A Report for the period 2017-2023

Group D: Condensed Matter Physics, Surface Physics and Material Science

INDRANIL DAS

Senior Professor H & Head Group D

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EDUCATION: 1994: Ph.D. TIFR (Mumbai)

1987: M.Sc. in Physics, Visva Bharati University, Santiniketan

1985: B.Sc. Physics Hons, Visva Bharati University, Santiniketan

Academic Profile:

- Senior Professor-H at Saha Institute of Nuclear Physics,Kolkata
- Professor at the Homi Bhabha National Institute (HBNI), Munbai
- H-index: 30, Since 2017 Journal pub:58, Total Journal Impact Factor: 217.2 Book Chapter: 1
- Since 2017 Ph.D. Students: Degree awarded: 7, Presently working: 5.

CURRENT RESEARCH AND DEVELOPMENT: We have achieved a record value of the colossal magnetoresistance (~10^{15}% in 90 kOe external Magnetic field. Previously known MR% anywhere in the world is ~10^{7}%) along with the ultra-sharp metamagnetic transition in half doped $Sm_{0.5}Ca_{0.25}Sr_{0.25}MnO_3$ manganite compound by suitably tuning the volume fraction of the competing phases [NPG Asia Materials (IF: 10.76), 10 (2018) 923]. We have done enhancement of the magnetoresistance just by tuning the strain (strain engineering) in oxide epitaxial $Sm_{0.5}Ca_{0.25}Sr_{0.25}MnO_3$ thin films prepared by PLD [J. Magn. Magn. Mater. 503 (2020) 166627]. Developed "two-step" technique for growing good quality half metallic $La_{0.7}Sr_{0.3}MnO_3$ ultra thin films on commercially useful thermally oxidized Si substrates using PLD and spin polarized transport across grain boundary was observed [J. Magn. Magn. Mater. 527 (2021) 167771]. $(Sm_{1-y}Gd_y)_{0.55}Sr_{0.45}MnO_3$ (y = 0.5 and 0.7) compounds prepared and shown that the spin-polarized tunneling (SPT) transport mechanism at the grain boundaries plays a crucial role in the enhancement of low-field magnetoresistance in the compound [J.Phys: Condens. Matter 33 (2021) 305601]. The particle size driven modification of the non-Griffiths phase to Griffiths phase and Giant enhancement of magnetoresistance in nanocrystalline $(La_{0.4}Y_{0.6})_{0.7}Ca_{0.3}MnO_3$ compound was reported [J. Alloys & Compound 745 (2018) 753]. Prepared ferromagnetic ($La_{0.67}Sr_{0.33}MnO_3$) - charge ordered ($Pr_{0.67}Ca_{0.33}MnO_3$), core-shell nanostructures and large value of magnetocaloric entropy change ($-\Delta S_M$) was observed in wider temperature range [J. Magn. Magn. Mater. 436 (2017) 97]. Observed a significantly large magnetocaloric effect near room temperature in $La_{0.83}Sr_{0.17}MnO_3$ compound & can be consider as magnetic refrigerant material [Physica B 545 (2018) 438]. We have shown in our prepared $BiGdO_3$ compound giant magnetocaloric effect (ΔS_M= 25 J $kg^{-1}K^{-1}$ & ΔT= 14.8K) at cryogenic temperature and explained its origin due to the existence of short-range magnetic correlation [J. Alloys and Compounds 846 (2020), 156221]. We have constructed complex magnetic phase diagram of the prepared single crystalline $Sm_{0.50}Ca_{0.25}Sr_{0.25}MnO_3$ compound using magnetocaloric effect [J. Magn. Magn. Mater. 497 (2020) 166066]. Real-space imaging of magnetic phase transformation in single crystalline $Sm_{0.5}Ca_{0.25}Sr_{0.25}MnO_3$ compound prepared using Travelling Solvent Float Zone Furnace was performed and the presence of AFM–FM phases on sub-micron length scale was observed [J.Phys: Condens. Matter 33(2021) 235402]. We have shown the dominant role of short-range magnetic interaction between core and surface spins in exchange bias and memory effect in nanocrystalline doped manganite [J. Alloys and Compounds 870 (2021), 159465]. In contrast to the generally used magnetization data, critical behavior and phase diagram of skyrmion-hosting material $Co_{3.6}Fe_{4.4}Zn_8Mn_4$ was probed by us using anomalous Hall effect. It can initiate a novel direction for investigations of critical phenomena using AHE in skyrmion hosting and other thin film multilayers, mesoscopic devices etc. It can be beneficial for the development of skyrmion-hosting material and to the development of future skyrmionic memory devices [J. of Alloys and Compounds 960 (2023) 170274].

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: I shall continue my research on emergent non-collinear magnetic phenomena & Magnetic skyrmionics along with Magnetoresistive, Magnetocaloric, Spintronic & Quantum materials in bulk, thin film & nano particle forms.

Post M.Sc. teaching:

I have taken few Post M.Sc. Class, delivered Colloquiums & several Post M.Sc. review project: (1) Preparation of thin film & Characterization Using X-ray reflectivity. (2) Origin of Magnetoresistance in different materials (3) Magnetic Skyrmions in Thin Films (4) Skyrmions in Thin Films -2 (5) Magnetic Skyrmion-1 (6) Intrinsic Van Der Waals Magnetic Materials from Bulk to the 2D limit: New Frontier of Spintronics-1 (7) Literature Survey of Multiferroic Materials-1 (8) Magnetic Skyrmion-2 (9) Vander waal materials in spintronics (10) Literature survey of multiferroic material-2. I have offered several short experiments to the Post MSc students. I have also served as a Post MSc. Coordinator.

SATYAJIT HAZRA

Sr. Professor H, SPMS division

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2000-……..	Faculty, Saha Institute of Nuclear Physics
1997-2000	PDF, Universite du Maine, France & SINP, Kolkata
1992-1997	RF, Indian Association for the Cultivation of Science
1996	PhD in Science, Jadavpur University

PUB STAT Publication in Journals [during 2017-2023]: **22**; [Total]: **82** *h*-index: **27**
Average Impact Factor [during 2017-2023]: **6**; [Total]: **4**; Average Citation: **26**

CURRENT RESEARCH AND DEVELOPMENT: Present research activities are primarily focused on the organic/polymeric semiconducting materials, which can act as active layers inelectronic andoptoelectronic devices [*Appl. Surf. Sci*. 2020, **499**, 143967]. In this regard, the *main emphasis is in understanding and tuning the structures and ordering* of those active layers or thin films, especially *near different interfaces* (namely, organic-metal interface and organic-dielectric or organic-substrate interface), which are known to play important roles in device performances. The charge injection across the organic-metal interface critically depends on itscharge injection barrier or energy level alignment (ELA) or electronic structures. The interfacial electronic structure again heavily influenced by thestructure (i.e., orientation, ordering, etc.) and coverage (i.e., wettability) of the molecules, governed by different interactions at the interface. For last few years attempts are on to understand such interactions on some the polar and non-polar molecules at the selected metal interfaces primarily from the electronic structures estimated using photoelectron spectroscopic (XPS and UPS) techniques [*ACS Appl. Mater. Interfaces* 2020, **12**, 45564; *Appl. Surf. Sci*. 2022, **597**, 153696*; J. Phys. Chem. C* 2023, **127**]. On the other hand, the in-plane charge transport in organic semiconducting devices heavily influenced by thestructures (namely, orientation, ordering, wettability or coverage) of the molecules (and connectivity of the ordered domains) in the film, especially near the buried organic-substrate interface. Large efforts are on to understand and tune such structures using X-ray scattering, atomic force microscopy and optical absorption spectroscopy techniques and adopting different pre- and post-deposition methods [*J. Mater. Chem. C* 2020, **8**, 8804; *J. Colloid Interface Sci.* 2022, **606**, 1153; *ACS Appl. Polym. Mater*. 2022, **4**, 1377; *ACS Appl. Polym. Mater*. 2023, **5**, 3359; *Macromolecules* 2023, **56**] for possible improvement of the device properties.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: Assemmbly or aggregation of conjugated organic molecules or polymers plays a crucial role in the thin film morphology and optoelectronic properties of solution processed organic electronics and photovoltaics. Understanding intermolecular interactions, responsible for such assembly, both in solution and in thin film, isof a prime importance, whichis one of our future research plans/interests. The information about the assembly, in solution and in film, can be obtained through transmission mode small- and wide-angle X-ray scattering (SAXS-WAXS) and reflection mode grazing incidence SAXS-WAXS (GISAXS-GIWAXS) techniques, respectively. Accordingly, a dedicated SAXS-WAXS-GISAXS-GIWAXS setupis planned to augment. Also, attemps will be made to substantiate the interfacial electronic structure through other powerful techniques namely, scanning tunilling microscopy and spectroscopy. Further, attempts will be made to correlate the observed structures with the properties by measuring the device parameters using probe station and semiconductor parameter analyzer.

TEACHING & GUIDANCE: Current Ph.D. students: **4**; Ph.D. awarded: **5** [Total]; **1** [during 2017-2023]
Involved in Post MSc teaching, by providing (a) part of advanced course: Advanced Surface Physics and Materials Science, (b) short experiments and (c) projects to the Post MSc students.

CHANDAN MAZUMDAR
Sr. Professor-H, CMP division

Qualification: Ph.D (IIT Bombay) ;M.Sc (Phys) (Univ. of Calcutta), B.Sc (Phys. Hons) (Univ. of Calcutta)

Subject of Interest: i) Structure-properties relation; ii) Polymorphic materials; iii) Bulk magnetic properties; iv) Magnetic frustration; v) Competing magnetic interaction; vi) Negative and Zero thermal expansion materials; vii) Thermoelectric power; viii) Spintronic materials and high spin polarization

CURRENT RESEARCH AND DEVELOPMENT: Some of the recent important findings from our group: Inducing structural transition in non-centrosymmetric RPt_3B to centrosymmetric RPt_3B_x (x<1) resulting in large (~9%) volume reduction; Observation of Ferromagnetically correlated clusters and large thermoelectric properties in VEC 24 Heusler alloys Ru_2NbAl and Ru_2TiGe; Associating Griffiths phase behaviour of $GdNi_{0.17}Sn_2$ with structural modification; Observation and explanation of contrasting magnetic properties of polymorphic RIr_3 and $TbPt_3$; Negative magnetization induced by particle-size reduction in $Gd_{1-x}Ca_xMnO_3$ nanoparticle systems; Large magnetocaloric effect without long-range magnetic order in Ho_2NiSi_3; Understanding the competing magnetic magnetic interaction in many members of R_2TSi_3 (R = rare earth ; T = Ni, Co, Ir) and multiple degenerate ground state in $Gd_2Ir_{0.97}Si_{2.97}$; Unusual observation of bidirectional frequency dependence of dynamical susceptibility in $Pr_2Ni_{0.95}Si_{2.95}$; Unusual observation of temperature dependence of magnetic coercive field in $Pr_2Co_{0.86}Si_{2.88}$ and $Nd_2Co_{0.85}Si_{2.88}$; Zero thermal expansion over wide temperature range (13K<T<330K) in $Ho_2Fe_{16}Cr$; Finding coexisting structural disorder and robust spin-polarization in half-metallic Heusler alloys; Understanding the origin of magnetic ordering in Half-Heusler RuMnGa having VEC 18.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: Single crystal growth and studies of physical properties of new intermetallic compounds

Publications: Total No. of papers (Since 1 April, 2017): 45
J. Alloys Compd. (IF 6.371): 4; Mater. Res. Bull. (IF 5.77): 1; Inorg. Chem. (IF 5.436): 1; Sci. Rep. (IF 4.6): 4; J Phys Chem Solids (IF 4.383): 2; J. Phys. Chem. C (IF 4.177): 1; Int J Refrig (IF 4.14): 1; Intermetallics (IF 4.075): 6; Phys. Rev. Mater. (IF 3.98): 1; Phys. Rev. B Condens. Matter (IF 3.908): 9; Phys. Chem. Chem. Phys. (IF 3.676): 5; Supercond. Sci. Technol. (IF 3.464): 1 (Review); J. Phys. D (IF 3.409): 1; J. Magn. Magn.Mater. (IF 3.097): 5; J. Phys. Condens. Matter (IF 2.745): 3.
Total IF = 184.748; Average IF/paper: 4.1055
Total citations of these 45 papers: 367

Since 2017 Ph.D students: Degree awarded: 4; Synopsis/Thesis Submitted: 3; Presently working: 2.

Invited Talk: 6 + 1 (session chair)

Teaching (Post M.Sc Experimental): 2018-19 (8 Classes); 2019-20 (8 Classes + Project guidance: 2) ; 2020-21(Project guidance: 1) ; 2021-22 (4 Classes) ; 2022-23 (Project guidance: 1)

Honours/Awards:
i) Elected as executive committee member of Magnetic Society of India in Dec., 2018.
ii) Elected Fellow of the West Bengal Academy of Science and Technology (WAST) in 2020

Extra-mural project application:i) Awarded IFCPAR project in collaboration with Dr. Eric Alleno (ICMPE, CNRS, Thiais, France) in the year 2022-23.

KRISHNAKUMAR S. R. MENON
Sr. Professor H, SPMS division

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2004-…….. Faculty, Saha Institute of Nuclear Physics
1999-2004 PDF, Univ. of Connecticut, USA; ICTP-ELETTRA Trieste: Freie Univ., Berlin
1993-1999 PhD in Science, Indian Institute of Science, Bangalore

PUB STAT In Journals [During 2017-2023]: **22**; [Total]: **74**

CURRENT RESEARCH AND DEVELOPMENT: My research activities at SINP have been primarily focused on the study of electronic structure and magnetism of surfaces, ultrathin films and low-dimensional materials and their structure-property correlations using various electron and soft x-ray methods. For this, during 2008-2009, I set up an Angle-resolved Photoemission Spectroscopy (ARPES) laboratory at the SPMS division where we can perform high-quality band mapping and Fermi-surface mapping using ARPES technique, high-resolution X-ray Photoemission Spectroscopy (XPS) for chemical and electronic structure studies and Low Energy Electron Diffraction (LEED) for the study of surface structure and surface antiferromagnetism (AFM). With this facility, we were able to explore the surface electronic structure and surface magnetism of materials in a spatially averaged way, with macroscopic scale (~mm) probed regions. However, our studies at SINP as well as using different synchrotron beamlines have pointed out the absolute necessity to probe the properties at the nanometer scale to obtain a microscopic understanding of the physical/chemical processes at the surfaces. To enable these microscopic studies, I have set up a Low-energy Electron Microscopy cum Photoemission Electron Microscopy (LEEM-PEEM) facility in our laboratory during 2018-19. Using this facility (the only one of its kind in the country), we can explore the surface structure, morphology, electronic structure as well as surface magnetism from the same sample region with a high spatial resolution (< 5 nm). Moreover, as the data collection is fast (<10 ms) we can study the different dynamical processes occurring at the surfaces/ultrathin films in real-time. Thus, by combining these macroscopic and microscopic facilities, we hope to make significant improvements in understanding the electronic structure and magnetism at the surfaces of interesting materials, both from the fundamental science as well as from the applications point of view.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: For detailed spectromicroscopic imaging of the chemical and electronic inhomogeneities on the samples, we plan to upgrade the existing LEEM-PEEM system to a state-of-the-art “Momentum Microscope” by introducing an imaging energy analyser and a focused UV light source. With this Momentum microscope, along with the real-space spectral imaging, we will also be able to study the reciprocal-space electronic structure from tiny crystals, flakes and domains (micro-ARPES) in real-time enabling us to study the dynamics at micro/nano scales. Further, for exploring the tailor-engineered epitaxial thin films of complex oxides and alloy materials for various potential applications, we plan to integrate an ultrahigh vacuum pulsed laser deposition (UHV-PLD) system with atomic layer control using a high-pressure reflection high energy electron diffraction (HP-RHEED) with the ARPES and LEEM-PEEM system using a ”vacuum suitcase” approach. This allows us to transfer samples between different experimental systems without exposing them to the ambient and thus avoiding surface oxidation and contamination for reliable measurements.

TEACHING & GUIDANCE: Ph.D. awarded: **9** [Total], **6** [during 2017-2023]; Current Ph.D. students: **3**
I have been teaching part of advanced course, ”Advanced Material Science and Surface Physics” to the Post-M.Sc students along with ``Research Methodology” course till a few years back. Presently, I am the Experimental Physics PMSc course co-ordinator at SINP.

SATYABAN BHUNIA

Professor G, SPMS division

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2004-……..	Faculty, Saha Institute of Nuclear Physics
2003-2004	Assitant Prof, IIT Bombay
1999-2003	PDF, University of Electrocommunications, Tokyo NTT Basic Research Laboratories, Japan
1998-1999	Scientist 'B', DRDO, GoI
1999	PhD in Science, Indian Institute of Technology, Kharagpur

PUB STAT Journals: 29 [during 2017-2023] and 88 [total]

AREA(S) OF RESEARCH: MOVPE growth of compound semiconductor and quantum structures, Electrical and optical properties of semiconductors, High efficiency solar cells, Synchrotron Beamline

CURRENT RESEARCH AND DEVELOPMENT: Presently I am involved in growth, characterization and device applications of optoelectronic and photovoltaic materials, both in the form of thin films and bulk crystals. I had successfully installed a Metalorganic Vapor Phase Epitaxy (MOVPE) in 2016 in this regard and grown GaAs/AlGaAs quantum wells, InAs/InP quantum dots, GaInAlP quaternary materials etc. Two students have completed their PhD on the subjects. Presently, the MOVPE system needs a major upgrade. I am also working on a state-of-the-art multi-deposition system which include RF sputtering, electron beam and thermal deposition system for growing high quality multilayer materials for photovoltaic applications. Apart from this, I am also working on emerging optoelectronic materials such as $ZnSnP_2$, $ZnSnS_2$, which are piezoelectric semiconductors. We characterize the materials using low temperature Photoluminescence (PL) spectroscopy, Raman spectroscopy, Current-voltage (I-V) and capacitance-voltage (C-V) measurements, and x-ray diffraction. Currently, I am also the in-charge of the "SINP Beamline" at Indus-2 synchrotron radiation facility, RRCAT, Indore. I had taken lead role in successful implementation of the facility. I am responsible for handling day to day running of the facility, selection and allotment of user proposals, facilitate their visit to the beamline. We are also working constantly to upgrade the facility to make it to the international standard by installing in-situ low and high temperature x-ray scattering, improving data acquisition etc. I make a regular visit to the facility for such purpose. I have also worked extensively on radiation safety and other hazards associated with the beamline. Made a safety manual and got Atomic Energy Regulatory Board clearance for operating the beamline. It is now a national facility open to users from all over India.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: I would like to continue to work on new emerging optoelectronic materials. I am interested in setting up a single crystal growth facility for such purpose. The single crystal materials have important applications in optical detectors as well as use in thin film applications. The existing PL system is used for optical characterization of materials under steady state, which needs an addition of time resolved spectroscopy. For further characterization of electronic properties, I propose to install a temperature dependent Hall effect measurement system. The "SINP Beamline" work will be further upgraded by adding higher efficiency area detector. We expect more number of users both from SINP as well as other institutes of India.

TEACHING & GUIDANCE: Ph.D. awarded: **5** [Total], **4** [during 2017-2023]; Current Ph.D. students: **1**
I have taught advance courses on Semiconductor Physics and Devices (theory class). Also, I offer experimental courses for post MSc students in PL spectroscopy, Raman Spectroscopy, I-V and C-V measurement techniques.

SUPRATIC CHAKRABORTY

Professor G, SPMS division

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2004 - date Faculty, Saha Institute of Nuclear Physics
1997 PhD in Science, Kalyani University

PUB STAT During 2017-2023: Journals: 14.

CURRENT RESEARCH AND DEVELOPMENT: Different physical and electrical properties of thin-films of transition metal oxides (TMOs) namely, oxides of hafnium, zirconium, vanadium, niobium and cerium have been studied during this period. The films are deposited on *n*- and *p*-type silicon wafers using dc and rf magnetron sputtering technique. The thickness of the films varies from 5 to 20 nm. Different techniques namely, GI-XRD, XPS, SEM and TEM are utilized for physical characterization of the films. Electron beam evaporation technique is used to deposit ~300 nm-thick top metal films and UV-photolithography technique is utilized to pattern top metal films to get 100 μm diameter top electrode for studying metal-oxide-semiconductor properties where the above oxides act as gate dielectric andC – V (HF and LF), I – V, C – f, C – t measurements are carried out for their characterization.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: Research activities in the similar lines will be pursued along with exploration of the use of TMOs for optoelectronic applications. Further, a research plan has been made for fabrication of MOSFETs with TMOs as gate dielectrics.

TEACHING & GUIDANCE: Number of Ph. D. students: **Five (5) + one (1)**
I taught a course entitled 'VLSI fabrication techniques' to the post-MSc students for the sessions 2017 – 18, 2019 – 20 and 2021 – 22.

Research student (presently working):
One student Ms. Mousri Paul is working under me. She has already completed her research work. But she has planned to submit her thesis in March, 2024.

Project handled (Jan 2023 to date):
A project amounting Rs. 50,00,000/- (rupees fifty lacs only), sanctioned by DRDO to carry out etching of Pt and Cr metals for fabrication of IMPATT diode on silicon substrate along with other activities is jointly handled by Professor Mrinmay Mukhopadhyay. Further, device simulation using commercial simulator Silvaco is also under the scope of the project. DRDO has so far achieved 8 W output power after the etching the metals in SINP where the target is 10 W.

<u>Research Outcome – a patent:</u>

Title: A Method of Independent Control Over Size and Density of Nanoparticles for Fabricating Metal Nanoparticle Embedded MOS Capacitor and a Metal Nanoparticle Embedded MOS Capacitor Thereof for Non-Volatile Memory Applications

Indian Patent No.: 438391 vide App. No. 201831001324 dated 11.01.2018.
Award date: 12.07.2023

BISWARUP SATPATI
Scientist F, SPMS division

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2016-……..	Scientist F, Saha Institute of Nuclear Physics
2010-2016	Scientist E, Saha Institute of Nuclear Physics
2009-2010	Scientist C, CSRI-CMERI, Durgapur
2007-2009	Scientist C, CSRI-IMMT, Bhubaneswar
2005-2007	PDF, Paul-Drude Institute, Berlin, Germany
1999-2005	Research Fellow, Institute of Physics, Bhubaneswar
2006	Ph.D. in Science, Utkal University

AWARDS/ HONOURS
2017: MRSI Medal, Materials Research Society of India
2018: Excellence Award in Microscopy, Electron Microscopy Society of India

PUB STAT				
During 2017-2023:	Journals: 164;	Impact Factor>6: 46		
Total:	Journals: 376;	Average Citation: 25;	*h*-index: 46	

CURRENT RESEARCH AND DEVELOPMENT: We have developed different cost-effective process to prepare stable surface-enhanced Raman scattering (SERS) substrate based on silver (Ag) and palladium (Pd) nanoparticles deposited on different substrates such as silicon (Si) and germanium (Ge) etc. [*ACS Appl. Mater. Interfaces*, 9, (2017), 34405−34415, *ACS Appl. Nano Mater.,* 2, (2019), 2503−2514, *Applied Surface Science*, 501, (2020), 144225]. We have also developed different core−shell structures [Gold@Silver nanorods, Gold@Silver hollow nanocubes] of varying length for application in higher SERS enhancement and non-enzymatic biosensor [*ACS Appl. Nano Mater.,* 1, (2018), 5589-5600, *Materials Chemistry and Physics*, 239, (2020), 122113]. Direct fuel cells (DFCs) are considered as one of the most promising, sustainable and eco-friendly energy conversion devices for the power supply of vehicles and mobile electronics. Our work on Au@Pd bipyramid shaped core-shell nanoparticles with different Pd shell thicknesses shows extraordinarily high mass and specific activities towards ethanol oxidation reaction [*Applied Surface Science*, 604 (2022) 154491].

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: Direct alcohol fuel cells (DAFCs) are considered one of the promising and sustainable energy conversion devices potentially applicable to the power supply of vehicles and mobile electronics. DAFCs utilize the chemical energy of alcohol to generate electricity through alcohol oxidation reactions (AORs). DAFCs rely on alcohol oxidation reactions (AORs) to produce electricity, which require catalysts with optimized electronic structure to accelerate the sluggish AORs. Herein, we are working on epitaxial growth of Pd layer onto the penta-twinned Au@Ag core-shell nanorods (NRs) to synthesize highly strained Au@AgPd core-shell structures for improved alcohol oxidation through synergistic effects of tensile lattice strain and twin defects in core-shell electrocatalysts. Further research is needed to explore the potential of using the same strategy to design and synthesize other similar core-shell electrocatalysts which could be used in the construction of industrial-scale DAFCs with superior performance.

TEACHING & GUIDANCE: Ph.D. awarded: **4** [Total], **3** [during 2017-2023];
Synopsis/Thesis Submitted: **2**; Current Ph.D. students: **2**
I have been teaching advance course on “Transmission Electron Microscopy and its application” for post M. Sc. students and short-experiment in research laboratory and delivered 11 invited and one plenary talk in different conferences/seminars etc. outside SINP.

MRINMAY K. MUKHOPADHYAY
Associate Professor F, SPMS division

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2011-…….. Faculty, Saha Institute of Nuclear Physics
2006-2011 PDF, APS, USA & KEK, Japan
1999-2005 Research Fellow, Saha Institute of Nuclear Physics
2005 Ph.D. in Science, University of Calcutta

PUB STAT Journal publications [during 2017-2023]: **21**, Total: **42**; Book Chapter: **1**; h-index: **17**

CURRENT RESEARCH AND DEVELOPMENT: The investigation of the corelation between the structure and property and the regulation of structural parameters to tune the desired properties of the grown materials is the theme of my research in SINP. Our research group has focussed on growth, investigation of structure and measurement of properties of some soft and hard materials grown in the laboratory of SINP. One such area is soft-bio materials, where we create model bio-membrane to study the changes in structure in presence of proteins and other exogenous molecules which can predict the basic mechanism involved in cell functions. We first studied the organization of spectrin proteins in the membrane depending on the membrane molecular composition and then changed the flexibility of the spectrin molecules to understand the effect of the elasticity of the protein molecules to modulate the membrane flexibility. We have also studied the structural changes of the membrane due to the attachment of cholesterol and hemin molecules which have very important functions for the cell membrane activities. We are continuing our work in the area of two-dimensional magnetic ordering by depositing two-dimensional array of magnetic ions separated by organic molecules. We have observed FM and AFM ordering in the case of Gd and Ho ions and explained their magnetic behaviour with respect to the existing theory of magnetization for 2D systems. In the area of energy research, we have developed a two-dimensional hybrid perovskite material which is known for its excellent optical activities as solar cell materials and photovoltaic cells. The formation of layered structures at the air-water interface due to the specific interaction with the surfactants is particularly useful to prepare broad wavelength photoluminescence spectra close to white light. We are tuning the organization of the perovskites by changing the physical environment like surface pressure or the chemical environment like replacing Br with Cl to achieve better properties. We are also working with organic semiconductor materials and studying the electrical properties as a function of thickness of thin films which has technological application as flexible organic electronic devices. Surface engineering to tune the surface characteristics for the enhancement of a system properties is another emerging area of research. In this direction, we have used the ion beam sputtering technique in combination with co-sputtered material deposition to modify the surface morphology of a material.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: We shall continue the research in this exciting field of science with the focus on the growth of new energy efficient material thin films and investigation of their structure to correlate with the properties for better efficiencies. The x-ray synchrotron techniques play a major role in these researches and so, the development of the x-ray beamlines is also a part of my research activities. I have developed two x-ray scattering beamlines, one at the Indus-2 synchrotron centre, RRCAT, Indore and the other at Photon Factory, KEK, Japan.

TEACHING & GUIDANCE: Ph.D. awarded: **3** [Total], **2** [during 2017-2023]; Current Ph.D. students: **2**
I am involved in teaching Post MSc courses. Mainly, the condensed matter physics advanced course and different experimental techniques in our laboratories as part of the Post MSc teaching.

BISWAJIT KARMAKAR

Associate Professor-F, CMP division

Qualification: Ph.D (TIFR); M.Sc (Phys) (Univ. of Calcutta), B.Sc (Phys. Hons) (Univ. of Calcutta)

CURRENT RESEARCH AND DEVELOPMENT: Our group is primarily investigating quantum Hall systems and Graphene hybrid devices. Under high magnetic field and low temperature, electron correlations give rise to fractional quasi-particles called Composite Fermions in high mobility two-dimensional electron systems that results in fractional quantum Hall effect. At the boundary of quantum Hall system, dissipation-less one dimensional chiral fractional edge modes carry current. These topologically protected edge modes are useful for realizing flying qubits and hence topological quantum computing. High coherence length of fractional edge mode can accommodate many qubits for scalable architecture. In this research direction, a robust fractional edge mode of conductance 1/3 (e^2/h) having equilibration length of the order of mm is found at unity Landau level filling and two other fractional edge modes posses low equilibration length of the order of micrometer. Tunability of the equilibration length by applied magnetic field is demonstrated. Also equilibration between integer and fractional edge modes are investigated, where suppression of equilibration between them is observed because of dissimilar quasi-particales in the edge modes. Apart from studying these equilibration properties, we are currently focusing on origin of unexpected half-integer fractional quantum Hall effect like 5/2, 3/4,1/2 etc., those can not be explained by Composite Fermion hierarchy. In the project of Graphene hybrid devices, we have invented ultra-high sensitive Hydrogen gas sensor based on Graphene field effect transistor decorated with thin film of Palladium. Here, Palladium adsorbs Hydrogen gas reversibly, that modulates the work function of Palladium and hence the resistivity of Graphene is changed by electrostatic doping. We find that transverse sensitivity, measured between two pair of transverse contact of Graphene channel, is higher than the conventional sensitivity, measured along the Graphene channel. Therefore, a differential measurement setup in the transverse sensitivity gives rise to ultra-high sensitivity of Hydrogen gas that arises from carrier density gradient across the graphene channel. For chemical sensing, other suitable functional materials instead of Palladium can be decorated on the Graphene field effect transistor. Hence, this type of Graphene hybrid devices can be used for versatile chemical sensing.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: Our short-term goal is investigating origin of unexpected half-integer fractional quantum Hall effect like 5/2, 3/4,1/2 etc., those can not be explained by Composite Fermion hierarchy. We also want to make a prototype of Hydrogen gas sensor that is invented recently by our group. In long term, we will focus on qubit realization using the invented robust fractional edge modes and then scalable architecture for quantum information processing. We will also focus on versatile chemical sensing using Graphene hybrid devices.

Publications: (Since 1 April, 2017): Phys. Rev. Lett. 125, 076802 (2020), Phys. Rev. B 104, 085304 (2021), *ACS Appl. Nano Mater.* 5, 8, 10941 (2022).

Patent: 1. A Highly Sensitive H_2 Sensor based on CVD Graphene. Indian Patent application no. 202331040958, dated 25 June 2023.

Ph.D students: Degree awarded: 1; Synopsis/Thesis Submitted: 1; Presently working: 2.

Invited Talk: 5

Teaching (Post M.Sc Experimental): Advanced Condensed Matter Physics course is taught by me jointly with other faculty members in the year 2017-2019 and 2023.

SAMIK DUTTAGUPTA
Associate Professor-E, CMP division

Qualification: Ph.D (Tohoku Univ.); M.Sc (Phys) (Jadavpur Univ.), B.Sc (Phys. Hons) (Univ. of Calcutta)

List of broad research areas: Quantum materials and devices, spintronics and nanomagnetism.

CURRENT RESEARCH AND DEVELOPMENT: I joined Condensed Matter Physics Division, SINP in August 2022. My current research objective pertains to the utilization of charge and spin degrees of freedom in magnetic structures and understanding of underlying quantum mechanical, relativistic, condensed matter phenomena, leading to the development of next generation spintronics concepts and mesoscopic multifunctional heterostructures. Some of my recent research achievements include clarification of the underlying physics concerning generation of non-equilibrium current-induced spin-orbit torque (SOT) in antiferromagnet (AFM)/ferromagnet (FM) bilayer systems, demonstration of reversible SOT-induced switching of an AFM (down to 1 µs current pulse width) and clarification the microscopic picture of the switching dynamics, first demonstration of skyrmion Hall effect-free SOT-induced motion of chiral skyrmion bubbles in synthetic AFM down to nanosecond-regime, observation of an unconventional Hall effect phenomena in 2D van der Waals FM system. From these exploratory research works, I have also demonstrated memristor-like behavior in an AFM/FM system, promisingfor the development of spintronics-based neuromorphic structures.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: My future research aims at the development of quantummaterials and devicesto offer a promising basis for the development of energy efficient, fault-tolerant, versatile computing paradigms and providing the blueprint for solving time and energy limitations faced by modern architectures, through the concerted utilization of charge, spin, and orbital degrees of freedomin magnetic devices. Specifically, my research is targeted towards the understanding of underlying quantum mechanical, relativistic, and topological condensed matter phenomena leading to the realization of nanoscale multifunctional quantum devices through the exploration of new physics, innovative material, device concepts. Recently, in collaboration with colleagues at SINP, we have demonstrated a magnetotransport approach using anomalous Hall effect (AHE) to clarify the spin-spin interactions in a ferromagnetic system. The uniqueness of our results pertains to its universality to understand the modifications of underlying interactions or the presence of low field magnetic phases from "bulk" to mesoscopic devices.

Publications:
Phys. Rev. Materials 6, 014002 (2022), *Journal of Alloys and Compounds* (accepted) (2023)

Ph.D students: Presently working: 2.

Invited Talk: 6

Post M.Sc. teaching:
I have taught the course of Advanced Condensed Matter Physics jointly with other faculty member for the Post MSc. Batch 2022-23. In addition, I have also supervised Term I and Term II projects for a Post MSc. Students.

SUDIPTO CHAKRABARTI
Associate Professor E, SPMS division

DoB	29 November 1986
Phone	91 33 23375346 (ext: 4217)
E-mail	sudipto.chakrabarti@saha.ac.in

2022-……..	Faculty, Saha Institute of Nuclear Physics
2015-2022	PDF, Weizmann Institute of Science, Israel
2010-2015	RF, Indian Association for The Cultivation of Science
2015	Ph.D. in Science, Jadavpur University

PUB STAT	During 2022-2023:	Journals: **1**;	Impact Factor: **10.8**	
	Total:	Journals: **13**;	Average Impact Factor: **7.4**;	Average Citation: **10.3**

CURRENT RESEARCH AND DEVELOPMENT: I joined Surface Physics and Material Science Division, SINP in August, 2022. My current research objectives focus on fundamental understanding of charge and spin transport in quantum structures, down to the scale of a single atom, as well as to explore the possibility of future nanoscale devices. Currently, our group is focusing in two different directions. In one of the projects, we intend to study current–voltage characteristics of ultrathin 2-dimensional nanosheets through scanning probe techniques, such as scanning tunneling microscopy (STM) and spectroscopy (STS); and via conductive atomic force microscopy (CAFM). 2d – nanosheets are a fascinating material which attracted considerable interest to the scientific community for their robustness, easy to fabricate and high prospect of applications in devices such as photovoltaics, field effect transistors, etc., while quantum confinement can be maintained in such nanostructures depending on the sheet thickness. In this project, 2d – nanosheets with varying thicknesses are used to first form self–assembled monolayers (SAM) on gold surfaces and using scanning probe microscopy tip as the top electrode, current versus voltage (I – V) characteristics are recorded. The nature of the I – V, which will be obtained as a function of sheet thickness is the primary focus of this project to understand the underlying mechanism of electron transport in the nanosheets. Such information is expected to play a crucial role in optimizing the performances of devices based on such nanosheets. In the other project, we are developing an atomic scale transport set up, based on break junction technique, to measure ultra-low current down to the scale of a single atom or a molecule. Such a set up will allow us to understand the fundamental principle behind the origin of current pathways in atomic scale conductors.

FUTURE RESEARCH AND DEVELOPMENTAL PLAN: My upcoming research plans aim to detect circular currents and associated magnetic flux in single-ring organic molecules, like benzene. These circular currents result from quantum interference between different current pathways within the molecule, potentially serving as magnetic bits for future information processing. Additionally, our group will also investigate magneto transport in single molecule junctions between ferromagnetic electrodes to understand spin transport at the ballistic limit. In a third project, we will explore the origin and effects of spin transfer torque (STT) in atomic-scale junctions, verifying its behavior at the atomic level. STT's potential application in next-gen memory devices is significant. Experiments will be carried out within a custom-made break junction setup, inside a vector magnet providing magnetic fields of 3T and 9T parallel and perpendicular to the sample plane, respectively, at a base temperature of liquid helium.

TEACHING & GUIDANCE: Current Ph.D. students: **1**; Ph.D. awarded: Nil
Involved in Post MSc teaching, mainly providing (a) advanced courses on Surface Physics and Materials Science, (b) short experiments and (c) projects

Staff Profile of Group D:
Avijit Das (Scientific Officer D) **Responsibility:** An expert on MBE, SIMS systems and SINP beamline at RRCAT operation and maintanence. He assits instruments and software development. **Arindam Chakrabarti (Scientific Assistant E)** **Responsibility:** An expert on X-ray crystallography system operation and software development. He takes care of X-ray crystallography system and assists all the students for X-ray crystallography measurements. Also responsible for maintenance & smooth functioning of PLD set-up. **Dhruba Jyoti Seth (Scientific Assistant E)** **Responsibility:** An expert on Nuclear Magnetic Resonance system and liquid Helium plant operation. He takes care of those systems along with cryogenic measurement systems in the division and assists all the students for measurements. **Jayant Kumar Mukherjee (Scientific Assistant D)** **Responsibility:** An expert of electronic instrumentation and maintenance. He assists quantum Hall and gas sensing experiments and takes care of cleanroom device fabrication facility and processing equipments. He helps all the students in official matters. **Papia Mondal (Scientific Assistant D)** **Responsibility:** An expert of chemical processing. She takes care of chemical laboratory and assists all the students in CMP Division. **Souvik Banerjee (Scientific Assistant D)** **Responsibility:** An expert on DSC, TGA, LEIB systems operation and assisting students. **Gautam Sarkar (Scientific Assistant D)** **Responsibility:** An expert on XPS-UPS, VXRD and DLS systems operation and assisting students. **Debraj Dey (Scientific Assistant D)** **Responsibility:** An expert on Nanocluster deposition unit, HRSEM-CL system operation and assisting students. **Ramkrishna Dev Das (Scientific Assistant D)** **Responsibility:** An expert on HRXRD system, LB trough, Raman spectroscopy system operation and assisting students. **Nilkamal Barai (Scientific Assistant C)** **Responsibility**: An expert on liquid Nitrogen and Helium plant operation and maintenance. He takes care of those systems and assists all the students in SINP by supplying the liquids. He specially takes care of water chiller plat attached with liquid Nitrogen and Helium plant. **Biswajit Dutta (Accountant)** **Responsibility:** All kind of file processing and official activities

Rajeshwar Dubey (Work Assistant C)
Responsibility: An expert on liquid Nitrogen operation. He assists liquid Nitrogen and Helium production and helps all the students by supplying the liquids. He also assists official file processing and organizing events like seminars, official visits etc.

Jhantu Mallik (Work Assistant C)
Responsibility: An office staff. He assists official file processing and organizing events like seminars, official visits etc. He helps all the students in official matters. He also assists liquid Nitrogen and Helium production and helps all the students by supplying the liquids.

Gobardhan Jana (Work Assistant C)
Responsibility: An office staff. He assists official file processing and organizing events like seminars, official visits etc.

Instruments and facilities in Group-D			
List of instruments available in the group	**Responsibility of faculty members for maintaining each instrument/ facility**	**Number of students and faculty members sharing each instrument/facility**	**Present Condition**
Cryogen free Low temperature magneto transport measurements	Prof. Indranil Das	10 + 1	Working in the temperature range 5-310K and magnetic field 0- 9 Tesla.
UHV Sputter deposition set-up for ultra thin film preparation	Prof. Indranil Das	5 + 2	Working but some issues related to RF sputtering and DC sputtering power supply requires attention.
Pulsed Laser Deposition (PLD)	Prof. Indranil Das	4 + 2	In working state. Proposed expansion for a new UHV deposition chamber. Premix KrF laser gas is procured and is awaiting delivery at SINP.
Ferroelectric Hysteresis (P-E) Measurement set-up	Prof. Indranil Das	2 + 1	Working up to 6000 Volt Temperature 15-310 K Magnetic field 0-9 Tesla.
Float Zone Furnace for Crystal Growth	Prof. Indranil Das	4 + 2	Working
Physical Property Measurement System (PPMS)	Prof. Biswajit Karmakar and Prof. Samik DuttaGupta	All divisional members and students	Under maintenance. Leak in the sample chamber. PO for service visit is issued.
Cryogenics Low Temperature set-up	Prof. Samik DuttaGupta	5 + 1	Under maintenance
Quantum Design Cryogen-free measurement set-up	Prof. Chandan Mazumdar	9 + 1	Under maintenance
SQUID Magnetometer	Prof. Biswajit Karmakar and Prof. Samik DuttaGupta	All divisional members and students	Under maintenance
XRD System	Prof. Chandan Mazumdar	CMP and other divisional students, All divisional members	Fully operational.
High Temperature vibrating sample magmetometer	Prof. Chandan Mazumdar	7 + 2	In working state
Dilution Refrigerator System	Prof. Biswajit Karmakar	4 +1	In working state
Cleanroom device fabrication facility	Prof. Biswajit Karmakar & Prof. Samik DuttaGupta	10 + 2	In working state
Central Cryogenic Facility	Prof. Biswajit Karmakar	40 + 6	In working state
Nuclear Magnetic Resonance facility	Prof. Chandan Mazumdar	1 + 1	Stand-by
Spin-coater unit	Prof. S. Hazra	4 + 2	Working
Sputter deposition unit	Prof. S. Chakraborty	2 + 1	Working
UV-photolithography system	Prof. S. Chakraborty	2 + 1	Working

Clean room facilities	Prof. S. Chakraborty	2 + 1	Working
Nanocluster deposition unit	Prof. S. Chakraborty	3 + 1	Working
UHV evaporation unit	Prof. S. Chakraborty	0 + 1	Working
Plasma enchanced chemical vapor deposition system	Prof. S. Chakraborty	4 + 1	Working
ICP-based reactive ion etch system	Prof. S. Chakraborty	2 + 1	Working
Electron beam evaporation system	Prof. S. Chakraborty	5 + 2	Working
Low energy ion implanter	Prof. S. Chakraborty		To be working
TEM sample preparation	Prof. B. Satpati	3 + 1	Working
Langmuir-Blodgett trough	Prof. M. K. Mukhopadhyay	2 + 2	Working
Molecular beam epitaxy	Prof. M. K. Mukhopadhyay	1 + 1	Working
Multideposition unit	Prof. M. K. Mukhopadhyay & Prof. S. Bhunia		To be working
Magnetron sputtering unit	Prof. M. K. Mukhopadhyay		To be working
Metal organic vapor phase epitaxy	Prof. S. Bhunia		Not Working
Photoelectronspectroscopy (XPS-UPS)	Prof. S. Hazra	20 + 10	Working
Scaning probe microscope (Ambient SPM)	Prof. S. Hazra	8 + 3	Working
UV-vis spectrophotometer	Prof. S. Hazra	10 + 4	Working
Dynamic light scattering (DLS)	Prof. S. Hazra	2 + 2	Working
Versatile X-ray diffractometer (VXRD)	Prof. S. Hazra	4 + 1	Working
Scanning probe microscopy (UHV-SPM)	Prof. Prof. S. Hazra & Prof. S. Chakrabarti		To be working
Angle-resolved photoemission spectroscopy (ARPES)	Prof. K. S. R. Menon	3 + 1	Working
Low energy electron microscopy (LEEM)	Prof. K. S. R. Menon	3 + 1	Working
Semiconductor parameter analyzer	Prof. S. Bhunia	2 + 2	Working
Photoluminescence (PL) setup	Prof. S. Bhunia	4 + 2	Working
Raman spectroscopy setup	Prof. S. Bhunia	2 + 2	Working
Semiconductor parameter analyzer	Prof. S. Chakraborty	5 + 2	Working
Differential scanning calorimetry	Prof. S. Chakraborty	8 + 4	Working
Secondary ion mass spectrometry	Prof. S. Chakraborty	3 + 2	Working

300 kV Transmission electron microscope	Prof. B. Satpati	24 + 10	Working
HRSEM-CL	Prof. B. Satpati	14 + 7	Working
Contact angle measurement	Prof. B. Satpati	2 + 2	Working
High resolution x-ray scattering	Prof. M. K. Mukhopadhyay	24 + 10	Working
Low temperature transport measurement	Prof. M. K. Mukhopadhyay		To be working
Brewster angle microscopy (BAM)	Prof. M. K. Mukhopadhyay		To be working
SINP beamline at INDUS-2	Prof. M. K. Mukhopadhyay	>40 + 20	Working
Physical property measurement system (PPMS)	Prof. Indranil Das		Under maintanence
Magnetic measurement (SQUID) setup			Not Working, Not repairable

Students profile of Group D

Full list of students working in the Group since 2017	1. Tapas Pramanik, 2. Sanjib Banik, 3. Snehal Mandal, 4. Apurba Dutta, 5. Suvayan Saha, 6. Dipak Mazumdar, 7. Amrita Dutta, 8. Arnab Bhattacharya, 9. Afsar Ahmed, 10. Amanulla Karikar, 11. Soma Chatterjee, 12. Kaustav Pal, 13. Santanu Pakhira, 14. Sudipta Mondal, 15. Binita Mondal, 16. Mily Kundu, 17. Sanchayita Mondal, 18. Sudip Chakraborty, 19. Shuvankar Gupta, 20. Soumya Bhowmik, 21. Arka Patra, 22. Moumita Das, 23. Ratnadwip Singha, 24. Subhankar Roy, 25. Susmita Roy, 26. Arnab Pariari, 27. Rajeswari Roy Choudhary, 28. Susmita Dhara, 29. Tanmay Maiti, 30. Pooja Agarwal, 31. Suvankar Purkait, 32. Suparna Sahoo, 33. Dibyendu Majee, 34. Sachin Majee, 35. Debasree Chowdhury, 36. Kaustabh Dan, 37. Uttam Kumar Basak, 38. Sk Abdul Kader Md Faruque, 39. Debaleen Biswas, 40. Shyamal Mondal, 41. Suvankar Chakraborty, 42. Arpan Bhattacharyya, 43. Madhumita Choudhuri, 44. Arka Bikash Dey, 45. Rajendra Prasad Giri, 46. Asish K. Kundu, 47. Tapas Ghosh, 48. Arpan Maiti, 49. Achyut Maity, 50. Gouranga Manna, 51. Barnamala Saha, 52. Sukanta Barman, 53. Arnab Singh, 54. Gourab Bhattacharjee, 55. Anway Pradhan, 56. Suman Mukherjee, 57. Abhishek Rakshit, 58. Abhijit Roy, 59. Mantu Modak, 60. Bibhuti Bhusan Jena, 61. Pintu Barman, 62. Smruti Ranjan Mohanty, 63. Anindita Deka, 64. Md. Saifuddin, 65. Arunava Kar, 66. Rezwana Sultana, 67. Karimul Islam, 68. Suchanda Mondal, 69. Subhankar Mandal, 70. Saugata Roy, 71. Mousri Paul, 72. Smruti Medha Mishra, 73. Sabyasachi Karmakar, 74. Subhadip Chowdhury, 75. Shuvankar Das, 76. Subrata Paul, 77. Tukai Singha, 78. Suman Dey, 79. Souvik Jana, 80. Suman K Ghosh, 81. Suswapna Mukherjee

Year-wise distribution of students	17-18	18-19	19-20	20-21	21-22	22-23
	50	51	45	44	38	38

Faculty-wise distribution of students

I. Das	C. Mazumdar	B. Karmakar	S. DuttaGupta	P. Mandal	B. Bandhyopadhyay
12	9	4	2	5	2

S. Hazra	K.S.R. Menon	S. Bhunia	S. Chakraborty	B. Satpati	M. K. Mukhopadhyay	S. Chakrabarti
5	8	2	7	7	5	1

M. K. Sanyal	D. Ghose	A. Datta	S. R. Bhattacharyya	T. K. Chini	S. Banerjee
3	1	3	3	2	2

Placements of students since 2017	**<u>Assistant/Associate Prof.</u>** : Tapas Pramanik, Dipak Mazumdar, Ratnadwip Singha, Subhankar Roy, Sudipta Mondal, Binita Mondal, Sanchayita Mondal, Pintu Barman, Bibhuti Bhusan Jena, Sukanta Barman, Barnamala Saha, Arpan Maiti, Rajendra Prasad Giri, Suvankar Chakraborty, Shyamal Mondal, Uttam Kumar Basak, Kaustabh Dan. **<u>Post doctoral Fellow</u>** : Snehal Mandal, Apurba Dutta, Sanjib Banik, Santanu pakhira, Moumita Das, Susmita Roy, Arnab Pariari, Mily Kundu, Rajeswari Roychoudhary, Susmita Dhara, Tanmay Maiti, Suvayan Saha, Karimul Islam, Rezwana Sultana, Arunava Kar, Md. Saifuddin, Smruti Ranjan Mohanty, Mantu Modak, Abhishek Rakshit, Suman Mukherjee, Anway Pradhan, Gourab Bhattacharjee, Arnab Singh, Gouranga Manna, Achyut Maity, Asish K. Kundu, Arka Bikash Dey, Madhumita Choudhuri, Arpan Bhattacharyya, Debasree Chowdhury. **<u>Scientific Assistant/Staff:</u>** Tapas Ghosh, Abhijit Roy

PDF profile of Group D						
Full list of PDFs working in the Group since 2017	1. Biswanath Samantaroy (2017), 2. C. Venkatesh (2017-2019), 3. Ayana Mukhopadhyay (2021-23), 4. Suvayan Saha (2023-present), 5. Dhrubojyoti Roy (2016-2018), 6. Somnath Mahato (2016-2018), 7. Satish Kumar Mandal (2019-2022), 8. Rajashri Urkude (2021-2023), 9. Rijul Roychowdhury (2022-present), 10. Arup Ghosh (2019-21).					
Year-wise distribution of PDFs	17-18	18-19	19-20	20-21	21-22	22-23
	3	3	2	3	4	3
Faculty-wise distribution of PDFs	Indranil Das	Chandan Mazumdar	SPMS	Manabendra Mukherjee	Prabhat Mandal	RRCAT beam line
	1	1	1	1	3	3

Research profile of Group D		
List of broad research areas	**Research area-wise distribution of faculty members**	**Research area-wise distribution of students**
Magneto caloric materials	ID, CM	15
Magneto transport	ID, CM, BK, SDG, PM	20
Quantum Hall effect	BK	4
Graphene hybrid devices	BK	2
Giant/Collosal magneto resistance	ID	10
Inter metallic compounds	ID, CM	10
Magnetic frustration and magnetism	ID, CM, PM	20
Structure-properties relation	CM	6
Nuclear magnetic resonance spectroscopy	CM, BB	3
Thermoelectric power	ID, CM	4
Spintronic materials, high spin polarization and nanoelectronics	ID, CM, SDG, SC2	11
Polymorphic materials	CM	2
Negative and zero thermal expansion materials	CM	2
Quantum materials, devices and nanomaterials	BK, SDG, ID	8
Non-collinear magnetism, magnetic skyrmion and anomolus Hall effect	ID, SDG, CM	13
Multiferroic materials	ID	2
Nano magnetism	ID, SDG	6
Growth-structure-property correlation in low dimensional systems	SH, KSRM, SB, SC1, BS, MKM, SC2	32
Optoelectronics, photovoltaics, and photonics	SH, SB, SC1, BS, MKM	13
Interfacial structures and their dynamics; ordering near buried interface	SH, BS, MKM	11
Electronic structure of thin films, especially near surfaces& interfaces	SH, KSRM, SB, SC1, SC2	12
Magnetism in thin films, especially near surfaces & interfaces	KSRM MKM SC2	6
Spectromicroscopy of surfaces and low-dimensional systems	KSRM	3
Low dimensional systems: thin films, nanostructures, nanoparticles, nanocomposites	SH, KSRM, SB, SC1, BS, MKM, SC2	31
Soft matter: organic and polymeric semiconductors, bio materials	SH, MKM, SC2	9
Transition metal oxide-based gate dielectric materials	SC1	3

1. ID: Indranil Das, 2. CM: Chandan Mazumdar, 3. PM: Prabhat Mandal, 4. BB: Bilwadal Bandhyopadhyay, 5. BK: Biswajit Karmakar, 6. SDG: Samik DuttaGupta, 6. SH: S. Hazra, 7. KSRM: K. S. R. Menon, 8. SB: S. Bhunia, 9. SC1: S. Chakraborty, 10. BS: B. Satpati, 11. MKM: M. K. Mukhopadhyay, 12. SC2: S. Chakrabarti

Other points of Group D	
Key areas in which the Group can make impact in the coming 3 to 5 years	1. Non-collinear magnetism & Magnetic skyrmion 2. Spintronic and quantum materials 3. Quantum Hall effect 4. Graphene hybrid devices 5. Growth-structure-property correlation in confined geometries 6. Electronic/optoelectronic/photonic/photovoltaic properties of low-dimensional systems 7. Growth of advanced materials for the better opto-electronic properties 8. Understanding buried interfaces and tuning interfacial structure and ordering 9. Soft matter research including bio materials 10. Oxide-based optoelectronic and resistive memory devices 11. Spectromicroscopy of low-dimensional materials 12. Electrocatalyst for fuel cell applications
Key areas in which the Group is planning to expand in next 3 to 5 years	1. Quantum phenomena and magnetism in bulk single crystal/polycrystal 2. Functional material research 3. Electronic and magnetic correlation effect and topological phenomena in thin film/layer materials 4. Quantum structures and device physics 5. Growth, structure & properties of advanced functional and energy efficient low-dimensional materials 6. Advanced scattering, spectroscopic & microscopic techniques 7. Further development of SINP beamline for the study of energy efficient materials 8. Spintronics and molecular electronics 9. Soft condensed matter
Faculty members (with their research areas) retired since 2017	1. Prof. Asok Poddar 2017 (Magnetism, nanomaterials, transport) 2. Prof. Barnana Pal 2019 (Ultrasonic Spectroscopy) 3. Prof. Bilwadwal Bandhyopadhay 2020 (NMR spectroscopy, nanomaterials) 4. Prof. Prabhat Mandal 2021 (Topological Insulator, Vander-walls materials, Oxide single crystal etc.) 5. Prof. Tapas Kumar Chini, 2023 (Ion beam and photonics) 6. Prof. Sangam Banerjee, 2021 (Magnetism and magneto-transport) 7. Manabendra Mukherjee, 2020 (Soft Matter: polymers and organic semiconductors)

	8. Satyaranjan Bhattacharyya, 2020 (Ion beam and nanoclusters) 9. Madhusudan Roy, 2017 (Thermal stability of metalo-organic compounds) 10. Alokmay Datta, 2017 (Soft Matter: polymers and amphiphilic molecules)
Faculty members (with their research areas) recruited since 2017	1. Samik DuttaGupta 2022 (Quantum materials and devices, spintronics and nanomagnetism) 2. Sudipto Chakrabarti, 2022 (Nanoelectronics and spintronics; mainly usingscanning probe and break junction techniques)
Number of seminars organized since 2017	Student seminars: 294; Postdoc seminars: 30; External speakers: 45
Number of conferences/workshops/schools organized since 2017	1. HBNI Interaction Meeting on Condensed Matter Physics: HBNI-im-CMP, 23-24 June, 2022 2. Young Scientists' Colloquium: YSC–2019, 17 September, 2019 3. Young Physicists' Colloquium: YPC-2018, 23-24 August, 2018 4. Discussion Meeting on Crystallization and Ordering at Surfaces andInterfaces, 2-4 Jan, 2018 5. Discussion meeting on Synchrotron Science, 13-15 December, 2017
Number of summer trainee (SINP / Academies) since 2017	7
Number of undergraduate trainee (SINP / Academies) since 2017	3
Number of outreach programs since 2017	Nearly 8 (participated)
Number of invited talks given by Group members since 2017	29
Instruments/facilities which the Group is planning to install/develop in next 3 to 5 years	1. Dedicated electron beam lithography system. 2. Single Crystal growth facility 3. Sample preparation and characterization facility 4. Device fabrication equipments and facility 5. Cryogen-free low temperature measurement setup 6. Magnetic measurement setup 7. Magnetic imaging setup 8. A dedicated SAXS-WAXS-GISAXS-GIWAXS setup 9. small- and wide-angle X-ray scattering (SAXS-WAXS) and grazing incidence SAXS-WAXS 10. A dedicated Fourier Transformed Infrared (FTIR) spectroscopy setup

	11. A break junction setup with a vector magnet upto 9T magnetic field parallel and perpendicular to the sample planeat a base temperature of liquid He 12. Transient PL spectroscopy 13. SPELEEM system through upgradation of LEEM system 14. Optically-coupled transmission electron microscopy 15. Upgradation of SINP beamline for the scattering studies using high energy photons
Number of courses offered by the Group in teaching since 2017	Advanced course: 19; Short experimental courses: 25; projects: 60
List of institutions collaborating with the Group	1. TCG Crest, 2. Bose Institute, 3. IACS, 4. SNBCBS, 5. IISER Kolkata, 6. IIT Bombay, 7. University of New South Wales, 8. Tohoku University, 9. IISER Bhopal, 10. IISER Pune, 11. VECC Kol, 12. CSIR-CGCRI, 13. CU kol, 14. JU Kol, 15. Presidency University, 16. IIT Kharagpur, 17. UB Burdwan, 18. Visva-Bharati University, 19. Vidyasagar University, 20. CSIR-CMERI, 21. CSIR-IMMT, 22. CSIR-NPL, 23. GGSIU Delhi, 24. DU Delhi, 25. IUAC Delhi, 26. IIT Ropar, 27. IIT Hydrabad, 28. IIT Bhubaneswar, 29. NISER, 30. IP Bhubaneswar, 31. UM Chennai, 32. CUJ Jammu, 33. RGU Arunachal Pradesh, 34. IISST Kerala, 35. CPPIPR Assam, 36. IPR Gandhinagar, 37. BARC Mumbai.
Main difficulties faced by the Group since 2017	1. Slow purchase procurement process 2. Difficulty in maintaining some of the instruments due to lack of fund for a period of time 3. Lack of sufficient number of students 4. Reduced Faculty strength
List of extramural projects with PI's names since 2017	1. IFCPAR project in collaboration with Dr. Eric Alleno (ICMPE, CNRS, Thiais, France) in 2022-23. PI: Prof. Chandan Mazumdar 2. CARS project with CMSDS, DRDO, Baruipur, Kolkata; PI: Prof. M. K. Mukhopadhyay
List of patents since 2017	1. Indian Patent No.: 438391 vide App. No. 201831001324 dated 11.01.2018. Award date: 12.07.2023. Title: A Method of Independent Control Over Size and Density of Nanoparticles for Fabricating Metal Nanoparticle Embedded MOS Capacitor and a Metal Nanoparticle Embedded MOS Capacitor Thereof for Non-Volatile Memory Applications 2. A Highly Sensitive H_2 Sensor based on CVD Graphene. Indian Patent application no. 202331040958, dated 25 June 2023