

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 (SPRING SEMESTER) (Dec 2025)

Candidates are encouraged to contact faculty members by e-mail directly in case they have any query.

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
1	Development of novel catalysts for sustainable conversion of Carbon Dioxide	Prof. Sonali Das, Chemical Engineering sonali.das@iitb.ac.in	Prof. Debabrata Maiti, Chemistry dmaiti@iitb.ac.in	Chemical Engineering or Chemistry	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Development of novel catalysts for sustainable conversion of Carbon Dioxide</p> <p>Abstract : The proposed research aims at developing novel catalysts for the sustainable one-step conversion of CO<sub>2</sub> to high value fuel and chemical products such as methanol and aromatics. The development of such catalysts can lead to major technological advances towards achieving a circular carbon economy. The work will involve development of new catalytic nanomaterials (such as tandem catalysts, core-shell catalysts, zeolites etc.), advanced catalyst characterization, testing of developed catalysts in continuous reactors and reactor design and kinetic modelling.</p>					
2	Data Science Techniques for Efficient Acquisition of NMR Spectroscopy Images	Prof. Ajit Rajwade, Computer Science & Engineering ajitvr@iitb.ac.in	Prof. Ashutosh Kumar, BSBE ashutoshk@iitb.ac.in	Mtech in CSE, EE or Biomedical engineering. Knowledge of signal processing and deep learning will be beneficial. Should be willing to take courses in NMR physics.	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Data Science Techniques for Efficient Acquisition of NMR Spectroscopy Images Abstract : NMR spectroscopy is a well-known modality for determining the (sometimes dynamic) structure of biomolecules. However, acquisition of 3D or 4D NMR data is known to be a time-consuming process. The paradigm of compressed sensing has been used in recent times for speedy acquisition of NMR images by deliberately undersampling the signals. At the same time, the associated estimators are capable of good quality reconstruction of these data. The aim of this research project is to advance the capabilities of this technique, by also fusing with modern deep learning techniques. The aim is to significantly speed up the acquisition of 3D or 4D NMR images while maintaining good quality reconstruction.</p>					

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
3	Study of fluid flow for controlled assembly of colloidal particles in evaporating droplets	Prof. Sunita Srivastava, Physics sunita.srivastava@iitb.ac.in abhijeet.kumar@iitb.ac.in	Prof. Abhijeet Kumar, Mechanical Eng	M.Sc in Physics/Material Science/Nanoscience and Nanotechnology, MTech in Mechanical Eng/Chemical Eng /Nanotechnology	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Study of fluid flow for controlled assembly of colloidal particles in evaporating droplets</p> <p>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 a 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 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.</p> <p>References: [1] S. Khawas, S. Bhattacharjee, S. Mukherjee, A. Sain, S. Srivastava, Directing the formation of tunable superlattice crystalline phases from anisotropic nanoparticles, <i>Colloid Surface A</i>, 690 (2024). [2] S. Srivastava, Z.A. Wahith, O. Gang, C.E. Colosqui, S.R. Bhatia, Dual-Scale Nanostructures via Evaporative Assembly, <i>Adv Mater Interfaces</i>, 7 (2020). [3] A.W. Zaibudeen, S. Khawas, S. Srivastava, Understanding multiscale assembly mechanism in evaporative droplet of gold nanorods, <i>Colloid Interfac Sci</i>, 44 (2021). [4] S. Bhattacharjee, S. Srivastava, Ordered stripes to crack patterns in dried particulates of DNA-coated gold colloids modulating nanoparticle-substrate interactions, <i>Soft Matter</i>, 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, <i>Colloid Interface Sci</i>, 65 (2025).</p>					
4	Catalytic Membrane Systems for the CO <sub>2</sub> conversion to value added products	Prof. Swatantra Pratap Singh, E.S.E.D. swatantra@iitb.ac.in	Prof. Debabrata Maiti, Chemistry dmaiti@chem.iitb.ac.in	Masters in Chemistry, chemical engineering, environmental engineering, materials science and engineering	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Catalytic Membrane Systems for the CO<sub>2</sub> conversion to value added products</p> <p>Abstract : Catalytic membrane systems offer a sustainable route for CO<sub>2</sub>, conversion into value-added products by integrating reaction and separation in a single platform. Embedding catalysts such as carbon nanomaterials within membranes enables simultaneous CO<sub>2</sub>, activation and selective transport, improving efficiency and product yield. These systems facilitate electrocatalytic pathways to produce fuels, chemicals, and precursors while enhancing catalyst stability and reducing energy demands. In this project we will develop catalysts and immobilized on laser induced graphene based membranes for the effective conversion of CO<sub>2</sub> to value added products.</p>					

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5	PFAS remediation and detection using electrospun nanofiber materials	Prof. Tabish Nawaz, E.S.E.D. tnawaz@iitb.ac.in	Prof. Chandramouli Subramaniam, Chemistry csubramaniam@iitb.ac.in	MTech/MSc in Chemistry, Chemical Engineering, Material Science or Environmental Science & Engineering	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : PFAS remediation and detection using electrospun nanofiber materials</p> <p>Abstract : PFAS are a class of compounds which have attract much global attention due to its versatile applications, presence in almost all environmental matrices and toxicity. Due to their trace concentration in different media, their detection and remediation is challenging. Particularly in India, there are lack of studies which focus on their detection, analysis and remediation. Moreover, to detect and remediate PFAS, highly selective approach and material are desired. In this work, electrospun nanofibers will be fabricated, and functionalized for their PFAS selectivity in presence of environmental matrices for detection and remediation. The role of background matrix, functional group properties, PFAS chain length will be investigated.</p>					

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6	Porous Transport Layers for Water Electrolyzers	Prof. Nagappan Ramaswamy, Chemical Engineering Nagappan@iitb.ac.in	Prof. Chandramouli Subramaniam, Chemistry csubbu@chem.iitb.ac.in	Chemistry, Chemical Engineering, Materials Science and Engineering	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Porous Transport Layers for Water Electrolyzers</p> <p>Abstract : Electrolyzers are critical technologies for producing green hydrogen through the electrolysis of water wherein electricity is used to split water molecules into its individual chemical components namely, hydrogen and oxygen. The integration of water electrolyzers with renewable energy sources such as wind or solar power enables the generation of green hydrogen which plays a key role in carbon-free, sustainable energy economy. Hydrogen is a major chemical feedstock in various industries and a potential energy carrier. A global research effort is underway to decrease the capital cost of electrolyzers and hence the cost of hydrogen generated. The performance and durability of water electrolyzers need to be improved which in turn depend on improving the properties of several structural components of the electrolyzer. At the core the electrolyzer are the catalysts for water splitting, membrane for ion transport and the Porous Transport Layer (PTL) for mass transport of reactants and products. Electrolyzer is fabricated by sandwiching an anode and a cathode catalyst layer in either side of the membrane. PTLs are composed of metal meshes and are placed on the back side of the catalyst layers. The PTL in water electrolyzer plays a crucial role in ensuring efficient reactant and product transport gas, water, and ion transport while maintaining structural and electrical integrity. Its primary functions include facilitating a) reactant water distribution to the catalyst layer, b) continuous hydrogen and oxygen product gas release, c) prevent gas bubble accumulation that could hinder mass transport, d) electrical conductivity between the catalyst layer and the current collector, ensuring efficient charge transfer with minimal resistance, e) maintain structural integrity, preventing electrode deformation and ensuring stable operation under varying pressure conditions and finally f) dissipate heat generated during electrolysis, preventing overheating and improving overall system durability. During electrolyzer operation a few critical challenges related to the anode PTL causes major performance losses of the electrolyzer. These include the development of a resistive passivation layer due to the high anode potential, delamination of the catalyst layer from the PTL and inefficient mass transport leading to lower reaction rates and system inefficiencies. Materials used for PTLs vary depending on the type of electrolyzer. In proton exchange membrane (PEM) electrolyzers, PTLs are often made of titanium due to its corrosion resistance in acidic environments, whereas alkaline electrolyzers typically use porous nickel-based structures. Optimizing the design, material properties and mass transport characteristics of the PTL is crucial for enhancing electrolyzer efficiency, durability, and cost-effectiveness. Given the multi-faceted role of the PTL, this provides an exciting research and development opportunity requiring a good understanding of the chemistry, chemical engineering and materials science aspects of the problem. The project will take an interdisciplinary approach involving the fabrication, characterization and diagnosis of PTLs in water electrolyzers. A key aspect of the doctoral dissertation would be to analyze the structure-property relationship of the PTL in electrolyzers, the impact of the pore structure, and the key interfacial aspects. Understanding and optimising PTL structures ensures a balance between reactant delivery, gas removal, and maintaining a robust interracial structure leading to improvement in electrolyzer efficiency and longevity.</p>					

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7	Understanding excitable and non-excitable cell responses using GUVs and GMPVs.	Prof. Rochish Madhukarrao Thakkar, Chemical Engineering rochish@iitb.ac.in	Prof. Shobhna Kapoor, Chemistry shobhnakapoor@chem.iitb.ac.in	Chemistry, ChemEngg, Phys, Biotechnology	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Understanding excitable and non-excitable cell responses using GUVs and GMPVs.</p> <p>Abstract : Giant Vesicles are artificial biomimetic cells of sizes of around 20 microns and more, artificially made in the lab, with the flexibility of controlling the membrane composition. GPMVs are produced by chemically inducing living cells to bleb off large fragments of their plasma membrane. The cytoskeleton is disrupted, and pieces of the cell membrane round up into vesicles. They help study membrane protein partitioning, curvature, and signaling domains without the complexity of the cytoskeleton and intracellular trafficking and 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 signalling in excitable and non-excitable cells, and the role of ion-channels, proteins, lipid domains, and membrane composition in the same.</p>					
8	Scalable Gas-Phase Synthesis of Nanomaterials: Enabling Functional Coatings, CO <sub>2</sub> , Utilization, and Emerging Applications	Prof. Manoranjan Sahu, E.S.E.D. mrsahu@iitb.ac.in	Prof. Prof. Smruti Ranjan Parida, MSME paridasm@iitb.ac.in	Students having M.Tech with chemical engineering/materials science engineering with material synthesis will be preferred. Other background having materials synthesis/ application is also ok.	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Scalable Gas-Phase Synthesis of Nanomaterials: Enabling Functional Coatings, CO<sub>2</sub>, Utilization, and Emerging Applications</p> <p>Abstract : The rapid, one-step synthesis of nanomaterials is crucial for a wide range of advanced applications, offering significant advantages over traditional multi-step batch processes, which are often time-consuming and can take several days to complete. In this study, a gas-phase aerosol process will be developed to synthesize nanomaterials with precisely controlled physicochemical properties. This continuous and scalable method allows for real-time tuning of material characteristics by adjusting process parameters, enabling the production of nanomaterials tailored for specific applications such as functional coatings, CO<sub>2</sub>, catalytic reduction, and other emerging applications. Furthermore, the study will investigate the scale-up potential of this process, aiming to achieve gram-scale material production per hour, thereby demonstrating its feasibility for industrial and commercial use.</p>					

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9	Ion Exchange Membranes for Water Electrolyzers	Prof. Nagappan Ramaswamy, Chemical Engineering Nagappan@iitb.ac.in	Prof. Prakash Chandra Ghosh, Energy Science and Engineering pcghosh@iitb.ac.in	Bachelors or Masters in Chemistry, Materials Science or Polymer Chemistry.	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Ion Exchange Membranes for Water Electrolyzers</p> <p>Abstract : The Government of India has established the National Hydrogen Mission and has set an ambitious target of 5 million metric tons of hydrogen to be generated from renewable sources. Hydrogen gas is a major chemical feedstock material in chemical industries and could also be a potential energy carrier molecule for use in automotive electric vehicle applications. In this context, the hydrogen gas is a critical molecule towards sustainability and the mitigation of climate change effects. Water electrolyzers are electrochemical energy conversion devices that split water into its elemental components (hydrogen and oxygen gases) using electricity generated from renewable resources (solar, wind etc). Water electrolyzers comprise of an anode and a cathode electrode sandwiched on either side of an ion exchange membrane. There are types of water electrolyzers that utilize the ion exchange membrane, namely the Proton Exchange Membrane (PEM) and Anion Exchange Membrane (AEM) water electrolyzers. Ion exchange membranes are electronically insulating materials that serve to selectively allow the conduction of ions from one electrode to the other while preventing the permeation of gases. In a typical PEM water electrolyzer, water is fed to the anode where it is oxidized to O<sub>2</sub> and protons. The protons are transported across the membrane to the cathode where it is reduced to evolve hydrogen gas. Similarly, in AEM water electrolyzer, water is fed to the cathode where it is reduced to hydrogen and hydroxide anions. The AEM material then selectively transport the hydroxide anions to the anode where it is oxidized to evolve oxygen gas. The ion-exchange membrane plays a critical role in enabling the water electrolyzer performance, stability, cost and it should be able to withstand an operational lifetime of greater than 40,000 hours. The current-state-of-the-art ion-exchange membranes are dominated by the fluorocarbon chemistry such as the perfluorosulfonic acid (PFSA) membranes commercialized under the name Nafion(R). While PFSA is highly conductive and durable, it possesses significant liabilities as it is based on the environmentally unfriendly fluorocarbon chemistry. In this project, you will synthesize and characterize aliphatic and aromatic hydrocarbon-based ion-exchange membranes for applications in PEM and AEM water electrolyzers. These synthesis efforts will include the use of polymer membrane backbone chemistry and various side chain chemistries. The characterizations will include ex situ studies to study polymer properties and in situ studies to understand performance and durability in water electrolyzers. The potential candidate will have a good background in polymer membrane synthesis and characterizations.</p>					

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10	Machine learning assisted joint computational and experimental design and development of novel biochar based catalyst for microbial fuel cells	Prof. Indrajit Chakraborty, E.S.E.D. indra.esed@iitb.ac.in	Prof. Sudarshan Vijay, Chemical Engineering sudarshan.vijay@iitb.ac.in	1. BTech / B.E. / B.S. or similar degrees in either Engineering (Chemical/Materials/Mechanical/Civil) or Science (Physics/Chemistry/Applied Science). 2. MTech/ M.E. / M.S. or similar degree in either Engineering (Chemical/Materials/Mechanical/Civil) or Science (Physics/Chemistry/Applied Science).	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Machine learning assisted joint computational and experimental design and development of novel biochar based catalyst for microbial fuel cells</p> <p>Abstract : High energy density fuel cells are critical to the energy transition from fossil fuels to renewable and sustainable sources of energy. Conventional fuel cells use transition metal electrocatalysts (such as platinum) to convert energy stored in chemical bonds into electricity. While these transition metal electrodes deliver state-of-the-art performance, they are expensive, difficult to source and maintain. Biochar, which is obtained from the pyrolysis of biomass, is trivial to source. It is rich in carbon, nitrogen, oxygen and sulphur. These elements combine to form amorphous materials that have been shown to be active at generating electricity by converting oxygen to water through the oxygen reduction reaction (ORR). Substituting platinum based electrodes with biochar based electrodes and its biochar-transition metal composites will significantly reduce the cost of device fabrication and maintenance. There are two key challenges with using biochar as an electrode for high energy density fuel cells. First, there is significant variability in the quality and composition of biochar due to the lack of standardization in biomass (from which it is produced). This variability translates into significant differences in the concentrations of carbon, nitrogen, oxygen and sulphur as well as varied amorphous phases and surface compositions. Second, biochar based materials are not stable for long durations under an electrochemical environment. These materials degrade under extreme potentials, leading to unstable electrodes. Both these challenges of lack of reproducibility and stability are solvable by replacing conventional fuel cells with microbial fuel cells. The bioelectrochemical systems use microorganisms to convert organic matter (present in the electrolyte) into electricity. Their composition, activity and stability under fixed electrochemical potential are tunable, offering pathways to precise design of high activity and electricity generation through ORR. Application of biochar anode can be beneficial for housing such exoelectrogens as biochar is biocompatible and offers high tunability of properties by varying the production parameters and appropriate choice of biomass as pyrolysis feedstock. A key challenge with using biochar electrodes with microbial fuel cells is matching the performance of commercial electrodes. From a design standpoint, it is currently unclear as to which organic moieties, surface composition and functional groups on the biochar substrate lead to the most active and stable ORR in microbial fuel cells when used as cathode. From an anode point of view, it is not clear as to how the extracellular electron transfer occurs from the microbe's cell surface to the outside environment. Trial-and-error based methods of designing these electrodes is time consuming and unlikely to succeed given the vast tunability of these microorganisms and biochar composition. Computational tools such as density functional theory (DFT), molecular dynamics simulations and machine learning techniques coupled with electrochemical characterization tools such as cyclic voltammograms have paved the way towards developing robust design principles and elucidating mechanisms for charge transfer in ORR. A key focus of this project will be on applying these tools to design and develop an understanding of charge transfer mechanisms on biochar for applications to microbial fuel cells. In this project, we will design, develop and characterize novel biochar-based cathodes to perform ORR for microbial fuel cells. We will apply state-of-the-art machine learning methods to perform high-throughput computational investigations to determine the most stable and active biochar electrodes for charge transfer reactions in ORR. To verify the results of our high-throughput investigation, we will perform long-length and time-scale machine learning assisted molecular dynamics simulations and report the atomistic mechanisms of charge and proton transfer. Best performing candidates from the machine-learning assisted computational investigations will be synthesized and characterized. We will synthesize these biochar materials and perform systematic electrochemical characterization using cyclic voltammograms and Tafel analysis. Through these computational and experimental methods, we will develop comprehensive design principles to generate compositions of biochar capable of performing efficient charge transfer reactions in a microbial fuel cell.</p>					

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11	AI/ML-Enhanced Electro-Optical Sensor Arrays integrated in Self-Adhesive Polymer Patches for Wearable Health Monitoring	Prof. Nirmal Suresh Punjabi, Koita Centre for Digital Health npunjabi@iitb.ac.in	Prof. Dipti Gupta, Metallurgical Engineering & Material Science diptig@iitb.ac.in	M.Tech/M.E./M.Sc./M.S. in Biomedical Engineering/Electronics & Communication Engineering M.Tech/M.E./M.Sc./M.S. in Materials Science & Engineering or Nanotechnology or Polymers	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : AI/ML-Enhanced Electro-Optical Sensor Arrays integrated in Self-Adhesive Polymer Patches for Wearable Health Monitoring</p> <p>Abstract : Continuous health monitoring through wearable devices is a critical need for at-home monitoring or remote patient monitoring, especially when there is limited availability of resources to provide personalized healthcare. The current solutions have limitations in multi-modal flexible sensing capabilities, comfortable skin interface design, and intelligent data interpretation. The proposed topic will focus on the development of an innovative AI/ML-enhanced electro-optical sensor platform integrated within self-adhesive polymer patches for seamless, comprehensive health monitoring. The project addresses three critical challenges: (1) Development of biocompatible, self-adhesive polymer substrates that maintain optimal skin contact, (2) Integration of heterogeneous sensor arrays combining electrodes, mechanical, and optical sensing within flexible substrates, and (3) implementation of advanced AI/ML algorithms for multi-modal sensor fusion, real-time health analytics, and personalized monitoring. The sensor platform integrates complementary sensing modalities: electrical sensors (ECG electrodes, bioimpedance measurement, electrodermal activity detection), mechanical sensors (piezoresistive pressure/strain sensors for respiratory and pulse monitoring), and optical sensors (multi-wavelength PPG arrays for cardiovascular assessment). Commercial LED-photodiode will be integrated into ultra-thin flexible PCB substrates, along with appropriately functional nanocomposite-based biocompatible polymer blends. The polymer system will provide reversible skin adhesion through medical-grade formulations and pressure-sensitive adhesives, ensuring comfortable long-term wear while maintaining electrical conductivity pathways and optical transparency. AI/ML frameworks will be developed to optimize the design processes and process the heterogeneous sensor data for the extraction of important health insights. Machine learning models will adapt to individual users through continuous learning, accounting for personal physiological baselines, skin properties, and lifestyle patterns. The research will contribute fundamental knowledge in multi-modal sensor integration, polymer-electronics interfaces, and AI-driven personalized healthcare. The project is interdisciplinary in nature and will combine sensors, polymer and conductive materials, flexible electronics, multi-modal sensing, and machine learning to create practical wearable health technologies for chronic disease management, elderly care, and preventive healthcare applications.</p>					
12	Perovskite - Si tandem cells and modules	Prof. Shaibal K. Sarkar, Energy Science & Engineering shaibal.sarkar@iitb.ac.in	Prof. Anindya Datta, Chemistry adutta@iitb.ac.in	MSc/BTech with relevant experience	T A P / P S
<p>Topic Name : Perovskite - Si tandem cells and modules</p> <p>Abstract : Perovskite - Si tandem cells and modules</p>					

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13	Development of Self-assembled monolayers (SAMs) for perovskite solar cells	Prof. Aswani Yella, Met.Engg & Mat.Science aswani.yella@iitb.ac.in	Prof. Chandra M R Volla, Chemistry chandra.volla@iitb.ac.in	M.Sc in any discipline preferable with fellowship	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Development of Self-assembled monolayers (SAMs) for perovskite solar cells</p> <p>Abstract : Self-assembled monolayers (SAMs) employed in inverted perovskite solar cells (PSCs) have achieved groundbreaking progress in device efficiency and stability for both single-junction and tandem configurations, owing to their distinctive and versatile ability to manipulate chemical and physical interface properties. In this project we will be examining the mechanistic roles of diverse SAMs in energy-level regulation, interface modification, defect passivation, and charge transportation. The goal of the project is to understand how interfacial molecular interactions influence the device parameters and fine tune to mitigate charge recombination losses in PSCs.</p>					
14	Electrochemical Energy application of nanomaterials prepared by gas-phase synthesis	Prof. Smrutiranjana Parida, Met.Engg & Mat.Science paridasm@iitb.ac.in	Prof. Manoranjan Sahu, Environmental science and engineering mrsahu@iitb.ac.in	MSc in chemistry, MTech in materials science, metallurgy, chemical engineering, environmental science, nanomaterials, and all relevant disciplines.	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Electrochemical Energy application of nanomaterials prepared by gas-phase synthesis</p> <p>Abstract : Gas-Phase Synthesis of Nanomaterials gives precise size and shape control, producing narrow size distributions and uniform particle morphologies. This fast, non-equilibrium growth in the gas phase produce nanomaterial with different degree of crystallinity with defect concentrations optimizing conductivity and electrochemical activity. These advantage along with high specific surface area make this nanomaterials useful for various electrochemical energy, which will be carried out in this project. Therefore, electrochemical supercapacitor, battery and hydrogen evolution will be tested using electrodes prepared using gas-phase synthesized nanomaterials, with an aim to develop an relationship between properties of these nanoparticles and their electrochemical performance. The study will develop high performance electrochemical energy devices using these materials.</p>					

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15	Growth and characterization of next-generation III-Nitride quantum heterostructures	Prof. Abhinandan Gangopadhyay, Met.Engg & Mat.Science abhinandan.g@iitb.ac.in	Prof. Apurba Laha, Electrical Engineering laha@ee.iitb.ac.in	B.Tech or M.Tech. in Metallurgical and Materials Engineering, Electrical Engineering.M.Sc. in Physics	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Growth and characterization of next-generation III-Nitride quantum heterostructures</p> <p>Abstract : The emergence of quantum technologies demands robust, room-temperature single-photon sources operating in the visible spectrum. III-Nitride semiconductors, with their wide bandgap tunability and proven material stability, offer a promising platform for scalable, solid-state quantum emitters. This project aims to advance the next generation of III-Nitride-based optoelectronic devices such as quantum emitters, green LEDs through a comprehensive exploration of epitaxial growth and nanoscale characterization. We will investigate site-controlled defect engineering and heterostructure design strategies to enable precise control over emission wavelength, purity, and photon indistinguishability. Advanced epitaxial growth techniques using Plasma Assisted Molecular Beam Epitaxy (PAMBE) will be utilized to realize high-quality nanostructures. We will develop and apply advanced transmission electron microscopy (TEM)-based characterization techniques, such as four-dimensional scanning transmission electron microscopy (4D STEM), to obtain nanoscale information about the defects and interfaces in these nanostructures. Furthermore, the performance of the nanostructures will be evaluated using optical spectroscopy and photo luminescence. The outcomes will contribute to establishing a materials roadmap for integrated quantum photonic platforms.</p>					
16	Development of electrochemical sensor for heavy metal sensing	Prof. Sumit Saxena, Met.Engg & Mat.Science sumit.saxena@iitb.ac.in	Prof. Venkatsailanathan Ramadesigan , DESE venkatr@iitb.ac.in	Masters in Chemistry, Chemical Engg, Materials Sc - Metallurgical Engg	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Development of electrochemical sensor for heavy metal sensing</p> <p>Abstract : Heavy metal contamination is one of upcoming problems with increasing scarcity of drinking water. Heavy metal contamination causes various types of diseases affecting different organs in human body. The Heavy metal contamination not only affects human but also the entire flora and fauna along with animals alike. In this project we aim to develop 2D materials based heavy metal electrochemical sensor.</p>					
17	Development of 2D materials for energy storage devices	Prof. Sumit Saxena, Met.Engg & Mat.Science sumit.saxena@iitb.ac.in	Prof. Venkatsailanathan Ramadesigan, DESE venkatr@iitb.ac.in	masters in chemistry, materials Sc - Metallurgy, Nanotechnology	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Development of 2D materials for energy storage devices</p> <p>Abstract : Depletion of fossil fuels have led to scarcity of fossil fuel. While a lot of research work has been done in development of renewable energy storage, unfortunately there remains a wide gap in efficient utilization of produced energy. The aim of the project would be to develop novel 2D materials for development of hybrid energy storage devices.</p>					

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18	2D/3D nanostructures patterning for studying cell alignments and growth	Prof. Shobha Shukla, Met.Engg & Mat.Science sshukla@iitb.ac.in	Prof. Abhijit Majumdar, Chemical Engg abhijitm@iitb.ac.in	Masters in life/naturalsciencesorMTechin Materials/EE/CE	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : 2D/3D nanostructures patterning for studying cell alignments and growth</p> <p>Abstract : Natural cell environment is inherently multi dimensional. Tissue engineering and regenerative medicine are promising techniques for creating functional tissue constructs by growing cells in 2D/3D biocompatible scaffolds. Conventional 2D cell culture methods fail to replicate the critical features of in vivo micro/nanoarchitecture, which is crucial for the growth of stem cells. Here we will be using laser lithography for patterning 2D/3D structures for creating scaffolds for cell growth and migration studies. Materials and other relevant characterization will be performed for qualifying the materials compatibilities and cell adhesion/proliferation. Finally a microfluidic device platform will be integrated to as developed susbstrate for developing prototypes.</p>					
19	Graphene based Nanomaterials for water purification	Prof. Shobha Shukla, Met.Engg & Mat.Science sshukla@iitb.ac.in	Prof. Kiran Kondabagil, BSBE kirankondabagil@iitb.ac.in	Masters in Life/natural sciences, MTech in Bio/Materials/EE	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Graphene based Nanomaterials for water purification Abstract : Water purification is the process of removing undesirable chemicals, biological contaminants, suspended solids, and gases from water. The goal is to produce water that is fit for specific purposes. Most water is purified and disinfected for human consumption (drinking water), but water purification may also be carried out for a variety of other purposes, including medical, pharmacological, chemical, and industrial applications. Here we will be using graphene for water quality sensing and purification.</p>					
20	Development quantum diamond microscope for semiconductor chip diagnostics	Prof. Kasturi Saha, Electrical Engineering kasturis@iitb.ac.in	Prof. Himadri Dhar, Physics Himadri.dhar@iitb.ac.in	MTech/ MSc/ BTech in Electrical Engineering, Physics, Nanoscience and Nanotechnology, Instrumentation and Applied Physics, and Quantum Technology are encouraged to apply	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Development quantum diamond microscope for semiconductor chip diagnostics</p> <p>Abstract : This project aims to develop an advanced microscope capable of imaging magnetic fields at the micron scale in both 2D and 3D. The system will be designed for analyzing integrated circuits and microchips, enabling fault detection and chip security assessment using Nitrogen Vacancy (NV) centers in diamond. A key focus is enhancing the per-pixel sensitivity of the magnetic field microscope. Another goal will be implementation of AC sensing in widefield.</p>					

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
21	Development chip-scale magnetic field sensor integrated with drone	Prof. Kasturi Saha, Electrical Engineering kasturis@iitb.ac.in	Prof. Himadri Dhar, Physics Himadri.dhar@iitb.ac.in	MSc/MTech/BTech in Electrical Engineering, Physics, Nanoscience and Nanotechnology, Instrumentation and Applied Physics and Quantum Technology are encouraged to apply.	TAP/PS
<p>Topic Name : Development chip-scale magnetic field sensor integrated with drone</p> <p>Abstract : This project aims to develop a precise, quantum enhanced portable magnetic field sensor using nitrogen-vacancy (NV) centers in diamond. NV centers possess unique quantum properties, enabling sensitive magnetic field detection by tracking changes in their spin states. The sensor will combine lasers and microwave systems for spin state control, offering high sensitivity and spatial resolution at room temperature. Applications range from navigation to oil-gas detection, allowing real-time magnetic field mapping. The student will design the sensor head, including optical design, simulations, and experiments, and interface it with electronic systems, creating a magnetometer that can be integrated with drones and other mobile platforms. The magnetometer will be coupled to cavity to achieve pico Tesla sensitivity and quantum enhanced performance.</p>					
22	Next-Generation Membrane Systems for Virus Removal and Antibody Recovery in Bioprocessing	Prof. Swatantra Pratap Singh, E.S.E.D. swatantra@iitb.ac.in	Prof. Ashutosh Kumar, BSBE ashutoshk@iitb.ac.in	M. Sc. in chemistry, Biochemistry/ M.Sc/M.tech in Environmental Science/ Engineering, Chemical Engineering, Chemistry, Physics, Materials Science and Engineering, Biotechnology, Bio-Engineering or equivalent	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Next-Generation Membrane Systems for Virus Removal and Antibody Recovery in Bioprocessing</p> <p>Abstract : Membrane separation technology plays a crucial role in biopharmaceutical processes, particularly in virus clearance, virus concentration, and antibody purification. The separation of viruses and antibodies is essential in vaccine production, monoclonal antibody (mAb) manufacturing, and gene therapy. The project will focus on the development of advanced membranes for better permeability and selectivity.</p>					

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
23	Chemical upcycling of plastics by solar photothermal valorization	Prof. Guruswamy Kumaraswamy, Chemical Engineering guruswamy@iitb.ac.in	Prof. C. Subramaniam, Dept. of Chemistry subramaniam@iitb.ac.in	M.Sc Chemistry / Polymer Science, M.Tech, Chemical Engineering / Polymer Engineering, Materials Science and engineering	TA/FA/SW/SF/IS/EX/CT
<p>Topic Name : Chemical upcycling of plastics by solar photothermal valorization 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.</p>					

Sr. No.	Name of Topic	Guide Name	Co-Guide Name	Qualification Required	Category
24	Development of Heterogeneous Nanocatalyst and allied process for direct hydrogenation of Furfural to Furfuryl Alcohol	Prof. Prof. Sanjay Mahajani, Chemical Engineering sanjaym@iitb.ac.in	Prof. Santosh Gharpure	M Tech	TA
<p>Topic Name : Development of Heterogeneous Nanocatalyst and allied process for direct hydrogenation of Furfural to Furfuryl Alcohol</p> <p>Abstract : The selected candidate will work on development, characterization, and performance evaluation of heterogeneous Nanocatalyst containing catalytically active Cu NPs on mesoporous supports for direct hydrogenation of bio-derived furfural to furfuryl alcohol. The student has to optimize catalyst synthesis protocols and verify using electron microscopy tools like TEM and SEM. X-ray characterization tools like XRD, XPS, EXAFS, etc. have to be used to understand other relevant surface properties. If necessary, in-situ techniques have to be employed to study evolution of catalyst surface under reaction conditions. After the optimal catalyst is synthesized, shaping has to be done and continuous experiments have to be performed to demonstrate readiness for commercialization</p>					
25	Development of Heterogeneous Nanocatalyst and allied process for direct hydrogenation of Cinnamaldehyde to Cinnamyl Alcohol	Prof. Prof. Sanjay Mahajani, Chemical Engineering sanjaym@iitb.ac.in	Prof. Santosh Gharpure	M Tech	TA
<p>Topic Name : Development of Heterogeneous Nanocatalyst and allied process for direct hydrogenation of Cinnamaldehyde to Cinnamyl Alcohol</p> <p>Abstract : The selected candidate will work on development, characterization, and performance evaluation of heterogeneous Nanocatalyst containing catalytically active Cu NPs on mesoporous supports for direct hydrogenation of bio-derived Cinnamaldehyde to Cinnamyl alcohol. The student has to optimize catalyst synthesis protocols and verify using electron microscopy tools like TEM and SEM. X-ray characterization tools like XRD, XPS, EXAFS, etc. have to be used to understand other relevant surface properties. Benchmarking experiments have to be performed against conventional homogeneous catalysts to demonstrate the superiority of the novel catalyst. Strategies like alloying of Cu with other transition elements, and addition of promoters have to be devised to improve selectivity towards cinnamyl alcohol. After the optimal catalyst is synthesized, shaping has to be done and continuous experiments have to be performed to demonstrate readiness for commercialization</p>					