

M. Ryyan Khan

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RESEARCH INTERESTS

Solid-state device physics and simulations, opto-electric modelling of solar cells and solar farms, bio-sensors, bio-medical signal processing, image processing

SKILLS AND EXPERTISE

Simulation Software: COMSOL (RF module); Stanford S^4 ; Meep; MEDICI; Sentaurus

Programming: Matlab; C/C++

Growth and characterization: Fabrication of organic photovoltaics; solar cell characterization (absorption spectrum, J-V, C-V, EQE)

RESEARCH EXPERIENCE

Current projects

- Design of solar farm: Physics; effects of varying insolation, albedo, temperature; tracking and global optimization.
- Experimental study of ground sculpted bifacial solar farms and floating bifacial solar farms (funded by EWU-CRT).
- Optimization of panel setup for reduced soiling and cleaning cost (funded by ICT innovation fund).
- Modeling and numerical analysis of agro-photovoltaics system (funded by IAR-UIU)
- Study and numerical modeling of EGFET based sweat sensor and Zika virus detector; paper based biosensors

PhD project

- Thermodynamic analysis of photovoltaics: Analyzed thermodynamic limit of wide range of PV technologies (conventional PV, organic/excitonic PV, bifacial tandem).
- Optical simulations: Proposed and modelled two absorption enhancement schemes—branched nanowire and meta-mirrored (MM) light trapping (LT). The MM-LT concept can break the conventional limit of absorption enhancement.
- Opto-electric simulations: We applied our coupled opto-electric simulation framework to analyze high efficiency solar cell physics (GaAs-cells, angle restricted cells, and bifacial tandem). The bifacial tandem shows prospects for considerable output improvement with little added fabrication complexity.
- Organic photovoltaics (OPVs) growth and characterization: Opto-electric simulations (J-V, EQE) provide physical insights into organic PV (OPV) operation. We have grown and characterized (J-V, EQE) OPVs to support our numerical studies and theories. Designs have been proposed to improve carrier collection in these poor mobility materials.

Undergrad project

- Noise cancellation in scans of duplex-printed documents; Noise suppression in speech
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EDUCATION

□ **PhD** [May 2016], Electrical and Computer Engineering, *Purdue University*

- CGPA: 3.90/4.00
- Dissertation: “Perspectives and designs towards solar cell performance limits”
- Advisor: Professor Muhammad A. Alam

□ **BSc** [March 2009] in Electrical and Electronic Engineering at *Bangladesh University of Engineering and Technology (BUET)*, Dhaka, Bangladesh

- CGPA: 3.99/4.00
 - Rank: 1/130
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WORK EXPERIENCE

- Lecturer, EEE, BUET: May 2009-August 2009.
 - Post-Doctoral research associate, ECE, Purdue University: May 2016-October 2017.
 - Assistant Professor, EEE, East West University: January 2018-present.
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AWARDS AND HIGHLIGHTS

- Received Dean's List Scholarship in all the academic sessions in BUET
 - Work on 'Single material organic tandem solar cell' submitted to DOE as one of the highlights of Columbia EFRC (Sep. 2013)
 - Our work on 'Collection-limited theory of OPVs' highlighted in press [Purdue, phys.org] (Aug. 2015)
 - One of the winners in the 2017 I2D Lab Exposition poster competition. (March 2017)
 - Our work on sustainable food-energy-water nexus system highlighted in press [phys.org] (June 2017)
 - Our study on bifacial panels highlighted in Nature Energy ["From both sides", Elsa Couderc] (April 2018)
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DEVELOPED SIMULATION TOOLS

1. Binglin Zhao, Xingshu Sun, **M. Ryyan Khan**, and Muhammad A. Alam (2018), "Purdue University Meteorological Tool," <https://nanohub.org/resources/pumet>. (DOI: 10.4231/D3PR7MW72).
 2. Binglin Zhao, Xingshu Sun, **M. Ryyan Khan**, and Muhammad Ashraf Alam (2018), "Purdue University Bifacial Module Calculator (PUB)," <https://nanohub.org/resources/pub>. (DOI: 10.4231/D3QV3C60N).
 3. **M. R. Khan**, X. Jin, Muhammad A. Alam (2016), "PVLimits: PV thermodynamic limit calculator," <https://nanohub.org/resources/pvlimits>. (DOI: 10.4231/D37H1DN7Q).
 4. B. Ray, C. A. G. Williamson, **M. R. Khan**, Muhammad A. Alam (2014), "OPV Lab", <https://nanohub.org/resources/opv>. (DOI: 10.4231/D3Z31NP7F).
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SELECTED PUBLICATIONS

(Full list of citations: <https://scholar.google.com/citations?user=yceS25cAAAAJ&hl=en>)

1. M. T. Patel, R. A. Vijayan, R. Asadpour, M. Varadharajaperumal, **M. R. Khan**, and M. A. Alam, "Temperature-dependent energy gain of bifacial PV farms: A global perspective," Applied Energy, vol. 276, p. 115405, Oct. 2020.
2. J. B. Jahangir, Md. Al-Mahmud, Md. S. S. Shakir, S. Rahman, A. Haque and **M. R. Khan**, "Time Division Multiplexed Data Analysis Technique using Auto-Morphing Experimental Studies of PV Systems to Minimize Variability," in IEEE Region 10 Symposium (TENSYP) 2020.
3. Muhammed Tahir Patel, Hassan Imran, Md. Sojib Ahmed, Nauman Z. Butt, Muhammad A. Alam, **M. Ryyan Khan**, "When and Where to Track: A Worldwide Comparison of Single-axis Tracking vs. Fixed Tilt Bifacial Farms," in 2020 IEEE 47th Photovoltaic Specialists Conference (PVSC), Jul. 2020.
4. J. B. Jahangir, Md. Al-Mahmud, Md. S. S. Shakir, Md. M. H. Mithhu, R. N. Sajjad, and **M. R. Khan**, "Prediction of Yield, Soiling Loss, and Cleaning Cycle: A Case Study in South Asian Highly Construction-Active Urban Zone," in 2020 IEEE 47th Photovoltaic Specialists Conference (PVSC), Jul. 2020.
5. Muhammad A. Alam and **M. Ryyan Khan**, "ShockleyQueisser triangle predicts the thermodynamic efficiency limits of arbitrarily complex multijunction bifacial solar cells," PNAS, Nov. 2019.
6. M. Tahir Patel, **M. Ryyan Khan**, Jim J. John, and Muhammad A. Alam, "Implications of Seasonal and Spatial Albedo Variation on the Energy Output of Bifacial Solar Farms: A Global Perspective", PVSC 2019.
7. M. Tahir Patel, **M. Ryyan Khan**, Xingshu Sun, Muhammad A. Alam, "A Worldwide Cost-based Design and Optimization of Tilted Bifacial Solar Farms", Applied Energy, 2019.

8. **M. Ryyan Khan**, E. Sakr, X. Sun, P. Bermel, and Muhammad A. Alam, "Ground sculpting to enhance vertical bifacial solar farm output," vol.-24, *Applied Energy*, May 2019.
9. M. Tahir Patel, **M. R. Khan**, and Muhammad A. Alam "Thermodynamic Limit of Solar to Fuel Conversion for Generalized Photovoltaic-Electrochemical Systems," *IEEE Journal of Photovoltaics*, vol. 8, no. 4, pp. 10821089, Jul. 2018.
10. Xingshu Sun, **M. R. Khan**, C. Deline, and Muhammad A. Alam "Optimization and Performance of Bifacial Solar Modules: A Global Perspective," *Applied Energy*, 2017.
11. **M. R. Khan**, Amir Hanna, Xingshu Sun, and Muhammad A. Alam "Vertical bifacial solar farms: Physics, design, and global optimization," *Applied Energy*, vol. 206, no. Supplement C, pp. 240248, Nov. 2017. (equal contribution)
12. E. Gener, C. Miskin, X. Sun, **M. R. Khan**, P. Bermel, M. A. Alam, and R. Agrawal, "Directing solar photons to sustainably meet food, energy, and water needs," *Scientific Reports*, vol. 7, no. 1, p. 3133, Jun. 2017.
13. M. A. Alam and **M. R. Khan**, "Thermodynamic efficiency limits of classical and bifacial multi-junction tandem solar cells: An analytical approach," *Applied Physics Letters*, vol. 109, no. 17, p. 173504, Oct. 2016.
14. **M. R. Khan**, X. Wang, M. A. Alam, "Nonideal Effects Limit the Efficiency Gain for Angle-Restricted Solar Cells" *IEEE Journal of Photovoltaics*, 6 (1), 172-178, Oct. 2015.
15. **M. R. Khan** and M. A. Alam, "Thermodynamic limit of bifacial double-junction tandem solar cells", *Applied physics letters*, 107, 223502, 2015.
16. B. Ray, A. G. Baradwaj, **M. Ryyan Khan**, B. W. Boudouris, and Muhammad A. Alam, "Collection-limited theory interprets the extraordinary response of single semiconductor organic solar cells," in *Proceedings of the National Academy of Sciences* 112 (36), 11193-11198, Aug. 2015.
17. **M. Ryyan Khan***, Reza Asadpour*, Raghu V. K. Chavali*, and Muhammad A. Alam, "Bifacial Si heterojunction-perovskite organic-inorganic tandem to produce highly efficient ($\eta_T^* \sim 33\%$) solar cell," in *Applied Physics Letters*, vol. 106, no. 24, p. 243902, Jun. 2015. (*equal contribution).
18. **M. R. Khan**, X. Wang, E. Sakr, M. A. Alam, P. Bermel, "Enhanced selective thermal emission with a meta-mirror following Generalized Snells Law", *MRS Proceedings*, vol. 1728, mrsf14-1728-102-09, Jan. 2015.
19. **M. Ryyan Khan**, X. Wang, P. Bermel, and Muhammad A. Alam, "Enhanced light trapping in solar cells with a meta-mirror following generalized Snells law," in *Opt. Express*, vol. 22, no. S3, pp. A973A985, May 2014.
20. **M. Ryyan Khan** and Muhammad A. Alam, "Critical Binding Energy for Exciton Dissociation" and its Implications for the Thermodynamic Limit of Organic Photovoltaics," in *72nd Device Research Conference (DRC)*, 2014.
21. **M. Ryyan Khan**, Peter Bermel, and Muhammad A. Alam, "Thermodynamic Limits of Solar Cells with Non-ideal Optical Response," in *2013 39th IEEE Photovoltaic Specialists Conference (PVSC)* , 2013.
22. **M. R. Khan**, B. Ray, and M. A. Alam, "Prospects of layer-split tandem cells for high-efficiency OPV," *Solar Energy Materials and Solar Cells*, vol. 120, Part B, pp. 716723, Jan. 2014.
23. R. Chen, S. R. Das, C. Jeong, **M. R. Khan**, D. B. Janes, and M. A. Alam, "Co-Percolating Graphene-Wrapped Silver Nanowire Network for High Performance, Highly Stable, Transparent Conducting Electrodes," *Adv. Funct. Mater.*, vol. 23, no. 41, pp. 51505158, Nov. 2013.
24. M. A. Alam and **M. R. Khan**, "Fundamentals of PV Efficiency Interpreted by a Two-Level Model," *American Journal of Physics*, vol. 81, no. 9, pp. 655662, Sept 2013.
25. M. A. Alam, B. Ray, **M. R. Khan**, and S. Dongaonkar, "The essence and efficiency limits of bulk-heterostructure organic solar cells: A polymer-to-panel perspective," *J. Mater. Res.*, vol. 28, no. 04, pp. 541-557, Feb. 2013.
26. **M. R. Khan**, X. Wang, and M. A. Alam, "Fundamentals of PV Efficiency: Limits for Light Absorption," *arXiv:1212.2897* , Dec. 2012.

27. **M. R. Khan***, A. Mohammad*, S. R. Das*, M. A. Alam, and D. B. Jane, "Wavelength-Dependent Absorption in Structurally Tailored Randomly Branched Vertical Arrays of InSb Nanowires," *Nano Lett.*, Nov. 2012. (*equal contribution)
28. J. E. Allen, B. Ray, **M. R. Khan**, K. G. Yager, M. A. Alam, and C. T. Black, "Self-assembly of single dielectric nanoparticle layers and integration in polymer-based solar cells," *Appl. Phys. Lett.*, vol. 101, no. 6, pp. 063105-063105-4, Aug. 2012.
29. B. Ray, **M. R. Khan**, C. Black, and M. A. Alam, "Nanostructured Electrodes for Organic Solar Cells: Analysis and Design Fundamentals," *IEEE J. Photovoltaics*, vol. PP, no. 99, pp. 1 -12, 2012.
30. C. Jeong, P. Nair, **M. R. Khan**, M. Lundstrom, and M. A. Alam, "Prospects for Nanowire-Doped Polycrystalline Graphene Films for Ultratransparent, Highly Conductive Electrodes," *Nano Letters*, vol. 11, no. 11, pp. 50205025, 2011.
31. **M. Ryyan Khan** and Md. Kamrul Hasan. "A Novel Model for Show-Through in Scan of Duplex Printed Documents." Accepted in *Signal, Image and Video Processing (SIVP)*, Springer, in Oct. 2010.

SUPERVISED UNDERGRADUATE PROJECTS/THESIS

1. "Length-Based, Equipment-Free Detection in Paper Based Sensor," by Md. Jahidur Rahman, Mortoja Tasrif Rashid, and Rifat Hossain. (Spring 2020)
2. "Time division multiplexed data acquisition technique for parametric sweep analysis in PV system experiments," by Tahmina Akter Chowdhury, Sadia Binte Alam, and Md. Ahsanul Haque Laskor. (Fall 2019)
3. "Physics of elevated bifacial panel array and single axis tracking," by Md. Sojib Ahmed, Fahim Hossain Evan, and Md. Rifayat Abbasi. (Fall 2019)
4. "Model and Parametric Analysis of Electrolyte-ISFET System for DNA/RNA/Protein Based Bio-molecule Detection," by Mohammad Didarul Islam, Zubair Akhter, and Akib Hasan Bhuiyan. (Spring 2019)
5. "Modeling of ISFET Sweat Sensor," by Sumayeara Akter Tamme, Md. Hossain Ali, and A K M Sadrul Alam. (Spring 2019)
6. "Implementation and Analysis of South Facing bifacial Solar Farms: Effects of Ground Materials and Patterns," by Md. Mostak Morshed Shuvo, Md. Al-Mahmud, and Md. Shahadat Sarker Shakir. (Spring 2019)
7. "Practical Implementation and Study of Ground Sculpted Vertical Bifacial Solar Farms," by Loknath Karmaker, Syed Rafayedt Ahmed, and Md. Sabbir Raihan. (Spring 2019)
8. "Effect of soiling on solar panels: Energy yield, LCOE, and optimized cleaning cycles", by Md. Mahamudul Hasan Mithhu, Tahmina Ahmed Rima, and Prince Mahmud Himel. (Fall 2018)

REFEREES

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