

Faculty Profile



Dr. Prafulla Kumar Mallik

Associate Professor

Contact Info:

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Administrative Contact:

Head of Department,

Metallurgical and Materials Engineering

Telephone No: 06768-267008

Education details:

PhD: Materials Science and Engineering; Indian Institute of Technology, Kanpur; Thesis defended in June, 2013 (Thesis submitted – April, 2013); specialization: **Biomaterials**

Thesis title: "**Spark Plasma Sintered Multifunctional HA-CaTiO₃ Composites for Bone Tissue Engineering Application**"

Under the guidance of Dr. Bikramjit Basu, Professor, MRC, IISc Bangalore and Dr. Kantesh Balani, Associate Professor, MSE, IIT Kanpur.

M.Tech: (First Class), Materials and Metallurgical Engineering; Indian Institute of Technology, Kanpur, India, 2003.

Thesis title: “**Tailoring the toughness of 8Y-ZrO₂: Role of Dopant Distribution**”

Under guidance of Dr.Bikramjit Basu, Associate Professor, MRC,IISc Bangalore, Karnataka

Bachelor of Engineering: (First Class), Metallurgical and Materials Engineering; Indira Gandhi Institute of Technology Sarang, Dhenkanal Odisha India, 2001.

Employment:

August , 2014 – till now	Assistant Prof., Indira Gandhi Institute of Technology Sarang, Dhenkanal -759146,Odisha India.
Nov, 2004 – 2013	lecturer, Indira Gandhi Institute of Technology Sarang, Dhenkanal -759146, Odisha India.
July, 2004-Oct 2004	Gust Faculty, Indira Gandhi Institute of Technology Sarang, Dhenkanal -759146, Odisha India.

Teaching Interests:

Nano Science & Technology, Transport Phenomena, X-ray & Electron Microscopy, Tribology of Materials etc.

Research Interests:

Nanomaterials and Nanocomposite, Biomaterials, Tribology of Materials, Multifunctional Materials etc

Research experience:

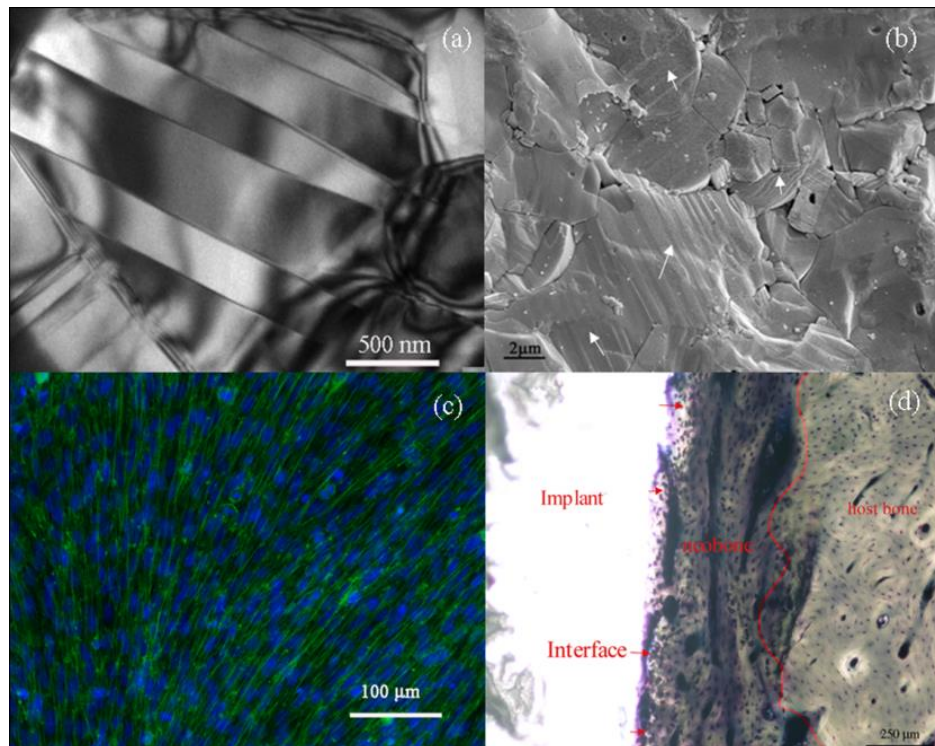
During M.Tech, I worked on a project in the field of “Advance Ceramics materials” in Ceramics Laboratory at Indian Institute of Technology, Kanpur under the guidance of **Dr.BikramjitBasu**, Associate Professor, **MME (IIT Kanpur)**, India. I was introduced with the idea of improving fracture toughness of mixed grades zirconia powders. The main objective was to find both

fracture toughness and wear optimization property in structural application. I implemented the following paper –“Toughness Tailoring of 8Y-TZ: New Result”. The implementation can be easily adapted to solve tribological as well as fracture toughness problems occur during the structural application.

During PhD, I worked in the field of biomaterials in Laboratory for Biomaterials at IIT Kanpur under the guidance of **Dr.Bikramjit Basu, Associate Professor, MRC,IISc Bangalore and Dr.Kantesh Balani, MSE, IIT Kanpur**. The recent trend in biomaterials research is to develop materials that will mimic the function and properties close to that of natural bone. One of the strategies of current research to improve osteointegration is by creating a new generation of the electrically bioactive hydroxyapatite-calcium titanate (HA-CaTiO₃) composites that will mimic and enhance bone osteogenesis, while enhancing the mechanical and electrical conductivity property. In order to restrict HA dissociation as well as any undesired sintering reaction, multi-stage spark plasma sintering (MSSPS) route has been optimized in the present work to develop HA-CaTiO₃ (CT) composites. The results of SPS processing revealed that 99 % theoretical density could be achieved for HA-CT composite at sintering temperature of 950°C /1100°C/1200°C. From phase analysis via x-ray diffraction, an absence of α and β -tricalcium phosphate Ca₃(PO₄)₂ or CaO phase was observed, which is also supported by FT-IR analysis. Fine scale microstructural characterization using TEM reveals the presence of twins in CaTiO₃ grains, whereas grain size of HA is observed to be ~1-2 μm via SEM. A moderate fracture toughness was obtained to be ~1.7 MPa m^{1/2} using SEVNB, while the fracture toughness for natural bone ranges between 2-12 MPa m^{1/2}. The diametral tensile strength of 17-34 MPa and flexural strength of 99-250 MPa was obtained, which is close to that of natural cortical bone. The difference in strength/toughness properties among HA-CaTiO₃ composites has been explained in terms of the twin width or twin density as well as using available theoretical models. In the perspective of evaluating electroconductive properties, the temperature (RT-200°C) and frequency (100Hz-1MHz) dependence of dielectric properties and AC conductivity for a range of HA-CaTiO₃ (HA-CT) composites is reported in the current work. AC conductivity of spark plasma sintered samples (~ up to 10⁻⁵ ohm⁻¹cm⁻¹) are found to be considerably higher than that of the pressureless sintered samples (~ up to 10⁻⁸ ohm⁻¹cm⁻¹). Overall, the results indicate the dependence of functional properties on processing route, as well as related advantages of

processing via spark plasma sintering route.

Cell-culture (using C2C12 mouse myoblast cells) indicated enhanced *in vitro* cytocompatibility with CaTiO₃ addition to HA. Importantly, parallel arrangement of myoblast cells on higher CaTiO₃ containing substrates indicate that self-adjustable cell patterning can be achieved on conductive biomaterials. Overall, the present study conclusively establishes the positive impact of the substrate conductivity towards cell proliferation as well as confirms the efficacy of HA-CaTiO₃ biocomposites as conductive platforms to facilitate the growth, orientation of myoblasts, even when cultured in the absence of external electric field. The ability of bone regeneration was assessed by implantation in cylindrical femoral bone defects of rabbit animal model for varying time period of 1, 4, and 12 weeks. The overall assessment of the histology results suggests that the progressive healing of bone defects around HA-80 wt. % CaTiO₃ is associated with a better efficacy with respect to early stage neobone formation, which is histomorphometrical around 140% higher than monolithic HA. Overall, the present study demonstrates that the *in vivo* biocompatibility property of HA-80 wt. % CaTiO₃ with respect to local effects after 12 weeks of implantation is not compromised when compared to control HA implant, which points toward the critical role of electrical conductivity on rapid early stage bone regeneration.



Top left: Representative BF TEM image of the twins in the CaTiO_3 grain of HA-40CT composites. **Top right:** Fracture surface of monolithic CaTiO_3 containing twinned grains, showing transgranular fracture. **Bottom left:** Fluorescence images stained nuclei of C2C12 mouse myoblast cells adhered on HA-80 wt. % CaTiO_3 ceramics incubated for 72 hrs of culture. **Bottom right:** Representative histological image of stevenel's blue stained regions of HA80CT implant/host bone interface after 4 weeks.

R & D Projects:

1. Dr. P.K. Mallik, PI, **Processing and Characterization of Al_2O_3 - CaTiO_3 Electroconductive Nanocomposite for the Femoral Head in Total Hip Replacement.** Sanctioned by SERB-DST, Government of India, and bearing file no. EEQ/2016/000546 amount of Rs.47,80,000/-

Research Publications:

List of publication:

1. P.K.Mallik, K.Balani, B.Basu “Nanoindentation Analysis of Multi Stage Spark Plasma Sintered Hydroxyapatite-Calcium Titanate Biocomposite” submitted to Applied Physics letter A (under review) May 2019.
2. M.R. Sahu¹, P.K.Mallik, S. C. Patnaik and Ajit Behera, “ Synthesis and Microstructure CaTiO_3 coating by Sol-Gel Spin-Coating Process, International Journal for Research in Applied Sciences and Biotechnology, 5 (1) (2018),pp.6-9.
3. R Kumar, **Prafulla Kumar Mallik** and B.Basu. Twinning induced enhancement of fracture toughness in ultrafine grained Hydroxyapatite-Calcium Titanate composites, Journal of the European Ceramic Society 36, (2016), pp-805-815.
4. Prafulla Kumar Mallik G.Biswal, S.C.Patnaik, S.Senapati, Characterisation of Sol-Gel Synthesis of Phase Pure Crystalline CaTiO_3 Nano Powders after Drying IOP conf, series Material Science and Engineering, 75, (2015)012005.
5. S. C. Patnaik, P. K. Swain, **P. K. Mallik**, S. K. Sahoo, Wear Characteristics of Aluminum Graphite Composite Produced by Stir Casting Technique, Journal of Materials & Metallurgical Engineering, 04 (3) (2014) pp.13.

6. **Prafulla Kumar Mallik**, Dhiren Kumar Behera, Bikramjit Basu, Effect of Ytria Distribution on the Fracture Toughness of Y-ZrO₂ Ceramic, International J. of Innovative and Research, 03, (2014) 01, pp.70-73.
7. Ashutosh Kumar Dubey **Prafulla Kumar Mallik**, Swarup Kundu and Bikramjit Basu, Dielectric and Electrical Conductivity Properties of Multi-stage Spark Plasma Sintered HA-CaTiO₃ Composites and Comparison with Conventionally Sintered Materials, Journal of European Ceramic Society 33(2013) 3445-3453.
8. Greeshma Thiriviraman, **Prafulla Kumar Mallik** and Bikramjit Basu, Substrate conductivity dependent modulation of cell proliferation and differentiation in vitro. Biomaterials 34 (2013) 7073-7085.
9. **Prafulla Kumar Mallik** and Bikramjit Basu, Better early osteogenesis of electroconductive HA-CaTiO₃ composite in a rabbit animal model, Journal of Biomedical Materials Research part A (2013)00:000-000.
10. **Prafulla Kumar Mallik** P.K.Swain, S.C.Patnaik, Characterisation of Suspension Precipitated Nanocrystalline Hydroxyapatite Powders, IOP conf, series Material Science and Engineering, 115, (2016)012025.
11. Nitesh Gupta, **Prafulla Mallik**, Mike Lewis and Bikramjit Basu, Improvement of toughness of Y – ZrO₂: role of dopant distribution, Key Engg. Materials, 264-268 (2004), pp.817-820.
12. Nitesh Gupta, **Prafulla Mallik** and Bikramjit Basu, Y – TZP ceramics with optimized toughness: New results; J. Alloys and Compounds, 379, (2004) 228, pp.228-232.

Conferences:

1. **P.K.Mallik**, and BikramjitBasu Improvement of toughness of Y – TZP Ceramics: role of Dopant Distribution, COMPOSIT2K3, National Conference, IIT ,Kharagpur, India.
2. **P.K.Mallik**, and BikramjitBasu, Development of HA-CT composites with enhanced physical and functional property” Oral presentation at 65th Annual Technical Meeting of the Indian Institute of Metals, 16th November, 2011, Hyderabad, India.
3. **P.K.Mallik**, KanteshBalani and BikramjitBasuCharacterisation of multi-stage spark plasma sintered HA-CaTiO₃ for biomedical application, Oral presentation at ISRS-2012, 13th Dec-2012, IIT Madras, India.

4. **P.K.Mallik**, KanteshBalani and Bikramjit Basu, Processing and Microstructure-Property of Multi Stage Spark Plasma Sintered Hydroxyapatite- Calcium Titanate Biocomposite, Oral presentation at the 37th International Conference & Exposition on Advanced Ceramics & Composites (ICACC), January 27 - February 1, 2013 at the Hilton Daytona Beach Resort and Ocean Center in Daytona Beach, Florida, USA.
5. **P.K.Mallik**,D.K.Behera,B.Basu,Effect of Ytria Distribution on the Fracture Toughness of Y-ZrO₂ ceramics, Oral Presentation at International Conference on Metallurgical and Materials Processes, Products and Applications (ICMMPPA-2014) at OP Jindal Institute of Technology(OPJIT),Raigarh, CG,India
6. **P.K..Mallik**,S.C.Patnaik,S.K.Sahoo, J.Majhi, A Comparative Study on the Densification of Spark Plasma Sintered with Microwave and Conventional Sintered Zirconia Ceramics, Oral Presentation at NCMTES-2013, IGIT,Sarang, Odhisa, India
7. IpsitaMadhumita Das, HimansuSahoo, Pawan Ku. Agarwalla, AvinashRana, **P.K.Mallik**, Structural Characterisation of Calcium Titanate (CaTiO₃), Oral Presntation at NCMTES-2013, IGIT,Sarang, Odhisa, India.
8. **P.K.Mallik**, G.Biswal, S.C.Patnaik, S.Senapati, Characterisation of Sol-Gel Synthesis of Phase Pure Crystalline CaTiO₃ Nano Powders after Drying, Oral Presentation at NCPM 2014, NIT Rourkela, Odisha, India.
9. G.Biswal **P.K.Mallik**, S.Senapati, S.C.Patnaik, Processing and Mechanical Characterization of UHMWPE-CaTiO₃ Composite for Biomedical Application, Oral Presentation at AMMS 2015, IGIT Sarang, Odisha, India.
- 10.**P.K.Mallik**, Pravat Kumar Swain, Synthesis and Characterization of Nanocrystalline Hydroxyapatite Powders using Solution Suspension Technique, Oral Presentation at AMMS 2015, IGIT Sarang, Odisha, India.
11. **P K Mallik**, G Biswal, Characterization of UHMWPE-Calcium Titanate Bio-Composites Prepared By Compression Moulding International conference on Frontier in Materials Science and Technology (ICFMST-2015) at NIST, Berhampur, Odisha.
12. **P K Mallik**, P K Swain , S.C Patnaik, Characterisation of Suspension Precipitated Nanocrystalline Hydroxyapatite Powders, National conference on Processing and Characterisation of Materials (NCPCM-2015) at Department of Metallurgical and Materials Engineering, NIT Rourkela, Odisha.

13. S. S. Das, S. S. Biswal, S. C. Patnaik, **P. K. Mallik**, Synthesis and Characterization of Al_2O_3 - CaTiO_3 Nano Composite for Structural Application in Bio Medical Industry, 6th National Conference on Processing and Characterization of Materials (2016 (NCPCM2016), Dept. of Metallurgical & Materials Engineering, NIT Rourkela.
14. S. Mallick, **P. K. Mallik**, S. C. Patnaik, Synthesis and Characterization of Calcium Titanate (CaTiO_3) reinforced Ultra High Molecular weight Polyethylene (UHMWPE) Bio Composite for Hip and Knee Application. 6th National Conference on Processing and Characterization of Materials (2016 (NCPCM2016), Dept. of Metallurgical & Materials Engineering, NIT Rourkela.
15. P..K..Swain ,**P. K. Mallik**, S. C. Patnaik, Novel investigation of nano-materials and MgB_2 based conductor: A perspective study, 6th National Conference on Processing and Characterization of Materials ((NCPCM2016), Dept. of Metallurgical & Materials Engineering, NIT Rourkela.
16. **P. K. Mallik**, S. S. Biswal S. C. Patnaik, “Fabrication and Characterization of Bioelectronic Al_2O_3 - CaTiO_3 Nanocomposite for Biomedical Application “International Conference on Materials Engineering (ICME-2017), 2nd -4th June, 2017 Dept. of Materials Science and Engineering, IIT, Kanpur.
17. **P. K. Mallik**, S. C. Patnaik, “Processing and Characterization of Al_2O_3 - CaTiO_3 Nanocomposite for Biomedical Application “International Symposium and NMD-ATM-2017, 11th -14th Nov, 2017, BITS Pilani Goa.
18. M.R. Sahu, **Prafulla Kumar Mallik** S. C. Patnaik , Synthesis and Microstructure CaTiO_3 coating by Sol-Gel Spin-Coating Process, 7th National Conference on Processing and Characterization of Materials ((NCPCM2018), Dept. of Metallurgical & Materials Engineering, NIT Rourkela.

Books/Books chapter

1. Shekhar Nath, Arjun Dey, Prafulla K. Mallik, Bikramjit Basu, and Anoop Kumar Mukhopadhyay”Nano indentation of Hydroxyapatite-Based Biocomposites” Nanoindentation of brittle solids, CRC press 2014, pp.201-208,

Organizing conferences/meetings/Symposiums (in INDIA):

1. Co-ordinator, Faculty Development Program on “Fundamentals of Processing, Properties and Application of Nanomaterials” (FPPANM-2019) held at IGIT Sarang during 16-28th December-2019.
2. Convener, Short Term Course on Nanomaterials Science and Technology-2018 (NANOMAST-2918) held at IGIT Sarang during 12-16th March-2018.
3. Convener, national Symposium cum seminar on Advance Materials and their Industrial uses and Manufacture (ADMANTIUM1.0), held at IGIT Sarang during 5-6th January, 2015
4. Convener, national symposium cum seminar on Processing and Characterization of Advanced Materials and their Industrial Application (ADMANTIUM2.0), held at IGIT Sarang during 27-28th February, 2016
5. Convener, Seminar for fresher’s “Will Power to Excel”, held at IGIT Sarang during December 11-12, 2014.

Invited Lectures/Presentations:

1. **Photocatalysis of Titanium dioxide: Clean and Green Technology** presented in Towards Holistic Science and Technology (THOST-2015), IIT, Kanpur, UP India.
2. **Natural Water Treatment**, presented in Towards Holistic Science and Technology (THOST-2016), IIT, Kanpur UP India.
3. **Transport Phenomena** , invited lectures in the Department of Metallurgical Engineering, GCE,Keonjhar, Odisha, India
4. **Nanomaterials: Processing, Properties and Application**, presented in Recent Advanced in Science and Technology, Department of Physics, IGIT Sarang, Odisha, India.
5. **Design of Biomaterials for Biomedical Application**, presented in Recent Trend in advanced Materials, Mechanical Design and its Application, Department of Mechanical Engineering, IGIT Sarang, Odisha, India.
6. **Green and Clean Technology using Titanium Dioxide** presented in national workshop on Application of Chemical Engineering in Natural Resources (ACHENRI), Department of Chemical Engineering IGIT Sarang

Students/Researchers supervised at IGIT Sarang:

B.Tech Project:

1. S.K.Mishra, H. C.Dalai, D. Mundari, S.Behera, Development of Al-Al₂O₃ Composites by Compocasting Technique, 2005
2. S.N.Panigrahi, S. P. Biswal, P.C.Rout, S.Behera, M.Mallick, "Preparation of TiO₂ powders and Thin Film by Sol-Gel dip coating method" 2006
3. S.N.Panigrahi, S. P. Biswal, P.C.Rout, S.Behera, M.Mallick, "In Situ Processing and Charcterisationof Al-TiAl₃ composites by casting Method", 2007.
4. S. Panda, D.Shankar, S.pandey, S.Das, S.Dejury, "Study of microstructure and hardness of Al and Al-TiO₂ composites" 2008
5. S.Gupta, L.Rout, S.sahoo, A.Khuntia, D.K.Sahoo, 2009.
6. M. M.Nayak, S. Padhi, De Das, N. Routray "Determination of Biocompatibility of TiO₂ Coated Al & Mild steel" 2010
7. S. Parida, M. Mali, B. Behera, S.Ku.Sahoo "Synthesis Characterization of Hydroxyapatite Powder" 2010
8. Ronak Shah, "Synthesis of Hydroxyapatite-Calcium titanate composites for biomedical application by Multistage Spark Plasma Sintering" IITKanpur-2011.
9. I.Das, H.K.Sahoo, S.Tripathy, P.Agrwal, "Structural Characterization of Spark Plasma Sintered Calcium titanate" 2013.
10. S.K.Biswal, N.B.Sahoo, S.K.Rout,R.Deepika, K.Jena,P.K.Behera "Sol-Gel Synthesis and Characterization of CaTiO₃ Nano powders.2014
11. S.K.Biswal, N.B.Sahoo, S.K.Rout, R.Deepika, K.Jena,P.K.Behera "In Situ Synthesis and Characterization of UHMWPE-CaTiO₃ Nanocomposites for Biomedical Application.2015
12. S. Panda, M. K. Behura, R. Nath, Synthesis and Characterization of CaTiO₃ Coating by Sol-Gel Spin-coating on Ti alloys for Biomedical Application" 2017
13. S.Pattnak, M.K.Sahu,P.R.Mallik, S.K.Das, Fabrication and characterization of ceramic ceramic nanocomposite (Al₂O₃-CaTiO₃) as a Tundish Material. 2017
14. Y.K.Sahoo,N.K.Sahoo,B.Sahoo, R.R.Mohanta, Preparation and Characterisation of Coating on 316l Stainless Steel For Biomedical Application-2018
15. B. Dwibedi, D. Agrawal, M. Barik, R. Khamari, R. P. Sahoo, T. R. Pattanaik, and A. Pattanaik Synthesis and Characterization of Nanostructured Calcium Aluminate for Dental Applications by Sol-gel Process-2018
16. A.Das, I. Dwibedy, S.K.Samal,A.Sutar,R.R.Kauri, T.P.Nayak Electrical Characterisation of Calcium Aluminate for Dental Application-2019
- 17.

Masters (M. Tech) Thesis:

1. Mr. Chandrasekhar Tripathy, "**Preparation and Characterization of Calcium Titanate Dielectric Ceramics for Capacitance Application**", 2014.
2. Mr. Girija Sankar Biswal "**Processing and Mechanical Characterization of UHMWPE -CaTiO₃Bicomposites**", 2015.
3. Mr. S. Biswal, **Electrical characterization of Al₂O₃-CaTiO₃ nano composites for bioelectrical application**, 2016

4. Miss S.Mallik, **Friction and Wear characterization of UHMWPE -CaTiO₃ Bicomposites Cup for Hip replacement application, 2016**
5. Miss S.S.Das, **processing –microstructure –mechanical properties correlation of Al₂O₃-CaTiO₃ composites for biomedical applications, 2016.**
6. Mr.Manash Ranjan Sahoo, **“Synthesis and Characterization of Nano-structured CaTiO₃ Coating on Cp-Ti alloys by Sol-Gel Spin-coating process” 2017**
7. Mr.Lamodar Samal, **Fabrication and characterization of ceramic ceramic nanocomposite (Al₂O₃-CaTiO₃) as a Tundish Material. 2017**
8. Mr.Biren Kumar Sahoo, **Processing and Characterization of nano CaTiO₃ powder using High Energy Ball Mill, 2018**
9. Miss Bandana Behera, **Processing and Electrical characterization of UHMWPE-CaTiO₃ Composites 2019.**

Teaching Contribution:

Existing courses taught at IGIT Sarang:

1. Instructor for an undergraduate course **“Nano science and Biotechnology”**
2. Instructor for an undergraduate course **“Transport Phenomena”**
3. Instructor for undergraduate core course **“Introduction to Physical Metallurgy”**
4. Instructor for undergraduate core course **“Biomaterials” in Materials for Advanced Applications,**
5. Instructor for postgraduate course **“Physical Metallurgy”**
6. Instructor for postgraduate course **“Characterization of Materials”**
7. Instructor for postgraduate course **“Tribology of Materials”**
8. Instructor for an undergraduate course **“X-Ray and Electron Microscopy”**
9. Instructor for undergraduate compulsory course **“ Metal working and Testing of Metallic Materials”**
10. Instructor for undergraduate core course of mechanical Engineering **“Introduction to Physical Metallurgy and Engineering Materials”.**

Administrative Experience:

1. Secretary, IGIT Alumni Association, 2009-2010.
2. Co-ordinator, Department academic monitoring committee.
3. Co-ordinator, DHRUVA club.
4. Academic Administrative Officer, Dean of Academic , July2007-June2010.
5. Co-ordinator, Post Graduate Programme from July 2014–till now.
6. Superintendent, Bhaskar Bhawan, August 2014 till now.
7. Assistant Superintendent, Arybhata Bhaawan, August 2006 to 2009.
8. Convenor, HORIZON tech fest-2014.
9. Department Co-ordinator of National Board of Accreditation (NBA) -2008, 2016.
10. Department Co-ordinator of equipment purchasing committee-2016.
11. Department Co-ordinator of TEQIP-III-2017 till now
12. Co-ordinator of IIM student Chapter- 2017 till now
13. Coordinator of Society of Metallurgical Engineering

Awards/prizes:

1. MHRD scholarship from Govt. of India for pursuing M.Tech. at IIT Kanpur.
2. QIP fellowship under AICTE from Govt. of India for pursuing PhD at IIT, Kanpur.
3. Cash awards for paper publication in reputed journals-2013.

Declaration:

I hereby declare that all the information mentioned above is true my knowledge and I bear the responsibility for the above mentioned particulars.

Date:

Place: IGIT Sarang



(Dr.P.K.Mallik)