ZACHARY CHARLES HOLMAN

Assistant Professor

School of Electrical, Computer, and Energy Engineering
Arizona State University
Tempe, AZ 85287-5706

Phone: (480) 965-9959
Fax: (480) 965-3837
zachary.holman@asu.edu

APPOINTMENTS

10/2016–	**Trustees of ASU Professor** School of Electrical, Computer, and Energy Engineering, Arizona State University (Tempe, Arizona)
03/2013–	**Assistant Professor** School of Electrical, Computer, and Energy Engineering, Arizona State University (Tempe, Arizona)
07/2014–08/2014	**Visiting Professor** Photovoltaics and Thin-Film Electronics Laboratory, Institute of Microengineering, Ecole Polytechnique Fédérale de Lausanne (Neuchâtel, Switzerland)
10/2010–03/2013	**Postdoctoral Researcher** Photovoltaics and Thin-Film Electronics Laboratory, Institute of Microengineering, Ecole Polytechnique Fédérale de Lausanne (Neuchâtel, Switzerland)

EDUCATION

10/2010	**Doctor of Philosophy** Mechanical Engineering; Nanoparticle Science and Engineering (minor), University of Minnesota (Minneapolis, Minnesota) Dissertation: *Germanium nanocrystal solar cells*; Advisor: Prof. Uwe Kortshagen
05/2005	**Bachelor of Arts** Physics, Reed College (Portland, Oregon) Thesis: *Electron transport in amorphous silicon*; Advisor: Prof. John Essick

RESEARCH INTERESTS

Broad research interests span the fields of solar cells, nanotechnology, semiconductors, plasmas, and aerosols. Specific interests include silicon-based tandem solar cells, contacts to solar cells, light management in silicon solar cells, novel uses of nanoparticles in devices, semiconductor nanoparticles, optical and electronic properties of nanoscale materials, plasma synthesis of powders, and deposition of powders and thin films.

AWARDS & HONORS

2017	ASU Fulton Schools of Engineering Top 5% Teaching Award
2016	Trustees of ASU Professorship
2016	Joseph C. Palais Distinguished Faculty Scholar Award
2016	Fulton Outstanding Assistant Professor Award
2015	ASU Fulton Schools of Engineering Top 5% Teaching Award
2014	ASU Senior Sustainability Scientist
2013	3rd International Conference on Crystalline Silicon Photovoltaics top 5% of papers
2010	NSF EAPSI Fellowship at the Tokyo Institute of Technology
2010	University of Minnesota Doctoral Dissertation Fellowship

2008	Particle Society of Minnesota Scholarship
2007	18th International Symposium on Plasma Chemistry Best Paper Award
2005	NSF IGERT Fellowship at the University of Minnesota

AWARDS WON BY STUDENTS AND POSTDOCS

2017	MRS Graduate Student Silver Award (Jason Yu)
2017	Rice Business Plan Competition DOE Cleantech University Prize (Peter Firth and Jonathan Bryan)
2017	ASU Innovation Open SRP Innovation Award (Peter Firth)
2017	SiliconPV Award (Jason Yu)
2017	SiliconPV Award (Mathieu Boccard)
2017	ASU Graduate and Professional Student Association Research Award (Jason Yu)
2017	ThinkSwiss Research Scholarship (Nathan Rodkey)
2017	ARCS (Achievement Awards for College Scientists) Award (Peter Firth)
2017	Zero Mass Water Materials Award (Peter Firth)
2017	DOE Science Undergraduate Laboratory Internship at NREL (Nathan Rodkey)
2017	Rhodes Scholarship (Ngoni Mugwisi)
2016	Palais Senior Design Prize (Heliovation senior design team)
2016	Arizona Student Energy Conference Distinguished Poster Award (Jason Yu)
2016	IEEE Photovoltaic Specialists Conference Best Paper Award (Mathieu Boccard)
2016	IEEE Photovoltaic Specialists Conference Best Poster Award (Mathieu Boccard)
2016	ASU Dean's Fellowship (Will Weigand)
2016	ASU Dean's Fellowship (Jonathan Bryan)
2016	ASU New Venture Challenge Winner (Peter Firth)
2016	ARCS (Achievement Awards for College Scientists) Award (Peter Firth)
2016	Micron Technology Team Prize (Hall Effect senior design team)
2015	IEEE Photovoltaic Specialists Conference Best Poster Award (Jason Yu)
2015	Harold and Lucille Dunn Memorial Engineering Scholarship (Jason Yu)
2015	Barrett Electronic Materials Fellowship (Peter Firth)
2015	ASU Dean's Fellowship (Peter Firth)
2015	Arizona Student Energy Conference Distinguished Poster Award (Priyaranga Koswatta)
2015	NSF Graduate Research Fellowship (Joe Carpenter)
2014	NSF Integrative Graduate Education and Research Traineeship (Michael Bernstein)
2014	NSF Integrative Graduate Education and Research Traineeship (Joe Carpenter)
2014	University Graduate Fellowship (Salman Manzoor)

PROFESSIONAL ACTIVITIES & OUTREACH

- Co-leader of Thrust 2 of the Quantum Energy and Sustainable Solar Technology ERC
- Symposium Organizer for the 2017 EMRS Spring Meeting
- Symposium Organizer for the 2017 IEEE Photovoltaic Specialists Conference
- Lead Symposium Organizer for the 2016 MRS Spring Meeting
- Symposium Organizer for the 2016 IEEE Photovoltaic Specialists Conference

- Symposium Organizer for the 2015 MRS Spring Meeting
- Session Chair for IEEE Photovoltaic Specialists Conference, MRS Spring Meeting, SiliconPV
- Member of the ASU Goldwater Materials Science Facility Steering Committee
- Member of the ASU Leadership Academy Materials Team
- Member of the ASU University Undergraduates Standards Committee
- Member of the ASU Instrument Design and Fabrication Board
- Member of the ASU ECEE Faculty Search Committee in photovoltaics
- Member of the ASU ECEE Website Design Committee
- Designer and instructor of a new course entitled *EEE 598: Manuscript Writing for Engineers*
- Reviewer for funding bodies, including NSF, and journals, including *Journal of Applied Physics, ACS Nano, Solar Energy Materials and Solar Cells*, *Thin Solid Films, Nanotechnology, IEEE Journal of Photovoltaics*
- Volunteer Scientist for ASU's Night of The Open Door, ASU's Summer Transportation Institute, Cesar Chavez High School, Minnesota FIRST LEGO League, and the Science Museum of Minnesota

FUNDING

Awarded; pending	BAPVC, "Low capex solar manufacturing enabled by perovskite semiconductors," (Co-PI)
05/2017–04/2019	NSF EAGER, "Collaborative research: 30%-efficient, stable perovskite/silicon monolithic tandem solar cells," (PI)
02/2017–04/2017	NSF SBIR, "The aerosol-spray deposition of photoluminescent quantum-dot coatings on substrates," (Co-PI)
01/2017–12/2019	ARPA-E SHIELD, "Single-pane windows with insulating sprayed particulate coatings," (PI)
12/2016–11/2017	NSF SBIR, "Low damage sputter magnetron for silicon heterojunction PV production," (Co-PI)
11/2016–10/2018	DOE NextGen III, "Developing efficient silicon cells for perovskite/silicon tandem devices," (Co-PI)
09/2016–08/2017	American Jobs Project, "Arizona's advanced energy landscape," (PI)
08/2016–07/2019	DOE PVRD, "Monolithic silicon module manufacturing at < 0.40 $/W," (PI)
08/2016–07/2018	DOE PVRD, "15%-efficiency (Mg,Zn)CdTe solar cells with 1.7 eV bandgap for tandem applications," (PI)
08/2016–07/2017	SolarReserve, "Hybrid heliostat development," (PI)
07/2016–01/2017	FSE Technology Innovation Laboratory, "Advanced manufacturing of nanoparticle-based coatings," (PI)
06/2016–05/2017	DOE PVRD SIPS, "A new class of tandems: Optically coupled III-V/silicon module with outdoor efficiency exceeding 30%," (PI)
05/2016–11/2016	FSE Technology Innovation Laboratory, "Hybrid heliostat for combined photovoltaic and solar thermal power plants," (PI)
04/2016–03/2019	NSF REU Site, "Solar energy research for the Terawatt Challenge," (PI)

01/2016–12/2018	DOE SuNLaMP, "Overcoming bottlenecks to low-cost, high-efficiency Si PV and industrially relevant, ion implanted interdigitated back passivated contact cell development," (Co-PI)
09/2015–08/2018	NSF Energy for Sustainability, "Collaborative research: 30%-efficient III-V/silicon tandem solar cells," (PI)
06/2015–05/2020	USAID, "U.S.-Pakistan Centers for Advanced Studies in Energy," (Co-PI)
05/2015–04/2016	ARPA-E I-Corps Supplement, "PVMirror: Cost competitive solar with storage," (PI)
02/2015–01/2017	RCSA Scialog, "Scalable tandem architecture for solar water splitting," (PI)
06/2014–05/2017	ARPA-E FOCUS, "PVMirror: A solar concentrator mirror incorporating PV cells," (PI)
09/2013–08/2016	DOE FPACE-II, "Thin silicon solar cells: A path to 35% Shockley-Queisser limits," (Co-PI)
08/2011–07/2021	NSF/DOE ERC, "Quantum Energy and Sustainable Solar Technologies: QESST," (Co-PI)
06/2010–08/2010	NSF EAPSI, "Novel solar cells using silicon nanocrystals synthesized in an atmospheric-pressure plasma," (PI)

STUDENTS ADVISED

- Ph.D.:
  - Jonathan Bryan (2016–)
  - Peter Firth (2015–)
  - Salman Manzoor (2014–)
  - Will Weigand (2016–)
  - Joe Carpenter (2014–)
  - Mehdi Leilaeioun (2013–)
  - Jianwei Shi (2013–)
  - Jason Yu (2014–)
- M.S.:
  - Michael Bernstein (2014–2016)
  - Peter Firth (2014–2015)
  - Alec Jackson (2014–2016)
  - Salman Manzoor (2013–2014)
  - Prateek Garg (2013–2015)
  - Trent Hoffman (2016–)
  - Priyaranga Koswatta (2013–2016)
- Undergraduate:
  - Ethan Bendau (2015; REU)
  - Emily Dafflon (2013)
  - William Firth (2015; REU)
  - Ngoni Mugwisi (2016–2017; Barrett's)
  - Nathan Rodkey (2015– ; FURI, Barrett's)
  - Nicholas Scheenstra (2015–2016; FURI)
  - Joe Carpenter (2013–2014; FURI)
  - Angelo Delluomo (2015–2016; FURI)
  - Sanketh Kamath (2014–2015; FURI)
  - Marcial Rodarte (2016–)
  - Kari Sanford (2015– ; FURI, Barrett's)
  - Marshall Styers (2015–2016)
- PCASE visitors:
  - Saleem Ahmed (2016)
  - Asad Ali (2016)
  - Waqar Ali (2016)
  - Mahmood Jamil (2016)
  - Maoz Maoz (2017)
  - Shah Naveed (2017)
  - Syeda Qudsia (2016)
  - Asma Shamim (2017)
  - Maham Akhlaq (2017)
  - Asghar Ali (2016)
  - Ijaz Husnain (2016)
  - Mehwish Javed (2016)
  - Warda Mushtaq (2016)
  - Farah Qazi (2016)
  - Hira Rehman (2017)

COURSES TAUGHT

- EEE 352: Properties of Electronic Materials (F15, F16)
- EEE 436/591: Fundamentals of Solid State Devices (F13, F14, S16)

- EEE 465/591: Photovoltaic Energy Conversion (S15)
- EEE 498/591: Solar Energy (S14)
- EEE 536: Semiconductor Characterization (S17)
- EEE 598: Manuscript Writing for Engineers (F14, F15)
- ASU 101: The ASU Experience (F14)

PEER-REVIEWED PUBLICATIONS

(ASU students in red; ASU postdocs and staff in orange)

47. S. Manzoor, Z. Yu, A. Ali, W. Ali, K. Bush, A. Palmstrom, S. Bent, M. McGehee, and Z. Holman "Improved light management in planar silicon and perovskite solar cells using PDMS scattering layer," (under review).

46. J. Becker, C. Campbell, Y. Zhao, M. Lassise, X.-H. Zhao, M. Boccard, Z. Holman, and Y.-H. Zhang "11.2%-efficient monocrystalline $Mg_{0.13}Cd_{0.87}Te$ solar cell with 1.7-eV bandgap," (under review).

45. M. Vaisman, K. Nay Yaung, E. Perl, D. Martín-Martín, Z. Yu, M. Leilaeioun, Z. Holman, and M. Lee "15.3%-efficient GaAsP top cells for high-efficiency, low-cost III-V/Si tandem photovoltaics," (under review).

44. M. Boccard, P. Firth, Z. Yu, K. Fisher, M. Leilaeioun, S. Manzoor, and Z. Holman "Low-refractive-index nanoparticle interlayers to reduce parasitic absorption in metallic rear reflectors of solar cells," (under review).

43. J. Carpenter, M. Bailly, A. Boley, J. Shi, M. Minjares, D. Smith, S. Bowden, and Z. Holman "Substrate-independent analysis of microcrystalline silicon thin films using UV Raman spectroscopy," (under review).

42. R. Saive, M. Boccard, T. Saenz, S. Yalamanchili, C. Bukowsky, P. Jahelka, Z. Yu, J. Shi, Z. Holman, and H. Atwater "Silicon heterojunction solar cells with effectively transparent front contacts," *Sust. Energy Fuels* DOI: 10.1039/C7SE00096K (2017).

41. C. Zhang, L. Ding, M. Boccard, T. Nærland, N. Faleev, S. Bowden, Z. Holman, M. Bertoni, and C. Honsberg "Practical approaches to mitigate minority-carrier lifetime degradation in Si wafers for III-V/Si integration," (under review).

40. J. Becker, M. Boccard, C. Campbell, Y. Zhao, M. Lassise, Z. Holman, and Y.-H. Zhang "Loss analysis of monocrystalline CdTe solar cells with 20% active-area efficiency," *IEEE J. Photovoltaics* **7**, 900–905 (2017).

39. K. Bush*, A. Palmstrom*, Z. Yu*, M. Boccard, R. Cheacharoen, J. Mailoa, D. McMeekin, R. Hoye, C. Bailie, T. Leijtens, I. Peters, M. Minichetti, N. Rolston, R. Prasanna, S. Sofia, D. Harwood, W. Ma, F. Moghadam, H. Snaith, T. Buonassisi, Z. Holman, S. Bent, and M. McGehee, "23.6%-efficient monolithic perovskite/silicon tandem solar cells with improved stability," *Nature Energy* **2**, 17009 (2017). * Denotes co-first author.

38. J. Becker, C. Campbell, Y. Zhao, M. Boccard, D. Mohanty, M. Lassise, E. Suarez, I. Bhat, Z. Holman, and Y.-H. Zhang "Monocrystalline CdTe/MgCdTe double-heterostructure solar cells with ZnTe hole contact," *IEEE J. Photovoltaics* **7**, 307–312 (2017).

37. M. Leilaeioun and Z. Holman, "Accuracy of expressions for the fill factor of a solar cell in terms of its open-circuit voltage and ideality factor," *J. Appl. Phys.* **120**, 123111 (2016).

36. Z. Yu, M. Leilaeioun, and Z. Holman, "Selecting tandem partners for silicon solar cells using spectral efficiency," *Nature Energy* **1**, 16137 (2016).

35. Z.-Y. He, C. Campbell, M. Lassise, Z.-Y. Lin, J. Becker, Y. Zhao, M. Boccard, Z. Holman, and Y.-H. Zhang, "CdTe nBn photodetectors with ZnTe barrier layer grown on InSb substrates," *Appl. Phys. Lett.* **109**, 121112 (2016).

34. S. Vorndran, B. Chrysler, B. Wheelwright, R. Angel, Z. Holman, and R. Kostuk, "Off-axis holographic lens spectrum splitting system for direct and diffuse solar energy conversion," *Appl. Opt.* **55**, 7522–7529 (2016).

33. B. Chen, Y. Bai, Z. Yu, T. Li, X. Zheng, Q. Dong, M. Boccard, A. Gruverman, Z. Holman, and J. Huang, "Efficient semi-transparent perovskite solar cells for 23%-efficiency perovskite/silicon four-terminal tandem cells," *Adv. Energy Mat*. 1601128 (2016).

32. J. Shi, M. Boccard, and Z. Holman, "Plasma-initiated rehydrogenation of amorphous silicon to increase the temperature processing window of silicon heterojunction solar cells," *Appl. Phys. Lett.* **109**, 031601 (2016).

31. Z. Yu, B. Wheelwright, S. Manzoor, and Z. Holman, "Silicon wafers with optically specular surfaces formed by chemical polishing," *J. Mater. Sci. Mater. Electron.* DOI: 10.1007/s10854-016-5108-y (2016).

30. Y. Zhao, M. Boccard, S. Liu, J. Becker, X.-H. Zhao, C. Campbell, E. Suarez, M. Lassise, Z. Holman, and Y.-H. Zhang, "Monocrystalline CdTe solar cells with open-circuit voltage over 1 V and efficiency of 17%," *Nature Energy* **1**, 16067 (2016).

29. M. Boccard and Z. Holman, "Amorphous silicon carbide passivating layers for crystalline-silicon-based heterojunction solar cells," *J. Appl. Phys.* **118**, 065704 (2015).

28. Z. Yu, K. Fisher, B. Wheelwright, R. Angel, and Z. Holman, "PVMirror: A new concept for tandem solar cells and hybrid solar converters," *IEEE J. Photovoltaics* **5**, 1791–1799 (2015). [Most downloaded paper in *IEEE J. Photovoltaics* in January and February, 2016.]

27. B. Terheiden, T. Ballmann, R. Horbelt, Y. Schiele, S. Seren, J. Ebser, G. Hahn, V. Mertens, M. Koentopp, M. Scherff, J. Müller, Z. Holman, A. Descoeudres, S. De Wolf, S. Martin de Nicolas, J. Geissbuehler, C. Ballif, B. Weber, P. Saint-Cast, M. Rauer, C. Schmiga, S. Glunz, D. Morrison, S. Devenport, D. Antonelli, C. Busto, F. Grasso, F. Ferrazza, E. Tonelli, and W. Oswald, "Manufacturing 100-µm-thick silicon solar cells with efficiencies greater than 20% in a pilot production line," *Phys. Status Solidi A* **212**, 13–24 (2015).

26. J. Seif, A. Descoeudres, M. Filipič, F. Smole, M. Topič, Z. Holman, S. De Wolf, and C. Ballif, "Amorphous silicon oxide window layers for high-efficiency silicon heterojunction solar cells," *J. Appl. Phys.* **115**, 024502 (2014). [Highlighted by *J. Appl. Phys.* as part of the journal's celebration of the International Year of Light.]

25. M. Deceglie, H. Emmer, Z. Holman, A. Descoeudres, S. De Wolf, C. Ballif, and H. Atwater, "Scanning laser-beam-induced current measurements of lateral transport near junction defects in silicon heterojunction solar cells," *IEEE J. Photovoltaics* **4**, 154–159 (2014).

24. Z. Holman, M. Filipič, B. Lipovšek, S. De Wolf, F. Smole, M. Topič, and C. Ballif, "Parasitic absorption in the rear reflectors of silicon solar cells: Simulation and measurement of the sub-bandgap reflectance for common dielectric/metal reflectors," *Sol. Energy Mater. Sol. Cells* **120**, 426-430 (2014).

23. Z. Holman, A. Descoeudres, S. De Wolf, and C. Ballif, "Record infrared internal quantum efficiency in silicon heterojunction solar cells with dielectric/metal rear reflectors," *IEEE J. Photovoltaics* **3**, 1243–1249 (2013).

22. M. Filipič, Z. Holman, F. Smole, S. De Wolf, C. Ballif, and M. Topič, "Analysis of lateral transport through inversion layer in amorphous silicon/crystalline silicon heterojunction solar cells," *J. Appl. Phys.* **114**, 074504 (2013).

21. Z. Holman, S. De Wolf, and C. Ballif, "Improving metal reflectors by suppressing surface plasmon polaritons: *A priori* calculation of the internal reflectance of a solar cell," *Light: Science & Applications* **2**, e106 (2013).

20. L. Barraud, Z. Holman, N. Badel, P. Reiss, A. Descoeudres, C. Battaglia, S. De Wolf, and C. Ballif, "Hydrogen-doped indium oxide/indium tin oxide bilayers for high-efficiency silicon heterojunction solar cells," *Sol. Energy Mater. Sol. Cells* **115**, 151–156 (2013).

19. Z. Holman, M. Filipič, A. Descoeudres, S. De Wolf, F. Smole, M. Topič, and C. Ballif, "Infrared light management in high-efficiency silicon heterojunction and rear-passivated solar cells," *J. Appl. Phys.* **113**, 013107 (2013). [Highlighted by *J. Appl. Phys.* as part of the journal's celebration of the International Year of Light.]

18. A. Descoeudres, Z. Holman, L. Barraud, S. Morel, S. De Wolf, and C. Ballif, ">21% efficient silicon heterojunction solar cells on n- and p-type wafers compared," *IEEE J. Photovoltaics* **3**, 83–89 (2013).

17. B. Demaurex, S. De Wolf, A. Descoeudres, Z. Holman, and C. Ballif, "Damage at hydrogenated amorphous/crystalline silicon interfaces by indium tin oxide overlayer sputtering," *Appl. Phys. Lett.* **101**, 171604 (2012).

16. R. Anthony, K.-Y. Cheng, Z. Holman, R. Holmes, and U. Kortshagen, "An all-gas-phase approach for the fabrication of silicon nanocrystal light-emitting devices" *Nano Lett.* **12**, 2822–2825 (2012).

15. Z. Holman and U. Kortshagen, "Absolute absorption cross sections of ligand-free colloidal germanium nanocrystals," *Appl. Phys. Lett.* **100**, 133108 (2012).

14. S. De Wolf, A. Descoeudres, Z. Holman, and C. Ballif, "High-efficiency silicon heterojunction solar cells: A review," *Green* **2**, 7–24 (2012).

13. Z. Holman, A. Descoeudres, L. Barraud, F. Zicarelli, J. Seif, S. De Wolf, and C. Ballif, "Current losses at the front of silicon heterojunction solar cells," *IEEE J. Photovoltaics* **2**, 7–15 (2012).

12. A. Descoeudres, L. Barraud, S. De Wolf, B. Strahm, D. Lachenal, C. Guerin, Z. Holman, F. Zicarelli, B. Demaurex, J. Seif, J. Holovsky, and C. Ballif, "Improved amorphous/crystalline silicon interface passivation by hydrogen plasma treatment," *Appl. Phys. Lett.* **99**, 123506 (2011).

11. Z. Holman and U. Kortshagen, "Nanocrystal inks without ligands: Stable colloids of bare germanium nanocrystals," *Nano Lett.* **11**, 2133–2136 (2011).

10. Z. Holman and U. Kortshagen, "Plasma production of nanodevice-grade semiconductor nanocrystals," *J. Phys. D* **44**, 174009 (2011).

9. Z. Holman and U. Kortshagen, "Quantum confinement in germanium nanocrystal thin films," *Phys. Status Solidi RRL* **5**, 110–112 (2011).

8. Z. Holman and U. Kortshagen, "A flexible method for depositing dense nanocrystal thin films: Impaction of germanium nanocrystals," *Nanotechnology* **21**, 335302 (2010).

7. Z. Holman, C.-Y. Liu, and U. Kortshagen, "Germanium and silicon nanocrystal thin-film field-effect transistors from solution," *Nano Lett.* **10**, 2661–2666 (2010).

6. C.-Y. Liu, Z. Holman, and U. Kortshagen, "Optimization of Si NC/P3HT hybrid solar cells," *Adv. Funct. Mat.* **20**, 2157–2164 (2010).
5. Z. Holman and U. Kortshagen, "Solution-processed germanium nanocrystal thin films as materials for low-cost optical and electronic devices," *Langmuir* **25**, 11883–11889 (2009).
4. C.-Y. Liu, Z. Holman, and U. Kortshagen, "Hybrid solar cells from P3HT and silicon nanocrystals," *Nano Lett.* **9**, 449–452 (2009).
3. U. Kortshagen, R. Gresback, Z. Holman, R. Ligman, C.-Y. Liu, L. Mangolini, and S. Campbell, "Plasma synthesis of group IV quantum dots for luminescence and photovoltaic applications," *Pure Appl. Chem.* **80**, 1901–1908 (2008).
2. R. Gresback, Z. Holman, and U. Kortshagen, "Nonthermal plasma synthesis of size-controlled, monodisperse, freestanding germanium nanocrystals," *Appl. Phys. Lett.* **91**, 093119 (2007).
1. A. LaLonde, M. Norton, D. McIlroy, D. Zhang, R. Padmanabhan, A. Alkhateeb, H. Han, N. Lane, and Z. Holman, "Metal coatings on SiC nanowires by plasma-enhanced chemical vapor deposition," *J. Mater. Res.* **20**, 549–553 (2005).

PATENTS

(ASU students in red; ASU postdocs and staff in orange)

5. Z. Holman, X. Meng, and K. Fisher, "Wavelength-selective specularly reflecting photovoltaic module and manufacture thereof," Serial No. 62/377,892, provisional application filed August 22, 2016.
4. Z. Holman and P. Firth, "Systems and method for large scale spray deposition of particulate coatings," Serial No. 62/344,283, provisional application filed June 1, 2016.
3. Y.-H. Zhang, Y. Zhao, M. Boccard, and Z. Holman, "Heterostructure solar cells and photodetectors based on CdTe," Serial No. --, provisional application filed March 31, 2016.
2. R. Angel, R. Kostuk, Z. Holman, and B. Wheelwright, "Tandem photovoltaic module with diffractive spectral separation," Serial No. 62/175,051, provisional application filed June 12, 2015.
1. Z. Holman, R. Angel, and B. Wheelwright, "System and method for manipulating solar energy," International Publication No. WO 2015/117134 A1, application filed February 3, 2015.

BOOK CHAPTERS

(ASU students in red; ASU postdocs and staff in orange)

2. Z. Holman and M. Boccard, "Light management in silicon solar cells," in *Photovoltaics: From fundamentals to applications*, edited by A. Reinders, P. Verlinden, W. van Sark, and A. Freundlich, Wiley (2017).
1. C. Ballif, S. De Wolf, A. Descoeudres, and Z. Holman, "Amorphous silicon/crystalline silicon heterojunction solar cells," in *Advances in Photovoltaics: Part 3*, edited by G. Willeke and E. Weber, Burlington: Academic Press (2014).

CONFERENCE PUBLICATIONS

(ASU students in red; ASU postdocs and staff in orange)

34. Z. Holman, K. Fisher, M. Jordan, T. Thornton, J. Husman, C. Honsberg, and T. Rowlands, "REU Site: Solar energy research for the Terawatt Challenge," *ASEE* (2016)

33. K. Fisher, Z. Yu, R. Stirling, and Z. Holman, "PVMirrors: Hybrid PV/CSP collectors that enable lower LCOEs," *SolarPACES* (2016).

32. Y. Zhao, M. Boccard, J. Becker, X.-H. Zhao, C. Campbell, E. Suarez, Z. Holman, and Y.-H. Zhang, "Monocrystalline CdTe / MgCdTe double-heterostructure solar cells with 1.122 V V_{oc} and 18.3% efficiency," *43rd IEEE PVSC Proc.* (2016).

31. C. Zhang, N. Faleev, L. Ding, M. Boccard, M. Bertoni, Z. Holman, R. King, and C. Honsberg, "Hetero-emitter GaP/Si solar cells with high Si bulk lifetime," *43rd IEEE PVSC Proc.* (2016).

30. S. Manzoor, M. Filipič, M. Topič, and Z. Holman, "Revisiting light trapping in silicon solar cells with random pyramids," *43rd IEEE PVSC Proc.* (2016).

29. M. Leilaeioun, Z. Yu, and Z. Holman, "Optimization of front TCO layer of silicon heterojunction solar cells for tandem applications," *43rd IEEE PVSC Proc.* (2016).

28. Z. Yu, K. Fisher, and Z. Holman, "Modeling of GaAs/silicon PVMirror tandem system: A case study," *43rd IEEE PVSC Proc.* (2016).

27. M. Boccard, A. Jackson, and Z. Holman, "Crystalline silicon passivation with amorphous silicon carbide layers," *43rd IEEE PVSC Proc.* (2016).

26. M. Boccard, X. Yang, K. Weber, and Z. Holman, "Passivation and carrier selectivity of TiO_2 contacts in silicon solar cells when combined with different passivation layers and electrodes," *43rd IEEE PVSC Proc.* (2016).

25. M. Boccard, N. Rodkey, and Z. Holman, "Properties of hydrogenated indium oxide prepared by reactive sputtering with hydrogen gas," *43rd IEEE PVSC Proc.* (2016).

24. C. Campbell, Y. Zhao, E. Suarez, M. Boccard, X.-H. Zhao, Z.-Y. He, P. Webster, M. Lassise, S. Johnson, Z. Holman, and Y.-H. Zhang, "1.7 eV MgCdTe double-heterostructure solar cells for tandem device applications," *43rd IEEE PVSC Proc.* (2016).

23. R. Saive, C. Bukowsky, S. Yalamanchili, M. Boccard, T. Saenz, A. Borsuk, Z. Holman, and H. Atwater, "Effectively transparent contacts for silicon heterojunction solar cells," *43rd IEEE PVSC Proc.* (2016).

22. M. Boccard, N. Rodkey, and Z. Holman, "High-mobility hydrogenated indium oxide without introducing water during sputtering," *6th SiliconPV Proc.* (2016).

21. Z. Yu, K. Fisher, and Z. Holman, "Evaluation of spectrum-splitting dichroic mirrors for PVMirror tandem solar cells," *42nd IEEE PVSC Proc.* (2015).

20. M. Leilaeioun and Z. Holman, "A new expression for intrinsic fill factor of silicon solar cells," *42nd IEEE PVSC Proc.* (2015).

19. M. Boccard, L. Ding, P. Koswatta, M. Bertoni, and Z. Holman, "Evaluation of metal oxides prepared by reactive sputtering as carrier-selective contacts for crystalline silicon solar cells," *42nd IEEE PVSC Proc.* (2015).

18. P. Koswatta, M. Boccard, and Z. Holman, "Carrier-selective contacts in silicon solar cells," *42nd IEEE PVSC Proc.* (2015).

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