Dr. Abhinanda Sengupta, Ph.D.

Postdoctoral Research Associate
Energy and Transport Sciences Laboratory (PI: Prof. Partha P. Mukherjee)
School of Mechanical Engineering, Purdue University
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RESEARCH INTERESTS

- Metal-ion, metal, metal-sulfur, anode-free, all solid-state batteries
- Battery thermal safety analysis
- Pouch, prismatic and cylindrical cell fabrication
- Synthesis and development of battery electrode materials
- Battery interfacial engineering
- Battery electrolyte modulation

EDUCATION

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY — **Mumbai, India**
Ph.D. in Energy Science & Engineering — *July 2018-Sept 2024*
Thesis: Mechanistic Insights of Heteroatom-doped Layered Oxide Cathode Materials for Next-gen Sodium-ion Batteries
Advisor: Prof. Sagar Mitra

University of Calcutta — **Kolkata, India**
M.Tech in Chemical Engineering (Gold Medalist) — *July 2015-July 2017*
Thesis: Optimization Pb-Sn based Perovskite Solar Cells
Advisor: Prof. Subhasis Roy

West Bengal University of Technology — **Kolkata, India**
B.Tech in Chemical Engineering — *July 2011-July 2015*
Projects: Fluoride removal from groundwater by adsorption technique using activated carbon from waste; Designing of Biogas upgradation using Pressure Swing Adsorption Technology
Advisor: Prof. Prasenjit Chakraborty

St. Thomas' Girls' School — **Kolkata, India**
Indian School Certificate — *April 2009-Mar 2011*

RESEARCH EXPERIENCE

PURDUE UNIVERSITY — **West Lafayette, USA**
Postdoctoral Research Associate — *January 2025-Present*
Advisor: Prof. Partha P. Mukherjee

- Investigating interphase formation and electrode crosstalk mechanisms governing thermal stability in sodium-ion batteries using ARC and complementary spectroscopic tools.
- Analysing oxygen evolution in P2-type $Na_{2/3}Fe_{1/2}Mn_{1/2}O_2$ cathodes as a surface-mediated process induced by cathode-electrolyte interfacial restructuring at high states of charge.

- Established an in-house electrode materials synthesis facility, enabling controlled fabrication of cathode and anode materials for sodium and lithium-based systems.
- Set up a complete pouch cell fabrication line, including electrode casting, calendaring, cell stacking, electrolyte filling, and vacuum sealing.
- Examined the influence of anode composition and electrolyte interactions on thermal stability of sodium-ion batteries through integrated ARC, SEM, and EIS studies.
- Evaluating thermal stability of sodium metal electrodes in various electrolyte formulations by correlating exothermic onset behaviour with electrode morphology changes.
- Assessing the role of cathode crosstalk in dictating thermal instability in lithium metal batteries with liquid electrolytes under high voltage and elevated temperature conditions.
- Performing thermal analysis of NVP cathodes paired with hard carbon composite anodes, focusing on interfacial stability and additive engineering strategies.
- Investigating sodium plating phenomena under varying thermal environments and high C-rates in commercial sodium-ion batteries using electrochemical and ARC diagnostics.
- Studying the impact of temperature variation on structural and compositional evolution of SEI layers in commercial sodium-ion batteries.
- Characterizing the thermo-electrochemical stability of composite anode systems for sodium-ion batteries by integrating impedance, calorimetry, and post-mortem analyses.
- Drafted technical equipment proposals and research project justifications for laboratory expansion, instrumentation procurement, and collaborative grant applications aligned with next-generation battery research initiatives.
- Mentoring Ph.D. scholars on experimental design, data interpretation, and manuscript preparation, fostering independent scientific thinking and rigor in advanced electrochemical energy storage research.

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY **Mumbai, India**
Postdoctoral Research Fellow *July 2024-December 2024*
Advisor: Prof. Sagar Mitra

- Synthesized and characterized Na-rich biphasic layered oxide cathodes, elucidating phase evolution, Na-vacancy ordering, and long-term cycling behaviour through advanced electrochemical and structural diagnostics.
- Developed room-temperature sodium-sulfur batteries with intercalation-type catalytic hosts, achieving high cycle life through polysulfide confinement and electrolyte optimization.
- Led the scale-up of sodium-ion and sodium-sulfur pouch cells by integrating material development with process engineering, including slurry formulation, electrode calendaring, and dry-room cell assembly.
- Contributed to proposal writing for national funding calls; mentored and guided graduate students on experimental design, material synthesis, cell fabrication, and data interpretation.

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY **Mumbai, India**
Research Assistant *May 2024-July 2024*
Advisor: Prof. Sagar Mitra

- Engineered high-entropy oxide cathode materials for sodium-ion batteries, optimizing cation disorder and multi-element synergy to achieve enhanced structural stability and electrochemical performance.
- Contributed to proposal writing; mentored and guided graduate students.

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY **Mumbai, India**
Ph.D. Research Scholar (Teaching Assistant) *July 2018-Sept 2024*
Advisor: Prof. Sagar Mitra

- Gained deep expertise in the synthesis and structural tuning of heteroatom-doped layered oxide cathodes for sodium-ion batteries, focusing on stabilizing high-voltage phases and enhancing redox reversibility.
- Engineered electrodes with tailored microstructure and optimized porosity to enable high-rate performance, long-term cycling stability, and controlled electrode–electrolyte interfacial chemistry.
- Designed and assembled full-cell configurations, including Swagelok, CR2032 and CR2016 coin cells, pouch cells, and 18650 cylindrical cells for performance validation and failure diagnostics.
- Operated and interpreted advanced characterization tools including high-resolution TEM, FEG-SEM, *in-situ* and *ex-situ* XRD, XPS, Raman spectroscopy, FTIR, and synchrotron-based EXAFS/XANES, to derive structure-function correlations and monitor phase transitions.
- Independently operated TEM and FEG-SEM systems for probing morphological evolution, phase interface dynamics, and transition metal migration during electrochemical cycling.
- Conducted Rietveld refinement and crystallographic analysis using FullProf, HighScore Plus, and VESTA; performed XPS deconvolution with CASA-XPS and XANES spectral fitting using Athena to study interfacial and bulk redox phenomena.
- Mentored and trained postgraduate and Ph.D. researchers in battery materials synthesis, cell assembly, and materials characterization workflows; supervised multiple M.Tech and B.Tech projects.
- Served as Teaching Assistant for core graduate and undergraduate courses: EN 658 Electrochemical Energy Storage, EN 656 Chemistry for Energy Science, EN 323 Renewable Energy Generation & Storage, and EN 309 Thermal and Fluid Engineering Lab.
- Contributed to the academic ecosystem by organizing technical workshops, project review meetings. national symposia, and international conferences on advanced battery materials and energy storage technologies.

NATIONAL CENTRE FOR PHOTOVOLTAICS REEARCH & EDUCTAION (NCPRE) Ministry of New and Renewable Energy, IIT Bombay **Mumbai, India**
December 2017-July 2018
Senior Research Fellow
Advisors: Prof. B. G. Fernandes; Co-advisor: Prof. Sagar Mitra

- Worked as the student head of the Energy Storage group, quarterly report writing and compilation of the group's work
- Synthesis of electrode materials for Li-ion batteries.
- Conducted physicochemical, morphological, electrochemical and post-mortem characterizations
- Cell fabrication (coin, pouch and 18650 cylindrical cells)
- Optimization of full-cell based on NMC//Graphite chemistry

UNIVERSITY OF CALCUTTA **Kolkata, India**
Research Assistant *July 2015-July 2017*
Advisor: Prof. Subhasis Roy

- Developed and optimized Pb–Sn alloyed perovskite absorber layers via compositional engineering to enhance light absorption and reduce bandgap for tandem solar cell applications.
- • Investigated the influence of annealing protocols, precursor stoichiometry, and interfacial passivation on phase stability, carrier lifetime, and device efficiency.

- Conducted optoelectronic and structural characterization using UV–Vis spectroscopy, XRD, SEM, and photoluminescence to correlate material quality with power conversion performance.

JADAVPUR UNIVERSITY **Kolkata, India**
Junior Research Intern *June 2013-July 2013*
Advisor: Prof. Chiranjib Bhattacharya

- Investigated the effect of temperature on lactose hydrolysis using β-galactosidase enzyme

INDUSTRIAL EXPERIENCE

INDIAN OIL CORPORATION LTD. **West Bengal, India**
Summer Intern *June 2014-July 2014*
Advisor: Mr. A. Chakraborti

- Studied the processes involved in the functioning of the following units: Effluent Treatment Plant, Oil Movement and Storage Unit, Bitumen Filling station, LPG station, Fuel Oil Block, Lube Oil Block, Dehydro- Desulfurization Unit, Hydrocracker Unit and Inspection Department.

PUBLICATIONS

- **PEER-REVIEWD JOURNALS**

1. **A. Sengupta**, A. Kumar, G. Barik, A. Ahuja, J. Ghosh, H. Lohani, P. Kumari, T. K. Bhandakkar, S. Mitra, Lower Diffusion-Induced Stress in Nano-Crystallites of P2-$Na_{2/3}Ni_{1/3}Mn_{1/2}Ti_{1/6}O_2$ Novel Cathode for High Energy Na-ion Batteries, ***Small***, 2023, 19(12), 2206248. https://doi.org/10.1002/smll.202206248
2. **A. Sengupta**, A. Kumar, A. Bano, A. Ahuja, H. Lohani, S. H. Akella, P. Kumar, M. Noked, D. T. Major, S. Mitra, Unleashing the Impact of Nb-doped, Single Crystal, Cobalt-free P2-type $Na_{0.67}Ni_{0.33}Mn_{0.67}O_2$ on Elevating the Cycle Life of Sodium-ion Batteries, ***Energy Storage Materials***, 2024, 69, 103435. https://doi.org/10.1016/j.ensm.2024.103435
3. J. Nongkynrih, **A. Sengupta**, B. Modak, S. Mitra, A. K. Tyagi, D. P. Dutta, Enhanced electrochemical properties of W-doped $Na_3V_2(PO_4)_2F_3$@C as cathode material in sodium ion batteries, ***Electrochimica Acta***, 2022, 415, 140256. https://doi.org/10.1016/j.electacta.2022.140256
4. A. Ahuja, A. Kumar, **A. Sengupta**, M. Gautam, H. Lohani, P. Kumari, S. Mitra, Single-crystal spinel $Li_{1.08}Mn_{1.92}O_4$ octahedra cathode covered with Li-ion permeable robust NMC thin-layer protection for high voltage lithium-ion batteries, ***Energy Storage Materials***, 2022, 52, 169-179. https://doi.org/10.1016/j.ensm.2022.07.013
5. A. Ahuja, S. H. Akella, **A. Sengupta**, P. Kumari, M. Noked, S. Mitra, Enhanced Stability and Performance of High-Voltage LNMO Cathodes with Dual-Anion Niobium Oxyfluoride Coating, ***Small***, 2025, e05389.
6. H. Lohani, A. Kumar, A. Bano, A. Ghosh, P. Kumari, A. Ahuja, **A. Sengupta**, D. Kumar, D. T. Major, S. Mitra, Inclusion of Anionic Additives in the Inner Solvation Shell to Regulate the Composition of Solid Electrolyte Interphase, ***Advanced Energy Materials***, 2024, 14 (32), 2401268. https://doi.org/10.1002/aenm.202401268
7. A. Kumar, A. Ghosh, A. Ghosh, A. Ahuja, **A. Sengupta**, M. Forsyth, D. R. MacFarlane, S. Mitra, Sub-zero and room-temperature sodium–sulfur battery cell operations: A rational current collector, catalyst and sulphur-host design and study, ***Energy Storage Materials***, 2021, 42, 608-617. https://doi.org/10.1016/j.ensm.2021.08.014
8. H. Lohani, A. Kumar, P. Kumari, A. Ahuja, M. Gautam, **A. Sengupta**, S. Mitra, Artificial organo-fluoro-rich anode electrolyte interface and partially sodiated hard carbon anode for improved cycle life and practical sodium-ion batteries, ***ACS App. Mat. & Int.***, 2022, 14(33), 37793-37803. https://doi.org/10.1021/acsami.2c09985
9. H. Lohani, D. T. Duncan, X. Qin, P. Kumari, M. Kar, **A. Sengupta**, A. Ahuja, A. Bhowmik, S. Mitra, Fluorine Rich Borate Salt Anion Based Electrolyte for High Voltage Next Generation Sodium Metal Battery Development, ***Small***, 2024, 20 (42), 2311157. https://doi.org/10.1002/smll.202311157
10. A. Ahuja, A. Kumar, K. Alam, H. Lohani, **A. Sengupta**, P. Kumari, K. Thapliyal, S Mitra, Enhancing High-Voltage LNMO Cathode performance in Li-metal batteries via Anionic Electrolyte Additive-Integrated CEI Engineering, ***Advanced Functional Materials***, 2025, 35 (10), 2416634. https://doi.org/10.1002/adfm.202416634
11. P. Kumari, A. Kumar, H. Lohani, A. Ahuja, **A. Sengupta**, S. Mitra, Pristine NASICON Electrolyte: A High Ionic Conductivity and Enhanced Dendrite Resistance Through Zirconia (ZrO_2) Impurity-free Solid-Electrolyte Design, ***Small Methods***, 2025, 9 (3), 2401019. https://doi.org/10.1002/smtd.202401019

12. P. Kumari, A. Kumar, **A. Sengupta**, H. Lohani, A. Ahuja, S. Mitra, Impact of Composite Cathode Architecture Engineering on the Performance of All-Solid-State Sodium Batteries, ***ACS Applied Materials & Interfaces***, 2025, 17, 30793-30805. https://doi.org/10.1021/acsami.5c01091
13. Sk A. Moyez, S. Maitra, K. Mukherjee, **A. Sengupta**, S. Roy, Structural Features and Optical Properties of $CH_3NH_3Pb_{(1-x)}Sn_xCl_3$ Thin-Film Perovskites for Photovoltaic Applications, ***Journal of Electronic Materials***, 2020, 49, 7133-7143. https://doi.org/10.1007/s11664-020-08529-5
14. A. Dey, P. Karan, **A. Sengupta**, Sk A. Moyez, P. Sarkar, S. Basu Majumder, D. Pradhan, S. Roy, Enhanced charge carrier generation by dielectric nanomaterials for quantum dots solar cells based on CdS-TiO_2 photoanode, ***Solar Energy***, 2017, 158, 83-88. https://doi.org/10.1016/j.solener.2017.09.038
15. Sk A. Moyez, **A. Sengupta**, A. B. Biswas, S. Roy, A. Dey, B. C. Das, Fabrication of environmentally friendly perovskite solar cell by partial replacement of lead with tin, ***Invertis Journal of Renewable Energy***, 2017, 7(2), 59-63. https://doi.org/10.1016/j.solener.2017.09.038

- **JOURNALS UNDER REVIEW OR COMMUNICATED**

1. Kausthubharam, **A. Sengupta**, B. S. Vishnugopi, D. R. R. Kannan, F. Gray, V. Premnath, W. S. Tang, J. A. Jeevarajan, P. P. Mukherjee, A Perspective on Degradation-Safety Interactions in Na-ion Batteries, ***ACS Energy Letters*** (under review), 2025.
2. P. Ranganathan, A. Karmakar, **A. Sengupta**, B. S. Vishnugopi, D. R. R. Kannan, F. Gray, V. Premnath, W. S. Tang, J. A. Jeevarajan, P. P. Mukherjee, Interrogating the Role of Anode Composition and Electrolyte Interactions on the Thermo-electrochemical Stability of Sodium-ion Batteries, ***ACS Applied Materials and Interfaces*** (under review), 2025.
3. S. Sau, J. Ghosh, A. P V, G. K. Mishra, **A. Sengupta**, S. Mitra, Preventing Chemo-mechanical Degradation of High Voltage Cathode and Li Metal Anode by Amorphous Lithium Silicon Oxide Coating and Solid Electrolytes, ***Journal of Power Source*** (under review), 2025.
4. P. Kumari, A. Kumar, H. Lohani, A. Ahuja, **A. Sengupta**, S. Mitra, Boosting Solid-State Sodium Battery Performance via Co-Sintering of Layered Iron, Manganese Based Oxide Cathode and NASICON Electrolyte, ***Energy Storage Materials*** (under review), 2025.

- **JOURNALS IN PREPARATION:**

1. **A. Sengupta**, A. Bano, A. Ahuja, K. Thapliyal, H. Lohani, P. Kumar, A. Kumar, M. Noked, D. T. Major, S. Mitra, Deciphering the Role of Ligand-to-Metal Charge Transfer in Triggering Anionic Redox Activity of P2-Type $Na_{0.67}Ni_{0.33}Mn_{0.67-x}Ru_xO_2$ ($0 \le x \le 0.16$) (manuscript ready, advanced draft available).
2. **A. Sengupta**, A. Kumar, A. Ahuja, S. H. Akella, A. Patil, H. Lohani, P. Kumar, M. Noked, D. T. Major, S. Mitra, Enhancing Sodium-ion Battery Efficiency via Interfacial Engineering in Layered Oxide Cathode Material (manuscript ready, advanced draft available).
3. B. S. Vishnugopi, **A. Sengupta**, Kausthubharam J. A. Jeevarajan, P. P. Mukherjee, Mechanistic Insight into the Thermal Stability and Safety of Solid-State Batteries (manuscript ready, advanced draft available).
4. Md T. Hasan, A. J. Miguel, A. Halverson, **A. Sengupta**, A. Karmakar, B. S. Vishnugopi, G. H. Waller, C. T. Love, P. P. Mukherjee, Deleterious Role of Moisture Exposure on the Thermal Stability and Safety of Sulfide-Based Solid-State Batteries (advanced draft available).

- **PATENTS:**

1. **A. Sengupta**, A. Kumar, A. Ahuja, H. Lohani, P. Kumari, S. Mitra, Lower Diffusion-Induced Stress in Nano-crystallites of P2-$Na_{2/3}Ni_{1/3}Mn_{1/2}Ti_{1/6}O_2$ Novel Cathode for High Energy Na-ion Batteries, IN Patent App. **202221064263**, ***Published***, 2024.
2. **A. Sengupta**, A. Kumar, A. Ahuja, H. Lohani, P. Kumari, S. Mitra, Development of a Heteroatom-doped, Single Crystal, Cobalt-free P2-type Layered Oxide Cathode Material for Elevated Cycling Life of Sodium-ion Batteries, IN Patent App. **202421022102**, ***Published***, 2024.
3. P. Kumari, H. Lohani, **A. Sengupta**, A. Ahuja, S. Mitra, A. Kumar, Scalable, energy-efficient and low-cost synthesis of densified pure-phase NASICON solid electrolyte, Indian Patent No.: **563760**, ***Granted***, 2025.
4. H. Lohani, A. Kumar, P. Kumari, A. Ahuja, M. Gautam, **A. Sengupta**, S. Mitra, Artificial Organo-Fluoro-Rich Anode Electrolyte Interface and Partially Sodiated Hard Carbon Anode for Improved Cycle Life and Practical Sodium-Ion Batteries, Indian Patent No: **546889**, ***Granted***, 2025.

- **BOOK CHAPTERS:**

1. P. K. Dutta, **A. Sengupta**, V. Goel, P. Preetham, A. Ahuja, S. Mitra, Nano-/Micro-engineering for Future Li–ion Batteries, Nano-Energetic Materials, Springer, 2019, ISBN 978-981-13-3268-5 ISBN 978-981-13-3269-2 (eBook), https://doi.org/10.1007/978-981-13-3269-2.
2. S. Sau, G. K. Mishra, H. Lohani, **A. Sengupta**, M. Gautam, S. Mitra, Challenges and opportunities for energy storage technologies, Elsevier, 2022, ISBN: 978-0-323-99860-4. https://doi.org/10.1016/B978-0-323-99860-4.00019-8

- **CONFERENCE PROCEEDINGS & PRSENTATIONS:**

1. **A. Sengupta**, S. Mitra, Engineering diffusion-induced stress-resistant nano-crystalline P2-type layered oxide cathodes for high-energy sodium-ion batteries, SBS4- International Sodium-ion Battery Symposium, September 2023 (Oral)
2. **A. Sengupta**, S. Mitra, P2-type Layered Transition Metal Oxide High Voltage Cathode for Na-ion Battery, B:FAT, Department of Ceramic Engineering, IIT (BHU) Varanasi, July 2022 (Oral)
3. **A. Sengupta**, S. Mitra, Co-Free Heteroatom-Doped P2-Type Layered Oxide Cathodes: Advancing High Power Sodium-ion Battery Technology, 244th ECS Meeting, Gothenburg, Sweden, October 2023 (Poster)
4. **A. Sengupta**, S. Mitra, Electrochemical Performance of $Na_3V_{1.96}W_{0.04}(PO_4)_2F_3@C$ as Cathode Material in Sodium-ion Batteries, 9th Interdisciplinary Symposium on Materials Chemistry, BARC, Mumbai, December 2022 (Poster)
5. **A. Sengupta**, S. Mitra, Development of Environmentally Stable and High Efficiency Cathodes for Sodium-ion Batteries, Proceedings of the international meeting on energy storage devices and industry-academia conclave, 185, 70, International Meeting on Energy Storage Devices, IIT Roorkie, Uttarakhand, December 2018 (Poster).
6. **A.** Sengupta, S. Dey, Optimization of Pb-Sn based Perovskite Solar Cells, CHEMCON, 69th Annual Session of the Indian Institute of Chemical Engineers, IIT Madras, December 2016 (Oral).
7. **A. Sengupta**, S. Dey, Fabrication of Environmental Friendly Perovskite Solar Cell by Partial Replacement of Lead with Tin, International Symposium on Semiconductor Materials and Devices (ISSMD-4), Jadavpur University, March 2017 (Poster).

AWARDS & RECOGNITIONS

1. **KPIT Shodh Best Thesis Award** for Ph.D. thesis, awarded by KPIT Technologies Ltd., 2025.
2. **Visiting researcher fellowship by Indo-Israel project**, funded by the Department of Science & Technology (DST), India to visit Prof. Malachi Noked's Laboratory at Bar-Ilan University, Israel, 2023.
3. **Travel Grant Award** from DST-SERB, Government of India, 2023.
4. **Best poster presentation award** by the American Chemical Society (ACS) at ISMC-2022 (Bhabha Atomic Research Centre), 2022.
5. **Fellowship for doctoral research** by the Ministry of New and Renewable Energy (MNRE) and Science & Engineering Research Board (SERB), Government of India, 2018.
6. **Gold Medal** for securing the first position in M.Tech at the University of Calcutta, 2017.
7. **Best poster award** at the National Conference on Green Energy, conducted by Chemical Engineering and Chemistry Department, Calcutta Institute of Technology, 2015.
8. **Best poster award** at the National Seminar for Chemical Engineering Education and Career Prospect, conducted by Chemical Engineering and Chemistry Department, Calcutta Institute of Technology, 2013.

PROFESSIONAL SOCIETIES

1. Member, The Electrochemical Society (ECS)
2. Member, The Electrochemical Society (ECS) Purdue University Chapter
3. Member, The American Chemical Society (ACS)
4. Member, The Indian Institute of Chemical Engineers (IIChE)