Md Hafijur Rahman

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Education

- **The Pennsylvania State University** — Pennsylvania, USA
  Ph.D. - Mechanical Engineering; CGPA: 4.00/4.00 — *Jan 2023 - Present*
  Courses: *Physics of radiation damage, Manufacturing Methods in Microelectronics.*

- **University of Alberta** — Edmonton, Alberta, Canada
  M.Sc - Mechanical Engineering; CGPA: 4.00/4.00 — *Jan 2021 - Dec 2022*
  Courses: *Continuum Mechanics, Macro Fracture Mechanics, Fundamental of Engineering Numerical Analysis, Applied Computational Intelligence for Engineers, Mechanics and Design of Composite Materials.*

- **Bangladesh University of Engineering and Technology** — Dhaka, Bangladesh
  B.Sc - Mechanical Engineering; CGPA: 3.81/4.00 — *July 2014 - Oct 2018*

Research Interests

My research focuses on defect physics, radiation resilience, and microstructural control in materials and devices. I specialize in low-temperature annealing using Electron Wind Force (EWF) to mitigate defects in wide-bandgap semiconductors (GaN, SiC, Zener diodes) and structural alloys (FeCrAl, ZrTi). My work integrates advanced characterization techniques such as EBSD, XRD, TEM, and Raman spectroscopy, along with theoretical modeling of defect dynamics and continuum mechanics in composite systems.

Key Skills

- **Materials Characterization Tools**: SEM-Scanning Electron Microscopy (Verios G4 UC from Thermo-Scientific; Apreo S from Thermo-Scientific), EBSD- Electron Backscatter Diffraction (Using Aztec), FIB-Focused Ion Beam (Scios 2; Helios 660), TEM-Transmission Electron Microscopy (FEI Talos F200X), EDS- Energy-dispersive X-ray spectroscopy (Aztec for SEM, Velox for TEM), X-Ray Diffraction (Malvern Panalytical Empyrean), Molecular Spectroscopy: Raman (Horiba Soleil), Optical Profilometer (Zygo NexView 3D), Nanoindentation (Bruker Hysitron TI-980).
- **Electrical Characterization Techniques**: SMU-Source measure unit (Keithley 2636B, Keithley 4200, Keithley 2651A, Keithley 2400), Pulse meter (Keithley 2601B), Laser diode drive (Northrop Grumman eDrive), Programmable Pulse Generator (Eagle harbor-IPM-16P-2003), Programmable DC power supply (Magna-power, SL600-2.5/UI), Probe station (Form factor 11000B), IV/CV Measurement.
- **Cleanroom Tools**: Wet Etching.
- **Research Instruments**: Thermal microscope (Optris Pi- 640), Ion milling (Leica), Ultrasonic cleaner, Tensile tester (Force Gauge M3-500), Optic illuminator (Fiber-Lite Pl-800).

Software Skills

- **Data Analysis**: AZtecCrystal (version 5.1), CrysTBox, LabSpec 6 (Horiba), Jade® software (version 8.9).
- **Design and Programming**: MATLAB, SOLIDWORKS, AutoCAD, LaTex, Python, C-Programming.
- **Simulation tools**: Finite element analysis (FEniCS), Molecular Dynamics (LAMMPS), Monte Carlo simulation (SRIM-(Stopping and Range of Ions in Matter)).
- **Machine Learning**: Principal Component Analysis (PCA), Classification algorithms (K-nearest neighbor-KNN, Support vector machine- SVM, Kernel support vector machine- KSVM, Multilayer perceptron- MLP), Optimization (Gradient descent, Simulated annealing), Linear regression, Logistic regression, Clustering, Fuzzy logic.
- **Image Processing Software**: ImageJ, Fiji.
- **Statistics and Optimization**: Origin Pro, Microsoft Office (Word, Excel, Power-Point.

Teaching Experience

- **The Pennsylvania State University** — Pennsylvania, USA
  Graduate Teaching Assistant — *Jan 2023 - May 2023*
  - : Teaching Assistant in Mechanical Design II course (ME 460) for spring-2023 semester.
  - : Question preparation and grading a class of 40 students.

- **University of Alberta** — Edmonton, Alberta, Canada
  Graduate Teaching Assistant — *Aug 2021 - Dec 2022*
  - : Assisted in delivering lectures, grading, and managing labs for 'MEC E 301 - Mechanical Engineering Laboratory-I' across four academic terms (Fall 2021, Winter 2022, Spring/Summer 2022, Fall 2022).
  - : Provided instructional support, exam question preparation, and grading for 'EN PH 131: Mechanics' in Winter 2022.
  - : Supported more than 300 students learning through office hours, tutorials, and detailed feedback on assignments and lab reports.

- **Bangladesh Army University of Science and Technology** — Saidpur, Bangladesh
  Lecturer -Department of Mechanical Engineering — *Nov 2019 - Dec 2020*
  - **Lectured Undergraduate Courses:**

    - ME 1181: Basic Mechanical Engineering
    - ME 1263: Fundamentals of Mechanical Engineering
    - ME 2103: Engineering Mechanics I
    - ME 2203: Engineering Mechanics II
  - **Laboratory Courses Supervised:**
    - ME 1264: Fundamentals of Mechanical Engineering Sessional
    - ME 2104: Engineering Mechanics Sessional
    - ME 3108: Measurement, Instrumentation and Quality Control Sessional
    - ME 3202: Heat Transfer Sessional

Research Experience

- **The Pennsylvania State University** — Pennsylvania, USA
  Graduate Research Assistant - Haque Research Group — *Jan 2023 - Present*
  - Leading NSF-funded research on developing a low-temperature, energy-efficient annealing technique based on Electron Wind Force (EWF) to mitigate defects in both structural alloys and semiconductor devices.
  - Designed and executed experimental protocols involving custom-built electropulsing setups, precision alignment for device probing, and high-resolution data acquisition.
  - Demonstrated EWF-driven defect recovery in cold-rolled FeCrAl alloy at temperatures as low as 200°C, achieving grain boundary realignment and removal of low-angle grain boundaries, validated by EBSD, XRD, and TEM analyses.
  - Revealed phase transformation and formation of textured α-lath structures in ZrTi alloys induced by directional electropulsing treatment.
  - Investigated gamma and ion radiation effects on wide-bandgap semiconductors (GaN HEMTs, SiC MOSFETs, and Zener diodes), focusing on EWF-based defect annihilation as an alternative to conventional thermal annealing.
  - Conducted in-situ EWF annealing experiments on Gamma-irradiated SiC MOSFETs, utilizing electrical measurements and Raman spectroscopy to assess carrier recovery and defect state evolution.
  - Explored directional current-pulse modulation for controlled grain orientation and stress relief in metallic systems at room temperature, enabling microstructure control without thermal budgets.

- **University of Alberta** — Edmonton, Alberta, Canada
  Graduate Research Assistant - Theoretical and Applied Mechanics Laboratory — *Jan 2021 - Dec 2022*
  - **Second Strain Gradient Continuum Model for the Mechanics of Fiber-Reinforced Composites**: Developed a continuum-based second strain gradient model to analyze elastic materials reinforced with uni/bi-directional fibers, addressing the complexities of finite plane deformations. This work can be found here .
  - : Solved sixth-order non-liner partial differential equation using **finite element analysis** tool FEniCS
  - **Fracture criteria accounting for T -stress**: The effect of T -stress on crack tip plastic zone has been investigated
  - **Heart disease prediction using Computational Intelligent model**: Used various machine learning models (K-Nearest Neighbor (KNN), Multi-Layer Perceptron (MLP), and Kernel Support Vector Machine (KSVM)) to classify and predict heart disease using Cleveland heart disease dataset

Publications (First-Author)

- **Improving radiation tolerance with room temperature annealing of pre-existing defects**: Rahman, M.H.; Cooper, F.; Crespillo, M.L.; Hattar, K.; Haque, A.; Ren, F.; Pearton, S.; Wolfe, D.; *Applied Physics Express*, 2025, 18, 17001. DOI
- **Microstructural modification and enhanced mechanical properties in Zr50-Ti50 alloy via low temperature electron wind force annealing**: Rahman, M.H.; Oh, H.; Waryoba, D.; Haque, A.; *Materials Characterization*, 2024, 215, 114188. DOI
- **Synergistic Thermal and Electron Wind Force-Assisted Annealing for Extremely High-Density Defect Mitigation**: Rahman, M.H.; Todaro, S.; Waryoba, D.; Haque, A.; *Materials (Basel)*, 2024, 17, 3188. DOI
- **Elimination of Low-Angle Grain Boundary Networks in FeCrAl Alloys with the Electron Wind Force at a Low Temperature**: Rahman, M.H.; Todaro, S.; Warner, L.; Waryoba, D.; Haque, A.; *Metals (Basel)*, 2024, 14, 331. DOI
- **Radiation Damage Mitigation in FeCrAl Alloy at Sub-Recrystallization Temperatures**: Rahman, M.H.; Rasel, M.A.J.; Smyth, C.M.; Waryoba, D.; Haque, A.; *Materials*, 2025, 18, 124. DOI
- **Effect of High Current Density Pulses on Performance Enhancement of Optoelectronic Devices**: Rahman, M.H.; Glavin, N.; Haque, A.; Ren, F.; Pearton, S.J.; *ECS Journal of Solid State Science and Technology*, 2024, 13, 25003. DOI
- **Improving radiation resilience of Zener diodes through preemptive and restorative electron wind force annealing**: Rahman, M.H.; Warner, L.; Bae, J.; Kim, J.; Haque, A.; Ren, F.; Pearton, S.J.; Wolfe, D.E.; *Physica Scripta*, 2024, 100, 015904. DOI
- **Rejuvenation of Degraded Zener Diodes with the Electron Wind Force**: Rahman, M.H.; Al-Mamun, N.S.; Glavin, N.; Haque, A.; Ren, F.; Pearton, S.; Wolfe, D.E.; *Applied Physics Express*, 2024, 17, 47001. DOI

- **Room Temperature Control of Grain Orientation via Directionally Modulated Current Pulses**: Rahman, M.H.; Oh, H.; Waryoba, D.; Haque, A.; *Materials Research Express*, 2023, 10, 116521. DOI
- **A Third Gradient-Based Continuum Model for the Mechanics of Continua Reinforced with Extensible Bidirectional Fibers Resistant to Flexure**: Rahman, M.H.; Yang, S.; Kim, C. Il.; *Continuum Mechanics and Thermodynamics*, 2023, 35, 563–593. DOI
- **A Shear Lag Theory Integrated with Second Strain Gradient Continuum Model for the Composite Reinforced with Extensible Nano-Fibers**: Rahman, M.H.; Islam, S.; Yang, S.; Kim, C. Il.; *Acta Mechanica*, 2023, 234, 4269–4296. DOI
- **Room Temperature Rejuvenation Technology for Irradiated Gallium Nitride Transistors**: Rahman, M.H.; Al-Mamun, N.S.; Stepanoff, S.P.; Haque, A.; Ren, F.; Pearton, S.J.; Wolfe, D.E.; *Advanced Materials Technologies*, 2025 (**Under Review**)
- **Repeated Rejuvenation of SiC MOSFETs for Unprecedented Ionizing Radiation Resilience**: Rahman, M.H., Chavda, C., Al-Mamun, N.S., Stepanoff, S.P., Haque, A., Wolfe, D.E., Ren, F., Pearton, S.J.; *APL Electronic Devices*, 2025 (**Under Review**)

Publications (Co-Author)

- **An In Situ Transmission Electron Microscopy Study on the Synergistic Effects of Au-Ion Irradiation and High Temperature on Nuclear Graphite Microstructure**: Thomas, M.P.; Schoell, R.; Rasel, M.A.J.; Rahman, M.H.; Kuo, W.; Watt, J.; House, S.; Hattar, K.; Windes, W.; Haque, A.; *Materials Research Express*, 2024, 11, 45601. DOI
- **Lateral NiO/AlN Heterojunction Rectifiers with Breakdown Voltage¿11 kV**: Thomas, M.P.; Schoell, R.; Rasel, M.A.J.; Rahman, M.H.; Kuo, W.; Watt, J.; House, S.; Hattar, K.; Windes, W.; Haque, A.; *ECS Advances*, 2024, 3, 33502. DOI
- **Low-Temperature Annealing of Nanoscale Defects in Polycrystalline Graphite**: Liu, G., Oh, H.; Rahman, M.H.; Du, J.; Windes, W.; Haque, A.; *Carbon*, 2024, 10(3), 76. DOI

Conference Presentations

- **Defect and Microstructure Control of Materials Using the Electron Wind Force**: Rahman,M.H.; Materials Science & Technology (MS&T) Technical Meeting and Exhibition, Oral presentation in *Processing and Performance of Materials Using Microwaves, Electric and Magnetic Fields, Ultrasound, Lasers, and Mechanical Work-Rustum Roy Symposium*, October 2024, Pittsburgh, PA, USA.
- **Enhancing Radiation Resilience of Wide-Bandgap Semiconductors and Alloys via Electron Wind Force Annealing**: Rahman,M.H; Materials Science & Technology (MS&T) Technical Meeting and Exhibition, Accepted for oral presentation in *Processing and Performance of Materials Using Microwaves, Electric and Magnetic Fields, Ultrasound, Lasers, and Mechanical Work-Rustum Roy Symposium*, , September 2025, Columbus, OH, USA.
  (upcoming)

Invited Talks

- **Defect and Microstructure Control of Materials Using the Electron Wind Force**: Rahman, M.H.;, Low Carbon Energy Systems (LCES) Talk Series, Organized by the LCES Research Super Group, College of Engineering, The Pennsylvania State University, April 2024.

Mentorship and Undergraduate Supervision

- Supervised and mentored undergraduate students including Sarah Todaro, Felix Cooper, Hajin Oh, and Luke Warner as part of NSF-funded research projects.
- Co-authored peer-reviewed journal publications with mentees as lead graduate researcher.
- One of the mentees, Luke Warner, received the *2025 Dr. John P. Karidis Department Head's Award for Research Achievement in Mechanical Engineering* for work conducted under my guidance.

Honors and Awards

- Dean's List and Semester's Top List Scholarship by Bangladesh University of Engineering and Technology. (2016-2018)
- University Merit Scholarship by Bangladesh University of Engineering and Technology. (2015-2018)

Trainings and Workshops

- Objective-Based Education: Challenges and Confronts — (2020)
- Safety and Operation Management of VVER-1200 Reactors — (2019)

Leadership and Volunteering

- **Vice President**, Bangladesh Student Association (BSA), The Pennsylvania State University— (2025)
- Coordinator, Student Seminar Series, Bangladesh Army University of Science and Technology — (2020)
- Co-Coordinator, Annual Student Sports Competition, Bangladesh Army University of Science and Technology — (2020)
- Organizer, Regional Mathematics Quiz for College Students — (2019)