International Symposium on Advanced Materials and Devices

SAMDeV 2025

Abstract Booklet

Venue : Bose Institute, Salt Lake Campus
December 19-20, 2025

Organised by
Department of Physics, IIT Kharagpur

Our Sponsors

➢ Government Sponsors

QMD Foundation, IIT Delhi

Anusandhan
National
Research
Foundation

DRDO

➢ Private Sponsors

Platinum Sponsor

Cadillac
Filters Pvt. Ltd.

Gold Sponsors

Specialise Instruments
INTELLIGENT SOLUTIONS

OXFORD INSTRUMENTS

Di
DYNOTECH
INSTRUMENTS
PVT LTD

Quantum Design
INDIA

EVIDENT

GATAN
AMETEK

EDAX

LASER SCIENCE
Bringing Tomorrow's Technology Today

VTPL
VT VACUUM TECHNOLOGIES PVT. LTD.

Silver Sponsors

QUANTEK
systems
A Division of Spectek Instruments Pvt. Ltd.

MACWIN INDIA
Growing Together

Aimil

ap advanced photonics

श्री
Shree Enterprises

Preface

The Department of Physics at IIT Kharagpur has a distinguished legacy of excellence in teaching and research for the last seventy-five years. With strong research programs spanning various areas of theoretical and experimental physics, the department continues to nurture innovation and contribute significantly to national and global scientific advancements. The department is organizing the *International Symposium on Advanced Materials and Devices (SAMDeV 2025)* during December 19-20, 2025 at the Bose Institute, Kolkata, India. This symposium is especially significant as it is being held on the occasion of the Platinum Jubilee of IIT Kharagpur, commemorating 75 years of pioneering contributions to education, research, and technological innovation.

SAMDeV 2025 aims to provide a vibrant forum for leading researchers, technologists, academicians, and young scientists to engage in meaningful discussions on the latest breakthroughs in advanced materials, semiconductor and photonic devices, electronic sensors, and quantum technologies. About forty eminent scientists from different institutes of India and abroad will deliver invited talks in the symposium. Additionally, three distinguished scientists will present plenary lectures focusing on frontier areas of advanced materials physics and device technologies. We are deeply honored to host a Keynote Lecture by Prof. Lorenzo Pavesi, University of Trento, Italy. His presence will enrich the symposium and provide invaluable insights into emerging photonics-driven quantum technologies. There has been an overwhelming response from the research students and young scientists for the contributed poster papers. More than 100 poster presentations will be made by the students during the symposium.

The symposium will also have a dedicated special session honoring Prof. Samit Kumar Ray, Department of Physics, IIT Kharagpur, in celebration of his 35 years outstanding contributions to research, teaching, mentoring, and knowledge sharing in condensed matter physics and device technology. His research works and inspirational leadership have profoundly shaped the growth of the field and influenced generations of students and collaborators.

We extend our sincere gratitude to Prof. Suman Chakraborty, Director, IIT Kharagpur and Prof. Somnath Bharadwaj, Head Physics for their constant advise and support. The valuable suggestions received from the Advisory and Organizing committee members are gratefully acknowledged. We also thank all the invited speakers who have kindly agreed to deliver the talk in this symposium. The financial support from ANRF, Quantum Foundation, IIT Delhi, DRDO and several other private sponsors in organizing the symposium is gratefully acknowledged.

On behalf of the organizing committee, we wish all the delegates fruitful, enjoyable and inspiring interactions during the symposium. We hope that SAMDeV 2025 will stimulate continued collaboration, innovation, and exploration within the global scientific community.

General Chairs, SAMDeV - 2025
on bealhaf of the Organizing Committee

Organizing Committee

1. Prof. Suman Chakraborty; Patron; Director, IIT Kharagpur
2. Prof. Somnath Bharadwaj, Co-Patron, Head-Physics, IIT Kharagpur
3. Prof. Amal Kumar Das, Dept. of Physics, IIT Kharagpur
4. Prof. Rajat Mahapatra, ECE, NIT Durgapur
5. Prof. Partha Roy Chaudhuri, Dept. of Physics, IIT Kharagpur
6. Prof. Shivakiran B N Bhakth, Dept. of Physics, IIT Kharagpur
7. Prof. Kaustuv Das, Dept. of Physics, Jadavpur University
8. Prof. Achintya Dhar, IIT Kharagpur
9. Prof. Siddheswar Maikap, Chang Gung University, Taiwan
10. Prof. Dipak Kumar Goswami, IIT Kharagpur
11. Prof. Samaresh Das, IIT Delhi
12. Prof. Sonjoy Mojumder, IIT Kharagpur
13. Prof. Subhrajit Mukherjee, Shiv Nadar University
14. Prof. Sanjeev Kumar Srivastava, IIT Kharagpur
15. Prof. Debashis Panda, Sri Sri University
16. Prof. Achintya Singha, Bose Institute

International Advisory Committee

1. Lorenzo Pavesi, University of Trento, Italy
2. D D Sharma, IISC Bangalore
3. Shunri Oda, Tokyo Institute of Technology, Japan
4. Gouri Sankar Kar, Vice President R&D, IMEC Belgium
5. Saptarshi Das, Pennsylvania State University, USA
6. Hans-Jorg Osten, Leibniz University, Germany
7. James Kolodzey, University of Delaware, USA
8. Tanusri Saha Dasgupta, Director, S.N. Bose National Centre for Basic Sciences, Kolkata
9. Dinakar Kanjilal, Former Director, IUAC, New Delhi
10. A. J Pal, IACS & Former Director UGC DAE CSR, Indore
11. Bhupendra Nath Deb, TCG CREST, Kolkata
12. Indranil Manna, Vice Chancellor, BIT Mesra
13. Sanjay Banerjee, University of Texas at Austin
14. G. P. Das, RISE, TCG CREST Kolkata
15. Bikramjit Basu, Director CSIR-CGCRI, Kolkata
16. V. Ramgopal Rao, Vice Chancellor, BITS-Pilani
17. S. Maikap, Chang Gung University, Taiwan
18. Kalobaran Maity, Director IACS Kolkata
19. Navakant Bhat, IISC, Bangalore
20. Chennapati Jagadish, Australian National University, Australia

Students Organizing Committee

1. Akash Kumar Sahu, IIT Delhi
2. Aditya Kumar, IIT Delhi
3. Shaona Bose, IIT Kharagpur
4. Deepak Kumar Sahu, IIT Kharagpur
5. Subham Saha, IIT Kharagpur
6. Tamal Dey, IIT Kharagpur
7. Sayan Chakrabarty, IIT Kharagpur
8. Santu Kumar Ghosh, IIT Kharagpur
9. Bijoy Jana, Jadavpur University
10. Pritam Sinha, Bose Institute
11. Subhajit Mahapatra, Bose Institute
12. Prithwiraj Majhi, Bose Institute
13. Mousumi Pramanik, Jadavpur University

Contents

Citation: Prof. S. K. Ray

Prof. Samit K. Ray is a Chair Professor in the Department of Physics, IIT Kharagpur. He has served as the Head of the Department of Physics (2011-2014), founder Chairperson of the School of Nanoscience and Technology (2014-2016), Dean, Postgraduate Studies and Research (2015–2016) at IIT Kharagpur and Director of S N Bose National Centre for Basic Sciences (2016-2021).

Prof. Ray's research interest in the broad area of experimental condensed matter physics focusses on semiconductor nanostructures, epitaxial growth of quantum structures, nanophotonics and physics of nanodevices.

Prof. Ray is a recipient of the INSA Young Scientist Award (1993), Homi J. Bhabha Award (2001), CDIL award of IETE (1997), MRSI medal lecture award (2007), MRSI-ICSC Superconductivity & Materials Science award (2015), MRSI-ICSC Superconductivity & Materials Science Senior Award (2020) and INAE Chair Professorship Award (2022). He is an elected fellow of the National Academy of Sciences (NASI), Indian Nation Academy of Engineering (INAE), West Bengal Academy of Science & Technology, Indian Academy of Sciences, Bangalore and Indian National Science Academy. Prof Ray has published more than 425 research papers in peer reviewed journals, one US patent, five Indian patents, seven book chapters and co-authored a book on "Strained Silicon Heterostructures: Materials and Devices" published by IEE, UK. He has served as a visiting faculty / Scientist at the Tokyo Institute of Technology, Japan, University of Delaware, Newark, USA, University of Texas, Austin, USA, Max-Planck Institute for Solid State Research, Germany, Queen's University of Belfast, UK, National Taiwan University, Taiwan and CGU University, Taiwan.

Prof. Ray is an editorial board member of Nanotechnology (IOP, UK), Scientific Reports and Frontiers in Materials: Optics and Photonics – Switzerland. He serves in number of National committees that include Chairs, Applied Research Solar Stream of Solar Energy Research & Development, DST, Technology Mission Division and Nanotechnology domain, STARS Program, Ministry of Education, and as a member in NQM T-Hub on Quantum Materials & Devices, IIT Delhi, DST committee for setting up Centralized NQM Facilities, PAC member on Condensed Matter Physics & Materials Science, ANRF and DST International bilateral projects, and formal PRMC members of several projects of the office of the Principal Scientific Advisor, GOI. Prof. Ray is currently representing India in the International Union of Pure and Applied Physics (IUPAP) C8 Committee on Semiconductors.

Program Details

Themes of Conference	
1.	Advanced Materials & Device Modelling and Simulation
2.	Quantum Materials and Devices
3.	Optoelectronic and Photonic Technologies
4.	Electronic Sensors and Emerging Functional Devices

Technical Programme schedule

19.12.2025 (Day-1)

Registration: 8:30 AM to 9:30 AM at Bose Institute, Kolkata

Time	**Venue**: **Bibha Chowdhuri Auditorium, Bose Institute, Kolkata**	
9:30-10 AM	Inauguration	
10:00-10:30 AM	Keynote Lecture: Lorenzo Pavesi, Chair: Samit. K. Ray	
10:30 -11:00 AM	**High Tea**	
11:00 AM-1:00 PM	Felicitation of Prof. S. K. Ray (11:00 AM-11:30 AM)	
	Plenary Lectures: (Chair: Amal Kumar Das and Samaresh Das)	
	Tanusri Saha Dasgupta (11:30 AM-12:00 Noon)	
	Saptarshi Das (12:00 Noon-12:30 PM)	
	Gouri Shankar Kar (12:30 PM-1:00 PM)	
1:00-2:00 PM	**LUNCH**	
2:00-4:00 PM	**Lecture Hall 1** (**Chair:** Dipak K. Goswami)	**Lecture Hall 2** (**Chair:** Supravat Karak)
	Quantum Materials & Devices	**Device Fabrication & Modelling**
	I L 1: Rajendra Singh	I L 5: Prasanta Guha
	I L 2: Siddheswar Maikap	I L 6: P.V. Satyam
	I L 3: Bijoy Krishna Das	I L 7: Saibal Mukherjee
	I L4: Kaushik Majumdar	I L 8: Chandan Samantaray
	SP 1 Achintya Singha	SP 4 Debraj Chowdhury
	SP 2 Subhrajit Mukherjee	SP 5 Sayan Bayan
	SP 3 Amit Chakraborty	SP 6 Sourav Roy
4:00 – 5:45 PM	Tea & Poster Presentation (Chair: Chumki Saha & Kaustuv Das) **Electronic Sensors and Emerging Functional Devices (13 posters)** **Optoelectronic and Photonic Technologies (40 posters)**	
6:00 PM	Conference Dinner	

Program Schedule: 20.12.2025 (Day-2)

Time	**Lecture Hall 1** (**Chair:** Partha Roy Choudhury)	**Lecture Hall 2** (**Chair:** Rajat Mahapatra)
10:00-11:30 AM	**Quantum Materials & Devices**	**Functional Materials & Sensors**
	I L 9: Bhupen Dev	I L 12: Amlan J. Pal
	I L 10: Supriyo Bandyopadhyay	I L 13: Rajib Mitra
	I L 11: Anjan Barman	I L 14: Maumita Chakraborty
	SP 7 Rishi Maiti	SP 10 Suvra Prakash Mondal
	SP 8 Ankur Goswami	SP 11 Akshay Moudgil
	SP 9 Atindra Nath Pal	SP 12 Sayan Dey
11:30 – 11:50 AM	**TEA**	
11:50-1:00 PM	(**Chair:** Achintya Dhar)	**(Chair:** Shiva Kiran Bhaktha**)**
	Device Fabrication & Modelling	**Optoelectronics & Photonics**
	I L 15: Milan Sanyal	I L 18: Suparna Pal
	I L 16: Sanatan Chattapadhyay	I L 19: Apurba Laha
	I L 17: Satyabrata Jit	I L 20: Minhaz Hossain
	SP 13 Debanjan Bhowmick	SP 14 Narendar Gogurla
1:00-2:00 PM	**LUNCH**	
2:00-2:50 PM	(**Chair:** Sanjeev Kumar Shrivastava)	(**Chair:** Bibekananda Panda)
	Optoelectronics & Photonics	**Functional Materials & Sensors**
	I L 21: Ritam Sarkar	IL 22: Dipankar Mondal
	SP 15 Poulomi Chakrabarty	SP 18: Tridip kumar Sinha
	SP 16 Subhendu Sinha Sarkar	SP 19 Subhashis Gangopadhyay
	SP 17 Aditi Sharma	SP 20 Kalisadhan Mukherjee
3.00–4:15 PM	Poster Presentation: Chair – Rajkumar Singha and Debashis Panda **Advanced Materials & Device Modelling and Simulation (18 Posters)** **Quantum Materials and Devices (29 Posters)**	
4:15 PM	Valedictory session and High Tea	

Key Note / Plenary Lecture: 30 mins
IL: Invited Lecture – 20 mins; SP: Short Presentation – 10 mins

Keynote Lecture

Prof. Lorenzo Pavesi
Professor
Department of Physics
University of Trento, Italy
Email: lorenzo.pavesi@unitn.it

Title: From Neural Interfaces to Computing Paradigms

Interest in Artificial Neural Networks (ANNs) has surged in recent years due to their remarkable versatility in addressing a wide range of complex problems. Today, ANNs are predominantly implemented on electronic platforms. While very-large-scale ANN models have been developed that surpass human performance in specific tasks, they do so at the cost of long training times and significant power consumption. A promising alternative lies in Photonic Neural Networks (PNNs), which leverage the inherent advantages of photonics—namely, high-speed processing, massively parallel transmission (enabled by Wavelength Division Multiplexing, WDM), and low power dissipation.

This seminar will explore a series of simple PNN prototypes implemented on a silicon photonics platform, illustrating the fundamental operating principles of silicon-based PNNs. Silicon photonics is particularly attractive due to its compatibility with electronic integration, enabling on-chip training and scalable fabrication of photonic circuits. A key example to be discussed is a basic optical neuron, in which multiple delayed versions of an optical input signal interfere before reaching the output port—demonstrating an essential mechanism for computation in photonic networks.

Finally, the hybrid approach that combines photonic neural networks with biological neurons will be discussed. It enables experiments in which optical signals are transduced into neuronal activity, activating specific neural circuits. This integration paves the way toward hybrid intelligence systems, opening new frontiers in neuromorphic computing and advanced neurological therapies.

Plenary Lectures

Tanusri Saha-Dasgupta
Professor
S. N. Bose National Centre for Basic Sciences, Kolkata, India
Email: **tanusri@bose.res.in**

Title: Design and Understanding of Materials Physics: A Machine-learning Approach

One of the strong pillars in advancement of designed materials and understanding of its physical properties is computation. The synthesis and optimization of properties of materials in experiment is both time-consuming and costly, being mostly based on trial and error. Computational approach in this connection is of natural interest to screen materials, before they can be suggested and tested in the laboratory. In the discussed approach new materials have been computationally predicted by combining electronic-structure methods with intelligent machine learning technique based on data mining and database construction. As will be discussed, this also helps in rendering microscopic understanding. Application will be discussed for prediction of new magnetic double perovskites, low-cost rare earth based permanent magnets, semiconductor heterostructures , binary nanoalloys, atomic wire formation and understanding elastic properties of MAX compounds.

Saptarshi Das
Professor
The Pennsylvania State University
Email: sud70@psu.edu

Title:2D Materials for Advanced Logic, 3D Integration, and Bio-Inspired Computing

In this lecture, I will show how atomically thin 2D materials and devices will enable efficient, low-voltage logic. I will discuss monolithic 3D integration that unifies logic, memory, and sensing to reduce data movement and latency. I will then demonstrate how bio-inspired hardware can embed adaptation and learning directly in sensor and compute layers. I will close with a practical roadmap, from materials and interfaces to circuits and systems, and highlight some unexpected uses of 2D materials.

Gouri Shankar Kar
IMEC, Leuven, Belgium,
Email: kar@imec.be

Power, performance, and cost improvement of compute technology relied on scaling of transistors and interconnections for several decades, as predicted over half a century ago by the late Gordon Moore. Gate length scaling limited performance improvement of planar transistor was compensated with different performance boosters over the last few decades example, channel mobility improvements through use of stressors, high-k metal gates enabled higher gate capacitance without compromising gate leakage, and Design Technology Co-Optimization (DTCO) etc. Tri-gate structure of finFETs offered additional gate length scaling and drive per footprint improvement over the last decade. Gate All Around (GAA) devices like nanosheets will enable incremental gate length and Contacted Poly Pitch (CPP) scaling and will enable logic scaling for coming few more technology nodes (example, N2, A14, A10, etc.). To continue device performance and logic scaling below six-track (6T) boosters like Buried Power Rails (BPR) and semidamascene metal integration with air-gaps are needed. Complementary FETs (CFETs) offer promise of ultimate scaling and ability to integrate alternate high mobility channels.

Beyond CFETs, CNTs, 2D materials such as MoS2, WS2 or HfS2 with high mobilities and gate length scaling potential can be used to form atomic channel transistors, improvements in material quality, gate stack and contact resistance are still needed. Despite device scaling and performance improvements, single thread performance at the System on chip (SoC) level has saturated. While there are computer architecture solutions being researched, process technology will continue to play a vital role in system scaling. 2.5D and 3D integration techniques are enabling system scaling today by deconstructing monolithic SoCs into multiple chiplets, each optimized for cost and yield. Beyond dimensional scaling and DTCO, it is expected that System Technology Co-Optimization (STCO) can identify technology solutions to best address issues like the memory wall, power distribution and partitioning of SoC sub-systems using 3D integration techniques.

Invited Lectures

IL1: Rajendra Singh

Professor

Department of Physics, IIT Delhi

I will primarily talk about the activities of QMD Hub established at IIT Delhi as a Section 8 company by National Quantum Mission (NQM), DST.
I will briefly describe about various Technology Groups (TGs) that are working under the QMD Hub. I will also present about our plan for the future and other activities of the Hub.

IL2: Siddheswar Maikap

Professor

Department of Electronic Engineering, CGU Taiwan

Email: sidhu@mail.cgu.edu.tw

High-density memories with low energy (<100 fJ), long endurance of >1012 cycles, and complementary metal-oxide-semiconductor (CMOS) compatibility are critically needed for next generation storage and neuromorphic computing. Addressing this ever-growing demand of solid-state memories, our work started with Ge nanocrystals flash memories on Si platform. Then, atomic layer deposited (ALD) high-k films were engineered for low voltage flash memories, including integration of TiNx nanocrystals. High-k multiple quantum wells were further designed in flash MOFETs, demonstrating enhanced endurance and data retention. As a solution of scaling issue, resistive random-access memories (RRAMs)/conductive bridging random access memories (CBRAM) in via-hole and cross-point structures were explored for high-density memory and neuromorphic computing applications. It is expected to be scaled down <10 nm technology node because of small diameter of conducting filaments, as confirmed by *ex-situ* HRTEM images after SET operations. In addition, cross-point RRAM/CBRAM was demonstrated for the first time in bio-sensing application. Then, further ferroelectric random-access memories (FeRAM) using ALD Hf-based high-k films were designed within BEOL process by introducing an interfacial capping layer (ICL) on TiN/Si platform. ICL engineering revealed the coexistence of polar (rhombohedral and orthorhombic), and non-polar phases, confirmed by geometrical phase analysis (GPA) of HRTEM images during wake-up, fatigue, and re-wakeup. FeRAM with optimized ICL shows long endurance, 10 years data retention, non-destructive read, and neuromorphic computing under low voltage operation. Ferroelectric Field Effect Transistor (FeFET) further shows good memory characteristics. This talk will deliver a long journey across volatile and non-volatile memory technologies, highlighting key insights and future pathways toward advanced solid-state memory development.

IL3: Bijoy Krishna Das

Professor
Dept. of Electrical Engineering
IIT Madras
Email: bkdas@ee.iitm.ac.in

Title: Optical Vias for 3D Integration in Silicon Photonics Platform

As the silicon photonics interconnects are becoming integral part of semiconductor industries, implementation of large-scale photonic integrated circuitsare emerging for application domains such as AI data centres, quantum photonics, microwavephotonics, etc. However, photonic devices are not scalable unlike electronic IC components and can't pack more and more components in a small area; they are constrained by the waveguide cross-sectional dimension for a given operating wavelength range. In this talk, I will be presenting a compact low-loss optical tunnel via (OTV) design allowing 3D integration of photonic integrated circuits in conventional silicon photonics technology platforms.

IL4: Kausik Majumdar

Associate Professor
Department of Electrical Communication Engineering
Indian Institute of Science Bangalore
Email: kausikm@iisc.ac.in

Title: 1D Exciton at Ferroelectric Domain Boundary

A pair of h-BN layers, when twisted near zero degrees, creates large triangular ferroelectric domains with successive domains having opposite vertical polarization. The abrupt change in the direction of the vertical polarization creates an in-plane electric field sharply peaked at the domain boundaries. This potential profile can be imprinted on a monolayer semiconductor (such as, MoS2) placed on top of the twisted h-BN stack through Coulomb coupling. The Stark effect due to the steep in-plane field at the domain boundary creates a strong 1D localization for the intralayer excitons in MoS2, while the free electrons and holes are depleted from the domain boundaries. I shall show how this creates an ideal platform for studying the Fermi polaron, where the 1D-confined polarized exciton interacts remotely with a Fermi sea. Experimental evidence of repulsive and attractive quantized Fermi polaron will be discussed.

IL5: Prasanta K Guha

Professor
Department of Electronics and Electrical Communication Engineering,
IIT, Kharagpur
Email: pkguha[AT]ece.iitkgp.ac.in

Title: Electrochemical L-Dopa Sensor

Neurological disorders are widespread, affecting more than 3 billion people worldwide. This number is growing due to aging population and stressful lifestyle. Neurological disorders include Alzheimer’s disease, Parkinson’s disease (PD), attention deficit hyperactivity disorder, stress, anxiety, depression, epilepsy, Huntington’s disease and schizophrenia. PD is a caused by loss of brain cells that produce dopamine. It leads to a range of symptoms including abnormal movements, rest tremors, muscle rigidity, impaired balance and speech difficulty. The primary treatment for PD involves a combination of levodopa (3,4-dihydroxyphenyl-l-alanine) and carbidopa. Lower L-Dopa level is not adequate for dopamine synthesis, whereas elevatedL-Dopa levels in the body leads to dyskinesias, psychosis, orthostatic hypotension and nausea. The present technique is mostly clinical based. The quantifying procedures of L-Dopa are expensive and not real time. So, it is important to develop low-cost sensor to monitor L-Dopa level. In this respect, electrochemical platform can play an important role. The initial results performed in our lab show trace level measurements of L-Dopa and C-Dopa from artificial body fluid, which shows promise for future development of real time minimally invasive sensor used for PD treatment.

IL6: P V Satyam

Professor
Department of Physics
IIT Bhubaneswar
Email: satyam@iitbbs.ac.in

Title: Ge on Si and SiC crystalline surfaces

Germanium (Ge) was the first semiconductor to be used as base substrate for the first transistor. However, due to abundance of Silicon and its better stability at higher compare to Ge made it as wonder material for the microelectronic industry. Due to higher mobility, a combination of Si and Ge or SixGey is used for specific components in present day technology. With need of power electronics emerging at the forefront, the thermal conductivity and breakdown voltage of Si has become a concern and hence a wide bandgap materials, such as, SiC is emerging now for power electronic devices. The SiC and Diamond materials are used for the electronic applications in strategic areas, such as, space environments, military armour controls and nuclear reactors require electronic materials that can withstand the extreme conditions.

The present talk is a review of the work done for a couple of decades with several Ph D works. We start with the MBE growth of Ge on Silicon and present on the results on graded Silicon Germanium alloys structures that are formed spontaneously due to high vicinality and growth temperature condition (we used Si 553, Si 557 and Si 5512 surfaces for this purpose and used MBE to grow) [1]. We show the role of Ge on Silicon in formation of endotaxial structures [2]. We report on the interfacial phenomena that occur at the initial stages of Ge nanowire growth using gold as the catalyst on Ge(100) substrates under ultra high vacuum (UHV) conditions using molecular beam epitaxy (MBE) using transmission electron microscopy. Going away from the MBE conditions, we present some interesting results on endotaxial structures of Silver are formed due to the present Ge or GeOx at the interface [3]. We will present preliminary studies of Ge on SiC surfaces and its charge confinement at the Ge-SiC interfaces [4]. Our results show that Ge wets on SiC surface inspite of having a different structures.

IL7: Saibal Mukherjee

Professor
Centre for Advanced Electronics (CAE) and Electrical Engineering,
Indian Institute of Technology Indore
Email: shaibal[at]iiti.ac.in

Title: 2D/3D Memories: From Image Processing to Logic Operation

Artificial Intelligence (AI)/ Machine Learning (ML) algorithms are being widely used currently for various applications that include self-driving cars, virtual assistants on smartphones, image processing algorithms, homeland security, and human speech processing, etc. Most of these algorithms involve updating parameters/weights in the model continuously during the training process. Currently, these algorithms are being run on giant, power-hungry computational hubs, which follow traditional von Neumann architecture, causing substantial loss in energy and time during training process due to von Neumann bottleneck. The most viable solution is the low-power memristor or memcapacitor, which alleviates the challenges of von Neumann bottleneck and scaling by plugging into processing-in-memory (PIM). Here, we present the realization of memory devices and crossbar to implement image processing and logic operations via implementing PIM.

IL8: Chandan B. Samantaray

Assistant Professor
Department of Engineering
Virginia State University
Email: csamantaray@vsu.edu

Title: Progress in Quantum Computing and Information Science

Quantum information Science (QIS) will open up many opportunities, not only in academia but also in software and hardware industries. Quantum information science and related technology are going together for millions of digital and web applications. Quantum computing, including algorithm development and especially quantum-error-correction processes are vital in the whole world of QIS technology. Quantum computation is based on revolutionary algorithms such as Deutsch–Jozsa, Bernstein–Vazirani, Shor's, and Grover's algorithms. Grover's algorithm can speed up the search quadratically for a given number of possible solutions which is the basis of Quantum Artificial Intelligence and machine learning (Q-AI/ML). Furthermore, thequantum Fourier transform(QFT) is the quantum analog of thediscrete Fourier transform, and is used in developing several quantum algorithms. TheHadamard transformis also an example of a quantum Fourier transform over an n-dimensional vector space. The quantum Fourier transform can be efficiently implemented on a quantum computer using a polynomial number ofquantum gates. Further, hybrid techniques such as Variational Quantum Eigen Solver (VQE), and Quantum Approximate Optimization Algorithm (QAOA), are advanced quantum algorithms with huge potential applications in finance and manufacturing sectors. Theeigen solveralgorithm applies classical optimization to minimize the energy expectation value of anansatz stateto find the ground state of a Hermitian operator. However, QAOA has successfully applied several combinatorial problems with practical implementations on IBM's circuit-based quantum computers. Quantum information Science & Technology will have in the next 100 years Tech. dominance in all sectors of Science, Engineering, Technology, and corporate world.

IL9: Bhupen Dev

Centre for Quantum Engineering, Research and Education,
TCG-CREST
Email: **bhupen.dev@tcgcrest.org**

Title: Advanced Materials for Superconducting Quantum Computers

The 2025 Physics Nobel Prize was awarded for a contribution to science that led to the development of superconducting quantum computers. In fact, one of the Laureates was the leader in the development of Google's superconducting quantum computer. The building blocks of a superconducting quantum computer are superconducting quantum bits (or qubits). One of the major aims of materials research in this area is to develop superior qubits with longer life time. As qubits have a number of materials imperfections, and the consequent sources of noise contribute to qubit decoherence, quest for newer superconducting materials continue. Aluminium is an extensively used superconducting material for superconducting qubits. However, recently it was found that another superconducting material, cobalt disilicide, has 2-3 orders of magnitude smaller $1/f$ noise compared to aluminium. It was conjectured that qubits fabricated with cobalt disilicide could provide longer decoherence time compared to aluminium. In this talk, I will present several aspects of superconductivity of cobalt disilicide. which is formed by annealing a cobalt film deposited on silicon, and a novel aspect of the cobalt film itself. Superconductivity of cobalt was recently discovered in cobalt thin films on silicon . We begin with such a superconducting cobalt film, which has a self-organised hybrid superconductor(S)-ferromagnet(F)-superconductor(S) trilayer structure. Such S/F/S structures have applications in quantum information processing. This superconducting cobalt film was thermally annealed to form superconducting cobalt disilicide. Following the presentation of superconductivity of cobalt disilicide, how it can provide superior qubits will be illustrated. The prospect of growth of both types of superconductors on the same silicon substrate and eventually the formation of qubits with very long decoherence time will be discussed.

IL10: Supriyo Bandypadhyay

Professor,
Department of Electrical and Computer Engineering
VCU, USA
Email: sbandy@vcu.edu

Title: Topological Analog Electronics: Quantum micro-antenna and electromagnetic beam steering based on spin-momentum locking in the topological insulator Bi2Se3

Quantum materials (topological insulators, Weyl semimetals, alter-magnets) are enabling new device functionalities that were hitherto inaccessible. A remarkable impact has been made in the field of analog electronics, specifically antennas, which have until now defied aggressive miniaturization because of the infamous Harrington limit. This limit postulates that the radiation efficiency of any traditional classical antenna will be limited to A/^2 where *A* is the radiating area and *l* is the wavelength of radiation. Clearly, the efficiency will plummet if the antenna is made much smaller than the wavelength. Recently, we were able to overcome this fundamental limit by embracing an unconventional antenna modality based on magnon-photon coupling in an artificial "magnonic crystal" comprising a periodic two-dimensional array of nanomagnets (made of cobalt) fabricated on a thin film of a topological insulator Bi2Se3. An alternating charge current of frequency 1-10 GHz flowing through the topological insulator (TI) injects a spin current of alternating spin polarization into the nanomagnets to excite spin waves (magnons) in them. The spin waves radiate electromagnetic waves in space via magnon-photon coupling, thereby implementing an antenna. The frequency of the emitted radiation is the same as the frequency of the current. The measured radiation efficiency exceeded the Harrington limit by more than 3 orders of magnitude. Because its lateral dimension (~550 ***μ***m) is 0.6-1.8% of the free space wavelength (3-9 cm), the micro-antenna is effectively a "point source" and yet it radiates *anisotropically* because of the anisotropy of the spin wave patterns generated within them, which endows the "point source" with internal anisotropy. One can change the anisotropic radiation pattern by changing the direction of the injected alternating charge current, which changes the spin wave patterns within the nanomagnets because of **spin-momentum locking**, which is a property of the quantum material. This implements *beam steering* using a single antenna, orders of magnitude smaller than the radiated wavelength, by exploiting the spin-momentum locking property of a TI. Normally, beam steering will require a phased array with multiple antennas each much larger than the wavelength. Here, we can accomplish beam steering with a single antenna much smaller than the wavelength.

IL11: Anjan Barman

Spin Texture Driven Magnetization Dynamics in Advanced Spintronic Materials

S. N. Bose National Centre for Basic Sciences, Block JD,
Sector III, Salt Lake, Kolkata 700106, India

Email: abarman@bose.res.in

Engineered magnetic materials will form important building blocks for next-generation spintronics and externally controlled spin textures offer new opportunities for energy efficient and on-demand spin-based device fabrication [1]. The optimization of these devices demands understanding and control of ultrafast spin dynamics as well as spin-wave (SW) propagation. Here, we will discuss femtosecond laser-induced ultrafast magnetization dynamics controlled by domain-wall origami in $[Co/Pt]_{22}$ multilayer. Depending on the underlying domain landscape, the spin-transport-driven magnetization dynamics shows a transition from ultrafast demagnetization to an anomalous transient magnetization enhancement (TME) via a state where both TME and demagnetization coexist in the system [2]. Thereby, the study reveals an extrinsic channel for the modulation of spin transport, which will introduce a route for the development of magnetic spin-texture-driven ultrafast spintronics devices. Furthermore, we will discuss the development of on-demand magnonic nanochannels by periodically tailoring perpendicular magnetic anisotropy using an electric field. Brillouin light scattering (BLS) measurement revealed magnonic bands, consisting of two SW frequency modes, along with a bandgap under the application of moderate gate voltage, which can be switched off by withdrawing the voltage. The anticrossing between these two modes gives rise to the observed magnonic bandgap [3]. This study will lead to on-chip parallel data communication and processing. Finally, we will discuss the magnetic microstate driven SW dynamics in artificial spin ice (ASI) structures [4]. Using BLS, we study the SW dynamics of a series of five carefully prepared microstates in a square ASI sample. We observe microstate-specific mode frequency shifting, mode creation and mode crossing. This versatility of characteristic SW peaks for specific magnetic microstates in ASI enables identification of microstate configurations via SW spectral characterization [5]. The wide reconfigurability of microstate-specific SW dynamics also opens avenues for developing rich magnonic devices operating in the GHz frequency regime and advances the understanding of ASI physics.

IL12: Amlan J Pal

School of Physical Sciences
Indian Association for the Cultivation of Science
Email: Jadavpur, Kolkata, India

Title : To Draw the Band-Diagram of Your Solar Cells through Scanning Tunneling Spectroscopy and Kelvin Probe Force Microscopy

The research on optoelectronic devices involves a selection of suitable materials, fabrication of devices, and their characterization. The selection is based on a materials-engineering approach while keeping in mind the function of the device to be envisaged. In other words, while selecting the semiconductors, their energy levels or band-edges have to be considered, since the energies are “seen” by charge carriers in a device during their transport.

We have introduced a combination of scanning tunneling spectroscopy (STS) and Kelvin probe force microscopy (KPFM) in deriving the semiconductors’ band edges with respect to the vacuum energy. While the STS provides band-energies with respect to the Fermi level of the semiconductor, the KPFM maps the surface potential or work-function differences on the nanometer scale. We will show the method to draw energy diagrams of heterojunction devices as fabricated in a lab.

While piezoresponse force microscopy (PFM) is usually used to probe ferroelectricity in thin-films, we have introduced KPFM to directly probe the intrinsic ferroelectricity in the microscopic domains of the thin-films; in this measurement method, the poling of the ferroelectric domains in the films could be achieved, which in turn would alter their surface potential. That is, the measurement method could probe a change in the surface potential upon a reversal of the poling direction and thereby evidence and quantify the electric polarization in mixed-halide perovskite thin-films. In a range of *p-i-n* heterojunctions, we have observed that the solar cell parameters are well-correlated to the electric polarization in the active layer. In this talk, we will present a flowchart of research on device physics with pathways to improve the efficiencies through a directed materials-engineering approach.

IL13: Rajib Kumar Mitra

Professor
Department of Chemical and Biological Sciences
S.N. Bose National Centre for Basic Sciences
Email: rajib@bose.res.in

Title: Role of Hydration in Biomolecular Condensation: Insight from THz Spectroscopy

Biomolecular condensation has emerged as a pertaining phenomenon in the field of soft-matter physics. The process involves formation of protein self-aggregates in the form of liquid droplets or amyloid fibrils, which are often cytotoxic and could develop detrimental health conditions including neuro-degenerative diseases. The process of biomolecular condensation has mostly been understood from the protein's perspective whereas the pivotal role of water as a matrix of the cellular environment has been shunned. Our group has been using THz spectroscopic technique to determine the role of water in various biophysical processes including biomolecular condensation. THz spectroscopy (1 THz = 1012 Hz) is a rather non-conventional but highly potential tool to determine the network structure of water at biomolecular interfaces. In this talk I will discuss some results from our group on the pivotal role of hydration towards biomolecular condensation.

IL14: Maumita Chakrabarti (IMEC)

Title: Towards Integrated Photonics advancement in the Si Photonics Technology

The era of innovative technologies for integrated photonics, using silicon and silicon nitride, has applications across telecom, life sciences, quantum computing, automotive, and sensing. This talk will discuss a few activities in integrated photonics using silicon photonics technology developed at imec.

IL15: Milan Sanyal

Professor
Saha Institute of Nuclear Physics
Email: milank.sanyal[AT]saha.ac.in

Title: Structure and optical properties of quantum materials

Low-dimensional semiconductor quantum materials are suitable to deliver properties on demand as structure-property correlation are tunable in these emerging systems. We shall discuss that the effect of dimensionality, structural orientations and local compositional inhomogeneities within these low-dimensional semiconductors, on optical properties. We shall use our recent results [1,2] obtained with synchrotron X-ray scattering techniques on single QD of InGaAs and two-dimensional (2D) organic–inorganic hybrid lead halide perovskite films for this discussion.

Epitaxially grown self-assembled semiconductor quantum dots (QDs) with atom-like optical properties have emerged as the best choice for single-photon sources required for the development of single-photon emitters for the quantum technology and quantum networks. Non-destructive selection of a single QD having desired structural, compositional, and optical characteristics is essential to obtain noise-free, fully indistinguishable single or entangled photons. We have used [1] scanning X- ray diffraction microscopy and X-ray fluorescence with a few tens of nanometres-sized X-ray beam to probe self-assembled single InGaAs QD. The obtained results show that the elemental composition and resultant strain profiles of a QD are sensitive to in-plane crystallographic directions. We also observe that lattice expansion after a certain composition-limit introduces shear strain within a QD, enabling the possibility of controlled chiral-QD formation. The composition and strain distribution of the materials within a single quantum dot can greatly impact shape of the bandgap and optical properties. Hybrid organic–inorganic perovskites (HOIPs) have emerged as one of the most promising classes of semiconducting material due to their astonishing optoelectronic properties. The excellent tunability of the band gap, made possible by varying the long spacer organic chains between the inorganic metal- halide octahedral layers, is promising for many solid-state light-emitting applications. Our results [2] show that the 2D single-crystalline nature of these HOIPs are suitable materials to develop broad- band white light emission across the entire visible range as well as to obtain lasing without external cavities. We have studied the structure and optical properties of (BA) 2 Pb(Br/Cl) 4 perovskite flakes, powder, and nanofilms of (BA) 2 Pb(HCOO) 4 using X-ray scattering, Raman scattering, and PL measurements as a function of temperature to understand the nature of electron-phonon interactions in 2D hybrid lead perovskites. The X-ray scattering and Raman spectroscopy studies show that the perovskite crystals do not undergo any structural transitions within the temperature range of 300K to 4K. The optical measurements illustrated that the different halide or pseudo-halide ions in the perovskite octahedral structures can be used to control the emission characteristics of these quantum materials.

IL16: Sanatan Chattopadhyay

Professor
Department of Electronic Science
Calcutta University
Email: scelc@caluniv.ac.in

Title: Voltage-tunable quantum dots (VTQDs) for achieving multi-threshold current levels in Si nanowire channel metal-oxide-semiconductor filed effect transistors

Quantum dots are going to play a very significant role over a wide range of applications including computation, data storing, data processing, communication, sensing etc. The metal-oxide-semiconductor field effect transistor (MOSFET) has been the fundamental functional unit of electronic systems since last six decades. Aggressive scaling of MOSFET dimensions has been the preferred route for sustained performance improvement for such devices. However, the present era of ‘big data’ has increased complexities in fabrication along with posing serious challenge for further scaling. Several alternative approaches, both at device-level and algorithm-level are being actively pursued. Among such approaches, multi-threshold devices have emerged as the potential candidate.

In this context, the atom-like energy states of quantum dots (QDs) can potentially enable multi-threshold devices. The QD energy states can be aligned with respect to source/drain reservoirs by applying suitable gate voltage(s) which can modulate the resonant tunneling transport of carriers to realize multiple thresholds.

This lecture will discuss the formation of VTQDs in Si-nanowire to model the gate voltage-modulated resonant tunneling transport in a double quantum dot channel Si-nanowire FET (NWFET) for realizing multiple thresholds. In such a device, two separate, localized gates along the channel create two coupled quantum dots in series within the channel, underneath the gates. Suitable voltages applied at the gates can enable modulation of the QD energy states so as to instigate resonant tunneling transport.

IL17: Satyabrata Jit

Professor
Department of Electronics Engineering
IIT(BHU), Varanasi
Email: sjit.ece@iitbhu.ac.in

Title: ZnO Colloidal Quantum Dots Based Photodetectors

Zinc oxide (ZnO) colloidal quantum dots (CQDs) have emerged as a versatile class of solution-processable semiconductors for next-generation ultraviolet (UV) and broadband photodetectors owing to their tunable optoelectronic properties, low-temperature synthesis, and compatibility with large-area flexible substrates. Their wide direct bandgap (~3.37 eV), high exciton binding energy, and strong intrinsic UV absorption make ZnO CQDs inherently suitable for solar-blind and visible-blind UV detection, while quantum-confinement effects enable bandgap engineering that extends spectral responsivity toward the visible region. The high surface-to-volume ratio of QDs enhances light–matter interaction and facilitates efficient charge separation, leading to improved photoconductive gain and responsivity. Furthermore, the ability to tailor surface ligands, control defect densities, and modulate trap states allows fine optimization of carrier dynamics, enabling high detectivity, rapid response, and low dark current.

This lecture will focus on the application of colloidal ZnO CQDs synthesized via the hot-injection method for fabricating various UV and UV–visible broadband photodetectors using diverse device architectures, including Schottky diodes, p–n heterojunctions, and hybrid organic–inorganic structures produced through simple and cost-effective spin-coating techniques. Both spectrally selective UV photodetectors and broadband detectors will be discussed. Heterostructures of ZnO CQDs with 2D materials (e.g., $MoSe_2$) and semiconducting polymers (e.g., TIPS-pentacene and F8BT) will be highlighted for their potential in enabling UV–visible broadband photodetection. Owing to their intrinsic UV sensitivity, surface-state tunability, and compatibility with scalable printing methods, ZnO CQDs represent a promising platform for low-cost, high-performance, and flexible UV/broadband photodetectors suitable for applications in environmental monitoring, flame detection, optical communication, and wearable electronics.

IL18: Suparna Pal

Raja Ramanna Centre for Advanced Technology, Indore
Email: suparna(at)rrcat.gov.in

Title: Multifunctional thin films for optical coatings and optoelectronic device applications

Silicon compatible, wafer scale 2D transition metal dichalcogenides (TMDs) thin film based heterostructure is a novel building block in the modern semiconductor industry, due to its flexibility and sharp heterointerface. High photoresponse and high detectivity p-n heterojunction photodiodes were fabricated depositing n-MoS2 colloidal quantum dots or few-layered nanotextured WS2 thin films on p-Si substrates. The photodiodes exhibited UV-visible broadband photodetection in the spectral range of 300 - 800 nm. Monolayer equivalent efficiency, i.e. high responsivity and high detectivity have been achieved in these devices using cost-effective, facile and large area deposition method. Wavelength selective photodetection was obtained using variable size MoS2 colloidal quantum dots. The photodiode exhibits superior photo-to-dark current ratio (~1000), photoresponsivity > 4 A/W and detectivity of ~ 5×1012 Jones under reverse bias condition. On the other hand, a sol–gel method was developed to produce homogenous thin films of amorphous Ta2O5, TiO2 and SiO2 for application in high energy laser optical coating as well as photodetection in the UV range. Using these sol-gel films, Ta2O5 (TiO2)/Si vertical heterojunction photodetectors were fabricated, which exhibited a responsivity of 0.5 – 1 A/W and specific detectivity ~ 1×1012 – 1×1013 Jones at −1 V bias voltage and 325 nm illumination wavelength.

Besides photodetection, the amorphous oxide thin films were used for high LIDT optical coatings for high energy laser application. Ta_2O_5/SiO_2 bi-layer anti-reflection (AR) films have been deposited for various wavelengths on ultra-smooth, large fused silica (FS) substrates using the sol-gel dip-coating technique. This method facilitates the development of transmission windows with high laser-induced damage thresholds (LIDT). The morphology, composition, and optical properties of these thin films were characterized before applying them as bi-layer AR coatings on FS substrates. AR coatings were deposited for four target wavelengths—850 nm, 1053 nm, 1300 nm, and 1550 nm—by varying the film thickness with precise control over the withdrawal speed during the dip-coating process. Deposition parameters were optimized to minimize optical absorption, achieving a maximum transmission of > 99% and reflectivity of <1% for all AR coatings. All sol-gel AR-coated FS transmission windows demonstrated a high LIDT of ~20 J/cm^2, making them highly suitable for high-energy laser applications. Further, high-quality TiO2 and TiO2-PMMA composite thin films prepared by sol-gel process were applied in optical coatings. The addition of PMMA to the TiO2 sol exhibits significant improvements in the optical quality and morphology of the TiO2 films which has direct implication for application in optical coatings for high-energy laser applications. The refractive index and bandgap of TiO2 are tailored by controlling the TiO2 sol:PMMA volume ratio. Incorporation of PMMA leads to reduction in absorption, passivation of defect states. These properties collectively enhance the laser induced damage threshold (LIDT) of 2.1 J/cm2 for TiO2 film to 17 J/cm2 of the TiO2-PMMA composite film.

IL19: Apurba Laha

Professor
Department of Electrical Engineering
IIT Bombay, Powai
Email: laha[AT] ee.iitb.ac.in

Title: Epitaxially Engineered III-Nitride Quantum Heterostructures: From the Spectrum of All-Color LEDs to Single-Photon Sources

The quest for high-quality, defect-free III-nitride heterostructures continues to drive innovation in semiconductor epitaxy. Plasma-Assisted Molecular Beam Epitaxy (PA-MBE), with its precise control over growth dynamics and empowered with in-situ diagnostics such as Reflection High-Energy Electron Diffraction (RHEED), has emerged as a versatile platform for engineering III-nitride nanostructures at the atomic scale. By carefully tuning growth conditions and surface kinetics, PA-MBE enables a seamless transition from two-dimensional quantum wells to zero-dimensional quantum dots, offering unprecedented control over quantum confinement. In this presentation, we will demonstrate how epitaxial process engineering in PA-MBE allows us to tailor the size, shape, and composition of III-nitride quantum heterostructures, thereby spanning a broad emission range—from visible all-color LEDs to quantum emitters operating at room temperature. The discussion will highlight the correlation between growth dynamics, structural evolution, and optical functionality, emphasizing the role of epitaxial precision in bridging the gap between classical optoelectronic devices and emerging quantum photonic technologies.

IL20: Syed Minhaz Hossain

Professor
Department of Physics
IIEST, Shibpur
Email: shminhaz@physics.iiests.ac.in

Title: White LED with Reduced Graphene Oxide-capped Nanostructured Silicon

Silicon, being earth-abundant, inexpensive, and fully compatible with the mature complementary metal–oxide–semiconductor (CMOS) platform, is an attractive candidate for next-generation integrated optoelectronic devices. However, bulk crystalline silicon is inherently limited as a light emitter due to its indirect band gap. This fundamental drawback has historically hindered the use of silicon in active light-emitting applications. To overcome these challenges, nanocrystalline silicon (NanoSi)-based technology has emerged as a promising strategy where the quantum confinement effects, surface passivation, and altered electronic states enable efficient visible photoluminescence with tunable emission properties. Though these features have the potential to effectively mitigate the limitations of bulk silicon while offering pathways for fabricating a CMOS-compatible light source, the omnipresent, unavoidable non-stoichiometric insulating silicon oxide layer surrounding the quantum structures acts as a window layer for the emitted photons from the core but hinders efficient carrier injection. This limits the Electroluminescence efficiency well below the same for its competitors with direct bandgap semiconductors. A transparent but conducting material that would create little hindrance in carrier injection and photon extraction could be a solution. Meanwhile, it has been seen in recent years that amine functionalized reduced graphene oxide (rGO) exhibits reasonable conductivity as well as band-gap tunability in the visible region. Motivated by these observations, we have incorporated the rGO layer as a cap that prohibits the growth of the silicon oxide layer on the NanoSi structures and hence minimises the hindrance in carrier injection without reducing the transparency. We have synthesised the NanoSi layer on n+p Si substrate and capped it using as-prepared rGO grown by suitably modified Hummer's method before minimum exposure to oxidising environment. Finally, we deposited a semi-transparent silver layer on the rGO as the cathode. The most remarkable outcome of the device is the highest ever reported external quantum efficiency (EQE)~ 3%, involving a nanocrystalline Si-based LED. Additionally, the colour of the emitted EL became white instead of the usually observed yellow-orange colour of the visible spectrum due to its convolution with the blue emission from the multilayered partially reduced graphene oxide film.

IL21: Ritam Sarkar (IMEC)

Tittle: From GAA Nanosheet to Beyond-Moore: Unlocking the Future of FET Scaling in the Ångström Era

As semiconductor technology advances into the Ångström era, traditional CMOS scaling faces fundamental physical and material limits, driving a transition from FinFET architectures to Gate-All-Around (GAA) nanosheet transistors. GAA nanosheets offer superior electrostatic control, higher drive current, and improved scalability, positioning them as the foundational device architecture for sub-3 nm technology nodes. This transition is not an endpoint but a stepping stone toward ultimate FET scaling, enabling the development of novel device architectures such as fork sheet FETs and complementary FETs (CFETs). Concurrently, CMOS 2.0 envisioned FET scaling "beyond Moore era" by introducing innovative device architectures, heterogeneous 3D integration schemes to sustain performance improvements in system level.

IL22: Dipankar Mandal

Professor
Quantum Materials and Devices Unit
Institute of Nano Science and Technology
Email: dmandal@inst.ac.in

Title: Piezoelectric Voiceprint Biometric for Healthcare Assessment

We explore the exciting possibilities of programmable piezoelectric interfaces, where the realms of nanotechnology converge with smart wearable technology.1-3 The fabrication of advanced piezoelectric sensors enabling us to unlock new dimensions in human-machine interaction. These sensors pave the way for a myriad of applications, from voice biometrics to the recognition of different emotions which is one of the prerequisite for meatal health assessment, and non-invasive disease detection. This study highlights the evolving landscape where piezoelectric materials and technology converge to shape the future of wearable devices with boundless potential.

Spotlight Lectures

SP1: Achintya Singha

Department of Physical Sciences, Bose Institute, EN 80, Sector V,
Bidhannagar, Kolkata 700091, India.

Title: Optical Access to Dark Trion States in Monolayer WS2 via Localized Plasmon Modes

Monolayer transition metal dichalcogenides (TMDs) host a rich hierarchy of excitonic complexes, including charged trions. Among them, **dark trions**—spin or momentum forbidden, negatively charged excitons—are particularly attractive for valleytronic and quantum-photonic applications due to their long lifetimes. Yet, accessing these states optically, especially in monolayer WS_2 and at elevated temperatures, has remained challenging.

In this talk, I will discuss our recent demonstration of **plasmon-assisted brightening of dark trions in monolayer WS_2 between 83–115 K**, enabled by placing the monolayer on a *disordered plasmonic gold film* [1]. The plasmonic substrate simultaneously provides strong electron doping, yielding a trion-dominated regime, while its structural disorder produces **localized surface plasmon modes** with strong out-of-plane components that couple directly to the out-of-plane dipole moment of dark trions, thereby activating and enhancing their emission.

Temperature-dependent photoluminescence (PL) spectra reveal a well-resolved spectral doublet in the 83–115 K range, separated by ~45 meV. The lower-energy feature is assigned to the semi-dark trion, and the higher-energy feature to the bright trion state. A theoretical model [1,2] suggests the semi-dark trion state to be a mixed state of the dark and bright trion states coupled via electron-electron intervalley scatterings. Using polarization-resolved PL spectroscopy, we further show that the degree of circular polarization is negative at the peak energy of the semi-dark trion state, a result which has not been reported earlier in the case of ML WS_2 [1].

I will discuss how this mechanism creates a new route for manipulating optically inaccessible excitonic states at elevated temperatures without magnetic fields or extreme cryogenic cooling. More broadly, the results illustrate how **disorder-engineered plasmonic environments** can uncover hidden excitonic physics, enabling new device strategies for valley memories and quantum-optical functionalities in 2D semiconductors.

SP2: Subhrajit Mukherjee

Department of Physics, School of Natural Sciences, Shiv Nadar Institution of Eminence, Delhi-NCR, Gautam Buddha Nagar, Uttar Pradesh, India 201314

Title: Unlocking High-Mobility Transport and Quantum Dot Control in van der Waals Heterostructures via Oxygen-Free Fabrication

Two-dimensional transition metal dichalcogenides promise exceptional performance in nanoelectronic and quantum devices but often fall short due to extrinsic disorder introduced during fabrication. Here, we demonstrate the ambient oxygen exposure during lithographic processing as a dominant, yet underappreciated source of charge doping and mobility degradation, even for nominally "ambient-stable" TMDs. By implementing an entirely oxygen-free device fabrication protocol inside an inert glovebox, we achieve monolayer MoS2 and WS2 field-effect transistors with mobilities approaching theoretical phonon-limited values and reduced variability across large device arrays. Density functional theory (DFT) reveals that O2 rapidly chemisorbs on defect sites, creating deep traps that persist despite mild annealing. Beyond performance recovery, our oxygen-free process enables ultraclean van der Waals heterostructures suitable for low-disorderquantum devices. We demonstrate gate-defined quantum dots in WS2 heterostructures, achieving single-electron transport at 43 mK. This work establishes oxygen freefabrication as a straightforward and broadly applicable route to intrinsic-limit transport andquantum ready 2D devices.

SP3: Amit K Chakraborty

**Energy Materials & Devices Laboratory, Department of Physics,
National Institute of Technology Durgapur, MG Avenue, Durgapur,
713209, WB, INDIA**

Title: Transition Metal Oxides/Hydroxides for High Performance Energy Storage Applications

The growing global energy demand and the transition toward renewable energy sources have intensified the need for efficient energy storage technologies. However, the main draw-back of renewable energy technologies is their inability to produce energy uninterruptedly. Energy storage devices like battery and supercapacitor are thus gaining increasing demand for practical use of renewable energy as they can store the intermittently produced energy and supply it when on demand. Supercapacitors are a type of energy storage device that store energy by forming electric double layers (EDLC) or by redox reactions (pseudo-capacitive) on the electrode surface making them distinct from batteries due to their fast charging-discharging mechanism compared to batteries which store energy by ion intercalation mechanism.[1] Due to their ability to deliver high power density, supercapacitors can complement batteries in times of high-power demand when batteries fail to perform.

In this paper, we primarily report some of our recent findings on development of asymmetric supercapacitors using transition metal oxides and oxyhydroxides. We show that doping with metal cations or incorporation of MXene into metal oxide nanostructures can significantly enhance their charge storage performance. We also show how a hierarchical core-shell architecture of transition metal oxyhydroxide-layered double hydroxide electrode can show remarkably high charge storage performance when used in a supercapacitor (Fig. 1).

SP4: Debraj Choudhury

Department of Physics, Indian Institute of Technology Kharagpur

Title: Engineering titanate-spinel oxides as a volatile memristor

I will discuss the volatile resistive-state switching properties in doped titanate spinel oxide. $MgTi_2O_4$ undergoes a rare concomitant magnetic (spin-singlet), structural and orbital-ordering (tetramer orbital ordering) transition driven by Jahn Teller active $Ti^{3+}(3d^1)$ ions. $MnTi_2O_4$ also undergoes a much weaker cubic to tetragonal structural transition driven by the Jahn-Teller active Ti^{3+} ions and instead stabilizes in a ferrimagnetic ground state [1]. Unique mixed-valent ground states can be engineered by doping these titanate-spinel oxides either by complimentary Jahn-Teller active ions (like V^{3+} ions) [2] or by vacancy doping at the A-site [3]. We will discuss the transport results revealing that both the V-doped and the vacancy-doped systems exhibit current/voltage -induced breakdown of their Mott insulating state to give way to a low-resistive state in presence of extremely-small threshold electric fields and exhibit the properties akin to a single-component artificial neuron.

SP5: Sayan Bayan

Department of Physics, Rajiv Gandhi University, Doimukh,
Arunachal Pradesh 791112, India

Title: Triboelectrification for self-powered sensors

In this modern era, energy harvesting from surrounding environment is considered to be an useful technique for achieving self-powered systems. In this context, fabrication of Triboelectric nanogenerators (TENG) to convert random mechanical energy of the surrounding environment into electrical energy has been reported worldwide [1]. Apart from the characteristics of the active material, various external factors like temperature, humidity, gaseous environment etc. significantly affect the output profile of a TENG. This fact encourages the development of various sensors using the virtue of triboelectrification. As an example, triboelectric sensor to analyze fruit freshness through simple touch and release action has been developed using zinc oxide (ZnO) nanowall and poly(vinyl alcohol) (PVA) film [2]. The utilization of such sensors enables the analysis of fruit surface conditions like dryness, firmness etc. to monitor their quality and is promising for minimizing losses throughout the food supply chain. On the other hand, energy harvesting from water waves or drops is proven to be an unique technique to monitor water quality as well as biological fluids [3]. Therefore, implementation of triboelectrification through liquid-solid interaction is promising for the development of water droplet based TENG and may offer path for the achievement of futuristic flexible bio-sensors.

SP6: Sourabh Roy

Department of Physics, National Institute of Technology Warangal, Telangana, India, 506004

Title: Designing and Performance Evaluation of Hybrid Silicon HfO2-ITO based Electro-Optic Modulator.

The high-speed, compact and power efficient electro-optic modulators (EOM) are the epitome for data centers with fundamental requirements of next-generation optical interconnects and advanced communication systems. Majorly silicon offers a fairly decent platform for designing such device, however Si attributes a very weak plasma dispersion effect resulting high power consumption. Our work presents a comprehensive design and simulation of a high-performance ring-resonator-based hybrid EOM that incorporates ITO and HfO2 layers on Si. HfO2 is a high-dielectric-constant material; it enhances field confinement while maintaining low optical loss and CMOS compatibility. The accumulation of carriers at the Si/HfO2 interface enhances modulation efficiency. Our device was analyzed, and its complete workflow lies in Lumerical MODE, FDTD, CHARGE, and INTERCONNECT solvers. We benchmarked a standard silicon-based EOM with a radius of 10,000 nm, and an extinction ratio (ER) of 15.5 dB. Our hybrid structure, Si–HfO2–ITO, was optimized for a 6,000 nm radius and ITO and HfO2 thicknesses of 15 nm. We achieved a modulation efficiency of 1.13 nm V−1. We conclude that our simulation is strong evidence of ITO's electro-optic response in a hybrid Si–HfO2–ITO platform, yielding improved efficiency. Our design is promising for low-voltage optical modulators. In the Fig. 1 (a) represents the schematic diagram of the structure and (b) the EO response with QF 390 and efficiency 1.22 nm/V.

SP7: Rishi Maiti

Department of Physics, IIT Guwahati

Title: Encoding Light on a Chip: Computational Spectrometers Using Atomically Thin Materials

Computational spectrometers are redefining the landscape of spectral sensing by replacing bulky optical dispersive elements with data-driven reconstruction techniques. By leveraging atomically thin two-dimensional (2D) materials and their heterostructures, these systems enable extreme miniaturization, integrating light detection and spectral analysis directly onto a chip. Such on-chip spectrometers promise high-resolution, real-time, and in- situ spectral sensing capabilities within an ultracompact footprint. This paradigm shift paves the way for next-generation hyperspectral imaging, environmental monitoring, and point-of care diagnostics, where accuracy and sensitivity are paramount.

SP8: Ankur Goswami

Department of Material Science Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016, India

Title: An electrochemical sensing on CYTOP electret surface

Fluoropolymer-based electrochemical sensors have gained increasing attention for pH detection due to their superior stability and sensitivity[1]. However, There are few limitations such as selectivity, durability, surface fouling, non-linearity and bulkiness still remains[2]. In this work, we report a Cyclic Transparent Optical Polymer (CYTOP)-based electret pH sensor (CE-pHS) that exhibits excellent charge storage, long-term dipole orientation, high signal stability and durability[3]. The CE-pHS demonstrates a remarkable sensitivity of 6 nA/pH, which outperforms conventional fluoropolymers pH based sensors. To enhance selectivity and minimize response variation, a machine learning algorithm was employed to analyse key parameters such as maximum and absolute current and voltage signals across various water types including rain water, ion-rich solutions. The integration of data driven machine learning modelling significantly improved pH classification accuracy and robustness under diverse environmental conditions. These findings establish the CE-pHS as a highly sensitive, durable and intelligent platform for advanced environmental and industrial water quality monitoring.

Keywords: Electrets, pH detection, Fluoropolymers, CYTOP, Machine learning

SP9: Atindra Nath Pal

S. N Bose National Centre for Basic Sciences, JD Block, Sector III,
Kolkata - 700106

Title: Light–Matter Interactions and Single Defect Spectroscopy in Engineered 2D Heterostructures

Two-dimensional (2D) materials and their hybrid interfaces provide a versatile platform for manipulating charge transport, excitonic processes, and light–matter interactions. This talk brings together three complementary directions. First, I discuss enhanced photodetection in 2D/0D and 2D/2D heterostructures, where graphene and TMDC devices exhibit tunable photoresponse driven by interface-mediated charge transfer, alloy engineering, and exciton–plasmon interactions. Second, I focus on ReS_2-based electronic and optoelectronic devices, where graphene-contacted ReS_2 FETs demonstrate nearly barrier-free carrier injection, reduced 1/f noise, and significantly enhanced photodetection enabled by van der Waals contact engineering. Building on this platform, I will present defect spectroscopy in ReS_2–hBN FETs, where ultraclean few-layer graphene contacts suppress disorder and allow direct observation of random telegraph noise from individual hBN defect centers. These single-defect signatures evolve into 1/f noise with increasing temperature, and statistical analysis attributes the traps to carbon-related substitutional defects. Third, I introduce 2D/organic hybrid heterostructures formed by spontaneous epitaxial growth of ultrathin vanadyl phthalocyanine (VOPc) on MoS_2, WS_2, and hBN. These systems exhibit tunable photoluminescence and hybrid charge-transfer excitons, revealed by transient absorption spectroscopy and supported by XPS/UPS and DFT analysis. Interface-induced band alignment and molecular conformation emerge as new knobs for controlling optical and excitonic properties. Together, these results establish interfacial engineering across 2D/0D, 2D/dielectric, and 2D/organic platforms as a powerful strategy for uncovering new excitonic phenomena, enhancing photoresponse, and probing defect dynamics in quantum materials.

SP10: Suvra Prakash Mondal

Department of Physics, National Institute of Technology, Agartala, Tripura, 799046, India

Title: Noninvasive Nitric Oxide Detection for Biomedical application

Nitric oxide (NO) is one of most important cellular signaling molecules responsible for blood pressure regulation, vasodilation, neurotransmission, immune response and several physiological process. Any deviation of NO concentration in body fluids causes deadly diseases like Parkinson's disease, fibrosis, hypertension, rheumatoid arthritis etc. Noninvasive detection of NO in our body fluids is very much attractive for early prediction of our health condition. Here, we report on the fabrication of nanomaterial based electrochemical sensors which selectively detect NO in human saliva and artificial tears. Platinum (Pt) decorated titanium dioxide (TiO_2) nanoparticles were studied for NO sensing in human saliva. The sensor demonstrated high sensitivity (~7.**8** $\mu A\ mM^{-1}cm^{-2}$) in wide linear detection range (10 *n*M-28 mM) and demonstrated ultra-low detection limit (~**2.**4 nM)**.** A paper-based Au nanoparticle deposited carbon cloth sensing electrode was studied for electrochemical NO detection in artificial tears. Working, reference and counter electrodes were fabricated by painting carbon ink on paper substrates. Such low-cost paper-based electrode demonstrated sensitivity of 0.42 $\mu A\ \mu M^{-1}$ in the linear range 10nM to 1.4 mM. The detection limit of the NO sensor was achieved 2.34nM. Both the sensing electrodes are highly stable, reproducible and selective towards NO among various interfering agents present in saliva and tears. Our study demonstrates the potential application of nanomaterials-based electrochemical NO sensors for biomedical applications.

SP11: Akshay Moudgil

Electrical Engineering, IIT Jodhpur

Title: Hybrid Organic Electrochemical Transistors for Next-Generation Bioelectronics

Organic electrochemical transistors (OECTs) are emerging as powerful building blocks for bioelectronic interfaces owing to their high transconductance, low operating voltage, and mixed ionic–electronic conduction. However, their widespread deployment in wearable and implantable systems remains constrained using liquid electrolytes, biocompatibility concerns, and mechanical instability. This talk presents the development of hybrid organic electrochemical transistors (OECTs) that integrate biocompatible ionic liquids, solid-state polymer electrolytes, and flexible device architectures to overcome these challenges. A novel ionic liquid, [MTEOA][MeOSO$_3$], enhances the conductivity and redox dynamics of conjugate polymer (channel), enabling high transconductance, fast response, and stable operation under mechanical deformation. Building upon this foundation, an extended-gate solid state OECT platform is realized for multiplexed Na^+, K^+, and Ca^{2+} ion sensing from sweat, combining high selectivity and rapid response with wearable form factors. Finally, thermoplastic polyurethane (TPU)–based solid electrolytes are introduced to achieve robust, all-solid-state OECTs (SSOECTs) that operate reliably from −50 °C to 120 °C and endure extensive bending and cycling. These devices demonstrate exceptional amplification and circuit-level integration capability. Overall, these advances outline a roadmap toward reliable, biocompatible, and high-performance transistor technologies that can power the next generation of wearable and implantable bioelectronic systems.

SP12: Sayan Dey

School of Electrical and Computer Sciences, IIT Bhubaneswar

Title: Bio-Inspired Chemical Sensors: From Materials to Technology

Advances in bio-inspired chemical sensing are increasingly driven by innovations in functional nanomaterials and spectroscopic transduction techniques. Semiconductor-based materials such as Ni_2O_3, rGO–metal oxide hybrids, ZnO/rGO junctions and 2D MoS_2 have enabled highly selective detection of toxic gases, VOCs and heavy metal ions. A significant development in this area is conductance spectroscopy, a nonlinear electrical method that utilises second-harmonic analysis (d^2I/dV^2) to extract molecular interaction signatures beyond conventional resistance measurements. This approach enhances selectivity, sensitivity and molecular discrimination under ambient conditions. The transition from materials to technology is demonstrated through flexible sensors, micro-sensor arrays and portable platforms for environmental and biomedical monitoring. This talk will highlight how biomimetic design, junction engineering and nonlinear spectroscopy collectively advance the development of next-generation chemical sensors.

SP13: Debanjan Bhowmik

Electrical Engineering
Indian Institute of Technology Bombay
debanjan@ee.iitb.ac.in

Title: Spintronics-Based Neuromorphic Computing and Ising Machines

With the scaling of conventional-silicon-transistor devices almost reaching saturation, conventional machine learning/ neural networks implementations hitting a major bottleneck (due to the separation of memory and computing units in conventional computers, popularly known as the von Neumann bottleneck), and solution of different combinatorial optimization problems taking enormous amount time on conventional computers, various unconventional computing paradigms have emerged recently, like neuromorphic computing and Ising computing, which make use of novel materials beyond silicon and devices beyond transistors. Neuromorphic computing is about solving machine learning tasks on brain-inspired energy-efficient hardware, while Ising machine/ computing is about solving combinatorial optimization algorithms heuristically on unconventional hardware. Magnetic materials and related nanomagnetic and spintronic devices are very important for both these computing schemes. Motivated by this, Prof Debanjan Bhowmik has carried out extensive amount of work on spintronics-based neuromorphic and Ising computing through both experiments and simulations. He will present his major research findings in this talk, along with providing a general introduction to this field of research.

SP14: Narendar Gogurla

Tufts University, USA

Title: Silk as a Platform for Bio-Integrated Electronic and Optical Devices

Recent advances in silk protein science have positioned it as a powerful material for next generation bio-integrated technologies. Tunable beta-sheet formation, precise micro/nanostructuring, optical clarity, and water-based processing have expanded silk's capabilities far beyond traditional biomedical uses. These developments have unlocked dynamic optical responses, mechanically adaptive interfaces, and environmentally benign fabrication strategies—creating new pathways for devices that harmonize with biological environments while meeting the performance demands of modern electronics and photonics. Building on these emerging capabilities, our work demonstrates three complementary directions: ultrathin electronic tattoo stickers that conform to skin for physiological sensing and human device interaction; adaptive silk-based optical elements that enable switchable photonic behavior through hydration, thermal, and mechanical cues; and water-soluble silk systems for nanoscale electronic fabrication, where controlled dissolution and molecular precision allow fine-resolution patterning and transfer processes without harsh chemicals. Together, these results illustrate how silk-driven innovation is bridging the gap between biology and technology, enabling sustainable, adaptive, and high-performance bio-integrated devices.

SP15: Poulomi Chakrabarty

Department of Computer Science and Engineering, Shiv Nadar University

Title: Strain-Polarized 2D WS_2 for Autonomous Vehicle Low-Light Sensing Applications

Event-based dynamic light detection, particularly in low-illumination environments, is a critical requirement for autonomous vehicles, night-vision systems, and industrial automation. Enhancing the response and speed of light detectors boosts AI applications by improving data accuracy, dynamic range, adaptability, and enabling real-time processing. However, there is a significant trade-off between the responsivity and speed of phototransistors; longer carrier lifetimes improve responsivity but reduce response speed.

The pyrophototronic effect in non-centrosymmetric semiconductors offers a promising approach to address this trade-off and simultaneously enhance both photodetector responsivity and speed. Odd layers of 2H-phase two-dimensional transition-metal dichalcogenides (TMDs) exhibit non-centrosymmetry due to the lack of an inversion centre. This work reports low-optical-power photodetection through the dynamic pyrophototronic effect in an ultra-thin 2D WS_2 phototransistor. A four-stage pyrophototronic photoresponse has been realized through biaxial-strain-induced polarization of the non-centrosymmetric five-layer WS_2 channel using a sub-wavelength nanopatterned hBN gate dielectric. The pyrophototronic effect enhances dynamic photoresponsivity ($0.7\ \mathrm{A\ W^{-1}}$) and detectivity (1.2×10^{15} Jones $\mathrm{cm^{-1}}$) by up to eight times and increases the photodetection speed by three times compared with the non-patterned (unstrained) phototransistor, demonstrating a path toward mitigating the responsivity–speed trade-off in 2D photodetectors. The gate tunability of the pyrophototronic current in the ultra-thin WS_2 channel has been utilized to create an optical spike-triggered dynamic alert system for accidents, featuring speed-specific control for self-driving applications[1].

SP16: Subhendu Sinha Sarkar

Solid State Physics Laboratory, Delhi

Title: Triple Junction Solar Cells and Silicon Carbide Power Devices for Green Energy

One of the key solution to India's transition to renewable energy is harnessing the solar power. For efficient harnessing of solar energy, both high-efficiency solar cells as well as high-performance power-conversion electronics, essential for real-world applications, are required. One of the key applications of solar power based energy sources is in the area of space exploration. Due to its radiation hardness properties, GaAs based multi-junction solar cells, eptaxially grown on Ge substrates, are widely used in space applications. Multi-Junction solar cells, unlike single junction cells, are solar cells having multiple p-n junctions of semiconductor materials having different band gaps. Different band gaps allow the absorption of broad spectrum of sunlight resulting in higher efficiency as compared to single junction solar cells. Typically a triple junction solar cell based on GaAs have three cells consisting of GaInP (band gap ~1.8 eV) as top cell, GaAs (band gap ~1.4 eV) as middle cell and Ge (band gap ~0.67 eV) as bottom cell. Typical efficiency for a triple junction solar cell under one sun illumination is ~30% while under concentrated sunlight this efficiency may go as high as ~45%.

Wide band gap, high breakdown voltage and high thermal conductivity of SiC makes SiC based devices a preferred choice over its other counterparts for power electronics applications in solar cells. For conversion of solar cell DC to AC power, inverters based on SiC Schottky diodes are used. As compared to their Si counterpart, SiC based diodes offer fast switching speeds, higher efficiency and better thermal performance. High breakdown voltage and low on-state resistance of SiC Schottky diodes allows fabrication of diodes with smaller form factors. Hence, very compact and light weight power electronic systems can be fabricated using SiC, which offers substantial advantage for space applications, where weight of the electronics is very critical.

SP17: Aditi Sharma
Symbiosis Institute of technology (SIT), Pune

Title: Bridging Intelligence and Security: Deploying Machine Learning in IoT-Enabled Smart Systems and Secure Architectures

The convergence of Machine Learning (ML) and the Internet of Things (IoT) has catalyzed the evolution of next-generation smart healthcare systems, where pervasive sensing, real-time analytics, and autonomous decision support enable continuous monitoring, diagnosis, and personalized treatment. However, the massive data heterogeneity and distributed intelligence in such systems introduce complex security, privacy, and trust challenges across both cloud and edge infrastructures. This talk, *"Bridging Intelligence and Security: Deploying Machine Learning in IoT-Enabled Smart Systems and Secure Architectures,"* presents a unified technical framework integrating intelligent learning models with secure computing architectures to ensure resilient, privacy-preserving, and context-aware healthcare solutions.

At the computational intelligence layer, the discussion focuses on the deployment of deep learning and Bayesian neural inference models for multimodal health data analysis, anomaly detection, and predictive diagnostics. The integration of Markov Sparse Bayesian Neural Networks (MSBNNs) and reinforcement learning allows adaptive system optimization and robust classification under dynamic IoT environments. On the communication layer, adversarial ML-based intrusion detection systems (AML-IDS) and trust-based cryptographic protocols strengthen data confidentiality and authentication in cloud-assisted healthcare networks. These methods enhance accuracy, specificity, and data transmission efficiency while maintaining compliance with healthcare privacy standards.

Further, the talk highlights hardware-assisted trust mechanisms such as Physical Unclonable Functions (PUFs) and their GAN-modeled counterparts for device-level authentication, along with federated and edge intelligence frameworks that enable decentralized learning with minimal data exposure. By leveraging adversarial robustness, holographic identity encoding, and lightweight encryption, the proposed architectures establish multilayer security while sustaining low-latency data analytics critical to medical IoT operations.

Collectively, these advancements mark a paradigm shift toward secure, intelligent, and ethically aligned healthcare ecosystems, where ML not only enhances clinical intelligence but also acts as a defensive mechanism against evolving cyber threats. The fusion of AI-driven inference, cryptographic computation, and IoT-enabled medical systems thus defines the future trajectory of trusted intelligence for smart healthcare and cyber-physical security.

Keywords: Machine Learning, Internet of Things, Smart Healthcare, Adversarial Learning, Cloud Security, Edge Intelligence, Physical Unclonable Functions, Cryptographic Trust Models, Federated Learning, Cyber-Physical Security, Industry 5.0.

SP18: Tridib Sinha

[1]Department of Chemistry, Applied Science Cluster, School of Advanced Engineering (SoAE) & [2]Centre for AI, School of Computer Science (SoCS), UPES, Dehradun, India

Title: Room-Temperature VOC Sensing Using an In-Situ-Grown PANI/rGO/ZnO Composite Heterostructure with a Machine-Learning-Based Decision Strategy.

This research work deals with the low or room temperature volatile organic compounds (VOC) sensing using hybrid composites of semiconductors both the inorganic (high temperature operable with very good response and recovery) and organic (low or room temperature operable but with long recovery) enabling development of p-n- or n-p-type heterojunctions, possibly causing enhanced electron transfer laid by a built-in electric field across the interface resulting in lowering the energy barrier of charge transport and allowing carriers to cross the interface even at limited availability of thermal energy. Towards realizing this kind of hybrid sensor/s, herein, instead of individually preparing and then mixing, an in-situ prepared hybrid ZnO (n-type)-PANI (p-type) composite material has been demonstrated for sensing of polar protic VOCs e.g., methanol & ethanol, and polar aprotic acetone at a very low concentration (~50 ppm). For fasten and homogenize electron transportation as well as formulation of homogenous composite structure rGO (in situ synthesized from GO) has been introduced within the composite. In this case, well mixed, water processable PANI (B), ZnCl2, and aqueous dispersion of GO was drop-casted over an ITO-coated electrode substrate and annealed at ~110°C for nearly 3 hrs. (180 mins.). As in normal laboratory practice, the annealing time may vary in a considerable manner (i.e., within a 10–15-minute range) while the reduction of rGO may change significantly. Herein, the PRZ has been processed for annealing temperatures of 3 hrs., 3 hrs. 10 mins., 3hrs. 15 mins., and 3 hrs. 20 mins. Although the sensing patterns look similar for all the PRZ sensors, their response percentages were found to be differ widely from each other. As a consequence, although the PRZ materials performing as room temperature sensor, with slight change in annealing temperature were found to result in huge variation in their responses. Considering, all the changes in the response peaks (instead of measuring only the response% traditionally being considered) for all the PRZ samples, machine learning has been introduced to realize their sensitivity and selectivity towards the VOCs and was found to discriminate well, irrespective of their annealing temperatures. It was also observed that the samples having lower resistance are performing better. This research work being facile and having an urgent need in current semiconductor era, could be considered praiseworthy for both the academia and industries (e.g., early-stage non-invasive health care monitoring).

SP19: Subhashis Gangopadhyay

Department of Physics, Birla Institute of Technology and Science Pilani, Rajasthan,333031

Title: Growth and Phase Engineering of Transition Metal Oxide Based Nanostructures for High Performance Chemiresistive Gas Sensing

Transition metal oxide (TMO) nanostructures have emerged as promising candidates for high performance chemiresistive gas sensors due to their tunable surface states, rich defect chemistry, and strong gas-solid interactions. However, their sensing efficiency is often limited by slow charge transfer, restricted active surface area, and poor selectivity when using single-phase oxides. Engineered nanostructures such as 1D/2D geometries, mixed phases, and core-shell heterojunctions offer a controlled pathway to enhance carrier separation, increase adsorption sites, and modulate band alignment, enabling improved sensitivity and ultra-low detection limits needed for real-world gas/VOC monitoring. Within this study, we systematically investigate the thermal oxidation-driven growth, phase evolution, and gas-sensing performance of diverse TMO based nanostructures including 1D ZnO nanostructures [1-2], ZnO@TiO2 core-shell heterostructures, CoO/Co3O4 core-shell nanowalls [3 4], MoOx nanorods, and mixed CuO–ZnO (CZO) 1D systems [5]. Controlled oxidation parameters enabled phase tuning and morphology control, yielding highly dense 1D/2D architectures with enhanced surface reactivity. ZnO nanoneedles and CoO/Co_3O_4 nanowalls exhibited high VOC sensitivity and fast response, while $ZnO@TiO_2$ heterostructures showed significantly enhanced formaldehyde sensing owing to efficient p-n junction charge separation. Mixed-phase CZO structures also demonstrated tunable gas-sensing activity. Overall, these results establish thermally grown TMO nanostructures as strong candidates for next-generation, selective, and low-power gas sensors.

SP20: Kalisadhan Mukherjee

Department of Chemistry, Pandit Deendayal Energy University, Gandhinagar, India

Title: Unveiling the Potential of Semiconducting Metal Oxide Chemiresistors for Detection Discrimination and Quantification of Isomeric Alcohols in the Binary Mixtures

Identification and quantification of individual isomeric volatile organic compounds (VOCs) in their mixtures are crucial for quality control in the chemical industry. Isomeric VOCs, despite having the same molecular weight, may differ in structures and chemical/physical properties, impacting differently the environment and biological systems. Sophisticated and costly analytical instruments, such as chromatography coupled with mass spectrometry, are usually employed to detect and quantify these isomers in mixtures. However, sensitive, low cost, easy operative technique is hardly known for predicting the volume ratio of isomeric VOCs in their mixture. In the present work, repeatable sensing signals corresponding to fixed concentrations (1000 ppm) of individual 1-propanol and 2-propanol isomers were discriminated by a cost effective TiO2 based chemiresistor kept at ~300°C. The sensing signals for the 1000 ppm mixture of 1 and 2-propanol (volume ratio 100:0, 75:25, 50:50, 25:75, 0:100) are also found distinct, repeatable and reproducible. The estimated response for the isomeric mixtures show linear variations with their volume ratio and thus enables the estimation of unknown volume ratios for a given mixture of 1 and 2-propanol (Figure 1). The proposed technique offers a cost-effective and reliable approach for characterizing isomeric mixtures, with potential applications in industrial process monitoring and environmental analysis.

Abstracts for poster presentation

Day 1 (19/12/2025)

1. Electronic Sensors and Emerging Functional Devices

ES-1: Improving the barrier properties of thermoplastic starch in the PLA_TPS_PLA multilayer films

Arnab Dutta, and Swati Neogi a,*
a Indian Institute of Technology Kharagpur, Kharagpur 721302, India
Corresponding Author: E-mail Address (Times New Roman, size 11, single spacing)

Of late, it has been observed from thermogravimetric analysis that the grafting of starch with different monomers can increase the starch's thermal stability wherein the −OH functional groups of starch can undergo strong hydrogen or covalent bonding with −COOH/ −CONH−/ −COOR groups of monomers. Thus, it can be stated that the starch graft copolymer exhibits higher barrier efficacy than the starch composite, most likely because the grafted polymer has a covalent connection as opposed to just close association in the composite. Hence, for enhancing the thermal properties of starch, I have been working on the scalable-and-reusable syntheses towards grafting of starch with other acrylic amidic monomers including N-hydroxyacrylamide, N,N dimethylacrylamide, N-methylolacrylamide, N-methoxylmethacrylamide, N-isopropoxymethylacrylamide, N- butoxymethylacrylamide, and N-hydroxyethylacrylamide, or some other properly substituted amides, other naturally derived dicarboxylic or polycarboxylic acids such as malic, tartaric, malonic, glutaric, succinic, and citric acid and/ or aliphatic acrylic esters viz. butyl acrylate, hydroxymethyl acrylate, hydroxyethyl methacrylate, methyl methacrylate methyl acrylate and ethyl acrylate to obtain multifunctional ter-/tetra- polymer(s) via O–H/ N–H functionalized C–C/ N–C/ O–C coupled polymerization of two (2) monomers and protrusion(s) of third and/ or fourth monomer(s) in situ, and characterized via advanced microstructural analyses such as NMR, FTIR, thermal analyses like TGA and DSC, topological and morphological analyses including XRD, AFM, SEM, FESEM, and TEM, water vapor transfer (WVT), gas permeability test, and ultraviolet (UV) visible spectroscopy, mechanical testing like tensile test, and rheological study alongwith theoretical calculations. Herein, grafting of starch with these biodegradable and non-biodegradable monomers will enhance the thermal stability due to the formation of a three-dimensional network via strong chemical bonds. These monomers esterify or etherify the hydroxyl functional group in starch resulting to reinforced with chemical bonds that form bridges by interconnecting the polymer chains and overcoming the inherent deficiencies in mechanical and barrier properties of biopolymers by involving their various reactive and functional groups.

Hence, cross-linked starch is expected to envisage high thermal and shear resistance with improved viscosity and consistency. Thus, grafting or crosslinking of starch improves the barrier properties of starch films by minimising the molecular movement resulting in a reduced vapour permeability and by creating a tortuous diffusion pathway in the resulting matrices. Furthermore, the starch films can be showing great prospect in flexible electronics, food packaging and selective gas membrane applications. Furthermore, the exsitu added monomers must impart rigidity, stiffness, and steric hindrance by N-branching; hydrophilicity; and hydrogen- bonding-associated interactions of primary alcohol (−CH2OH) of starch and secondary/ tertiary amide (−CONH) groups to enlarge the fluorescence efficacy. Interestingly, the rotation around the amidic C−N bond is expected to be restricted by resonance along with the electron delocalization index between nitrogen and oxygen atoms in amides, leading to the proton transfer and amide−imidol (−CONH/−CN(OH)) tautomerism.

ES-2: Detailed Study of the Various Textile Substrates for Optimizing the TENG Output

Aman Negi1, *, Sayan Chakraborty2, Prof Samit Kumar Ray1

1Department of Physics, Indian Institute of Technology Kharagpur, Kharagpur-721302, India
2School of Nanoscience and Technology, Indian Institute of Technology Kharagpur, Kharagpur-721302, India
amannegi007.24@kgpian.iitkgp.ac.in

The Triboelectric Nanogenerator (TENG) is a promising device for energy harvesting. It can convert biomechanical energy into electrical energy, which is generally not utilised in our daily lives. Electrostatic induction and contact electrification are the fundamental principles underlying the operation of the TENG. The TENG operates in four primary modes: vertical contact-separation mode, lateral-sliding mode, single-electrode mode, and freestanding triboelectric layer mode. Numerous studies have focused on enhancing the output performance of TENGs through methods such as surface modification via physical and chemical processes, incorporation of an intermediate layer, utilisation of nanocomposite materials, selection of triboelectric materials, injection of artificial ions, and optimisation of the device's design [1,2]. Creating microstructures and nanostructures on the surfaces of triboelectric materials is challenging; lithography techniques involving dry etching are costly and necessitate prolonged production timelines [3]. This work primarily examines the single electrode mode (SE mode) because of its straightforward design [4], utilising various fabrics such as nylon, flex, wool, cotton, and silk, integrated with and without MOF (ZIF-67), which serves as a tribo-positive layer [5], while PDMS functions as a tribo-negative layer. Initially, utilise the substrate functioning as a controlled device devoid of any integrated MOF to experimentally address the PDMS, measuring the open circuit voltage as it fluctuates over time for all substrates. Ultimately, MOF integrated the substrate that had been coated with PDMS following thorough examination. The superior combination following optimisation is nylon and PDMS, yielding a maximum open circuit voltage of approximately 21 V, representing a 262 percent increase compared to the scenario without MOF integration, which is about 8 V. Subsequently, an analysis of the area variation with substrate areas of around 9 cm2, 4 cm2, 1 cm2, and 0.25 cm2, in relation to voltage, reveals fluctuations in the voltage. The augmented substrate area concurrently elevates the open-circuit voltage in each instance. Subsequently, by affixing nylon and substituting PDMS with alternative dielectrics such as PTFE, mica, and Kapton to identify the combination yielding the highest open circuit voltage over time, analysis reveals that the PTFE-nylon configuration produces a voltage of approximately 25V, surpassing the previously examined nylon-PDMS combination.

ES:3 Development of Cu2SnSe3 Nanomaterials for Supercapacitor Applications

Sourav Karmakar 1, Subrata Mandal 1 , Arindam Basak 2 , & Rinky Sha 1 *

1 Sensors for Health-care and Environmental Monitoring (SHE) Lab, Department of Electronics and Communication Engineering, Indian Institute of Information Technology, Kalyani, West Bengal,India;

2School of Electronics Engineering, Kalinga Institute of Industrial Technology (KIIT) –Deemed to be University, Bhubaneswar 751024, Odisha, India.

* Corresponding author’s email-id: rinky@iiitkalyani.ac.in

The rise of environmentally friendly and stable renewable energy storage systems is garnering significant research attention due to the rapid depletion of fossil fuels and the urgent need to meet the soaring global energy demands. In contrast to traditional capacitors, the energy storage mechanism in supercapacitors is based on an electrochemical process, making the advancement of highly efficient electrode materials a significant focus for achieving enhanced energy storage devices.

Supercapacitors can be classified into three distinct types, depending on the materials used for electrodes and the mechanisms of charge storage: i) electric double-layer capacitors (EDLCs), ii) pseudocapacitors (PC), iii) hybrid supercapacitors (HSC). HSCs represent a novel class of energy storage technology, exhibiting advantageous features including high power density, high energy density, and cyclic stability. In recent years, HSCs have attracted significant attention owing to their impressive energy density and cyclic stability, which may provide more durable power supplies in comparison to traditional supercapacitor electrodes. This paper encompasses the ball milling synthesis process for the nanostructure of Cu2SnSe3, as well as its characterization and analysis of the supercapacitive behaviors. Cu2SnSe3 was synthesized via a ball milling route, and the process was conducted at 300 rpm for approximately 30 h. The X-ray diffraction (XRD) technique was employed to investigate the crystallinity of the Cu2SnSe3 with Cu-Kα radiation (λ= 0.154 nm, 2θ=150 – 900). The XRD pattern of the synthesized nanomaterial demonstrated a polycrystalline nature, and the primary dominant peak is oriented along the (111) axis at 2θ = 27.070 as depicted in Fig. 1(a). The GCD profiles as shown in Fig. 1(b) of the electrode does not adhere to a triangular shape instead it demonstrates a discharge plateau during discharge process which indicating the faradic behavior of the electrode. Each curve shows the faradic character of discharging, alluding to the redox reaction-based charge storage mechanism [1].

ES-4: Synthesis of ZIF-67 MOF and Structural Optimization of TENGs for Enhanced Energy Harvesting

Shivalingadevaru S Hiremath1,* Sayan chakraborty2, Prof. Samit K. Ray1

1Department of Physics, Indian Institute of Technology Kharagpur, West Bengal – 721302, India

2School of Nanoscience and Technology, Indian Institute of Technology Kharagpur, West Bengal 721302, India

*shivahiremath24.24@kgpian.iitkgp.ac.in

The growing demand for sustainable and portable power sources has accelerated research into triboelectric nanogenerators (TENGs), which convert mechanical energy into electrical energy through the combined action of contact electrification and electrostatic induction. Owing to their simple design, low cost, and flexibility, TENGs are emerging as promising candidates for powering wearable, self-sustained, and Internet of Things (IoT) devices. In this work, we focus on the synthesis of ZIF-67 metal-organic framework (MOF) and the structural optimization of TENG configurations to achieve enhanced energy conversion efficiency. ZIF-67, a cobalt-based MOF synthesized via a room-temperature chemical route, exhibits a highly porous structure, a large specific surface area, tunable conductivity, and excellent chemical stability. These characteristics are expected to facilitate charge trapping, interfacial polarization, and improved dielectric performance in triboelectric layers. To explore the influence of material integration, silk fibrent films incorporated with ZIF-67 nanoparticles were spin-coated onto copper electrodes, forming flexible tribo-layers. Further, several device architectures were designed and optimized, including (i) copper-paraffin film-copper configuration, (ii) copper-silk fibrent/ZIF 67-copper configuration, (iii) copper-PTFE tape-copper configuration, (iv) silicon-PTFE-copper configuration, and (v) PTFE substrate with a single copper electrode. The optimization involved varying device size, electrode spacing, and dielectric thickness to determine ideal design parameters for maximum voltage, current, and power density. The structural and material modifications are anticipated to significantly enhance surface charge density and triboelectric output, providing insights into the design of efficient and scalable TENG devices for self-powered sensing and sustainable energy harvesting applications.

ES-5: Piezoelectric Response of Lysozyme-PVA Composite Films for Flexible and Biocompatible Energy Harvesting Applications

Ruhaan Mukherjee,1,*Subhajit Mahapatra,1,$ Prithwiraj Majhi,1,$ Chumki Nayak,1 and Achintya Singha1

1Department of Physical Sciences, Bose Institute, EN 80, Salt Lake City, Bidhan Nagar, Kolkata-700091, West Bengal, India.

$ Equally contributing authors

* ruhaanmukherjee.cis@gmail.com

The future of wearable and implantable electronics demands power sources that are not only flexible and efficient but also biocompatible and environmentally sustainable. While synthetic piezoelectrics dominate the field, their frequent use of toxic elements and energy-intensive processing presents a significant drawback [1,2]. This work presents a green alternative by unlocking the piezoelectric potential of Lysozyme, a natural and abundant enzyme, within a flexible Polyvinyl Alcohol (PVA) matrix [3,4]. We have adopted a facile, solution-based fabrication process to create flexible composite films where lysozyme crystals are uniformly dispersed in a PVA network. Comprehensive characterisation through Raman spectroscopy and optical microscopic images confirms the presence of strong interfacial interactions and a homogeneous morphology, both of which are critical for efficient stress transfer and charge generation. This biocompatible composite exploits the inherent molecular dipole moments of lysozyme, which are effectively polarised and stabilised by the surrounding polymer network. Upon the application of mechanical stress, the optimised film exhibits a pronounced piezoelectric response, verified by piezoelectric force microscopy (PFM) measurements.

To probe the piezoelectric behaviour of the composite film, we measured the time-dependent current response under controlled strain (applied along the film’s length) and pressure, with a bias voltage of 5 V [5]. The resulting piezoelectric output characteristics are presented in Figure 1. The applied perturbations induce deformation of α-helices and other helical structures within the lysozyme crystals, leading to dipole reorientation and charge separation in the lattice. These microscopic polarization processes collectively generate a measurable potential difference between the electrodes under periodic stress. Furthermore, the reversed-connection test yielded output signals of identical amplitude but opposite polarity, confirming the piezoelectric origin of the generated current. In contrast, control devices fabricated using pure PVA films did not exhibited any measurable response, highlighting the pivotal role of lysozyme in the composite. We also demonstrated the potential of this material for human motion sensing, enabling real-time monitoring of physiological activities such as body movement and pressure variations [5]. Overall, this study effectively establishes that high-purity, synthetic materials are not a prerequisite for effective energy harvesting. Our Lysozyme-PVA film stands as a compelling, sustainable, and biocompatible platform poised to power the next generation of transient medical implants, smart packaging, and eco-friendly wearable sensors. The performance of our Lysozyme-PVA composite film not only surpasses that of pure polymer films but also establishes a new paradigm for "waste-to-energy" and "edible electronics."

ES-6: Development of room temperature CO2 sensor using VLS grown Si- incorporated TiO2 film

Bodhishatwa Roy,1,* Anupam Karmakar,1 and Sanatan Chattopadhyay1,2

1Department of Electronic Science, University of Calcutta, 92 APC Road, Kolkata-700009, India

2Center for Research in Nanoscience and Nanotechnology (CRNN), JD Block, Sector 3,Bidhannagar, Kolkata-700106, India

*bodhishatwar@gmail.com

Global warming is one of the burning issues of this 21st century that is severely affecting the entire global ecosystem [1]. The enormous emission of pollutants due to aggressive industrialization and human activities causes emission of various types of greenhouse gases, among which CO2 is the major greenhouse gas contributing ~76% to increase the global temperature [2]. Therefore, monitoring and controlling emission of CO2 will be extremely beneficial for sustenance of the society. Moreover, CO2 detection also finds it's applications in monitoring air quality index [3] health monitoring [3], food packaging industry [4] and to monitor the occupancy rate within a closed room for health and safety purposes [5]. In this context, the current article demonstrates, the operation of Si-incorporated TiO2 thin films towards detection of CO2 at room temperature (300 K). Vapour-Liquid-Solid (VLS) growth technology has been adopted to grow the pristine and Si-incorporated TiO2 films on cleaned Si-substrate by using TiO2 powder and 9:1 weight ratio of TiO2 and SiO2 powder, respectively at 250 oC for 20 minutes under a constant argon environment [6]. The schematic of such fabricated sensors after depositing Al, for defining contacts is shown in Fig. 1(a). Fig. 1(b) indicates the top surface FESEM image of such grown film indicating the formation of continuous film with a thickness of ~40 nm. The XRD profile employing PANalytical X'Pert Powder with 1.540598 Å Cu-Kα1 emission line (Cu-kα2 line stripped) of the pristine and Si-incorporated TiO2 films is depicted in Fig. 1(c). A prominent XRD peak at 2θ = 38.5o corresponds to the formation of [112]-crystalline plane of anatase TiO2 (JCPDS : 84- 1285). The UV-Vis absorption spectra of the grown films obtained using Perkin Elmer is plotted in Fig. 1(d). An absorption peak at ~380 nm indicates presence of Ti-vacancy (VTi) related defect states within the pristine TiO2 films [6]. Such VTi-defects is found to be reduced due to Si-incorporation within the TiO2 lattice structure.

ES-7: PVDF/α-MoO3 Nanowire Triboelectric Nanogenerators for Dual Energy Harvesting and Morse Code Signal Applications

Alipsa Das*, Manoj Kangsabanik, and Rabindra Nath Gayen

Department of Physics, Jadavpur University, Kolkata-700032, India

*Presenting Author E-mail: alipsadas2512@gmail.com

Triboelectric nanogenerators (TENGs) have emerged as sustainable, lightweight devices capable of converting small mechanical motions into electrical energy. Their high conversion efficiency, simple fabrication, and material versatility make them promising for next-generation self- powered electronics. However, challenges such as low power density and limited charge storage hinder practical use. To address this, material engineering, particularly dielectric modification, has become an effective strategy to enhance output performance and stability.

In this work, a PVDF-based triboelectric nanogenerator was fabricated by incorporating one-dimensional α-MoO3 nanowires via a simple solution process. The inclusion of α-MoO3 enhanced the dielectric constant and facilitated β-phase formation in PVDF, leading to improved charge generation. The optimized composite with 2 wt.% α-MoO3 (PM2) exhibited the highest β-phase content (~84%), strong dipole alignment, and enhanced interfacial polarization. Consequently, the PM2 device achieved a 3.4-fold increase in output voltage and a peak power density of 153.7 µW/cm2 under a 4 N force at 4 Hz (Figure 1).Beyond energy harvesting, the device demonstrated real-time Morse code signaling, where finger taps generated distinct voltage pulses. Using this feature, the PM2 TENG successfully encoded all 26 English letters (A–Z) (Figure 2) and transmitted short words such as “HELP” and “DANGER,” highlighting its potential for self-powered communication and sensing applications.

Overall, this study presents a simple, cost-effective, and scalable strategy to enhance TENG performance via dielectric engineering, paving the way for multifunctional self-powered electronic systems.

Keywords: Triboelectric Nanogenerator, PVDF, α-MoO3 Nanowires, β-Phase Enhancement, Energy Harvesting, Morse Code Signalling

ES-8: Active Noise Control :Evolution, Integration & Through Industry 4.0

Kalyani Panigrahi,1,∗ Kalyani Panigrahi,1 and Prachi Pattnaik2
1AcSIR, Ghaziabad, Uttar Pradesh, India
2KIIT, Bhubaneswar, India
*Corresponding author: kalyanip.panigrahi@gmail.com

Active Noise Control (ANC) has emerged as a critical technology for managing acoustic environments in industrial settings, leveraging principles of destructive interference to mitigate unwanted sound through out-of-phase wave generation using sensors and actuators. As industries transition toward smarter, more interconnected paradigms, ANC's integration into these ecosystems becomes more significant. This paper explores ANC, its relevance and application with specific references to Industry 4.0: the era of digitalization, cyber-physical systems (CPS), Internet of Things (IoT): and the emerging Industry 4.5, which emphasizes human-centric personalization, societal collaboration, and advanced human-machine symbiosis. We have outlined how ANC has evolved from a standalone noise mitigation tool for low frequency noise to a networked CPS component in Industry 4.0, enhancing efficiency and safety, and further holds promising strategy to adapt to Industry 4.5 by incorporating bio- feedback, customization for individual workers, and sustainable societal impacts. Emphasis I placed on technological synergies, challenges, and transformative roles in manufacturing, highlighting ANC's contribution to quieter, more productive, and humane industrial ecosystems. Industry 4.0, often termed the Fourth Industrial Revolution, revolves around the fusion of physical assets with digital technologies, enabling smart factories where data-driven decisions optimize operations in real-time. Core pillars include IoT for connectivity, big data analytics, artificial intelligence (AI), and CPS for seamless cyber-physical interplay. ANC aligns inherently with CPS, as it involves sensors (e.g., microphones) capturing physical noise phenomena, computational algorithms (e.g., FxLMS or neural network-based filters) processing data, and actuators (loudspeakers) effecting physical changes.
ANC systems are deployed via edge computing devices embedded in machinery, allowing low-lag adaptation to dynamic noise sources like conveyor belts or robotic arms. For instance, in automotive manufacturing, ANC integrated with IoT sensors monitors noise levels across assembly lines, feeding data into cloud platforms for predictive analytics. This enables proactive noise reduction, where anomalous patterns trigger maintenance alerts, reducing downtime by up to 20% in simulated environments. Wireless sensor networks facilitate distributed ANC arrays, thus helping create "quiet zones" in open-plan factories, complying with standards such as ISO 11201 for acoustic measurements. Moreover, ANC leverages Industry 4.0's additive manufacturing for customized transducers and AI for algorithm optimization. Machine learning models predict noise propagation using digital twins (virtual replicas of physical systems) allowing simulation-based tuning before deployment. This integration not only attenuates noise (e.g., reducing levels by 10-20 dB in low-frequency bands) but also enhances energy efficiency by modulating actuation based on real-time data, aligning with sustainable manufacturing goals under frameworks like the European Green Deal for industries.

ES-9: ZnO nanorods factionalized textile based triboelectric nanogenerator for self-powered volatile organic compound sensing application

Anwesha Deb* 1 , A. Dash1 , S. Das1 , B. Das1 and Suvra Prakash Mondal1
1Department of Physics, National Institute of Technology, Agartala, India -799046.
* Presenting author's email-id: anweshadeb1997@gmail.com

With the rapid development in the technology, demand of continuous energy resource is also rising. To meet the demand, a sustainable green energy source is very important. To overcome the limits of renewable resources, new technologies are developed which can act as small power resources to operate small sensors, electronics and other devices. The developed technology of the triboelectric nanogenerators (TENGs) can be a promising and efficient candidate for the self-powered devices. TENGs basically utilises the mechanical energy such as wind flow, water flow, ocean wave, along with mechanical energies produced by human activities which are usually wasted in everyday life. In the present work, a simple and low-cost textile based TENG (T-TENG) device was fabricated for energy harvesting and volatile organic compound (VOC) sensing application. A tribo-positive layer was prepared by surface modification of tightly woven cotton cloth using hydrothermally grown zinc oxide nanorods (ZnO NRs). Flexible PET substrate was used as the counter tribo-negative layer. The device was tested by varying parameters like growth layer and operating frequencies. The as-grown ZnO NRs on cotton cloth were characterized using scanning electron microscopy (SEM) and x-ray diffraction (XRD) study. The optimised device reported 1.42 times enhancement of open circuit voltage (Voc) and 1.98 times higher short circuit current (Isc) compared to bare cotton cloth. The prepared T-TENG device can be used to light up multiple light emitting diodes. The T-TENG device showed prominent change in output voltage with acetone gas showing the potential in self-powered VOC sensing application. The sensitivity of the device towards acetone was recorded to be 0.15% per ppm with limit of detection of 45 ppm.

ES-10: Room temperature ammonia sensing using reduced graphene oxide(rGO)-tungsten sulphide (WS2) nanocomposites

Binoy Das*, A. Dash, A. Deb, S. Das, D. Acharyya and Suvra Prakash Mondal

Department of Physics, National Institute of Technology, Agartala, India -799046.

* Presenting author email-id: binoyz.br@gmail.com

Ammonia (NH3) is an important indicator gas in animal husbandry, industry, and healthcare application. In farming and industrial environments, NH3 levels must be monitored for safety and productivity. In human breath, elevated NH3 can considered as kidney or liver malfunction while in healthy human ammonia concentration ranging from 0.2 to 1 ppm. Two-dimensional (2D) materials are highly attractive for gas sensing applications due to their high surface-area-to-volume ratio, which offers superior adsorption sites for gas molecules, leading to ultra-high sensitivity and fast response times at room temperature. In this study, a room temperature chemiresistive NH3 gas sensor was fabricated using 2D WS2 nanostructure. The nanostructures were grown by a cost effective controlled hydrothermal process at 200°C temperature. The WS2 nanostructures were characterized by x-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), and UV–Visible spectroscopy to confirm its crystalline phase, morphology, and optical properties, respectively. Sensor devices were fabricated by dispersion of WS2 on interdigitated gold electrodes and sensor response were monitored toward different concentrations of NH3 at ambient conditions. Chemically grown reduced graphene oxide (rGO) was mixed with WS2 to improve sensitivity. This study demonstrates the potential used of 2D nanomaterials for the development of low-cost, high-performance room temperature NH3 sensor for real-time monitoring of ammonia emissions in farming environments, industrial workplaces, and non-invasive medical diagnostics.

ES-11: Highly Sensitive and selective room temperature resistive CO sensor for Respiratory illnesses monitoring Applications

Anabadya Dash*, Suvra Prakash Mondal, Anwesha Deb, Sudipta Das and Binoy Das

Department of Physics, National Institute of Technology, Agartala, India -799046

*Corresponding author: danabadya@gmail.com

Respiratory illnesses include a broad range of acute and chronic conditions that affect the lungs and airways such as asthma, chronic obstructive pulmonary disease (COPD), lung cancer, chronic bronchitis, emphysema, pulmonary fibrosis, etc. These conditions are caused by environmental pollutants, tobacco smoke, allergens, occupational hazards and infectious agents such as bacteria or viruses . As exhaled human breath contains a complex mixture of gases, including a variety of volatile organic compounds (VOCs) and inorganic gases that serve as potential biomarkers for noninvasive diagnosis of respiratory and metabolic disorders. VOCs such as acetone (C3H6O), alcohol (C2H5OH), ammonia (NH3), hydrogen peroxide (H2O2) and gases such as nitric oxide (NO) and carbon monoxide (CO) present in exhaled breath have been identified as potential indicators of specific respiratory disorders. Elevated CO is a known marker for smoking-induced lung damage and COPD. In recent years, the analysis of exhaled breath biomarkers has emerged as a promising non-invasive diagnostic approach. Early and accurate detection is crucial for effective management, especially for chronic respiratory diseases, which often progress silently. Traditional diagnostic methods are often invasive, painful and time-consuming. Metal oxide chemiresistive (MOS) gas sensors offer a low-cost, handheld, miniaturized, real-time diagnosis, portable, low detection limit, highly sensitive and selective for detecting CO enabling early disease screening and continuous health monitoring which is essential for respiratory healthcare, particularly in point-of-care and wearable diagnostic systems. Ruthenium oxide (RuO2) has attracted considerable interest as an n-type semiconductor among many MOS materials, owing to its unique rutile crystal structure, minimal synthesis cost and easy synthesis which works at room temperature. RuO2 NRs and rGO were synthesized using simple thermal annealing and chemical reduction method. The incorporation of rGO in RuO2 NRs enhanced the sensitivity, limit of detection, response and recovery time as compared to RuO2 NRs. The sensitivity of RuO2 NRs was 0.44 ppm−1 whereas for rGO sensitized RuO2 NRs was found to be 1.4 ppm−1 which is 286 % times higher, with a ultra-low detection limit ~4 ppb. The sensor also demonstrated high selectivity towards CO in the presence of other interfering oxidizing and reducing gases like nitric oxide, acetone, alcohol, ammonia and carbon dioxide along with humidity, that are strong interfering VOCs found in human breath. The sensor is applied to detect CO concentrations (eCO) in exhaled human breath of both smokers and non-smokers of different age groups. Interestingly, smokers have elevated CO concentration in their exhaled breath as compared to non-smokers.

ES-14: Influence of Nanowire Diameter on Gas Detection Performance in FIB-Fabricated Suspended CuO Nanostructures

Sourav Kumar Kajli,1,⁎ Somnath C Roy2 , Debdutta Ray3 , and Bidhan Pramanick1,4

1 School of Electrical Sciences, Indian Institute of Technology Goa, Farmagudi, Ponda-40340, India
2Department of Physics, Indian Institute of Technology Madras, Chennai, Taminadu 600036, India
3Department of Electrical Engineering, Indian Institute of Technology Madras, Chennai, Taminadu 600036, India
4CoE-PCI, Indian Institute of Technology Goa, Farmagudi, Ponda-40340, India
*souravkajli@iitgoa.ac.in

Semiconducting metal oxides, such as TiO2, ZnO, SnO2, and WO3, have been employed as gas sensors for the early detection of toxic, flammable, and hazardous gases [1]. The unique material features of nanostructured metal oxide materials, including thin film , nanoparticle, nanotube, nanobelt, and nanowire, led to their synthesis and investigation for gas sensor applications [2]. One-dimensional (1D) metal oxide nanostructures such as nanowires have garnered considerable attention due to the growing demand for compact, low-power, and highly selective gas sensors [3], [4]. Given its exceptional surface reactivity, chemical stability, and affordability, copper oxide (CuO), a p-type semiconductor with a low bandgap (~1.2 eV), has emerged as a potential alternative among these [5],[6]. The effect of nanowire diameter on the gas detection capabilities of suspended CuO nanowire (NW) devices made with focused ion beam (FIB) nanofabrication is methodically examined in this work. Using a dual-beam FIB-SEM system, single CuO nanowires with diameters between 50 and 300 nm were selectively separated and patterned across microfabricated gold electrodes on Si/SiO2 substrates. The FIB was used to ensure low-resistance, ohmic-like connections by manipulating nanowires and depositing platinum contacts locally. The suspended structure was utilised to promote full circumferential gas exposure, reduce substrate-induced scattering, and enhance efficient gas-nanowire surface interaction.Using selected area electron diffraction (SAED) and high-resolution transmission electron microscopy (HRTEM), the structural and morphological properties of the nanowires were examined, confirming the monoclinic phase of CuO. Under regulated ambient conditions, gas sensing investigations were conducted for hydrogen gas at operating temperatures ranging from 100°C to 300°C. Responsivity/recovery times, selectivity, and response % were measured and compared across nanowires of varying sizes. A noticeable diameter- dependent sensing pattern was observed. Due to their improved surface-to-volume ratio and total charge carrier channel depletion following gas exposure, the thinnest nanowires exhibited better sensitivity and faster response compared to thicker ones. According to the space-charge model for semiconducting nanostructures, while the Debye length (λD) is crucial in regulating the conduction channel width, the performance of gas sensing is significantly impacted by geometrical scaling at the nanoscale, as demonstrated experimentally in this work. The results indicate that tunable sensitivity, selectivity, and response kinetics are achieved by regulating the nanowire diameter during synthesis and FIB-based integration. This opens the door for the logical development of ultraminiaturized, low-power, and highly effective CuO-based gas sensors for wearable and environmental applications.

ES-16: Integration of metal–organic framework (MOF) embedded dielectrics in organic field-effect transistors for low-power neuromorphic computing applications

Sk. Shaharukh1, Satayender K. Sangwan1, Achintya Dhar1,* 1
Indian Institute of Technology Kharagpur, Kharagpur, India
*Corresponding author email-id: adhar@phy.iitkgp.ac.in

The development of energy-efficient neuromorphic devices has driven interest in alternative computing beyond traditional von Neumann architectures, as they emulate brain-like functionalities by integrating parallel logic and memory operations. Recent advancements in neuromorphic synaptic devices have enabled applications in artificial vision systems, neuroprosthetics, and artificial olfaction [1]. A key challenge remains novel material engineering for efficient charge trapping to enhance memory retention. Although inorganic materials are the dominant choice for synaptic devices owing to their superior performance, recently organic materials have also gained research attention due to their low-cost fabrication process, mechanical flexibility, and biocompatibility. Two-terminal organic memristors have been extensively investigated and recognized as promising candidates for replicating synaptic functionalities in neuromorphic systems. Recently, three-terminal organic field effect transistors (OFETs) have attracted considerable research attention due to their capability to emulate complex synaptic behavior while offering enhanced control and exhibiting multisensory integration capabilities [2]. This work demonstrates the potential of a multifunctional hybrid dielectric incorporating the metal organic framework namely zeolitic imidazolate framework (ZIF67) for application in both two-terminal and three-terminal memory devices. In two-terminal Al/PMMA-ZIF67/Al devices, ZIF67 enabled non-volatile resistive switching with high ON/OFF current ratio (~105) and set and reset voltage >2V and -3.5V, confirming its viability for low power memory applications. The hybrid dielectric also supports fabrication of low-voltage organic semiconductor-based synaptic transistors. Further, the transistor exhibits gate sweep delay-dependent hysteresis behaviour, indicative of slow charge trapping-crucial for memory retention. As evident from the figure 2(i) the area inside the dual sweep transfer curve increases from 37 nA·V to 100 nA·V at lower sweep delay of 1 millisecond. This behavior indicates slow charge trapping and retention processes, primarily attributed to the porous nature and intrinsic trap states introduced by ZIF67. Being a microporous material ZIF67 present in PMMA matrix enables the charge trapping at the semiconductor-dielectric interface during current flowThe devices also emulate key biological synaptic functions such as spike-duration dependent plasticity (SDDP) and spike-rate dependent plasticity (SRDP), where excitatory post-synaptic current (EPSC) varied systematically with pulse duration and frequency. The SDDP and SRDP gain affirm synaptic plasticity and neural behaviour mimicry. Overall, the results highlight the potential of ZIF67-based organic-inorganic hybrid materials in enabling multifunctional neuromorphic devices that integrate memory and synaptic plasticity. Integrating ZIF67 into PMMA offers a scalable, solution-processable, low-cost dielectric engineering strategy for neuromorphic memtransistor.

2. Optoelectronic and Photonic Technology

OPT-1 : Harnessing Negative Potentiation in Mn-Doped $CsPbI_3$ for Energy- Efficient Inhibitory Synaptic Devices

Shaona Bose[1], **Baidyanath Roy**[2], **Santu Kumar Ghosh**[1], **Subham Saha**[1], **Saranya Das**[1] **and Sanjeev Kumar Srivastava**[1] **and Samit K. Ray**[1,*]

[1]*Dept. of Physics, Indian Institute of Technology Kharagpur, West Bengal, India*

[2]*School of Nanoscience and Technology, Indian Institute of Technology Kharagpur, West Bengal, India*

*Corresponding author: physkr@phy.iitkgp.ac.in

Presenting author: shaona.bose@kgpian.iitkgp.ac.in

This research investigates the emergence of negative photoconductivity (NPC) in $CsPbI_3$-based synaptic devices, a behavior driven by the native defect-dominated charge trapping dynamics in perovskites rather than the typical positive conductivity. Unlike most reports showcasing light-induced potentiation, our devices exhibit inhibitory post-synaptic current (IPSC) upon optical stimulation [1], simulating synaptic depression. Capacitance–voltage measurements link this phenomenon to coupled ionic–electronic dynamics at the perovskite/electrode interface, where slow mobile ions interact with faster electronic carriers to suppress conductivity under illumination. Doping further modifies this effect: while Zn incorporation diminishes charge retention, doped Cu and especially Mn introduce energy states that effectively delay recombination and facilitate the formation of stable charge reservoirs. First-principles calculations confirm that Mn doping, with its localized charge perturbation and distinct electronic structure, creates shallow energy states and increases carrier lifetime, providing an optimal environment for robust synaptic plasticity. Our findings demonstrate reliable short-term plasticity (STP) to long-term plasticity (LTP) transition, with the Mn-doped device exhibiting superior charge retention and stable synaptic potentiation. This is further validated by paired-pulse depression (PPD) experiments, where the Mn-doped device showed the highest PPD index, confirming its enhanced charge trapping capacity and energy efficiency. Crucially, the observed NPC is not a parasitic anomaly but a controllable and functional synaptic feature, rooted in the intrinsic defect chemistry of halide perovskites and optimized through interface engineering. These results highlight the critical role of dopant-modulated electronic and ionic charge interplay at interfaces in dictating neuromorphic behavior, offering a new pathway for developing energy-efficient, inhibitory synaptic devices for neuromorphic computing.

OPT-2 : A Study on the impact of dielectric screening on exciton physics in monolayer WSe2

Saranya Das[1, *], **Shreyasi Das**[2], **Samit K. Ray**[1]

[1]*Department of Physics, Indian Institute of Technology Kharagpur, Kharagpur, India.*

[2]*School of Nano Science and Technology, Indian Institute of Technology Kharagpur, Kharagpur, India.*

Corresponding author: sarudastista95@gmail.com

Coulomb interaction between an electron and a hole, forming bound states in semiconductors, gives rise to various quasiparticles, such as excitons and trions. The interplay of excitonic complexes and unbound electron-hole pairs is at the heart of excited-semiconductor physics. Owing to their tunable optical properties, Two-dimensional (2D) Transition metal dichalcogenides (TMDs) emerge as prominent candidates for studying quantum phenomena, leveraging their strong light-matter interactions and significant spin-orbit coupling. The excitonic quasiparticles in monolayer TMDs are formed at the energy- degenerate ±K valleys. These 2D materials display a robust Coulomb interaction, which arises from the cumulative effect of quantum confinement and a weaker dielectric screening. This leads to the formation of tightly bound excitons with an exceptionally high binding energy (~ 500 meV) [1], sufficient to retain their stability under the thermal fluctuation at room temperature. The enhanced stability of excitons in these materials provides a unique opportunity to explore many distinct many-body interactions. The variation in temperature, strain, carrier population, and dielectric environment can alter the many-body effects in these 2D systems, leading to the formation of higher-order excitonic complexes, shifts in quasiparticle transition energies, and anomalous variations in their emission spectral weight. The elevating carrier population induced by external optical stimulation can trigger a cascade of many-body interactions, giving rise to complex phenomena such as the excitonic Mott transition. At a very high carrier density, the excitons start to interact with each other. As a result of the interplay of several many-body interactions, the excitons lose their individual quasiparticle identity and transform into a collective electron-hole plasma (EHP) phase. This phase transition from an insulating exciton gas phase to a metallic EHP phase is known as the excitonic Mott transition. This is an inherently non-equilibrium phase transition owing to the ultrafast dynamics of excitons and electron-hole plasma. The occurrence of the excitonic Mott transition in 2D TMDs is indicated by an anomalous RBC of the excitonic resonance energy and was reported previously in transient absorption spectroscopy measurements [2]. However, due to the prolonged carrier lifetime of excitonic complexes in TMD monolayers, observing this nonlinear phenomenon with a continuous wave laser excitation in the steady state condition is possible [3].

In this work, the excitonic Mott transition has been systematically investigated in monolayer tungsten diselenide (WSe2) using steady-state Photoluminescence (PL) spectroscopy at room temperature. The monolayer flakes were mechanically exfoliated from a bulk WSe2 crystal using the Scotch tape method. The tape was then used to further exfoliate on two different substrates, namely, polydimethylsiloxane PDMS and few-layer hBN on SiO2/Si substrates. Few-layer hBN flakes were also exfoliated on SiO2/Si from a commercial hBN bulk crystal using the same method. Then, the monolayer WSe2 flakes were transferred by a PDMS stamp-assisted dry transfer method, which ensures a dry and residue-free transfer.

The monolayers were identified using an optical microscope based on their optical contrast. The thickness of the flake was verified by Atomic Force Microscopy and PL emission spectroscopy. A highly intense PL peak, as obtained for the monolayers compared to the thicker layers, signifies the indirect-to-direct band gap transition from bulk to monolayer. Further, excitation power-dependent PL spectroscopy was conducted at room temperature to probe several many-body interactions and modulate the exciton physics by photo-induced carrier doping. PL spectra at different powers have been deconvoluted into two Gaussian peaks corresponding to the exciton and trion, respectively, to analyze the shift of quasiparticle resonance energies and the variation of their emission spectral weight. With increasing excitation power, the emission spectra demonstrate an anomalous redshift to blueshift crossover (RBC) of the exciton resonance energy, as shown in Figure 1, which serves as an indication of the excitonic Mott transition. The Mott transition occurred beyond a critical carrier density where the exciton concentration becomes so high that the average distance between these quasiparticles is reduced to their exciton Bohr radius limit, and they cannot sustain this bound state anymore. The energy shift is modeled with a Lennard-Jones potential-like function, and the excitonic Bohr radius is extracted for both substrates.

Due to their reduced dimensionality, the electric lines of force extend beyond the perimeters of this atomically thin monolayer TMDs, and the Coulomb interaction is heavily influenced by the surrounding dielectric environment, leading to bandgap renormalization and reduction of exciton binding energy owing to the substrate-induced dielectric screening. The effect of the substrate-dielectric screening is manifested in the variation of the Mott transition point with changing the substrate. This research unveils the evolution of many-body interactions in ML TMDs at different carrier concentration regimes and under different dielectric environments, thus highlighting the importance of substrate selection for tailoring the optical properties of these materials and providing a conclusive perspective on device engineering.

OPT-3 : Enhanced Near-Infrared Photodetection Via Exciton-Plasmon coupling in Ag Nanoparticle Decorated MoS2/Si-Nanowire Hybrid

Mousumi Pramanik [1], Pritam Sinha [2], Achintya Singha [2], Kaustuv Das [1,*]

[1]*Department of Physics, Jadavpur University, Kolkata 700032, India*

[2]*Department of Physics, Bose Institute, Kolkata 700009, India*

* *Corresponding author address: kaustuv12@gmail.com*

This work presents the development of high-performance near-infrared (NIR) photodetectors based on MoS_2/Si nanowire array (NWA) heterostructures decorated with plasmonic silver nanoparticles (Ag NPs). The three-dimensional MoS_2 layers vertically integrated on Si NWAs enable a broad spectral response spanning 400–1100 nm, with a strong peak around 900 nm. Incorporation of surface plasmonic Ag NPs markedly enhances device performance by inducing plasmon–exciton coupling, which promotes light absorption and improves carrier separation. The AgNPs/MoS_2/Si NWA photodetectors achieve a high responsivity of 110 A/W and detectivity of 9×10^{10} Jones, representing a three-fold improvement compared to devices without plasmonic nanoparticles. Notably, the devices also operate efficiently in a self-powered mode, delivering a responsivity of 1.0 mA/W. These results highlight the promise of AgNPs/MoS_2/Si NWA heterostructures for next-generation broadband and energy-efficient NIR photodetection applications.

OPT-4 : Resolving Trion Emission and Achieving Tuneable Photo capacitance in RIE-Thinned WSe_2: A Path to Miniaturized Optoelectronics

Abir Mukherjee[1], Akash Sahu[1], Kajal Sharma[1], and Samaresh Das[1,2] *

[1] Centre for Applied Research in Electronics, Indian Institute of Technology Delhi, India

[2] Department of Electrical Engineering, Indian Institute of Technology Delhi, Delhi, India

We present a precise, damage-free thinning strategy for CVD-grown WSe_2 using reactive ion etching (RIE), enabling controlled reduction of layer thickness from ~20–25 nm down to ~5–6 nm on a single substrate. This thickness engineering allowed us to systematically explore electronic and optical properties across different regimes. Structural integrity and uniformity were validated through Raman and KPFM, showing stable work function values despite thinning. Optical quality was confirmed using cathodoluminescence, where we observed clear band-edge emission and trion peaks in the few-layer limit, with minimal substrate effects. To assess device behavior, we fabricated a dual-MOS structure, which exhibited pronounced thickness-dependent photo capacitance—thicker regions showing stronger photo-response and robust electron inversion even at high frequencies. Low-temperature C–V studies further revealed photo-induced inversion capacitance. Together, these findings establish RIE as an effective route for controlled WSe_2 thinning while preserving material quality and highlight its potential for scalable integration in tuneable optoelectronic devices, including spin-selective quantum emitters and quantum photonic applications.

Keywords: Reactive Ion Etching, Transition Metal Dichalcogenides, Chemical Vapor Deposition, Cathodoluminescence Spectroscopy, Low Temperature Capacitance Measurement

OPT-5 : Gold nanorods-decorated ternary alloy $Mo_{0.5}W_{0.5}S_2$-*p* Si vertical heterojunction high-performance photodetector

Deepak Kumar Sahu,[1,*] Shreyasi Das[2], and Samit K. Ray[1]

[1]*Department of Physics, IIT Kharagpur, Kharagpur, West Bengal, 721302*

[2]*School of Nano Science and Technology, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, 721302*

*Corresponding author email ID: physkr@phy.iitkgp.ac.in

Transition metal dichalcogenides (TMDC) are layered semiconducting materials (MX_2; M-transition metal; X-chalcogen) that show atomic-scale thickness, tunable bandgap, and strong spin-orbit coupling. But binary TMDCs contain deep-level defect states (DLDS) that adversely affect their optoelectronic device performance. An extension to these binary TMDCs is the ternary TMDC (MXY or M_1M_2X), which displays wider bandgap tunability through facile composition modulation and high ambient stability with suppressed DLDS. Here in this work, we synthesized a TMDC alloy $Mo_{0.5}W_{0.5}S_2$ through a low-cost solution-processed hydrothermal technique by varying the composition and studied its structural and optical properties [1]. Gold nanorods (AuNR) of varying aspect ratio were synthesized using a highly reproducible one-pot wet-synthesis method. Finally, we developed an MSM type-Au/AuNR/$Mo_{0.5}W_{0.5}S_2$-p Si/Al heterojunction photodetector, which was found to exhibit a high rectification ratio of 532 and a high photoresponsivity of the order of nearly 2000. Since the formation energy of sulfur vacancy surrounded by tungsten atom, i.e., $V_{S-W} < V_{S-Mo}$. Hence, the effect of V_{S-W} dominates and acts as shallow-level traps in the forbidden gap of $Mo_{0.5}W_{0.5}S_2$ and donates electrons to the conduction band (CB), increasing the free carrier density. Hence, the photocurrent of the as-fabricated photodetector made up of $Mo_{0.5}W_{0.5}S_2$ is higher than that of their binary counterparts. To further enhance the photodetection ability, gold nanorods were decorated on $Mo_{0.5}W_{0.5}S_2$ nanosheets, and a hybrid AuNR-$Mo_{0.5}W_{0.5}S_2$ -p-Si visible to near IR photodetector was fabricated through metal nanoparticle-assisted surface plasmon resonance (SPR) effect. Moreover, SPR-induced electromagnetic field enhancement in the TMD nanosheets causes higher light absorption, which indirectly helps in increasing the light-to-dark current ratio.

OPT-6 : Role of Different Trapping Layers on the Performance of All- Inorganic CsPbBr3 Nanocrystal-based Optical Synapses

Subham Saha,[1] Shreyasi Das,[2] Baidyanath Roy,[2] Santu Kumar Ghosh,[1] and Samit K. Ray[1, *]

[1]*Department of Physics, Indian Institute of Technology Kharagpur, Kharagpur, India*

[2]*School of Nanoscience and Technology, Indian Institute of Technology Kharagpur, Kharagpur, India*

*Presenting author email-id: subhamsaha@kgpian.iitkgp.ac.in

Neuromorphic vision sensors are emerging as a promising alternative to conventional machine vision systems, which are typically based on the von Neumann architecture, where the photodetection, memory, and processing units are physically separated. Bio-inspired optical synapses are a key element for neuromorphic vision sensors, enabling visual information processing, learning, memorizing, and recognition tasks with energy efficiency. All-inorganic cesium lead bromide (CsPbBr3) is gaining attention as a material platform for optical synapse due to its strong light absorption coefficient, long carrier-diffusion length, and high photoconductivity. However, the overall efficiency of these devices strongly depends on the charge trapping layers, which play a key role in modulating the photocarrier dynamics and memory retention. Here, we demonstrate and comparatively analyze the performance of a two-terminal optical synapse with all inorganic CsPbBr3 nanocrystals integrated with three different trapping layers: PEDOT: PSS, ZnO nanoparticles, and ZnO nanorods. Each trapping layer was selected based on its distinct morphology, band alignment, and trap-state density, thereby influencing synaptic plasticity, response time, and memory retention behavior. All configurations exhibit UV (325 nm) light-induced excitatory postsynaptic current and tunable conductance state under pulsed illumination. Comparative analysis reveals that the ZnO nanorod-based device shows superior performance with prolonged retention time and the highest paired-pulse facilitation index of 175%. We further investigated the underlying mechanisms responsible for the distinct optical synaptic responses. This work highlights the critical role of material-interface engineering for the design and optimization of two-terminal optical synapses for efficient neuromorphic visual systems.

OPT-7 : Study of optoelectronic synaptic devices based on ferroelectric $In_2Se_3/MoWS_2$ heterojunction

Sneha[1], Saranya Das[2], Deepak Kumar Sahu[2], Samit K. Ray[1]*

Department of Physics, Indian Institute of Technology, Kharagpur, India

*Corresponding email: physkr@phy.iitkgp.ac.in

Neuromorphic computing systems are based on new architecture inspired by biological learning behaviour to overcome the shortcomings of the conventional von Neumann system, such as high energy consumption and generation of excessive redundant data. However, common synaptic-device designs like electrical synaptics still need to carry an external power source, which is disadvantageous for both the miniaturization of smart devices and the reduction of energy consumption. Therefore, self-powered optoelectronic synapses hold great promise for achieving energy-efficient artificial intelligence applications. Building on this foundation, optical synaptic devices have emerged as next-generation candidates for sensory data processing and machine vision, leveraging light as a stimulus to achieve ultrafast, energy-efficient, and high-bandwidth signal transmission. It can directly emulate photonic plasticity and handle raw visual input at the sensor layer, mimicking the human retina and visual cortex in artificial systems. [5]

Recent years have witnessed significant advancements in the development of optical synaptic devices based on various two-dimensional (2D) materials, including Transition Metal Dichalcogenides (TMDs), graphene, black phosphorus, and 2D perovskites, paving the way for innovative applications in artificial intelligence, neuromorphic computing, and machine vision systems. TMDs, in particular, have garnered significant attention due to their tunable bandgaps, strong light-matter interactions, and suitability for heterojunction engineering, which allows for finely controlled charge transfer at the interface and enhanced device performance.Two-dimensional materials renowned for their atomic-scale thickness, extraordinary electrical and optical properties and mechanical flexibility have unlocked new ways for constructing synaptic devices. These materials have a hexagonal lattice structure with one layer of transition metal atoms sandwiched between two layers of chalcogen atoms therefore a single layer emerges with a three-atom thickness. Last but not least, thanks to their inherent large surface-to-volume ratio, high carrier mobility and greater stability, makes TMD materials promising to be used in optical synaptic applications.[1]

Transition Metal Dichalcogenides (TMDs) have gained attention as promising materials for optical synaptic devices, owing to their direct bandgap, strong light–matter interaction, and two-dimensional structure. These properties enable efficient light absorption, low-power operation, and the emulation of key synaptic functions such as plasticity and memory retention. Additionally, their compatibility with van der Waals heterostructures allows for flexible and scalable integration with other 2D materials. These advantages position TMDs as ideal candidates for neuromorphic computing in future optoelectronic and wearable systems.Heterojunctions represent an advanced approach in device design combining the complementary properties of two distinct 2D materials to achieve combined effects for charge separation, responsivity and plasticity.

The $MoWS_2$-In_2Se_3 heterostructure, selected for this study, exemplifies these concepts- $MoWS_2$ provides visible light absorption and high carrier mobility, while α - In_2Se_3 brings ferroelectricity and switchable polarization, allowing for robust modulation of synaptic behaviour under optical stimulation. The choice of this particular heterojunction is motivated by its strong interlayer coupling, tunable interface properties and capability to mimic key synaptic phenomena such as excitatory postsynaptic current (EPSC), paired pulse facilitation (PPF) and long-term potentiation (LTP) under optical stimulation, with stable performance under mechanical strain, mechanical flexibility, and pronounced plasticity suitable for wearable and flexible electronics.

In this work, we have planning to exfoliate few-layer flakes of In2Se3 from bulk In2Se3 crystal and transferred it on a prepatterned SiO2 (thickness 300 nm) on Si substrate by the PDMS-assisted dry transfer method. The SiO2/Si has pre-patterned electrodes made of Cr (10 nm)/Au (50 nm), deposited by e-beam and thermal deposition techniques, respectively. We have synthesized few-layer MoWS2 from bulk crystal through mechanical exfoliation, transfer printing through PDMS-assisted dry transfer method and by transfer setup through careful alignment make the heterostructure $MoWS_2$-In_2Se_3.

After exfoliation, the initial marking of the desired flakes will be done by an optical microscope. AFM was used to check the thickness of the flakes. Raman spectroscopy was performed to find layer numbers. Photoluminescence was performed to bandgap measurement. XPS and EDS were used to analyze stoichiometry and element mapping. We plan to perform synaptic measurements under optical stimulus to investigate the optoelectronic synaptic behaviour of this device.

The anticipated outcomes of these devices include high optical responsivity, ultra-low energy consumption, stable synaptic plasticity and compatibility with next-generation neuromorphic computing architectures. Prospective applications cover a wide spectrum, including adaptive vision sensors, wearable robotics, integrated artificial intelligence, biomedical monitoring and autonomous object recognition.

OPT-8 : Brain-inspired ferroelectric and resistive memory performances in PVDF/MoS2 heterojunction

Santu Kumar Ghosh,[1,*] **Tamal Dey,**[1,] **Subhajit Jana,**[1,] **Subham Saha,**[1,] **Amal Kumar Das,**[1] **and Samit K. Ray,**[1,]
[1]*Department of Physics, Indian Institute of Technology, Kharagpur, India*
*santuarjyo699@gmail.com

The human brain is an extraordinary biological system capable of executing massively parallel, energy-efficient information processing. It comprises approximately 10^{11} neurons connected through around 10^{15} synapses, operating with high adaptability, low latency, and remarkable energy efficiency [1,2]. In this work, we demonstrated semiconducting TMDs (i.e., MoS2) and polymer PVDF materials using simple and cheap synthesis methods for memory device applications. The structural and morphological studies of the samples have been performed before device fabrication to verify the coexistence of MoS2 nanocrystals and PVDF. FTIR vibrational bands of β phase of PVDF at the peaks of 840 cm^{-1}, 880 cm^{-1}, 1075 cm^{-1}, 1174 cm^{-1}, 1274 cm^{-1} and 1431 cm^{-1}, which agree well with existing literature reports. β phase has shown the highest dipole moment of any polar phase, and its copolymers have been used for the development of memory, and artificial synapses$_{2g}$. The intense peak at$_{g}$ ~14.38° is associated with the (002) plane of MoS2, which is characteristic of 2D materials for the hexagonal semiconducting 2H phase, and two Raman peaks of exfoliated MoS2 are obtained at the frequencies of 378 cm^{-1} and 402 cm^{-1} , corresponding to the in-plane E^{1}and out-of-plane A vibration modes, which agree well with existing literature reports. We fabricated two-terminal vertical memristor devices based on the PVDF and MoS2 nanocrystals as shown in Fig.1(a). Fig.1(b). shows the ferroelectric hysteresis loop (P-V) of PVDF/MoS2 heterostructure for different applied voltages of ±2V, ±3V, ±4V, ±6V, and ±8V. We investigate the polarization-voltage characteristics which provide critical information regarding a material's polarization behavior and serve as essential evidence for confirming ferroelectric character by demonstrating the nonlinear relationship between polarization and electric field (voltage), including key parameters such as remnant polarization (Pr) and maximum polarization (Pmax), which quantify the material's ability to maintain polarization after field removal and its total polarization capacity, respectively.

These combined advantages make PVDF/MoS_2 heterostructures particularly attractive for non-volatility, energy-efficient, flexible, and scalable neuromorphic devices. To evaluate the neuromorphic potential of this device, we explored its ability to mimic fundamental synaptic behaviors such as excitatory postsynaptic current (EPSC), paired-pulse facilitation (PPF), long-term potentiation (LTP), short-term depression (STD), and long-term depression (LTD). The paired-pulse facilitation index (PPF), which quantifies the relative change in current between successive pulses, further validated the short-term memory effect of the device. These behaviors were reproduced by applying voltage pulses that modulate the conductance of the device in an analog and non-volatile manner, thereby emulating biological synaptic weight changes. Overall, this work presents the successful synthesis and characterization of a PVDF/MoS_2-based ferroelectric memristor that not only exhibits stable resistive switching and robust synaptic plasticity but also holds promise for scalable integration in neuromorphic computing hardware.

OPT-9 : Superior Photoconversion Efficiency of Nanocrystals-Sensitized Solar Cells Based on All-Inorganic $CsPbX_3$ (X= Br, I) Perovskites

Baidyanath Roy[1*], Tamal Dey[1,†], Shaona Bose[2], Somnath Mahato[3], Narayan Chandra Das[4] and Samit K. Ray[2,]

[1]*School of Nano Science and Technology, Indian Institute of Technology Kharagpur, West Bengal 721302, India*
[2]*Department of Physics, Indian Institute of Technology Kharagpur, West Bengal 721302, India*
[3]*Łukasiewicz Research Network-PORT Polish Centre for Technology Development, Stabłowicka 147, 54-066 Wrocław, Poland*

[4]*Rubber Technology Centre, Indian Institute of Technology Kharagpur, West Bengal 721302, India*
[†]*Currently at Department of Electrical & Computer Engineering, Rutgers, The State University of New Jersey, Piscataway, New Jersey 08854, United States*

*Corresponding or Presenting author email-id: baidya.chemistry@gmail.com

Nanocrystal-sensitized solar cells have emerged as potential alternatives to traditional photovoltaic technology due to their unique light absorption and emission characteristics and size-dependent bandgap

(1). In this work, we report the successful synthesis of cubic-phase CsPbI3 and CsPbBr3 nanocrystals for their use as photosensitizers in solar cells, referred to as perovskite nanocrystal-sensitized solar cells (PNCSSCs). Among the two systems, CsPbI3 is found to be superior for PNCSSCs because of its high absorption efficiency, (2) lower bandgap, and higher photoluminescence yield, as compared to CsPbBr3. Our study examines the structural, compositional, optical, and electrical properties of these perovskite nanocrystals, focusing on their contributions to photoconversion efficiency. CsPbBr3 nanocrystals exhibit a band gap of ~2.4 eV along with defect states-induced short carrier lifetime of around 18 ns. In contrast, CsPbI3 demonstrates a band gap of ~1.8 eV closer to the peak of the solar spectrum with a much longer carrier lifetime of ~130 ns, which facilitates better separation and collection of photogenerated charge carriers. Consequently, CsPbI3 nanocrystal-sensitized solar cells fabricated with mesoporous TiO2 reveal a photoconversion efficiency of ~12.5%, as compared to 3.8% for CsPbBr3 nanocrystal solar cells. To the best of our knowledge, this is the highest reported photoconversion efficiency in solution-processed perovskite nanocrystal-sensitized solar cells.

OPT-10 : From Vision to Reservoirs: Perovskite Films for Versatile Neural Hardware

Sagarneel Ghoshal[1,*], Santu Kumar Ghosh[1], Baidyanath Roy[1], Samit Kumar Ray[1]

[1]*Department of Physics, Indian Institute of Technology, Kharagpur, India*

* sagarneelgh1107@gmail.com

Mixed halide perovskite ($CsPbI_{1.5}Br_{1.5}$) thin films combined with a PEDOT:PSS charge transport layer create a highly tunable platform for light based neuromorphic computing. The PEDOT:PSS layer provides stable hole transport, balanced charge distribution at interfaces and improved light to electrical signal conversion, while the light sensitive perovskite allows optical control of conductance, closely mimicking the adaptive behavior of biological synapses [1][2]. When exposed to pulsed light, the device shows excitatory postsynaptic current (EPSC) responses whose strength and decay behavior represent synaptic activity. The EPSC–time profiles serve as quantitative measures of plasticity: short-term memory (STM) comes from transient decay and paired-pulse facilitation (PPF) controlled by fast ion movement, whereas long-term memory (LTM) results from accumulated ion migration and stable defect alignment under repeated light pulses. Measurements using different light pulse frequencies and powers reveal the transition between these modes as high-frequency stimulation produces enhanced PPF ratios due to incomplete ion relaxation, while increased light power yields larger EPSC amplitudes and slower decay times, indicating stronger charge accumulation and deeper trap filling.

These tunable time-dependent responses directly translate into distinct computing functions. In artificial neural networks (ANNs), the gradual strengthening and weakening of EPSC under controlled light enable analog weight adjustment in crossbar arrays, achieving in-memory matrix–vector multiplication with high energy efficiency [3]. In spiking neural networks (SNNs), the temporal overlap between EPSC responses triggered by successive light spikes reproduces spike-timing-dependent plasticity (STDP), allowing the device to perform event-driven computation where learning strength depends on spike frequency and relative timing [4]. Reservoir computing (RC) architectures exploit the nonlinear relaxation and frequency dependent memory effects of the EPSC to process time varying inputs, performing complex temporal pattern recognition and chaotic time-series prediction without explicit reservoir training [5]. Moreover, the wavelength and intensity dependent EPSC control enables adaptive optical noise filtering, where realtime conductance adjustment selectively enhances contrast and reduces unwanted fluctuations in dynamic imaging conditions [6]. Experimentally measured EPSC–time and PPF characteristics are converted to digital form and integrated into IBM's AIHWKit simulator to capture non-ideal behaviours, retention decay and nonlinear strengthening behaviour [7]. Together, these results establish PEDOT:PSS–perovskite hybrid synapses as compact, frequency-tunable, and optically reconfigurable building blocks for next-generation neuromorphic and vision-computing systems.

OPT-11 : Tailoring Photoresponse through Plasmonic Coupling in Ag-SnO_2 Nanocomposite-Based Broadband Photodetectors

Rajesh Mandal,* and Rajib Nath

Department of Physics, Sidho-Kanho-Birsha University, Purulia, West Bengal, India, 723104.

*Presenting author email-id: rajeshmandalpzs@gmail.com

The rapid advancement of optoelectronic technologies demands highly sensitive, broadband, and cost-effective photodetectors for emerging optical sensing and imaging applications. In this study, high-performance Ag-SnO_2 nanocomposite-based photodetectors were successfully fabricated using scalable and economical dip coating technique. The incorporation of Ag nanoparticles into the SnO_2 matrix noticeably enhanced the performance of the photodetector, resulting in a 22-fold increase in responsivity and external quantum efficiency (EQE), along with an order-of-magnitude enhancement in detectivity. The optimized Ag-SnO_2 photodetector showed excellent performance. It achieved a peak responsivity of ~1.68 A/W and external quantum efficiency (EQE) of ~207% under 275 nm deep UV illumination. The device also exhibited a high detectivity of $\sim 2.7 \times 10^{13}$ Jones. In addition, the noise equivalent power (NEP) was significantly reduced to $\sim 10^{-12}$ $W/Hz^{1/2}$, confirming its superior sensitivity. Moreover, the Ag-SnO_2 photodetectors demonstrated higher responsivity in the visible region (~400-500 nm) and faster response than the bare SnO_2 photodetectors. The observed superior performance in Ag-SnO_2 photodetector is primarily attributed to the localized surface plasmon resonance effects of Ag nanoparticles, which promote efficient light absorption and charge carrier transport. The simplicity and scalability of the solution-based fabrication approach further underscore the potential of Ag-SnO_2 nanocomposites for low-cost, large- scale integration in next-generation broadband photodetector applications.

OPT-12 : Novel TMDC/Si Heterojunction Based Direct Current UV Sensitive Tribovoltaic Nanogenerator and Visual-Image Sensors

Didhiti Bhattacharya[1], Shubhrasish Mukherjee[1], Avijit Chowdhury[1], Samit Kumar Ray[1,2]

[1]*S. N. Bose National Centre for Basic Sciences, Sector III, Block JD, Salt Lake, 700106, India*

[2] *Indian Institute of Technology Kharagpur, 721302, India*

E-mail: bhattacharyadidhiti@gmail.com

Triboelectric nanogenerators have recently gained enormous attention as a low-cost method for converting abundant mechanical energy into electricity. Here, a continuous direct current (DC) output from a triboelectric nanogenerator (TENG) is achieved using 2D-WS_2/Si heterojunctions, without any need for a rectifier circuit element. At the interface of the p-Si and n-WS_2 heterojunction, the "Tribo- photovoltaic effect" is observed, responsible for the generation of direct tribo-outputs. The demonstrated multifunctional DC-TENG with remarkable performance can concurrently convert mechanical and photonic energy into an electrical one. In comparison to dark conditions, the device's output performance is enhanced under UV illumination (365 nm, 1022 $\mu W/cm^2$), and the exhibited output voltage (10.75 V) and current (466 nA) are higher by a factor of 3.9 and 2.4, with excellent power harvesting ability and outstanding robustness. This versatile DC-TENG is demonstrated to be an attractive platform for high-performance vision sensors and UV detection, which has significant implications for the rapid development of self-powered portable sensing and IoT devices based on Si CMOS technology.

OPT-13: Optimizing Convolutional Neural Networks for Image Classification on Hardware-Based Optoelectronic Memristors

Rohit Satpathy,[1,*] Subham Saha,[1] and Prof. Samit K. Ray[1]

[1]*Department of Physics, IIT Kharagpur, Kharagpur, India*

*Presenting author email-id: rs18june.24@kgpian.iitkgp.ac.in

The growing demand for real-time, energy-efficient image processing in neuromorphic systems has accelerated the search for hardware alternatives to conventional CMOS-based computing. Optoelectronic memristive devices offer a promising alternative by enabling in-memory computation, high parallelism. However, the intrinsic nonidealities of these devices—such as conductance variability, nonlinear response, and limited dynamic range can severely impact the Convolutional Neural Network (CNN) implementation for image recognition tasks. This study presents a comprehensive optimization framework for CNN architecture for image classification using hardware-based optoelectronic memristive devices on the CIFAR-10, STL-10, and Fashion-MNIST datasets. The article develops a hardware-aware quantization technique that maps network weights onto actual device conductance states using experimentally determined nonlinearity parameters from ZnO nanorods-based optoelectronic memristive synapses. The effectiveness of this mapping is subsequently confirmed by means of comprehensive simulations, which show strong image classification performance on the FMNIST, CIFAR10, and STL10 datasets. In order to maximize compatibility with synaptic weight mapping, the CNN architecture used for CIFAR 10 and STL10 is RESNET 18, which combines an optimized four-layer convolutional structure with residual connections designed especially for memristive inference hardware. It also includes rectified linear unit activations, batch normalization layers, and adaptive pooling mechanisms. While Fashion-MNIST (28×28 grayscale) uses a specialized lightweight convolutional architecture with three convolutional layers with 3×3 filters, batch normalization, and four fully-connected layers optimized for grayscale fashion item classification, the RESNET 18 architecture processes 32×32 RGB images for CIFAR-10 and 96×96 RGB images for STL- 10 [1]. Variance-aware quantization methods for device-to-device variations and environmental noise are integrated into the noise training phase to guarantee reliable performance. Gaussian and uniform noise patterns up to 30% intensity, learning rate optimization tactics, and memory management procedures are all included in the thorough noise resilience test in order to achieve steady convergence throughout 50–100 training epochs. Simulation results show that the improved ResNet-18 designs achieve 92.38% classification accuracy on CIFAR-10, 74.6% on STL-10, and 93.28% on Fashion- MNIST while improving energy consumption by 40-60% compared to standard digital float-based implementations. The study provides the role of long-term potentiation and long-term depression behaviors in memristive weight update protocols and their implication in classification accuracy, laying the groundwork for biologically inspired learning algorithms in neuromorphic computing.

OPT-14 : Morphological and Charge Transport Modulation in Ternary Organic Solar Cells Using Fluorescent Dye

Satayender K. Sangwan,[1,*] Sk Shaharukh,[1] Samit K. Ray,[1] and Achintya Dhar[1]

[1]*Department of Physics, Indian Institute of Technology, Kharagpur, India-721302*

*sksangwan99@gmail.com

Organic solar cells (OSCs) have attracted significant attention over the past few decades owing to their unique advantages, such as low-cost fabrication, mechanical flexibility, and compatibility with transparent and flexible substrates. Continuous progress in the design and synthesis of organic semiconductors has led to remarkable improvements in device efficiency and stability. Among various strategies, the concept of ternary organic solar cells, where an additional component is introduced into the binary donor-acceptor blend, has emerged as a promising approach to fine-tune the morphology and optoelectronic properties of the active layer. However, this area still remains relatively less explored compared to conventional binary systems.

In this work, we introduce a highly emissive fluorescent dye as the third component in the active layer comprising donor and acceptor materials. Fluorescent and delayed-fluorescent organic molecules, which have been extensively employed in organic light-emitting diodes and organic light-emitting transistors, are utilized here to enhance light absorption and modify charge transport characteristics. The incorporation of the fluorescent dye leads to a notable improvement in device performance, which can be attributed to multiple synergistic effects: the dye molecules extend the absorption spectrum and contribute to additional light harvesting, the active-layer morphology becomes more ordered and favorable for exciton dissociation, and charge-carrier dynamics are enhanced through the creation of an additional transport pathway across the donor–acceptor interface. Overall, our study demonstrates that incorporating fluorescent dye into ternary OSCs is an effective strategy to modulate the optical and electronic properties of the active layer, thereby enhancing their photovoltaic performance.

OPT-15 : Self-Powered Deep UV Photodetector Based on Si-doped n-($\bar{2}$01) Ga2O3 Grown on p-(0001) GaN/Sapphire Substrates using PLD

Ajoy Biswas[*], **Bhabani Prasad Sahu, Amandeep Kaur, Umakanta Patra, Subhabrata Dhar**

Department of Physics, Indian Institute of Technology Bombay, Powai, Mumbai 400076, India

[*] Corresponding author email-id: ajoybiswas975@gmail.com

Recently, β-phase gallium oxide (Ga2O3) has received much attention for applications in UV-light emitting diodes and detectors due to its ultra-wide bandgap (~4.9 eV) nature [1]. The material also exhibits high thermal and chemical stability. It has been reported that intrinsic Ga2O3 often shows unintentional n-type behavior, which can be attributed to the oxygen vacancies. Ga2O3 can also be extrinsically doped n-type with Si and Sn [2]. However p-type doping of Ga2O3 is still a challenge. GaN is another wide bandgap semiconductor which can be controllably doped p-type. There are reports of epitaxial growth of Ga2O3 on GaN. It will thus be interesting to study n- Ga2O3 /p-GaN heterojunctions for UV detector applications.

Here, we have deposited Si-doped Ga2O3 layers on p-type Mg-doped (0001)GaN/c-sapphire substrates using pulse laser deposition (PLD) technique. It is observed that the epitaxial quality of Ga2O3 film depends on the oxygen pressure inside the chamber and the substrate temperature during growth. The optimum growth conditions are obtained by analyzing the X-ray diffraction (XRD) data. It has been found that the grown Ga2O3 layer has monoclinic β-phase with ($\bar{2}$01) growth orientation. Surface morphology and roughness of the films are investigated using scanning electron microscopy (SEM) and atomic force microscopy (AFM) techniques, respectively. This devices are found to show rectifying current-voltage characteristics, which suggests the formation of p-n junctions. Photo-responsivity of this detector found to be as high as 56.8 mA/W at 270 nm wavelength of the photons. This devices are also found to respond very fast; within a few milliseconds.

OPT-16 : Electrically reconfigurable triple band light absorber and modulator based on ENZ n-InSb

Soham Chatterjee[1]* and Rishi Maiti[2]

[1,2]Department of Physics, IIT Guwahati, Guwahati, India

*Corresponding or Presenting author email-id: chsoham04@gmail.com

Modern photonic systems demand compact, reconfigurable components that can manipulate light across multiple spectral bands with a single control mechanism [1]. To meet this need, we numerically demonstrate a Fabry-Perot nanocavity that provides simultaneous, electrically reconfigurable, and selective light absorption in the **ultraviolet (UV), visible, and near-infrared (NIR)** regions. Our design leverages n-doped Indium Antimonide (InSb), an epsilon-near-zero (ENZ) material, whose optical properties are highly sensitive to external voltage.

The device architecture is a Ag/InSb/ HfO_2/Ag stack, where a 100 nm HfO_2 layer acts as a high-k gate dielectric to maximize field-effect modulation. The operating principle relies on modulating the carrier concentration within the 50 nm InSb film. Applying a positive gate voltage to the bottom Ag electrode induces a dense electron accumulation layer at the InSb/HfO_2 interface, as shown in **Figure 1**, boosting the local carrier concentration from an intrinsic level of 3.5×10^{17} cm^{-3} to over 2.68×10^{22} cm^{-3}. According to the Drude model [2], this sharp increase in charge carriers causes a significant blue-shift in the plasma frequency (ωp), which in turn alters the complex permittivity and refractive index of the InSb layer across the spectrum, as detailed in **Figure 2**. The ENZ (epsilon-near-zero) wavelength of InSb shifts from 35.17 microns to 126 nm with the shift in corresponding carrier concentration. This change in the active layer's optical properties dynamically tunes the resonant wavelengths of the entire Fabry-Perot cavity. This multi-physics process was modelled by coupling electrostatic simulations, using Ansys CHARGE with the Transfer Matrix Method (TMM) [3] to compute the device's optical response.

Our simulation results, presented in **Figure 3**, confirm the device's powerful triple-band functionality. At 0V bias, the nanocavity exhibits three distinct, absorption peaks located at approximately 360 nm (UV), 520 nm (Visible), and 1250 nm (NIR). When a 15V bias is applied, in the ultraviolet (UV) region, although the spectral shift is quite small (~ 20 nm blue shift), absorption gets modulated quite significantly from nearly 80% to 99%, thus transforming the device into a near perfect light absorber. In the Visible region, the device not only achieves a good spectral blue shift of about 40 nm but also modulates the reflection dip from 80% (in 0V condition) to 99.8% (in 15V condition). In the near infrared region, the device experiences a significantly large spectral blue shift of about 240 nm but the reflection dip remains almost the same (~90%). On applying the voltage biasing, the bandwidth of the absorption peaks decreases across all the three bands, thus implying a much faster change in reflection.

OPT-17 : Geometrical Phases in $\chi^{(2)}$ nonlinear process

Bindu,[1*] **Ritwick Das**[1]

[1]*Optics & Photonic Centre, IIT Delhi, New Delhi 110016*

* opz238622@iitd.ac.in

This work investigates the geometrical and topological properties of a second-order nonlinear optical[1] process described by a non-Hermitian Hamiltonian exhibiting anti-PT symmetry[2]. By mapping the $\chi^{(2)}$ interaction into a complex Bloch-parameter space[3], the system dynamics are expressed through an effective two-level model whose eigen-structure reflects both PT-symmetric and Anti-PT symmetric in non-Hermitian regimes. Symmetry constraints imposed by PT and anti-PT operations govern the evolution of geometrical quantities such as the Berry connection and curvature. A subsequent gauge analysis reduces the three-dimensional parameter manifold to an effective one- dimensional trajectory, significantly simplifies the problem of evaluation of the accumulated Berry phase.

The analysis reveals two distinct regimes: unbroken anti-PT region ($2\Gamma > \Delta k$), the Berry phase attains a quantized plateau of value $-\pi$, constituting a $\mathbb{Z}_2$ topological invariant with $\nu=1$, whereas in the Anti-PT broken region ($2\Gamma < \Delta k$), the berry phase becomes continuously varying and geometrical parameter-dependent marking the topological trivial phase with $\mathbb{Z}2$ invariant as $\nu=0$. The transition occurs at the exceptional point (EP) at $2\Gamma = \Delta k$, marking a non-Hermitian topological phase boundary. These results demonstrate that the $\chi^{(2)}$ coupling operator realizes a $\mathbb{Z}_2$-type topological phase protected under anti-PT symmetry, offering a platform for stability-oriented photonic configurations in the unbroken regime and sensitivity-enhanced devices in the broken regime.

.

OPT-19 : Design and Simulation of On-Chip Terahertz Amplitude Modulator based on GaN-HEMT

Sinjini Misra,[1,*] Umair Ansari,[2] Suprovat Ghosh[1], Samik Mukherjee[2] and Samaresh Das[1]

[1]*Centre for Applied Research in Electronics Indian Institute of Technology Delhi, India*

[2]*Jio Institute, Navi Mumbai, India*

*Corresponding author email-id: misrasinjini1@gmail.com

The terahertz (THz) frequency range (0.1-10 THz, corresponding to wavelengths of 0.03-3 mm) finds application in multiple domains, including spectroscopy, biomedicine, communication, and sensing, owing to the development of next-generation THz devices such as filters, polarizers, sensors, and modulators [1-3]. In particular, wireless communication stands out because the high carrier frequency of THz waves supports substantially larger signal bandwidths compared to traditional RF bands [3]. To fully exploit this advantage, on-chip THz modulators are required as essential building blocks, allowing precise control over the amplitude, phase, or both of high-frequency carrier signals. However, the realization of efficient on-chip THz modulators remains challenging, primarily due to the need for electrically tunable active media, low-loss THz waveguides for interconnects, and the monolithic integration of both waveguide and modulator on a single chip [3].

In this work, we present the design and simulation of an on-chip THz amplitude modulator operating in frequency range of 278-288 GHz using ANSYS HFSS, based on a co-planar waveguide (CPW) integrated with GaN-based high electron mobility transistor (HEMT) structure. The CPW, with signal and ground lines made of gold, was implemented on a high-resistive Si/GaN/AlN/AlGaN multilayer stack. The signal line, gap, and ground line widths were 15 µm, 3 µm, and 79 µm, respectively, with a metal thickness of 1.8 µm. The underlying layers had heights of 300 nm for GaN, 1 nm for AlN, and 25 nm for AlGaN, optimized to ensure efficient THz transmission. A channel of 5µm was introduced in the signal line, as shown in Figure 1a, to enable amplitude modulation through the gated two- dimensional electron gas (2DEG). The scattering parameters (S-parameters) of the modulator were studied to evaluate its transmission characteristics.

At zero gate bias, when the 2DEG conductivity was minimal, the simulated transmission coefficient (S21) remained close to 0 dB and the reflection coefficient (S11) stayed well below -20 dB, confirming low-loss propagation. As the gate voltage (0-2 V) is increased, the conductivity of the 2DEG correspondingly increases, leading to a reduction in transmission due to enhanced carrier-induced absorption, as shown in Figure 2a. The modulation depth was found to increase with gate bias, reaching approximately 63% at Vgs = 2 V (Figure 2b). These results highlight the structure's potential as a compact, electrically tunable on-chip THz amplitude modulator suitable for integration in next- generation 6G communication and sensing platforms.

OPT-20 : Asymmetric Contact Engineering for Enhanced Avalanche Multiplication in Sub-micron WSe_2 FETs

Subham Mahanti[1], Poulomi Chakrabarty[2], Anshuman Kumar[3], and Saurabh Lodha[2]*

[1] *Center for Research in Nanotechnology and Science, Indian Institute of Technology Bombay, Mumbai-400076, India,*

[2] *Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai-400076, India*

[3] *Department of Physics, Indian Institute of Technology Bombay, Mumbai-400076, India*
**Email: slodha@ee.iitb.ac.in*

Introduction: Recently, there has been a growing interest in avalanche multiplication related studies in two- dimensional (2D) materials due to their single photon detection capability and application to quantum communication networks [1-7]. Schottky barrier modulation via contact-metal engineering offers a key approach to enhancing multiplication factor (M) and reducing noise [6]. Amongst all 2D materials, WSe_2-based avalanche photodetectors show ambipolar avalanche, however previous reports show low multiplication factor (M) in symmetric metal contact [5] and homojunction-based [7] device architectures, while the asymmetric metal contact devices lack a comparison of electron and hole avalanche [6]. Addressing this gap, we **present for the first time,** a comparison of majority carriers (electrons or holes) and contact barriers (nickel or platinum) in a scaled, sub-micron asymmetric-contact WSe_2 transistor, with **high multiplication factor ($M_{max} \sim 10^3$)** at **low critical voltage for avalanche ($V_{cr} \sim 15$ V).**

Results and discussion: WSe_2 device fabrication involves micromechanical exfoliation and transfer of hBN and WSe2flakes onto a 280 nm SiO2/Si substrate. Subsequently, electrical contacts are made using electron beam lithography, followed by the deposition of **Ti/Pt/Au (5 nm/30 nm/100 nm)** and **Ti/Ni/Au (5 nm/30 nm/100 nm)**. The fabricated WSe2 FETs were annealed at 100 °C for 1 h in air, to enhance electrical performance [1-7]. A schematic of the device architecture is shown in Fig. 1(a) and an optical image of the as-fabricated device [$L_{ch} \approx 0.73\ \mu m$] is shown in Fig.1(b). Equilibrium band diagram of the device with different Schottky barrier heights is shown in Fig.1(c). In order to investigate the relation between the majority carrier and the contact metal for avalanche multiplication, we have measured the devices in four possible measurement schemes (Table 1). The relative Schottky barrier heights were ascertained by analyzing the output curves at a specified gate bias (VGS=10 V) in Fig.2. The IDS drop signifies a higher barrier on the Pt contact side and a lower barrier on Ni contact side when electrons are the majority carriers. Fig. 3 shows the output curves of the device indicating avalanche breakdown phenomena, along with the corresponding band diagrams during avalanche ($_{e,h}$VGS ≠ 0 V and VDS > V_{cr}). In the inset, **multiplication factor M** ($M = I_{DS}/I_{DS,SAT}$), is plotted against the drain voltage (VDS) for different gate voltages (VGS). Fig.4(a) presents a plot of **M_{max} (maximum multiplication factor)** and VGS for four combinations, **M_{max} is higher** when **electrons are injected from the larger electron barrier Pt contact (Pt-e)** compared to the Ni contact (Ni-e). Similarly, M_{max} is higher when holes are injected from the larger hole barrier Ni contact (Ni-h) compared to Pt contact (Pt-h). This is because an increased barrier height reduces the injection of majority carriers into the channel, leading to an increased multiplication factor. The **critical voltage for avalanche**

(V_{cr}) remains almost constant over different V_{GS} (Fig.4(b)), indicating that the secondary rise in the drain current (I_{DS}) (Fig. 3) is due to avalanche breakdown rather than ambipolar transport in the WSe_2 FET [5]. The critical voltage for avalanche is found to be in the range **13-25 V** as can be seen in Fig. 4(b) which is much lower than that of conventional Si APDs [8]. Fig. 6. presents the output characteristics **under dark and illuminated conditions** for Ni-h and Pt-e configurations, measured with 532 nm laser illumination covering the entire device, including the channel and metal-semiconductor contacts. **Ionization rates of electrons** (α_e) **and holes** (α_h) as a function of inverse electric field ($\alpha_{e,h} = \alpha^{\infty}\, exp\,(-\beta_{e,h}/E_{DS})$) is plotted in Fig.7(a) for V_{GS}=10 V, the electron ionization rates are less than that of holes $(\alpha_e < \alpha_h)$ which is expected since the electron critical voltage (V_{cr}) and hence the critical field ($E_{cr}=V_{cr}/L_{ch}$) for avalanche are higher than for holes (Fig. 4(a,b)). This discrepancy may be due to a combined effect of effective mass, mean free path, and the shape of the bands near the band gap [5]. Fig.7(b) shows the electric field dependence of M for a gate voltage of $|V_{GS}|$=10 V, the semi-log plot clearly indicates **10^2 -fold increase in M** for Ni-h and Pt-e configurations. Table 2 compares key parameters of previous reports on 2D avalanche FETs with this work, while Fig. 5 plots M_{max} vs. the critical electric field (E_{cr}) for different reported avalanche FETs.

Conclusion: In this study, we have demonstrated the operation of a WSe_2 field-effect transistor (FET) with asymmetric metal contacts, **platinum (Pt) for electron injection** and **nickel (Ni) for hole injection**, with **high multiplication factor (~10^3)**, **low V_{cr} (~15 V)** and **room temperature operation**. Furthermore, this work provides a comparative understanding of the avalanche phenomenon based on Schottky barrier modulation via contact engineering in 2D materials, which can lead to improved device design for 2D avalanche photodetectors.

OPT-21 : Development of UV Emitters and Detectors by PA-MBE: Effect of Compositional Inhomogeneities on device properties

Anirban Bhattacharyya,[1,*] Pushan Guha Roy,[1] Sayantani Sen,[2] and Pallabi Pramanik[2]

[1] *Institute of Radio Physics and Electronics, University of Calcutta, Kolkata–09, INDIA*

[2] *CRNN, University of Calcutta, Kolkata–106, INDIA*

*Corresponding author: anirban1@gmail.com

In this work, we present our research at the University of Calcutta on the development of ultraviolet optoelectronic devices, including both emitters and detectors, based on AlGaN alloys grown by the plasma assisted molecular beam epitaxy (PA-MBE) technique.

Blue LEDs based on InGaN alloys are bright, in spite of large dislocation densities, due to the presence of alloy fluctuations where carriers are localized away from defect sites where they recombine radiatively. AlGaN alloys, on which UV LEDs are based, are not expected to show such phenomena, due to the similarity of size of Al and Ga atoms. However, our group has developed Molecular Beam Epitaxy processes, where such alloy fluctuations can be deliberately generated by selective choice of growth parameters that control the surface mobility of the adatoms.

For growth under stoichiometric conditions, the surface mobility of the Al adatoms is limited. This leads to the formation of localized compositional fluctuations. If the Ga flux is increased keeping all other conditions the same, the overall alloy composition does not change. However, a thin layer of metallic Ga resides on the growth surface, and nanoscale Al and Ga composition fluctuations are replicated in the AlGaN film formed underneath. Both these phenomena directly affect the device characteristics of the ultraviolet emitters and detectors fabricated from them.

MSM wavelength selective photodetectors based on AlGaN MQWs have been developed and both the photosensitivity as well as the spectral response depend strongly on the nature and magnitude of the compositional inhomogeneities. Multiple quantum well (MQW) UV LEDs grown with optimized level of fluctuations exhibit stronger luminescence and reduced droop. However, they also display a significant red-shift in the emission peak. This has also led to the development of wavelength- switchable UV LEDs. LED devices that showed clear dual-wavelength behavior. Interestingly, switching between two peaks was observed when the duty cycle of the excitation was varied from 10% to dc values, without any change in the other excitation parameters. This phenomenon has been linked to the difference in thermal dissociation of excitons in fluctuations of different energy depths.

We believe the control over alloy phenomena by optimization of growth parameters of MBE will lead to efficient UV LEDs that will fully replace mercury lamps for germicidal applications, and eventually to skin-safe Deep UV LEDs which will allow irradiation even in the presence of human beings.

OPT-22 : Ultrafast and Self-Powered MSIM Photodetector Featuring Organic Semiconductor/Dielectric Interfaces for High-Sensitivity Visible-to-NIR Communication

Suryakant Singh[1] and Supravat Karak[1]*

[1]Organic & Hybrid Electronic Device Laboratory, Department of Energy Science and Engineering, Indian Institute of Technology Delhi, New Delhi 110016, India.

*Corresponding author: supravat@iitd.ac.in

The increasing significance of high-speed and energy-efficient photodetectors in broadband optical communication has sparked considerable interest in organic materials due to their tunable optical properties and ease of fabrication. However, the conventional Schottky-type organic photodetector (OPD) has low detectivity and elevated dark current, necessitating supplementary voltage biasing. Herein, this paper presents the development of a highly sensitive self-powered OPD featuring a metal-semiconductor- insulator-metal (MSIM) structure (ITO/PEDOT:PSS/organic photoactive layer/dielectric/silver), utilizing donor polymer PM6, non-fullerene acceptor Y6, and its blend with parylene as the dielectric layer for broadband spectral detection across the visible to near-infrared (NIR) spectrum at high speeds. This novel class of devices generates rapid transient photocurrent signals with opposite polarities during light ON/OFF cycles under pulsed optical stimuli, hence enhancing the distinguishability of the signals. Comprehensive transient photocurrent measurements are conducted on the fabricated MSIM OPD under varying illumination conditions and operational frequencies. The PM6:Y6-based devices exhibit superior sensitivity relative to single-component devices, attributable to enhanced charge generation and accumulation in the absence of voltage biasing. Moreover, the rapid response time (about nanoseconds) of both the positive and negative peaks, coupled with an exceptionally high cutoff frequency in MHz range, surpassed the majority of contemporary OPD technologies. The remarkable efficacy of the MSIM photodetector, evidenced by its real-time NIR optical communication of diverse ASCII codes, indicates its potential for infrared communication. The adjustable polarity of the signal provides an innovative foundation for next-generation transient-type MSIM photodetectors, improving their detectivity and response time without requiring supplementary biasing across various applications.

OPT-24 : In House Developed Cost-Effective Dry Transfer System for Controlled 2D Material Transfer in Optoelectronic Device

Suman Dolai, Ayub Sekh, Rishi Maiti*

Research Scholar, Indian Institute of Technology, Guwahati suman.dolai@iitg.ac.in

The quest for a reliable and deterministic way to transfer two-dimensional (2D) materials using dry transfer tools has gained significant attention in recent years. Building van der Waals heterostructures from 2D materials enables countless material combinations and exciting possibilities. However, commercial dry transfer systems are often too expensive for many research groups, especially when funding is limited. Although a few low-cost transfer setups have been reported, their portability and full functionality are still lacking. In this work, we present a low-cost deterministic transfer system for 2D materials and demonstrate its high precision and reliability by fabricating van der Waals heterostructure- based optoelectronic devices.

Since the discovery of graphene and other 2D materials (2004-2006), precise and reliable transfer systems have become crucial for assembling van der Waals heterostructures and integrating 2D materials onto photonic or electronic circuits [1]. However, commercial deterministic transfer systems remain costly (~$2300), limiting accessibility for low-budget labs and young researchers [2]. Recent efforts have focused on developing affordable alternatives (~$1000) capable of achieving similar performance. Incorporating lightweight PID-controlled heating and portable vacuum-assisted sample stages can further enhance precision, portability, and cost-effectiveness in low-cost 2D material transfer setups.

In this work, we develope an in-house, low-cost and portable 2D material dry transfer system at a total cost under ~1k USD with compact footprint using affordable, readily available and relatively inexpensive components sourced from online suppliers [3].

Our system is designed to be economical, compact and highly customizable, including features like PID control substrate heating, thermal isolation of the sample stage and integrated sample vacuum functionality. The preciseness of the system is successfully demonstrated with the creation of $MoTe_2$/GaSe van der Waals heterostructures on a Si/SiO_2 wafer [4]. To illustrate the potential of the system a multilayered GaSe along with two $MoTe_2$ films are transferred onto the prepatterned gold (Au) electrodes deterministically.

OPT-25 : Ultra-Wideband Log-Periodic Antenna on High-Resistivity Silicon for Terahertz Applications

Rajana R. S. S. D. Prasad[1,*], Suprovat Ghosh[2], Ishrat Bashir[1], Tanima Lai[1], Suvadip Masanta[1], Samaresh Das[2], and Santanu Manna[1]

[1]*Department of Electrical Engineering, Indian Institute of Technology Delhi, New Delhi – 110016, India* [2]*Centre for Applied Research in Electronics, Indian Institute of Technology Delhi, New Delhi – 110016,India*

*Presenting author e-mail: eey247517@iitd.ac.in

A planar log-periodic antenna (LPA) has been designed and analyzed on a high-resistivity Si/SiO_2 sub- strate for broadband terahertz (THz) operation. Multiple simulations were performed in Ansys HFSS by varying the geometric parameters at a solution frequency of 0.29 THz, including the scaling factor (τ), spacing factor (σ), bow-tie angle (α°), and tooth angle (β°), for optimal performance [1, 2]. The frequency of 0.29 THz was selected as a corresponding experimental source is available for subsequent antenna testing. Several other simulations were also carried out at 0.29 THz by systematically varying these geometric parameters, and some of the representative results are tabulated below. Among the op- timized structures, the one with an outer radius of 200 µm and an inner radius of 140 µm ($\tau = 0.5, \sigma = 0.7, \alpha = 45^\circ, \beta = 63^\circ$) exhibits excellent characteristics, achieving a minimum reflection coefficient of $|S_{11}| = -31.3$ dB at 0.575 THz and an additional resonance of -14.85 dB near 0.305 THz. The an- tenna demonstrates a peak realized gain of 3.50 dB and a directivity of 5.27 dB at $\theta = 60^\circ$ and $\phi = -78^\circ$, indicating better performance across the 0.1–1.2 THz frequency range.

The initial simulation was carried out at a solution frequency of 0.29 THz to align with the available experimental source, and the same optimized design was subsequently analyzed over a frequency sweep from 0.1–1.5 THz, with a solution frequency of 1.12 THz, to evaluate its broadband characteristics. For the geometry ($\tau = 0.5$, $\sigma = 0.6$, $\alpha = 45^\circ$, $\beta = 65^\circ$), the antenna exhibited $|S_{11}| = -39.87$ dB at 1.12 THz and -21.75 dB near 0.26 THz, with a modest reduction in gain (1.34 dB) and directivity (4.33 dB) at $\theta = 80^\circ$ and $\phi = 98^\circ$. The simulated $|S_{11}|$ response confirmed a wide impedance bandwidth spanning 0.1–1.5 THz, featuring strong resonances at 0.565 THz and 0.325 THz. A peak realized gain of 7.17 dB and a directivity of 9.02 dB were obtained at $\theta = 166^\circ$ and $\phi = 88^\circ$, demonstrating that optimization of the geometric parameters not only ensured stable impedance matching across the entire band but also yielded enhanced antenna gain at higher terahertz frequencies. These results demonstrate that the optimized geometry sustains ultra-wideband impedance matching and provides better S_{11} and gain performance well into the upper-THz regime. The optimized LPA exhibits broadband performance with efficient THz radiation coupling, which is promising for next-generation terahertz devices. Its enhanced gain and S_{11} characteristics suggest po- tential use in rectifying detectors, modulators, and spectroscopic systems. Further optimization of met- allization geometry and substrate parameters—such as thickness, radius, scaling factor, spacing factor, bowtie and tooth angles—can improve coupling efficiency. Future work will focus on lithography-based fabrication and on-wafer validation to extend device operation at the higher THz regimes.

OPT-26 : Supercontinuum Generation through Dispersive Wave Emission in GeAsSe–MgF$_2$ Buried Rib Waveguides with two different Core Geometries

Pappu Naskar[1]**, Somen Adhikary**[1]**, Mousumi Basu**[1*]

[1]*Department of Physics, IIEST Shibpur, Howrah - 711103, West Bengal, India*

*corresponding author: mbasu@physics.iiests.ac.in

Abstract: A chalcogenide buried rib waveguide with $Ge_{11.5}As24\ Se_{64.5}$ core and MgF$_2$ cladding is designed to investigate core-shape effects on supercontinuum generation at the telecommunication wavelength of

1.55 µm. Transitioning from a rectangular to a parabolic core shape enhances both dispersive and nonlinear effects, resulting in the generation of dispersive waves at a comparatively higher wavelength. A 50-fs hyperbolic-secant pulse with a low-power input of 50 W produced a broad supercontinuum when operating in the anomalous dispersion regime.

Keywords: core shape, phase matching, dispersive wave, supercontinuum generation.

Introduction: Supercontinuum generation (SCG) is a nonlinear optical process that has garnered significant attention from the research community due to its practical applications in various domains of optics [1–3]. When a narrowband laser pulse propagates through a waveguide in the anomalous dispersion regime, nonlinear effects such as self-phase modulation and soliton dynamics lead to spectral broadening. For higher-order soliton numbers, soliton fission occurs in the presence of higher-order dispersions(HOD), generating multiple fundamental solitons. When part of the broadened spectrum reaches the normal dispersion regime (where group velocity dispersion becomes positive), phase-matched dispersive waves are emitted, further extending the supercontinuum toward the mid-infrared region [4]. This broadband light source has diverse applications, including medical imaging, such as optical coherence tomography (OCT) [1], defense technologies like LIDAR [2], and high-capacity optical communication systems [3].

Design of the waveguides: We have designed two different waveguides, with rectangular and parabolic core shapes, utilising a GeAsSe core and MgF2 clad, having dimensions of 800nm x 3000nm (height x width). The modal field confinement at an operating wavelength of 1.55 µm is shown in Figures 1 (a) and

(b). The Kerr nonlinearity of the core (n_2') is $8.6\,X\,10^{-18}\ m^2/w$ while the two-photon absorption

coefficient (β_{tpa}) is $9.3\,X\,10^{-14}\ m/w$ [5].

Core shape	Effective modal area (μm^2) $A_{eff} = \frac{\lvert\int E^2 dA\rvert^2}{\int \lvert E\rvert^4 dA}$	Nonlinear coefficient (W^{-1}m^{-1}) $\gamma' = \left(\frac{k_0 n_2'}{A_{eff}} + \frac{i\beta_{TPA}}{2A_{eff}}\right)$	Dispersion (ps/nm.Km) $D = -\left(\frac{2\pi c}{\lambda^2}\right)\beta_2$
Rectangular	1.50	23.14	89.81
Parabolic	1.13	30.73	178.63

Table 1: All effective parameters for the waveguides with rectangular and parabolic core shapes.

Dispersive wave generation: In the anomalous dispersion region, an input laser pulse with a higher number of soliton orders $N = \sqrt{\frac{L_D}{L_{NL}}}$, can undergo soliton fission due to the perturbation of HOD [6] and the Raman effect, generating dispersive waves at lower as well as higher wavelengths, also. where the phase-matching condition [4] is satisfied, given below:

$$\sum_{k\geq 2} \frac{\beta_k(w_s)}{k!}(w_{Dis} - w_s)^k = \frac{\gamma\, p_{sol}}{2} \tag{1}$$

Where w_{Dis} is the DW frequency, w_s is the soliton frequency and β_k is the kth order dispersion coefficient. At the phase-matched frequency, energy transfers from the soliton to the DW in the normal dispersion regime. This extends the output supercontinuum into the MIR region.

Variation of Dispersion and Nonlinear Coefficient: Transforming from a rectangular to a parabolic core shape [7] flattened the dispersion variation with wavelength, decreased the A_{eff}, and elevated the nonlinear coefficient. Here, the emitted dispersive waves are more red-shifted at higher wavelengths and more blue-shifted at lower wavelengths for the parabolic core shape compared to the rectangular one.

Pulse propagation: When we have operated a hyperbolic secant pulse throughout the propagation length of 5mm at the pulse width of 50 fs and 50 W pulse power, described by the equation, GNLSE [8] :

$$\frac{\partial A(z,T)}{\partial z} = \sum_{k\geq 2} \frac{i^{k+1}}{k!} \beta_k \frac{\partial^k A}{\partial T^k} - \frac{\alpha_{lA}}{2} + i\gamma'(1 + i\tau_{sh} \frac{\partial}{\partial T})A(z,T) \int_{-\infty}^{\infty} R(T)|A(z,T-t)|^2 dt \tag{2}$$

We have achieved a broader supercontinuum for the parabolic core shape than the rectangular one.

Conclusion: The rectangular-core GeAsSe/MgF$_2$ waveguide produced a 1.13-octave spanning supercontinuum from 1.18 to 2.60 µm(bandwidth 1.42µm), while the parabolic core achieved a broader 1.52-octave spanning from 1.07 to 3.07 µm (bandwidth 2 µm) at –50 dB scale. Positioning the parabolic- core design as promising for mid-infrared photonic applications highlights the advantages of this core-clad combination waveguide. Performance enhancement regarding DWs enabled SC generation by such a parabolically shaped core GeAsSe–MgF$_2$ buried rib waveguide with respect to a rectangular core is not reported earlier, as per our knowledge goes. Both the output SCGs encompass all the telecommunication bands, starting from O-U, making them suitable for communication purposes.

OPT-27 : Wavelength Conversion in a Silicon-Core Optical Fiber Using Symmetric and Asymmetric Triangular Pulses

Atrayee Mishra[1], Somen Adhikary[1]*, and Mousumi Basu[1]
[1]Department of Physics, IIEST Shibpur, Howrah 711103, India

*E-mail: adhikary.somen@gmail.com

Abstract: A silicon-core fiber enables low-power wavelength conversion using triangular and asymmetric pulses, with analytical and simulated results confirming Kerr-induced spectral doubling or single-peak shift for compact all-optical conversion.

1. Introduction: Efficient wavelength conversion is crucial for modern optical communication and processing technologies [1]. Conventional silica fiber schemes for this purpose, based on SPM and FWM, require long lengths and high powers, limiting integration [2]. This work explores silicon-core fibers (SCFs) offering high nonlinearity and strong confinement for efficient conversion over centimeter scales. Results show that symmetric TPs cause spectral doubling, while ATPs yield single-peak conversion with higher efficiency, demonstrating a compact and energy-efficient approach for integrated photonics.

2. Design Framework and Pulse Propagation Dynamics: A normal dispersion SCF with refractive indices $\mathbf{n_1 = 3.45}$ and $\boldsymbol{n_2 = 1.435}$ is designed for pulse propagation at $\boldsymbol{\lambda_0 = 2.2}$ µm. Numerical optimization yields an optimal core diameter of 490 nm, providing a GVD of ~ 1.61 ps^2/m and a nonlinear coefficient γ ~ 115 W^{-1}m^{-1}. This balance enables strong nonlinear interaction with minimal dispersion, modeled using the generalized nonlinear Schrödinger equation (GNLSE) [3]

$$\frac{\partial A}{\partial z} + i\frac{\beta_2}{2}\frac{\partial^2 A}{\partial T^2} = i(\gamma + \frac{\Gamma}{2}) \mid A \mid^2 A - \frac{1}{\omega_0}\frac{\partial(|A|^2 A)}{\partial T} - \frac{(g-\alpha-\alpha_f)}{2}A \tag{1}$$

Here, $A(z,t)$ denotes the pulse envelope of the electric field along propagation distance z and time t. The term $(g-\alpha)$ represents net gain, where g is the external gain and α_l the linear loss, while α_f accounts for free-carrier absorption (FCA). The GNLSE is solved using the split-step Fourier (SSF) method to study nonlinear pulse propagation and wavelength conversion.

3. Spectral Shifting Mechanism for Triangular and Asymmetric Triangular Pulses: Wavelength conversion in a highly nonlinear fiber arises from frequency shifting (δω(T)) induced by SPM [4], governed by the intensity-dependent refractive index. Introducing a normalized field $\boldsymbol{U = A(z,\tau) = \sqrt{P_0}e^{-\alpha z/2}U(z,\tau)}$, such that the instantaneous frequency shift is given by $\boldsymbol{\delta\omega(T) = -\frac{\partial\varphi_{NL}}{\partial T} = -L_{eff}\gamma P_0\frac{\partial|U(0,T)|^2}{\partial T}}$ where $\boldsymbol{\varphi_{NL} = \mid U(0,T) \mid^2 L_{eff}/L_{NL}}$and $\boldsymbol{L_{NL} = 1/(\gamma P_0)}$.

3. a) Input Triangular Pulse: For a symmetric triangular pulse, the field amplitude is

$$\boldsymbol{U_{TP}(0,T)} = \begin{cases} \boldsymbol{\sqrt{1-\mid T/T_0 \mid}}, & \boldsymbol{\mid T \mid \leq T_0}, \\ \boldsymbol{0}, & \text{otherwise}, \end{cases} \tag{2}$$

Here, $\boldsymbol{T_0}$ is the pulse half-width. The constant chirp across both edges generates two distinct frequency shifts, causing spectral doubling. The input pulse spectrum is then expressed as

$$\tilde{U}(0,\Omega) = \int_{-\infty}^{\infty} U(0,T)e^{i\Omega T}dT = \frac{T_0\ Sinc^2\left(\frac{\Omega T_0}{2}\right)}{2}; \qquad where\ \Omega = (\omega - \omega_0) \tag{3}$$

and after propagating the length z, the output field becomes, $\tilde{U}(z,\Omega) = \int_{-\infty}^{\infty} U(0,T)e^{i(\Omega T+\phi_{NL})}dT$; The spectral intensity at the output of the effective fiber length (L_{eff}) can thus be obtained as

$$S(\Omega) = \left|\int_{-\infty}^{\infty} U(0,T)e^{i(\Omega T+\phi_{NL})}dT\right|^2 = \tilde{U}(L_{eff},\Omega) \times \tilde{U}^*(L_{eff},\Omega) \tag{4}$$

where a suitable analytical calculation reveals the following form of $\tilde{U}(L_{eff},\Omega)$ as given by

$$\tilde{U}(L_{eff},\Omega) = e^{i\phi_0}\frac{T_0}{2}\left[\left\{\left(\frac{1}{{\Omega_b}^2} + \frac{1}{{\Omega_a}^2}\right) + 2i\left(\frac{1}{\Omega_b} - \frac{1}{\Omega_a}\right)\right\} - \left\{\left(\frac{e^{i\Omega_b}}{{\Omega_b}^2} + \frac{e^{-i\Omega_a}}{{\Omega_a}^2}\right) - i\left(\frac{e^{i\Omega_b}}{\Omega_b} - \frac{e^{-i\Omega_a}}{\Omega_a}\right)\right\}\right] \tag{5}$$

And $\Omega_a = (\Omega T_0 + \phi_0)$; $\Omega_b = (\Omega T_0 - \phi_0)$; $\phi_0 = \phi_{NL(max)}$. Launching a 5 ps, 15 W triangular pulse into the gained silicon-core fiber with gain over the loss value 1.5dB/cm produces two spectral peaks near 2176 nm and 2224 nm (Fig. 1), matching the analytical prediction of Eq. (5) and confirming wavelength conversion through spectral doubling.

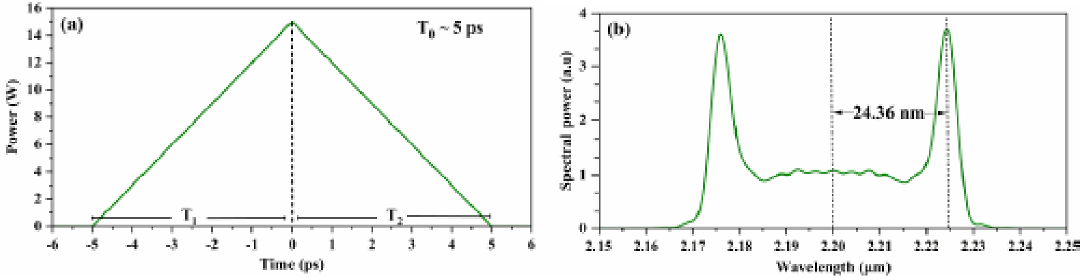


Figure 1: a) Input TP of width = 5ps; b) Spectral evolution of TP at the end of the fiber length (5 cm).

3(b). Input Asymmetric Triangular Pulse (ATP): To achieve a single-peak spectral translation, the temporal symmetry is deliberately broken. The asymmetric triangular pulse is defined as

$$\boldsymbol{U_{ATP}(T)} = \begin{cases} \sqrt{\boldsymbol{1 + T/T_1}}, & \boldsymbol{-T_1 \le T \le 0}, \\ \sqrt{\boldsymbol{1 - T/T_2}}, & \boldsymbol{0 \le T \le T_2}, \end{cases} \tag{6}$$

and the asymmetic factor (AF) is given by

$$\boldsymbol{\delta = \frac{T_1 - T_2}{T_1 + T_2} \times 100\%} \tag{7}$$

Due to the unequal slopes, the instantaneous frequency shift derived has an asymmetric nature, producing a net frequency bias. The corresponding output spectral field at L_{eff} is

$$\widetilde{U}(L_{\text{eff}}, \Omega) = \frac{e^{i\phi_0}}{2}\left[\frac{T_1}{\Omega_{bb}^2} + \frac{T_2}{\Omega_{aa}^2} + 2i\left(\frac{T_2}{\Omega_{bb}} - \frac{T_1}{\Omega_{aa}}\right) - \left(\frac{T_2 e^{i\Omega_{bb}}}{\Omega_{bb}^2} + \frac{T_1 e^{-i\Omega_{aa}}}{\Omega_{aa}^2}\right) + i\left(\frac{T_2 e^{i\Omega_{bb}}}{\Omega_{bb}} - \frac{T_1 e^{-i\Omega_{aa}}}{\Omega_{aa}}\right)\right] \tag{8}$$

where, $\Omega_{aa} = \Omega T_1 + \phi_0$ and $\Omega_{bb} = \Omega T_2 - \phi_0$. Simulation results for an asymmetry factor (δ) = 60% (Fig. 2) show that an ATP with a 5ps width ($T_0 = (T_1 + T_2)/2 = 5$ ps) induces progressive blue-shift (or red-shift depending on the nature of asymmetry) and spectral narrowing, yielding a single dominant wavelength consistent with the analytical prediction of Eq. (8). While the analytical model considers only Kerr nonlinearity, simulations include dispersion, TPA, FCA, and self-steepening, with the maximum contribution from nonlinearity. However, both show strong agreement, validating the wavelength conversion behavior.

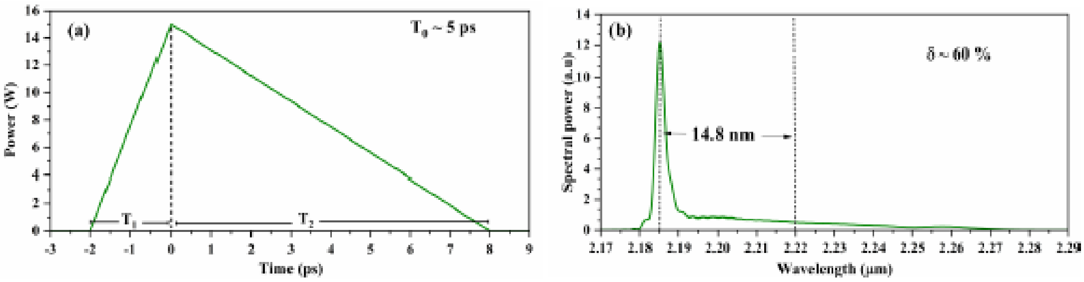


Figure 2: a) Input ATP of width 5 ps; b) Spectral evolution of ATP at the end of the fiber length (5 cm).

Conclusion: A compact silicon-core fiber enables efficient wavelength conversion using triangular and asymmetric pulses, presenting a novel strategy for low-power, centimeter-scale all-optical devices. Strong Kerr nonlinearity facilitates spectral doubling with symmetric pulses and single-peak shifts with asymmetric pulses, while analytical and simulation results validate nonlinear phase modulation as the key mechanism, emphasizing its promise for compact, low-power all-optical applications.

OPT-28 : Photocatalytic dye degradation and photosensing properties of carbon quantum dots sensitized TiO_2 nanotubes

Sudipta Das*[1], A. Dash[1], A. Deb[1], B. Das[1] and Suvra Prakash Mondal[1]

[1]*Department of Physics, National Institute of Technology, Agartala – 799046, India*

*Presenting author email-id: sudiptad865@gmail.com

Photocatalytic dye degradation using functionalized nanomaterials is attractive for environmental remediation by efficiently breaking down harmful organic chemicals in wastewater found in garment industry. On the other hand, one dimensional semiconductor nanomaterials play a vital role for developing highly sensitive and selective photosensing devices for environmental monitoring and diagnostics. In this report we have studied photocatalytic dye degradation and photosensing application using carbon quantum dot (CQDs) functioned TiO2 nanotubes (TiO2 NTs).The growth of vertically aligned TiO2 NTs was done on Ti foil using an easy and cost-effective electrochemical anodization process. The CQDs had been prepared by electrochemical exfoliation process of graphite rods. The microstructural, chemical bonding and the optical properties of TiO2 NTs and CQD functionalized TiO2 NTs were studied in detail. The photocatalytic (PC) and photoelectrochemical (PEC) studies have been conducted with functionalized TiO2 NTs. Best PC dye degradation and photosensing properties were obtained after attachment of CQDs for two hours duration. This present study demonstrates the potential of CQD as green photosensitizer for photocatalytic and photosensing applications.

OPT-29 : Temperature-Dependent Photocurrent and Stability Analysis of WSSe-Based 2D Photodetectors

Chandani Dubey[1,*], Ishrat Bashir[1,], Tanima Lai[1,] ,Suvadip Masanta[1,], Surya Singh[2,], Suprovat Ghosh[3,],Sakshi Garg[4,], Rajendra Singh[4,], Samaresh Das[3,], Supravat Karak[2,], Santanu Manna[1]

[1]*Department of Electrical Engineering, Indian Institute of Technology Delhi, New Delhi, Delhi 110016, India*

[2]*Department of Energy Science and Engineering, Indian Institute of Technology Delhi, New Delhi, Delhi 110016, India*

[3]*Center for Advanced Research in Electronics, New Delhi, Delhi 110016, India*

[4]*Department of Physics, Indian Institute of Technology Delhi, New Delhi, Delhi 110016, India*

*Presenting author email-id: eez228487@ee.iitd.ac.in

Two-dimensional (2D) transition metal dichalcogenides (TMDCs) have attracted considerable at- tention for their exceptional optoelectronic properties and thermal stability. Among them, tungsten sulfoselenide (WSSe), a tunable ternary TMDC, offers a unique platform to explore high-temperature photodetection due to its adjustable bandgap and strong light–matter interaction.In the present work, we report the fabrication and high-temperature optoelectronic characterization of a tungsten sulfoselenide (WSSe)-based photodetector on a SiO_2/Si substrate. The device was systematically investigated over a temperature range of 298–353 K to evaluate its photoresponse and performance metrics. Time-dependent photocurrent (I–T) measurements conducted at a fixed bias voltage of 2.0 V exhibit stable and repro- ducible switching behavior, with the photocurrent increasing progressively as the temperature rises and reaching its maximum at 353 K, indicating enhanced carrier transport at elevated temperatures.

Current–voltage (I–V) analysis at room and elevated temperatures demonstrates enhanced carrier trans- port and reduced trap-assisted recombination at higher temperatures, indicating thermally assisted con- duction in the WSSe layer. Temperature-dependent responsivity exhibits a similar trend, with higher photocarrier generation and collection efficiency observed at elevated temperatures, resulting in maxi- mum responsivity at 353 K. The specific detectivity (D*) of the photodetector reaches 8.8×10^9 Jones, confirming excellent sensitivity and operational stability. The observed high-temperature performance highlights the thermal robustness of the $WSSe/SiO_2$ heterostructure, making it a promising candidate for next-generation high-temperature optoelectronic devices and photodetection applications. These results provide a framework for the development of thermally resilient 2D-material photodetectors suitable for operation under extreme conditions.

OPT-30 : Highly Sensitive FAPbI3 Photodetector with a Wide Linear Dynamic Range and Fast Response Speed

Prabal Dweep Khanikar,[1,2,3]* Sahil Shah,[4] Atul Shukla,[4] Zhanglin Guo,[5] Toshinori Matsushima,[5] Shih-Chun Lo,[6] Samaresh Das,[3] and Ebinazar B. Namdas[2]

[1]UQ-IITD Research Academy, Indian Institute of Technology Delhi, New Delhi, 110016, India, [2]School of Mathematics and Physics, The University of Queensland, Brisbane, 4072, Australia, [3]Centre for Applied Research in Electronics, Indian Institute of Technology Delhi, New Delhi,110016, India,

[4]Institute of Physics and Astronomy, University of Potsdam, Potsdam, 14476, Germany, [5]International Institute for Carbon-Neutral Energy Research, Kyushu University, Fukuoka, 819-0395, Japan

[6]School of Chemistry and Molecular Biosciences, The University of Queensland, Brisbane, 4072, Australia

*Email-id: qiz208584@iitd.ac.in

Organic-inorganic halide perovskites have attracted significant scientific curiosity in numerous optoelectronic applications, such as photodetectors, solar cells, LEDs, lasers, and X-ray detection [1,2]. Their strong optical absorption, adjustable bandgap, high carrier mobility, and economical fabrication render them exceptionally promising materials. Among various perovskite compositions, formamidinium (FA)-based perovskite formamidinium lead triiodide (FAPbI3) exhibits remarkable promise for photodetection. However, challenges remain in detecting light under low-intensity conditions and maintaining photocurrent linearity under high-intensity illumination, primarily due to the limitations related to the charge transport layers in n-i-p structured devices. Furthermore, factors such as environmental instability and the higher production costs of frequently utilized hole transport layers (HTLs), notably 2,2′,7,7′-tetrakis(N, N-di-p-methoxyphenylamine)-9,9′-spirobifluorene (spiro- OMeTAD), constrain overall performance. Spiro-OMeTAD facilitates efficient charge extraction; nonetheless, its dependence on dopants may accelerate device deterioration and affect the long-term stability of the device [3,4]. On the other hand, dioctylbenzothieno [2,3-b] benzothiophene (C8- BTBT), a small-molecule organic semiconductor, exhibits great inherent electron mobility and exceptional stability, rendering it a viable option as an HTL material [5]. This study examines the effects of these two-hole transport layers in FAPbI3-based photodetectors, assessing their impact on critical performance indicators pertinent to photodetection. Some HTLs were doped, and some were left undoped to fabricate doped and undoped HTL versions of FAPbI3 devices.

The FAPbI3-based photodetectors exhibit an exceptionally high linear dynamic range (LDR) exceeding 200 dB using doped spiro-OMeTAD and doped C8-BTBT as the HTL. The devices showed outstanding low-light detection capabilities, with the undoped spiro-OMeTAD HTL device detecting signals as weak as 0.16 pW. Meanwhile, C8-BTBT HTL-based devices demonstrate the fastest response time of 1.1 μs. Overall, doping is essential for spiro-OMeTAD to achieve high performance and enhanced stability, while C8-BTBT can provide reasonably good performance and long-term stability without requiring chemical doping.

OPT-32 : Design of a Visibly Transparent Radiative Cooler for Efficient Smart Window Cooling

Subhradeep Pal, Rajib Lochan Ghadei, Rishi Maiti*
Indian Institute of Technology, Guwahati, Assam, India
p.subhradeep@iitg.ac.in

As global temperatures rise and air-conditioning demand increases, developing energy-free cooling technologies becomes crucial for sustainable living**.** Passive radiative cooling (PRC) offers a sustainable and energy-efficient way to cool surfaces, contributing significantly to global energy savings. However, most existing radiative coolers are opaque, making them unsuitable for windows or transparent surfaces. In this work, we demonstrate two types of daytime radiative coolers: (i) an opaque radiative cooler (ORC) and (ii) a visibly transparent radiative cooler (VTRC). that allows daylight to pass through while still reflecting sunlight and radiating heat away efficiently. Using optical simulations, we demonstrate that our multilayer structure - consisting of PDMS and a thin dielectric–metal–dielectric (Si_3N_4/Au/Si_3N_4) stack—achieves an average visible transparency of ~58% and a mid-infrared emissivity of ~88%**,** comparable to conventional opaque coolers. Thermal modeling under sunlight (1000 W/m^2) shows that the VTRC can achieve a net cooling power of ~170 W/m^2 and maintain its surface ~10 °C cooler than ambient, matching the performance of opaque designs. Thus our study illustrates that a visibly transparent cooler can match the cooling performance of opaque design with retaining its visibly transparent nature which can open avenues for high-performance energy-saving windows and covers.

The VTRC is a multilayer structure engineered to maintain visible transmittance while providing strong mid- infrared emission; it comprises a 30-μm PDMS layer on top of a dielectric–metal–dielectric (DMD) sandwich (55- nm silicon nitride (SIN) / 20-nm Au / 55-nm SIN) backed by a 5-μm glass substrate (Fig. 1(b)). The data of real and imaginary part of the reflective index for SIN, PDMS, Au are taken from experimentally verified sources. The PDMS thickness was optimized to ensure high emissivity in the atmospheric window (8-13 μm) while remaining optically transparent in the solar window (0.3-2.5 μm), whereas the thin metallic layer in the VTRC balances NIR/visible reflection with minimal visible absorption through thickness tuning.

All optical simulations were carried out using the finite-difference time-domain (FDTD) solver in ANSYS Lumerical. Material dispersion was included by importing refractive-index data for PDMS, SIN, Au and Ag from standard optical databases. The simulation time chosen is 1000 fs and periodic boundary conditions were applied in both in-plane (x & y) directions, whereas perfectly matched layers (PML) were used in out of plane (z) direction. A broadband plane-wave source covering 0.3–16 μm was used to compute spectral reflectance R(λ) and transmittance T(λ) at normal incidence; angle-dependent calculations used oblique incidence plane waves for both S and P-polarizations. Spatial meshing is enforced with a conformal variant 0 mesh refinement method. The maximum mesh step size is set to be 5 nm in x and y direction, 10 nm in z-direction, respectively.This technology could be integrated into smart windows, vehicle roofs, and building facades**,** providing daylight illumination and passive cooling simultaneously**.** Such visibly transparent radiative coolers represent a promising step toward reducing dependence on air conditioning, lowering carbon emissions, and making our everyday surroundings more energy-efficient and comfortable.

OPT-33 : Development of Efficient Solar-blind Photodetector Using MIST-CVD Grown β-$(Al_{0.16}Ga_{0.84})_2O_3$ Thin Film at Optimized Temperature

Tithi Saha,[1,*] **Arnab Mondal,**[1] **Lalit Katariya,**[2] **Shiv Kumar,**[1] **Ankush Bag,**[1,2]
[1]*EEE Dept., IIT Guwahati, Guwahati, India*
[2]*Centre for Nanotechnology, IIT Guwahati, Guwahati, India*
*sahatithi1510@gmail.com

Abstract—Ultra-wide bandgap β-$(Al_xGa_{1-x})_2O_3$ thin films have emerged as promising semiconductors for high- performance solar-blind ultraviolet photodetectors. This study demonstrates that β-$(Al_xGa_{1-x})_2O_3$ thin films were successfully grown on c-plane sapphire substrate at optimized temp. of 900°C using mist chemical vapor deposition (mist CVD) with metal-semiconductor-metal (MSM) configurations for deep ultraviolet (DUV) photodetector applications. XRD depicted heteroepitaxial β-phase formation, and optical studies revealed a tunable bandgap of 5.16 eV at an Al concentration of 0.16 (approximately). The MSM photodetector exhibited a low dark current (4.86 pA), a high photo-to-dark current ratio (5.21×10^3), a rejection ratio of ~ 10^5, and peak responsivity at 235 nm with a sharp cut-off at 275 nm. These findings illustrate mist-CVD as a straightforward and cost-effective method for fabricating high-performance, solar-blind UV photodetectors with bandgap tunability via Al incorporation.

Keywords— Ultra-wide Band Gap semiconductors, β-Aluminum Gallium Oxide, Heteroepitaxial growth, Mist- CVD, Solar-blind photodetector

I. INTRODUCTION

Solar-blind photodetectors play a vital role in detecting deep ultraviolet (DUV) radiation for applications such as environmental monitoring, biological sensing, and secure optical communication. Conventional Si-based photodetectors, with their broad detection range (200–1100 nm), are unsuitable for solar-blind operation due to visible-light sensitivity and the need for optical filters [1]. Recently, ultra-wide bandgap (UWBG) semiconductors have attracted great interest for DUV detection because of their high breakdown strength, thermal stability, and intrinsic solar-blind characteristics [2]. Among these, gallium oxide (Ga_2O_3) stands out for its ultra-wide bandgap (~4.4–5.3 eV) and high DUV sensitivity, with β-Ga_2O_3 being the most stable polymorph [3]. Alloying β-Ga_2O_3 with aluminum (Al) enables bandgap tuning, reduced dark current, and improved device performance [4]. Expensive growth systems like MOCVD, ALD are used to grow $(Al_xGa_{1-x})_2O_3$ thin films and subsequently DUV photodetectors [5,6], while mist-CVD offers a cost-effective and simpler alternative [7]. In this work, the synthesis, structural characteristics, and photodetection performances of UWBG β-$(Al_xGa_{1-x})_2O_3$- based DUV photodetector have been investigated. A layer of β-$(Al_xGa_{1-x})_2O_3$ has been grown on a c- plane sapphire substrate, and Ti/Au electrodes have been deposited to fabricate the MSM DUV photodetector.

II. EXPERIMENTAL METHODS

β-$(Al_xGa_{1-x})_2O_3$ thin films were grown on c-plane sapphire via mist-CVD using $Ga(acac)_3$ (0.02M) and $Al(acac)_3$ dissolved in 10 mL DI water with 300 µL HCl. The solution was atomized by a 2.4 MHz ultrasonic transducer and carried into the chamber by 500 sccm N_2 and 210 sccm O_2. Depositions were first performed at 800 °C-1000 °C, followed by Al concentration variation (0.02M-0.06M) at 900 °C. Ti/Au (20/80 nm) electrodes were deposited via E-beam evaporation to fabricate the MSM devices.

III. RESULTS AND DISCUSSION

Fig. 1(a) displays the 2θ–ω HRXRD diffraction patterns of β-$(Al_xGa_{1-x})_2O_3$ film grown on c-plane sapphire at 800 °C-1000 °C, where at 900 °C β-phase has shown stability with more intense and sharpened peaks, and at 1000 °C peak intensity has reduced, denoting low crystallinity. A family of planes in β-phase, such as (-201) at 18.9°, (-402) at 38.337°, and (-603) at 59.01°, has been observed at 0.02M at 900 °C, which indicates heteroepitaxial growth of the thin film, and peaks are shifting slightly towards the right with increasing Al concentrations from 0.02M to 0.06M, shown in Fig. 1(b). At 0.03M, the thin film showed better surface morphology and cross-sectional FESEM analysis, depicted in Fig. 2(a) and 2(b), revealing the film thickness of 280 ± 20 nm. UV–Vis spectroscopy was used to study the optical properties of the β-$(Al_xGa_{1-x})_2O_3$ film shown in Fig. 2(c). The bandgap, determined from the Tauc plot (inset of Fig. 2(c)), was found to be 5.16 eV and estimated (from Vegard's Law) Al concentration is 0.16 (approx.). Compared to pure β-Ga_2O_3 (4.5–4.9 eV), the increased bandgap confirms successful Al incorporation in the film.

Electrical characteristics of the MSM device were evaluated under dark and UV light illumination, which are shown in Fig. 2(d-f). Device matrices are illustrated in Table I.

Table I: β-$(Al_xGa_{1-x})_2O_3$-based Photodetector device performance

Device	Idark (pA)	PDCR	Peak Responsivity ($R\lambda$)	Detectivity (D^*) (Jones)	Rejection Ratio
Ti/Au-β-$(Al_{0.16}Ga_{0.84})_2O_3$-Ti/Au	4.86	5.21×10^3 (10 V)	18.6 mA/W	8.71×10^{11}	$\sim 10^5$ (R235/R400)

CONCLUSIONS

This study demonstrates the heteroepitaxial growth of β-$(Al_xGa_{1-x})_2O_3$ thin film on c-plane sapphire at optimized temp. of 900 °C, using mist CVD. The film with a thickness of ~280 nm exhibits a widened bandgap of 5.16 eV compared to β-Ga_2O_3. The fabricated MSM photodetector shows a low dark current (4.86 pA), high PDCR (5.21×10^3) under 254 nm illumination, and a responsivity of 18.6 mA/W with a detectivity of 8.71×10^{11} Jones. With the spectral response onset at 275 nm and culminating at 235 nm wavelength, the device exhibits an excellent rejection ratio of 10^5. These results confirm that mist-CVD-grown β-$(Al_xGa_{1-x})_2O_3$ is a promising material for high-performance solar- blind UV photodetectors, where Al incorporation effectively tunes the bandgap and spectral response.

OPT-35 : CdZnTe-based room temperature semiconductor detectors for X-ray detection and imaging

S. Singh*, L. Montpetit, E. Rahier, M. R. M. Atalla, S. Koelling, O. Moutanabbir*
Department of Engineering Physics, École Polytechnique de Montréal, Montréal,
C.P. 6079, Succ. Centre-Ville, Montréal, Québec, Canada H3C 3A7
*Corresponding or Presenting author email-id: sudarshan.singh@polymtl.ca

X-ray detectors play a vital role in contemporary medical imaging and security screening. Cadmium zinc telluride (CZT) stands out as a highly attractive material for detecting X-rays and γ- rays, offering distinct benefits over conventional direct conversion detectors such as silicon and germanium, notably its superior density and resistivity that remove the requirement for cryogenic cooling. However, the performance of radiation detectors is significantly influenced by the surface characteristics of the CZT crystal. This work presents the fabrication and interpixel passivation of CZT detectors using a 10 nm-thin layer of Al_2O_3 deposited at a substrate temperature of 250 °C via atomic layer deposition. The CZT samples, after chemical-mechanical polishing, exhibit a relatively smoother surface but contain uniformly distributed Te-inclusions, 10–15 µm in size, as confirmed using infrared imaging. Two device configurations were developed: metal-semiconductor and metal-insulator-semiconductor, both of which were passivated with the Al_2O_3 layer. The devices demonstrate uniform dark current across various pixel pairs and show nearly an order of magnitude reduction in surface leakage current in interpixel measurements after passivation, in both MS and MIS structures, compared to unpassivated MS devices. Overall, these findings demonstrate that high-temperature ALD-grown Al_2O_3 provides a dual benefit of surface and interface passivation in CZT detectors without inducing material degradation, in contrast to prolonged thermal annealing approaches reported previously. The synergistic reduction of dark current, enhancement in rectification ratio, and elimination of hysteresis collectively establish Al_2O_3 passivation as a promising strategy for advancing the electrical performance and long-term stability of next-generation CZT-based radiation detectors.

OPT-36 : Molecular Beam Epitaxy (MBE)- grown 2H-MoSe$_2$/Highly Resistive -Si Heterostructure for Optically Pumped- THz Amplitude Modulation

***Sujan Sasmal[1], Suprovat Ghosh[2], Kamlesh Bhatt[3], Rajendra Singh[3], Santanu Manna[4] and**

Samaresh Das[2]

[1]*School of Interdisciplinary Research, Indian Institute of Technology Delhi, Hauz Khas, New Delhi- 110016, India.*

[2] *Centre for Applied Research in Electronics, Indian Institute of Technology Delhi, Hauz Khas, New Delhi- 110016, India.*

[3]*Department of Physics, Indian Institute of Technology Delhi, Hauz Khas, New Delhi- 110016, India.* [4]*Department of Electrical Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi- 110016, India.*

*Presenting author email-id: srz248211@iitd.ac.in

In recent decades, the rapid advancement of terahertz (THz) technology has driven the demand for ultra- high-speed, broadband THz modulators [1], highly sensitive detectors, and intense, broadband THz sources. The performance of these devices critically depends on material properties like bandgap, thermal conductivity, carrier lifetime, etc. Two-dimensional (2D) transition metal dichalcogenides (TMDCs) such as molybdenum diselenide (MoSe$_2$), molybdenum ditelluride (MoTe$_2$), Tungsten diselenide (WSe$_2$), etc., have emerged as promising candidates for next-generation terahertz (THz) optoelectronic devices due to their tunable electronic band structure[2], high carrier mobility, and strong light–matter interaction. Among them, 2H-MoSe$_2$ exhibits superior optical absorbance and luminescence properties across the visible to near-infrared (NIR) region compared to other TMDCs [3] . In this work, we demonstrate high-quality growth of few-layer 2H-MoSe$_2$ over highly resistive silicon (HR-Si) using molecular beam epitaxy (MBE) at a temperature of 550˚C. Subsequently, we have fabricated a few modulator devices to investigate the performance in the THz regime. Measurements were carried out under a 355 nm pump laser with different powers.

The schematic of the 2H-MoSe$_2$/HR-Si THz modulator is shown in Figure 1(a). The transmittance of this modulator has been measured using a continuous-wave frequency-domain THz system (CW-FDS, TOPTICA’s Tarascan 1500), covering a wide frequency range from 0.1-1.0 THz. However, the measured transmittance of this device as a function of frequency, under different laser power densities, is illustrated in Figure 1(b). During this measurement, we have used air transmittance as a reference. At a higher lasing power density of 5.0 W/mm^2, the transmittance of this THz device is minimum; the graph (Figure 1(c)) shows a transmittance value of around 60%. The modulation depth (MD) was derived from the transmittance spectra with and without laser excitation. Figure 1(d) presents the frequency-dependent MD (%) for both the MoSe$_2$/HR-Si heterostructure and HR-Si under a laser power density of 5.0 W/mm^2. The maximum MD shown by MoSe$_2$/HR-Si heterostructure is 63% at 1.0 THz frequency, which is 2.5 times higher than HR-Si at the same frequency under 5.0 W/mm^2 laser power condition.

OPT-37 : Photo and Electroluminescence from Nanostructured Silicon: A comparative study

Subhajit Roy Chowdhury[1], Suman Santra[1], Saddam Khan[1], Syed Minhaz Hossain[1]

1. Department of Physics, Indian Institute of Engineering Science and Technology, Shibpur, Howrah, West Bengal, India, 711103

*Corresponding Author's email id: subhajit2014home@gmail.com

Nanostructured silicon (nanoSi) has emerged as a promising material for silicon-compatible optoelectronics since the discovery of visible photoluminescence (PL) from porous silicon by L.T. Canham in the early 1990s [1]. Despite bulk silicon's indirect band gap, nanoSi exhibits efficient room- temperature luminescence due to quantum confinement in silicon nanocrystals and surface passivation by an oxide matrix. Although PL and electroluminescence (EL) from nanoSi have been extensively studied, direct comparative investigations under identical structural conditions remain limited. In this work, both PL and EL characteristics of nanoSi layer were examined under identical conditions.The nanoSi sample was prepared by electrochemical etching of p-type Si wafers at 10 mA cm^{-2} for 3 mins in an HF(48%)–ethanol electrolyte. HRTEM analysis revealed randomly oriented nanocrystals with an average size of ~7 nm (Fig.1 (a) and (b) respectively), while FTIR spectra confirmed the presence of a non-stoichiometric oxide shell (Fig. 1(c)). The PL emission spectrum was analysed under variying excitations and intensities before establishment of metal contact for EL measurement. Subsequently, a Schottky junction was formed by depositing a thin Ag layer via thermal evaporation, exhibiting rectifying I–V behavior (Fig. 1(d) and inset)[2]. Both the PL and EL spectra displayes similar broad visible emission (Fig. 2(a) and (b)) with multiple overlapping bands associated with different radiative channels like Band_to_Band (B-B), Trap_to_Band (T-B) and Trap_to_Trap (T-T) recombination as depicted in the insets of Fig.2(a) and (b) by deconvolutiong spectra [3]. It is interesting to note that the PL spectrum shows a distinct red-shift compared to EL, implying different recombination mechanisms under optical and electrical excitation. The PL spectra showes minimal wavelength dependence (Fig.2(a)) whereas voltage-dependent EL measurements revealed a gradual blueshift and the emergence of higher-energy peaks with increasing forward bias. This suggests that the PL emission is dominated by the large Si nanocrysttalites resides at the surface of nanoSi layer where agglomeration due to overlapping of oxide matrix of different nanocrysttalites is higher than the other region of the nanoSi layer whereas for EL, the result is attributed to field-enhanced carrier injection to conduction band and more involvement of smaller nanocrystals resides beneath the surface in emission process. To verify this, we have studied the PL spectra under different exitation intensity and found that it varies with excitation intensity (Fig. 2(c)). It can also be observed from the Fig.2(c) that the intensity of high energy peak corresponding to B-B transition channels is becoming more prominent compared to trap assisted radiative channels suggesting more penetration of the optical excitation in the nanoSi layer acquiring more optical signals from less agglomerated particles beneath the surface. The cross sectional view of the nanoSi layer and top view of the nanoSi surface is presented in Fig.2(d). Overall study suggests that PL emission is likely dominated by near-surface, oxide-passivated regions whereas EL is governed by less-oxidized subsurface zones.

OPT-38 : Influence of Surface Oxidation on Temperature-Dependent Radiative Recombination in Nanostructured Silicon

Shayari Basu[1,2,*], **Syed Minhaz Hossain**[2]

[1]*Department of Basic Science and Humanities, Dr. Sudhir Chandra Sur Institute of Technology & Sports Complex, Kolkata 700074, West Bengal, India*

[2]*Department of Physics, Indian Institute of Engineering Science and Technology (IIEST), Shibpur, Howrah 711103, West Bengal, India*

*Corresponding author: shayari.bs@gmail.com

Nanostructured silicon with Si nanocrystallite (SiNC)@SiO_x core@shell geometry exhibits unique photoluminescence (PL) properties that depend strongly on the crystallite size (a), surface chemistry and temperature [1, 2]. The broad PL spectra observed in nanostructured silicon manifest as a convolution of three distinct radiative decay channels: band-to-band, band-to-trap, and trap-to-trap transitions. At lower temperatures ($\lessapprox$225 K), the temperature coefficients of PL peak energy associated with the quantum-confined Bloch states exhibits size-dependence, while that attributed to interfacial oxide trap-related peak energies is found to be size-independent throughout the experimental temperature range (5-350 K) [2]. A clear understanding of the impact of invasive oxidation on radiative recombination pathways is essential for revealing the fundamental mechanisms governing carrier dynamics in nanostructured silicon. In this work, we have investigated the effect of chemical oxidation treatment in piranha solution on samples with two different initial core sizes by varying duration of the reaction as well as temperature, focusing on the modification occurred in the decay channels. Chemical oxidation is found to alter the density of interfacial defect states, as confirmed by FTIR measurements. The resulting changes in the optical band gap and electronic transitions are further examined using UV– Vis absorption and continuous-wave PL spectroscopy. Temperature coefficient (α) is calculated for the peak energies associated with three distinct channels, providing the measure of the shift in the effective joint density of states following the relaxation in k-selection rules in quantum-confined structures [3]. It is observed that α increases with oxidation time for all three recombination channels. The oxidation-induced enhancement in α corresponding to the transitions involving Bloch states is more significant for samples with larger core sizes. This can be attributed to the increased quantum confinement resulting from the reduction in core size due to oxidation [4, 5]. The schematic band diagram in Figure 1 illustrates the SiNC@SiO_x core@shell structure of nanostructured Si samples before and after chemical oxidation. The blue and red regions represent the distribution of effective density of states for electrons and holes, respectively. Upon oxidation, core size gets reduced resulting in the modification in the band gap

$E_g(a)$, and the temperature coefficient $\alpha(a)$, while the band tails of the electron and hole density of states within the band gap broaden. Furthermore, oxidation results in the broadening and redistribution of trap states toward the band edges, accounting for the linear increase in α associated with trap-related transitions. The findings provide valuable insights into the interplay among surface chemistry, size confinement and radiative decay channels in nanostructured Si systems, offering useful implications for the design of efficient nano-silicon based optoelectronic devices.

OPT-39 : Tuning Light-Matter Interaction in 2D Bi2Se3 through Plasmonic Particle Coupling

Tara Shankar Bhattacharya[1*] Sreyan Raha[1*], Prasanna Kumar Mondal[2], Mukul Pradhan[3] Sukanya Ghosh[4] Achintya Singha[1]

[1] *Department of Physical Sciences, Bose Institute, EN 80, Sector V, Bidhannagar, Kolkata 700091, India.*

[2] *Department of Physics, Surendranath College, Kolkata 700009, India.*

[3] *Department of Chemistry, National Institute of Technology Warangal, Warangal 506004, Telangana, India.*

[4] *Department of Physics, Central University of Kashmir, Jammu & Kashmir, India.*

tarashankar1992@gail.com

Topological insulators (TIs) are a unique class of quantum materials that exhibit an insulating bulk while hosting conductive surface or edge states protected by time-reversal symmetry [1,2]. Bismuth selenide (Bi2Se3), a well-known TI, have recently emerged as highly promising candidates for optoelectronic applications, for its unconventional chiral surface exciton-mediated photoluminescence (PL) properties. [2,3]. However, its low PL efficiency and limited emission tunability restrict its device application possibility. In this study, we synthesize 2D Bi2Se3 via a simple chemical method, and a hybrid system integrating gold nanoparticles (Au NPs) are developed [4]. The integration of Au NPs with Bi2Se3 induces orbital hybridization among Au-*5d*, Se-*4p*, and Bi-*6p* states, giving rise to a new chiral excitonic recombination pathway in addition to the intrinsic one. Raman studies reveal phonon softening, enhanced peak intensity, and the appearance of a surface phonon mode after Au NP decoration, indicating charge transfer from Au to Bi2Se3, as supported by first-principles calculations [4,5]. By varying the Au NP decoration time, the tunable exciton-plasmon coupling is achieved. With increasing Au NP decoration time, the nanoparticle size and density grow, shifting the plasmon resonance closer to the new excitonic transition and then starts formation of dimers for longer decoration time. Electrodynamics simulations confirm strong near-field enhancement at Au NP dimer junctions around 2 eV, matching the PL enhancement seen in experiments. The hybrid system also exhibits enhanced circular polarization of the intrinsic recombination channel of Bi2Se3 upon Au decoration [5]. This study establishes Au-Bi2Se3 hybrids as a versatile platform for manipulating chiral light–matter interactions and advancing tunable topological optoelectronic devices.

OPT-40 : Bloch Surface Wave Enhanced Emission in Perovskite Embedded Photonic Crystal

<u>Somnath Pandit</u>[1,#], Rahul Murali[2,#], Prasanta Kumar Guha[3], Sai Santosh Kumar Raavi[2,*], Shivakiran Bhaktha B.N.[4,*]

[1]School of Nanoscience and Technology, Indian Institute of Technology Kharagpur, Kharagpur, 721302, West Bengal, India

[2]Department of Physics, Indian Institute of Technology Hyderabad, Kandi-502285, Telangana, India [3]Department of Electronic and Electrical Communication Engineering, Indian Institute of Technology Kharagpur, Kharagpur 721302, India

[4]Department of Physics, Indian Institute of Technology Kharagpur, Kharagpur 721302, India # These authors contributed equally

panditsomnath@kgpian.iitkgp.ac.in

Photonic crystals (PhC) have photonic band structure arising from the periodicity of the dielectric function $\varepsilon(\vec{r})$ much like an electronic band in atomic crystals [1]. Depending on the periodicity of $\varepsilon(\vec{r})$ there are one, two, and three-dimensional PhCs. A properly tailored PhC, confines states resonantly at specific wavelengths with extremely high Q-factors, increasing significantly the local density of optical states, can control spontaneous emission [2]. Bloch surface wave (BSW) mode of photonic crystal has very high energy confinement on the surface of the PhC [3]. A schematic of one-dimensional (1D) PhC, its dispersion and field confinement of BSW are shown in Figs. 1(a-c), respectively.

Perovskite quantum dots (QDs) having high luminescent efficiencies are of great interest in optoelectronics [4], but further improvement of luminescence efficiency is desired for their device applications. The spontaneous emission rate and photoluminescence of $CsPbBr_3$ QDs coupled to the BSW mode increases by Purcell effect in the weak coupling regime. Furthermore, the emission becomes highly directional following the dispersion characteristics of BSW.

The transfer matrix method (TMM) is used to computational design a PhC for efficiently coupling of the emission to BSW mode. For the fabrication of the 1D PhCs, the sol-gel, dip-coating process is adopted for its simplicity and good quality of the fabricated sample. The substrate was dip-coated in SiO_2 and TiO_2 sols to form the respective layers. After each coating, the sample was annealed at 900 ^{0}C for a few minutes to form a thin film of required thickness. Final polymer layer was spin-coated with proper solvent-dilution to achieve the required thickness.

Normal incidence reflectance (Fig. 2(a)) of the fabricated 1D PhCs is acquired using a fiber-coupled UV-visible spectrometer. To probe the modes of PhC, prism coupling setup is used in Kretschmann Raether (KR) and reverse Kretschmann (RK) configuration. The $CsPbBr_3$ QDs are doped into the polymer layer of thickness ∼50 nm on the PhC, whose structure is shown in Fig. 1(a). The modes are identified by comparing the angle dependent reflectance in KR configuration (Fig. 2(b)) with the computational results. In the RK configuration, the QDs in the polymer layer are excited with 405 nm laser, and the emission coupled into the modes of the PhC exit at very narrow angles through the prism (Fig. 2(c)). This angle dependent emission through the PhC is referred to as PhC coupled emission (PCCE). The maximum intensity in the PCCE is observed to be ~40 times of the free space (FS) emission, as shown in Fig. 2(d).

This emission enhancements are highly demanding in applications of imaging, nanolasers, single photon sources [5] etc. Due to the well-designed structure, the k-vector of the BSW which lies along the surface, and the dielectric nature of the structure, the emitted light is found to propagate several millimeters of distance [6], which has applications in on-chip devices. Lasing of perovskite crystals embedded PhC using the BSW platform [7] is also promising in integrated photonics domain.

OPT-41 : Surface and Volume Nanopatterning by Holographic and Interference Lithography

Biplab Dhara[1 *], **Sarbojit Mukherjee**[2], **Shivakiran Bhaktha B. N.**[1]

[1]*Department of Physics, IIT Kharagpur, Kharagpur, 721302, India*

[2]*Advanced Technology Development Centre, IIT Kharagpur, Kharagpur, 721302, India*

*Email: biplabdhara.24@kgpian.iitkgp.ac.in

Holographic lithography, mostly used interchangeably with Interference lithography, is a maskless fabrication technique that creates patterns by recording the interference fringes from two or more coherent light beams. This periodic light intensity distribution is used to expose a photosensitive material (photoresist), forming a pattern without a physical mask. By carefully controlling the number, angle, and phase of the interfering beams, this method can generate not only 2D surface gratings but also complex 3D periodic structures, or volume patterns, such as photonic crystals [1]. In this study, we present an approach to efficiently fabricate volume and surface gratings using a holographic technique [2]. This advancement holds the promise of driving progress in the development of diffraction gratings, tunable optical filters and cost-effective on-chip spectrometers [3]. The surface and volume patternssolution and exposing them within a Denisyuk-style setup utilizing a 2D grating as the object, as seen in Figure 1(a). Sample 1 received an exposure without grating, while sample 2 was exposed in presence of 2D grating in Figure 1(a). Figure 1(b) is the optical microscopic image of the sample 1, which shows absence of patterns on the surface. Figure 1(c) is the optical microscopic image of the sample 2, which shows the surface grating pattern formed on the sample surface. The cross-sectional scanning electron microscope image of sample 1 in Figure 1(d), shows the existence of Bragg structure across the volume of the sample. Figure 1(e) shows the room temperature reflection spectrum of sample 1, which again confirms that volume patterns are present inside the sample. Figure 1(f) shows the angle dependent reflection spectra measured at room temperature which provides the dispersion characteristics of the sample 1. Figure 1(g) presents the reflection spectra for the sample heated from 27 °C to 69 °C, confirming the tunability of the reflection spectra. The developed technique for both volume and surface nanopatterns, has wide application in combining multiple diffractive optical elements into one, increasing its compactness, portability and decreasing the cost of the optical elements. The temperature-tunability enhances its capability in optical filter category. Further details of the fabrication and characterization of the samples will be presented in the conference, shedding light on the scope and potential of this approach.

OPT-42 : Enhanced Light-Matter Interaction and Photodetection in TMDs using Distributed Bragg Reflectors (DBRs)

Kritika Bhattacharya,[1*] Chumki Nayak,[2] Aditya Kumar,[1] Achintya Singha,[2] and Samaresh Das[1]

[1]Centre for Applied Research in Electronics, Indian Institute of Technology Delhi, New Delhi 110016, India

*[2]Department of Physical Sciences, Bose Institute, 93/1, Acharya Prafulla Chandra Road, Kolkata, 700009, India**

Email ID: kritikabhattacharya19@gmail.com

Over the years, transition metal dichalcogenides (TMDs), with their atomically thin geometry, strong excitonic resonances, and broadband absorption features, have emerged as attractive candidates for next-generation photodetectors [1-2] and light-harvesting devices [3-4]. However, their intrinsically low absorption cross-section in the visible-near-infrared range severely limits device efficiency. For example, the monolayer of TMDs can approximately absorb only 30% of incident photons in the blue region of the visible light [5]. Overcoming this bottleneck requires strategic engineering of the optical environment to boost light-matter interaction without compromising CMOS compatibility.

This work presents a comprehensive experimental and simulation-driven study on the use of distributed Bragg reflectors (DBRs) as engineered substrates for enhancing TMD-based photodetection. Alternating TiO_2/SiO_2 multilayers were designed and fabricated to create a broadband high-reflectance stopband centered around 600 nm, offering constructive optical interference and strong field confinement at the surface. Finite-difference time-domain (FDTD) simulations predicted near-unity reflectivity and significant localization of electromagnetic intensity at the DBR-air interface. The fabricated DBRs achieved ~70% reflectivity, with deviations attributed to interfacial roughness and imperfections as revealed by cross-sectional FESEM and TOF-SIMS analyses. Despite these non-idealities, the DBRs provided a substantial enhancement in optical interaction with TMD layers compared to conventional Si/SiO_2 substrates.

To probe these effects, layered WSe_2 and $MoSe_2$ flakes were transferred onto both DBR and Si/SiO_2 platforms, and two-terminal photodetectors were fabricated. Raman scattering and photoluminescence (PL) spectroscopy demonstrated strong enhancement effects on DBR substrates. Specifically, Raman signals of WSe_2 under 633 nm excitation increased by ninefold, and PL intensity exhibited a twentyfold enhancement relative to Si/SiO_2. The strong wavelength dependence of the enhancement, significant at 633 nm but modest at 514 nm, correlated well with the DBR reflectance profile, underscoring the role of optical interference.

Electrical characterization revealed a consistent performance boost across multiple devices. WSe_2 photodetectors on DBRs showed up to fivefold enhancement in responsivity at 660 nm, achieving values of ~30 mA/W, while $MoSe_2$ devices demonstrated nearly tenfold improvement, with peak responsivity as high as 200 mA/W. These figures match or exceed previously reported results for TMD-based photodetectors integrated with optical cavities or plasmonic structures, but with the added advantages of CMOS compatibility and large-area scalability. Importantly, transient measurements revealed sub-millisecond response times and long-term stability, further validating the suitability of DBR for practical photodetection applications.FDTD simulations provided mechanistic insight into the observed enhancements. While WSe2 on Si/SiO2 suffered from photon leakage into the substrate, leading to reduced absorption, WSe2 on DBR exhibited uniform and maximized absorption across the flake, with negligible photon escape. The DBR thus acts as a photonic mirror, recycling incident photons into the active TMD layer and facilitating stronger exciton-light interactions.

Conclusively, these findings position distributed Bragg reflectors as robust and scalable platforms to boost the efficiency of 2D material photodetectors. The observed gains in Raman response, photoluminescence, and device responsivity underscore their promise as versatile foundations for future imaging, sensing, and optoelectronic technologies.

OPT-43 : Exceptionally High Nonlinear Optical Response in Two-dimensional Type II Dirac Semimetal Nickel di-Telluride (NiTe2)

Saswata Goswami, Chandra Sekhar Tiwary*, and Samit K. Ray*
S. Goswami,
School of Nano Science and Technology, Indian Institute of Technology, Kharagpur,
West Bengal-721302, India
C. S. Tiwary
Department of Metallurgical and Materials Engineering, Indian Institute of
Technology Kharagpur, West Bengal 721302, India
chandra.tiwary@metal.iitkgp.ac.in

S. K. Ray: Department of Physics, Indian Institute of Technology Kharagpur, West Bengal
721302, India physkr@phy.iitkgp.ac.in

Nickel ditelluride (NiTe2) is a recently discovered Type-II Dirac semimetal, exhibiting unique properties in electrical transport and optical investigations. In this study nonlinear optical properties of two-dimensional NiTe2 by experimental method is investigated. Layered two-dimensional NiTe2 (2D-NiTe2) is synthesized via liquid phase exfoliation (LPE) and characterized using X-ray diffraction, transmission electron microscopy, and atomic force microscopy techniques. The nonlinear refractive index (n_2) and third-order nonlinear susceptibility ($3^{(3)}_{total}$) of the synthesized 2D-NiTe2 are evaluated from the self-induced diffraction pattern generated at various wavelengths (λ = 405, 532, and 650 nm) in the far field. In addition, the diffraction pattern generated by spatial self-phase modulation (SSPM) is further verified by varying concentration (2D-NiTe2 in the IPA solvent), wavelength (of incoming laser beams), and cuvette width (active path length). Lastly, utilizing the reverse saturable absorption property of 2D-hBN, asymmetric light propagation is also demonstrated in the 2D-NiTe2/2D-hBN heterostructure.

OPT-44 : Optical and Dielectric Spectroscopy for Relaxation Study in Gum Acacia Biopolymer Modified by Natural Pigment Anthocyanin and Betalain of Fruit Exudates

Rajkumar Singha[1], Himadri Mullick[2]

[1]Dept. of Physics, Visva-Bharati, Santiniketan 731235, West Bengal, India, [2]Dept. of Physics, Charuchandra College, Kolkata, India.

Exponential increase of energy resources and production of greenhouse gases are the two major immediate negative impact of industrial revolution post second world war. Inevitable global warming along-with climate change are the two long term effects that the world is facing for the last two decades. Scientists are finding ways to curb this menace. One of the little but effective way to combat the battle is lowering the use of synthetic polymer material while increase of biodegradable materials from natural resources.

In this study an effort has been devoted to achieve the visible light absorption capability and enhancement of ionic conductivity of a biodegradable polymer by tailoring its chemical structure, morphology and introducing defect concentrations (vacancies or interstitials).

This process has been achieved in gum Acacia biopolymer which is available in powder form, thereby preparing its water solution and mixing acid extracts of different fruits namely black grapes, black jamun and vegetables namely red beet; which influence chemical structure of the said biopolymer. The resultant of the products has been observed in uv-vis absorption spectroscopy, photoluminescence spectroscopy and dielectric spectroscopy and therefore analysed. Red shift in the absorption peak is observed in each case due to polymerisation of conjugated bonds of biopolymer with weak acids and lowering of energy levels due to inclusion of chromophore in the host biopolymer background [1-3]. The analysis shows that the selection of proper fruit acid solvent and vegetable acid solvent makes appearance of spectra in visible spectrum range. Enhancement of ionic conductivity in the order of 10^2 is markedly observed over the unmodified biopolymer which was previously reported.

Keywords: Biopolymer, Chromophore, Absorption Spectroscopy, Impedance Spectroscopy

OPT-45: Topological Catalysis in Vanadium-Doped SnTe Nanostructures for Hydrogen Evolution

<u>Parul Kumar Sharma</u>[1], Samit Kumar Ray[2], and *Samik Mukherjee[1],**

[1]Jio Institute (RFIER), Navi Mumbai Sector 4, Maharashtra 410206, India,
[2]Department of Physics, IIT Kharagpur, Kharagpur, India
Corresponding author email: samik.mukherjee@jioinstitute.edu.in

Vanadium-doped SnTe nanostructures (SnTe@V) exhibit topological surface state (TSS) driven catalytic activity toward the hydrogen evolution reaction (HER). [1] Controlled V doping modulates spin texture and carrier delocalization, verified by XRD, XPS, and Raman analyses. Electrochemical measurements show a reduced overpotential (142 mV @ 10 mA cm^{-2}) and Tafel slope (78 mV dec^{-1}) compared to pristine SnTe. DFT results reveal that vanadium improves spin-polarized states near the Dirac point, lowering ΔG_{H^*} and enhancing charge transfer. [2] These findings demonstrate the role of spin-polarized TSS in improving catalytic efficiency, offering a route for designing spin-active topological catalysts.

20-12-2025 (Day 2)

3. Materials/Device Modelling

MDM-1: White-light emitting self-assembled graphene quantum dots from coal soot

Tuhin Mandal,1,2 Shiv Rag Mishra,1,2 and Vikram Singh1,2,*

1Environment Emission and CRM Section, CSIR-Central Institute of Mining and Fuel Research, Dhanbad, Jharkhand, 828108, India 2Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 201002, India
Presenting author’s e-mail address: tuhi.chem2@gmail.com

Coal soot, a byproduct of thermal power plants, is a major contributor to air pollution. It poses serious health risks, including lung and heart diseases, as well as respiratory and cardiovascular complications. Environmentally, it promotes global warming by absorbing short-wave solar radiation [1,2]. Transforming coal soot into white-light-emitting (WLE) materials not only promotes the sustainable valorisation of harmful environmental pollutants but also offers an innovative strategy for pollution mitigation and resource recovery. We represented a rapid 2.0-minute synthesis method of WLE graphene quantum dots (GQDs) from coal soot using ethylene diamine-assisted ultrasonication at room temperature. The GQDs exhibited broad emission across the visible spectrum, featuring two prominent peaks at 475 and 635 nm under 380 nm photoexcitation, corresponding to monomer and J-aggregate emissions, respectively. The GQDs also had the CIE chromaticity coordinates of (0.28,0.33) in solution and (0.25, 0.30) in polyvinyl alcohol made film, indicating nearly ideal white light emission (0.33, 0.33) in both media. The photophysical and surface studies of the GQDs confirmed that the strong reducing and basic nature of ethylene diamine facilitated the self-assembly of J-aggregate GQDs through hydrogen bonding and electrostatic interactions [3]. This research opens new avenues for integrating sustainable chemistry and advanced materials science to drive progress in the optoelectronic sector.

MDM-2: Experimental and Theoretical Investigation of 3D MoSe2/Graphene Flake Composites for Advanced Symmetric Supercapacitors

Bijoy Jana*, Kaustuv Das
Dept. of Physics, Jadavpur University, Kolkata-700032, India
*Presenting author's email ID: bijoyjana524@gmail.com

This work presents an experimental and theoretical investigation of the development of symmetric supercapacitor electrodes based on MoSe2 and graphene flakes. Preliminary calculations and detailed theoretical analysis confirm the suitability of the MoSe2/graphene composite as both anode and cathode material in symmetric configurations, attributing its superior charge-storage capability to enhanced electronic states near the Fermi level and improved quantum capacitance. Three-dimensional MoSe2/graphene flake composites with varying compositions were synthesized via a hydrothermal route. The optimized electrode delivered an impressive specific capacitance of 748 F g-1 at 1 A g-1 with high coulombic efficiency, highlighting its strong potential for energy storage. In addition, the device achieved an energy density of 48 Wh kg-1 at 1 A g-1 and a power density of 3 kW kg-1 at 5 A g-1. Excellent cycling stability was observed, with 78% capacitance retention at 6 A g-1 after 13,000 cycles. A pair of symmetric supercapacitors was also able to illuminate sixteen red LEDs for several minutes, demonstrating practical applicability. Furthermore, the device retained stable electrochemical performance under mechanical bending (00–1650), confirming good flexibility. These findings establish MoSe2/graphene composites as a highly promising electrode material for next-generation high-performance and flexible supercapacitors.

MDM-3: Study the effect of applied gate voltage on threshold potential and carrier transport behavior of three-terminal novel prototype device having configuration p-type Si/SiO2/CuFeS2/Al

Asmita Patra,1,* Suman Das,1 and Animesh Layek2

1 Department of Physics, Jadavpur University, Kolkata-700032, India

*Corresponding author e-mail: asmitapatra12@gmail.com

This is the first approach of fabrication p-Si/SiO2/CuFeS2/Al (Figure 1) based novel prototype field dependant three terminal electronic device to study the charge transport behavior of various junctions by applying bias voltages. Here CuFeS2 semiconductor has been applied for first time within field induced electronic device. The effect of external field on carrier transport from source to drain within the device has been investigated. An unusual change of threshold voltage has been observed on application of gate bias voltage. The underlying physics is investigated in accordance with the results and is accounted in this report.

MDM-4: Development of Cu2ZnSiS4 (CZSiS) thin films as a Sustainable Material for Photodetection and Resistive Memory Applications

Manoj Kangsabanik* and Rabindra Nath Gayen

Department of Physics, Jadavpur University, Kolkata-700032, India

*Presenting Author E-mail: manojkb1404@gmail.com

In the modern technological era, Cu2ZnSnS4 (CZTS) has gained significant attention as a sustainable and non-toxic material for optoelectronic applications. This work focuses on enhancing environmental compatibility by replacing tin (Sn) with the more abundant and non-toxic silicon (Si), leading to the synthesis of Cu2ZnSiS4 (CZSiS) and the investigation of its photodetection (PD) and resistive switching (RS) applications. Our initial work aims to develop a self-biased photodetector (SBPD) in a superstrate configuration based on a TiO2/CZSiS heterojunction. The device demonstrated a responsivity of ~0.04 mA/W under 1 sun illumination. However, it exhibited relatively slow rise and decay times (~55 s/58 s). FESEM analysis revealed that the porous morphology of the CZSiS film generated trap centers, which contributed to the delayed response. Interestingly, this characteristic indicated the material's potential for memory applications. Motivated by these observations, we investigated the RS performance of CZSiS in metal–semiconductor (MS) device architectures. Our findings show that CZSiS exhibits excellent RS characteristics, including a high ON/OFF switching ratio of ~1725 and robust endurance over 150 switching cycles. Impedance spectroscopy and cyclic I–V measurements suggest that the enhanced performance primarily arises from the efficient formation and rupture of conductive filaments within the inter-grain regions of the film. These results highlight the beneficial impact of Sn-to-Si substitution, not only in enhancing device performance but also in enabling the use of environmentally friendly and low-cost materials. CZSiS thus emerges as a promising and scalable candidate for next-generation resistive memory technologies.

Keywords: CZSiS; resistive memory; Photodetector; Impedance spectroscopy

MDM-5: Sono-Chemically Engineered MoSe2–PVDF Nanocomposites for Efficient Flexible Piezoelectric Energy Harvesting

Sayan Chakraborty,1* Sourabh Pal2, and Samit K. Ray1
1Indian Institute of Technology Kharagpur, Kharagpur, India
2 Max Planck Institute for Polymer Research, Mainz, Germany
*Corresponding author: csayan14@iitkgpian.ac.in

The pursuit of high mechanical-to-electrical energy conversion efficiency in piezoelectric nanogenerators (PENGs) has been a persistent challenge driving extensive research efforts. Bridging the gap between conventional technologies and advanced material designs remains crucial to this endeavor. In the present work, we advance the performance frontier of PENGs by introducing a novel nanocomposite friction layer composed of sono-chemically exfoliated two-dimensional molybdenum diselenide (MoSe2) and polyvinylidene fluoride (PVDF). The MoSe2 nanosheets, obtained through a scalable sono-chemical exfoliation process, exhibit exceptional interfacial compatibility and electromechanical properties that synergize effectively with PVDF. A sandwich-structured PENG was meticulously fabricated by spin-coating a homogeneously dispersed PVDF–MoSe2 nanocomposite (prepared in dimethylformamide, DMF) onto an indium tin oxide (ITO)-coated polyethylene terephthalate (PET) substrate. A second ITO-coated PET sheet was subsequently placed atop the film to serve as the upper electrode, forming a well-defined sandwich configuration with the PVDF–MoSe2 layer acting as the active dielectric medium. Comprehensive experimental characterization revealed an impressive open-circuit voltage of approximately 57 V and a peak power density of ~680 µW/cm2 under normal finger tapping at ~3 kPa. This remarkable enhancement underscores the pivotal role of 2D MoSe2 in promoting polarization alignment and improving interfacial charge transfer within the PVDF matrix. Overall, this study establishes the PVDF–MoSe2 nanocomposite as a promising material platform for next-generation, high-performance piezoelectric nanogenerators with significant potential for flexible and wearable energy-harvesting applications.

References:

[1] S. Chakraborty, S. Pal, S. K. Ray, ACS Appl. Energy Mater. 8, 2620 (2025).

[2] D. Bhattacharya, S. Bayan, R. K. Mitra, S. K. Ray, Nanoscale 13, 15819 (2021).

MDM-6: Insights into synthesis temperature, molarity of LiF/HCl on structural quality of Ti3C2Tx-MXene films for advanced energy storage applications

Papi Sarkar, *Kaustuv Das
Department of Physics, Jadavpur University, Kolkata, 700032, India
*Presenting author email-id: papisarkar1994@gmail.com

MXenes (Mn+1XnTx), a rapidly growing class of quasi-2D transition metal carbides, nitrides, and carbonitrides, are promising candidates for free-standing flexible electrodes in supercapacitors.They are formed by selective etching of interlayer aluminium (Al) of MAX (M n+1AXn) phases. Understanding etching mechanisms and the influence of etchants on structure is crucial for enhancing MXene electrochemical performance. The present work focuses on the effect of etching temperature on Ti3AlC2 using a safe, reliable, single-step MILD (LiF/HCl) method with varying LiF molarities to synthesize Ti3C2 MXene films.The crystal structure, microstructure and composition of the MXene are characterized using X-ray diffraction, Raman spectroscopy and electron microscopy. Flexible free-standing MXene film with largest shift in the characteristic (002) peak at $2\theta = 5.78°$, indicating large interplanar spacing of 1.53 nm, has been successfully achieved repeatedly for an optimum molar concentration of etchants at 40°C temperature. The synthesized pristine flexible Ti3C2Tx (12.0 M) electrode in 1.0 M KOH electrolyte shows good specific capacitance of 442.86 F g-1 at 5 mVs-1.

[1] M. Naguib, M. Kurtoglu, V. Presser, J. Lu, J. Niu, M. Heon, M. W. Barsoum, Advanced materials, 23,37 (2011).

[2] J. Zhang, N. Kong, S. Uzun, A. Levitt, S. Seyedin, P. A. Lynch, J. M. Razal, Advanced Materials, 32,23 (2020).

MDM-7: Study of Zn Diffusion Effects on Multiplication Layer and Breakdown Characteristics in InGaAs/InP SPADs

Smita Srivastava,1,∗ Harmanpreet Kaur Sandhu,1 Vikash Sharma,1 Santanu Manna,2 RajendraSingh,3 Ankur Gupta,1 and Samaresh Das1
1Centre for Applied Research in Electronics, Indian Institute of Technology Delhi, New Delhi 110016, India
2Department of Electrical Engineering, Indian Institute of Technology Delhi, New Delhi 110016, India
3Department of Physics, Indian Institute of Technology Delhi, New Delhi 110016,India
*Email ID: crz248468@iitd.ac.in

We present a Sentaurus TCAD simulation analysis of InGaAs/InP single-photon avalanche diodes (SPADs), highlighting the significant impact of Zn diffusion depth on the multiplication region thickness and the determination of the breakdown voltage. In the Separate Absorption, Grading, Charge, and Multiplication (SAGCM) design, the effective multiplication layer is characterized by the undiffused portion of weakly doped InP situated beneath the Zn-diffused p+ area. Our simulation have been conducted methodically to alter the Zn diffusion profile which demonstrates that shallow Zn diffusion maintains a thicker undiffused InP multiplication area, necessitating a greater applied bias to achieve the necessary electric field for avalanche breakdown. This leads to an increased breakdown voltage, since the electric field must be dispersed over a greater volume before attaining the threshold. In contrast, increased Zn diffusion penetrates more extensively into the InP layer, diminishing the thickness of the undiffused multiplication region. This thinning effect intensifies the electric field, enabling the device to attain avalanche conditions at a reduced bias, hence decreasing the breakdown voltage. Our TCAD results support the direct association between Zn diffusion depth and breakdown voltage, demonstrating a drop in breakdown voltage as diffusion depth increases. This relationship offers a robust mechanism for manipulating the electric field configuration and enhancing SPAD performance metrics, including dark count rate, photon detection efficiency, and avalanche uniformity. Our findings are particularly relevant to the design of single-diffusion InGaAs/InP SPADs for operation at room temperature, where precise control of Zn diffusion is essential. Through the optimization of the diffusion process, we can refine the balance between breakdown voltage, noise characteristics, and uniformity of avalanche triggering, thereby advancing SPADs with improved performance for applications in quantum communication, LiDAR, and low-light imaging. These findings correspond with current literature, emphasizing the importance of doping profile engineering and the optimization of the multiplication zone in next-generation SPAD technologies.

MDM-9: Design and Performance Analysis of Drain-Extended NMOS for ESD Applications

Prabhat Kumar*, Ravi Prakash, Dheeraj Kumar Sinha and Sanjay Kumar
Indian Institute of Information Technology Bhagalpur, India
*Corresponding author email-id: prabhat.ece.2203007@iiitbh.ac.in

In this paper, we have demonstrated the physical features of n-FET based electrostatic discharge (ESD) protection devices [1], including Drain-extended NMOS (De-NMOS) with Shallow Trench Isolation (STI) [2] to understand their performance and current-voltage (I-V) characteristics under ultra-high current pulsing (1 A/ns) circumstances. The parasitic bipolar activity in the DeNMOS structure is investigated to clearly understand the terminal properties [3]. The schematic 2-D cross- sectional view of STI based DeNMOS device is shown in Fig.1 (a). In the recommended DeNMOS device setup, the gate, source, and substrate terminals have been grounded, and the ESD pulse is linked across the drain terminal. The Drain Contact to Gate Spacing (DCGS)-induced I-V characteristics of the device are shown in Fig.1 (b). The influence of DCGS on ESD design windows are shown using an organized parametric approach. Therefore, 180 nm DeNMOS device simulations were performed using a predetermined drain current pulse of human body model pulses (1 A/ns) at different values of DCGS. From the graph, as shown in figure 1 (b), it is observed that the first snapback triggering voltage (Vt1) increases by 10% and holding voltage (Vh) increases by 4% when DCGS is changed from 0 nm to 20 nm with the constant first triggering current (It1). Further, the second triggering voltage (Vt2) and current (It2) decreases by 0.61% and 4.3%, respectively. The results indicate that DCGS has a significant effect on the ESD design window.

MDM-10: Low Temperature and Solution Processed Flexible Organic Solar Cells Based on PM6:Y6

Pooja Rani, Suryakant Singh, Supravat Karak
Department of Energy Science and Engineering, Indian Institute of Technology Delhi
Contact: ppoojaarani@gmail.com, Supravat.Karak@dese.iitd.ac.in

Flexible organic solar cells (OSCs) are promising candidates for next-generation photovoltaic technologies due to their lightweight, roll-to-roll (R2R) processability, and eco-friendly fabrication. In this work, we report the fabrication and characterization of flexible OSCs based on the high-efficiency donor-acceptor system PM6:Y6. The devices were fabricated using low-temperature solution processing techniques including spin-coating and thermal annealing.

The inverted device architecture used was PET/ITO/ZnO/PM6:Y6/MoO_3/Ag. The fabrication parameters were optimized based on previous studies on rigid substrates and successfully translated to flexible substrates. The resulting flexible OSCs exhibited a power conversion efficiency (PCE) of up to 7%, with excellent mechanical stability and reproducibility. These results demonstrate the potential of PM6:Y6-based flexible OSCs for scalable, lightweight, and sustainable energy harvesting applications.

Keywords
Flexible Organic Solar Cell, Inverted Architecture, Spin Coating, Device Stability, Power Conversion Efficiency

MDM-11: Multi-Layer Hexaferrite–Graphene Derivative Incorporated PVDF Nanocomposite Films for Enhanced Microwave Absorption in the X-Band Frequency Region

Suman Saha1, Sukhen Das1, Soumyaditya Sutradhar1*
1Department of Physics, Jadavpur University, Kolkata-700032, West Bengal, India
*Corresponding author: sds.phy1@gmail.com (Dr. Soumyaditya Sutradhar).

The rapid miniaturization of electronic devices and the proliferation of wireless communication systemsdemand lightweight, flexible, and broadband electromagnetic interference (EMI) shielding materialscapable of suppressing unwanted radiation without compromising structural integrity. In this context,we report a comprehensive study on multi-layer polymer-based magneto-dielectric nanocomposites, where Y-type strontium hexaferrite (SrY) nanoparticles are hybridized with graphene derivatives (GO and rGO) and embedded within a poly(vinylidene fluoride) (PVDF) matrix. SrY nanoparticles synthesized via the sol–gel route was combined with graphene oxide (GO) and reduced graphene oxide (rGO) to form binary nanofillers (SrY/GO and SrY/rGO). These binary fillers were then incorporated into PVDF to fabricate both mono-layer and multi-layer nanocomposite films (SrY/GO/PVDF and SrY/rGO/PVDF). The crystalline phase purity, morphological integrity, and successful incorporation of the fillers in PVDF matrix were confirmed through XRD, Raman spectroscopy, XPS, and FESEM analyses. Current vs voltage characterization indicated distinct conduction mechanisms in the two nanocomposite systems: SrY/rGO/PVDF exhibited the formation of percolative conductive networks, whereas SrY/GO/PVDF showed pronounced dipolar and interfacial polarization under applied electric fields. Magnetic hysteresis (M–H) loops of SrY nanoparticles revealed a magnetization of ≈ 28.24 emu g-1

And coercivity of ≈ 1200 Oe at room temperature, which is favourable for incurring high magnetic losses in the GHz frequency range. Electromagnetic characterization in the 8–12 GHz (X-band) range demonstrated that multi-layer SrY/GO/PVDF films exhibit a substantial increase in total shielding effectiveness (SET) from –63.16 dB for mono-layer composite film to –82.53 dB for multi-layer composite film, with absorption (SEA) ≈ –60.11 dB which dominates over reflection (SER) ≈ –24.26 dB at a matching frequency of ~9.6 GHz. Conversely, the SrY/rGO/PVDF films showed higher reflection (SER) ≈ –28.66 dB than absorption (SEA) ≈ –23.72 dB due to enhanced surface conductivity and lower dielectric loss. The comparative analysis highlights that the oxidation state of graphene derivatives governs the dielectric relaxation, charge transport, and impedance-matching characteristics of the composite. Multi- layer stacking further amplifies multiple internal reflections and interfacial polarization, contributing to improved absorption bandwidth and attenuation efficiency. The insights offer a promising strategy for designing lightweight, flexible, and tunable magneto-electric laminated nanocomposite films suitable for advanced microwave absorbers, stealth coatings, and EMI shielding applications in the X-band [1-6].

MDM-12: Surface Engineering of Sputter-Deposited HfO2 Films on SiO2/Si Substrates by Controlled Etching of the Intermediate SiO2 Layer for Hydrophobic Surface Fabrication

Priyanka Biswas,1, ∗ Debopam Bhattacharya,1 Aindrila Roy,1 and Sanatan Chattopadhyay1,2,#
1Department of Electronic Science, University of Calcutta, Kolkata 700009, India
2Center for Research in Nanoscience and Nanotechnology (CRNN), University of Calcutta, Kolkata 700106, India
*Presenting author: miss.priyanka.biswas.phd@gmail.com
#Corresponding author: scelc@caluniv.ac.in

Silicon-based Digital Microfluidic (DMF) devices have enabled the development of highly uniform and precisely patterned electrode arrays capable of manipulating micro-liter to nano-liter of sample volumes [1]. It is also compatible with CMOS technology [1]. The present work focuses on fabricating a high-k dielectric film with controllable hydrophobicity on silicon (Si) substrates for DMF applications. SiO2 is grown on thoroughly clean p-Si (111) and p-Si (100) substrates by thermal oxidation at 850°C for 4 hr. The resulting SiO2 films are chemically etched by using a 1% HF solution for different durations (0s, 30s, 1 min, 1.5 min, and 2min). Spectroscopic Ellipsometry is used to measure the thickness of SiO2 films. Subsequently, a high-k dielectric HfO2 layer was sputter-deposited onto the etched SiO2 surfaces at 150 W for 15 min. Field Emission Scanning Electron Microscope (FESEM) and 3D surface profiling are employed to analyze surface morphology and surface roughness of the deposited HfO2 films. The thermally grown SiO2 films on p-Si (111) are found to be thicker than those on p-Si (100), which is attributed to the higher surface atomic density (~15 %) of the (111) plane, promoting greater SiO2 formation upon oxidation [2]. Additionally, as etching time increases, SiO2 film thickness decreases with a simultaneous increase in surface roughness. Such results corroborate with previously reported dependence of oxide thickness and surface roughness on chemical etch time [3]. Furthermore, an increase in the surface roughness of sputter-deposited HfO2 films is observed for time-controlled chemically etched SiO2/Si substrates. The wetting behavior of these films is evaluated by static contact angle (CA) measurements of a de-ionized water droplet (20 μl). A consistent enhancement in surface hydrophobicity is observed with increasing surface roughness, which is in agreement with previous studies [4]. The maximum contact angle of 106.01° is achieved for the HfO2/SiO2/Si (111) substrate with the longest SiO2 etching duration. Thus, it is evident that controlled etching of the underlying SiO2 film induces surface roughness in the subsequently deposited HfO2 thin films, with an improvement in surface hydrophobicity. The observed behavior can be attributed to the higher surface atomic density of Si (111), which
facilitates the formation of a thicker SiO2 layer. Subsequent controlled chemical etching of this layer increases surface roughness, leading to enhanced hydrophobicity of the device surface compared to HfO2/SiO2/Si (100). Thus, the present study demonstrates that controlled etching of the underlying dielectric films on Si substrate can modify surface morphology, enabling effective tuning of the hydrophobicity which can be used for potential microfluidic applications.

MDM-13: Miniaturized UV-Visible Computational spectrometer with a van der Waals Heterojunction

Rishabh Sahoo, Shibesh Pramanik, Rishi Maiti *
Indian Institute of Technology, Guwahati, Assam, India
r.sahoo@iitg.ac.in

The increasing demand for portable, on-chip systems for real-time, in situ analysis in fields like point of care diagnostics and environmental monitoring necessitates the miniaturization of analytical tools1. While spectrometers are vital for such tasks, conventional instruments are limited by bulky dispersive optics and complex arrangement of optical elements. Computational spectrometers, which replace large components with sophisticated algorithms, present a viable solution, especially given their compatibility with CMOS integration for widespread use. Miniaturized computational spectrometers have attracted widespread attention and a variety of materials, photonic structures, and photodetectors are adopted for encoding with the cooperation of reconstruction algorithms2. This approach involves capturing and encoding spectral data using a limited number of encoding elements, followed by algorithmic reconstruction of the incident light spectrum from these captured signals. Unlike traditional spectrometers that rely on gratings, prisms, or interference for dispersion, computational spectrometers employ diverse encoding methods, such as nanophotonic structures, metamaterials, 2D materials, and micro-optical elements, significantly reducing device size3. Moreover, these spectrometers avoid the need for long optical paths, characteristic of traditional spectrometers for achieving high spectral resolutions, by tightly integrating the encoding structure with the signal detection unit, further compacting their overall sizes. With the development of micro-nano fabrication technology and novel emerging materials, more elaborate encoding structures can be produced, facilitating the performance enhancement of computational spectrometers. On the algorithmic side, the rapidly increasing computing power of integrated circuit chips accelerates the reconstruction speed and accuracy.

Motivated by the need for on-chip spectral analysis, we have demonstrated and characterized an ultraminiaturized computational spectrometer based on a single, electrically tunable van der Waals (vdW) junction. This approach exploits the unique properties of 2D materials, which are atomically thin and exhibit strong light-matter interaction. Through comprehensive experimental measurements, we demonstrated high-performance operation over a broad bandwidth from approximately 250 nm to 700 nm, covering the ultraviolet (UV) and visible light ranges. A high spectral resolution of ~3 nm was achieved, indicating the device's ability to resolve fine spectral features. Furthermore, a peak wavelength accuracy of ~0.5 nm was obtained, demonstrating excellent fidelity for identifying monochromatic light sources like lasers. The governing equation that is used for reconstruction4:

$$\min\{\| R \cdot S - Iph \|_2^2 + \gamma^2 \| S \|_2^2\}$$

where R is the responsivity matrix encoding the responsivity values of the fabricated device as a function of wavelength and source-drain voltage values. Iph is the input photocurrent that is used for reconstruction. S is the spectrum function used for reconstruction and it can be expanded as the weighted sum of various gaussian basis functions.

$$S(\lambda) \approx \sum \alpha_j \varphi_j(\lambda)$$

where α_j is the weight coefficients vector and $\varphi_j(\lambda)$ is the gaussian basis function for a particular wavelength.

MDM-14: Silver Nanoparticle-Enhanced 2D CuO Nanoflakes for Simultaneous Solar-Driven Photocatalysis and Antimicrobial Activity

Saraswati Mandi1*, Rajesh Mandal1, Partha Sarathi Das1, Biswanath Mukherjee1, and Rajib Nath1
1Department of Physics, Sidho-Kanho-Birsha University, Purulia-723104, W.B, India
*Author email-id: saraswatimandi86@gmail.com

It is very important to come up with good ways to cut down on and stop water pollution caused by too many dangerous contaminants. So, new catalyst materials need to be made to make the wastewater treatment plant's oxidation processes work better, making sure that trace organic contaminants are mineralized. We carefully changed the surfaces and shapes of copper oxide (CuO) nanostructures with silver (Ag) nanoparticles (~12–20 nm), a range of Ag-decorated (~7–16%) CuO two-dimensional (2D) nanoflakes (length ~400 nm and width ~70 nm) with better photocatalytic and antibacterial properties. These changes could lead to long-term solutions to current environmental problems. Its photocatalytic effectiveness, which breaks down the harmful methylene blue dye effluent pollution, is 95% when exposed to sunshine. Also, their antibacterial capabilities help them fight off Enterococcus faecalis, Pseudomonas aeruginosa, Escherichia coli, and Proteus mirabilis bacteria. They also have better antibacterial activity than their pristine (CuO) counterparts, with larger inhibitory zone diameters (>10 mm). Therefore, we propose that Ag-decorated CuO 2D nanoflakes exhibit significant potential for extensive utilization in photocatalytic wastewater treatment and bacterial decontamination in sunlight.

MDM-16: Modulation of thermoelectric performance in off-stoichiometric Sb2Te3

Swapnadeep Goswami,1, * Golam Nosib,1 and Aritra Banerjee1,2
1 Department of Physics, University of Calcutta, Kolkata – 700009, India
2CRNN, University of Calcutta, JD Block, Sector -III, Bidhannagar, Kolkata- 700106, India
*Presenting author email-id: 22swapnadeep@gmail.com

Sb2Te3 is a well-known thermoelectric (TE) material for near room temperature applications [1]. Pristine Sb2Te3 is found to have inherent Te vacancy, making it p-type in nature [1,2]. Pristine Sb2Te3 is thus always off-stoichiometric and better expressed as Sb2Te3-□. Here we report the improvement of the TE properties by tuning defect concentration in off-stoichiometric Sb2Te3. Sb2Te3 samples with varying Te concentration, viz., Sb2Te3 and Sb2Te3.7 are synthesized by spark plasma sintering (SPS) method. In- depth structural characterization of the synthesized samples was performed through X-Ray diffraction followed by Rietveld refinement. Presence of excess Te is observed to alter the electrical and thermal transport properties. In Te-rich condition, the changes in the defect dynamics of Sb2Te3 is reflected in temperature dependent (5 – 300 K) carrier concentration (nH) and mobility (μ) data. Thermal variation of resistivity (ρ) and Seebeck coefficient (S) in the range 2 – 300 K demonstrate the role of carrier-carrier and carrier-phonon scattering. Existence of quasi-localized phonons has been realized by fitting low temperature (2 – 150 K) specific heat (Cp) data. Single Band Pisarenko model has been employed to the estimate the effective mass of carriers in the synthesized samples. Measurement of temperature dependent thermal conductivity (κ) has been carried out in the range 2 – 300K, following which the advantageous effect of additional Te in the synthesized Sb2Te3 samples is revealed through the lowering of the lattice thermal conductivity (κL) near room temperature. TE Figure of Merit, zT (=S 2T/ρκ), which is the most important parameter of the TE performance of a material is estimated to be ~30% greater for Te-rich Sb2Te3.7, as compared to its pristine counterpart around room temperature.

MDM-18: Piezo-Responsive Flexo-electric Er3+-ZnO/PVDF Nanocomposites for Sustainable Energy Harvesting and Motion Sensing

Subhojit Dutta1, Sukhen Das1, Soumyaditya Sutradhar1*
1Department of Physics, Jadavpur University, 188 Raja S.C. Mallick Road, Kolkata – 700032, Kolkata, India
Presenting author email-id: subhojitdutta2@gmail.com

The ongoing processes of industrialization and technological advancement in the modern world have precipitated a rising global demand for energy, a need largely met through the rapid exploitation of fossil fuels. In this context, the harvesting of kinetic energy and its subsequent transformation into electrical power is becoming increasingly prevalent, capitalizing on the abundant and readily accessible nature of mechanical and vibrational energy sources. This approach offers a sustainable pathway that reduces the production of dangerous greenhouse gases. Concurrently, the research community has maintained a strong interest in nanomaterials over recent decades due to their exceptional qualities, which include a high surface-to-volume ratio, extensive grain boundary areas, and quantum size effects. Among the various metal oxide nanomaterials, zinc oxide has garnered significant attention because of its intriguing physical characteristics, such as a high excitonic binding energy of 60 meV, a tunable direct band gap of 3.1 eV, and the capacity for both n-type and p-type semiconductor behavior through the introduction of specific dopants into its lattice structure. Building upon the significant technological advancements enabled by doped ZnO nanomaterials, the present work selects the 4f cation Er3+ as a dopant within the ZnO lattice. These Erbium-doped ZnO (EZ) nanoparticles were synthesized using a hydrothermal preparation technique. This study focuses on the creation of flexible piezoelectric nanogenerators for sustainable power generation. The central premise is that the presence of EZ nanoparticles within a piezoelectric PVDF polymer matrix can greatly enhance the electroactive β-phase content of the resulting EZ-PVDF nanocomposite films, thereby improving the overall electric polarization properties of the system. Utilizing the solution casting technique, the hydrothermally- synthesized, rod-like EZ nanoparticles were successfully integrated into the PVDF matrix. Field Emission Scanning Electron Microscopy (FESEM) and X-ray Diffraction (XRD) studies verified both the existence of the rod-like EZ nanoparticles within the polymer and the formation of the desired crystallographic phase of the nanocomposite films. Furthermore, Fourier-Transform Infrared (FTIR) spectroscopy quantified a significant increase in the β-phase percentage within the EZ-PVDF film compared to bare PVDF. It is proposed that the development of extensive interfacial regions between the EZ nanoparticles and the PVDF matrix promotes the formation of a ferroelectric phase, a behavior that was conclusively verified through P-E loop measurements. Due to their demonstrated ability to generate a strong and responsive piezoelectric voltage signal in response to external mechanical stimuli, such as the movement of human body parts, these nanocomposite films present an excellent option for human-machine interface (HMI) applications. This includes their use in bending sensors and human motion detectors. Consequently, the EZ-PVDF nanocomposite film emerges as a highly promising candidate for a wide array of piezo-responsive device applications, encompassing wearable electronics, E-skins, human motion sensors for controlled robotic applications, flexibility monitors for various body parts, and efficient piezoelectric nanogenerators.

MDM-19: InGaAs QD as a Single-Photon Source for Quantum Technologies

I. Bashir1*, S. F. C. da Silva2, R. Singh1, S. Das1, A. Rastelli2, and S. Manna1
1Department of Electrical Engineering, Indian Institute of Technology Delhi, New Delhi,110016, India 2
Institute of Semiconductor and Solid State Physics, Johannes Kepler
University Linz, Linz, 4040, Austria
*email-id: ez238343@ee.iitd.ac.in

With the advent of quantum photonics, deterministic sources of single and entangled photons have become a cornerstone of next-generation quantum technologies. Among different quantum emitter platforms, III-V epitaxially grown semiconductor quantum dots (QDs) exhibit excellent potential as single-photon sources [1]. Recently, GaAs QDs in an AlGaAs matrix, fabricated via local droplet epitaxy (LDE), have demonstrated superior ensemble homogeneity, minimal intrinsic strain, ultra- small fine-structure splitting, narrow emission linewidths, and fast radiative decay [2][3]. In this work, we investigate shallow InxGa1−xAs nanohole QDs (~8 nm high, 50–60 nm wide) embedded in AlGaAs with varying indium compositions. The study focuses on strain effects and extending emission wavelengths beyond those accessible with GaAs or conventional InGaAs/GaAs QDs. The QDs are approximated as quantum wells, where vertical confinement dominates, and their electronic structure is modelled using the envelope function approximation by self-consistently solving the Schrödinger– Poisson equations. Two approaches are employed: the single-band effective mass model (SBM) and the more rigorous 8-band k·p method, which incorporates band coupling and strain effects. Strain fields resulting from lattice mismatch are incorporated using continuum elasticity theory. Figure 1 shows the simulated conduction and valence band profiles at 6 K, highlighting quantized energy levels and corresponding wavefunctions within the InxGa1−xAs QDs. We analyze the lowest-electron and higher-hole states, and evaluate the emission behaviour with and without strain. Estimated PL spectra from SBM at 6 K are shown in Figure 2, revealing multiple sharp transitions labelled (n,m), corresponding to radiative recombination between quantized hole (n) and electron (m) states. The results indicate that compressive strain induces a clear blue shift in transition energies, SBM predicts slightly lower transition energies than the 8-band k·p model as shown in Figure 3, While Increasing indium composition results in a systematic red shift, enabling emission tuning across a broader spectral range. These findings demonstrate that strain and alloy composition provide complementary tuning knobs for engineering the emission of InGaAs nanohole QDs. The insights gained from this modelling establish design guidelines for wavelength-specific QD emitters, paving the way for their integration into scalable single-photon sources for quantum communication and quantum information technologies.

MDM-22: Efficient dye degradation performance of Fe3O4-rGO nanocomposite.

Mihir Ranjan Bera1,2, Tilak Narayan Ghosh3, Makhanlal Nanda Goswami
1Department of Physics, Midnapore College (Autonomous), Midnapore, 721101, India. 2Department of Physics, Raja N.L. Khan Womens College (Autonomous), Midnapore, 721102, India. 3Department of Electronics, Midnapore College (Autonomous), Midnapore 721101, India.
e-mail: mihirranjanbera@gmail.com Abstract

Fe O -rGO nanocomposite has been successfully synthesized through a chemical co-precipitation process. The structural, morphological and elemental composition of the prepared nanocomposite have been thoroughly characterized using X-ray diffraction (XRD), Raman spectroscopy, field emission scanning electron microscopy (FESEM), Fourier-transform infrared spectroscopy (FTIR) and X-ray photoelectron spectroscopy (XPS). The XRD analysis represents the cubic nature of crystalline structure for Fe O nanoparticles with an average crystallite size around 15 nm. Raman and FTIR spectra reveal the successful reduction of GO and strong interfacial interaction between Fe O and rGO sheets. The study of XPS indicates the effective synthesis of Fe O -rGO nanocomposite protecting the main functionalities of rGO sheet while embedding mixed-valence iron oxides. The magnetic property of the sample has been investigated using a vibrating sample magnetometer (VSM) at room temperature confirms the superparamagnetic behaviour of the nanocomposite with saturation magnetization 15.85 emu/g. The bandgap energy of pure rGO and Fe O -rGO nanocomposite has been estimated from the study of UV-Vis spectra. It has been found that the bandgap energy is reduced for nanocomposite material than the pure rGO and suggested that the nanocomposite material have enhanced electronic interaction and improved light absorption ability. The photocatalytic performance of the synthesized nanocomposite has been evaluated for cationic Methyl Blue (MB) and anionic Methyl Green (MG) dyes under solar irradiation. The Fe O - rGO nanocomposite has exhibited excellent photocatalytic degradation efficiency, achieving over 90% removal of both dyes within optimized reaction conditions. These results suggest that the Fe O - rGO nanocomposite is a promising multifunctional material with significant potential for photocatalytic applications. The details of the result will be discussed at the time of presentation.

MDM-25: Impact of various Anti-Reflection Coating materials on GaInP solar cell performances

Madhupriya Samanta,1∗ Akhilesh Pandey,2 Mahadeva Bhat2 and Subhendu Sinha Sarkar2
1Centre for Millimeter wave Semiconductor Devices and Systems (SSPL), DRDO, Kolkata, India2
Solid State Physics Laboratory, DRDO, Delhi, India

*Corresponding or Presenting author email-id: madhu.samanta.drdo@gov.in

Recently, multijunction solar cell technology using III-V compound semiconductor gains immense importance in the field of renewable energy due to its ability to utilize almost the entire range [300-1800 nm] of solar spectrum. Triple junction solar cell (TJSC) is one of them in which, three p-n junction devices with different bandgaps are being integrated monolithically in tandem fashion. In this work, we explore the performance of single junction GaInP top cell of TJSC configuration and the effect of various Anti-Reflection Coating (ARC) materials on it. The entire design is carried out using Silvaco ATLASTM simulation package. Initially, GaInP cell with similar reported structure are simulated under AM1.5 solar radiation at 300K and performance parameters are found to be in close proximity with the existing literature under one sun illumination. In our study, quaternary material (AlxGa1-x)0.51In0.49P [x=0.3] is introduced as back surface field (BSF) materials instead of ternary BSF material i.e. Ga0.51In0.49P. In addition, the study includes the effect of various double layer ARC material combinations (SiO2/TiO2 and SiO2/Ta2O5) on top cell performances with AlGaInP as BSF layer at center wavelength 600 nm. The device structure and cell performances are presented in Figure 1a and 1b, respectively. Simulation results proclaim SiO2/Ta2O5 as more promising candidate as ARC material than SiO2/TiO2. Also, performances are simulated with theoretically calculated refractive index and thicknesses of each layer and results are in close proximity with SiO2/Ta2O5 ARC combinations. As compared to TiO2,Ta2O5 exhibits high thermal and chemical stability that in turn offers excellent protection for underlying materials [1]. In addition, Ta2O5 shows high optical transparency [2] in broad wavelength region ranges from the near-UV through the visible and into the near-infrared spectrum, whereas TiO2 is opaque in UV region. Its refractive index is also very close to theoretically calculated value [3]. The obtained results also indicate that almost 31% conversion efficiency improvement is achieved using double layer ARC as compared to bare [without ARC] devices. These results confirm the potential applicability of this cell as the top cell module in TJSC for space applications.

4. Quantum Materials and Devices

QMD-1: High Negative Differential Resistance in MBE grown Tri-layer MoTe2 based Resonant Tunneling Devices

Kajal Sharma1, Abir Mukherjee1, Samaresh Das1,2
1 Centre for Applied Research in Electronics, Indian Institute of Technology Delhi, India
2 Department of Electrical Engineering, Indian Institute of Technology Delhi, Delhi, India

Abstract
This study presents the observation of a distinct resonant conductance peak in a resonant tunneling diode (RTD) structure based on 2H-phase MoTe2. The fabricated heterostructure, comprising n-type WSe2/HfO2/intrinsic MoTe2/HfO2/Au, features a symmetric double-barrier configuration. The constituent layers include Molecular Beam Epitaxy (MBE) grown 2H-MoTe2 and Chemical Vapor Deposition (CVD) synthesized 2H-WSe2. A peak-to-valley current ratio (PVR) of approximately 4 was achieved at 4 K, marking the first such experimental demonstration in MoTe2-based RTDs. The PVR diminishes progressively with increasing temperature and becomes indiscernible beyond 60 K under low-bias conditions. Such resonant peak values increase with downscaling of the well width up to a certain value and then decrease with further miniaturization. These findings provide a pathway for the design and realization of MoTe2-based two-dimensional quantum tunneling devices, potentially enabling future low- temperature and high-frequency quantum electronic applications.

Keyword: Quantum Transport, Molecular Beam Epitaxy, Chemical Vapor Deposition, 2D-vertical Heterostructures

QMD-2: Understanding the role of environment and dielectric capping on the electrical properties of WS2 monolayers grown by Chemical vapour deposition technique

Umakanta Patra1, Sushantika Saha1, Shreyasi Das2, Mamta Raturi2, Ajoy Biswas1, Bhabani Prasad Sahu1,Saurabh Lodha2, Subhabrata Dhar1*

1Department of physics, Indian institute of technology Bombay, Mumbai, India,400076.
2 Department of electrical engineering, Indian institute of technology Bombay, Mumbai, India,400076.
*Corresponding author email: umakantapatra321@gmail.com

Effect of the environmental conditions and the dielectric capping on the electrical properties of monolayer (1L) WS2 film grown by chemical vapor deposition (CVD) technique is systematically studied. Characteristics of field effect transistors (FETs) fabricated on these films are investigated before and after capping the monolayer channels with Al2O3. 1L-WS2/SiO2/Si FETs under back-gated configuration show excellent performance with the on/off ratio reaching as high as 2 107, electron mobility of 26 cm2/V-s and subthreshold swings (SS) of 2.5 V/decade. Electron concentration ( ) and mobility ( ) in the channel increase by several-folds after capping. To understand the effect, annealing experiments are carried out under vacuum and controlled environments of different gases on uncapped device. The results point to the physisorption of oxygen molecules ( ) at the S-vacancy ( ) sites is the likely cause for the reduction of both and of the uncapped monolayer. Study reveals that and increase as a result of the removal of from the -sites upon capping. Al2O3 capped FETs are also examined using top-gate configuration. Interestingly, mobility is found to reduce by an order of magnitude when measured using top-gate as compared to the back gate configuration. This has been attributed to the gate-bias driven filling of the Al2O3/1L- WS2 interfacial traps acting as the carrier scattering centres. Al2O3/1L-WS2 interface is found to offer higher density of traps than SiO2/1L-WS2 interface. The study highlights the need of developing a comprehensive strategy to tackle the influence of intrinsic defects, adsorption and interfacial traps induced by gate dielectric on the performance of 1L-WS2 based FETs.

QMD-3: 2D Mo0.5W0.5S2 Ternary Alloy Micro-Supercapacitors for Flexible High-Energy Storage Devices

Animesh Mandal1*, Nikita Dey2, Deepak Kumar Sahu1, Prasanta Kumar Guha2,3 and Samit Kumar Ray1,
1 Department of Physics, Indian Institute of Technology Kharagpur, India-721302
2School of Nano Science and Technology, Indian Institute of Technology Kharagpur, India-721302,
3 Department of Electronics and Electrical Communication Engineering, Indian Institute of Technology Kharagpur, India-721302
*Corresponding author e-mail: animesh00108@gmail.com

Two-dimensional (2D) ternary alloys, such as MoxW1-xS2, have emerged as promising candidates for energy storage applications due to their superior conductivity, redox activity, and structural flexibility. Despite extensive studies on MoS2 and WS2, the potential of MoxW1-xS2 for supercapacitor applications remains largely unexplored, aside from a few reports on hydrogen evolution reactions (HER). In this study, we present the hydrothermal synthesis of Mo0.5W0.5S2 and its first application in flexible micro-supercapacitors with exceptional properties. The fabricated Mo0.5W0.5S2 electrode exhibits a high specific capacity of 171 F.g-1. Furthermore, the screen-printed flexible Mo0.5W0.5S2- based micro-supercapacitors showed a higher volumetric specific capacitance of 49.6 F·cm-3 (41.6mF·cm-2), an energy density of 6.89 mWh·cm-3, and a power density of 4769.2 mW·cm-3 within the 0–1.0 V operating window in an aqueous electrolyte. The device demonstrates excellent mechanical durability, retaining 76% of its capacitance after 300 charge-discharge cycles and 81% after 300 bending cycles. These results establish the potential of ternary 2D Mo0.5W0.5S2 as a high-performance electrode material for next-generation flexible and wearable energy storage applications.

QMD-4: Controlled Growth of Two-Dimensional Transition Metal Dichalcogenide (MoS2) Thin Films Using Chemical Vapor Deposition Technique

Pritam Mondal1*, Deepak Kumar Sahu1, Samit K. Ray1
1Department Of Physics, Indian Institute of Technology Kharagpur, Kharagpur-721302, India
pritamphy.24@kgpian.iitkgp.ac.in

Transition Metal Dichalcogenides, characterized by the chemical formula MX_2 (where M represents a transition metal and X denotes a chalcogen), have emerged as two-dimensional materials owing to their adjustable electrical and optical properties. However, the growth of single-layer, uniform large-scale 2D materials remains a tough challenge due to various aspects (precursor flow rate, growth temperature, growth duration, and precursor reaction rate) that can significantly affect film development. The chemical vapor deposition technique is one approach for synthesizing these materials. Among all deposition processes, chemical vapor deposition (CVD) is considered as the most adaptable method for producing high-quality, precisely controlled films with strong adhesion and large-area synthesis. We have achieved large-area growth of bilayer/few-layer MoS_2 films on SiO_2/Si substrates via the CVD process and evaluated the optimal growth parameters for uniform large-area deposition. We utilized molybdenum trioxide (MoO_3) and sulfur (S) as precursors for the growth of MoS_2, with argon being supplied as the carrier gas. The synthesis was conducted at atmospheric pressure within a two-zone CVD chamber. Zone 1 comprises S powder on a quartz boat at a temperature of 300°C, whereas zone 2 has MoO_3 powder on a quartz boat at varying temperatures between 800°C and 850°C. We have synthesized MoS_2 by adjusting the gas flow rate between 20 SCCM and 100 SCCM. Optical microscopy and Raman characterization revealed that at a flow rate of 20 SCCM and a temperature of 800°C in zone 2, a substantial area of uniform bilayer/few-layer MoS_2 growth is present. Conversely, at elevated precursor flow rates, the flow diverges from the deposition zone. At high deposition temperatures, triangular flakes are absent or present in small numbers, accompanied by numerous cracks due to growth-induced strain. Future investigations into MoS_2 will focus on wafer-scale, defect-controlled synthesis for integration with silicon platforms, enabling the development of high-performance nanoelectronics and optoelectronic devices [1].

QMD-5: Studying the quantum dot position induced variability in the multi-threshold transfer characteristics of a Double Quantum Dot Nanowire Field-Effect-Transistor (DQD-FET)

Nilayan Paul,1,* and Sanatan Chattopadhyay,1,2
1Department of Electronic Science, University of Calcutta, 92 A. P. C. Road, Kolkata 700009, India.
2Centre for Research in Nanoscience and Nanotechnology (CRNN), University of Calcutta, JD Block Sector III, Kolkata 700106, India.
*Corresponding author: npelc_rs@caluniv.ac.in

The emergence of fundamental physical limits to dimensional scaling of materials and devices has hindered the aggressive downscaling of Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET) devices, which are the building blocks of modern-day information processing systems. Therefore, to tackle increased information densities in the present era of 'Big data', researchers are actively pursuing alternative information processing techniques both at the device-level and algorithm- level. Among such techniques, multi-valued logic (MVL), where information is encoded in a basis of n number of states (n>2) has gained significant attraction [1, 2]. However, MVL systems built on basis of the binary CMOS devices suffer from increased complexities in their implementation [3 – 5]. In this context, monolithic multi-threshold devices exhibiting with emerging materials, phenomena including resonant tunneling and negative differential resistance/transconductance are attractive for MVL [6 – 9]. Utilizing the energy states of quantum dots (QDs) to manifest thresholds is also being explored to generate MVL devices due to the tunablity of their size and hence, the transfer characteristics [10 – 11]. However, chemically synthesized QDs are cumbersome to incorporate in CMOS process which are essential for large scale device fabrication. Thus, QDs manifested in already achieved quantum scale FET architectures can be adapted for voltage-controlled multi-threshold devices, even with the possibility of room temperature operation [12]. Also, more than one QD can be generated in the channel to create the opportunity for accommodating process level variabilities [13].

Therefore, current work studies the impact of variability in quantum dot positions on the multi-threshold transfer characteristics of a double quantum dot generated in the channel of a silicon nanowire field effect transistor (see Fig. 1(a)) using non-equilibrium Green's function (NEGF) formalism. In such a device two separate localized gates create two QDs within the channel. Transport through the QDs is modulated through appropriately applied voltages, VG1 and VG2 at gate-1 and gate-2, respectively. The transfer characteristics of the device exhibits multiple thresholds as shown in Fig. 1(b). The impact of variability in QD-1 and QD-2 positions on the transfer characteristics are shown in Fig. 2 and 3, respectively. As apparent variability in QD-1 position has a lesser impact on the nature of thresholds than QD-2 position, indicating the resonant tunneling from QD-2 to drain to be the driving factor for manifesting thresholds. A smaller separation between QD-2 and drain broadens the resonance to create broadened thresholds (higher sub-threshold swing ~ 46 mV/decade) at relatively lower voltages whereas a larger separation sharpens such resonance to lead to sharpened thresholds (lower sub-threshold swing ~ 12 mV/decade) at higher gate voltages. However, a smaller inter-dot separation, i.e., larger QD-2/drain separation improves inter-dot tunneling to lead to enhanced drain current. As apparent in Fig. 2, the current level increases from ~ 10-5 μA/μm in Fig. 2(a) (7 nm inter- dot separation) to ~ 10-1 μA/μm in Fig. 2(e) (3 nm inter-dot separation). Further, the variability in QD- 1 position has negligible impact on current levels and sub-threshold swing as apparent in Fig. 3. Therefore, any variability in current levels due to QD-2 position may be accommodated by suitably varying the voltage applied at QD-1.

QMD-6: Noninvasive Nitric Oxide Detection for Biomedical application

Suvra Prakash Mondal*, and Dulal Chandra Patra
Department of Physics, National Institute of Technology, Agartala, Tripura, 799046, India
*Corresponding or Presenting author email-id: suvraphy@gmail.com

Nitric oxide (NO) is one of most important cellular signaling molecules responsible for blood pressure regulation, vasodilation, neurotransmission, immune response and several physiological process. Any deviation of NO concentration in body fluids causes deadly diseases like Parkinson’s disease, fibrosis, hypertension, rheumatoid arthritis etc. Noninvasive detection of NO in our body fluids is very much attractive for early prediction of our health condition. Here, we report on the fabrication of nanomaterial based electrochemical sensors which selectively detect NO in human saliva and artificial tears. Platinum (Pt) decorated titanium dioxide (TiO2) nanoparticles were studied for NO sensing in human saliva. The sensor demonstrated high sensitivity (~7.8 µA mM-1 cm-2) in wide linear detection range (10 nM-28 mM) and demonstrated ultra-low detection limit (~2.4 nM). A paper-based Au nanoparticle deposited carbon cloth sensing electrode was studied for electrochemical NO detection in artificial tears. Working, reference and counter electrodes were fabricated by painting carbon ink on paper substrates. Such low-cost paper- based electrode demonstrated sensitivity of 0.42 µA µM-1 in the linear range 10nM to 1.4 mM. The detection limit of the NO sensor was achieved 2.34nM. Both the sensing electrodes are highly stable, reproducible and selective towards NO among various interfering agents present in saliva and tears. Our study demonstrates the potential application of nanomaterials-based electrochemical NO sensors for biomedical applications.

QMD-9: Improved Charge Retention in Chemically Tailored Cellulose Triboelectret Aerogels for High-Performance, Sustainable, Self-Powered Tactile Sensors

Sunidhi Mishra,1 Dalip Saini,2 Sudip Naskar,2 Dipankar Mandal*,2 and Pradip K. Maji*1
1Department of Polymer and Process Engineering, Indian Institute of Technology Roorkee, Saharanpur Campus, Saharanpur, 247001, Uttar Pradesh, India
2 Quantum Materials and Devices Unit, Institute of Nano Science and Technology, Knowledge City, Sector 81, Mohali 140306, Punjab, India
*Corresponding authors: Pradip K. Maji, Email: pradip@pe.iitr.ac.in
Dipankar Mandal, Emal: dmandal@inst.ac.in

With the rapid proliferation of wearable electronics, biomedical devices, and smart sensors, there is an urgent need for sustainable, reliable power sources capable of enabling long-term autonomous operation.1 Triboelectric nanogenerators (TENGs) have emerged as a promising solution by harvesting ambient mechanical energy; however, their widespread adoption is hindered by poor charge retention and limited device stability.2,3 To overcome these challenges, we report the design of a novel triboelectret nanogenerator (E-TENG) based on hydrophobic, chemically functionalized cellulose nanofibers derived from waste biomass. The cellulosic materials are selectively modified with nitro groups to establish tribo-negative interfaces and stearoyl groups for tribo-positive interfaces (Figure 1). The tribo-positive layer is fabricated as a hydrophobic aerogel with corona discharge electret properties, significantly enhancing charge storage and operational durability. This approach yields a high-power density with electrical output stability sustained over 30 days. Additionally, the E-TENG effectively transduces complex biomechanical motions finger, wrist, and muscle movements as well as tactile stimuli in real-time without external power. This scalable, eco-friendly platform advances the development of next-generation self-powered wearable electronics, human-machine interfaces, and implantable healthcare systems.

QMD-10: Photo-Induced Phase Modulation in Ferroelectric Polymer: A Pathway to Next-Generation Electroactive Devices

Utsa Sarkar,1 Ashish,2 Dalip Saini,1 Gaurav Jhaa,2 Sudip Naskar,1 Ankit Kumar Gaur,2 Priyakumari Chakkingal Parambil,2 Sugumar Venkataramani2,* and Dipankar Mandal1,*

1Quantum Material and Devices Unit, Institute of Nano Science and Technology, Knowledge city,sector-81, Mohali 140306, India
2Department of Chemical Sciences Indian Institute of Science Education and Research (IISER) Mohali Sector 81, SAS Nagar, Knowledge City, Manauli, Punjab 140306, India
*Corresponding Authors: Sugumar Venkataramani, Email: sugumarv@iisermohali.ac.in, Dipankar Mandal, Email: dmandal@inst.ac.in

Polyvinylidene fluoride (PVDF), a semi-crystalline ferroelectric polymer, exhibits multiple crystalline polymorphs with the nonpolar α-phase (TGTG′ conformation, space group: P21/c) being the most thermodynamically stable but non-electroactive, while the polar β-phase (TTTT conformation, space group: C2mm) possesses the highest net dipole moment and is highly desirable for electroactive
applications [1]. Conventional methods to induce the β-phase, such as mechanical stretching, high electric field poling and thermal annealing are constrained by low conversion efficiencies, irreversible microstructural degradation and risk of dielectric breakdown [2]. In this study, a photoactive strategy is introduced to modulate phase content and electroactive behaviour in PVDF. Light irradiation is utilized to induce conformational transitions that enhance the β-phase proportion in the polymer, leading to notable improvements in its ferroelectric and dielectric characteristics. The practical implications are validated by fabricating a piezoelectric nanogenerator. Additionally, the composite displays robust piezo-phototronic coupling under simultaneous mechanical and optical stimuli producing a three-fold increased current after light treatment. This work establishes a novel paradigm for the reversible, non- destructive tuning of the electroactive and ferroelectric characteristics of PVDF using light as an effective tool, offering a versatile platform for the development of smart materials with tuneable ferroelectric and piezoelectric functionalities for advanced applications in sensors, actuators, and energy harvesting devices.

Keywords: Photoactive, Light Irradiation Ion-Dipole Interaction, Energy Harvesting, Piezo-Phototronic Effect

QMD-11: Spatiotemporal Interactions in Nickelates Neural Networks: Imaging and Neuromorphic Applications

Tamal Dey1, 2*, Shriram Ramanathan1
1Department of Electrical and Computer Engineering, Rutgers University, New Jersey 08854, United States
2Currently at Department of Physics, Indian Institute of Technology Kharagpur, West Bengal 721302, India
*Corresponding author: tamald40@gmail.com

Perovskite Nickelates are a well-known class of strongly correlated quantum materials that exhibit a collective phase change at their metal-to-insulator transition (MIT) temperature. $NdNiO_3$, referred to as NNO hereafter, is one of the well-known nickelate materials whose MIT phase change happens between 100K and 150K, hindering their application in room temperature electronics. Hydrogen doping of NNO exhibits a dramatic change in electrical resistance, and NNO becomes highly insulating hydrogenated $NdNiO_3$ (H-NNO) at room temperature. Hydrogen doping incorporates a proton into the nickelates, which moves through the lattice through drift and diffusion, and causes local phase change and resistance tuning. Protons, the lightest ion, enable very low-power device operations. Here, we present perovskite nickelate devices with spatiotemporal protonic dynamics and successful wafer-scale integration of their networks to demonstrate an all-perovskite neuromorphic computing platform. Kelvin probe microscopy has been used to spatially map the density of protons locally at different drift and diffusion distances to image the dopants in neuromorphic hardware.
Neuromorphic computing aims to create intelligent systems that mimic the brain's way of processing information. Current hardware approaches to neuromorphic computing typically focus on individual components such as discrete neuron or synapse devices rather than the network as a whole. This contrasts with the complex topology of biological computation systems, where the interaction between structure and function is critical for emergent computational capabilities. As a result, such approaches may fall short in capturing the emergent collective dynamics of biological neural networks, where complex computation naturally arises from self-organizing spatiotemporal interactions among interconnected neurons. No single material system has demonstrated the complex interplay of nonlinear switching dynamics and emergent spatiotemporal behavior, nor have nonvolatile switching characteristics been required for such integration. We achieved this by uniquely combining distinct ultrafast nonlinear transient dynamics, nonvolatile switching characteristics, and emergent spatiotemporal interactions possessed by devices made of hydrogenated perovskite nickelates, a single, unified material system. Spontaneous spatial interactions characteristically emergent in networks of hydrogenated perovskite nickelate devices enhanced feature transformations and increased accuracy in spoken digit recognition. Nonlinear spatiotemporal interactions also enabled early detection of seizures in neural recordings from humans. Protonic information processing in perovskite nickelates provides substantial savings in energy consumption and operation speed compared to conventional neuromorphic approaches, while offering seamless integration with existing semiconductor technologies, positioning it as a compact and scalable solution for next-generation intelligent systems. By engineering symmetric and asymmetric H-NNO junctions, we realized the dynamic, time-dependent short-term properties essential for nonlinear spatiotemporal processing, and the stable,

programmable long-term characteristics required for output encoding—all within a single integrated system. Spatiotemporal interactions between nodes emerge naturally from the intrinsic properties of the material and external inputs, facilitating the self-organized formation of recurrent connections. Our approach leverages ultrafast protonic dynamics (~500 ns) and emergent connectivity in H-NNO films, creating an energy- efficient (0.2 nJ per input) and compact brain-inspired computational system capable of real-time data processing without the need for fine-tuning of individual nodes. The synaptic plasticity measurements are implemented in spiking neural networks and show promising results for classification (SciKit Learn's Iris and Wine data sets) and control (OpenAI's CartPole-v1 and BipedalWalker-v3) simulation tasks.

QMD-12: Investigating the impact of Au-nanoparticle modified interface on the electrical and photo-electrical performance of Al/ZnO/p-Si MOS structure

Anisa Mukherjee,1,*Nilayan Paul,1 Aindrila Roy,1 and Sanatan Chattopadhyay1,2
1Department of Electronic Science, University of Calcutta, Kolkata 700009, India
2Center for Research in Nanoscience and Nanotechnology (CRNN), Kolkata, India
*Corresponding author: anisamukherjee04@gmail.com

The uncontrollable charge carrier tunneling through gate oxide poses major challenges towards the realization of emerging nanoscale electronic and optoelectronic devices. Therefore, engineering of gate dielectrics and interfaces in nanoscale Metal-Oxide-Semiconductor (MOS) structures is a critical area of research, since it can enable desired control over such tunneling [1]. Interestingly, zinc oxide (ZnO), which commonly exhibits n-type conductivity, can also exhibit insulating property in presence of negligible effective carrier concentration. This can be achieved by engineering both the stoichiometry as well as the presence of self-compensating donor and acceptor defects [2]. Further, ZnO exhibits CMOS compatibility, with a dielectric constant in the range of 6-10 [3]. However, very few electrical studies have been conducted on silicon-based MOS structures with ZnO and doped ZnO as gate dielectrics [4-6]. Thus, further engineering of nanoscale ZnO/Si MOS structure is essential for achieving controlled tunneling of carriers. In this context, the current work aims to engineer such ZnO-based MOS structures by embedding gold (Au) nanoparticles (NPs) at the ZnO/Si interface. To understand the impact of Au nanoparticle incorporation, electrical and photo-electrical measurements have been carried out on Al/ZnO/p-Si and Al/ZnO/Au NP/p-Si structures. For such purpose, ZnO thin film is thermally evaporated on RCA cleaned p-type Silicon (p-Si) substrates with resistivity 1-10 Ωcm. The thickness of the ZnO film is obtained to be ~30nm from spectroscopic ellipsometry. The sheet resistance of the film is found to be higher than 1 MΩ. Au nanoparticles have been chemically synthesized using citrate reduction method [7]. UV-Vis Absorbance spectroscopy is employed to obtain absorbance of the as-deposited ZnO film and synthesized Au NPs. For Al/ZnO/Au NP/p-Si structure, a 60 μL volume of the as-synthesized Au nanoparticles solution is drop-casted on cleaned silicon substrate and followed by ZnO deposition. Subsequently, aluminium metal contacts have been evaporated on both ZnO/p-Si and ZnO/Au NP/p-Si structures using a shadow mask. Frequency dependent capacitance-voltage (C-V) measurements have been conducted to investigate the influence of Au NP incorporation on the dielectric response of the Al/ZnO/p-Si MOS structure. Additionally, current-voltage (I-V) measurements have been performed both in dark and light conditions (AM 1.5 solar simulated illumination) to examine the leakage current behavior. UV-Vis absorbance spectroscopy of ZnO thin film revealed absorption peak in the UV wavelength region of 320-350 nm as shown in Figure 1(a). The optical bandgap of as-deposited ZnO film is obtained as 3.25 eV from Tauc's plot in inset of Figure 1(a). Figure 1(d) portrays the optical absorbance spectrum of the synthesized Au NPs with an absorption peak at 520 nm which is consistent with reported values in literature [8]. The C-V plots of Al/ZnO/p-Si and Al/ZnO/Au NP/p-Si for varying frequencies in the range of 50 kHz to 1 MHz is presented in Figure 1(b) and Figure 1(e), respectively. The increased frequency dispersion and negative shift of flat band voltage is observed in the Au NP incorporated MOS structure which indicates the introduction of higher defect density into the structure. The interface trap density (Dit) and fixed oxide charge density is calculated and presented in Table 1. It shows that the Dit is increased by almost 4 times whereas, the fixed oxide charge density has approximately doubled due to Au NP incorporation. Such increase in the defects is also observed to affect the I-V characteristics of the MIS structures as shown in Figure 1(c) and Figure 1(f). The dark current has increased from 8.56×10-6 A/cm2 to 2.37×10-5 A/cm2 (Table 1). Interestingly, the incorporation of Au NPs in the Al/ZnO/p-Si MOS structure also leads to an enhancement in photocurrent and an improved photo-to-dark current ratio, as depicted in Table 1. Thus, this investigation shows the potential of nanoparticle engineered ZnO-based MOS structures for the development of future nanoelectronic and optoelectronic devices.

QMD-13: Ni-Doped $CuCo_2O_4$ Spinel Nanostructures for Enhanced Supercapacitor and Oxygen Evolution Reaction Performance: An Experimental and Theoretical Insight

Pritam Sinha[1,*], Arun Karmakar[2], Krishnanshu Basak[3], Subrata Kundu[4], Debnarayan Jana[5] and Achintya Singha[6]
1,*. Department of Physical Sciences, Bose Institute, EN 80, Sector V, Bidhannagar, Kolkata 700091, India.
2. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002,India.
3. Department of Physics, University of Calcutta, 92 Acharya Prafulla Chandra Road, Kolkata-700009, India.
4. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India.
5. Department of Physics, University of Calcutta, 92 Acharya Prafulla Chandra Road, Kolkata-700009, India.
6. Department of Physical Sciences, Bose Institute, EN 80, Sector V, Bidhannagar, Kolkata 700091,India.
*Email-id: pritam.sinha@jcbose.ac.in

The transition towards sustainable and renewable energy systems requires the development of high-performance materials that can efficiently store and convert energy[1, 2]. In this context, transition metal-based spinel oxides have attracted considerable attention due to their unique redox properties, structural stability, and abundant active sites[3]. Among them, $CuCo_2O_4$ has emerged as a promising bi-functional material for both energy storage and electro-catalytic water splitting applications. However, its practical performance is often limited by moderate electrical conductivity and sluggish charge transfer kinetics[4]. To address these challenges, we designed and synthesized Ni-doped $CuCo_2O_4$ nanostructures through a facile hydrothermal method, where Ni^{2+} ions were selectively incorporated into the octahedral sites of the spinel lattice with varying doping levels (2, 4, 6, and 8 at%). The structural, morphological, and compositional analyses confirmed successful Ni incorporation without disturbing the spinel phase, while inducing subtle lattice distortions beneficial for electronic modulation. The electrochemical performance was evaluated in both supercapacitor and oxygen evolution reaction (OER) configurations. In the case of supercapacitors, the 4% Ni-doped $CuCo_2O_4$ electrode exhibited the highest specific capacitance of 470 F g^{-1} at a current density of 1 A g^{-1}, which is significantly higher than the pristine $CuCo_2O_4$. The improvement can be attributed to the optimized Ni doping that enhances electrical conductivity and promotes faster redox reactions. Electrochemical impedance spectroscopy (EIS) analysis revealed a marked decrease in charge transfer resistance with Ni incorporation, supporting the improved ion–electron transport dynamics within the electrode material. For the OER activity, the 6% Ni-doped $CuCo_2O_4$ sample displayed superior catalytic performance, requiring an overpotential of only 340 mV to achieve a current density of 10 mA cm^{-2}, along with a low Tafel slope of 96 mV dec^{-1}, indicating faster reaction kinetics. Moreover, the turnover frequency (TOF) analysis revealed a maximum value of 1.01 s^{-1} for the 6% Ni-doped catalyst, demonstrating its enhanced intrinsic catalytic activity compared to the un-doped sample.

These findings suggest that controlled Ni substitution at octahedral Co sites optimizes the balance between structural stability and electronic conductivity, leading to synergistic improvements in both charge storage and oxygen evolution processes. To further understand the experimental observations, density functional theory (DFT) calculations were performed to examine the electronic structure and quantum capacitance of the pristine and Ni-doped systems. The density of states (DOS) analysis showed that Ni doping significantly increases the population of electronic states near the Fermi level, thereby improving electrical conductivity and charge transfer capability. In addition, the calculated quantum capacitance (Cq) values exhibited a noticeable enhancement with Ni incorporation, correlating well with the experimental capacitance results. Beyond a certain level excessive Ni doping introduced structural distortions and reduced electronic mobility, explaining the observed decline in performance at higher doping concentrations. In summary, this combined experimental and theoretical investigation demonstrates that controlled Ni doping in CuCo2O4 spinel oxide effectively tailors its electronic configuration, facilitates charge transport, and enhances electrochemical activity. The optimized Ni-doped CuCo2O4 material exhibits excellent bi-functional performance, making it a promising candidate for integrated energy storage and green hydrogen generation technologies. The insights gained from this study provide valuable guidance for rational design of multicomponent spinel oxides toward next-generation sustainable energy systems.

QMD-14: Alloying as a new route to generating interlayer excitons

Suvadip Masanta,

1, a, ∗ Chumki Nayak,1 Premananda Chatterjee,2 Atindra Nath Pal,2Indrani Bose,1and Achintya Singha1
1 Department of Physical Sciences, Bose Institute, EN 80, Sector V, Kolkata 700091, India
2 Department of Condensed Matter and Materials Physics, S. N. Bose National Centre for Basic Sciences, Kolkata 700106, India
* Email-id: suvadip.masanta@gmail.com

Heterobilayers formed by stacking two-dimensional atomic crystals are particularly promising for low-dimensional semiconductor optics, as they host interlayer excitons-bound states of electrons and holes residing in different layers. They inherit the valley-contrasting physics of the individual monolayers, leading to a range of novel and intriguing properties that distinguish them from other solid-state nanostructures. Here, we propose a novel route for the generation of interlayer excitons based on the synthesis of a transition metal dichalcogenide (TMDC) bilayer alloy material, $WS_{2x}Se_{2(1-x)}$ .Using piezoelectric force microscopy, we demonstrate the existence of an internal electric field oriented in the out-of-plane direction. Interlayer excitons have so far been mostly observed in heterostructures with a type-II band alignment [1-3]. The generation of interlayer excitons in the alloy bilayer has, however, not been demonstrated as yet. In the presence of an internal electric field, a similar alignment occurs in the alloy bilayer resulting in an efficient generation of interlayer excitons [4].
Photoluminescence spectroscopy measurements involving circularly polarised light come up with key observations like a negative degree of circular polarization of the interlayer excitons which increases as a function of temperature [4]. A simple theoretical model provides a physical understanding of the major experimentally observed features. With experimentally fitted parameter values, the dominant contribution to the degree of circular polarization is shown to arise from spin polarization and not from valley polarization, a consequence of the spin-valley-layer coupling characteristic of a TMDC bilayer. The interlayer excitonic transition at room temperature in the bilayer alloy TMDC holds profound implications for fundamental physics, including the study of emerging states of matter such as Bose- Einstein condensation and high-temperature superfluidity. Additionally, it would offer enhanced functionalities for valleytronics and quantum information applications.

QMD-17: Performance Analysis of Graphene Nanoribbon Interconnect

Kirti P. Pattanaik,* Simran Patra, Arabinda Sahoo, and Narayan Sahoo
Electronic Science Department, Berhampur University, Berhampur, Odisha, India
*bkp.gopal10@gmail.com

Copper (Cu) has been the dominant interconnect material in electronics for decades. However, as technology scaled down to nanometer dimensions, copper faces significant reliability challenges, including reduced electrical and thermal conductivity, skin and parasitic effects, short mean free path, and mechanical stress issues [1]. These limitations prompted researchers to find alternative materials suitable for nanoscale integrated circuits. Graphene, particularly in the form of Graphene Nanoribbons (GNR), emerged as an alternative material for interconnects due to its high electron mobility, low resistivity, and high thermal conductivity. In addition, its limited widths, which are carved from a monolayer graphene sheet, have been demonstrated to possess peculiar electronic characteristics. Depending on the limited width, armchair graphene nanoribbons (AGNRs) are classified into three configurations: 3n, 3n+1, and 3n+2, where n is an integer [2]. Out of the three configurations, 3n+2 exhibited metallic behaviour. Thus, using this extraordinary property different shaped GNR interconnects have been designed, which helps in improving the transport properties of nanocircuits and nanoelectronics [3, 4]. Here, we investigated the electronic and transport properties of AGNRs with a width of Wa = 11 atoms and different angles, such as 1800, 1200, and 600 , as shown in Fig. 1(a)-(c), respectively. The numerical computation is analysed based on the tight binding model with a combination of non- equilibrium Green's function (NEGF) formalism using an open-source tool TBETA [5]. It is observed that, although the lead angle changes, a zero bandgap is present near the energy E = 0 eV, as depicted in Figs. 2(a)-(c), respectively. Therefore, the conductance near the zero energy possesses unity (1 e2 /h) [Fig. 3(a)-(c)] for the lead. Further, when we move away from the E = 0 eV to 1.5 eV, the conductance increases for all three cases (Fig. 3). It is because the number of subband energies increases in the band structure, as illustrated in Fig. 2. While moving beyond 1.5 eV, the conductance decreases for all three angles due to the reduction of subband energy states. However, for the junction region, we obtain a unity step conductance at an angle of 1800. Due to the absence of the junction region, electrons can easily transmit from one end to the other [Fig. 3(a)]. While the 1200 AGNR junction produces zero conductance at E = 0 eV [Fig. 3(b)]. Due to the angle variation, the edge of the corresponding configuration changes, as shown in Fig. 1 (b). Therefore, the density of states near the junction is very low at E = 0 eV, resulting in electron scattering near the junction, which causes zero conductance.
However, at 600 the AGNR junction possesses 1 e2/h with some fluctuation at around E = 0 eV. It is because the contacts are coupled with the inverse sublattices of the scattering region [Fig. 1 (c)] resulting from delocalised electron density of state over the junction region, which leads to the flow of electrons from one end to another end with minimal line edge scattering.

QMD-18: Modelling and Optimizing Flexible Multimodal Nanogenerators Using Thevenin's Theorem

Parvathy Ravindranath, Dalip Saini, and Dipankar Mandal*
Quantum Materials and Devices Unit, Institute of Nano Science and Technology, Knowledge City, Sector 81, Mohali, 140306, India
*E-mail: dmandal@inst.ac.in

Flexible energy harvesters that convert ambient mechanical, thermal, and magnetic fluctuations into electricity are crucial for powering the expanding ecosystem of wearable sensors, implantable medical devices, and distributed Internet-of-Things nodes1 . In real-world settings, these systems must deliver stable power despite intermittent stimuli, which places stringent demands on their internal impedance and power-density dynamics. Although bimodal hybrid harvesters that combine piezoelectric, pyroelectric, and magnetoelectric effects have been proposed2, systematic studies on how the simultaneous activation of multiple energy-conversion pathways reshapes the device's internal resistance and thus its power-transfer characteristics remain scarce. Here, we report, for the first time, a trimodal piezo-pyro-magnetoelectric nanogenerator (PPyMENG) fabricated from an electrospun poly(vinylidene fluoride) (PVDF) fibre mat uniformly embedded with polydopamine (PDA)-coated cobalt-ferrite (CFO) nanoparticles. The flexible composite utilizes β-phase crystallites confined within PVDF nanofibers for piezo- and pyroelectric responses, and the magnetostrictive response from CFO nanoparticles within the nanofiber matrix, enabling three parallel energy conversion processes to occur concurrently. Progressive activation of the three modes reduced the measured internal resistance from 1.9 MΩ (piezo-only) to 0.7 MΩ under combined stimuli, a 63% decrease, corresponding to a power density increase to 22.4 μW m−2. A comprehensive Thevenin equivalent circuit comprising three resistive-capacitive branches was derived, and the Maximum Power Transfer Theorem was applied to predict optimal load matching. Experimental load-power measurements matched the circuit model with <5 % deviation, confirming the analytical framework. The results demonstrate that multi-stimuli activation can be harnessed as a deterministic tool for internal-resistance engineering, unlocking higher power densities without altering the device geometry. This insight provides a robust design paradigm for next-generation flexible multimodal harvesters, paving the way toward truly autonomous wearable and implantable electronics.

Keywords: PVDF nanofibers, Ferrite composites, Magnetoelectric, Pyroelectric, Hybrid nanogenerator

QMD-19: Gate-Defined Few-Electron/Hole Quantum Dots: An Indigenous Effort towards Developing a Spin Quantum Computing Architecture

Sounak Samanta,1,2,* Varsha Jangir,1,2 Devashish Shah,1,2 Siddarth Rastogi,1,2 Lokesh Patra,1,2Arnav Jain,1,2 Kanishk Modi,1,2 Uditendu Mukhopadhyay,1,2 and Suddhasatta Mahapatra,1,2
1Department of Physics, Indian Institute of Technology Bombay, Mumbai, 400076, India
2Centre of Excellence in Quantum Information, Computing, Science & Technology, IIT Bombay, Mumbai, 400076, India
* Corresponding or Presenting author email-id: sounak@iitb.ac.in

The spin states of a single electron (or hole), confined in a semiconductor quantum dot (QD), offer a compelling realization of a quantum two-level system that can serve as a robust and scalable qubit candidate. Electron/hole spins can be manipulated using electric and magnetic fields, and read-out via spin-to-charge conversion, thus enabling high-fidelity coherent control, initialization and measurement. Furthermore, the inherent technological advantage of the semiconductor platform - compactness, compatibility with the CMOS technology and scalability, make the spin qubits strong candidates for development of quantum computing architectures. In this work, I will summarize the progress we made towards fabrication and characterization of few-electron (few-hole) QDs, towards realization of a scalable spin-QC architecture. In particular, I will report the fabrication of a linear array of 8 QDs in a modulation-doped GaAs/AlGaAs heterostructure, and demonstrate efficient control of the QD occupancy, by dynamical tuning of the tunnel barriers [1]. Next, we report the characterization at mK temperature of a few-hole tunnel-coupled double-QD device in a fully-depleted silicon-on-insulator (FDSOI) platform. The FDSOI platform is particularly promising due to its compatibility with standard CMOS processes, and foundry-based fabrication technology, offering a practical route to large-scale integration. Here, we emphasize on our study of the spin blockade phenomenon in transport measurements, and discusspossible reasons for its lifting in the FDSOI platform.

QMD-20: Enhanced cathodoluminescence in hBN-encapsulated two-dimensional WSSe alloy

Tanima Lai,1,* Suvadip Masanta,1 Chandani Dubey,1Ishrat Bashir,1 Samaresh Das,2and Santanu Manna1
1Department of Electrical Engineering, Indian Institute of Technology, New Delhi, 110016, India
2Centre for Applied Research in Electronics, Indian Institute of Technology, New Delhi, 110016, India
*Email-id: laitanima1@gmail.com

Two-dimensional (2D) transition metal dichalcogenide (TMDC) alloys offer extended tunability in their optical and electronic properties compared to their binary counterparts, making them highly attractive for applications in light-emitting diodes, valleytronics, photodetectors, and quantum emitters. While light- induced luminescence, known as photoluminescence (PL), in alloyed TMDCs has been explored to some extent, luminescence triggered by electron-beam, known as Cathodoluminescence (CL), provides an alternative excitation pathway with strong potential for novel device applications. This technique enables the probing of light emission beyond the diffraction limit by focusing an electron beam (e-beam) into a nanoscale probe (<100 nm) [1] and detecting the resulting optical emission in the far field. By tuning the energy of the e-beam, different depths within the sample can also be selectively excited.

CL thus allows nanoscale mapping of strain, composition, and doping through correlation with the corresponding optical emission. However, achieving efficient CL in 2D materials remains challenging due to their intrinsically low cross-section for electron-hole pair generation, which severely limits radiative recombination efficiency [2].

In this study, we demonstrate that CL emission from 2D WSSe alloy can be substantially enhanced by embedding the active layer within a van der Waals heterostructure. Specifically, the luminescent WSSe layer is encapsulated between two wide-bandgap hexagonal boron nitride (hBN) flakes, forming an hBN/WSSe/hBN heterostructure that exhibits a pronounced enhancement in emission intensity at 717 nm (1.72 eV) compared to single-sided configurations. This enhancement is attributed to the dual hBN layers acting as potential barriers that confine charge carriers within the WSSe layer, thereby promoting stronger excitonic recombination. In addition to the WSSe excitonic peak, the spectra also display several higher- energy features associated with defect-related emissions from hBN, consistent with spectra obtained from bare hBN regions showing a characteristic defect peak near 1.9 eV [3,4]. The emission intensity is further found to depend strongly on the thickness of the surrounding hBN layers. These observations establish that the hBN/WSSe/hBN heterostructure effectively enhances CL efficiency, overcoming the inherently weak electron-hole pair generation in 2D semiconductors. This approach offers a robust route for integrating WSSe alloys into next-generation optoelectronic and quantum photonic devices, and also holds promise for electron-emission–based technologies such as transmission electron microscope displays, surface- conduction electron emitters, and field-emission displays.

QMD-22: Skyrmionic phase in thin film metallic multilayers and two-dimensional van der Waals magnetic heterostructures

Neesha Yadav1, Yogesh Kumar1, Hurmal Saren1, Harish Chandr Chauhan1, Sandeep1, Nilesh Chowdhury1, Mayank Shukla1, Nicolas Reyren2, Fernando Ajejas2, Sachin Krishnia2, Vincent Cros2 and Pintu Das1
1Department of Physics, Indian Institute of Technology Delhi, New Delhi, India - 110016
2Unité Mixte de Physique, CNRS, Thales, Université Paris-Saclay, 91767, Palaiseau
Email: (Neesha.Yadav@physics.iitd.ac.in)

Skyrmions are two-dimensional, topologically protected, vortex-like swirling spin configurations [1]. Their unique properties, such as a low depinning threshold current, nanometric size scale, and robustness against external perturbations, make them promising candidates for high-density and energy-efficient memory and logic devices [2]. Electrical detection is critical to their potential application in spintronics-based devices [1,2]. To enable such applications, understanding the contributions of skyrmions to electronic transport properties is of paramount importance. Among various techniques, topological Hall resistivity—arising from the emergent magnetic field created by skyrmions on conducting electrons—has been widely utilized for identifying skyrmion phases [3].

In this work, we investigate the topological-like Hall resistance in the skyrmion-hosting thin film multilayer heterostructures. The skyrmion phase is characterized by a weak peak and hump behavior in Hall effect. Magnetic Force Microscopy (MFM) data are used to correlate these observations with the underlying magnetic textures. Also, the skyrmionic phase is investigated in van der Waals heterostructures comprising of a spin orbit coupled material and a ferromagnet. Mechanically exfoliated flakes of these materials are used to fabricate heterostructure devices which are used for magnetotransport measurements. We observe a clear signature of the magnetic skyrmions in the van der Waals heterostructures in electrical transport measurements. The results are discussed in light of the recent progress on topological Hall effect in such chiral magnetic textures.

QMD-23: Direct verification of Charge Density Wave State in Cu2-xTe single crystal: A Scanning Tunneling Microscopic study

Subhrajyoti Koley1, Suman Kamboj1, Sreelekshmi B.R.1, Mehdi Frachet2, A.A. Haghighirad2, Pintu Das1

1 Department of Physics, Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110016, India 2Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany Email (Presenter): Subhrajyoti.Koley@physics.iitd.ac.in

Charge density wave (CDW) is a subject of great interest in low-dimensional materials for decades. The formation of CDWs refers to spontaneous periodic variation in electronic charge density, that often are accompanied by a corresponding distortion in the crystal lattice [1]. Transition metal chalcogenides (TMCs) have emerged as prominent candidates for exploring the physics of CDW due to their diverse electronic properties and structural versatility. Cu2-xTe is one such material, possessing a hexagonal Nowotny phase [2]. Here we report the results of comprehensive temperature dependent Scanning Tunneling Microscopy/Spectroscopy (STM/S) studies of well characterized Cu2-xTe single crystals which were grown by flux method [3]. The CDW transition temperature of (Tcdw) ≈ 150 K was confirmed by electrical transport measurements. STM/S measurements were carried out using a commercial STM (make: Unisoku, Japan) for crystals which were cleaved at room temperature and under UHV conditions. Atomically flat terraces of height ≈ 0.62 nm are observed, hexagonal atomic arrangement is observed on the surface as well (inset, top left) (Fig. 1a). The atomic resolution topographic images at T ≈ 77 K show direct evidence of linearly ordered clusters of atomic dimers on Te terminated ab plane (Fig. 1b). Additionally, a series of other different reconstructions are also observed. The atomic distance on the surface is found to be ≈ 0.44 nm. The local STS measurements carried out on the dimers reveal a gap like feature of ≈ 280 meV (Fig. 1c). Our STS results on differently reconstructed surfaces at $T<T_{cdw}$ may provide important insights for electronic states of Cu2-xTe close to the Fermi level.

QMD-25: Formation of Quantum Pyramids in Electrochemically Etched Nanostructured Silicon Powder

Saddam Khan, 1,* Suman Santra, 1 Subhajit Roy Chowdhury, 1 Sudipta Chakrabarty, 2 Shayari Basu,3 and Syed Minhaz Hossain1
1Department of Physics, Indian Institute of Engineering Science and Technology, Shibpur, Howrah, India
2 Institute of Physics, Bhubaneswar, India
3Department of Basic Science and Humanities
Dr. Sudhir Chandra Sur Institute of Technology and Sports Complex, Kolkata, India
*Corresponding or Presenting author email-id: saddam.iiests@gmail.com

Nanostructured silicon (NanoSi) has emerged as a promising material for next-generation optoelectronic, photovoltaic, and sensing devices due to its tunable electrical and optical properties [1]. Controlling nanoscale morphology and crystallinity is crucial for optimizing material performance in such applications. Despite extensive progress in the electrochemical synthesis of NanoSi, the fundamental mechanisms governing strain development and morphological evolution during etching remain insufficiently understood. In particular, deviations from the commonly assumed columnar or rod-like geometries suggest the presence of complex growth pathways influenced by anisotropic dissolution. Conventional characterization techniques, such as Atomic Force Microscopy (AFM), Raman spectroscopy, and High-Resolution Transmission Electron Microscopy (HRTEM), have provided information on surface features, vibrational properties, and lattice structure respectively. However, X-ray diffraction (XRD), although well-established for probing internal crystallinity, has not been fully exploited for analyzing the external morphology of electrochemically etched silicon except to estimate average crystallite size by using the Scherrer equation [2].

In this work, we have explored a novel framework that extends XRD analysis to compute the shape and size of the synthesized crystallites. Using this approach, we have found that the etched nanostructures contain pyramidal geometry in contrast to the common belief of prolate shape [1].

QMD-28: Magnetization Dynamics in Co90Fe10 Thin Films and Square Artificial Spin Ice Probed by TRMOKE Microscopy

Susmita Das1, ∗ Najrul Ansary,M. Benjamin Jungfleisch, 2and Anjan Barman1
1S. N. Bose National Centre for Basic Sciences, Block-JD, Salt Lake, Sector-3, Kolkata-700106, India
2 Department of Physics and Astronomy, University of Delaware, Newark, Delaware 19716, USA
*Presenting author email ID: susmitadas6025@gmail.com

Artificial spin ice (ASI) systems, consisting of arrays of strongly interacting nanomagnets, have attracted great interest due to their complex magnetic behavior and potential for reconfigurable spintronic and magnonic applications [1]. It exhibits geometric frustration, tunable spin configurations, controlled dipolar interactions, and emergent magnetic phenomena such as magnetic monopole-like excitations, enabling reconfigurable and advanced magnonic functionalities that are absent in continuous thin films [2]. In this work, we initially investigated Co90Fe10 thin films to understand their basic magnetic properties, such as the frequency of the uniform precessional mode and damping. Next, we focus on a square lattice ASI composed of periodically arranged Co90Fe10 nanomagnets. Local magnetization dynamics were explored using Time-Resolved Magneto-Optical Kerr Effect (TRMOKE) microscopy by probing a small region of the ASI under varying external magnetic fields. The investigation shows clear differences between thin films and ASI systems in the characteristics of the uniform precessional mode to localized spin wave modes based on the geometrical properties, frustration, and generated microstates of the ASI system. These observations provide important contributions to the basic understanding of artificial spin systems and support the innovative design and fabrication of reconfigurable functional magnonic crystals.

QMD-29: Temperature dependent magnetization dynamics of van der waals Ferromagnet Fe5GeTe2.

Soumava Mondal1, Suchetana Mukhopadhyay1, Satyabrata Bera2, Susmita Das, Mintu Mondal2, Anjan Barman1,*
1Department of Condensed Matter and Materials Physics, S.N. Bose National Center for Basic Sciences, Block-JD, Sector III, Salt Lake, Kolkata, 700106, India
2School of Physical Sciences, Indian Association for the Cultivation of Science, Jadavpur, Kolkata 700032, India
*Email of Presenting Author: soumava.mlv@gmail.com

Spintronics is an emerging branch of physics that looks to utilize the electronic spin in devices, promising faster and energy efficient memory devices, low power logic circuits etc. 2D van der waals (vdWs) magnets have emerged as an important class of materials in the field of spintronics due to their unique structural, electronic, and magnetic properties that offer new possibilities for spintronic applications. The advantage of Fe5GeTe2 over other 2D vdWs magnets is that it possesses relatively higher Curie temperature (around 300K) [1]. We carried out temperature dependent magnetization dynamics measurements in Fe5GeTe2 single crystal samples using a Cryo-FMR set up. Ferromagnetic resonance (FMR) is a well-established technique to measure the magnetization of a ferromagnetic material. When performed under cryogenic conditions, it allows investigation of spin dynamics, anisotropy, and damping at low temperatures, revealing temperature dependent magnetic behavior. In this study we extracted the anisotropy, Lande g-factor, Gilbert damping constant (α) from FMR spectra of Fe5GeTe2 for various temperatures. Our result shows a clear temperature dependence in all three parameters. We observe a change in anisotropy from out-of-plane to in-plane direction at lower temperature. This indicates a possible structural change from UDU to UUU configuration [2]. UUU and UDU are the arrangements of Fe1 atoms in Fe5GeTe2 where Fe1atoms can occupy two vertically displaced sites within the crystal structure, leading to different spin arrangements along the c-axis. In UUU arrangement all Fe1 spins are aligned parallel, resulting in a ferromagnetic configuration with higher net magnetization and in UDU arrangement Fe1 spins are aligned in an alternating sequence, leading to a partially antiferromagnetic configuration with reduced net magnetization. The change in damping and g-factor reflect shifts in spin-orbit interaction and magnetic inhomogeneity. Increasing damping value with decrease in temperature suggests a conductivity like scattering is dominant in Fe5GeTe2 sample. These findings offer deeper insights into the spin dynamics of Fe5GeTe2 and highlight its potential for cryogenic spintronic device applications.

QMD-30: PVDF-PBAT Blends Film and Fibers for Energy Harvesting and Sensing

Chirag, Sudip Naskar, Utsa Sarkar, Parvathy Ravindernath and Dipankar Mandal*
Quantum Materials and Devices Unit, Institute of Nano Science and Technology, Knowledge City, Sector 81, Mohali, 140306, India
*Corresponding author E-mail: dmandal@inst.ac.in

The enhancement of ferroelectric and mechanical properties of polymer composites through blending is a promising pathway for flexible electronic applications.1-3 Poly(vinylidene fluoride) (PVDF) is valued for its strong ferroelectric β-phase and piezoelectric response, while poly(butylene adipate-co- terephthalate) (PBAT) offers superior flexibility and processability.2,3 However, the limited miscibility and phase stability between PVDF and PBAT present challenges in achieving optimized performance. This study addresses this research gap by systematically investigating the structural, thermal, and electromechanical behavior of PVDF/PBAT blends prepared using N,N-dimethylformamide (DMF) as a solvent at varying PVDF–PBAT ratios and casting temperatures (60, 120 and 180 °C).

The blend films were characterized to monitor the evolution of crystalline phases and melting transitions. The results reveal that both critical crystallization and melting temperatures shift as a function of blend composition and processing temperature, indicating altered intermolecular interactions and modified crystalline phases. In situ poling during electrospinning further enhanced polarization, suggesting improved ferroelectric alignment within the PVDF matrix mediated by PBAT flexibility.

The study demonstrates that controlled tuning of the PVDF–PBAT ratio and processing conditions can optimize phase stability and electroactive properties, offering valuable insight for the development of high-performance, flexible sensors, actuators, and energy-harvesting devices.

QMD-31: The study of neodymium (Nd) doping on structural, dielectric, magnetic, and magnetodielectric properties of BiFeO3 (BFO) multiferroic nanoparticles

Rajkumar Singha1 and Makhanlal Nanda Goswami2
1 Department of Physics, Visva-Bharati, Santiniketan 731235, West Bengal, India,
2 Department of Physics,Midnapore College (Autonomous), Midnapore 721101, West Bengal, India

$BiFe_{1-x}Nd_xO_3$ (x = 0.00–0.12) multiferroic nanoparticles were synthesized via a simple, energy- efficient chemical coprecipitation route to examine the effects of Nd^{3+} substitution on their structural, dielectric, magnetic, and magnetodielectric properties. Rietveld-refined X-ray diffraction confirmed that all samples retain the rhombohedral perovskite structure (R3c), while Nd incorporation leads to lattice contraction, bond-angle modification, and reduced crystallite size, evidencing enhanced structural distortion. TEM, HRTEM, and SAED analyses showed highly crystalline nanoparticles sized 9–11 nm, and EDX verified the intended stoichiometry, confirming successful Nd doping.

Dielectric studies revealed that Nd substitution significantly increases the dielectric constant and reduces dielectric loss across a broad frequency range, owing to improved polarization and decreased space-charge effects. Impedance analysis indicated enhanced electrical conductivity in doped samples, associated with modified grain-boundary responses and reduced oxygen-vacancy concentration. Magnetic measurements demonstrated that Nd doping suppresses the intrinsic cycloid spin structure of $BiFeO_3$, producing stronger ferromagnetic components and higher coercivity, with x = 0.06 exhibiting the highest magnetization. A notable improvement in magnetodielectric coupling was observed, yielding a maximum MD coefficient of 4.6% at 100 kHz for x = 0.06, confirming effective strain-mediated magnetoelectric interaction. Leakage-current analysis further showed that Nd doping suppresses oxygen-vacancy–driven conduction, enhancing ferroelectric behavior. Overall, x = 0.06 emerges as the optimal Nd concentration, offering balanced enhancement of dielectric, ferromagnetic, magnetodielectric, and ferroelectric properties, making these nanoparticles promising for advanced spintronic and multifunctional electronic applications.

QMD-32: Room-Temperature Near-Infrared Excitons and Optoelectronics in 2D/Organic Heterostructures via Spontaneous Epitaxial Growth

Dayal Das1, Sk Md Obaidulla1, Akash Tripathi2 , Afreen2 , K. V. Adarsh2 and Atindra Nath Pal1
1Department of Condensed Matter and Materials physics, S. N. Bose National Centre for Basic Sciences, Kolkata 700106, India.
2Department of Physics, Indian Institute of Science Education and Research (IISER), Bhopal, 462066 India
*Corresponding or Presenting author email-id: ddayal0891@gmail.com

Two-dimensional (2D) materials, with their atomic-scale thickness and extraordinary physical properties, have become a cornerstone of modern materials research, offering exciting possibilities for future nanoelectronics and optoelectronic devices. Introducing organic molecules onto 2D surfaces enables the creation of hybrid interfaces where charge transfer, molecular orientation, and interfacial interactions can be precisely tuned to manipulate the material's electronic and optical behaviour. In this work, we demonstrate that vanadyl phthalocyanine (VOPc) molecules can self-assemble into highly ordered ultrathin films on atomically flat van der Waals crystals such as MoS2, WS2, graphene, and hBN under ambient conditions. The resulting heterostructures exhibit a pronounced photoluminescence (PL) blue shift—from 870 nm to 805 nm—arising from dipole-mediated molecular dimer formation. Comprehensive studies of VOPc/MoS2 hybrid interfaces uncover pronounced interfacial charge-transfer processes that give rise to mixed or hybrid excitonic states, as revealed by transient absorption spectroscopy. Complementary insights from X-ray Photoelectron Spectroscopy (XPS), Ultraviolet Photoelectron Spectroscopy (UPS), and UV-Vis Spectroscopy collectively confirm the emergence of a coupled 2D/organic electronic structure that promotes the stabilization of bound excitons across the interface.

Importantly, when incorporated into a phototransistor architecture, the VOPc/MoS2 hybrid channel exhibits highly enhanced photo response, achieving a responsivity on the order of 105 A W−1 under 810 nm LED illumination. This exceptional performance highlights the synergistic role of molecular ordering, interfacial dipoles, and hybrid exciton formation in amplifying photocarrier generation and transport. Together, these results demonstrate that molecular arrangement and local structural ordering can be strategically leveraged to tune both the optical response and device functionality of 2D/organic heterostructures—particularly within the near- infrared regime—while providing a versatile platform for exploring unconventional excitonic phenomena and spin–valley interactions in hybrid quantum materials.

QMD-33: Noise Spectroscopic Signatures of the Metal–Insulator Transition in 1T-TaS2

Premananda Chatterjee1, Dayal Das1 , Rafiqul Alam1, Dr. Bikash Gajar2 Modhumita Sariket1
, Sk Kalimuddin3 , Nitesh Kumar1 , Mintu Mondal3 , Atindra Nath Pal1
1S.N. Bose National Centre for Basic Sciences, Block JD, Sector III, Salt Lake, Kolkata 700106, India
2Nano magnetics instruments Ltd.,Suite 290, 266 Banbury Road, Oxford,OX2 7DL,UK
3Indian Association for the Cultivation of Science, Jadavpur, Kolkata 700032, India
Email-premananda.chatterjee@bose.res.in

1T-TaS2 undergoes a series of phase transitions upon cooling and ultimately enters an insulating state whose microscopic origin remains debated. While some studies interpret this state as a band insulator stabilized by interlayer stacking order, others attribute it to Mott physics that may support a quantum spin liquid. In our work, we fabricate a six-terminal Hall bar device by mechanical exfoliation followed by optical lithography and e-beam metal deposition. Using this device, we probe the electronic transition through noise spectroscopy and observe a pronounced increase in the noise amplitude near the metal– insulator transition, accompanied by a clear deviation of the noise spectral density from conventional 1/f behavior. Additionally, Hall and planar Hall measurements reveal distinct anomalies near the transition, indicating modifications and a possible reconstruction of the Fermi surface as the system approaches the insulating phase. These results collectively suggest the presence of an electronic transition at low temperature.

QMD-34: Hydrothermally Synthesized Quasi-2D Tellurium Flakes and Quasi-1D Nanowires: Structure, Fabrication, and Transport Properties

Mohana Roy 1, Premananda Chatterjee1 , Shubhadip Moulick2, Atindra Nath Pal1
1Department of Condensed Matter and Materials Physics, S. N. Bose National Centre for Basic Sciences, Kolkata 700106, India.
2Aalto University, Finland
*Presenting author email-id: mohanaroy2000@gmail.com

Tellurium (Te), an emerging p-type two-dimensional semiconductor with a narrow bandgap and high carrier mobility, is a promising material for van der Waals (vdW) homojunction devices such as diodes and transistors. In this work, we demonstrate the controlled hydrothermal growth of high-quality Te flakes and nanowires by optimizing precursor concentration, reaction temperature, and reaction time.

The resulting Te nanostructures exhibit uniform morphology and excellent crystallinity, making them suitable for device fabrication. Field-effect transistors (FETs) were fabricated using individual Te flakes and nanowires, and their electrical transport properties were systematically studied under back-gate, top-gate, and dual-gate configurations. The back gate provides baseline channel modulation, while the top gate offers stronger electrostatic control due to the reduced dielectric thickness. The dual-gate configuration further enables enhanced tunability, allowing independent and combined modulation of carrier density and electric-field distribution in the Te channel. To understand the intrinsic transport behaviour, we investigated hydrothermally grown multilayer Te FETs and observed dominant p-type conduction with high hole mobilities reaching ~242 cm2V−1s−1 at room temperature. Temperature- dependent transport measurements allowed us to extract a low Schottky barrier height of ~ 20 meV, indicating efficient carrier injection and good-quality electrical contacts. Overall, these results highlight the strong potential of hydrothermally grown tellurium nanostructures for high-performance, gate- tunable, and low-power electronic applications, and establish Te as a promising candidate for future vdW semiconductor device technologies.

QMD-35: Optimization of CoSi2-based weak-link Josephson junction fabrication using focused ion beam

Biplab Biswas1,2, Ayan Kumar Ghosh1,3, Archan Banerjee1, Snehal Mandal1, and B. N. Dev1,3
1Centre for Quantum Engineering, Research and Education, TCG CREST, Kolkata, India.
2Department of Physics, Indian Institute of Technology Tirupati, Yerpedu, Andhra Pradesh, India
3Academy of Scientific and Innovative Research (AcSIR), CSIR-HRDC Campus, Uttar Pradesh, India

Superconducting qubits for quantum computing consist of Josephson tunnel junctions with superconductor/insulator/superconductor (S/I/S) trilayer structures, where Al/AlOx/Al (Al=Aluminum) is the most used heterostructure. While these tunnel junctions are widely adopted in superconducting qubits, their coherence is fundamentally limited by losses arising from defects, such as two-level systems (TLS), in the amorphous AlOx barrier layer and native oxide layers on the Al electrodes [1]. Mitigating these sources of losses remains a central challenge for materials scientists to realize high-coherence superconducting qubits by means of choosing alternative superconducting material and qubit design.

As an alternative superconducting material, CoSi2 can be a good candidate due to its resistance to oxidation and superconducting transition temperature being close to that of Al. More importantly, a surge in utilizing this material in superconducting quantum circuits started recently, after it was discovered that the 1/f noise in CoSi2 (arising from the surface and interface) is 2-3 orders of magnitude less [2] than that in Al. Use of CoSi2 is also facilitated by the easy epitaxial growth method on Si, along with existing CMOS techniques.

As an alternative to S/I/S junctions, Josephson junctions (JJs) can also be formed by weak links, like a nanobridge/constriction, where there is no need for an oxide barrier layer. Fabricating such constricted junctions is also easier, requiring a single fabrication step. Hence, unlike in Al, which is highly prone to oxidation, the possibility of undesirable TLS and dielectric losses arising from oxide layers can be eliminated in CoSi2-based weak-link JJs.

Towards this goal, we investigated superconductivity in CoSi2 films [3], which are obtained through high-vacuum annealing from a Co film on silicon that is already superconducting [4]. Weak link nanobridge junctions were then patterned on the resulting CoSi2 films using focused ion beam (FIB) lithography. Process optimization was carried out to achieve the required junction dimensions, enabling the fabrication of nanobridges as small as 100 nm. The fabricated structures were then verified using scanning electron microscopy (SEM) and atomic force microscopy (AFM).

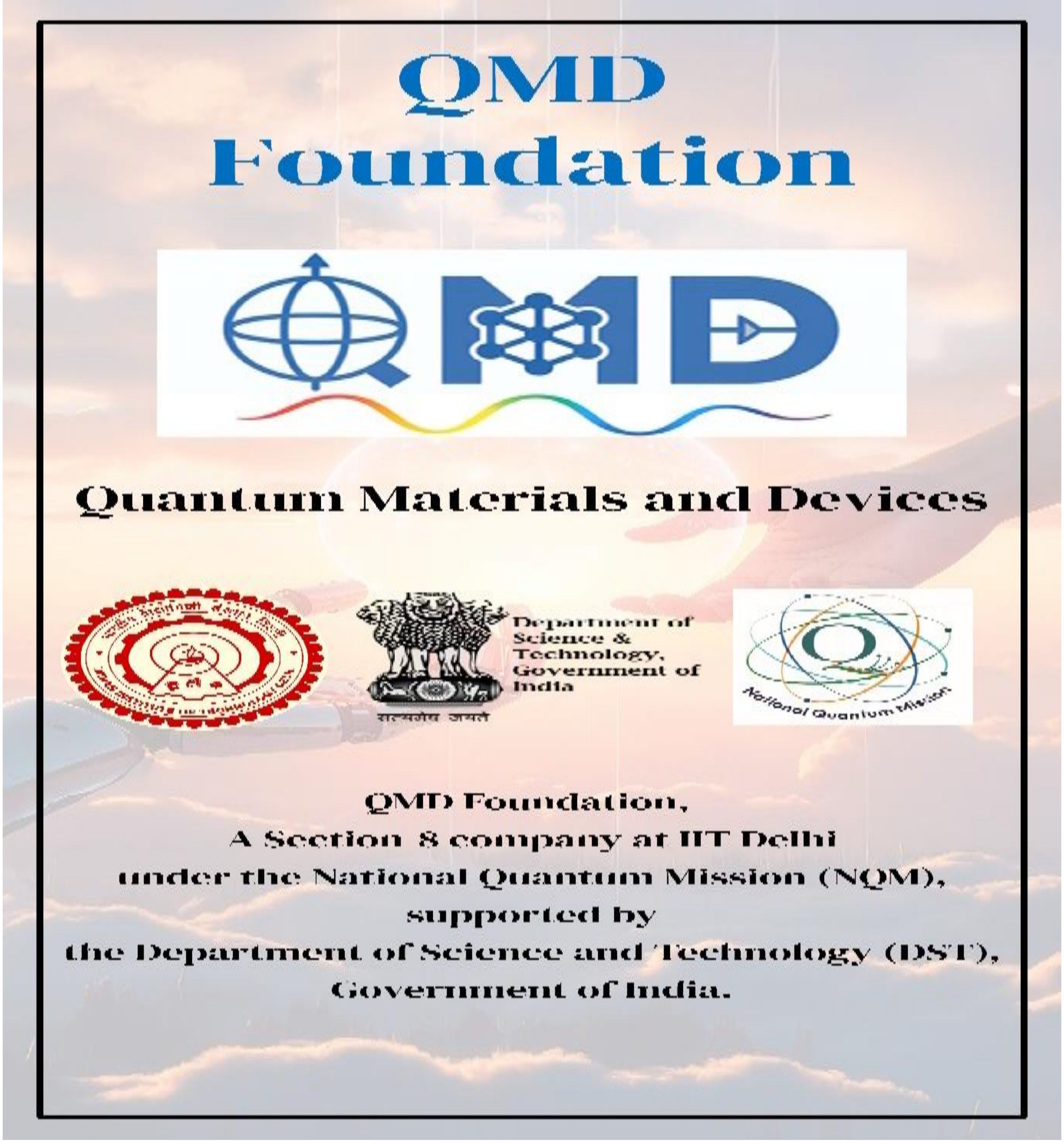
QMD-36: Optimization of Reactive Ion Etching process for CoSi2-based superconducting microwave co-planar waveguide development

Ayan Kumar Ghosh1,2, Biplab Biswas1,3, Snehal Mandal1, B. N. Dev1,2
1Centre for Quantum Engineering Research and Education, TCG-CREST, Kolkata – 700091
2Academy of Scientific and Innovative Research (AcSIR), CSIR-HRDC Campus, Uttar Pradesh - 201002
3Department of Physics, Indian Institute of Technology Tirupati, Andhra Pradesh – 517619

Material development is the cornerstone of advanced quantum processors based on superconductors. Traditionally, a superconducting quantum processor, which consists of a number of qubits and microwave coplanar waveguide (CPW) resonators, is lithographically fabricated using Aluminium (Al) films on silicon or sapphire substrates. However, Al being highly prone to oxidation, the performance of the qubits becomes limited by decoherence times due to losses arising from defects in the oxide layers that form on the Al layers.

Recent progress in CPW resonator fabrication using superconducting Tantalum has demonstrated elevated decoherence times of a few hundred microseconds (on sapphire) [1], which further improved to millisecond (when Ta is deposited on high resistive Si substrate) [2]. This is mainly facilitated by the limited oxidation of Ta (compared to Al). As an alternative, we propose to utilize superconducting cobalt disilicide (CoSi2) for fabricating CPW based resonators mainly owing to its ultralow 1/f noise (2 to 3 orders of magnitude less than that of superconducting Al films) [3] and being resistant to oxidation. Additionally, CoSi2 has Tc (~ 1.5K, close to that of Al) and can be epitaxially grown on Si [4].

This work focuses on optimizing CoSi2-based CPW resonator fabrication on Si using photolithography and reactive ion etching (RIE) followed by SEM characterization [5]. Our resonators have feature sizes of 6 μm and 10 μm. The optimization steps consist of careful plasma ashing of the etch-pits/scums followed by controlling the CF4/Ar plasma RIE in order to obtain vertical sidewalls of the CPW resonators. We further plan to perform microwave measurements of the fabricated CoSi2 based resonators.



QMD Foundation

Quantum Materials and Devices

QMD Foundation,
A Section 8 company at IIT Delhi
under the National Quantum Mission (NQM),
supported by
the Department of Science and Technology (DST),
Government of India.

Private Sponsors

Cadillac
Filters Pvt. Ltd.

Specialise
Instruments
INTELLIGENT SOLUTIONS

OXFORD
INSTRUMENTS

Di
DYNOTECH
INSTRUMENTS
PVT LTD

Quantum Design
INDIA

EVIDENT

GATAN
AMETEK

EDAX

LS
LASER®
SCIENCE
Bringing Tomorrow's Technology Today

VTPL
VT VACUUM TECHNOLOGIES PVT. LTD.

QUANTEK
systems
A Division of Spectek Instruments Pvt. Ltd.

MACWIN INDIA
Growing Together

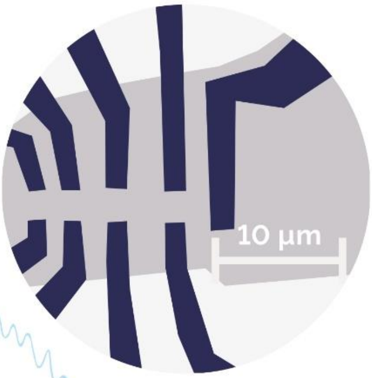
Aimil

ap
advanced
photonics

श्री
Shree Enterprises

TeslatronPT Plus

Open-Architecture Low Temperature Measurement System

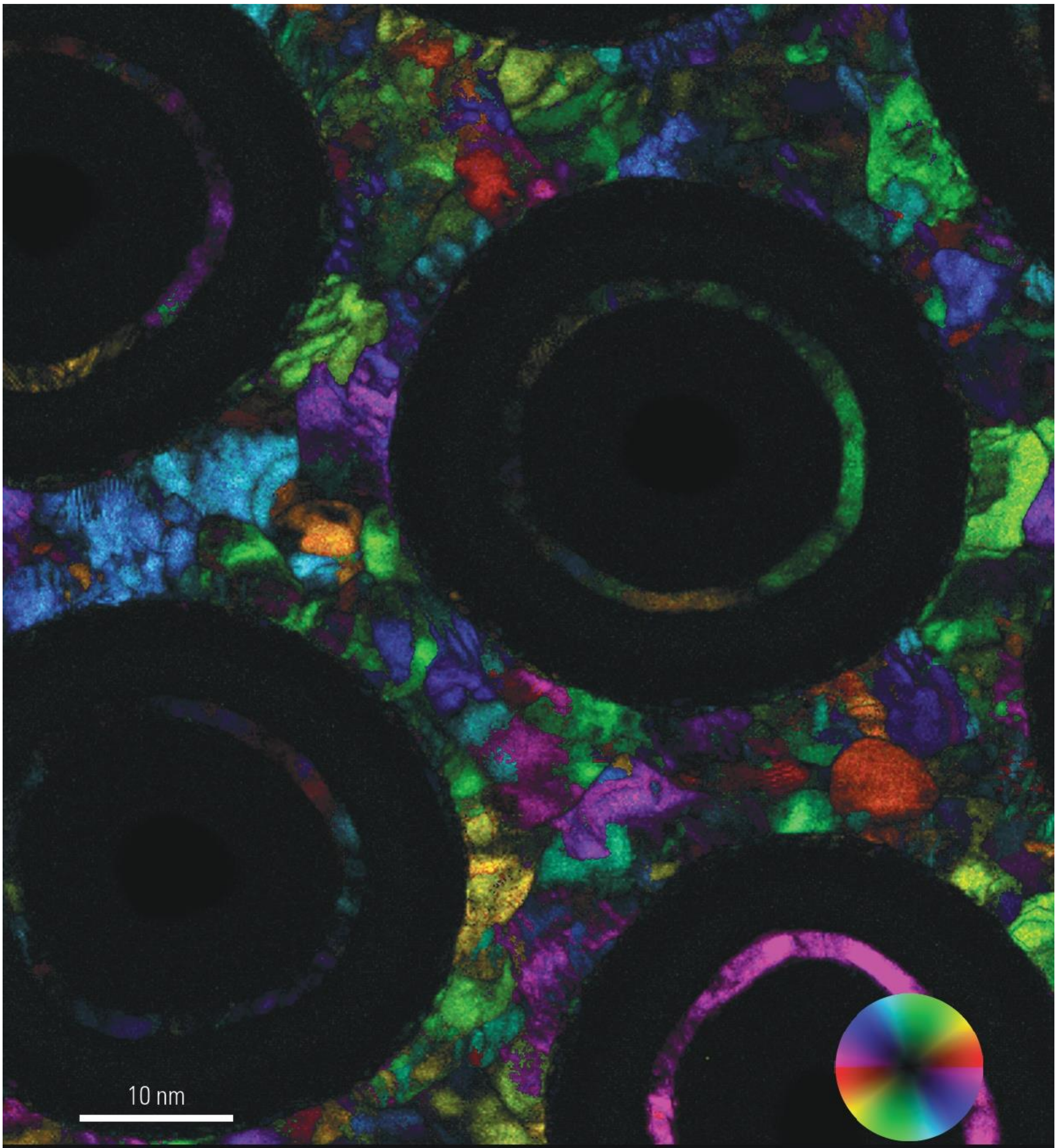


Measurement.
Made Simple

Measurement.
Made Flexible

Measurement.
Made Future-proof

Visit: nanoscience.oxinst.com/products/teslatronptplus



Capture 4D STEM data with sharper detail and less background noise

4D STEM collected with the Metro™ counting camera and STEMx® from a 3D NAND sample. Data was processed via a Python script in DigitalMicrograph® to produce a map of crystalline regions.

Gatan.com/Metro

GATAN
AMETEK

VTPL

VT VACUUM TECHNOLOGIES PVT. LTD.

www.vtvacuum.com

Connecting to the world's leading manufacturers

We are the representatives for the world's leading manufacturers of Vacuum and Cryogenic equipment and components in India

OUR PARTNERS:

MKS Instruments, Inc.
2 Tech Drive, Suite 201
Andover, MA 01810, USA
www.mks.com

Advanced Research Systems, Inc.
7476 Industrial Park Way
Macungie, PA 18062, USA
www. arscryo.com

BlueFors Oy
Arinatie 10, 00370 Helsinki
FINLAND
www.bluefors.com

Kurt J. Lesker Company
1925 Route 51
Jefferson Hills, PA 15025, USA
www.lesker.com

MTI Corporation
860 S. 19th Street
Richmond, CA 94804-3809
www.mtixtl.com

GNB Corporation
3200 Dwight Road, Suite 100 Elk
Grove, California 95758
www.vacuumchamber.com

MeiVac (FerroTec)
5830 Hellyer Avenue
San Jose, CA 95138
www.meivac.ferrotec.com

UHV DESIGN LTD
Judges House, Lewes Road
Laughton, East Sussex
England, BN8 6BN
www.uhvdesign.com

Zurich Instruments AG
Technoparkstrasse 1
8005 Zurich, Switzerland
www.zhinst.com

VTPL

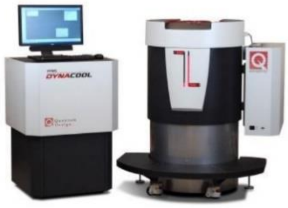
VT VACUUM TECHNOLOGIES PVT. LTD.

www.vtvacuum.com

No. 36A, 'Krishna House', 1st Floor, A.G.S Layout, M.S.R. Nagar, Bangalore-560054
Phone: 91-80-2360 3253, 91-80-2360 8104 Fax: +91-80-2360 5664. Website: www.vtvacuum.com E-mail: contact@vtvacuum.com

Quantum Design
INDIA

Quantum Design: MPMS 3 Squid Magnetometer
Temperature Range: 1.8K - 400K
Magnetic Field: ±7T



Quantum Design: PPMS DynaCool (Cryogen Free)
Temperature Range: 1.8K - 400K
Magnetic Field: ±14T

Quantum Design: PPMS VersaLab (Cryogen Free)
Temperature Range: 50K - 400K
Magnetic Field: ±3T

Introducing the FusionScope !
Innovative correlative microscope that combines the power of AFM with the benefits of SEM imaging. Switch between a sub-nanometer resolution AFM and SEM imaging with a simple click of a button to extract your desired data

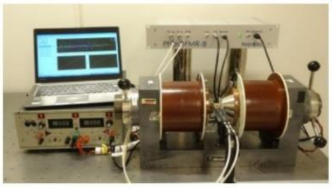
Durham Magneto Optics, Ltd: MicroWriter ML
Direct Write Lithography Machines
(0.4 & 1 µ resolution)
Up to 180mm^2/minute (resolution dependent)
Compact Size

Quantum Design: OptiCool
Low Vibration: <10nm peak to peak
Temperature Range: 1.7K to 350K
7T Split-Coil Conical Magnet
Automated Temperature & Magnet Control

Fully integrated cryogenic characterization system,
Includes MeasureReadyM81-SSM synchronous source measure system, Janis Cryostat , Temp controller, PC with MeasureLINK for automating entire experiments

Lake Shore
CRYOTRONICS
ADVANCING SCIENCE

QD now offers Lake Shore products in India.
Cryogenic probe stations
Cryostats
Cryogenic sensors, monitors, and controllers.
Vibrating sample magnetometers (VSMs)
Magnetic test/measurement instruments and sensors
Hall effect analysis systems
FastHall measurement in PPMS



FMR Spectrometers (Ambient and Cryogenic)
Turn-key Broadband FMR spectrometer
CryoFMR operates in all Quantum Design PPMS
Calculates the effective magnetization, anisotropy, gyromagnetic ratio, damping and inhomogeneous broadening
Extraction of exchange stiffness and inverse spin Hall effect ISHE

Quantum Design India Pvt Ltd.
Tel: +91-22-27781011/12/13
Email: info@qd-india.com

DYNOTECH INSTRUMENTS PRIVATE LIMITED

DYNOTECH INSTRUMENTS PRIVATE LIMITED
Your Trusted Partner in Advanced Instrumentation Solutions

About Us:
Dynotech Instruments Pvt. Ltd. is a premier provider of high-precision scientific and industrial instruments in India. We partner with leading global companies to bring cutting-edge technology and innovative solutions across photonics, spectroscopy, semiconductor processing, and material analysis. Our commitment is to empower researchers, engineers, and industry professionals with reliable, world-class instruments and support.

Our Principal Partners and Their Applications:

SVT Associates https://www.svta.com/	Products: MBE (Molecular Beam Epitaxy) systems. Applications: Semiconductor testing, high-compound semiconductor epitaxy, high-frequency electronics validation, device characterization	
Veeco Instruments https://www.veeco.com/	*Products:* Atomic Layer Deposition (ALD) systems, MOCVD solutions. *Applications:* Semiconductor device fabrication, nanotechnology research, MEMS, thin film coatings.	
Ecopia Corp. http://www.ecopia21.co.kr/	*Products:* Hall-effect measurement systems, Probe stations, Rapid Thermal Processing (RTP / RTA) systems. *Applications:* Semiconductor research & manufacturing, Wafer processing and thermal treatment	
NKT Photonics A/s https://www.nktphotonics.co	*Products:* High-power lasers, supercontinuum sources, single frequency fiber lasers, ultrafast Lasers, Optical fibers and modules. *Applications:* Optical sensing, spectroscopy, fiber-optic communication, metrology, scientific research..	
JNE Corporation http://www.junghwaeng.com/	*Products:* ICP-PECVD Plasma Processing system, RIE and/or PECVD.	
Sciencetech Inc. https://sciencetech-inc.com/	Products: Quantum Efficiency Measurement Systems. Applications: Photovoltaic / Solar-Cell Performance Testing, Material comparison / development of new PV materials, Characterizing photodetectors, photodiodes, and optoelectronic devices.	

Contact Us:
Dynotech Instruments Pvt. Ltd.
B1/639 A, Janakpuri, New Delhi – 110058, India
Phone: +91-9353104574 / +91-8217848475
Email: info@dynotechmail.in | Website: www.dynotech.in

Cadillac
Filters Pvt. Ltd.

Semiconductor-Grade Clean Room & HVAC Turnkey Solutions

Specialized engineering solutions for Semiconductor, Microelectronics, Nanotechnology, PCB Manufacturing, and High-Precision Assembly

Who We Are

Cadillac Filters Pvt. Ltd. is a trusted turnkey provider of Ultra-Clean Environments, offering advanced Semiconductor Clean Rooms, HVAC systems, Validation, and AMC/CMC services. With 45+ years of engineering excellence, Cadillac delivers high-performance, particle-controlled, ESD-safe facilities meeting global semiconductor Standards.

YELLOW ROOM (LITHOGRAPHY)

Semiconductor Clean Room Expertise

- End-to-End Execution (Design Build → Validate)
- ISO Class 6, 7,8 Clean Room Construction
- Ultra-Low Particle & Low RH (<30%) Environments
- Semiconductor-grade HVAC layouts & airflow mapping
- Clean utilities: CDA, N_2(UHP), Ar, DI plants, etc.
- ESD-Controlled Modular Panels & Flooring
- validation Team with 21 CFR–compliant instruments

Semiconductor Applications We Serve

- Semiconductor Wafer Fabrication
- Microelectronics Assembly
- Chip Packaging & Testing Facilities
- Photolithography & Etching Rooms
- High-Precision Instrumentation Labs
- PCB Assembly & Inspection Units
- Nanotechnology & R&D Labs

CORPORATE & PROJECT OFFICE
Aurora Water Front Building
12th Floor, Office No. 12
Sector V, Salt Lake, Kolkata – 700091

BRANCH OFFICE
69B, Santoshpur Avenue,
Kolkata – 700075

REGD OFFICE & FACTORY
Karbala, P.O. Narendrapur,
Kolkata – 700103

Email: info@cadillacfilter.com Call : +91 9831060169/+91 89106 99423 Website: www.cadillacproject.com

EVIDENT

Precision
Made Simple

DSX2000
Digital Microscope

GOOD DESIGN
AWARD 2025

Fully motorized
digital microscope

EvidentScientific.com

Specialise Instruments
INTELLIGENT SOLUTIONS

attocube
WITTENSTEIN Group

attoDRY 800
Cryo-optical table (closed cycle)
Ultra-low vibration optical cryostat integrated into an optical table with unobstructed optical access for quantum optics experiments

Features:

- Ultra-low vibrations < 5nm peak-to-peak (vertical direction)
- Extremely low drifts and optimal collection efficiency due to cold objective at 4K
- Fully automated temperature control between 3.8 and 320 K
- Free workspace & obstruction-free optical access
- Customizable vacuum shroud
- Touchscreen user interface

Displacement Measuring Interferometer (IDS3010)

- Certified accuracy in nanometer range
- large distance range - from a few mm up to 30 m
- compact and modular design - 3-Axis measurement, sensor heads to Ø 1.2 mm
- Vacuum and clean room compatible - UHV_10 bar, a few mK _423 K

LASER SCIENCE
Bringing Tomorrow's Technology Today

Bringing Tomorrow's Technology Today

Recognized for going above and beyond in customer care

COHERENT
COMPex series
Most stable Excimer laser
- PLD – Pulsed Laser Deposition
- Thin Wafer Processing

PLD CHAMBER
Chamber by Excel Innovators & Integrators
- Customized thin-film deposition for RHEED
- Customized thin-film deposition for complex oxides

COHERENT
Chameleon Ultra
Ultrafast Lasers Oscillators
- Multiphoton Excitation (MPE) Microscopy
- Non-linear Optics
- Time Resolved Spectroscopy

Beneq
Beneq TFS 500
Atomic Layer Deposition
- SnO_2 ALD for photovoltaic cells
- HfO_2, SiO_2 and SiN ALD on semiconductor applications

A·P·E
OPO-X FS | PS
Tunable fs & ps OPO for Ti:Sa Laser
- Independent Pump and Signal tuning
- Jitter-free generation of pulses
- Windows-based Control Software included

THORLABS
Components

Representing 25 global leaders in Lasers and Photonics

Visit our official website to discover more products

www.laserscience.co.in ls_marketing@laserscience.in +91 77100 12972 laserscienceservices