Ph.D. Program

Collaborative Research on Science and Technology (CReST)
Centre for Sophisticated Instruments and Facilities (CSIF)
Indian Institute of Technology - Bombay
Topics for CReST Ph.D.Program (Autumn 2026)

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
1	Halide perovskite based memristors	Aswani Yella, aswani.yella@iitb.ac.in	Dasari Venkatakrishnarao, chemistry dasarikrishna@iitb.ac.in	Masters in sciences or engineering of relevant discipline.	TA/FA/SW/SF/IS/EX/CT

Topic Name : Halide perovskite based memristors

Abstract : Hybrid metal halide perovskite (MHP) materials, with the general structure ABX3, have recently had a significant and rapid influence on optoelectronics, particularly in their rise as leading contenders for next-generation photovoltaic (PV) devices.1 One major advantage of MHPs is their ability to be deposited through simple and cost-effective solution-processing methods.2 Despite this ease, they exhibit properties on par with or better than traditional semiconductors, such as GaAs, which are more expensive to produce. Beyond their influence in photovoltaics, MHPs also possess unique properties that make them well-suited for neuromorphic information processing.3 Unlike transition metal oxides, which have been a primary focus of neuromorphic research, these materials exhibit significant ionic and electronic responses to external stimuli like voltage, temperature, light, and strain. While ionic migration in MHPs poses challenges for PV applications,4 it has recently been explored as a potential enabler for neuromorphic functions. This ion migration can enable memristive or memcapacitive switching, and when harnessed effectively, it can also encode temporal information in a way that mimics biological synapses, a critical component for advanced neuromorphic computing.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
2	2D Hybrid Organic/ Perovskite Composites for the Generation of Electrically Pumped Lasers	Dasari Venkatakrishnarao, dasarikrishna@iitb.ac.in	Aswani Yella, MEMS aswani.yella@iitb.ac.in	M.Sc in Chemistry, Physics, Nanoscience and Nanotechnology. M.Tech in Chemical Engineering, MEMS, and Electrical Engineering.	TA/FA/SW/SF/IS/EX/ CT

Topic Name : 2D Hybrid Organic/Perovskite Composites for the Generation of Electrically Pumped Lasers

Abstract : The realization of an electrically pumped laser based on solution-processable materials remains a long-standing challenge in optoelectronics. While organic semiconductors and metal halide perovskites have independently demonstrated efficient light emission, optical gain, and low-threshold optically pumped lasing, neither system has yet enabled stable electrically driven laser emission due to fundamental limitations such as triplet accumulation, low charge-carrier mobility, electrode-induced optical losses, and thermal instability under high current densities.

This project proposes a systematic investigation of 2D hybrid organic/perovskite composites as a new gain medium for electrically pumped lasers by integrating thermally activated delayed fluorescence (TADF) organic emitters within layered Ruddlesden–Popper and Dion–Jacobson perovskites. The hybrid architecture is designed to synergistically combine the high in-plane charge-carrier mobility and exciton confinement of 2D perovskites with the near-unity internal quantum efficiency and triplet harvesting capability of TADF molecules. In particular, hot-exciton TADF emitters based on DABNA-derived donor–acceptor motifs will be synthesized and functionalized for incorporation as organic interlayers, enabling efficient charge or energy transfer from the perovskite host to the organic gain medium.

The project will encompass molecular design and synthesis, controlled growth of vertically oriented 2D hybrid perovskite stacks, and advanced ultrafast spectroscopic studies to elucidate charge-transfer dynamics and amplified spontaneous emission thresholds. Optical lasing will be investigated using microcavities and Fabry–Pérot resonators, followed by fabrication of LED-type device architectures to probe electrically driven emission and spectral narrowing under pulsed electrical excitation.

Successful demonstration of stimulated emission or lasing from electrically excited 2D organic/perovskite hybrids would represent a first-of-its-kind advance, addressing a critical bottleneck in organic and perovskite photonics. The outcomes are expected to establish new design principles for electrically pumped soft-material lasers and enable future applications in integrated photonics, sensing, and low-cost coherent light sources.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
3	Biophysical understanding of the role of proteins and lipids during membrane signalling using giant membrane vesicles and their de-regulation in neurodegeneration	Rochish Thaokar, rochish@che.iitb.ac.in	Shobhna Kapoor, Chemistry shobhnakapoor@chem.iitb.ac.in	M.Tech / B.Tech / M.Sc in Chemistry, Chemical Engineering, Biotechnology/ Bioengineering, Physics, Material Science	TA/FA/SW/SF/IS/EX/ CT

Topic Name : Biophysical understanding of the role of proteins and lipids during membrane signalling using giant membrane vesicles and their de-regulation in neurodegeneration

Abstract : Giant vesicles are artificial biomimetic cells of sizes of around few microns artificially made in the lab, but offer the flexibility of controlling the membrane composition. Giant plasma membrane vesicles (GPMVs) on the other hand are produced by chemically inducing living cells to bleb off large fragments of their plasma membrane containing proteins, ions channels and lipids. GUVs and GMPVs help investigate important biological processes such membrane protein partitioning, effect of curvature, and signalling domains without the complexity of the cellular cytoskeleton and intracellular trafficking and hence serve as a bridge between fully synthetic systems (liposomes) and living cells. The project would involve producing biomimetic excitable and non-excitable cells using GPMVs and GUVs, and understanding their response to electrical stress as induced by AC fields or pulsed DC fields. The study will help in understanding biophysical processes at the heart of cellular signalling in excitable and non-excitable cells, and the role of ion-channels, proteins, lipid domains, and membrane composition in the same and their de-regulation in diseased conditions like neurodegeneration.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
4	Membrane Filtration Strategies for Virus Retention and Enrichment in Pharmaceutical Manufacturing and Environmental Monitoring	Swatantra P. SIngh, swatantra@iitb.ac.in	Ashutosh Kumar,	MSc/M.Tech/in chemistry, biotech, chemical engineering, environmental engineering, or related field.	TA/FA/SW/SF/IS/EX/ CT

Topic Name : Membrane Filtration Strategies for Virus Retention and Enrichment in Pharmaceutical Manufacturing and Environmental Monitoring

Abstract : This project will investigate advanced membrane filtration strategies for virus retention and enrichment, bridging biopharmaceutical manufacturing and environmental monitoring. Leveraging ultrafiltration (UF), nanofiltration (NF), and next-generation virus-retentive membranes (e.g. nanostructured composites with enhanced flux and >6 LRV parvovirus clearance), the study will optimize tangential flow filtration (TFF) processes to achieve high-yield viral clearance in monoclonal antibody and vaccine production while minimizing fouling and ensuring regulatory compliance (ICH Q5A). Concurrently, it will develop scalable concentration protocols for low-titer viral pathogens in wastewater, supporting wastewater-based epidemiology for emerging threats like novel coronaviruses. By integrating antifouling modifications, real-time analytics, and hybrid systems, the project aims to improve efficiency, sustainability, and cross-domain applicability, fostering safer biologics and enhanced public health surveillance.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
5	Membrane-Integrated Electrochemical CO , Reduction to Value-Added Products for Sustainable Decarbonization	Swatantra P. Singh, swatantra@iitb.ac.in	Debabrata Maiti, Chemistry	MSc/M.Tech/in chemistry, biotech, chemical engineering, environmental engineering, or related field.	TA/FA/SW/SF/IS/EX/CT

Topic Name : Membrane-Integrated Electrochemical CO , Reduction to Value-Added Products for Sustainable Decarbonization

Abstract : Electrochemical CO , reduction represents a promising strategy to convert captured carbon dioxide into value-added fuels and chemicals while supporting sustainable decarbonization. This proposed project aims to develop a membrane-integrated electrochemical CO , reduction system through the simultaneous design of advanced electrocatalysts and high-performance ion-conducting membranes. Novel nanostructured catalysts will be engineered to enhance CO , activation, selectivity, and stability toward targeted products such as carbon monoxide, formate, and multi-carbon compounds. In parallel, functional membranes, including advanced anion exchange and composite membranes, will be developed to improve ion transport, minimize gas crossover, and regulate the local reaction environment. The integration of optimized catalysts and membranes will enable efficient, stable, and scalable electrochemical reactors for sustainable CO , conversion and industrial decarbonization.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
6	Environmental degradation and Toxicity studies of nanomaterials	Shobha Shukla, sshukla@iitb.ac.in	Kiran Kondabagil, BSBE Kiran Kondabagil <kiranko ndabagil@iitb.ac.in>	Masters in sciences or engineering of relevant discipline.	TA/FA/SW/SF/IS/EX/CT

Topic Name : Environmental degradation and Toxicity studies of nanomaterials

Abstract : Nanomaterials offer groundbreaking applications, but their environmental degradation and toxicity pose serious risks, especially in aquatic and agricultural systems. Recent studies highlight silver, titanium dioxide, and carbon-based nanomaterials as particularly concerning due to persistence, bioaccumulation, and oxidative stress effects. Sstandardized toxicity testing, environmental monitoring, and safe disposal practices should be adopted. A detailed investigation and thorough studies will be performed in this project on the carbon based nanomaterials. Chemical and biotoxicity will be performed in this project.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
7	Conversion of Carbon Dioxide into Medicinal Compounds: Sustainable Pathways for Pharmaceutical Synthesis	Debabrata Maiti, dmaiti@iitb.ac.in	Prof. Swatantra Pratap Singh, Environmental Science and Engineering Department (swatantra@iitb.ac.in	M.Sc. or an equivalent degree in Chemistry	TA/FA/SW/SF/IS/EX/CT

Topic Name : Conversion of Carbon Dioxide into Medicinal Compounds: Sustainable Pathways for Pharmaceutical Synthesis

Abstract : Rising atmospheric carbon dioxide levels present both an environmental challenge and an opportunity for innovative chemical utilization. This PhD research project focuses on the development of sustainable methods to convert captured carbon dioxide into valuable medicinal compounds and pharmaceutical intermediates. The study will investigate catalytic, electrochemical, and biotechnological approaches for transforming CO , into bioactive molecules and drug precursors used in the pharmaceutical industry. Emphasis will be placed on green chemistry principles, efficient carbon capture and utilization technologies, and scalable reaction pathways. The research aims to integrate environmental sustainability with drug development by converting a major greenhouse gas into therapeutically relevant compounds. The outcomes are expected to contribute to carbon management strategies while opening new routes for eco-friendly pharmaceutical synthesis.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
8	Dynamics and structural biology of 19F labelled proteins using an integrated 19F NMR and X-ray crystallography approach	Ishita Sengupta, 10001920@iitb.ac.in	Professor Prasenjit Bhaumik, BSBE pbhaumik@iitb.ac.in	Msc/Mtech in chemistry/ biochemistry/ biophysics or biotechnology	TA/FA/SW/SF/IS/EX/ CT

Topic Name : Dynamics and structural biology of 19F labelled proteins using an integrated 19F NMR and X-ray crystallography approach

Abstract : For high resolution snapshots of proteins in various conformations, X-ray crystallography is highly successful. However, to uncover the timescales of motion, population of these conformations and to detect hidden intermediates with atomic resolution, NMR spectroscopy is the most powerful spectroscopic technique. Recently, 19F NMR has been tremendously successful in probing such motions in complex biomolecules, not amenable to analysis by traditional methods. Transiently populated invisible intermediates of functional relevance have been uncovered by 19F NMR, when no other spectroscopic tool has succeeded. Unfortunately, the introduction of a 19F label can also perturb the structure in unpredictable ways and must be validated. Together, 19F NMR and X-ray crystallography provides a comprehensive description of dynamics across timescales and structural perturbation introduced by the 19F label.

This project entails a systematic analysis of 19F labelling on the model fold-switching protein RfaH using 19F NMR and X-ray crystallography. While 5F-Trp labelling has been explored, 19F labelling of phenylalanine and tyrosine residues, which are much more abundant and offer a large number of site-specific probes of dynamics in both the DNA binding domain and the fold-switching domain of RfaH are yet to be studied. The candidate will introduce and label strategically positioned aromatic sidechains in RfaH, solve their high-resolution structures by X-ray crystallography and study their dynamics using 19F NMR. The candidate will carry out sample preparation, 19F NMR and analysis in the guide's laboratory and X-ray crystallography of fluorinated proteins in the co-guide's laboratory.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
9	Fabrication and application of nanomaterials for industrial wastewater treatment	Tabish Nawaz, tnawaz@iitb.ac.in	Rahul Kashyap, Physics rahulkashyap@iitb.ac.in	M.Sc in Chemistry/Material Science or M.Tech in Chemical Engineering/Environmental Engineering/Material Science & Engineering	TA/FA/SW/SF/IS/EX/CT

Topic Name : Fabrication and application of nanomaterials for industrial wastewater treatment

Abstract : India generates approximately 14,000 to 44,000 MLD of industrial wastewater containing a variety of organic and inorganic pollutants. There is a need for developing materials such as membranes, adsorbents, catalysts and electrodes that can be effective in removing these contaminants and make the polluted water of reusable standard. In this research topic, emphasis would be on fabricating, characterizing and testing the functional nanomaterials as ion exchange membranes and electrodes prepared via electrospinning and other casting techniques. Industrial wastewater of prime interest would be from oil & gas and food industries. After the material development and performance evaluation at lab scale, there would be focus on to develop rate kinetic models and non-dimensional parametric mathematical models for understanding scale-up and reactor design and improve the material properties further by incorporating the suitable modifications.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
10	fs laser patterned materials for optoelectronic applications	Shobha Shukla, sshukla@iitb.ac.in	Deepak marla, Mechanical Engg dmarla@iitb.ac.in	Masters in sciences or engineering of relevant discipline.	TA/FA/SW/SF/IS/EX/CT

Topic Name : fs laser patterned materials for optoelectronic applications

Abstract : Direct laser–patterned materials are emerging as a powerful platform for optoelectronic applications, enabling precise micro/nano-structuring of semiconductor materials to enhance light management, device integration, and performance. These techniques combine ultrafast processing with high spatial resolution, offering scalable and cost-effective fabrication routes for next-generation photonic and optoelectronic devices. In this project we plan to use femto econd laser for patterning high refractive index materials. Extensive material and spectroscopic characterization will be performed to ascertain the suitability of the materials for photonics applications such as waveguiding, precise sensing, switching etc.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
11	Chemical recycling of plastics using solar energy harnessed by carbon nanostructures	Guruswamy Kumaraswamy, guruswamy@iitb.ac.in	Chandramouli Subramaniam, Chemistry csubbu@chem.iitb.ac.in	BTech, MTech or MSc in chemistry, chemical engineering, polymer science and engineering, or materials science.	TA/FA/SW/SF/IS/EX/CT

Topic Name : Chemical recycling of plastics using solar energy harnessed by carbon nanostructures

Abstract : The global annual production of synthetic plastics stands at about 400 million tons at this time. The vast majority of these materials are discarded after single-use - therefore, plastic pollution is one of the defining challenges of our time. One approach to address this problem is to recycle the plastics so that their effective use-life is increased, decreasing the need for fresh petrochemically derived monomer. Commonly, this takes the route of thermomechanical recycling, wherein waste plastic is melted and reprocessed. However, there are difficult technical challenges to this route. Post consumer plastic streams are often mixed, comprising different plastics like polyethylene and polypropylene. Separating these is challenging, and processing a mixed stream results in blends with poor mechanical properties. Even if a pure stream is available, chemical degradation results in poor properties for thermomechanically recycled plastics. Therefore, chemical recycling, viz. depolymerization of waste polymers to yield monomers or other value added chemicals is of great contemporary interest. Since most polymerization reactions are downhill in free energy, de-polymerization is energy intensive. Therefore, we propose to explore the utilization of solar photothermal routes to valorization of waste plastic.
This project will combine the use of advanced carbon-based nanostructures to harness solar radiation, to generate high temperatures locally, that will be used to effect depolymerization of plastic. Our interest is mainly in commercially relevant commodity materials such as polyethylene and polypropylene - though other plastics such as polystyrene and polyethylene terephthalate might also be investigated. Students interested in this project should have a background in chemical engineering or chemistry. Some exposure to polymers is preferable but not mandatory. This project will involve development and fabrication of carbon structures that are optimized to absorb solar radiation, improving on motifs previously developed in Prof Subramaniam's group. These will then be combined with a process for processing plastic, to effect thermal depolymerization. The resultant products will be analyzed using advanced analytical tools (including separation using chromatography, spectroscopic characterization, etc).
Therefore, the student will have the opportunity to work on a problem of great current academic interest, and with important industry implications. S/he will be exposed to polymer chemistry, physics and engineering and to a wide swathe of experimental tools.

Prof. Guruswamy’s group currently works in polymer recycling, including thermomechanical and chemical recycling. We have experience with polymer processing and polymer characterization tools.
Prof. Subramaniam’s group works on nanomaterials for solar-thermal and/ior photothermal for energy conversion, along with expertise in materials characterization tools and techniques.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
12	Data Science Techniques for Efficient Reconstruction of Nuclear Magnetic Resonance Spectroscopy Images	Ajit Rajwade, ajitvr@cse.iitb.ac.in	Ashutosh Kumar, BSBE ashutoshk@iitb.ac.in	MTech/MS/MSc/ME/MEng in one of the following: Computer Science and Engineering, Electrical Engineering, Electronics, Statistics, Engineering Physics	TA/FA/SW/SF/IS/EX/CT

Topic Name : Data Science Techniques for Efficient Reconstruction of Nuclear Magnetic Resonance Spectroscopy Images

Abstract : Nuclear magnetic resonance (NMR) spectroscopy is an established technique for imaging of biomolecules. However, it is time consuming especially for high dimensional data (eg: volumetric data acquired across time is 4D data), and the acquisition time can range into several hours or even several days. The aim of this project is to use techniques from the area of compressed sensing in signal processing to develop techniques for efficient acquisition of these images fused with accurate reconstruction of the NMR images from a sparse set of measurements, which will save drastically on acquisition time. The project will also use latest advances from deep learning in its various flavours to enhance the speed as well as accuracy of the compressed sensing techniques. These flavours include but are not limited to neural network unrolling, deep priors, untrained neural networks or CNNs.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
13	Understanding controlled assembly of colloidal particles in evaporating droplets through fluid flow properties	Sunita Srivastava, sunita.srivastava@iitb.ac.in	Prof. Abhijeet, Mechanical Engineering abhijeet.kumar@iitb.ac.in	MSc in Phys/Material Science. Đ ORĐ Mtech in Nanoscience and Nanotechnology/Material Science and Engineering;Đ ORĐ Btech in Engineering Physics/ Mechanical Engineering/ Chemical Engineering/Material Science and Engineering	TA/FA/SW/SF/IS/EX/CT

Topic Name : Understanding controlled assembly of colloidal particles in evaporating droplets through fluid flow properties

Abstract : Droplet evaporation based self-assembly technique offers easy and affordable methods for ordering nanoscale colloids in crystalline structures and design complex materials[1, 2]. Solvent evaporation based assembly of nanomaterials over a flat surface has been reported to yield various surface structures in dried deposits, such as the ubiquitous coffee-ring [1, 3], concentric rings [2] and crack patterns [4]. During evaporation of a colloidal droplet with non-volatile solute particles, it typically leaves behind a ring-like deposit known as the coffee-ring due to dominant capillary flow whereas Marangoni flow results in the formation of an uniform film deposition [5]. The complex interplay of fluid flow and nanoscale interactions plays an important role in controlling the nanoparticle patterns formed during evaporation. However, achieving precise control remains challenging and has been less extensively explored. This project aims to address this gap by correlating the role of fluid flow in directing the assembly of nanoscale scale object during droplet evaporation. The studies will involve utilizing fluorescence-based particle tracking and particle image velocimetry measurements to correlate fluid flow with nanoscale object assembly, enabling controlled and predetermined colloid organization.
Keyword 1”G&÷ ÆWG2 ° Self-Assembly; Particle Tracking; Particle Image Velocimetry

References:
[1] S. Khawas, S. Bhattacharjee, S. Mukherjee, A. Sain, S. Srivastava, Directing the formation of tunable superlattice crystalline phases from anisotropic nanoparticles, Colloid Surface A, 690 (2024).
[2] S. Srivastava, Z.A. Wahith, O. Gang, C.E. Colosqui, S.R. Bhatia, Dual-Scale Nanostructures via Evaporative Assembly, Adv Mater Interfaces, 7 (2020).
[3] A.W. Zaibudeen, S. Khawas, S. Srivastava, Understanding multiscale assembly mechanism in evaporative droplet of gold nanorods, Colloid Interfac Sci, 44 (2021).
[4] S. Bhattacharjee, S. Srivastava, Ordered stripes to crack patterns in dried particulates of DNA-coated gold colloids modulating nanoparticle-substrate interactions, Soft Matter, 19 (2023) 2265-2274.
[5] N.P. Vaisakh, S. Bhattacharjee, S. Srivastava, Role of fluid forces and depletion interactions in directing assembly of aqueous gold nanorods on hydrophobic surfaces, Colloid Interface Sci, 65 (2025).

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
14	Mapping the thermodynamic and kinetic pathway of DNA Melting	Prof. Sunita Srivastava, sunita.srivastava@iitb.ac.in	Prof. Sandip Kaledhonkar, BSBE sandipk@iitb.ac.in	MSc in Phys/Material Science. Đ ORĐ Mtech in Nanoscience and Nnaotechnology/Material Science and Engineering;Đ ORĐ Btech in Engineering Physics.Đ /Material Science and Engineering	TA/FA/SW/SF/IS/EX/CT, TAP/PS (Incase if you choose this category, Please fill the Project related details as asked below)

Topic Name : Mapping the thermodynamic and kinetic pathway of DNA Melting

Abstract : This research project offers a unique opportunity to investigate the fundamental thermodynamic and kinetic pathways of DNA melting. By integrating Time-Resolved X-ray Scattering with Cryo-Electron Microscopy (Cryo-TEM), we aim to resolve the transient structural intermediates that occur during the DNA zipping process. We will utilize these complementary techniques to bridge the gap between dynamic ensemble measurements and high-resolution structural snapshots, ultimately mapping the energy landscape of the double helix formation. This project is ideal for students interested in biophysics, providing hands-on experience with world-class instrumentation to understand biomolecular interactions for creation of functional materials and its applications in nanoscience and nanotechnology.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
15	Rheological characteristics of marine deposits above the liquid limit water content	Ashish Juneja, ajuneja@iitb.ac.in	Partha Sarathi Goswami, Chemical Engineering psg@iitb.ac.in	MTech/ME or equivalent degree in Civil Engineering with research in Geotechnical Engineering. Chemical Engineering, Mechanical Engineering, Computational Engineering, Applied Mechanics, or allied disciplines will also be considered if they demonstrate strong preparation in soil mechanics/ geomechanics, rheology, and CFD/ numerical modelling.	TA/FA/SW/SF/IS/EX/CT

Topic Name : Rheological characteristics of marine deposits above the liquid limit water content

Abstract : Seabed deposits exist as structured suspensions or weak gels at high water content. Subsea equipment, anchors, foundations and communication cables are often made to rest on these seabeds. The engineering response of these soils is governed by their time-dependent deformation and viscous nature, yield stress, thixotropy, and structural breakdown. Understanding the rheological characteristics of the marine deposits is therefore essential for predicting and managing many offshore problems including submarine mudflow and seabed instability. Better characterisation of the marine deposits will support safer design and more reliable offshore operations e.g. laying of seabed communication cables or dredging.

Marine sediments are extremely fine grain soils with high natural water content and low shear strength. These soils exhibit liquid rheological properties due to disturbance. All this cannot be captured by conventional soil mechanics alone. The soil slurry flow behaviour is non-Newtonian and shows shear-thinning (softening) and reduction in modulus, all of which are controlled by yield stress, shear rate and viscosity. The rheological response is influenced by grain size, mineral composition, salinity, pH and temperature. Rheometers are effective for these ultra-soft soils with extremely low shear strength. These high-precision instruments can analyse the soil shear stress, shear rate, viscosity, yield stress and thixotropic properties.

This research aims to quantify and characterise the loss of soil shear strength during its slurry transition and flow-dominated behaviour. The objective of this study is twofold. First, to determine the rheological parameters of representative marine deposits at water contents above the soil liquid limit. About 250 tests will be conducted. The rheological parameters include modulus, time-dependent viscosity and creep, and normal stress coefficients. The results will be used to describe the viscous behaviour of the seabed sediments. They will be used as input to CFD–DEM simulations of one or two turbulent fluid-solid flow problems. Second, to establish practical guidance for safer design and more reliable offshore operations. Experimental and numerical results will be compared to establish the transition criteria for flow initiation, structural collapse and residual behaviour. It will allow the prediction of erosion, remoulding and loss in strength. Rheological testing will be conducted using the CSIF-IoE funded rheology facility located in the Chemical Engineering Advanced Rheology Laboratory. This work will contribute to collaborative, interdisciplinary research by connecting sedimentology, fluid and granular mechanics, and geotechnics. Prof. Ashish Juneja’s expertise will be required for baseline soil mechanics testing and interpretation, and implement computational flow modelling of the lumpy slurry using CFD-DEM simulations. Prof. Partha S. Goswami’s expertise will be required for interpretation of rheometer testing and study of fluid granular mechanics. The following methodology will be followed: (1) Characterise the slurry state using rotational and oscillatory rheometer testing; (2) Identify the rheological parameters that represent strength degradation, yielding, structural breakdown and viscous behaviour; and (3) Establish a transition criterion linking conventional geotechnical indices and shear strength to rheometer outputs.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
16	Development of nano-structured steels for automotive applications	Prof. Aparna Singh, aparna_s@iitb.ac.in	Prof. Dipanshu Bansal, Mechanical Engineering dipanshu@iitb.ac.in	MTech/Btech in Materials Science/Mechanical Engineering/Metallurgy	TA/FA/SW/SF/IS/EX/CT

Topic Name : Development of nano-structured steels for automotive applications

Abstract : The growing demand for fuel-efficient, lightweight, and high-performance vehicles has significantly influenced the evolution of advanced materials in the automotive sector. Among these, nano-structured steels have emerged as a promising class of materials due to their exceptional combination of strength, toughness, and durability. Characterized by grain sizes typically below 100 nanometers, nano-structured steels exhibit unique mechanical and physical properties that surpass those of conventional coarse-grained steels. These enhanced properties arise primarily from grain boundary strengthening mechanisms, as described by the Hall–Petch relationship, which becomes particularly significant at the nanoscale.

The development of nano-structured steel involves advanced material processing techniques designed to refine grain size and engineer microstructures. Severe plastic deformation (SPD) methods such as equal channel angular pressing (ECAP), high-pressure torsion (HPT), and accumulative roll bonding (ARB) are widely employed to achieve ultrafine and nano-sized grains. In addition to SPD, thermomechanical processing, controlled phase transformations, and rapid solidification techniques play a crucial role in tailoring the microstructure. The formation of nano-bainitic and nano-martensitic phases has been particularly effective in achieving a balance between strength and ductility. Alloying elements such as carbon, manganese, silicon, and chromium are strategically used to stabilize fine microstructures and control transformation kinetics.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
17	Effect of cooling conditions on the formation of oxide and nitride inclusions in steel	Deepoo Kumar, deepook@iitb.ac.in	Prof. Shyamprasad Karagadde, Mechanical Engineering s.karagadde@iitb.ac.in	M.Tech. in Metallurgical Engineering OR Mechanical Engineering OR Materials Science	TA/FA/SW/SF/IS/EX/CT

Topic Name : Effect of cooling conditions on the formation of oxide and nitride inclusions in steel

Abstract : Inclusions play an important role during the processing and application of steel. There is a plenty of work on the control of oxide and sulphide inclusions during solidification. However, the work on the effect of local cooling conditions on the formation of inclusions needs further attention. We propose to perform controlled cooling experiments using the high temperature confocal scanning laser microscope (HTCSLM). HTCSLM will be used for the microscopic observation during melting and solidification. The segregation will be studied using SEM-EPMA. A solidification model will be developed will be developed to predict the effect of micro and macro-segregation on inclusion formation during solidification. The experimental method and model will be tuned for practical scenarios such as solidification phenomena during continuous casting, ingot casting, welding and additive manufacturing.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
18	Long-wavelength III-nitride Light-emitting Diodes (LEDs) for Next-generation Optoelectronics: Growth and Characterization	Abhinandan Gangopadhyay, abhinandan.g@iitb.ac.in	Apurba Laha, Electrical Engineering laha@ee.iitb.ac.in	B.E./B.Tech./M.E./M.Tech. in Metallurgical Engineering/ Materials Engineering/ Electrical Engineering/ Chemical Engineering/ Mechanical Engineering; M.Sc. or equivalent degree in Physics/ Materials Science.	TA/FA/SW/SF/IS/EX/ CT

Topic Name : Long-wavelength III-nitride Light-emitting Diodes (LEDs) for Next-generation Optoelectronics: Growth and Characterization

Abstract : Group III-nitride semiconductors have revolutionized solid-state lighting and optoelectronics, enabling highly efficient blue and green light emitters. However, extending emission into the orange–red spectral region (>600 nm) remains one of the most challenging problems in semiconductor physics and materials science.

This project focuses on the design, epitaxial growth, and nanoscale characterization of high-Indium-content InGaN quantum heterostructures to achieve efficient long-wavelength III-nitride LEDs. Achieving emission beyond 600 nm requires >25% indium incorporation, which can severely degrade the crystalline quality of InGaN layers via phase separation, strain relaxation, and compositional inhomogeneity. The project aims to develop strategies for atomic-scale indium incorporation using advanced plasma-enhanced molecular beam epitaxy (PAMBE). To assess the efficacy of novel growth strategies for achieving high-indium-content InGaN layers, state-of-the-art scanning/transmission electron microscopy (S/TEM) techniques will be developed and applied to characterize interfaces and defects in the PAMBE-grown heterostructures. The highly complementary growth and characterization efforts will help develop III-nitride red LEDs with higher external quantum efficiency.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
19	Turbostratic graphene - Waste Carbon Valorisation	Sandeep Kumar, sandeep.kumar@iitb.ac.in	Sunita Srivastava, Physics Dept. sunita.srivastava@iitb.ac.in	MSc in Phys/Material Science. OR Mtech in Nanoscience and Nnaotechnology/Material Science and Engineering; OR Btech in Engineering Physics. /Material Science and Engineering	TA/FA/SW/SF/IS/EX/CT

Topic Name : Turbostratic graphene - Waste Carbon Valorisation

Abstract : Turbostratic graphene od Flash graphene, a unique carbon nano-material which is characterized by a rotational misalignment between adjacent graphene layers. It is a promising alternative to conventional stacked graphene and graphite due to its unique electronic and structural properties. Unlike Bernal-stacked graphene, turbostratic graphene exhibits weak interlayer coupling, preserving the intrinsic properties of monolayer graphene even in multilayer systems. This proposal aims to investigate scalable synthesis methods, structural characterization, and potential applications of turbostratic graphene in advanced electronics, energy storage, and thermal management.

The study will focus on preparation of Turbostratic graphene using flash Joule heating method and using activated carbon derived from waste biomass/ plastic. Advanced characterization tools, including Raman spectroscopy, X-ray scattering and electron microscopy will be employed to analyze layer orientation, defects, and electronic behavior. Furthermore, the proposal explores the material’s enhanced electrical conductivity, flexibility, and reduced interlayer friction for use in high-performance batteries, supercapacitors, and flexible electronic devices.

By addressing current challenges in large-scale production and integration, this research seeks to unlock the full potential of turbostratic graphene, positioning it as a key material for next-generation nanotechnology, sustainable building material and energy solutions.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
20	AI driven scanning probe microscopy	Prof. Alankar, alankar.alankar@iitb.ac.in	Prof. M. Aslam, Physics m.aslam@iitb.ac.in	M.Sc. in PhysicsÐ M.Tech. in Materials Engineering B.Tech. in Metallurgical Engineering M.Tech. in Mechanical Engineering B.Tech. in Materials Engineering (for direct Ph.D.) B.Tech. in Metallurgical Engineering (for direct Ph.D.) B.Tech. in Mechanical Engineering (for direct Ph.D.)	TA/FA/SW/SF/IS/EX/CT

Topic Name : AI driven scanning probe microscopy

Abstract : Tapping or intermittent contact mode in scanning probe microscopy has been one of the most commonly utilized imaging techniques. Optimization of tapping mode consumes considerable time for both the equipment and the operator and frequently results in probe and sample damage, inadequate image quality, and issues with reproducibility for novel sample types especially for less experienced users. The optimization of tapping mode imaging presents significant challenges, making it less suited for conventional control strategies and machine learning approaches. This project proposes an Artificial Intelligence (AI) driven workflow for automating the optimization process of the SPM in tapping mode. The project will involve understanding the SPM technique, machine learning (ML) and AI. One of the key objectives of the work will be to setup an optimization procedure based on the controls of SPM, material properties and model of characterization. A few other techniques that may be explored for improving the procedure are Bayesian optimization, Reinforcement learning and generative AI.