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EDUCATION

- Ph.D. Electrical and Computer Engineering, University of Delaware, 1990.
Dissertation title: "Characterization of Midgap States by Capacitance Techniques in Amorphous Silicon and Amorphous Silicon Germanium p-i-n Solar Cells."
- M.E.E. Electrical Engineering, Cornell University, 1981.
Thesis title: "Modeling and Analysis of Polycrystalline GaAs Schottky Barrier Solar Cells."
- B.S.E.E. Electrical Engineering, Case Western Reserve University, 1977.

EXPERIENCE – 40+ years in Photovoltaic R&D and Education

2018-present Professor, Dept Electrical and Computer Engineering (ECE), University of Delaware

Teaching: Graduated 3 PhD students and 1 MS student in 2018. Currently supporting 4 PhD students. Have supervised, supported, and graduated 12 PhD and 9 MS students from Electrical and Computer Engineer (ECE) since my secondary appointment in 2005. Currently teaching ELEG 428/628 Solar Electric Technology and Applications ELEG (for 20+ years). Co-teaching ELEG 457/657 Design and Operation of Renewable Microgrids. Co-teaching ELEG 298 Sophomore Circuit Design Challenges. **Research:** Secondary appointment as Senior Scientist at Institute of Energy Conversion (IEC) where my research is conducted. Have funded and installed two new solar test bed facilities at IEC to further research at IEC and ECE: a 5 kW test bed for bifacial modules with residential smart inverter, charge controller and battery (funded by an external gift); and a hardware-in-loop (HIL) test bed for evaluating cyber security and grid control functions of power electronics like solar inverters (funded by 3 year Department of Energy (DOE) award). Funded by Unidel to develop Agrivoltaic Test Bed for research on growing crops under unique custom-built solar tracking array. Funded by DelDOT to analyze and recommend options for PV charging of EV and E-Bus fleet. Funded by Sustainable Energy Utility to develop Integrated Resource Plan survey for DE's 11 municipal and regulated utilities. **ECE Department service:** Undergraduate Curriculum Committee (2018-2020), Faculty Search Committee (2022), Strategic Planning Committee (2020-2021), COE Educational Activities Committee (2018-2019). Served on 6 PhD committees (4 ECE, 1 MSEG, 2 ENEP). **External Service:** Appointed to State Renewable Energy Task Force (2015-present). Invited participant in Senator Hansen's Energy Stakeholder Panel providing guidance and technical expertise on clean

energy technology and energy policy (2020-present). Appointed Chair of Grid Modernization Working Group of the Governor's Energy Advisory Council (2023-present)

2013-present Senior Scientist, Institute of Energy Conversion (IEC), University of Delaware
PI of \$1.2M DOE 3 year award "Rapid patterning and advanced device structures for low cost manufacturable Si IBC solar cells" (ended 2/2020) and \$600K DOE 3 year sub-award "Faster than real time simulation and demonstration of high penetration distributed energy resources" (ending 4/2023). Completed work as PI of \$3.8M DOE award to fabricate Heterojunction back contact solar cells. involving consortium of other university and industry partners (ended 2015). Co-PI on proposals to DOE, USDA and Unidel for combined agriculture-solar (Agrivoltaic) project with professor in CANR. Unidel selected us for \$900K funding 2022 to install world's first Agrivoltaic tracking array. Participated in three studies funded by State of Delaware: 1) apply LiDAR imaging to evaluate solar rooftop potential at UD and local urban areas ; 2) Identify critical issues limiting Community Solar projects and propose viable approach for DE; and 3) PI of project to evaluate and simulate microgrids with funding from State of Delaware (DNREC). Managing the Solar Cell Characterization and Accelerated Life Testing (ALT) Facility at IEC. Collaborated with administrators and facilities at STAR to build a microgrid. Wrote Unidel proposal to build microgrid at STAR (rejected). Assisting STAR personnel in defining and evaluating PV projects and test bed for STAR.

2007-2013 Scientist, Institute of Energy Conversion, University of Delaware
Principal investigator on 3 DOE and 1 DARPA contracts: 1) DOE FPACE award "Low cost back contact heterojunction solar cells on thin c-Si wafers: Integrating laser and thin film processing for improved manufacturability" (2012-2015, \$1.2 M) to fabricate IBC-SHJ on kerfless Si wafers with laser fired contacts and patterning; 2) Subcontract to Air Products from DOE "Enhanced growth rate of amorphous and nanocrystalline Si single and tandem solar cells" (2009-2012, \$1.1M); 3) Subcontract to Konarka from DOE "Characterization of degradation modes in OPV cells and modules" (2008-2010, \$230K); and 4) Subcontract to SiOnyx on DARPA program to develop heterojunction solar cells on very thin (50 μm) Si wafers with 'black' laser texture surface.

Manager of the Solar Cell Characterization Facility at IEC including hiring, training and assisting in the calibration and troubleshooting of optoelectronic measurements. Create the Accelerated Life Test (ALT) Lab at IEC using customized environmental chambers for solar cell degradation studies. Collaborate with industry groups on ALT for encapsulated Cu(InGa)Se₂ and organic module stability. Applied Laser Beam Induced Current (LBIC) to evaluate uniformity of thin film solar cells and minimodules. Supervised 10+ graduate students from various departments. Taught graduate class on PV technology and applications for > 10 years. Edited second edition of "Handbook of PV Science and Engineering" for Wiley and Sons. Consulting with US PV industry. Has secondary appointment in ECE and Fellow in Center for Energy

and Environmental Policy. Wrote invited paper comparing outdoor performance of crystalline Si vs thin film PV modules. Gave invited webinars and talks.

1993 - 2007 Associate Scientist, Institute of Energy Conversion, University of Delaware
 Responsible for optimization, analysis and characterization of thin film a-Si and CdTe solar cells. Developed lumped circuit model and applied to a-Si p-i-n JV data to obtain fundamental transport properties of the i-layer. Extended model to analyze state-of-the-art a-Si/a-SiGe multijunction solar cells. Developed analysis of QE to quantify optical enhancement due to light trapping in a-Si solar cells. Characterized JV behavior of contacts and junctions between transparent conductive oxides and a-SiC or $\mu\text{-Si}$ doped layers. Developed novel method to characterize SnO_2/p contact in a-Si p-i-n solar cells. Designed and operated multichamber environmental stress test system to evaluate stability of CdTe solar cells under controlled electrical bias, atmosphere, and thermal stress. Developed comprehensive loss analysis for CdTe solar cells including new treatment of voltage-dependent photocurrent. Develop and apply bifacial QE and JV analysis to CdTe devices. Collaborate with CdTe industry on improving stability. Represent IEC on a-Si and CdTe Thin Film Partnership Teams. Developing approaches for thin Si bottom cell for tandem application. Maintain and critically evaluate IEC's solar simulator, and spectral response equipment. Wrote paper on solar cell characterization that has >1100 citations (as of 2021). Direct and train technicians, visiting scientists, post-docs, graduate and undergraduate students. Supervised one Ph.D. and two Master's degree students. Obtained several contracts with new industry partners. Advised UD student team designing and building all-solar house for DOE competition. Teaching graduate course on "Solar Energy Technology and Applications." Co-editor and co-author of "Handbook of PV Science and Engineering," published by Wiley and Sons, UK, in 2002, the most comprehensive book on PV. Consulting editor of "Progress in Photovoltaics." Appointed Fellow in UD's Center for Energy and Environmental Policy in 2005.

1982-1993 Research Associate III Institute of Energy Conversion, University of Delaware
 Studied photoresponse of CdS/CuInSe₂ heterojunctions. Characterized and analyzed a-Si devices from new photoCVD process leading to first 10% efficient a-Si cell by university group in U.S. Became co-principal investigator of photoCVD a-Si program. Developed several optoelectronic techniques to characterize devices, including sub-bandgap QE, to study light-induced defects. Detailed study of midgap density of states in a-SiGe p-i-n cells by capacitance lead to Ph.D. dissertation in 1990. Analyzed mechanisms determining V_{oc} . Studied CdS/CdTe devices, used QE measurements to identify S interdiffusion and formation of CdTe(S) alloy. Engineer in one of the earliest demonstrations of PV for demand side management study, providing technical assistance in assembling data acquisition and control system in PV powered solar house.

1977 - 1982 Semiconductor Device Engineer
 IBM Corp., Endicott, New York

Responsible for modeling, testing, design and diagnostics of analog and digital integrated circuit devices. Designed and tested a new stress-independent integrated Hall effect sensor.

ACHIEVEMENTS

- Lead the first US university effort to fabricate a 10% a-Si solar cell (1988, publication 16)
- One of the earliest demonstrations of PV for residential demand side management (1994, publication 38)
- Lead the Multijunction Device Team for DOE National Thin Film Partnership (1992-2000, publications 35, 40, 48)
- Developed methodology to separate contact and junction degradation in a-Si and CdTe solar cells (2000, publications 56, 58)
- Developed comprehensive approach to characterize performance losses in thin film solar cells (2004, publication 70, cited > 700 times)
- Identified transient degradation and recovery in CdTe solar cells (2005 publication 72)
- Conducted accelerated degradation studies and device analysis on all commercially relevant thin film solar cells: a-Si, CdTe, organic, CIGS
- Editor of highly-cited book “*Handbook of Photovoltaic Science and Engineering*” (with Antonio Luque, Wiley and Sons 1st and 2nd Eds 2003, 2011)
- Principal Investigator of two DOE-funded multi-institution programs to fabricate Si Integrated Back Contact Heterojunction (IBC-HJ) Cells using lasers (2012, 2017)
- Lead project showing first demonstration of laser fired contacts on IBC-HJ cells (2014, publication 113)
- Establishing microgrid and solar inverter cyber security test facilities and team to provide new focus for ECE Dept and for IEC.

SYNERGISTIC ACTIVITIES

- 2021: Advising MEGR Solar Decathlon student design team
- 2020: Advised ECE Senior Design team on solar powered emergency medical back-up power system
- 2017-present: Serve on State DNREC Renewable Energy Task Force
- 2016: Co-chaired UDEI Solar Fuels Workshop, co-wrote white paper to DOE
- 2014-17: Regular guest lecture on Photovoltaics to CIEG 402, CIEG 465
- 2015-16: Executive Committee of Delaware Chapter of Sierra Club
- 2011-12: Lead team of UD graduate students designing and building Mobile Solar Demonstration Cart for K-12 education and training on solar energy
- 2002-12: Faculty advisor, UD Students for the Environment
- 1995-present: make presentations on solar electricity to local churches, schools, community groups; assist them in evaluating bids from solar contractors
- 1992-99: Team Leader, National Center Photovoltaics Thin Film R&D Industry Partnership Program

PROFESSIONAL MEMBERSHIPS

- Lifetime member, American Solar Energy Society
- Lifetime member, American Physical Society
- Senior Member, IEEE

PROFESSIONAL TRAINING

- 2016: Basic Training for HOMER Hybrid Microgrid Software Optimization
- 2013: 60 hr on-line class “Solar Electric Design and Installation of Grid Connected Systems” from industry-leading trainers Solar Energy International

PROFESSIONAL SERVICE

- 2020: Review ORAU proposals for new faculty
- 2019: Reviewer for IEEE Photovoltaics Specialists Conference Area 4
- 2018: External reviewer for 2 international PhD students (IIT-India, UNSW-Australia)
- 2017: Presentation on Solar Technology and Careers to IEEE Young Professionals (Philadelphia)
- 2012-present: Tutorial Instructor at five IEEE Photovoltaics Specialists Conference:
 - *Thin Film Solar Cells* (2012-2014, 2017);
 - *Fundamentals of PV Science and Technology* (2015-2016)
- 2009: Chair of Program Area 5 (Thin Film Si), 34rd IEEE Photovoltaics Specialists Conference, Philadelphia.
- 2003-2010: Hosted UD IEEE Student chapter several times for presentation and lab tour
- 2003-present: Consulting Editor of *Progress in Photovoltaics*
- 2015-present: Reviewer for IEEE J of Photovoltaics and other journals.

PATENTS

“Processes for fabricating all back contact heterojunction solar cells” Robert Birkmire, Steven Hegedus, Ujjwal Das. US2010319769A1, awarded Dec 2010.

BOOKS and CHAPTERS

- *Handbook of Photovoltaic Science and Engineering*, published John Wiley and Sons (2nd Edition 2011). A. Luque and S. Hegedus, editors.
- “Achievements and Challenges of Solar Electricity from Photovoltaics” S. Hegedus, A. Luque, in *Handbook of Photovoltaic Science and Engineering*, published John Wiley and Sons (2nd Edition 2011). A. Luque and S. Hegedus, editors.
- “Amorphous Silicon Solar Cells” E. Schiff, S. Hegedus, X. Deng, in *Handbook of Photovoltaic Science and Engineering*, published John Wiley and Sons (2nd Edition 2011). A. Luque and S. Hegedus, editors.

INVITED PUBLICATIONS

1. "Introduction to the Thin Film Photovoltaic Symposium Commemorating the 25th Anniversary of the Institute of Energy Conversion at the University of Delaware, USA," Robert W. Birkmire and Steven S. Hegedus, *Progress in Photovoltaics* **5**(5), 305 (1997).
2. "Summary of 4 1/2 Years of Research Experience of the US Amorphous Silicon Research Teams," B. von Roedern, E. Schiff, J.D. Cohen, S. Wagner and Steven S. Hegedus, *Progress in Photovoltaics: Res. Appl* **5**(5), 345 (1997).
3. "Substrates, Contacts and Monolithic Integration," Steven S. Hegedus, Scot Albright, Frank Jeffrey, T.J. McMahon and S. Wiedeman, *Progress in Photovoltaics* **5**(5), 365 (1997).
4. "Thin-Film Solar Cells: Device Measurements and Analysis," Steven S. Hegedus, and William N. Shafarman, *Progress in Photovoltaics* **12**(3), 155 (2004). **>1100 citations**
5. "Thin Film Solar Modules: The Low Cost, High Throughput and Versatile Alternative to Si Wafers," S. Hegedus, *Progress in Photovoltaic* **14**, 393 (2006)
6. "Review of photovoltaic module energy yield (kWh/kW): comparison of crystalline Si and thin film technologies" Steven Hegedus, *Wiley WIRE Energy Environ* 2012. doi: 10.1002/wene.61

REGULAR PUBLICATIONS

7. "The Photoresponse of CdS/CuInSe₂ Thin-Film Heterojunction Solar Cells," Steven S. Hegedus, *IEEE Trans. Electron Devices* Ed. **31**, 629 (1984).
8. "Transport Properties of LPCVD a-Si:H Solar Cells," S.S. Hegedus, *J. Noncryst. Sol.* **66**, 369 (1984).
9. "CVD Amorphous Silicon Solar Cells," S.S. Hegedus, R.E. Rocheleau, and B.N. Baron, *Proc. 17th IEEE PVSC*, 239 (1984).
10. "Properties of Intrinsic a-Si Films Deposited from Higher Order Silanes by CVD," R.E. Rocheleau, S.S. Hegedus, and B.N. Baron, *Proc. Mater. Res. Conf.* **49**, 15 (1985).
11. "Quantum Efficiency of Amorphous Alloy Solar Cells," V.L. Dalal, M. Leonard, J. Booker, A. Vaseashta, and S. Hegedus, *Proc. 18th IEEE PVSC*, 837 (1986).
12. "Electronic and Optical Properties of a-(SiGe):H Alloys," V. Dalal, M. Leonard, J. Booker, and S.S. Hegedus, *Proc. 18th IEEE PVSC*, 1500 (1986).
13. "Properties of a-Si:H and a-SiGe:H Films Deposited from Photo-Assisted CVD," R. Rocheleau, S. Jackson, S.S. Hegedus, and B. Baron, *Proc. Mater. Res. Soc. Conf.* **70**, 37 (1986).
14. "Density of Midgap States and Urbach Edge in Chemically Vapor Deposited Hydrogenated Amorphous Silicon Films," Steven S. Hegedus, R. E. Rocheleau, J.M. Cebulka, and B.N. Baron, *J. Appl. Phys.* **60**(3), 1046 (1986).

15. "Laboratory Safety Procedures for Processing II-VII and Related Compounds for Thin Film Photovoltaics," Steven S. Hegedus, J.D. Meakin, B.N. Baron, and J.A. Miller, *Solar Cells* **19**, 225 (1987).
16. "Measurement of the Built-in Potential in Amorphous Silicon *p-i-n* Solar Cells," Steven S. Hegedus, Martin Schmidt and Neil Salzman, *Proc. 19th IEEE PVSC*, 210 (1987).
17. "Analysis of a Transparent Cu/ITO Contact and Heat Treatments on CdTe/CdS Solar Cells," R.W. Birkmire, S.S. Hegedus, B.E. McCandless, J.E. Phillips, and W.N. Shafarman, *Proc. 19th IEEE PVSC*, 967 (1987).
18. "Novel Photochemical Vapor Deposition Reactor for Amorphous Silicon Solar Cell Deposition," Richard E. Rocheleau, Steven S. Hegedus, Wayne A. Buchanan, and Scott C. Jackson, *Appl. Phys. Lett.* **51**(2), 133 (1987).
19. "Performance and Analysis of Amorphous Silicon *p-i-n* Solar Cells Made by Chemical-Vapor Deposition from Disilane," Steven S. Hegedus, R.E. Rocheleau, W. Buchanan, and B.N. Baron, *J. Appl. Phys.* **61**(1), 381 (1987).
20. "Effects of Impurities on Film Quality and Device Performance in a-Si:H Deposited by Photo-Assisted CVD," Richard E. Rocheleau, Steven S. Hegedus, Wayne Buchanan, and Robert Tullman, *Proc. 19th IEEE PVSC*, 699 (1987).
21. "Low Bandgap Amorphous Silicon-Germanium Alloys for Thin Film Solar Cells Using a Novel Photo-CVD Reactor," Steven S. Hegedus, R.M. Tullman, H.S. Lin, J.M. Cebulka, W.A. Buchanan, R. Dozier, and R.E. Rocheleau, *Proc. 19th IEEE PVSC*, 867 (1987).
22. "Photo-assisted CVD of a-Si:H Solar Cells and a-SiGe:H Films," S. S. Hegedus, R.E. Rocheleau, R.M. Tullman, D.E. Albright, N. Saxena, W.A. Buchanan, K.E. Schubert, and R. Dozier, *Proc. 20th IEEE PVSC*, 129 (1988).
23. "The Relation of Dark and Illuminated Diode Parameters to the Open-circuit Voltage of Amorphous Silicon *p-i-n* Solar Cells," Steven S. Hegedus, Neil Salzman, and Edward Fagen, *J. Appl. Phys.* **63**(10), 5126 (1988).
24. "Light-induced Degradation in Undoped Hydrogenated Amorphous Silicon Films Studied by the Surface Photovoltage Technique: A Comparison of Lifetime Versus Space-charge Effects," Steven S. Hegedus, Hong-sheng Lin, and A.R. Moore, *J. Appl. Phys.* **64**(3), 1215 (1988).
25. "Amorphous Silicon-Germanium Deposited by Photo-CVD: Effect of Hydrogen Dilution and Substrate Temperature," R.E. Rocheleau, R.M. Tullman, D.E. Albright and S.S. Hegedus, *Mater. Res. Society Symposium* **118**, 653 (1988).
26. "The Open Circuit Voltage of Amorphous Silicon *p-i-n* Solar Cells," Steven S. Hegedus, *Proc. 20th IEEE PVSC*, 102, (1988).
27. "Characterization of Defects in a-Si:H Solar Cells Using Sub-band Gap Photocurrent Spectroscopy," Steven S. Hegedus and James M. Cebulka, *Proc. 20th IEEE PVSC*, 186 (1988).

28. "Midgap Defects in a-SiGe:H Devices from Capacitance Measurements," Steven S. Hegedus and Theodore X. Zhou, Proc. Mater. Res. Society Spring Meeting **149**, 533 (1989).
29. "Stable High Efficiency Amorphous Silicon Based Solar Cells," B.N. Baron, C.M. Fortmann, S.S. Hegedus, W.A. Buchanan, D.E. Albright, N. Saxena, and T.W.F. Russell, Proc. 9th Euro. Communities PV Solar Energy Conf., 56 (1989).
30. "Design Considerations for Low Band Gap a-SiGe:H Alloy Solar Cells," S.S. Hegedus, C.M. Fortmann, and W.A. Buchanan, J. Non-Crystalline Solids **115**, 21 (1989).
31. "Capacitance Studies of a-SiGe:H p-i-n Solar Cells," Steven S. Hegedus, Proc. 21st IEEE PVSC, 1544 (1990).
32. "Steady-state Mobility-lifetimes and Photoconductivity in a-SiGe:H Thin Films," S.S. Hegedus and J.M. Cebulka, J. Appl. Phys. **67**(8), 3885 (1990).
33. "Influence of CdS Window Layers on Thin Film CdS/CdTe Solar Cell Performance," B.E. McCandless and S.S. Hegedus, Proc. 22nd IEEE PVSC, 967 (1991).
34. "Hydrogen Content and the Goal of Stable Efficient Amorphous-Silicon-Based Solar Cells," C.M. Fortmann, S.S. Hegedus, T.X. Zhou and B.N. Baron, Solar Cells **30**, 255 (1991).
35. "Polycrystalline Heterojunction Solar Cells: Device Perspective," J.E. Phillips, W.N. Shafarman, R.W. Birkmire, S.S. Hegedus, and B.E. McCandless, AIP Conf. Proc. **268**, 206 (1992).
36. "Polycrystalline Heterojunction Solar Cells: Processing Perspective," R.W. Birkmire, S.S. Hegedus, B.E. McCandless, J.E. Phillips, TWF Russell, W.N. Shafarman, S.Verma, and S. Yamanaka, AIP Conf. Proc. **268**, 212 (1992).
37. "Effects of Processing on CdTe/CdS Materials and Devices," R. W. Birkmire, B.E. McCandless, and S.S. Hegedus, Int. J. Solar Energy **12**, 145 (1992).
38. "Midgap States in a-Si:H and a-SiGe:H p-i-n Solar Cells and Schottky Junctions by Capacitance Techniques," Steven S. Hegedus and E. A. Fagen, J. Appl. Phys. **71**(12), 5941 (1992).
39. "Characterization of a-Si:H and a-SiGe:H p-i-n and Schottky Junctions by Admittance Circuit Modeling," Steven S. Hegedus and Edward A. Fagen, IEEE Trans. on Elect. Dev. **39**(10), 2368 (1992).
40. "Understanding Graded a-SiGe Solar Cells Using Bifacial Photocurrent Collection," Steven Hegedus and Wayne Buchanan, Proc. 23rd IEEE PVSC, 991 (1993).
41. "Recent Progress in Amorphous Silicon PV Technology," W. Luft, H.M. Branz, V.L. Dalal, S.S. Hegedus, and E.A. Schiff, AIP Conf. Proc. **306**, 31 (1994).
42. "Parametric Analysis of a-Si Solar Cells from Current Voltage Measurements," Steven S. Hegedus and James E. Phillips, Proc. IEEE First WCPEC and 24th IEEE PVSC, 654 (1994).

43. "Built-in Potentials via Electroabsorption Measurements in a-Si:H p-i-n Solar Cells: A Critical Assessment," Q. Wang, E.A. Schiff, and S.S. Hegedus, *Mater. Res. Society Symp. Proc.* **336**, 365 (1994).
44. "Photovoltaics as a Demand-side Management Technology: An Analysis of Peak-shaving and Direct Load Control Options," John Byrne, Steven Hegedus, and Young-Doo Wang, *Progress. in Photovoltaics* **2**, 235 (1994).
45. "Current Transport in Amorphous Silicon n/p Junctions and their Application as "tunnel" Junctions in Tandem Solar Cells," Steven S. Hegedus, Frank Kampas, and Jianping Xi, *Appl. Phys. Lett.* **67**(6), 813 (1995).
46. "Progress in Amorphous Silicon PV Technology: An Update," W. Luft, H.M. Branz, V.L. Dalal, S.S. Hegedus, and E.A. Schiff, *Amer. Inst. Physics Conf. Proc.* **353**, 81 (1995).
47. "Transparent Conducting Oxides (TCO's) for n-i-p and p-i-n Amorphous Silicon Solar Cells," Steven S. Hegedus, Wayne A. Buchanan, Erten Eser, James E. Phillips, and William N. Shafarman, *Amer. Inst. Physics Conf. Proc.* **353**, 465 (1995).
48. "Effect of Textured Tin Oxide and Zinc Oxide Substrates on the Current Generation in Amorphous Silicon Solar Cells," S. Hegedus, W. Buchanan, X. Liu, & R. Gordon, *Proc. 25th IEEE PVSC*, 1129 (1996).
49. "Analysis of Optical Enhancement in a-Si n-i-p Solar Cells Using a Detachable Back Reflector," Steven S. Hegedus & Xunming Deng, *Proc. 25th IEEE PVSC*, 1061 (1996).
50. "Progress Report on the Amorphous Silicon Teaming Activities," B. von Roedern, K. Zweibel, E. Schiff, J.D. Cohen, S. Wagner, S.S. Hegedus and T. Peterson, Proc. 14th NREL/SNL PV Program Review Meeting, *Amer. Inst. Physics Conf. Proc.* (1996).
51. "Analysis and Optimization of High Efficiency Multijunction a-Si:H Solar Cells," Richard E. Rocheleau, Moe Tun, and Steven S. Hegedus, *Proc. 26th IEEE PVSC*, 703 (1997).
52. "Improving Performance of Superstrate p-i-n a-Si Solar Cells by Optimization of n/TCO/Metal Back Contacts," Steven S. Hegedus, Wayne A. Buchanan, and Erten Eser, *Proc. 26th IEEE PVSC*, 603 (1997).
53. "Optical losses in Amorphous Silicon Solar Cells Due to Back Reflectors," B. L. Sopori, J. Madjdpour, B. V. Roedern, W. Chen, and S. S. Hegedus, *Proc. Mater. Res. Society Symp.* (1997).
54. "Current-Voltage Analysis of a-Si and a-SiGe Solar Cells Including Voltage-dependent Photocurrent Collection," Steven S. Hegedus, *Progress in Photovoltaics* **5**(3), 151 (1997).
55. "Preparation and Characterization of Micro-Crystalline Hydrogenated Silicon Carbide p-Layers," Erten Eser, Steven S. Hegedus, and Wayne A. Buchanan, *Amer. Inst. Physics Conf. Proc.* **462**, 254 (1998).
56. "Optical Modeling of a-Si Solar Cells," B. Sopori, J. Madjdpour, Y. Zhang, W. Chen, S.S. Hegedus, *Proc. MRS Spring Meeting* **557**, 755 (1999).

57. "Infrared Electroabsorption Spectra in Amorphous Silicon Solar Cells," J.H. Lyou, Eric A. Schiff, Steven S. Hegedus, S. Guha and J. Yang, *Proc. MRS Spring Symp.* **557**, 457 (1999).
58. "A New Method to Characterize TCO/P Contact Resistance in a-Si Solar Cells," Steven S. Hegedus, Michael Gibson, Gautam Ganguly and Rejeewa Arya, *Mat. Res. Soc. Symp. Proc.* **557**, 737 (1999).
59. "Characterization of the SnO₂/p and ZnO/p Contact Resistance and Junction Properties in a-Si p-i-n Solar Cells and Modules," Steven S. Hegedus, Ruhi Kaplan, Gautam Ganguly and George S. Wood, *Proc. 28th IEEE PVSC*, 728 (2000).
60. "Interfacial Optical Spectra in Amorphous Silicon Based *pin* Solar Cells," Kai Zhu, J.H. Lyou, E.A. Schiff, R.S. Crandall, G. Ganguly and S.S. Hegedus, *Proc. 28th IEEE PVSC*, 725 (2000).
61. "Analysis of Stress-Induced Degradation in CdS/CdTe Solar Cells," Steven S. Hegedus, Brian E. McCandless, and Robert W. Birkmire, *Proc. 28th IEEE PVSC*, 535 (2000).
62. "Initial and Stressed Performance of CdTe Solar Cells: Effect of Contact Processing," S. S. Hegedus, B. E. McCandless and R.W. Birkmire, *Proc. NCPV Prog. Rev. Mtg.*, 119 (2001).
63. "Thin Si p-layers Containing Boron Doped Micro-crystalline Si and a-SiO_x Phases," E. Eser, W. Buchanan and S. Hegedus, *Proc. NCPV Prog. Rev. Mtg.*, 183 (2001).
64. "Effect of Plasma and Thermal Annealing on Optical and Electronic Properties of SnO₂ Substrates Used for a-Si Solar Cells," Steven S. Hegedus, *J. Appl. Phys.* **92**(1), 620 (2002).
65. "Optical Design and Analysis of Textured a-Si Solar Cells," Steven Hegedus, Bhushan Sopori, P.D. Paulson, *Proc. 29th IEEE PVSC*, 1122 (2002).
66. "Analysis of Quantum Efficiency and Optical Enhancement in Amorphous Si p-i-n Solar Cells," Steven S. Hegedus and Ruhi Kaplan, *Prog. Progress in Photovoltaics: Res. and Appl.* **10**, 257 (2002).
67. "Correlation of Surface Phases with Electrical Behavior in Thin-film CdTe Devices," B.E. McCandless, S.S. Hegedus, R.W. Birkmire, D. Cunningham, *Thin Solid Films* **431**, 249 (2002).
68. "Role of Process Chemistry and Stability on CdTe-based Solar Cell Performance," by B. McCandless, K. Dobson, S. Hegedus, and P. Paulson, *Proc. NCPV Rev. Mtg.*, 401 (2003).
69. "Photoconductive CdS: How Does it Affect CdTe/CdS Solar Cell Performance?" S. Hegedus, D. Ryan, K. Dobson, B. McCandless, D. Desai, *Proc. MRS Symp.* **763**, 447 (2003).
70. "Status, Trends, Challenges, and the Bright Future of Solar Electricity from Photovoltaics," S. Hegedus, A. Luque, Handbook of Photovoltaic Science and

Engineering, Chapter 1 (A. Luque and S.S. Hegedus, eds.), Wiley and Sons, Chichester, UK, 1 (2003).

71. "Correlation of Surface Phases with Electrical Behavior in Thin-Film CdTe Devices," B.E. McCandless, S.S. Hegedus, R.W. Birkmire and D. Cunningham, *Thin Solid Films* **431-432**, 249 (2003).
72. "Improved Fill Factors in Amorphous Silicon Solar Cells on Zinc Oxide by Insertion of a Germanium Layer to Block Impurity Incorporation," G. Ganguly, D.E. Carlson, S.S. Hegedus, D. Ryan, R.G. Gordon, D. Pang, R.C. Reedy, *Appl. Phys. Lett.* **85(3)**, 479 (2004).
73. "Accurate Determination of Optical Constants of Textured SnO₂ Using Low Incidence Angle Spectroscopic Ellipsometry," P.D. Paulson and Steven S. Hegedus, *Journal of Applied Physics* **96(10)**, 5469 (2004).
74. "Transient Degradation and Recovery of CdS/CdTe Solar Cells," Steven Hegedus, Darshini Desai, Dan Ryan and Brian McCandless, *Proc. 31st IEEE PVSC*, 319 (2005).
75. "Real BOS and System Costs of Off-grid PV Installations in the US: 1987-2004," Steven Hegedus and Nozumi Okubo, *Proc. 31st IEEE PVSC*, 1651 (2005).
76. "CdTe Contacts for CdTe/CdS Solar Cells: Effect of Cu Thickness, Surface Preparation and Recontacting on Device Performance and Stability," Steven S. Hegedus and Brian E. McCandless, *Solar Energy Materials & Solar Cells* **88**, 75 (2005).
77. "Transparent ZnTe:Cu Contacts for Bifacial Characterization of CdTe Solar Cells," Sarshini Desai, Steven Hegedus, Brian McCandless and Daniel Ryan, *Mater. Res. Soc. Symp. Proc.* **865**, 431 (2005).
78. "Thin CdTe Solar Cells with High Throughput Processing," B.E. McCandless, K.D. Dobson, S.S. Hegedus, W.A. Buchanan, D. Desai, R.W. Birkmire, *presented at the DOE Solar Program Review Meeting*, (2005).
79. "Thin Film Si Bottom Cells for High-Efficiency Polycrystalline Tandem Cells," Vijay Yelundur, Steven Hegedus, Ujjwal Das, Michael Burrows, Ajeet Rohatgi, and Robert Birkmire, *presented at the DOE Solar Program Review Meeting*, (2005).
80. "Pathways to Thin Film Polycrystalline Silicon Using Amorphous Silicon Precursors," O. Ebil, S. Hegedus, M. Lu and R. Birkmire, *presented at the DOE Solar Program Review Meeting*, (2005).
81. "How CdTe Solar Cells Operate: Determining Collection Using Bifacial Device Characterization," D. Desai, S. Hegedus, B. McCandless, R. Birkmire, K. Dobson, D. Ryan, *Proc. 32nd IEEE PVSC and WCPEC-4*, 368 (2006).
82. "Effect of Process Parameter Variation in Deposited Emitter and Buffer Layers on the Performance of Silicon Heterojunction Solar Cells," Ujjwal Das, Stuart Bowden, Michael Burrows, Steven Hegedus and Robert Birkmire, *Proc. 32nd IEEE PVSC and WCPEC-4*, 1283 (2006).
83. "Carrier Lifetime as a Developmental and Diagnostic Tool in Silicon Heterojunction Solar Cells," S. Bowden, U.K. Das, S.S. Hegedus, R.W. Birkmire, *Proc. 32nd IEEE PVSC and WCPEC-4*, 1295 (2006).

84. "Break-even Price Estimates for Residential PV Applications in OECD Countries with an Analysis of Prospective Cost Reductions," Daniele Poponi, John Bryne and Steven Hegedus, *Energy Studies Rev.* **14**(1), 104 (2006).
85. "Voltage Dependent Photocurrent Collection in CdTe/CdS Solar Cells," Steven Hegedus, Darshini Desai and Chris Thompson, *Progress in Photovoltaics*.**15**, 587 (2007).
86. "Improved Passivation of a-Si:H/c-Si Interfaces Through Film Restructuring," M.Z. Burrows, U.K.Das, S. Bowden, S.S. Hegedus, R.L. Opila, and RW. Birkmire, *Mater. Res. Soc. Symp. Proc.* **1066**, 1066-A02-05 (2008).
87. "Temperature Dependence of V_{OC} in CdTe and Cu(InGa)(SeS)₂-based Solar Cells," Christopher Thompson, Steven Hegedus, William Shafarman and Darshini Desai, *Proc. 33rd IEEE PVSC*, (2008).
88. "Progress Towards High Efficiency All Back Contact c-Si Heterojunction Solar Cells," U. Das, S. Bowden, M. Lu, M. Burrows, D. Xu, O. Jani, S. Hegedus, R. Birkmire, *Proc. 18th Workshop on Crystalline Silicon Solar Cells*, 70 (2008).
89. "Optimization of Interdigitation Parameters for Back Contact Si Heterojunction Solar Cells," O. Jani, U. Das, S. Herasimenka, M. Lu, D. Xu, S. Bowden, S. Hegedus, R. Birkmire, *Euro. Photovoltaic Solar Energy Conf. PVSEC18* (2009).
90. "Designing Rear Surface for Carrier Transport in Back Contact Si Heterojunction Solar Cells," U. Das, M. Lu, D. Xu, O. Jani, S. Bowden, S. Hegedus, R. Birkmire, *Euro. Photovoltaic Solar Energy Conf. PVSEC18* (2009).
91. "Optimization of Interdigitated Back Contact Silicon Heterojunction Solar Cells by Two-dimensional Numerical Simulation," Meijun Lu, Ujjwal Das, Stuart Bowden, Steven Hegedus and Robert Birkmire, *Proc. 34th IEEE PVSC, Philadelphia, PA, June 8-12, 2009*.
92. "Low Temperature Front Surface Passivation of Interdigitated Back Contact Silicon Heterojunction Solar Cell," Brent Shu, Ujjwal Das, Omkar Jani, Steven Hegedus, and Robert Birkmire, *Proc. 34th IEEE PVSC, Philadelphia, PA, June 8-12, 2009*.
93. "A Comparative Study of Photoconductivity and Carrier Transport in a-Si:H p-i-n Solar Cells with Different Back Contacts, R. Kaplan, B. Kaplan, S.S. Hegedus, *Solid-State Electronics* **54**, 22 (2010).
94. "Alternative Approaches for Low Temperature Front Surface Passivation of Interdigitated Back Contact Silicon Heterojunction Solar Cell,": Brent Shu, Ujjwal Das, Jesse Appel, Brian McCandless, Steven Hegedus and Robert Birkmire, *Proc. 35th IEEE PVSC, Waikiki, Hawaii, June 20-25, 2010*.
95. "Encapsulation of Cu(InGa)Se₂ Solar Cells with ALD Al₂O₃ Flexible Thin-film Moisture Barrier; Stability Under 1000 Hour Damp Heat and UV Exposure," Steven S. Hegedus, P.F. Carcia, R.S. McLean, Bradley Culver, *Proc. 35th IEEE PVSC, Waikiki, Hawaii, June 21-25, 2010*.
96. "Quantative Analysis and Extraction of Cell Parameters from Interconnected Thin-Film Solar Modules through LBIC-Voltage Sweeps," Jonathan M. Frey, Steven S. Hegedus and Christopher P. Thompson, *Proc. 35th IEEE PVSC, Waikiki, Hawaii June 20-25, 2010*.

97. "Investigation of Hetero-Interface and Junction Properties in Silicon Heterojunction Solar Cells, Ujjwal Das, Steven Hegedus, Lulu Zhang, Jesse Appel, Jim Rand, and Robert Birkmire, *Proc. 35th IEEE PVSC, Waikiki, Hawaii, June 21-25, 2010*.
98. "Effect of Junction Interface Modification of Silicon Heterojunction Solar Cells," Jesse Appel, Lulu Zhang, Ujjwal Das, Steven Hegedus, Swapna Mudigonda, Robert Birkmire, Jim Rand, *Proc. 35th IEEE PVSC, Waikiki, Hawaii, June 21-25, 2010*.
99. "Encapsulation of Cu(InGa)Se₂ Solar Cell with Al₂O₃ Thin-film Moisture Barrier grown by Atomic Layer Deposition," P.F. Carcia, R.S. McLean, Steven Hegedus, *Solar Energy Materials & Solar Cells* **94**, 2375-2378 (2010).
100. "Optimization of Interdigitated Back Contact Silicon Heterojunction Solar Cells: Tailoring Hetero-interface band Structures While Maintaining Surface Passivation," Meijun Lu, Ujjwal Das, Stuart Bowden, Steven Hegedus and Robert Birkmire, *Prog. Photovolt. Res. Appl. DOI: 10.1002/pip. 1032 (2010)*.
101. "Interdigitated back contact Si heterojunction solar cells: effect of doped layer defect levels and rear surface i-layer band-gap using 2D simulation" John Allen, Brent Shu, Lulu Zhang, Ujjwal Das, Steven Hegedus, *Proc. 37th IEEE PVSC, Seattle WA, June 2011*.
102. "Improved FF in p-Si heterojunction solar cells due to optimized ITO/emitter contact" Zeynep Eygi, Ujjwal Das, Steven Hegedus, Robert Birkmire, *Proc. 37th IEEE PVSC, Seattle WA, June 2011*.
103. "Impact of Back Surface Patterning Process on FF in IBC-SHJ Solar Cells" Lulu Zhang, Brent Shu, Robert Birkmire, Steven Hegedus and Ujjwal Das, *Proc. 38th IEEE PVSC, Austin TX, June 2012*.
104. "The Effects of Device Geometry and TCO/Buffer Layers on Damp Heat Accelerated Lifetime Testing of Cu(In,Ga)Se₂ Solar Cells" Christopher P. Thompson, Steven Hegedus, Peter Carcia and R. Scott McLean, *Proc. 38th IEEE PVSC, Austin TX, June 2012*
105. "Laser textured heterojunction solar cells on 45 um thick Si wafers: effect of optical configuration and light trapping" Steven Hegedus, Ujjwal Das, Chris Vineis, Moran Levy-Finklshtein, J. Sickler, Jim Carey *Proc. 38th IEEE PVSC, Austin TX, June 2012*
106. "Characterization and Modeling of Low Temperature Surface Passivation for Interdigitated Back Contact Silicon Hetero-junction Solar Cell" Brent Shu, Ujjwal Das, Steven Hegedus, and Robert Birkmire, *Proc. 38th IEEE PVSC, Austin TX, June 2012*
107. "Design of Anti-Reflection Coating for Surface Textured Interdigitated Back Contact Silicon Hetero-junction Solar Cell" Brent Shu, Ujjwal Das, Lei Chen, Lulu Zhang, Steven Hegedus, and Robert Birkmire, *Proc. 38th IEEE PVSC, Austin TX, June 2012*
108. "Analysis of voltage and temperature dependent photocurrent collection in p3ht/pcbm solar cells," Bakhtyar Ali, Roy Murray, Steven S. Hegedus, and S. Ismat Shah, *J. Appl. Phys.* **112**, 114514 (2012).
109. "Modeling and Experimental Study of SiH₄/GeH₄/H₂ Gas Discharge for Hydrogenated Silicon Germanium Deposition by RF PECVD" "Zhao, L., Hunsperger, R., & Hegedus, S. *Material Research Soc MRS Proceedings 1426*, 403-408 (2012). doi:10.1557/opl.2012.841
110. "Experimental and simulated analysis of front versus all-back-contact silicon heterojunction solar cells: effect of interface and doped a-Si:H layer defects", Z. Shu, U.

- Das, J. Allen, R. Birkmire, and S. Hegedus, *Progress in Photovoltaics* (2013) DOI: 10.1002/pip.2400.
111. "Sensitivity of surface passivation and interface quality in IBC-SHJ solar cells to patterning process", U. Das, J. He, Z. Shu, L. Zhang, C. Thompson, R. Birkmire, and S. Hegedus, *39th IEEE Photovoltaic Specialists Conference, Tampa, FL (2013)*.
 112. "Laser fired contact for n-type crystalline Si solar cell", J. He, S. Hegedus, U. Das, Z. Shu, M. Bennett, and R. Birkmire, *39th IEEE Photovoltaic Specialists Conference, Tampa, FL (2013)*.
 113. "Laser fired contacts for n-type c-Si solar cells" J. He, S. Hegedus, U. Das, Z. Shan, M. Bennett, L. Zhang, R. Birkmire *Progress in Photovoltaics*, published online: 17 June 2014 DOI: 10.1002/pip.2520
 114. "The role of back contact patterning on stability and performance of Si IBC heterojunction solar cells" U. Das, H-Y Liu, J. He, S. Hegedus, *40th IEEE Photovoltaic Specialists Conference; Denver, CO; June 8-13, 2014*.
 115. "Experimental and simulated analysis of p a-Si:H defects on silicon heterojunction solar cells: trade-offs between Voc and FF" L. Zhang, U. K. Das, Z. Shu, H. Liu, R. W. Birkmire and S. S. Hegedus, *42th IEEE Photovoltaic Specialists Conference; New Orleans, LA; June, 2015*.
 116. "The Role of the Intrinsic Zinc Oxide Layers on the Performance of Wide-bandgap (AgCu)(InGa)Se₂ Thin-Film Solar Cells" Uwadiae Obahiagbon, Christopher P. Thompson, William N. Shafarman, Steven S. Hegedus, *42th IEEE Photovoltaic Specialists Conference; New Orleans, LA; June, 2015*.
 117. "Wafer-level Integrated Micro-Concentrating Photovoltaics" Tian Gu, Duanhui Li, Lan Li, Bradley Jared, Gordon Keeler, Bill Miller, William Sweatt, Scott Paap, Michael Saavedra, Ujjwal Das, Steve Hegedus, Robert Birkmire, Anna Tauke-Pedretti, Juejun Hu Invited Paper presented at *Optical Society of America Energy and Environment Congress, August 2016*
 118. "Processing Approaches and Challenges of Interdigitated Back Contact Si Solar Cells" U Das and S Hegedus. *44th IEEE Photovoltaic Specialist Conference, Washington DC June 2017*.
 119. "Electroluminescence Analysis For Separation of Series Resistance From Recombination Effects in Silicon Solar Cells with Interdigitated Back Contact Design" Nuha Ahmed, Lei Zhang, Ujjwal Das, and Steven Hegedus. *44th IEEE Photovoltaic Specialist Conference, Washington DC June 2017*.
 120. "Hydrogen Plasma Post-Deposition Treatment for Passivation of a-Si/c-Si Interface for Heterojunction Solar Cell by Correlating Optical Emission Spectroscopy and Minority Carrier Lifetime" A Soman, U Nsofor, L Zhang, U Das, T Gu, S Hegedus. *44th IEEE Photovoltaic Specialist Conference, Washington DC June 2017*.
 121. "Gap passivation structure for scalable n-type interdigitated all back contacts silicon hetero-junction solar cell processes" Lei Zhang, Ujjwal Das, Steven Hegedus. *44th IEEE Photovoltaic Specialist Conference, Washington DC June 2017*.
 122. "Wafer integrated micro-scale concentrating photovoltaics" Tian Gu, Duanhui Li, Lan Li, Bradley Jared, Gordon Keeler, Bill Miller, William Sweatt, Scott Paap, Michael Saavedra, Ujjwal Das, Steve Hegedus, Anna Tauke-Pedretti, Juejun Hu, 13th International Conference on Concentrator Photovoltaic Systems (CPV-13) AIP Conference Proceedings **1881**, 080004 (2017); <https://doi.org/10.1063/1.5001442>

123. "Modeling and Analysis of Photovoltaic Electrochemical System using Module - Level Power Electronics" Gowri M. Sriramagiri, Nuha Ahmed, Kevin D. Dobson, Steven S. Hegedus, *44th IEEE Photovoltaic Specialist Conference*, Washington DC June 2017.
124. "Towards Practical Solar-Driven CO₂ Flow-Cell Electrolyzer: Design and Optimization" Gowri M. Sriramagiri, Nuha Ahmed, Wesley Luc, Kevin D. Dobson, Steven S. Hegedus, Feng Jiao. *American Chemical Soc. Sustainable Chemistry and Engineering*, 2017, 5 (11), pp 10959–10966 DOI: 10.1021/acssuschemeng.7b02853
125. "Study of Passivation in the Gap Region between Contacts of Interdigitated Back Contact Silicon Heterojunction Solar Cells: Simulation and Voltage-modulated Laser-beam-induced-current" Lei Zhang, Nuha Ahmed, Christopher Thompson, Ujjwal Das, and Steve Hegedus, *IEEE J Photovoltaics* 2018, Vol 8, pp. 404-412 [https://DOI: 10.1109/JPHOTOV.2017.2783852](https://doi.org/10.1109/JPHOTOV.2017.2783852)
126. "Raman spectroscopy study of Hydrogen Plasma Treatment effect on a single layer Graphene/MoS₂ hybrid structure," Anishkumar Soman, Jianping Shi, Ugochukwu Nsofor, Steve Hegedus, Yanfeng Zhang, Robert Burke, Tingyi Gu in *Frontiers in Optics* 2017, OSA Technical Digest (Optical Society of America, 2017), (paper-JW4A.40) <https://doi.org/10.1364/FIO.2017.JW4A.40>
127. "Analysis of silicon wafer surface preparation for heterojunction solar cells using X-ray photoelectron spectroscopy and effective minority carrier lifetime" Ugochukwu Nsofor, Lei Zhang, Anishkumar Soman, Christopher Goodwin, H. Liu, Kevin Dobson, Ujjwal Das and Steven Hegedus, *Solar Energy Mat. Solar Cell*, 2018, <https://doi.org/10.1016/j.solmat.2018.03.006>
128. "Electroluminescence Analysis for Spatial Characterization of Parasitic Optical Losses in Silicon Solar Cells", by Nuha Ahmed, Lei Zhang, Gowri Sriramagiri, Ujjwal Das, and Steven Hegedus, *Journal of Applied Physics* (March 2018) <https://doi.org/10.1063/1.5007048>
129. "Wafer Integrated Micro-Scale Concentrating Photovoltaics" Duanhui Li, Lan Li, Bradley Jared, Gordon Keeler, Bill Miller, Michael Wood, Christopher Hains, William Sweatt, Scott Paap, Michael Saavedra, Charles Alford, John Mudrick, Ujjwal Das, Steve Hegedus, Anna Tauke-Pedretti, Juejun Hu, Tian Gu, *Progress in Photovoltaics* (2018) <http://dx.doi.org/10.1002/pip.3034>
130. "Urban solar rooftop potential: Technical and economic analysis for rooftop solar generation in Wilmington and Newark Delaware" Soojin Shin, Nuha Ahmed, Nick Dinardo, Jing Xu, Dr. Steven Hegedus, Dr. Michael Chajes Dr. Job Taminiau, Dr. John Byrne; *Technical report prepared for the Delaware General Assembly* May 2018
131. "Improving the Interface Passivation of Si HJ Solar Cells by Interrupted Deposition of Thin a-Si:H Film" Ugo Nsofor, Anishkumar Soman, Ujjwal Das, Steve Hegedus, *Proc. 45th IEEE Photovoltaic Specialist Conf. Waikoloa HI, June 2018*.
132. "Effect of dielectric layers on laser-fired-contact performance in a-Si/c-Si heterojunction Solar Cells" Ujjwal Das, Christopher Thompson, Ugo Nsofor, Zeming Sun, Mool C. Gupta, and Steven Hegedus, *Proc. 45th IEEE Photovoltaic Specialist Conf. Waikoloa HI, June 2018*.
133. "Direct Laser Isolation For Interdigitated Back Contact Heterojunction Solar Cells" Zeming Sun, Ugo Nsofor, Nuha Ahmed, Ujjwal K. Das, Steven Hegedus, and Mool C. Gupta, *Proc. 45th IEEE Photovoltaic Specialist Conf. Waikoloa HI, June 2018*.
134. "Computation and assessment of solar electrolyzer field performance: comparing coupling strategies" Gowri M. Sriramagiri, Wesley Luc, Feng Jiao, Kathy Ayers, Kevin

- D. Dobson and Steven S. Hegedus, *Sustainable Energy and Fuels*, 2018, DOI: 10.1039/c8se00399h
135. “Correlation between in Situ Diagnostics of the Hydrogen Plasma and the Interface Passivation Quality of Hydrogen Plasma Post- Treated a-Si:H in Silicon Heterojunction Solar Cells” Anishkumar Soman, Ugochukwu Nsofor, Ujjwal Das, Tingyi Gu, and Steven Hegedus, *ACS Appl. Mater. Interfaces* 2019, 11, 16181–16190 DOI: 10.1021/acsami.9b01686
 136. “Direct Laser Patterned Electroplated Copper Contacts for Interdigitated Back Contact Silicon Solar Cells” Kevin D. Dobson, Zeming Sun, Ugochukwu Nsofor, Ujjwal Das, Arpan Sinha, Mool Gupta, and Steven S. Hegedus, *Proc. 46th IEEE Photovoltaic Specialist Conference Chicago* June 2019
 137. “a-Si:H/c-Si interface hydrogenation for implied Voc = 755 mV in Silicon heterojunction solar cells” Anishkumar Soman, Ugochukwu Nsofor, Ujjwal Das, Tingyi Gu, Steve Hegedus, *Proc. 46th IEEE Photovoltaic Specialist Conference Chicago* June 2019
 138. “Feasibility Study of City-Scale Solar Power Plants Using Public Buildings: Case Studies of Newark and Wilmington Delaware with Early Investigations of Bifacial Solar Modules and Dual Orientation Racking as Tools for City-Scale Solar Development.” Byrne, J., Nyangon, J., Hegedus, S., Chajes, M., Taminiau, J., Ahmed, N., Dinardo, N., Li, P., and Xu, J., *Technical report prepared for the Delaware General Assembly, June 2019*. DOI: 10.13140/RG.2.2.22115.40489/3
 139. “Feasibility and Design of Very Low Emission Smart Microgrids in DE: Sizing, Location, Cost, and Barriers” Dr. Steven Hegedus, *Technical report submitted to DE Natural Resources and Environmental Conservation (DNREC) Agency*, April 2019.
 140. "Electroluminescence Characterization of Recombination in Back Junction Silicon Heterojunction Test Structures: Role of Inversion Layers" N. Ahmed, L. Zhang, U. Das, Steven S. Hegedus, *IEEE J. Photovoltaics*, November 2019.
 141. “Policy and regulations for designing a Community Solar Market in Delaware” Joseph Nyangon, Pengyu Li, Karice Redhead and Nick DiNardo, Steven Hegedus, Job Taminiau, John Byrne, *Technical Report Prepared for the DE General Assembly* (2020).
 142. “Nanosecond Pulsed Laser Patterning of Interdigitated Back Contact Heterojunction Silicon Solar Cells” Arpan Sinha; Anishkumar Soman; Ujjwal Das; Steven Hegedus; Mool C. Gupta *IEEE Journal of Photovoltaics* (Volume: 10, Issue: 6, Nov. 2020) pp. 1648 – 1656 DOI: [10.1109/JPHOTOV.2020.3026907](https://doi.org/10.1109/JPHOTOV.2020.3026907)
 143. Sepúlveda-Mora, S. B. & Hegedus, S. (2021). “Making the Case for Time-of-Use Electric Rates to Boost the Value of Battery Storage in Commercial Buildings with Grid Connected PV Systems”. *Energy*, 218, 119447. <https://doi.org/10.1016/j.energy.2020.119447>
 144. Sepúlveda-Mora, S. B. & Hegedus, S. (2021). “Design of a Resilient and Eco-friendly Microgrid for a Commercial Building”. *Aibi Revista de Investigación, Administración e Ingeniería*, 9 (1), 8–18. <https://doi.org/10.15649/2346030x.919>
 145. Soman, A.; Silva-Quinones, D.; Hegedus, S.; Teplyakov, A.; Das, U. “Understanding the role of hydrogen plasma treatment and thermal annealing in improving the a-Si:H/ c-Si interface passivation”, MRS Fall, December 2021, Boston, USA (Control ID: 3615871)

146. S. Hegedus "Photovoltaic Test Bed for Characterization of Photovoltaic Modules" Final Report Submitted to Delaware Department of Natural Resources and Environmental Control, October 1, 2021
147. SB Sepúlveda-Mora, S Hegedus, [Resilience analysis of renewable microgrids for commercial buildings with different usage patterns and weather conditions](#) *Renewable Energy* 192, 731-744
148. T. Kaewnukultorn, S. B. Sepúlveda-Mora and S. Hegedus, "Characterization of Voltage Stabilization Functions of Residential PV Inverters in a Power Hardware-in-the-Loop Environment," in *IEEE Access*, vol. 10, pp. 114802-114813, 2022, doi: 10.1109/ACCESS.2022.3217472.
149. Kaewnukultorn T., Sepúlveda-Mora S. B., & Hegedus S. (2022). "Seasonal Dependence of Bi-facial Photovoltaic Array Gain due to Inverter Clipping". *49th IEEE Photovoltaic Specialists Conference (PVSC)*.
150. Soman, Anishkumar; Das, Ujjwal; Hegedus, Steven "Interface engineering by Intermediate Hydrogen Plasma treatment using dc-PECVD for silicon heterojunction solar cells" *ACS Appl. Electronic Materials*. 2023, Publication Date: January 24, 2023 <https://doi.org/10.1021/acsaelm.2c01336>
151. T. Kaewnukultorn, S. B. Sepúlveda-Mora, R. Broadwater, D. Zhu, N. G. Tsoutsos and S. Hegedus, "Smart PV Inverter Cyberattack Detection Using Hardware-in-the-Loop Test Facility," in *IEEE Access*, vol. 11, pp. 90766-90779, 2023, doi: 10.1109/ACCESS.2023.3308052.
152. Anishkumar Soman, Ujjwal K. Das, Nuha Ahmed, Arpan Sinha, Mool C. Gupta, Steven S. Hegedus, "Process-induced losses by plasma leakage in lithography-free shadow masked interdigitated back contact silicon heterojunction architectures" *ACS Materials Science in Semiconductor Processing*, Volume 166, 2023, 107762, ISSN 1369-8001, <https://doi.org/10.1016/j.mssp.2023.107762>.
153. Gbenga D. Obikoya, Anishkumar Soman, Ujjwal K. Das, Steven S. Hegedus, "Investigation into fill factor and open-circuit voltage degradations in silicon heterojunction solar cells under accelerated life testing at elevated temperatures" *Solar Energy Materials and Solar Cells*, Volume 263, 2023, 112586, <https://doi.org/10.1016/j.solmat.2023.112586>.

Papers in review

T. Kaewnukultorn, S. B. Sepúlveda-Mora, Ryan Purnell, Steven S. Hegedus "Inverter Clipping Effects on Bifacial Photovoltaic System and Utilization of Clipped Solar Power" submitted to *Progress in Photovoltaics* October 2023.