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Shuvro Chowdhury

Postdoctoral Scholar
Department of Electrical & Computer Engineering (ECE)
University of California Santa Barbara
Santa Barbara, CA 93106, USA

Curriculum Vitae

Academic Qualification

2016–2022   **Doctor of Philosophy in Electrical & Computer Engineering**, *Purdue University*, IN, USA, Supervisor: Prof. Supriyo Datta.
Thesis - Quantum Emulation with Probabilistic Computers

2011–2014   **Master of Science in Electrical & Electronic Engineering**, *Bangladesh University of Engineering & Technology*, Dhaka, Bangladesh.
Thesis - Accurate drain current modeling of long channel junctionless double-gate field effect transistor

2006–2011   **Bachelor of Science in Electrical & Electronic Engineering**, *Bangladesh University of Engineering & Technology*, Dhaka, Bangladesh.

Research Overview

My research spans the intersection of physics, electrical engineering, and computer science, with a primary emphasis on probabilistic and quantum computing, machine learning, and nanoscale device modeling. I am passionate about leveraging interdisciplinary approaches to solve key challenges in acceleration and the integration of emerging computing paradigms into real-world applications.

In particular, my work in probabilistic computing has led to the development of methods and algorithms for emulating quantum systems using generalized Ising machines. I have proposed stochastic nanomagnet-based probabilistic hardware and benchmarked its performance to emulate sign-problem-free quantum Hamiltonians, offering an innovative approach to enhancing computational efficiency in quantum emulation.

In the field of nanoscale semiconductor devices, I have developed a surface potential-based analytical model for long-channel double-gate junctionless field-effect transistors (FETs), providing new insights into device behavior. My research also includes the development of a two-dimensional NEGF-based device simulator for double-gate MOSFETs with high-κ gate oxides. This work enabled analysis of temperature and wave function penetration effects in nanoscale double-gate MOSFETs, contributing to our understanding of device physics at ultra-small dimensions.

Earlier in my research career, I have explored multi-valued logic and quantum computation, where I developed methods for synthesizing ternary and quaternary Galois Field based reversible/quantum logic circuits. I have proposed realizations of multi-input ternary and quaternary Toffoli gates and square functions, advancing quantum logic design with reduced overhead.

Looking ahead, my research aims to further explore the application of probabilistic computing in quantum systems and machine learning. I plan to continue pushing the boundaries of hardware acceleration and integrating machine learning with quantum computation to solve real-world optimization problems and enhance computational performance through efficient hardware and algorithm design, addressing both academic challenges and industrial needs.

Postdoctoral Experience

2022–present   **Postdoctoral Scholar**, *Supervisor: Prof. Kerem Y. Camsari*, ECE, University of California Santa Barbara, CA, USA.

○ Developing probabilistic computing hardware and architecture using FPGA and magnetic p-bits for optimization, quantum emulation, and machine learning problems, resulting in several high-impact publications.
○ Investigating possibilities of hardware acceleration techniques for chaotic bits (c-bits).
○ Leading collaborative projects on neural quantum state (NQS) using probabilistic computers.
○ Mentoring graduate students and collaborating with interdisciplinary teams on quantum computing and machine learning applications.

Selected Peer-reviewed Publications

Journal Papers:

1. **Shuvro Chowdhury**, Kerem Y. Camsari, and Supriyo Datta, "Accelerated quantum Monte Carlo with probabilistic computers" in *Communications Physics*, 2023.

2. **Shuvro Chowdhury**, Kerem Y. Camsari, and Supriyo Datta, "Emulating Quantum Circuits With Generalized Ising Machines" in *IEEE Access*, 2023.

3. **Shuvro Chowdhury**, Andrea Grimaldi, Navid Anjum Aadit, Shaila Niazi, Masoud Mohseni, Shun Kanai, Hideo Ohno, Shunsuke Fukami, Luke Theogarajan, Giovanni Finocchio, Supriyo Datta, and Kerem Y. Camsari, "A full-stack view of probabilistic computing with p-bits: devices, architectures and algorithms" in *IEEE Journal on Exploratory Solid-State Computational Devices and Circuits*, 2023.

4. Srijan Nikhar, Sidharth Kannan, Navid Anjum Aadit, **Shuvro Chowdhury**, Kerem Y. Camsari, "All-to-all reconfigurability with sparse and higher-order Ising machines", in *Nature Communications*, 2024.

5. Shaila Niazi, Navid Anjum Aadit, Masoud Mohseni, **Shuvro Chowdhury**, Yao Qin, and Kerem Y. Camsari, "Training Deep Boltzmann Networks with Sparse Ising Machines", in *Nature Electronics*, 2024.

6. Kerem Y. Camsari, **Shuvro Chowdhury**, and Supriyo Datta, "Scalable Emulation of Sign-Problem–Free Hamiltonians with Room-Temperature $\boldsymbol{p}$-bits", in *Physical Review Applied*, 2019.

7. Kyle Lee, **Shuvro Chowdhury**, Kerem Y. Camsari "Noise-augmented Chaotic Ising Machines for Combinatorial Optimization and Sampling" in *arXiv*, 2024 (in review).

8. Mohammad Asif Zaman, Shuvro Chowdhury, "Modified Bézier Curves with Shape-Preserving Characteristics Using Differential Evolution Optimization Algorithm", in *Advances in Numerical Analysis*, 2013.

9. Esmat Farzana, **Shuvro Chowdhury**, Rizvi Ahmed, and M. Khan, "Analysis of temperature and wave function penetration effects in nanoscale double-gate MOSFETs", *Applied Nanoscience*, 2012.

10. Esmat Farzana, **Shuvro Chowdhury**, Rizvi Ahmed, and M. Z. Rahman Khan, "Performance Analysis of Nanoscale Double Gate MOSFETs with High-κ Gate Stack", *Applied Mechanics and Materials*, 2011.

Conference Papers:

1. **Shuvro Chowdhury** and Kerem. Y. Camsari, "Machine Learning Quantum Systems with Magnetic p-bits," in *2023 IEEE International Magnetic Conference (INTERMAG)*, 2023.

2. **Shuvro Chowdhury**, Supriyo Datta and Kerem Y. Camsari, "A Probabilistic Approach to Quantum Inspired Algorithms," in *2019 IEEE International Electron Devices Meeting (IEDM)*, 2019.

3. **Shuvro Chowdhury**, Md. Ziaur Rahman Khan, "Surface potential modeling of Junctionless Double Gate MOSFETs using gradual depletion approximation," in *2014 International Conference on Electrical and Computer Engineering (ICECE)*, 2014.

4. Nihal Sanjay Singh, Shaila Niazi, **Shuvro Chowdhury**, Kemal Selcuk, Haruna Kaneko, Keito Kobayashi, "Hardware Demonstration of Feedforward Stochastic Neural Networks with Fast MTJ-based p-bits", in *2023 International Electron Devices Meeting (IEDM)*, 2023.

5. Andrea Grimaldi, Kemal Selcuk, Navid Anjum Aadit, Keito Kobayashi, Qixuan Cao, **Shuvro Chowdhury**, Giovanni Finocchio, Shun Kanai, Hideo Ohno, Shunsuke Fukami, Kerem Y. Camsari, "Experimental evaluation of simulated quantum annealing with MTJ-augmented p-bits" in *2022 International Electron Devices Meeting (IEDM)*, 2022.

6. Md. Mahmud Muntakim Khan, Ayan Kumar Biswas, **Shuvro Chowdhury**, Masud Hasan, and Asif Islam Khan, "Synthesis of GF(3) Based Reversible/Quantum Logic Circuits without Garbage Output," in *IEEE International Symposium on Multiple-Valued Logic*, 2009.

7. Ayan Kumar Biswas, **Shuvro Chowdhury**, Md. Mahmud Muntakim Khan, Masud Hasan, and Asif Islam Khan, "Some basic ternary operations using toffoli gates along with the cost of implementation," in *2011 41st IEEE International Symposium on Multiple-Valued Logic (ISMVL)*, 2011.

8. Md. Mahmud Muntakim Khan, Ayan Kumar Biswas, **Shuvro Chowdhury**, Mehbuba Tanzid, Kazi Mohammad Mohsin, Masud Hasan, and Asif Islam Khan, "Quantum realization of some quaternary circuits," in *TENCON 2008 - 2008 IEEE Region 10 Conference*, 2008.

Peer-reviewed Workshop Papers:

1. **Shuvro Chowdhury**, Shaila Niazi and Kerem Yunus Camsari, "Mean-Field Assisted Deep Boltzmann Learning with Probabilistic Computers", in Workshop Machine Learning with New Compute Paradigms, NeurIPS 2023.

Book Chapters:

1. Kerem Y. Camsari, **Shuvro Chowdhury**, and Supriyo Datta, "The Non-Equilibrium Green Function (NEGF) Method", in *Springer Handbook of Semiconductor Devices*, 2021.

Invited Talks and Seminars

1. **Shuvro Chowdhury** and Kerem Y. Camsari, "A Full-Stack View of Probabilistic Computing with p-bits: Devices, Architectures, Algorithms", in *IEEE SSCS Open Journal Webinar Series*, February 2024.

2. **Shuvro Chowdhury**, "Accelerated quantum Monte Carlo with probabilistic computers", in *International Network of Quantum Annealing (INQA) Seminar*, October 2023.

3. **Shuvro Chowdhury**, "Probabilistic Computing with p-bits: Co-designing Devices, Algorithms and Architectures", in *Workshop on Non-conventional Approaches to Hard Optimization (NAHO)*, Sponsored by NSF and University of Notre Dame, USA, June 2023.

Technical Shortcourses Instructed

- **Training on Computer Interfacing and Embedded System**, organized by – IEEE GOLD Bangladesh Section & ITRRC of Jagannath University, Dhaka, Bangladesh in 2013.
- **Workshop on LaTeX and Scientific Writing**, organized by – IEEE GOLD Bangladesh Section in 2013.
- **Short Course on FPGA Digital Logic Design**, organized by – IEEE ED/SSCS Bangladesh Chapter in 2013.
- Along with two other colleagues, jointly designed **'ATMEGA32 Development Kit'** - an ATMEGA32 microcontroller based trainer board.

Accolades

- **3rd Prize** in Electronics group for undergraduate research work, EEE Undergraduate Project Workshop (EUProW) 2011, organized by Dept. of EEE, Bangladesh University of Engineering and Technology.
- **University Merit Scholarship** for good results in term examinations.
- **University Dean's List Award** for 3.75+ CGPA in all levels.
- **Dhaka Board Scholarship** for obtaining GPA 5.00 in Higher Secondary Certificate examination.

Professional Affiliations

Member **Institute of Electrical and Electronics Engineers (IEEE)**.

Member **IEEE Electron Devices and Solid-State Circuits Society (ED/SSCS)**.

Professional Activities

Referee **Nature**.

npj Unconventional Computing.

Electron Device Letters.

IEEE Transactions on Circuits and Systems.

NeurIPS Workshop on Machine Learning with new Compute Paradigms.

Synergistic Activities

2011-2016 ***Member***, *Board of Undergraduate Studies*, Dept. of EEE, Bangladesh University of Engineering and Technology.

2014-2016 ***Member***, *Bureau of Research, Testing and Consultation*, Dept. of EEE, Bangladesh University of Engineering and Technology.

2014 **Member**, *Technical Committee*, 8th International Conference on Electrical and Computer Engineering (ICECE).

2013 **Vice Chair**, *GOLD Affinity Group*, IEEE Bangladesh Section.

2013 **Secretary**, *IEEE Electron Devices and Solid-State Circuits Society*, Bangladesh Chapter.

2012 **Secretary and Treasurer**, *IEEE Electron Devices and Solid-State Circuits Society (ED/SSCS)*, Bangladesh Chapter.

2012   **Treasurer**, *GOLD Affinity Group*, IEEE Bangladesh Section.

2012   **Member**, *Technical Committee*, 7th International Conference on Electrical and Computer Engineering (ICECE).

Professional Experience

2016–2022   **Graduate Research Assistant**, *Supervisor: Prof. Supriyo Datta*, ECE, Purdue University.

2020–2022   **Graduate Teaching Assistant** – *Fundamentals of Current Flow, Introduction to Quantum transport, Boltzmann Law: Physics to Computing* – ECE, Purdue University.

2015–2016   **Assistant Professor**, *Department of Electrical and Electronic Engineering (EEE)*, Bangladesh University of Engineering and Technology (BUET), Dhaka-1000, Bangladesh.

2011–2015   **Lecturer**, *Department of EEE*, BUET, Dhaka-1000, Bangladesh.

Courses Taught   **Theory** – *Solid State Devices, Electrical Properties of Materials, Microprocessor and Interfacing, Electrical Circuits I, Electrical and Electronic Technology* – 60 undergraduate students per class.

Laboratory – *Control System Laboratory, Microprocessor and Interfacing Laboratory, Electrical Circuit Simulation Laboratory, Electronic Circuit Simulation Laboratory, Communication Laboratory, Measurement and Instrumentation Laboratory* – 30 undergraduate students per class.

Programming and Software Skills

Advanced   C/C++, MATLAB, Vivado, Assembly Language, Adobe Illustrator, Octave, Proteus, Circuit Maker, Microsoft Office Visio, OriginPro, Microsoft Office, Libre Office, LaTeX and CAD tools like ORCAD PSPICE & Capture, HSPICE, Quartus II.

Intermediate   Python, C#, Java, Microwind & Dsch, CYMBASE, CYMFLOW, Vivado, Fedora, Ubuntu.

Basic   Macromedia Flash, Simulink, COMSOL, AutoCAD

References

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