R & D Newsletter
Indian Institute of Technology Roorkee

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Message from Dean, Sponsored Research and Industrial Consultancy (SRIC)

Welcome to vol. 2 of R&D Newsletter along with the new academic session and a fresh batch of students at the institute. With several new sponsored research projects awarded to faculty members, this issue is essentially going to dwell on "Recent Projects''.

In order to strengthen research activities at the institute, a restructuring of the SRIC office has been undertaken with the creation of positions of (i) Associate Dean, Innovation and Incubation (ADII) and (ii) Associate Dean, Corporate Interaction (ADCI). This restructuring has been designed to accelerate industry interaction, pursue filing of more patents, and disseminate research through active media engagement besides other regular activities of the SRIC office.

Efforts are being made to involve students with SRIC activities through mentoring of the Students' Technical Cell, students' media body, supporting incubation and running a state of the art Tinkering Laboratory.

We wish to provide all the support expected by the vibrant research community at IIT Roorkee encompassing faculty, researchers and students under a common umbrella.

ManoranjanParida

Addressing next generation energy challengesusing low cost, dye sensitized solar cells. A device developed using naturally occurring anthocyanine dye from Indian berry (jamun) by Prof. SoumitraSatapathi and his group at Physics department, IIT Roorkee.

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Recently Registered Research Projects

Title: Probing intermolecular contacts between capsid and envelope proteins of Chikungunya Virus

Sponsor: Indian Council of Medical Research (ICMR)

Prof. Shailly Tomar
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Abstract: Chikungunya disease epidemic continues to re-emerge in our country and in Indian sub-continent every year during the monsoon season. Presently, no vaccine or antiviral drug is available in the market to treat viral infection. This project investigates the protein-protein interactions between the capsid protein (CP) and the glycoproteins of the virus. These interactions are essential for the virus budding process. Project aims to target the molecular contacts between CP-glycoprotein by structure-based small antiviral molecules to inhibit the virus budding process and combat viral infection. Project Applicability: The project proposal is expected to identify a potential Chikungunya virus inhibitor molecule that could be developed into an antiviral drug for the treatment of Chikungunya disease.

Title: Metal-catalyzed Functionalization of Unactivated C-H Bonds

Sponsor: Young Scientist Research Award, DAE-BRNS

Prof. Debasis Banerjee
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Abstract: Catalysis is the key technology that supports the global economy and offers a myriad of benefits to chemical, petroleum, agriculture, polymer, electronics and pharmaceuticals industries. Worldwide more than 90% of chemicals produces from catalytic processes and has reached market value of about 900 billion dollars per annum. Notably, the increasing movement towards environmentally benign and sustainable catalysis rated as one of the most significant current interest to organic chemistry community. The proposed research is mainly based on the conceptual development in the field of green and sustainable catalysis for inactivated C-H bond activation for the synthesis of complex molecular structure from simpler starting materials using dual-catalysis or artificial bio-catalysis strategy. This newly developed dual-catalysis concept would be highly interesting for the synthesis of C-X (X = O, P, N, B or Si) base compounds with interesting applications in academia as well as in pharmaceutical industries.

Title: Reactive Transport Modelling for Discrete Fracture Network (DFN) in Porous Media

Sponsor: Centre for Computational Technology Private Limited, Pune

Prof. Brijesh Kumar Yadav
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Abstract: Subsurface geological formations are often very complex due to presence of heterogeneity and fault/fracture networks. Analysis of fluid flow through such geologically media is required to model multi-physics processes like environmental flow, CO2 sequestration, Oil and Gas flows etc. Precise and efficient modelling of such

complex fractured networks requires fractures to be represented as lower dimensional objects which require efficient gridding and better numerical discretization. Main focus of this project is to develop a RTM capabilities for DFN single-phase flow simulator with direct application for fracture modelling at the discrete fracture network scale.

Title: Development of Nanoscale Multiferroic Heterostructures Integrated on Silicon for Room Temperature ME-RAM And Magnetic Sensors Applications

Sponsor: Department of Science & Technology under Nano Applications & Technology Development Programme

Prof. Davinder Kaur
Department of Physics & Centre for Nanotechnology
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Abstract: The aim of the proposed work is to develop nano structured thin film multiferroicheterostructure based on ferromagnetic shape memory alloys and strong piezo electrics. Such multi ferroichetero structures integrated on semiconductor substrate are expected to yield giant direct magneto-electric coupling (DME) due to shape memory behavior of Ferromagnetic Shape Memory Alloys and converse magneto-electric coupling (CME) due to strong piezoelectricity of PZT at room temperature. The combination of DME and CME in one system provides the possibility to utilize the suggested heterostructures for range of applications like: magnetic sensors, logic circuits, magnetoelectric RAM, microwave devices, spintronics devices, etc. Moreover, the integration of FSMA/piezo electric heterostructues on Silicon in the present work made them worthy for IC technology. The current work will also offer a way to understand the physical phenomena of ME effect in thin film multi ferroicheterostructures at nano scale.

Title: Developing Polymer Based Scaffold with Electrical and Topographical Cue for Neural Tissue Engineering

Sponsor: Indian Council of Medical Research

Prof. Debrupa Lahiri
Center for Nanotechnology & Department of Metallurgy and Materials Engineering
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Abstract: Providing electrical cue through a soft polymeric neural scaffold for directional neuron growth is a challenge in itself. The shortcomings of existing polymeric neural scaffolds are their poor electrical conductivity, which is essential for providing electrical cue assisting directional and accelerated growth of neurons. Carbon nanotubes, with their excellent electrical conductivity, can be of help, if aligned in the scaffold. However, the reports available till date could only have CNTs aligned on the surface of hard substrate, which cannot be used as neural scaffold in-vivo. This research proposes fabrication of aligned CNT reinforced biodegradable polymeric scaffold, which would take care of all the shortcoming of existing scaffolds. Achievement of this would open up the potential use of this scaffold in treating injury to peripheral nerve repair and would create new opportunities in neural tissue regeneration.

Title: Ichnofabric Analysis and high Resolution Sequence Stratigraphic Modelling

Sponsor: Oil and Natural Gas Corporation Limited

Prof. Biplab Bhattacharya
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Abstract: Record of vertical changes in softgroundichnoassemblages is applied to identify high-resolution sequence boundaries through the recognition of substrate-controlled ichnofabrics. Detail study of the control of climatic

changes on sedimentation and behavioural changes of organic community reveals important clues in reconstructing the sea level fluctuation, change in accommodation and high frequency parasequences. Thus, ichnofabric analysis acts as complementary to high resolution sequence stratigraphy of outcrop and subsurface successions. The present research proposal aims to combine ichnofabric architecture study with high resolution sequence stratigraphy from the siliciclastic reservoir systems to reconstruct detailed 3-D paleogeographic model.

Title: Hydrological Experiment for the Validation of Scatterometer Derived Hydrological Products and Application for River Basin Management

Sponsor: Space Applications Centre, ISRO, Ahmedabad

Prof. Ashish Pandey
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Abstract: In this project hydrologic models and space borne data shall be employed to improve hydrological and hydraulic models for initialization, calibration and understanding of hydrologic process representation at catchment scale. Scatterometer derived hydrological products validation framework will be developed through in-situ measurements. Validated products will be used for hydrological applications involving mathematical model simulation techniques with the following specific objectives:

1. Hydrological experiment to measure river/reservoir water levels, discharge and soil moisture to test the scatterometer derived hydrological products.
2. Integration of scatterometer derived hydrological variables into a suitable hydrological model for water balance simulations.

Title: Tunable phononic materials for low frequency band gap using computational and experimental approaches

Sponsor: Department of Science and Technology

Prof. Siladitya Pal
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Abstract: Phononic materials are newly emerging fields of basic research for scientific discoveries and tremendous applications potentials. Of special interest is widening the frequency band gap over low frequencies range. A myriad number of applications include vibration isolation, acoustic absorptions, sub-wave length focusing (super lenses/ hyper lenses) for fine scale imaging applications, acoustic/elastic cloaking, and zero index medium. However, key challenge is to develop acoustic meta-materials, a class of phononic materials with low frequency, for wider band gap along with tunability as needed during its service without changing its constituents. In the proposed research, acoustic meta-materials with wide and controllable band gap at low frequency will be designed and fabricated. The main idea is to achieve wide band gap through sophisticated tailoring of micro-structural and materials parameters. The proposed work will employ computational modeling that will provide a set of acoustic meta-material designs for low frequency wide band gaps. Finally, acoustic meta-material will be fabricated using additive manufacturing techniques to conform simulated design. The band gap behavior will be obtained experimentally and compared with numerical predictions. Multiple acoustic meta-material specimens will be designed and fabricated for various ranges of band gap.

Title: Understanding graphene growth on Cu-Ni substrates through chemical vapour deposition

Sponsor: Science and Engineering Research Board

Prof. Indranil Lahiri
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Abstract: Chemical vapour deposition (CVD) emerged out as the best choice for high-quality graphene. While Cu is more popular for growing single- or bi-layer graphene, Ni is known for growing few-layer graphene. Since Cu and Ni form homogenous solid solution, Cu- Ni alloy could be used to control C solubility in alloy substrate. On the other hand, since polycrystalline materials are used as substrates, effect of grain size and texture of substrate material is known to have some effect on graphene morphology and hence, on properties, too. Keeping in view of the gaps in understanding graphene growth, the current research is focused on understanding graphene growth on different Cu-Ni alloy substrates, with a variety of properly controlled crystallographic texture.

Title: Developing novel antimicrobial therapeutics by exploring multi-enzyme targets

Sponsor: Indian Council of Medical Research

Prof. Saugata Hazra
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Abstract: Antibiotic resistance has been considered as one of the biggest global concern. Without anti-microbials, death rates even from common infectious diseases would be extremely high and beyond control. Especially in a developing country like ours, where awareness of maintaining proper hygienic habits or taking proper course of medicine is still not reached at the grass-root level, new approaches are highly required to combat against drug resistant variants of those deadly pathogens. In the current project we are developing new therapeutics against the enzymes involved in folate biosynthesis pathway. A thorough interdisciplinary approach is designed including in-silico, in-vitro and in-vivo techniques with a novelty of targeting multiple enzymes to reduce the probability of

Title: Software defined techniques for hardware limitations in spectrum and power efficient 4G/5G communication

Sponsor: Science and Engineering Research Board

Prof. Meenakshi Rawat
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Abstract: While looking forward to 5G communication, many countries, including India, are still using 2G and 3G along with 4G. However, multichannel transmission topologies such as multiband operation (for supporting different generations) and MIMO transmission (throughput-enhancing applications) have hardware limitations where linear and nonlinear crosstalk between channels adds to signal corruption. Practically, actual signal quality becomes very poor and does not benefit from many popular methods such as MIMO, carrier aggregation and multiband operations. Originating from this research gap between proposition of spectral and power efficient techniques and their practical realization, this proposal project proposes software-defined solutions for power efficient operation of transmitter/receiver system for 4G/5G communication.

Title: Investigation of Earth's Upper Atmosphere using Optical Imaging Techniques

Sponsor: Science & Engineering Research Board

Prof. Sumanta Sarkhel
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Abstract: The proposed sponsored research on exploring Earth's upper atmosphere using optical imaging techniques offers a unique opportunity to investigate plasma irregularities in the F region of ionosphere. It will help us to understand the mechanism behind the interaction of mid latitude plasma irregularities on low-latitude plasma irregularities with the collaborative use of multiple optical imaging instruments and will bring out the knowledge of coupling between magnetic low and mid latitude over Indian sector. The outcome of the proposed research will open up new scientific explorations in the field of airglow imaging. The proposed research is to attempt for the detection of the magnetic mid-latitude generated Medium Scale Traveling Ionospheric Disturbances (MSTIDs) and its effect on low-latitude plasma irregularities will help to locate the dynamic boundary between magnetic low and mid latitude over Indian sector. This proposed research needs a multi-wavelength airglow imager and will be operated from a high altitude observatory, Hanle, Leh-Ladakh (32.78 N, 78.96 E; altitude: 4.5 km above mean sea level) operated by Indian Institute of Astrophysics, Bengaluru. There is no such Aeronomical observations reported from this part of Himalayan region so far. Therefore, the investigation on upper atmosphere and operating the airglow imager from Hanle, Leh-Ladakh is itself is a unique opportunity to study MSTIDs over the Indian sector.

Title: Biodegradation of phthalates

Sponsor: Department of Biotechnology, Govt. of India

Prof. Pravindra Kumar
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Abstract: Micro-organisms are able to partially degrade a vast number of xenobiotic compounds. The pathological symptoms caused by these compounds include heart disease, pain, joints, and cancer disease and so on. The elucidation of pertinent enzyme structures and the investigation of reaction mechanisms will facilitate the identification of the determinants of substrate specificity and the design of improved catalysts for bioremediation. 3D structure analysis of Phthalate dioxygenase enzyme and will help in elucidating the structure-function relationship and will facilitate the designing of more potent enzymes. Eventually, it will lead to engineer a potent strain of bacteria to degrade toxic pollutants.

Title: Investigation of Semiconductor/electrolyte interfaces by impedance spectroscopy and photo-Transient Measurement

Sponsor: Science and Engineering Research Board

Prof. Monojit Bag
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Abstract: Almost 40 year ago Nobel laureate Herbert Kroemer said that "the interface is the device", In fact most of the electronic devices are consist of multiple interfaces between metals, semiconductors or insulators. Therefore understanding interface is much more important than the device itself. This proposal focuses on the importance and

utilities of interface engineering in organic, bio-electronic and organic-inorganic hybrid devices especially semiconductor/electrolyte interface based devices. The proposed research program is to study the semiconductor/electrolyte and polyelectrolyte interfaces using electrochemical impedance spectroscopy and transient photocurrent/photo-voltage measurement. The impact of our research will elucidate parameters for better performance of organic and bio-electronic devices. This research program will also open up the opportunities for the interdisciplinary studies among material science, bioscience and engineering.

Title: Layered and Hybrid Perovskites for Sunlight-driven Photocatalytic Water Splitting and Decontamination

Sponsor: Science & Engineering Research Board

Prof. Tapas Kumar Mandal
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Abstract: With the burgeoning demands of energy and depletion of fossil fuel based energy sources, development of renewable sources of energy to meet the energy needs of the growing global population is imperative. Moreover, solar energy harvesting in power generation and environmental remediation is a promising green technology of the future. Various research groups world over have focused on different type of materials for hydrogen production through water-splitting and degradation of environmental contaminants by use of solar energy. However, the quantum yield of these processes and degradation efficiency of contaminants are not always high enough and often require UV irradiation. In this project we undertake investigations on a new class of materials, namely, the low-dimensional perovskites (layered and hybrid variants) to improve upon the sunlight harvesting efficiency and catalytic activity through band engineering by structural and compositional manipulation. The project is aimed at the development of new generation of sunlight active photocatalysts with the layered and hybrid perovskite structures and testing their feasibility in industrial effluent treatment, waste treatment, water purification and hydrogen generation.

Title: Geotechnical Investigation of Slope Stability along Koraput-Rayagada Railway Track, Odisha

Sponsor: Department of Science & Technology, Govt. of India

Prof. Sarada Prasad Pradhan
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Abstract: The Koraput-Rayagda railway track witnessed many landslides in recent times. Large scale boulders and mud come on the tracks and block the route of communication and transportation. This region is affected by heavy rain accompanied by south-east monsoon or cyclonic disturbance. It has been seen that after a heavy rain fall in this region, landslides occur in several places along the Koraput-Rayagada railway track. A detail study and investigation of slope stability analysis along the Koraput–Rayagada railway track would be conducted. A continuous slope monitoring will be done at vulnerable slopes. The study will encompass detailed geotechnical investigations of slopes and numerical simulation of stability analyses of slopes with the state of art simulator.

Title: Catalytic oxidation of Cyclohexane using Co-Fe/Al_2O_3 catalysts at low temperature

Sponsor: Science and Engineering Research Board (SERB)

Prof. Taraknath Das
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Abstract: It would be interesting and worthwhile to undertake a thorough understanding of oxidation of cyclohexane to cyclohexanone/cyclohexanol using Co-M-Fe/Al_2O_3 (M=Cu, Mn, Ce, Cr, V) (supported/unsupported) catalyst which involves characterizations and simultaneous reactivity measurement at low temperature and high pressure to obtain fundamental information about the catalysts synthesis, reaction intermediates and the reactions. The information is basically the correlation in between the catalyst, transient species, and conversion/selectivity/yield of products. Thus, the information will hopefully assist in understanding the working catalytic phenomena, transient species formation, reaction mechanism, the future development of the catalyst, and reactor design. The oxidation reactionof cyclohexane with molecular oxygen will be performed at high pressure (1 to 13 atm) by considering 1) an autoclave (reactor) and 2) an in-situ FTIR and HVC-DRM-5 cell (reactor).

Title: Design and Experimental Explorations on Phase Change All-Photonic Memory (DEEPAM)

Sponsor: Science and Engineering Research Board (SERB)

Prof. Rajesh Kumar
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Abstract: In order to provide a partial solution to von Neumann bottleneck, this project aims to investigate all-optical non-volatile memory with low foot-print, high switching speed and lower power consumption as compared to electronic solutions available commercially. The target material for realization of proposed all-optical memory is a phase change material-$Ge_2Sb_2Te_5$(GST). The GST material will be embedded in- or integrated on top of - Silicon-on-Insulator(SOI) waveguide circuit. The SOI platform is chosen due to its compatibility with Complementary-Metal-Oxide-Semiconductor(CMOS) fabrication processes. The resonant and non-resonant waveguide devices will be investigated to demonstrate single as well as multi-bit all-photonic memories.

Recent International Projects

1. Identification of three Dimensional attenuation structure using earthquake data investigations for Himalayas and Mexico. (**DST India-Mexico Collaboration**)
   PI: **Prof. Anand Joshi, Department of Earth Sciences.**
2. Morphology Optimization and Performance Enhancement in organic solar cells utilizing nanoparticles of low band gap polymers and PC 71 BM. (**DST-DAAD India-Germany Collaboration**)
   PI: **Prof. SoumitraSatapathi, Department of Physics**
3. Numerical Study in Dynamic brittle Fracture in Impact Problems. (**DST India-Russia Collaboration**)
   PI: **Prof. Mohd. Ashraf Iqbal, Department of Civil Engineering.**
4. Cloning and Targeted Delivery of anti-oxidant gene and drug for Treatment of Chronic Obstructive Pulmonary Disease (COPD). (**DST India-Russia Collaboration**)
   PI: **Prof. P. Gopinath, Department of Biotechnology.**

5. Research and Development of now optical fibers for applications in Modern laser systems. (**DST India-Russia Collaboration**)
   PI: **Prof. Vipul Rastogi, Department of Physics.**
6. Development of a unified approach concerning the cryptographic and combinatorial properties of Boolean functions and their generalizations. (**DST-India-Belarus Collaboration**)
   PI: **Prof. SugataGangopadhyay, Department of Computer Science & Engineering.**

Technology Incubation at IIT Roorkee

Technology Incubation and Entrepreneurship Development Society (TIEDS), registered under Societies Registration Act 1860, has been set up to promote innovation and entrepreneurship among the Faculty, Research Scholars, and Students/Alumni of IITR.

- TIEDS runs and manages a Business Incubator "**Technology Innovation & Development of Entrepreneurship Support" (TIDES) Centre** at IIT Roorkee to facilitate incubation of new enterprises with innovative technologies by incubating them at TIDES Centre.
- The TIDES Centre provides office space, infrastructure facilities, mentorship, networking, IPR/legal advice, technical support/access to labs & interns to incubated companies.
- **Physical Infrastructure**: Total space – 10,000 sq. ft., Work Space Size – 8000 sqft
- The start-up company is incubated for up to two years, with review-based financial support.
- The centre has secured funding from DST, MeitY as well as IIT Roorkee. TIDES Centre has also received in-principle approval for funding from NSTEDB, DST under NIDHI-SSS (Seed Support System).

The TIDES Centre team is led by: Prof.AjitChaturvedi (Chairman, TIDES and Director IIT Roorkee); Dr Sanjeev Manhas, ECE Dept. (faculty-in-charge); Mr. Neeraj Gupta (CEO); Prof. M Parida (Dean SRIC) and other members from academia and industry.

ReThink: The Tinkering Laboratory

The Tinkering Lab at IIT Roorkee became operational on 24th January 2017, following which invitation was extended to Faculty members and Students in both Roorkee and Saharanpur campus, leading up to their tour of the lab and familiarization with the machines and equipments available. Subsequently biometric registration (at two levels: common areas and work-space) and training programs were launched, leading up to students' usage of the following facilities:

- **Additive Manufacturing Machines** (**Desktop 3D Printers and Rapid Prototyping Machine**):
  To fabricate designs with intricate features those are otherwise much more difficult and expensive to manufacture.
- **Desktop 3D Scanners** : For inspection and reverse engineering applications.
- **Power and hand tools**: To create prototypes/products by cutting out material andfinishing them to give aesthetics and final shape.
- **Laser Etching machine:** To etch designs on raw material and/or product prototypes.
- **CNC carving machines**: To carve out the 2D shapes and designs.
- **CNC Turning machine & Vertical Machining Centre:** For high-end 3D metal cutting on projects related to automotive and robotics.

- **High end GPU's:** For CAD Modelling and Simulations; coding, software design &development.
- **Electronics domain facilities**: For soldering stations, digital storage oscilloscope, DCpower supplies, LCR, Multi-meter are being used for the testing and calibration ofvarious circuits.

  The above facilities have been and are being used to pursue the following projects:
- **Group Level Projects**: Automation of telescope; Frisbee throwing bot; Humanoid bot;

  Martian harmony; Smart window pane; Personal assistant in walking; Smart wheelchair; Graffiti bot; and Microfluidic Channel.
- **Individual projects**: Merger sponge; Wheel hub; Klein bottle; Tensile testing;

  Architectural design of school model; Gear box; Electrochemical flow capacitor (EFC);

  Fan shroud; and product prototyping by the students of Architecture department.

The Tinkering Laboratory at IITR

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