Md Zesun Ahmed Mia

Curriculum Vitae

Curiosity drives me to seek new questions and create new knowledge. I believe progress in science comes from collaboration, open-mindedness, and the courage to explore beyond boundaries.

Education

08/2022–05/2027 (Expected) **Ph.D. in Electrical Engineering**, *Pennsylvania State University*, University Park, PA, USA, *CGPA: 4.00/4.00*
Advisor: Dr. Abhronil Sengupta

08/2022–08/2024 **M.S. in Electrical Engineering**, *Pennsylvania State University*, University Park, PA, USA, *CGPA: 4.00/4.00* | Thesis: Neuromorphic Computing for Lifelong Learning

02/2015–04/2019 **B.Sc. in Electrical and Electronic Engineering**, *Bangladesh University of Engineering & Technology (BUET)*, Dhaka, Bangladesh, *CGPA: 3.81/4.00*

Academic Research and Teaching Experience

08/2022–Present **Graduate Research Assistant**, *Penn State*, State College, PA

- Developed fabrication processes for and characterized spintronic devices; also performed electrical characterization of Ferroic devices (e.g.FeFETs, Hallbars) to extract key performance parameters.
- Engineered physics-based device models using TCAD (Silvaco/Sentaurus) and developed compact models in Verilog-A and MATLAB from characterization data for circuit simulation.
- Architecting a novel, high-performance ML accelerator tailored for Transformer-based workloads, focusing on hardware-software co-design principles.
- Pioneered a hardware-aware training framework to integrate fabricated spintronic devices into system-level designs, co-optimizing device physics and ML model performance.
- Investigated advanced neuromorphic and brain-inspired algorithms (e.g., Equilibrium Propagation, Astromorphic Transformer), evaluating their performance against traditional DNN/SNN models.
- Developed an adaptive Spike-Timing-Dependent Plasticity (STDP) learning rule for Dynamic Spiking Neural Networks (SNNs) to enable continual learning, with performance validated in cybersecurity threat detection scenarios.

08/2024–05/2025 **Graduate Teaching Assistant**, *Penn State*, State College, PA

- Taught Cadence Virtuoso (schematic/layout), PDK usage, DRC/LVS, and analog/digital design flows; created hands-on lab modules and guided tool/debug workflows.
- Supervised Capstone projects for 90+ undergraduate students across communications, electronics, and firmware: supported Raspberry Pi/Arduino development, software-defined radio experiments, PCB design, and system integration end-to-end.

02/2021–08/2022 **Lecturer**, *University of Liberal Arts Bangladesh*, Dhaka, Bangladesh

- Taught undergraduate courses: Solid State Devices, Digital Circuit Design, Semiconductor Device Physics, Power Electronics.
- Developed lab modules and supervised projects on semiconductor devices and circuits.
- Supervised student projects on semiconductor devices and circuits.

02/2020–02/2021 **Lecturer**, *BUET*, Dhaka, Bangladesh, part-time

- Supervised labs (Digital Circuit Design, Power Electronics).

Industrial Experience

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05/2025–07/2025 **Graduate Technical Intern**, *Intel Corporation*, Hillsboro, OR

- Designed and executed Design of Experiments (DOE) for exploratory thin film deposition projects, contributing to advanced technology node development.
- Investigated first-of-its-kind process integration tool for advanced technology node development, evaluating integration feasibility and process window optimization.
- Conducted comprehensive material characterization using DSIMS, XRR, stress analysis, and TEM image analysis to validate process performance and material properties.
- Developed predictive analysis framework using AI and machine learning to assess thin film deposition impact on semiconductor process flows and device characteristics.

09/2020–07/2021 **R&D Engineer**, *SEMWAVES Ltd.*, London, UK, part-time

- Delivered a 50 kW hybrid renewable system (solar + smallscale hydro) for an offgrid Bangladeshi site, supporting reliable community power.
- Owned technical leadership and coordination (vendors, field teams, stakeholders); directed device selection, integration, QA/safety procedures, and optimization against load profiles and uptime targets.

Technical Skills

Research	Neuromorphic Computing; Transformer/LLM architectures; brain-inspired AI; long-context sequence modeling; hardware-aware ML; Device Physics; Circuits; Process Integration; PIM; near-memory computing; AI accelerator development
Teaching	Course Design; Lecturing; Mentoring (90+ undergrads); Lab Supervision; Cadence Virtuoso instruction; Semiconductor Device Physics
Programming	Python; CUDA; C++; MATLAB; Verilog; Shell/Bash; Git
ML Frameworks	PyTorch; TensorFlow; JAX; ONNX; experiment tracking (W&B, Matplotlib); data tooling (Pandas, NumPy, Jupyter)
AI Dev.	Generative and agentic AI tools (Cursor, Copilot, etc.) for research, design, and code development
Writing	Scientific Writing; Grant Proposals; Peer Review; LaTeX; Mendeley/Zotero; journal/conference publication
EDA/Simulation	Cadence Virtuoso; Spectre; HSPICE; TCAD; COMSOL; ModelSim; Synopsys (Design Compiler, PrimeTime, VCS)
Characterization	AFM; SEM; TEM; Probe Station; IV/CV; R-H loops; Hall effect; e-beam lithography; sputtering; lift-off patterning; reliability testing; parameter extraction
Collaboration	Cross-functional collaboration; mentoring; technical writing; Microsoft Office; Google Workspace

Research Interests

Neuromorphic Computing	Brain-inspired hardware, spiking neural networks (SNNs), event-driven sensing/compute, on-chip learning (STDP), crossbar synapses, oscillatory/phase-change/spintronic neurons, temporal coding, algorithm-device co-design, low-power edge intelligence
Machine Learning Hardware	DNN/GNN/Transformer accelerators, systolic and dataflow architectures, sparsity- and quantization-aware compute, mixed-signal MACs, compute-in-memory, near-memory compute, memory hierarchies, compilation and mapping, performance/energy modeling
Emerging Devices	Spintronics (STT/SOT-MRAM), FeFET/NCFET, RRAM/PCM memristors, 2D materials, analog programmability, endurance and variability
Semiconductor Process Integration	Device fabrication, FEOL/BEOL and BEOL-compatible memory, 3D monolithic integration, DTCO (design-technology co-optimization), compact modeling, variability and yield, process-device-circuit co-design
AI for Semiconductor	ML for process/device optimization, virtual metrology, yield prediction and defect classification, Bayesian optimization and surrogate modeling, inverse design, reinforcement learning for tool control

Research Projects

Astromorphic Transformer Lead Student Researcher, 2022–2025. Pioneered a bioplausible transformer architecture leveraging neuron-astrocyte interactions to emulate self-attention mechanisms. Incorporated Hebbian and presynaptic plasticities with non-linearities and feedback dynamics, achieving superior accuracy and faster convergence on sentiment classification (IMDB), image classification (CIFAR-10), and language modeling (WikiText-2) tasks with improved perplexity compared to conventional transformers. Established the first scalable astromorphic framework for sequential tasks. See publication: [IEEE TCDS 2025].

RMAAT: Bio-Inspired Long-Context Transformers Lead Student Researcher, 2024–Present. Developed RMAAT (Recurrent Memory Augmented Astromorphic Transformer), a recurrent transformer architecture for efficient long-context sequence processing. Integrated astrocyte-inspired memory compression via adaptive retention factors and linear-complexity attention from astrocyte short-term plasticity. Achieved competitive accuracy on Long Range Arena (LRA) benchmark with up to 1.73× training speedup and 4.4× memory reduction (3.4 GB vs. 15.0 GB) compared to standard recurrent transformers. Introduced AMRB (Astrocytic Memory Replay Backpropagation) training algorithm for memory-efficient recurrent learning. Accepted at ICLR 2026. See publication: [OpenReview].

Neuromorphic Cybersecurity with Lifelong Learning Lead Student Researcher, 2023–2025. Architected a Hierarchical Dynamic Spiking Neural Network (D-SNN) for Network Intrusion Detection Systems (NIDS) combining static SNN detection (94.3% accuracy) with adaptive dynamic SNN classification using GWR-inspired structural plasticity and novel Adaptive STDP (Ad-STDP) learning. Achieved 85.3% overall accuracy on UNSW-NB15 benchmark in semi-supervised lifelong learning scenarios, demonstrating superior adaptation to new attack types while mitigating catastrophic forgetting (5.3% improvement over static baseline). Demonstrated high operational sparsity (∼0.0008 spike rate) suitable for neuromorphic hardware deployment. See publication: [arXiv], [ICONS 2025].

Spintronic Device-Based Memory Systems Lead Student Researcher, 2023–Present. Led end-to-end fabrication of spintronic memory arrays using e-beam lithography, sputtering deposition, and lift-off patterning. Performed comprehensive electrical characterization (I-V, R-H loops, retention, endurance) and extracted device parameters for compact model development. Advanced non-volatile memory technologies for neuromorphic computing and in-memory processing applications.

Self-Sensitizable Neuromorphic Devices Co-Author, 2023–2024. Contributed to development of perovskite-based neuromorphic neurons with adaptive self-sensitization enabled by hydrogen gradient modulation. Demonstrated networks processing 250% more structural information than traditional networks in edge detection tasks and achieved 110% improvement in vehicle classification accuracy under varying lighting conditions. See publication: [Matter 2024].

Ultra Low Cost Electronic Braille Device First Author, 2022–2024. Designed and fabricated a portable, solenoid-based electronic Braille device using 3D printing and Arduino microcontroller. Achieved ultra-low cost ($20) and lightweight design (338g) with 100 frames/s refresh rate, enabling real-time text-to-braille translation. Implemented PWM control for low power consumption and USB/Bluetooth connectivity for cellular devices and laptops. See publication: [iCACCESS 2024].

MIPS Microprocessor Design Lead Student Researcher, 2018–2019. Designed and implemented a 5-stage pipelined MIPS microprocessor in Verilog with instruction/data memory, forwarding, and hazard detection. Verified functionality through comprehensive simulation and synthesized for FPGA deployment, demonstrating computer architecture expertise.

ECG Rats Processor Lead Student Researcher, 2023. Developed a custom digital signal processing (DSP) processor, "ECG Rats," for real-time ECG signal analysis. Implemented core modules for filtering, feature extraction, and arrhythmia detection. Achieved efficient processing with low latency and power consumption, suitable for wearable health monitoring applications.

IRFD: Electricity Fraud Detection First Author, 2021. Developed IRFD, a feature engineering-based ensemble classification method for detecting electricity fraud in traditional meters. Demonstrated improved detection accuracy on real-world meter datasets using advanced machine learning techniques. See publication: [IEEE ICCIT 2021].

DCNN-LSTM Audio Classification
Co-Author, 2022. Developed a DCNN-LSTM based audio classification system combining multiple feature engineering and data augmentation techniques. Achieved robust performance on diverse audio datasets. See publication: [ICO 2021, Springer].

2D Monolayer GaN Nanoribbons
First Author, 2024. Investigated the impact of doping and defects on thermal transport of monolayer GaN nanoribbons using molecular dynamics simulation. Provided insights into nanoscale heat management for next-generation electronics. See publication: [ICECE 2024].

Research Grants

NSF Award #2318101
Graduate Researcher, 2023–Present. **EFRI BRAID: Neuroscience Inspired Visual Analytics**: Supported research on neuromorphic hardware and algorithms for energy-efficient AI as part of an NSF EFRI-funded project at Penn State (PI: V. Narayanan, Co-PI: A. Sengupta). See award: [NSF 2318101].

NSF Award #2333881
Graduate Researcher, 2024–Present. **Spintronics Enabled Stochastic Spiking Neural Networks with Temporal Information Encoding**: Contributed to NSF-funded research on stochastic SNN hardware co-design, focusing on spintronic device physics, temporal spike encoding, and neuromorphic algorithm development (PI: A. Sengupta). See award: [NSF 2333881].

NSF Award #2028213
Graduate Researcher, 2022. **EAGER: An Experimental Exploration for Spin-Based Neuromorphic Computing**: Participated in NSF EAGER-funded work on spin-orbit torque device fabrication and characterization for neuromorphic computing, including device-circuit-algorithm co-design (PI: A. Sengupta). See award: [NSF 2028213].

ARO Grant W911NF-24-1-0127
Graduate Researcher, 2024–Present. **Army Research Office – Basic Scientific Research**: Supported neuromorphic and astromorphic computing research at Penn State (PI: A. Sengupta). Funded work underlying the astromorphic transformer publications (DOI: 10.1109/TCDS.2025.3564285). Award period: May 2024–Apr 2027, $300K. See award: [USAspending W911NF-24-1-0127].

Publications

[1] Md Zesun Ahmed Mia, Malyaban Bal, and Abhronil Sengupta. "RMAAT: Astrocyte-Inspired Memory Compression and Replay for Efficient Long-Context Transformers". In: *International Conference on Learning Representations (ICLR)*. 2026. URL: https://openreview.net/forum?id=sTkJdbVxsI.

[2] Md Zesun Ahmed Mia, Malyaban Bal, and Abhronil Sengupta. "Delving deeper into astromorphic transformers". In: *IEEE Transactions on Cognitive and Developmental Systems* (2025).

[3] Md Zesun Ahmed Mia et al. "Neuromorphic Cybersecurity with Semi-Supervised Lifelong Learning". In: *Proceedings of the International Conference on Neuromorphic Systems (ICONS '25)*. IEEE Press, 2025, pp. 235–238. DOI: 10.1109/ICONS69015.2025.00043.

[4] Arnob Saha et al. "Toward Variation-Tolerant Ferroelectric Neural Computing: Special Session Paper". In: *2025 IEEE 68th International Midwest Symposium on Circuits and Systems (MWSCAS)*. IEEE. 2025, pp. 583–587.

[5] Md Zesun Ahmed Mia and Kazi Toukir Ahmed. "Ultra Low Cost, Low Power, High Speed Electronic Braille Device for Visually Impaired People". In: *2024 International Conference on Advances in Computing, Communication, Electrical, and Smart Systems (iCACCESS)*. IEEE. 2024, pp. 1–6.

[6] Md Zesun Ahmed Mia et al. "Impact of Doping and Defects on Thermal Transport of Monolayer GaN Nanoribbons: A Molecular Dynamics Simulation Study". In: *2024 13th International Conference on Electrical and Computer Engineering (ICECE)*. IEEE. 2024, pp. 685–690.

[7] Tao Zhang et al. "Self-sensitizable neuromorphic device based on adaptive hydrogen gradient". In: *Matter* 7.5 (2024), pp. 1799–1816.

[8] KM Ashraful Hoque Fahim et al. "Study of 3-nm Cylindrical GAAFETs with Variations in High-k Dielectric Gate-oxide Materials". In: *2022 IEEE Symposium on Industrial Electronics & Applications (ISIEA)*. IEEE. 2022, pp. 1–5.

[9] Md Moinul Islam et al. "DCNN-LSTM based audio classification combining multiple feature engineering and data augmentation techniques". In: *Intelligent Computing & Optimization: Proceedings of the 4th International Conference on Intelligent Computing and Optimization 2021 (ICO2021) 3*. Springer. 2022, pp. 227–236.

[10] Md Zesun Ahmed Mia et al. "Irfd: A feature engineering based ensemble classification for detecting electricity fraud in traditional meters". In: *2021 24th International Conference on Computer and Information Technology (ICCIT)*. IEEE. 2021, pp. 1–6.

Recognitions and Awards

- Harry G. Miller Fellowships in Engineering (2025)
- The Wormley Family Graduate Fellowship (2025)
- Arthur Waynick Graduate Scholarship (2024)
- Milton and Albertha Langdon Memorial Fellowship (2023)
- Melvin P. Bloom Memorial Fellowship (2022)
- Undergrad Dean's List (2016–2018)
- Honorable Mention, Notre Dame College, Dhaka (2014)

Professional Service and Affiliations

- Reviewer, Design Automation Conference (DAC) 2025 [link]
- Reviewer, IEEE MWSCAS 2025 [link]
- Reviewer, IACCESS (2024)
- Member, Graduate Student Advisory Committee, Penn State (2024-Present)
- Student Member, IEEE (2015-Present)
- Executive Member, EDS, IEEE Bangladesh Section (2021-2022)
- Vice President, Notre Dame Nature Study Club (2013-2014)

Outreach and Leadership

Academic Service	Served as a lecturer at University of Liberal Arts Bangladesh (ULAB), teaching undergraduate courses and developing lab modules in electronics and device physics.
Research Leadership	Led and supervised student projects on semiconductor devices, circuits, and neuromorphic computing as a graduate research assistant and lecturer.
Interdisciplinary Collaboration	Collaborated with cross-functional teams in academia and industry on projects spanning AI, machine learning, and semiconductor process/device optimization.
Mentoring	Provided guidance and mentorship to undergraduate students, supporting their research initiatives and professional development.

References

Dr. Abhronil Sengupta	Associate Professor, Penn State University, Email: sengupta@psu.edu
Dr. Samia Subrina	Professor, BUET, Email: samiasubrina@eee.buet.ac.bd