Science Sectional Committee, Indian Science Congress Association (ISCA), 1997-98, 1995-96 and 1992-94** (Elected by the Indian Science Congress Association, Calcutta).
65. **Institute Scheme for Innovative Research and Development (ISIRD) 1992-93** (Awarded by IIT, Kharagpur to young faculty members as research seed money).
66. **Partial Travel Assistance, 1991 and 2000** (Provided by DST, AICTE and CSIR to attend International Conferences abroad).

**c. Academic Distinctions:**

67. **Topper** in M.Tech. Final Exam. (1984) - I.I.T., KANPUR.
68. **2nd Topper** in B.E. Final Exam. (1983)- B.E.College, HOWRAH, (Calcutta University).
69. **43 rd Rank** in the Madhyamik Pariksha (secondary (class X) school leaving examination).

## **10. Specialization and Major Fields of Interest:**

### **PHYSICAL METALLURGY and MATERIALS ENGINEERING**

#### **(Phase Transformation; Microstructure-Property-Process Parameter Correlation)**

- a> **Nanocrystalline Materials:** Synthesis of nanometric metallic/intermetallic/ceramic and amorphous alloys and composites by mechanical alloying, chemical precipitation or physical vapor deposition (sputtering or pulsed laser deposition), and characterization of microstructure and its stability by SEM, EDS, TEM, DSC, XRD, DLS, PAS, NMR. Compaction/sintering of powders by conventional, spark plasma, high pressure, laser or microwave sintering and severe plastic deformation. Evolution of phases including new metastable/polymorphic phases, crystal to glass and glass to nanocrystal transition under non-equilibrium processing condition. Characterization of mechanical (strength, hardness,

toughness) or functional (permeability, conductivity, reactivity) properties, and correlating properties with microstructure and process parameters. Development and characterization of nanofluid for advanced thermal engineering. Nanocrystalline spinel ferrites and nano oxides (ZnO and SnO<sub>2</sub> hybrid) for gas sensors, superparamagnetic devices, and nano-oxide (doped) electrolytes for solid oxide fuel cell

- b> **Surface Engineering:** Laser, plasma, PVD and electrodeposition assisted surface modification to improve resistance to wear, corrosion, oxidation and other surface dependent properties by forming metastable microstructure (extended solid solution / amorphous phases) and/or composition in the near-surface region. Characterization of surfaces by the electron-optic analytical techniques, X-ray diffractometry/spectrometry, and testing of the mechanical and electrochemical properties. Microstructural evolution and properties in laser/e-beam assisted welding, cladding, composites surfacing and rapid manufacturing under non-equilibrium conditions
- c> **Mathematical Modeling:** Mathematical modeling of thermal and mass transfer profile in laser material processing (surface engineering, welding). Developing suitable mathematical models to correlate the microstructure/composition with properties by analytical/numerical techniques to simulate the temperature/compositional distribution profile following mechanical alloying (by high-energy ball milling), plasma ion implantation, discontinuous precipitation. Thermodynamic modeling of solid-state amorphization, phase transition, etc.
- d> **Solid State Phase Transition:** Development of bainitic microstructure in ferrous alloys and correlating microstructure with properties and process parameters. Studying the mechanism and kinetics of moving boundary (interface diffusion controlled) phase transitions like discontinuous precipitation, eutectoid reaction including determination of Arrhenius parameters of grain/interphase boundary diffusion through kinetic analysis.

## 11. Summary of Research Output:

1. THESIS GUIDANCE: *Ph.D* = 16 (completed) + 09 (in progress)  
*M.Tech/MS* = 32 (completed) + 1 (in progress)  
*B. Tech* = 42 (completed)
2. PUBLICATION: *Journal* = 213 (Published)  
*Conf. Proc.* = 41 (Printed)  
*As lecture notes in short term course* = 24  
*Invited papers (presentation only)* = 67 + 44 = 111  
*In seminar/symp./conf. (abstracts)* = 116
3. PATENT: = 1 (granted) + 2 (filed)
4. SPONSORED PROJECTS (as PI): 32 worth over Rs. 160 million (only at IIT Kharagpur)

## 12. Most Significant Research Contributions:

Prof. Manna's research endeavors concern the broad area of **phase transformation and structure-property correlation in engineering materials including nanometric solids (metallic/ceramic) and nanofluids, surface engineered metallic and ceramic systems**. The most significant contributions made by him in this direction are summarized below.

### 1. On Nanostructured and Amorphous Materials:

Prof. Manna's interest lies in **synthesis, phase transformation, properties and application of nano-structured materials** prepared by mechanical alloying/milling. The major contributions:



- **Al-alloy composites**: Developed a new series of Al-based simple ternary **Al-Cu-TM/Al-TM-Si** alloys (TM = early transition metals = Ti, Nb, Zr) by mechanical alloying amenable to forming **an amorphous phase dispersion in nanocrystalline matrix, or nano-intermetallic dispersion in amorphous or nanocrystalline matrix** either during controlled milling or subsequent annealing. A number of other Al-based composites (AlNiTi, ACuCr and Al + stainless steel) have also been developed. A **patent** has recently been granted on the **Al-Cu-Ti** system. Recently, utilized ball milling to develop ultrafine fly ash for structural application.
- **Nanofluid**: Developed **nanofluid** (stable colloidal dispersion of nanometric metallic (Al-alloy) or ceramic (zirconia/titania) particles (< 1 vol.%) in water or ethylene glycol) by single- or two-step synthesis process and obtained **50-100% increase in thermal conductivity ratio**, ideal for advanced heat transfer applications. Also, investigated the role of aspect ratio, volume percent size and chemistry of nanoparticles on conductivity ratio.
- **Size-dependent polymorphism**: Discovered **bcc→fcc** (in Nb) and **hcp→fcc** (in Zr, Ti) **polymorphic transformation** in early transition metals during mechanical attrition due to **nanocrystallization and high degree plastic strain/strain-rate**. Also, proposed a thermodynamic model based on isothermal equation of state to explain the genesis of such transformation upon nanocrystallization and proved that the said change is not impurity driven and could be reversible. Similar transformation has since been report in other ceramic and metallic alloys.
- **Functional nanomaterials**: Synthesized **nanocrystalline superparamagnetic** ( $H_c < 1$  Oe) Mn-Zn spinel-ferrites, nano-oxides for memory devices, electrolytes in solid oxide fuel cell, polymers for photovoltaic packaging and most recently, ZnO+SnO<sub>2</sub> hybrid with varying size, shape and morphology for gas sensors.
- **Synthesis of nanoalloys**: Developed several **nanocrystalline aluminides** (Nb-Al, Cu-Al, Ni-Al) and **γ-brass** at room temperature with *metastable* microstructure or composition from elemental powder blend by mechanical alloying.

## 2. **On Surface Engineering**:

Dr. Manna has made a number of noteworthy contributions in the area of laser or plasma assisted surface engineering to enhance surface dependent properties like wear, corrosion and oxidation resistance of metallic systems.

- (a) **Laser Surface Engineering (LSE)**: Majority of these efforts were based on various innovations and strategies based on laser surface alloying (LSA), cladding (LSC), melting (LSM), hardening (LSH) or composite surfacing (LCS) of different ferrous and non-ferrous metallic metals/alloys:
- Explored developing Fe-Cr-Mo-Y-B-C **amorphous/glassy coating on steel substrate** to enhance wear resistance and investigated the role of substrate in heterogeneous nucleation or epitaxial growth.
  - Improved **oxidation and wear resistance of Ti** by laser surface alloying (LSA) with Si, Al or Si+Al forming Ti<sub>5</sub>Si<sub>3</sub>-rich layer and established the concerned **mechanism and kinetics** of oxidation and wear resistance due to Ti<sub>5</sub>Si<sub>3</sub>-rich layer.
  - Developed a new strategy of **laser assisted composite surfacing (LCS)** (compositional grading of surfaces with varying degree of dispersion) to significantly enhance wear resistance of components based on **Al/Al-alloys, Cu/Cu-alloys, Mg-alloys and mild/stainless steel**.
  - Enhanced **wear and erosion resistance** (both at room/high temperature) of Cu by LSA with Cr by solid solution and dispersion hardening. A process map on variation of surface microstructure, composition and hardness as a function of laser parameters has been established.

- Improved **corrosion and wear resistance of Mg-alloys** by laser surface melting (LSM), LSA with Al+Mn or thermal oxidation, and studied the defect structure and its influence on corrosion and wear resistance.
- Enhanced **oxidation resistance of 2.25Cr-1Mo ferritic stainless steel** by LSA with Cr, **nimonic superalloy with Si+Al** and **pitting and general corrosion resistance and wear resistance of AISI 304/316 austenitic stainless steel** by LSA with Mo.
- Developed high specific surface area **neural stimulation electrode material** by LSA of Ti with Ir and mimic the spatio-temporal profile of neuronal activation to cure neuronal disorders (like tinnitus, cardio-vascular stimulation, etc.).
- Demonstrated *for the first time* that **laser surface hardening (LSH)** is more appropriate for enhancing wear and fatigue resistance of austempered ductile iron than that by LSA or laser surface melting due to a residual compressive stress on the surface.
- Proved that **LSH of plain carbon and ball bearing steel** could provide equivalent hardening of surfaces as that in bulk hardening operations.
- Explored **laser assisted deposition of Co, surface melting, oxidation or laser nitriding** of Ti6Al4V based bio-implants for developing prosthesis with enhanced surface functionality.
- Investigated laser bending steel and residual stress associated with it.
- Published several **invited review** articles on different aspects of LSE.

**(b) Plasma Surface Engineering (PSE):**

- Enhanced wear and corrosion resistance of ball bearing steel by different surface engineering approaches (gas and plasma nitriding, plasma ion implantation) to enhance hardness and corrosion resistance of stainless and ball bearing steel. Prof. Manna installed a plasma-immersion-ion-implantation (PIII) facility in 2000 with a DST project, which has now been upgraded to an indigenously designed/developed plasma assisted implantation and deposition (PAID) unit (**a new hybrid deposition and implantation technology**) through another DST funding in 2005. This is the first university based PIII/PAID laboratory in India (for metallic/ceramic components).

**(c) Supplementary Studies on Surface Engineering:**

- Earlier Prof. Manna developed a novel technique of **enhancing diffusion coating kinetics** by increasing specific boundary area on surface through controlled surface deformation and diffusion annealing. A similar method, called SMAT, has now been commercialized.
- Developed a **co-deposition technique** to apply nano-aluminides on surfaces of copper to enhance wear resistance without deteriorating electrical conductivity. This is the first time that co-deposition of nano-aluminide/intermetallic has been possible.
- Achieved **laser assisted bending** of stainless steel (for automobiles) and **laser assisted fabrication** of stainless steel.
- Initiated a new program on **laser assisted transmission lap welding** (transparent sheet on translucent substrate) of polymeric sheets.
- Initiated a program on **electron beam assisted welding** of dissimilar nuclear grade metals/alloys (Nb, Zr alloys, stainless steel, Cu), and thermal spray deposition on steel.
- A new initiative is being undertaken to develop **plasma assisted jet vapor deposition (PEJVD)** as a new Zn-free coating technology for steel in collaboration with Tata Steel and FCIPT-Gandhinagar.

**3. On Moving Boundary (Discontinuous or Invariant) Reactions:**

Prof. Manna has made a commendable contribution in furthering the knowledge concerning discontinuous reactions, particularly, discontinuous precipitation (DP) and coarsening (DC) including publishing three review articles and numerous papers in specific areas of mechanism and kinetics like:

- Reported **occurrence of DP/DC** in several new binary systems *for the first time*: Cd-Ag, Zn-Al, Zn-Ag, Zn-Cu.
- Established that the **dynamic properties** (diffusivity, mobility, etc.) of the grain vis-à-vis interphase boundaries are comparable in moving boundary reactions and proved that grain boundaries undergo no structural transformation to attain mobility from static condition in moving boundary reaction (hence static/dynamic boundaries have same structure). In this regard, a **generalized criterion** for selection of the initiation sites for DP and DC from among different types of natural and/or synthetic grain and phase boundaries, including the necessity or otherwise of maintaining Livingston-Cahn relation was proposed. Indeed, it was shown that initiation of DP is feasible from interphase boundaries and a **new mechanism** of DP initiation from interphase boundaries was formulated *for the first time*
- Proposed a new **resistometric method** of determining **metastable solvus** for DP], and detecting a **clustering reaction** ( $D_v$ -controlled) preceding DP in Pb-Sn for the first time.
- Developed a novel technique of **determining the Arrhenius parameters of boundary diffusion** through kinetic analysis of DP and DC. Utilizing this, he has determined boundary diffusivity through kinetic analysis in many systems in which reliable data on the same were not available. This approach is proven applicable in principle to all moving boundary reactions.
- Resolved the controversy about the effect of ternary addition on DP kinetics and proving that ‘**solute drag**’ exerted by the ternary atoms, neither atomic size difference nor valence electron difference constitutes the main mechanism of retarding the DP kinetics.
- Reported that **volume diffusion controlled metastable decomposition** (say, clustering) precedes boundary diffusion controlled eutectoid reaction in Cu-In or DP in Zn-Al or Pb-Sn *for the first time*.

#### 4. On Mathematical/Thermodynamic Modeling:

Prof. Manna has utilized mathematical modeling as a tool for investigating the mechanism and simulating the kinetics of several phase transitions.

- Moving Boundary Phase Transition: Contributed significantly towards **developing analytical/numerical models of peritectic and peritectoid** transformation kinetics that showed better insight into the transformation mechanism and better agreement with experimental data.
- Synthesis and Properties of Nanostructured Materials: Proposed a **numerical model of mechanical alloying kinetics** capable of considering the concentration dependent diffusivity, interface shift, and introducing the idea of an ‘*effective temperature*’ of diffusion in mechanical alloying *for the first time*. Correlated the **excess free volume or volume per atom in nanocrystals with grain size** and accounted for the “*inverse Hall-Petch*” relation, “*enhanced diffusivity*” and “*polymorphism*” in terms of negative hydrostatic pressure generated due to nanocrystallization (crystallite size reduction beyond a critical level). Proposed a **mathematical model of milling dynamics** to predict the optimum conditions of mechanical alloying to develop nanocrystalline alloys.
- Heat Transfer in LSE: Developed transient or steady state models of LSA (under pre-deposition scheme) based on explicit finite difference technique to predict the temperature profile, thermal history and microstructure of the alloyed zone. This has been the maiden effort to model LSH or LSA involving transient melting and solidification of a bi-metallic layer. A similar model is applied to model the effect of laser assisted austenitizing on degree/uniformity of martensitic change in LSH of steel by self quenching.
- DP Kinetics: Modified the Cahn’s equation to **analytically predict the solute distribution profile** in solute depleted matrix behind the reaction front in DP that shows excellent agreement with experimental data.

- **Frictional Heating:** Modeled the heat transfer process during a pin-on-disc wear-testing operation to demonstrate that accumulation of frictional heat may irreversibly degrade the microstructure.
- **Solid State Amorphization:** Applied empirical thermodynamic model of Miedema to predict phase evolution including the genesis of solid state amorphization in mechanically alloyed Al-alloys.
- **Austempering:** Analyzed heat transfer in a engineering components of complex shape during austempering by finite element modeling.

### 5. **Physical Metallurgy of Steel and Cast Iron:**

- Studied microstructural stability of FeCrB or FeCrNiCoB glassy alloys subjected to simulated high strain rate deformation (milling).
- Developed bainitic microstructure in SAE 52100 steel in order to explore the possibility of developing tougher bearing material by austempering instead of conventional practice of achieving tempered martensitic microstructure by hardening and tempering.
- Proposed an innovative combination of creating martensitic surface by laser surface hardening on bainitic core (developed by austempering) in SAE 52100 steel for bearing applications].
- Modeled the heat transfer condition of austenitizing and austempering of spheroidal graphitic iron to optimize bainitic transformation and microstructure.
- Studied the effect of environmental on fatigue strength (crack growth retardation) of HSLA 80A steel and effect of thermal cycling on Fe-Ni-Mn maraging steel.

### 6. **On Texture:**

Dr. Manna developed an optimum routine of cold rolling followed by recrystallization and magnetic annealing for two indigenously developed **Ti and Ti+Cr added soft magnetic Ni-Fe-Cu permalloys** and correlated the microstructural evolution with texture/process parameters. He has recently utilized texture analysis to throw new insight into improvement in wear resistance of SAE 52100 steel by gas nitriding.

## 13. **Sponsored Research Schemes (at IIT Kharagpur):**

1. **Development, synthesis, characterization and thermo-physical property measurement of ceramic nanoparticle dispersed nanofluids for thermal applications (OLP 280)**  
(Principal Investigator)  
Sponsor: Council of Scientific & Industrial Research (CSIR), New Delhi  
Duration: 3 years  
Fund: Rs. 0.52 million (approx.)  
Status: Commenced on October 2010 (at CSIR-CGCRI).
2. **Euro-Indo forum for nano-materials research coordination & cooperation of researchers in sustainable energy technologies (RST)**  
(Co-Principal Investigator)  
Sponsor: European Union FP 7) Code name: e-ICOON, Grant agreement no.: 233466  
Duration: 4 years  
Fund: Rs. 741,428.00 (1<sup>st</sup> Installment)  
Status: Commenced in March, 2011.
3. **INAE Visvesvarya Chair Professorship (code: VVC)**  
(Principal Investigator)  
Sponsor: Indian National Academy of Engineering (INAE), New Delhi  
Duration: 2 years

- Fund: Rs. 1.83 million (approx.)  
Status: April 2009 to March 2011.
4. **Grain Boundary Segregation, Precipitate Morphology and Surface Modification in case of Complete and Incomplete Grain Boundary Wetting by a Second Solid Phase in Steels (code: GBS)**  
(Principal Investigator)  
Sponsor: Department of Science and Technology (Indo-Russian Collaborative Research Project, RFBR)  
Duration: 2 years  
Fund: Rs. 1.3 million (approx.)  
Status: Commenced on March, 2009.
  5. **Nano-fluid Based Coolant and Combustion Fuel System (Code: NBS)**  
(Principal Investigator)  
Sponsor: Indian Space Research Organization (ISRO) and KCSTC, IIT, Kharagpur  
Duration: 1 year  
Fund: Rs. 0.5 million (approx.)  
Status: Commenced on April 2009.
  6. **Versatile nano-zirconia for Indian rare Earth Limited, OSCOM (Code: VNZ)**  
(Co-principal Investigator)  
Sponsor: Indian Rare Earth Limited, Research Center, Kollam, Kerala  
Duration: 3 years  
Fund: Rs. 4.5 million (approx.)  
Status: Commenced on June 2008.
  7. **Development and Characterization of Nano-fluid for Heat-Transfer Applications in Nuclear Power Plants (code: NPP)**  
(Principal Investigator)  
Sponsor: Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam  
Duration: 2 years  
Fund: Rs. 1.9 million (approx.)  
Status: Commenced on May 2008.
  8. **Development and characterization of copper based brazing alloy by rapid solidification and mechanical alloying (code: RSM)**  
(Principal Investigator)  
Sponsor: Indian Space Research Organization (ISRO) and KCSTC, IIT, Kharagpur  
Duration: 1 year  
Fund: Rs. 0.4 million (approx.)  
Status: Commenced on April 2007.
  9. **Development of Compositionally and Microstructurally Graded Thermal Barrier Coating by Plasma Spraying**  
(Co-Principal Investigator; PI: Dr. J. Dutta Majumdar)  
Sponsor: Department of Science and Technology, New Delhi  
Duration: 3 years  
Fund: Rs. 3.5 million (approx.)  
Status: Approved, to begin shortly after the funds are transferred.
  10. **Development and characterization of Nanostructured Thin Films for SiGe Quantum Well Infrared Photodetector (QWIP) and Ferroelectric based Gas/Chemical Sensors (code: FIR)**  
(Principal Co-investigator; PI: Prof S K Ray)

- Sponsor: *Defense Research and development Organization (DRDO), New Delhi*  
Duration: 5 years  
Fund: Rs. 20.02 million  
Status: Commenced on Aug. 2007.
11. **Establishment of an Advanced Research Facility for EB Welding and Process Development Related to Programs of Interest to DAE (code: EBW)**  
Sponsor: *Board of Research in Nuclear Sciences (BRNS) and Dept. of Atomic Energy, GoI*  
Duration: 3 years  
Fund: Rs. 13.3 million (Rs 4.3 m from BRNS + Rs 9 m from DAE)  
Status: Commenced on Mar 2007.
12. **Development of multifunctional surface on Ti and its alloys for tailoring wear resistance and biocompatibility (code: TWR)**  
*(Co-principal Investigator, PI: Prof J Dutta Majumdar)*  
Sponsor: *Council of Scientific & Industrial Research (CSIR), New Delhi*  
Duration: 2 years  
Fund: Rs. 1 million (approx.)  
Status: Commenced on May 2007.
13. **Development of nanocrystalline coating by combined plasma assisted implantation and deposition (code: PAI)**  
*(Principal Investigator)*  
Sponsor: *Deptt. of Science & Technology (DST), New Delhi*  
Duration: 3 years  
Fund: Rs. 5.3 million  
Status: Commenced on Mar 2006.
14. **Synthesis and Characterization of Nanostructured Materials for Functional and Structural Applications (code: SCM)**  
*(Principal Investigator)*  
Sponsor: *Deptt. of Science & Technology (DST), New Delhi under Nanomaterials Science and Technology Initiative (NSTI)*  
Duration: 5 years  
Fund: Rs. 28 million  
Status: Commenced on Mar 2006.
15. **Surface Engineering of Ball Bearing Steel by Plasma Immersion Ion Implantation (code: SPI)**  
*(Principal Investigator)*  
Sponsor: *TATA STEEL, Jamshedpur*  
Duration: 2 years  
Fund: Rs. 1 million (approx.)  
Status: Commenced on Aug., 2003.
16. **Laser Assisted Manufacturing of Compositionally Graded Coating and Drilling of Metals and Alloys**  
*(Co-Principal Investigator)*  
Sponsor: *Council of Scientific & Industrial Research (CSIR), N. Delhi*  
Duration: 3 years  
Fund: Rs. 1.3 million (approx.)  
Status: Commenced on Mar. 2003.
17. **Laser Assisted Fabrication of Functionally Graded Component for Hip Joint and Femoral Replacement**

- (Co-Principal Investigator)*  
Sponsor: BRNS, Department of Atomic Energy  
Duration: 3 years  
Fund: Rs. 1.6 million (approx.)  
Status: Commenced on Aug. 2003.
18. **Thermal Performance of Nanofluid Based Cooling Systems (code: NBC)**  
*(Principal Investigator)*  
Sponsor: Delphi Automotives Systems, Pvt. Ltd., Bangalore  
Duration: 6 months  
Fund: Rs. 0.1 million (approx.)  
Status: Completed in July 2008.
19. **Development and Characterization of Novel Nanocrystalline Metallic/Ceramic Based Hydrogen Sensor Materials (code: NNM)**  
*(Principal Investigator)*  
Sponsor: Ministry of Human Resource Development (MHRD) – R&D projects  
Duration: 3 years  
Fund: Rs. 1.5 million  
Status: Completed in May 2008.
20. **Synthesis and Characterization of Al-based Nanocrystalline Composites (code: ANC)**  
*(Principal Investigator)* – Indo-Polish Collaborative Project  
Sponsor: Deptt. of Science & Technology (DST), New Delhi and Komitet Badań Naukowych (KBN), Poland under Scientific and Technological International Cooperation Joint Project for the years 2004-2006  
Duration: 2 years  
Fund: International travel and contingency, Rs. 0.3 million  
Status: Completed in July 2007.
21. **Development of Wear-resistant Cu-alloy with Nanocrystalline Ceramic Phase Dispersion by Mechanical Alloying for Electrical Contacts/Components (code: DWR)**  
*(Principal Investigator)*  
An International Project Award (selected from 145 proposals from 27 countries)  
Sponsor: International Copper Association, USA  
Duration: 1 year  
Fund: USD 22000.00  
Status: Completed in Mar 2006.
22. **Production of porous TiNi shape memory alloys from mechanically alloyed powders for biomedical applications – A Fast Track Research Scheme for Dr B B Panigrahi**  
*(Principal Investigator)*  
Sponsor: Deptt. of Science & Technology (DST), New Delhi  
Duration: 2 year  
Fund: Rs. 1 million (approx.)  
Status: Completed in December 2006.
23. **Development and Characterization of Nano-fluid for Micro-thermal Heat Transfer Applications in Advanced Satellite (code: DCN)**  
*(Principal Investigator)*  
Sponsor: Indian Space Research Organization (ISRO) and KCSTC, IIT, Kharagpur  
Duration: 2 years  
Fund: Rs. 0.5 million (approx.)  
Status: Completed in August 2006.

24. **Synthesis and characterization of nanocrystalline ZrO<sub>2</sub>-based electrolyte for solid oxide fuel cells (code: SOF)**  
(Principal Investigator)  
Sponsor: Council of Scientific & Industrial Research (CSIR), New Delhi  
Duration: 3 years  
Fund: Rs. 1.1 million (approx.)  
Status: Completed in April 2007.
25. **High Speed Laser Synthesis of Amorphous Surface Structure (code: LSH)**  
(Principal Investigator)  
Sponsor: Deptt. of Science & Technology (DST), New Delhi and National Science Foundation (NSF), USA  
Duration: 3 years  
Fund: Rs. 1.7 million (approx.)  
Status: Completed in March 2007.
26. **Development of Al-based Nanocrystalline and Amorphous Alloys by Mechanical Alloying (code: AMA)**  
(Principal Investigator)  
Sponsor: Council of Scientific & Industrial Research (CSIR), New Delhi  
Duration: 3 years  
Fund: Rs. 1.7 million (approx.)  
Status: Completed in Aug. 2007.
27. **Compressor Driven Metal Hydride Cooling and Heating Systems**  
(Co-Principal Investigator)  
Sponsor: Ministry of Non Conventional Energy Sources, New Delhi  
Duration: 3 year  
Fund: Rs. 1.7 million (approx.)  
Status: Completed in Dec. 2004.
28. **Plasma Based Ion Implantation for Surface Engineering of Titanium Alloys to Improve Wear and Oxidation Resistance**  
(Principal Investigator)  
Sponsor: Deptt. of Science & Technology (DST), Govt. of India (under the CDPS program)  
Duration: 3 years  
Fund: Rs. 5.2 million (approx.)  
Status: Completed in Dec 2003.
29. **Laser Surface Engineering of Magnesium and Its Alloys to Enhance Wear and Oxidation Resistance**  
(Principal Investigator)  
Sponsor: DST-DAAD Exchange Research Fund.  
Duration: 2 years  
Fund: Rs. 0.4 million and DM 4000.00 (approx.)  
Status: Completed in Dec. 2001.
30. **Laser Surface Engineering for Enhanced Abrasion and Impact-Fatigue resistance of Excavator Components**  
(Principal Investigator)  
Sponsor: UK-INDIA Science and Technology Research Fund.  
Duration: 2 years  
Fund: Rs. 0.5 million and UKP 5000.00 (approx.)  
Status: Completed in Dec. 2000.



31. **Laser Surface Engineering of Commercial Metals for Improved Corrosion and Oxidation Resistance**  
*(Principal Investigator)*  
Sponsor: Min. of Human Resource Development (MHRD), N. Delhi.  
Duration: 3 years  
Fund: Rs. 0.8 million (approx.)  
Status: Completed in Mar. 2000.
32. **Development of Superior Corrosion and Oxidation Resistant Materials for Fast Breeder Reactors by Laser Surface Engineering**  
*(Principal Investigator)*  
Sponsor: Coun. of Sci. & Indus. Res. (CSIR), N. Delhi  
Duration: 4 years  
Fund: Rs. 0.6 million (approx.)  
Status: Completed in Mar. 2000.
33. **Improvement in Oxidation Resistance of Nimonic Alloys By Laser Surface Engineering**  
*(Principal Investigator)*  
Sponsor: All India Council of Technical Education (AICTE), N. Delhi  
Duration: 4 years  
Fund: Rs. 0.6 million (approx.)  
Status: Completed in Mar. 1999.
34. **Development of High Temperature Resistant Materials By Laser Surface Engineering**  
*(Principal Investigator)*  
Sponsor: All India Council of Technical Education, N. Delhi  
Duration: 3 years  
Fund: Rs. 0.2 million + Personal Salary for 3 years  
Status: Completed in Sept. 1998.
35. **Measurement of Grain Boundary Diffusivity Through Kinetic Analysis of Discontinuous Precipitation - A Novel Technique**  
*(Principal Investigator)*  
Sponsor: Coun. of Sci. & Indus. Res. (CSIR), N. Delhi  
Duration: 3 years  
Fund: Rs. 0.5 million (approx.)  
Status: Completed in Mar. 1996.
36. **Development of Nanocrystalline Composites by Mechanical Alloying & Characterization**  
*(Co-Investigator with Prof. S. K. Pabi)*  
Sponsor: Deptt. of Science & Technology (DST), Govt. of India  
Duration: 3 years  
Fund: Rs. 3 million (approx.)  
Status: Completed in May 1998.
37. **Investigation into Solidification Behaviour, Thermophysical Characteristics and Mechanical Properties of Composites**  
*(Co-Investigator with Profs. B. K. Dhindaw & S. C. Panigrahi)*  
Sponsor: All India Council of Technical Education (AICTE), N. Delhi  
Duration: 3 years  
Fund: Rs.0.5 million (approx.)  
Status: Completed in Mar. 1995.

38. **Development of Superior Corrosion and Oxidation Resistant Materials By Laser Surface Treatment**  
(Investigator-in-Charge)  
Sponsor: Indian National Science Academy (INSA), New Delhi  
Duration: 3 years  
Fund: Rs. 0.1 million (approx.); Status: Completed in Nov. '95.
39. **Development of Wear and Corrosion Resistant Materials Through Laser Surface Alloying** (Investigator-in-Charge)  
Sponsor: Inst. Scheme for Innovation Res. & Dev., I.I.T., Kharagpur  
Duration: 1 year; Fund: Rs. 25 k (approx.); Status: Completed in Mar. '94.

## Recent Industrial Consultancy

- Failure analysis of failed sucker rods in petroleum pipeline (Lonestar Alpha Laboratories, Dubai)
- Plate cooling efficiency of nanofluid for automobile applications (DELPHI, Bangalore)
- Characterization of spinel content in Mn-Zn ferrites (EPCOS Ferrites Ltd., Kolkata)
- XRD analysis of sinter products and welded joints (Tata Steel, Jamshedpur)
- Phase analysis of bearing steel (Bearings Division, Tata Steel, Kharagpur)
- Structural characterization of nanomaterials (Vidyasagar University)
- Volume fraction of phases (National Metallurgical Lab., Jamshedpur)

## 14. Details of Courses Taught at IIT Kharagpur (1985-2010):

Sl.	Subject	Number	L-T-P	Level
1.	Phase Transformation & Phase Equilibrium	MT31003	3-1-0	3 <sup>rd</sup> year MME B Tech + Integrated M Tech
2.	Phase Transformation & Heat Treatment (Theory and Laboratory)	MT34005	3-1-3	3 <sup>rd</sup> year MME B Tech + Integrated M Tech
3.	Phase Transformation	MT60028	3-1-0	1 <sup>st</sup> year MME M Tech
4.	Phase Transformation Laboratory	MT69008	0-0-3	1 <sup>st</sup> year MME M Tech
5.	Kinetics of Metallurgical Processes	276002	3-1-0	1 <sup>st</sup> year MME M Tech
6.	Surface Engineering*	274018	3-0-0	4 <sup>th</sup> year MME B Tech
7.	Introduction to Materials (Theory)*	272001	3-1-0	2 <sup>nd</sup> year MME B Tech
8.	Introduction to Materials (Lab.)	272901	0-0-3	2 <sup>nd</sup> year MME B Tech
9.	X-ray Diffraction (Theory)	273006	3-1-0	3 <sup>rd</sup> year MME B Tech
10.	X-ray Diffraction (Lab.)	MT33106	0-0-3	4 <sup>th</sup> year MME B Tech
11.	Advanced Thermodynamics	27601	3-1-0	1 <sup>st</sup> year MME M Tech
12.	Materials Characterization (partly)	27422	3-0-0	4 <sup>th</sup> year MME B Tech
13.	Engineering Metallurgy (Theory)	27202	3-1-0	Non-dept. 2 <sup>nd</sup> year B Tech
14.	Engineering Metallurgy (Lab.)	27292	0-0-3	Non-dept. 2 <sup>nd</sup> year B Tech
15.	Engineering Materials (Theory)	27421	3-0-0	Non-dept. 4 <sup>th</sup> year B Tech
16.	M. Tech Seminar	27604	0-0-3	2 <sup>nd</sup> year MME M Tech

(\*introduced for the first time at the IIT, Kharagpur; MME = Metall. & Mater. Engg. Dept.)

### Teaching Assignments at the Nanyang Technological University, Singapore (2000-2001):

1. Material Structure and Mechanical Behavior (theory) - 4 credit UG course.

2. Thermodynamics of Solids (theory) - 4 credit PG course - introduced for the first time in NTU.
3. Properties of steel (experiment) - UG laboratory.

**Short Term Courses or Lectures offered to the Industry:**

1. Hindustan Aeronautics Limited (HAL), Bangalore – Spring-2006, Autumn-2006, Spring-2007, Autumn-2007
2. Hindustan Zinc Limited, Udaipur – Autumn 2005
3. Tata Steel and Tata Motors, Jamshedpur – April, May, 2005 and September 2006

**15. Professional/Administrative Service to other Institutions:**

1. Editorial Board Member, Lasers in Engineering, Old City Publishing Co, USA (2010-present).
2. Editorial Board Member, High Temperature Materials and Processes, Publisher: DeGruyter, Germany [www.degruyter.com/page/flavor](http://www.degruyter.com/page/flavor) (2009-present).
3. Appointed DAAD Honorary Adviser for Indian students willing to carry out higher studies in Germany (appointed by German Academic Exchange Service) 2006-2009.
4. Served as a member of the Advisory Committee of international conferences and symposia namely, MATS-2008 and ISCS-2008 (organized by Tata Steel in Feb. 2008), ICMAT-2008 (organized by IGCAR+INAE in Mar. 2008).
5. Appointed a member of the Research Council (highest administrative and advisory body) of National Metallurgical Laboratory (NML), Jamshedpur (a CSIR unit).
6. Served as an expert for faculty/scientist selection in National Institute of Foundry and Forge Technology (NIFFT), Ranchi; National Metallurgical Laboratory (NML), Jamshedpur; and National Institute of Technology (NIT), Durgapur.
7. Served in the National Organizing Committee of the Annual Technical Meeting of the Indian Institute of Metals in 2005 (Chennai), 2006 (Jamshedpur) and 2007 (Mumbai).
8. Serving in the Editorial Board of STEEL TECH, a bi-monthly bulletin on Steel published by Tata Steel.
9. Served as a member of the Program Advisory Committee of NANO 2006 (An International Conference in Bangalore in Aug. 2006).
10. Served as Guest Editor of a special issue of the Transactions of the Indian Institute of Metals on NanoScience and Technology [Vol. 58(6), 2005].
11. Deputy Managing Editor of Metal News, a bi-monthly bulletin of the Indian Institute of Metals, Kolkata from August 2005 onwards.
12. Serving the National Council of the Indian Institute of Metals since 2004 and maintaining the IIM web site ([www.iim-india.net](http://www.iim-india.net))
13. Serving as a member of the Board of Editors for the International Scientific Journal Computers, Materials and Continua, published by Tech Science Press international journal (ISSN 1546-2218), California, USA.
14. Coordinator, Session on Nanotechnology, MEMS-NANO – An International Conference at the IIT-Kharagpur in Dec 2005.
15. Member, Advisory Committee, ICAMMP 2006 (International Conference on Advanced Materials and Materials Processing), to be held in Kharagpur in Feb 2006.
16. Member, National Organizing Committee, National Laser Symposium, Indian Laser Association, IIT-Kharagpur, December 22-24, 2003.
17. Member, Curriculum Revision Committee on Materials Engineering, Indian National Engineering Academy (INAE), 2003.

18. Referee, Acta/Scripta Mater. (Elsevier Science); J. Appl. Phys. (Amer. Inst. of Phy.), Appl. Surface Science (Elsevier), Metall. & Mater. Trans. (ASM, USA), Philos. Mag. (Gordon & Breach), J. Mater. Research (MRS).
19. Referee, Bulletin of Materials Science, published by Ind. Acad. of Sci., Bangalore.
20. Expert, SRF & RA Selection Committee and Project Review Expert of the CSIR.
21. Expert, Young Scientist Selection and Project Evaluation of the CSIR.
22. Paper Setter & Examiner - B.E. College (Cal. Univ.).
23. Paper Setter & Examiner - Indian Inst. of Metals, Associateship (AMIIM) Examn.
24. Examiner - Inst. of Engineers (India), AMIE (I) Examn.
25. Examiner - Graduate Aptitude Test (GATE), IIT-Kharagpur.
26. Examiner - Joint Entrance Examination (JEE), IIT-Kharagpur.
27. Examiner - confidential work related to GATE and JEE at the IIT-Kharagpur.
28. Examiner – PhD, MS, BS thesis – I.I.Sc., Bangalore, B.E. College (Cal. Univ.).
29. Consultant, Consultancy rendered to Century Extrusions Ltd., Nimpura, Kharagpur.
30. Principal Consultant, EPCOS Ferrites Ltd, Kolkata.

## **16. Membership of Academic/Professional Bodies:**

1. Fellow, Electron Microscopy Society of India (EMSI), Kolkata
2. Fellow, Indian National Science Academy (INSA), New Delhi
3. Fellow, West Bengal Academy of Science & Technology (WAST), Kolkata
4. Fellow, Indian Academy of Sciences (IAS), Bangalore
5. Fellow, The National Academy of Sciences, India (NASI), Allahabad
6. Fellow, Indian National Academy of Engineering (INAE), New Delhi
7. Fellow, Institution of Engineers (India), Kolkata
8. Life Fellow, Indian Institute of Metals, Kolkata
9. Member, National Academy of Sciences, Allahabad, India
10. Life Member, Indian Institute of Metals (I.I.M.), India.
11. Life Member, Materials Research Society in India (MRSI), India.
12. Life Member, Indian Laser Association (ILA), India.
13. Life Member, Indian Science Congress Association (ISCA), India.
14. Life Member, Plasma Science Society of India (PSSI), PRL, Ahmedabad.
15. Life Member, Texture Society of India (TSI), DMRL, Hyderabad.
16. Member, Materials Advantage [American Society of Metals (ASM), The Materials Society (TMS), The Association for Iron & Steel Technology (AIST) and the American Iron and Steel Institute (AISI)] USA

## **17. University/Institute/Laboratory Visited/Delivered Lecture:**

1. Univ. of Saarbruecken, Germany (Prof. H. Gleiter) Feb.'90.
2. Univ. of Bochum, Germany (Prof. E. Hornbogen), Feb.'90.
3. Univ. of Munster, Germany (Prof. Chr. Herzig), Feb.'90.
4. National Metallurgical Lab., Jamshedpur, India (Prof. O. N. Mohanty), Jul.'90.
5. Ind. Inst. of Science., Metall. Dept., Bangalore, (Prof. K. Chattopadhyay), Mar.'91
6. Regional Research Lab., Bhubaneshwar, India (Prof. H. S. Ray), Sept.'91.
7. Mass. Inst. of Tech. (MIT), USA (Prof. Morris Cohen), Dec.'91.
8. Harvard University, USA (Prof. D. Turnbull), Dec.'91.
9. Defence Metall. Research Lab., Hyderabad, India (Dr. C. R. Chakraborti), Oct.'92.
10. Centre for Advanced Technology, Indore, India (Dr. A. K. Nath), Oct.'92.

11. National Chemical Metallurgical Lab., Bombay, India (Dr. D.K. Biswas), Mar.'94.
12. University of Sheffield, UK (Profs. H. A. Davies, H. Jones), May'95.
13. Imperial College, London, UK (Profs. D. R. F. West, H. M. Flower), May'95.
14. Univ. of Cambridge, UK (Dr. H. Bhadeshia, Dr. C. L. Clyne), May'95 and Jun.'98.
15. The Welding Institute, Abbingdon, UK (Dr. P. Hilton), May'95.
16. National Physical Laboratory, Teddington, UK (Dr. S. R. J. Saunders), May,95.
17. University of Manchester, UK (Profs. G. W. Lorimer, F. J. Humphreys, Drs. N. Ridley, R. Elliot, R. I. Todd), Jun.'95 and Jun.'98.
18. University of Leeds, UK (Prof. D. V. Edmonds, Dr. R. F. Cockrane), Jun.'95.
19. University of Birmingham, UK (Prof. T. Bell), Jun.'95.
20. Fraunhofer Inst. f. Lasertechnik, Aachen, Germany (Dr. A. Gasser and Dr. A. Weisheit), Dec.'95 and Dec.'99.
21. Technische Universitaet, Clausthal, Germany (Prof. Dr. B. L. Mordike), Dec.'95, May'97, Jun.'98, Dec.'99, May'00.
22. Technische Universitaet, Berlin, Germany (Prof. Dr. H. J. Fecht), Dec.'95.
23. RWTH, Aachen, Germany (Prof. Dr. G. Gottstein), Dec.'99.
24. IFSW, Univ. Stuttgart, Germany (Dr. F. Dausinger), Dec.'99.
25. Wright State Univ., Dayton, USA (Prof. S. Mukhopadhyay), Mar.'00.
26. ARL, Penn. State Univ., USA (Dr. P. Martukanitz), Mar.'00.
27. UTSI, Univ. of Tennessee, USA (Prof. N. B. Dahotre), Mar.'00.
28. IFW, Dresden, Germany (Prof. Dr. L. Schultz), May '00.
29. IWW, TU-Clausthal, Germany (Prof. Dr. Y. Estrin), Dec.'01
30. IIT-Technion, Haifa, Israel (Prof. E. Rabkin), Mar.'02.
31. Unipress (Polish Academy of Sciences), Warsaw (Prof. W. Lojkowski), Apr.'02.
32. Warsaw University of Technology, Warsaw, Poland (Prof. T. Kulik), Apr.'02.
33. Inst. of Metallurgy & Mater. Sci. (IMIM), Polish Academy of Sciences, Krakow, Poland (Profs. J. Dutkiewicz, P. Zieba), Apr.'02.
34. Mech. & Manufac. Engg. Dept., UMIST, Manchester, U.K. (Prof. Lin Li), May '02.
35. Department of Engineering, University of Liverpool, UK (Prof. D. Bacon), May'02.
36. Mater. Sci. Division, Argonne National Lab., USA (Dr. J. A. Eastman), June'02.
37. Mater. Sci. Engg. Dept., Ohio State Univ., USA (Prof. M. Mills), June '02.
38. Dept. of Physics, Univ. Delaware, USA (Prof. G. Hadjipanayis), June '02.
39. Institute of Solid State Physics, Chernogolovka, Russia (Prof B Straumal), May '03.
40. Advanced Research Center for Powder Metallurgy (ARC-I), Hyderabad, India (Dr. G. Sundararajan), July '03.
41. Technical University of Clausthal, Clausthal-Zellerfeld (Prof Dr J Estrin), Jun.2004.
42. Technical University of Darmstadt, Germany (Prof Dr J Eckert), Jun.2004
43. Ecole des Mines, Saint Etienne, France (Dr A Fracewicz), Jun.2004.
44. Ecole Nationale de Ingenieur (ENISE), St Etienne, France (Prof I Smurov), Jun.2004.
45. Indian Institute of Science, Bangalore, India (Prof T Abhinandan), Aug. 2004.
46. India Science Center, General Motors, Bangalore, India (Dr A Tewari), Aug. 2004.
47. Defense Metallurgical Research Lab., Hyderabad (Dr A Sriramamurty), Apr. 2005.
48. Indira Gandhi Center for Atomic Research, Kalpakkam (Dr S L Mannan), May 2005.
49. University of Central Florida, Orlando, Florida, USA (Prof S Seal), June 2005.
50. University of British Columbia, Vancouver, Canada (Prof M Wells), July 2005
51. University of Chile, Santiago, Chile (Prof R Leteier), June 2006
52. University of Trinidad and Tobago, Port of Spain (Prof K D Srivastava) Aug. 2006
53. High Pressure Research Institute, Warsaw, Poland (Prof W Lojkowski), Aug. 2006
54. National Inst of Foundry Forge Tech, Ranchi, India (Prof M K Banerjee), Sept 2006
55. Sociedade Portuguesa da Inovação (SPI), Porto, Portugal (Dr Rachel Newton), Sept 14-15, 2006 (under Euro-Net project on Nanotechnology).
56. Federal University of Rio Grande do Sul (UFRGS) (Nov 6), National Inst. Of Metrology, Standardization, and Industrial Quality (INMETRO) (Nov 7), CENPES/Petrobrás (Industry) and Min. of Development, Industry and Foreign Trade (UFRJ) (Nov 8), Instrumentation Center for Agriculture (EMBRAPA) and Institute of Chemistry and Physics, State University

- of Campinas (UNICAMP) (Nov 9), Synchrotron Center (LNLS), Campinas (Nov 10) (Host: J A Brum, I Hümmelgen and S Guterres, under the India-Brazil-South Africa Joint Program) on Nov 5-11, 2006.
57. Inst. For Plasma Research (IPR), Gandhinagar (Dr S Mukherjee), Nov 24, 2006
  58. Georgia Technological Univ, Atlanta, USA (Prof WO Winer, Y Joshi), Mar 26'2007
  59. Wright State University, Dayton, USA (Prof S Mukhopadhyay), Mar 28, 2007
  60. Colorado School of Mines, Golden, USA (Prof B Mishra), Mar 29, 2007.
  61. Inst. for Mater. Res., GKSS, Geesthacht, Germany (Prof K U Kainer), Jun 15, 2007.
  62. Unipress - High Pressure Research Institute, Warsaw, Poland (Prof W Lojkowski) Sept. 2007.
  63. Dept of Materials, Univ. of Queensland, Australia (Prof G Schaffer) and Dept of Materials Engineering, Monash University, Australia (Prof Y Estrin), Oct. 2-6, 2007.
  64. Ithemba Laboratory (Cape Town), Silver Lakes (Pretoria), NECSA and Mintek (CSIR), Johannesburg and KwaMaritane, South Africa (N Coville, T Hille, N Marule) Nov 18-25, 2007 (under India-Brazil-South Africa – IBSA tripartite collaboration on Nanotechnology).
  65. University of Witwatersrand, Johannesburg, South Africa (N. Coville, B Tait) Aug 25-30'08.
  66. CSIR Nanotechnology Laboratory, Pretoria, South Africa (S Sinharay) Aug. 27,2008.
  67. Helmholtz Centre Berlin for Materials and Energy (Hahn Meitner Institut), Germany (J Banhart, G Schumacher) Jan 23, 2009.
  68. Tokyo Institute of Technology (Yokohama Campus), Japan (M Kajihara), 19 June 2009
  69. WPI, Tohoku University, Sendai, Japan (A Inoue, D Louzguine) 23 June 2009 ; and IMRAM, Tohoku University, Sendai (H Fukuyama) 16 June 2009
  70. NIMS, Tsukuba, Japan (K Hono) June 2009

## **18. Extra-curricular activities:**

1. Captained Nadia District Junior cricket team in 1977-79.
2. Captained B.E. College cricket team in 1982-83.
3. Represented I.I.T. Kanpur in Inter-IIT sports Meet (cricket & volleyball) in 1984.
4. Participated in several All India Radio (Calcutta) Science Quiz Programmes.
5. Represented I.I.T.-Kharagpur (cricket) at the Inter-IIT Staff Meet in 1986-87.
6. Member, Executive Council, Global Alumni Association of BESU, Howrah (2009-2011).