

David P. Fenning

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Professional Preparation

Massachusetts Institute of Technology, Mechanical Engineering, Ph. D.	2013
Massachusetts Institute of Technology, Mechanical Engineering, M.S.	2010
Stanford University, Mechanical Engineering, B.S.	2008

Research & Professional Experience

Assistant Professor, Nanoengineering Department, UC San Diego	2015-
MIT/Battelle Postdoc, Electrochemical Energy Lab	2013-2015
R&D consultant, 1366 Technologies, Bedford, MA	2013
Graduate Research Assistant, PV Lab, MIT	2008-2013
Research Assistant, Microfluidics Laboratory, Stanford	2007-2008

Research Interests

Defect engineering in materials for energy conversion and storage, focused on low-cost photovoltaics, photoelectrochemistry, and hybrid photovoltaic-electrochemical systems. Current research includes high-efficiency silicon solar cells, emerging perovskite solar cell materials, CO₂ electrocatalysis, and solar fuels. Emphasis on quantifying defect and reaction kinetics, synchrotron-based X-ray chemical characterization, including *in situ* synchrotron-based measurements of semiconductors, catalysts, and electrode interfaces, and development of predictive modeling of material processing.

Honors and Awards

Portland Cement Association Fellowship Mentor, PhD mentee Yanqi Luo, 2016
UC Carbon Neutrality Initiative fellowship Mentor, PhD mentee Yanqi Luo, 2015
ACS PRF Doctoral New Investigator Award, 2015
MIT/Battelle Postdoctoral Associate Program, 2013
IEEE Photovoltaics Specialist Conference Student Award Finalist, 2013
MIT de Florez Graduate Design Award, 2012
Martin Family Fellow for Sustainability, MIT, 2011

NSF Graduate Research Fellowship, 2008
MIT Presidential Fellowship, 2008
Terman Engineering Scholastic Award, Stanford University, 2008
Tau Beta Pi Engineering Honor Society, 2007

Professional Activities

Service

IEEE Photovoltaics Specialist Conference
Co-Chair, Area 4.2: Junction Formation, 2016
Reviewer, Area 4: Crystalline Silicon Photovoltaics, 2012
NREL Workshop on Crystalline Silicon Solar Cells & Modules
Co-Chair, Characterization Discussion, 2015
Contributor to APS-U beamline concept white paper, *PtychoProbe* (2016)
Center for Integrated Nanotechnologies Proposal Reviewer, Sandia National Laboratories (2015-)
Peer Review: ACS Applied Materials & Interfaces, AIP Advances, Chemistry of Materials, Energy Reports, Frontiers in Energy, J. Applied Physics, J. Materials Chemistry A, J. Materials & Design, J. Materials Research, J. Power Sources, IEEE J. Photovoltaics, Materials, NPG Asia Materials, Nano Energy, Physica Status Solidi Rapid Research Letters, Physica Status Solidi (a), Physica Status Solidi (b), Physica Status Solidi (c), Materials Science & Engineering B
Member Materials Research Society, American Chemical Society

Mentorship

Research (current) 2 Graduate Student Researchers, 1 Postdoctoral Researcher, 1 Staff, 8 Undergraduate Researchers
Dissertation Committee Member Kasra Sardashti (Chemistry), Erick Martinez (Nanoengineering), Serdar Yavuz (Materials Science)
Founding Faculty Advisor Energy Club @ UCSD, 2015-
Mentor Assistance Program Local High-Schooler Mentor, 2015-
Engineering Resident Tutor, Dunster House, Harvard University, 2011-2015

Teaching

CENG101A Introductory Fluid Mechanics, F15
NANO203 Synthesis & Characterization of Nanomaterials, W16
NANO120B Nanoengineering Systems Design II, S16
CENG176B Chemical Engineering Process Laboratory II, S16

Patents

“Peristaltic pump with constrictions at fixed locations,” Patent No. 8,382,460, issued 2/26/13.

Peer-Reviewed Journal Publications

9. L. Kornblum*, **D. P. Fenning***, J. Faucher, J. Hwang, A. Boni, M. G. Han, M. D. Morales-Acosta, Y. Zhu, E. I. Altman, M. L. Lee, C. H. Ahn, F. J. Walker*, Y. Shao-Horn*, “Catalyst-free Solar Hydrogen Production at Neutral pH,” *submitted*, 2015. *equal contributions
8. M. Stuckelberger, T. Nietzold, G. N. Hall, B. West, J. Werner, B. Niesen, C. Ballif, V. Rose, D. P. Fenning, M. I. Bertoni, “Elemental Distribution and Charge Collection at the Nanoscale in Perovskite Solar Cells,” *IEEE Journal of Photovoltaics*, *submitted*, 2016.
7. Y. Luo, S. Gamliel, S. Nijem, M. Holt, B. Stripe, V. Rose, M. I. Bertoni, L. Etgar, **D. P. Fenning**, “[Spatially Heterogeneous Chlorine Incorporation in Perovskite Solar Cells](#),” *Chemistry of Materials*, 28 (18), 6526-6543, 2016.
6. J. B. Chou, X.-H. Li, Y. Wang, **D. P. Fenning**, A. Elfaer, J. Viegas, M. Jouiad, Y. Shao-Horn, S.-G. Kim, “[Surface Plasmon Assisted Hot Electron Collection in Wafer-Scale Metallic-Semiconductor Photonic Crystal](#),” *Optics Express*, 24(18), A1234-A1244 (2016).
5. S. Bernardis, S. C. Fakra, E. Dal Martello, R. B. Larsen, B. K. Newman, **D. P. Fenning**, M. Di Sabatino, T. Buonassisi, “[X-ray microprobe investigation of iron during a simulated silicon feedstock extraction process](#),” *Metallurgical and Materials Transactions B*, doi:10.1007/s11663-016-0795-6, 2016.
4. H. Laine, V. Vähänissi, A. E. Morishige, J. Hofstetter, A. Haarahiltunen, B. Lai, H. Savin, **D. P. Fenning**, “[Impact of Iron Precipitation on Phosphorus-Implanted Silicon Solar Cells](#),” *IEEE Journal of Photovoltaics*, 6(5), 1094-1102, 2016.
3. A. E. Morishige, M. A. Jensen, J. Hofstetter, P. X. T. Yen, C. Wang, B. Lai, **D. P. Fenning**, T. Buonassisi, “[Synchrotron-based investigation of transition-metal getterability in n-type multicrystalline silicon](#),” *Applied Physics Letters*, 108, 202104, 2016.
2. M. Gauthier, T. J. Carney, A. Grimaud, L. Giordano, N. Pour, H.-H. Chang, **D. P. Fenning**, S. Lux, O. Pachos, F. Maglia, S. Lupart, P. Lamp, Y. Shao-Horn, “[The Electrode-Electrolyte Interface in Li-ion Batteries: Current Understanding and New Insights](#),” *Journal of Physical Chemistry Letters*, **6**, 4653-4672, 2015.

1. M. A. Jensen, J. Hofstetter, A. E. Morishige, G. Coletti, B. Lai, **D. P. Fenning**, T. Buonassisi, “[Synchrotron-based analysis of chromium distributions in multicrystalline silicon for solar cells,](#)” *Applied Physics Letters*, **106**, 202104, 2015.
23. K. J. May, **D. P. Fenning**, T. Ming, W. T. Hong, D. Lee, K. A. Stoerzinger, M. D. Biegalski, A. M. Kolpak, Y. Shao-Horn, “[Thickness-Dependent Photoelectrochemical Water-Splitting on Ultra-Thin LaFeO₃ Films Grown on Nb:SrTiO₃,](#)” *Journal of Physical Chemistry Letters*, **6** (6), 977, 2015.
22. J. Hofstetter, **D. P. Fenning**, D. M. Powell, A. E. Morishige, and T. Buonassisi, “[Sorting metrics for customized phosphorus diffusion gettering,](#)” *IEEE Journal of Photovoltaics*, **4**(6), 1421, 2014.
21. **D. P. Fenning**, J. Hofstetter, A. E. Morishige, D. M. Powell, A. S. Zuschlag, G. Hahn, T. Buonassisi. “[Darwin at High Temperature: Advancing Solar Cell Material Design through Defect Kinetics Simulation and Evolutionary Optimization,](#)” *Advanced Energy Materials*, **4**(13), 1400459 (2014).
20. **D. P. Fenning**, A. S. Zuschlag, A. Frey, J. Hofstetter, M. I. Bertoni, G. Hahn, T. Buonassisi. “[Investigation of Lifetime-Limiting Defects After High-Temperature Phosphorus Diffusion in Silicon Solar Cell Materials,](#)” *IEEE Journal of Photovoltaics*, **4**(3), pp. 866-873 (2014).
19. J. Hofstetter, **D. P. Fenning**, D. M. Powell, A. E. Morishige, and T. Buonassisi, “[Iron Management in Multicrystalline Silicon through Predictive Simulation: Point Defects, Precipitates, and Structural Defect Interactions,](#)” *Solid State Phenomena*, **205-206**, pp.15-25 (2014).
18. D. M. Powell, J. Hofstetter, **D. P. Fenning**, R. Hao, T. S. Ravi, T. Buonassisi “[Effective lifetimes exceeding 300 microseconds in thin p-type epitaxial kerfless silicon for photovoltaics achieved via defect engineering,](#)” *Applied Physics Letters*, **103**, 263902, (2013).
17. **D. P. Fenning***, Annika Zuschlag*, M. I. Bertoni, B. Lai, G. Hahn, T. Buonassisi. “[Improved Iron Gettering in Contaminated Multicrystalline Silicon by High-Temperature Phosphorus Diffusion,](#)” *Journal of Applied Physics*, **113**, 214504 (2013). *equal contributions
16. J. Lindroos, **D. P. Fenning**, D. Backlund, E. Verlage, A. Gorgulla, S. K. Estreicher, H. Savin, T. Buonassisi. “[Nickel: A Very Fast Diffuser in Silicon,](#)” *Journal of Applied Physics*, **113**, 204906 (2013).
15. **D. P. Fenning**, B. K. Newman, M. I. Bertoni, S. Hudelson, S. Bernardis, M. A. Marcus, S. C. Fakra, T. Buonassisi, “[Local Melting in Silicon Driven By Retrograde Solubility,](#)” *Acta Materialia*, **61**(12), 4320 (2013).

14. **D. P. Fenning**, J. Hofstetter, M. I. Bertoni, G. Coletti, B. Lai, C. del Cañizo, T. Buonassisi. “[Precipitated Iron: A Limit on Gettering Efficacy in Multicrystalline Silicon](#),” *Journal of Applied Physics*, **113**, 044251 (2013).
13. H. J. Choi, M. I. Bertoni, J. Hofstetter, **D. P. Fenning**, D. M. Powell, S. Castellanos, T. Buonassisi, “[Dislocation density reduction during impurity gettering in multicrystalline silicon](#),” *IEEE Journal of Photovoltaics*, **3** (1), pp 189-198, (2013).
12. J. Schön, A. Haarahiltunen, H. Savin, **D. P. Fenning**, T. Buonassisi, W. Warta, and M. C. Schubert, “[Analysis of the Evolution of Iron Precipitates in Multicrystalline Silicon During Solar Cell Processing](#),” *IEEE Journal of Photovoltaics*, **3** (1), pp 131-137 (2013).
11. J. Hofstetter, **D. P. Fenning**, J.F. Lelièvre, C. del Cañizo, and T. Buonassisi, “[Engineering Metal Precipitate Size Distributions to Enhance Gettering in Multicrystalline](#),” *Phys. Status Solidi (a)*, **209** (10), pp 1861-1865, (2012).
10. S. Bernardis, B. K. Newman, M. Di Sabatino, M. I. Bertoni, **D. P. Fenning**, S. C. Fakra, R. B. Larsen, and T. Buonassisi. “[Synchrotron-based Investigation of Impurities in Raw Quartz- and Carbon-Bearing Feedstock Materials for Photovoltaic Applications](#),” *Prog. Photovolt.: Res. App.*, **20**, 217-225, (2012).
9. J. Hofstetter, J.F. Lelièvre, **D. P. Fenning**, M.I. Bertoni, T. Buonassisi, and C. del Cañizo. “[Towards the tailoring of P diffusion gettering to as-grown silicon material properties](#),” *Solid State Phenomena*, **178-179**, pp. 158-165 (2011).
8. M. I. Bertoni, **D. P. Fenning**, M. Rinio, J. Maser, T. Buonassisi. “[Nanoprobe X-ray Fluorescence Characterization of Defects in Large-Area Solar Cells](#),” *Energy and Environmental Science*, **4**, pp. 4252-4257, 2011.
7. J. Hofstetter, J. F. Lelièvre, **D. P. Fenning**, M.I. Bertoni, T. Buonassisi, A. Luque, C. del Cañizo, “[Enhanced iron gettering by short, optimized low-temperature annealing after phosphorus emitter diffusion for industrial silicon solar cell processing](#),” *Physica Status Solidi c*, **8** (3), pp. 759-972, (2011).
6. **D. P. Fenning**, J. Hofstetter, M. I. Bertoni, S. Hudelson, M. Rinio, J. F. Lelièvre, B. Lai, C. del Cañizo, and T. Buonassisi. “[Iron Distribution in Silicon After Solar Cell Processing: Synchrotron Analysis and Predictive Modeling](#),” *Applied Physics Letters*, **98**, 162103, 2011.
5. V. Ganapati, **D. P. Fenning**, M.I. Bertoni, C.E. Kendrick, A.E. Fecych, J.M. Redwing, and T. Buonassisi. “[Seeding of Silicon Wire Growth by Out-Diffused Metal Precipitates](#),” *Small*, Vol. 7, Issue 5, 563-567 (2011).

4. J. Hofstetter, **D. P. Fenning**, M. I. Bertoni, J. F. Lelièvre, C. del Cañizo, T. Buonassisi. “[Impurity-to-Efficiency Simulator: Predictive Simulation of Silicon Solar Cell Performance Based on Iron Content and Distribution](#),” *Prog. Photovolt.: Res. App.*, Vol. 19, Issue 4, 487-497 (2011).
3. M. I. Bertoni, S. Hudelson, B. K. Newman, S. Bernardis, **D. P. Fenning**, H. F. W. Dekkers, E. Cornagliotti, A. Zuschlag, G. Micard, G. Hahn, G. Coletti, B. Lai, T. Buonassisi. “[Influence of defect type on hydrogen passivation efficacy in multicrystalline silicon solar cells](#),” *Prog. Photovolt.: Res. App.*, Vol. 19, Issue 2, 187-191 (2011).
2. V. Shkolnikov, D. G. Strickland, **D. P. Fenning**, J. G. Santiago. “[Design and Fabrication of Porous Polymer Wick Structures](#),” *Sensors and Actuators B: Chemical*, Vol.150, Issue 2, 556-563 (2010).
1. S. Hudelson, B. K. Newman, S. Bernardis, **D. P. Fenning**, M. I. Bertoni, M. A. Marcus, S. C. Fakra, B. Lai, T. Buonassisi. “[Retrograde Melting and Internal Liquid Gettering in Silicon](#),” *Advanced Materials* 22, 3948-3953 (2010).

Other Journal Publications

1. D. M. Powell, **D. P. Fenning**, J. Hofstetter, J. F. Lelièvre, B. Lai, C. del Cañizo, and T. Buonassisi. “[TCAD for PV: A fast method for accurately modelling metal impurity evolution during solar cell processing](#),” *Photovoltaics International*, 15th edition, April 2012.

Talks

10. (forthcoming, invited) D. P. Fenning “Engineering Defects for Solar Fuels,” TMS Meeting, San Diego, March 2017.
9. L. Kornblum, D. P. Fenning, J. Faucher, J. Hwang, A. Boni, M.-G. Han, M. D. Morales-Acosta, Y. Zhu, E. I. Altman, M. L. Lee, C. H. Ahn, F. J. Walker and Y. Shao-Horn, “Unlocking stable III-V solar hydrogen production with oxide epitaxy,” Toward Oxide-Based Electronics Fall Meeting, Ljubljana, Slovenia, September 2016.
8. A. Morris, D. P. Fenning, ”Implementation of Photoluminescence Saturation Current Density Measurement,” Academic Enrichment Programs’ Summer Research Conference, San Diego, CA, August 2016.
7. (invited) D. P. Fenning, “Engineering Defects to Enable Cost-Effective Solar Cells,” Nanoscience and Technology Seminar, Argonne National Lab, Argonne, IL, June 2016.
6. M. Stuckelberger, T. Nietzold, G. N. Hall, B. West, J. Werner, B. Niesen, C. Ballif, V. Rose, D. P. Fenning, M. I. Bertoni, “Elemental Distribution

- and Charge Collection at the Nanoscale on Perovskite Solar Cells,” IEEE Photovoltaics Specialist Conference, Portland, OR 2016.
5. D. P. Fenning, L. Kornblum, J. Faucher, J. Hwang, A. Boni, M.-G. Han, M. D. Morales-Acosta, Y. Zhu, E. Altman, M. L. Lee, C. H. Ahn, Y. Shao-Horn, F. J. Walker, “Integrating Crystalline Oxides on III-Vs for Solar-to-Fuels,” Spring MRS, Phoenix, CA, April 2016.
 4. (invited) D. P. Fenning, “Engineering Defects for Cost-Effective Solar Cells,” 251st ACS Meeting, San Diego, March 2016.
 3. (invited) D. P. Fenning, L. Kornblum, J. Faucher, J. Hwang, A. Boni, M.-G. Han, M. D. Morales-Acosta, Y. Zhu, E. Altman, M. L. Lee, C. H. Ahn, Y. Shao-Horn, F. J. Walker, “Integrating Crystalline Oxides on III-Vs for Solar-to-Fuels,” Workshop on Compound Semiconductor Materials and Devices 2016, Tucson, AZ, February 2016.
 2. A. E. Morishige, R. Chakraborty, M. Ann Jensen, P. Yen, B. West, M. Stuckelberger, J. Maser, B. Lai, D. P. Fenning, M. I. Bertoni, T. Buonassisi, “Emerging *in-situ* tools for X-ray Nanoprobe Investigations of Energy Materials at the Advanced Photon Source,” Denver X-ray Conference, Westminster, CO, August 2015.
 1. A. E. Morishige, D. B. Needleman, M. Ann Jensen, H. Wagner, J. Hofstetter, D. P. Fenning, C. del Cañizo, T. Buonassisi, “Vertically-Integrated Defect Engineering for Photovoltaics,” 25th NREL Workshop on Crystalline Silicon Solar Cells & Modules, July 2015.
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43. Jeffrey B. Chou, David P. Fenning, Yu Wang, Miguel A. M. Polanco, Jonathan Hwang, Asmaa El-Faer, Firas Sammoura, Jaime Viegas, Mahmoud Rasras, Alexie Kolpak, Yang Shao-Horn, Sang-Gook Kim, “Broadband Photoelectric Hot Carrier Collection with Wafer-Scale Metallic-Semiconductor Photonic Crystals” 42nd IEEE Photovoltaics Specialist Conference, New Orleans, June 2015.
 42. Rafael Jaramillo, Sin Cheng Siah, Rupak Chakraborty Douglas M. Powell, Mallory Ann Jensen, Sergio Castellanos, Jörg Maser, Barry Lai, Matthew A. Marcus, David P. Fenning, Jasmin Hofstetter, Tonio Buonassisi, “Synchrotron-Based Analytical Techniques Elucidate Defect Structure-Property Relations in Silicon and Thin-Film Solar Cell Materials,” Spring MRS, San Francisco, CA, April 2015.
 41. David P. Fenning, Yoon Hee Jang, Julia O’Donnell, Dong Ha Kim, Yang Shao-Horn “Engineering Hematite Nanostructures for Improved Photoelectrochemical Water Oxidation,” Fall MRS, Boston, MA, Dec 2014.

40. H. Laine, V. Vähänissi, J. Hofstetter, A. E. Morishige, A. Haarahiltunen, D. P. Fenning, and H. Savin. "The size distribution of iron precipitates in phosphorous-implanted emitters," Extended Defects in Semiconductors, Göttingen, Germany, September 2014.
39. J. Hofstetter, A. E. Morishige, M. A. Jensen, D. M. Powell, M. M. Kivambe, S. Castellanos, D. B. Needleman, S. M. Scott, J. Mailoa, J. Z. Lee, H. Wagener, D. P. Fenning, T. Buonassisi, "Alternative Approaches for High-Efficiency Silicon Wafers," 24th NREL Workshop on Crystalline Silicon Solar Cells and Modules, Breckenridge, CO, July 2014.
38. D. P. Fenning, J. Hofstetter, A. E. Morishige, H. Laine, V. Vähänissi, A. Haarahiltunen, S. C. Castellanos, M. A. Jensen, B. Lai, H. Savin, "Iron Precipitation upon Gettering in Implanted Czochralski Silicon and Its Impact on Solar Cell Performance," 40th IEEE Photovoltaics Specialist Conference, Denver, CO, June 2014.
37. R. Jaramillo, J. Hofstetter, A. E. Morishige, R. Chakraborty, S. C. Siah, S. Castellanos, M. Ann Jensen, B. Lai, J. Maser, D. P. Fenning, M. I. Bertoni, T. Buonassisi, "Opportunities in Photovoltaic Research with a Diffraction-Limited Storage Ring," APS User Meeting, May 2014.
36. D. P. Fenning, "Predictive Process Simulation Supported by Defect Characterization," QEERI Workshop on Science and Tools for Solar Energy Conversion, Doha, Qatar, April 2014.
35. D. Lee, C. Kuryak, S. Lee, D. P. Fenning, C. Carlton, Y. Hu, G. Chen, Y. Shao-Horn, "Improved power factor at the interface of silicon and PEDOT:PSS," MRS Fall Meeting, Boston, MA, December 2013.
34. J. Hofstetter, S. Castellanos, D. P. Fenning, A. E. Morishige, M. M. Kivambe, B. Lai, M. Rinio, T. Buonassisi, "Studying metal decoration at dislocations in multicrystalline silicon using X-ray probes," MRS Fall Meeting, Boston, MA, December 2013.
33. D. M. Powell, J. Hofstetter, D. P. Fenning, R. Hao, T. S. Ravi, T. Buonassisi, "High Lifetime Thin Kerfless Silicon Wafers for Solar Cells," MRS Fall Meeting, Boston, MA, December 2013.
32. D. P. Fenning, M. I. Bertoni, B. Lai, J. Maser, T. Buonassisi, "*In-situ* X-ray Nanocharacterization of Defects in Solar Cells," Materials Science & Technology 2013, Montreal, Canada, October 2013.
31. J. Hofstetter, D. P. Fenning, D. M. Powell, A. E. Morishige, T. Buonassisi, "Iron Management in Multicrystalline Silicon through Predictive Simulation: Point Defects, Precipitates, and Structural Defect Interactions," 15th Gettering and Defect Engineering in Semiconductor Technology (GADEST 2013), Oxford, UK, September 2013.

30. A. Akey, D. Berney Needleman, S. Castellanos, D. P. Fenning, J. Hofstetter, M. M. Kivambe, A. E. Morishige, D. M. Powell, S. C. Siah, T. Buonassisi, "Simulating defect physics to improve the cost-performance ratio of kerfless silicon-based photovoltaics," International Conference on Defects in Semiconductors, Bologna, Italy, July 2013.
29. J. Lindroos, D. P. Fenning, D. J. Backlund, Y. Boulfrad, T. Buonassisi, S. K. Estreicher, H. Savin, "Fast-Diffusing Interstitial Cu, Fe, and Ni in Silicon," 25th Nordic Semiconductor Meeting, Espoo, Finland, June 2013.
28. D. P. Fenning, A. S. Zuschlag, A. Frey, M. I. Bertoni, B. Lai, G. Hahn, T. Buonassisi, "Investigation of Lifetime-Limiting Defects after High-Temperature Phosphorus Diffusion in Silicon Solar Cell Materials," 39th IEEE Photovoltaics Specialist Conference, Tampa, FL, June 2013.
27. A. E. Morishige, D. P. Fenning, J. Hofstetter, D. M. Powell, T. Buonassisi, "Moving Beyond Traditional Silicon Solar Cell Manufacturing: Optimizing for Performance and Throughput," Lab for Manufacturing & Productivity Seminar Series, MIT, May 2013.
26. D. P. Fenning, "High-Temperature Defect Engineering for Silicon Solar Cells," UCSD Nanoengineering Seminar Series, UCSD, May 2013.
25. D. P. Fenning, J. Hofstetter, A. E. Morishige, D. M. Powell, T. Buonassisi. "Engineering Metal Impurities to Enable Low-Cost Silicon Solar Cells," Micro-Nano Seminar Series, MIT, April 2013.
24. D. M. Powell, J. Hofstetter, D. P. Fenning, S. C. Siah, C. B. Simmons, T. Buonassisi, "Bulk Minority-carrier Lifetime Enhancements in Thin Kerfless Silicon," Spring MRS, San Francisco, CA, April 2013.
23. D. P. Fenning, J. Hofstetter, A. Zuschlag, A. E. Morishige, G. Hahn, T. Buonassisi, "Iron Kinetics Simulation and Experimentation Demonstrating Potential for Novel Industrial Processing of Silicon Solar Cells," MRS Fall Meeting, Boston, MA November 2012.
22. D. P. Fenning, M. I. Bertoni, V. Rose, J. Maser, T. Buonassisi, "Multi-scale Synchrotron-based Study of the Physics and Device Impacts of Metal-Dislocation Interactions in Silicon Solar Cell Materials," MRS Fall Meeting, Boston, MA, November 2012.
21. H. Choi, M. Bertoni, J. Hofstetter, D. P. Fenning, S. Castellanos, D. Powell, T. Buonassisi, "Solute drag reversed? Dislocation density reduction during impurities gettering in multicrystalline silicon," MRS Fall Meeting, Boston, MA November 2012.
20. H. Choi, M. Bertoni, J. Hofstetter, D. P. Fenning, S. Castellanos, D. Powell, T. Buonassisi, "Dislocation density reduction during impurity gettering in multicrystalline silicon," 6th International Workshop on Crystalline Silicon Solar Cells, Aix-les-bains, France, October 2012.

19. J. Hofstetter, D. P. Fenning, D. M. Powell, A. E. Morishige, A. Zuschlag, G. Hahn, & T. Buonassisi, "Design Guidelines for Tailored Phosphorus Diffusion Gettering," Challenges in PV Science, Technology, and Manufacturing: A workshop on the role of theory, modeling, and simulation, Purdue, IN, August 2012.
18. (invited) D. P. Fenning, J. Hofstetter, D. M. Powell, A. E. Morishige, A. Zuschlag, G. Hahn, & T. Buonassisi. "Design Guidelines for Tailored Phosphorus Diffusion Gettering," 22nd NREL Workshop on Crystalline Silicon Solar Cells & Modules, Vail, CO, July 2012.
17. M. I. Bertoni, D. P. Fenning, G. Sarau, M. Rinio, V. Rose, J. Maser, & T. Buonassisi. "Nanoprobe-XRF and micro-Raman Studies of Metal Impurity Decoration around Dislocations," 38th Photovoltaics Specialist Conference, Austin, TX, June 2012.
16. H. Choi, M. Bertoni, J. Hofstetter, D. P. Fenning, S. Castellanos, D. Powell, & T. Buonassisi, "Effect of Dislocation-Impurity Interaction on Dislocation Annihilation in Solar-Grade Silicon," 38th IEEE Photovoltaics Specialist Conference, Austin, TX, June 2012.
15. J. Hofstetter, D. P. Fenning, J. F. Lelièvre, C. del Cañizo, & T. Buonassisi. "Engineering metal distributions to enhance gettering," EMRS Spring Meeting, Strasbourg, France, May 2012.
14. M. Bertoni, D. P. Fenning, B. K. Newman, S. Hudelson, S. Fakra, M. A. Marcus, B. Lai, V. Rose, J. Maser, & T. Buonassisi "Enabling low-cost solar cells: Synchrotron X-ray Investigation of Device-Limiting Defects," Advanced Photon Source User Meeting, Argonne, Illinois, May 2012.
13. T. Buonassisi, M. I. Bertoni, D. P. Fenning, J. Hofstetter, B. Lai, & J. Maser. "Advancing Inorganic Photovoltaics via High-Throughput in-situ X-ray Microscopy," Advanced Photon Source User Meeting, Argonne, Illinois, May 2012.
12. D. P. Fenning, J. Hofstetter, D. M. Powell, A. E. Morishige, & T. Buonassisi. "Efficient, Low-Cost Silicon Solar Cells by Predictive Process Optimization," Lab for Manufacturing & Productivity Seminar Series, MIT, April 2012.
11. D. P. Fenning, B. K. Newman, S. Hudelson, T. Buonassisi. "High-Temperature Reactions of Nickel in Silicon via Synchrotron-Based Characterization Techniques," Gettering and Defect Engineering in Semiconductor Technology XIV, Loipersdorf, Austria (2011).
10. J. Hofstetter, J.F. Lelièvre, D. P. Fenning, T. Buonassisi, and C. del Cañizo. "Towards customizing the solar cell process to as-grown silicon material properties," Gettering and Defect Engineering in Semiconductor Technology XIV, Loipersdorf, Austria (2011).

9. D. P. Fenning, T. Buonassisi. "Effective Iron Gettering in Lightly-Doped Emitters," 37th IEEE Photovoltaics Specialist Conference, Seattle, WA (2011).
8. M. I. Bertoni, D. P. Fenning, M. Rinio, M. Holt, V. Rose, J. Maser, T. Buonassisi. "Nanoprobe X-ray Fluorescence Studies of Metal Impurity Decoration of Dislocations in Large-Area Solar Cells," 37th IEEE Photovoltaics Specialist Conference, Seattle, WA (2011).
7. J. Hofstetter, D. P. Fenning, M. I. Bertoni, J.F. Lelièvre, T. Buonassisi, and C. del Cañizo. "Impurity-to-Efficiency Simulator: Predictive Simulation of Solar Cell Efficiencies Based on Measured Metal Distribution and Cell Processing Conditions," 25th European Photovoltaic Solar Energy Conference, Hamburg, Germany (2010).
6. D. P. Fenning, J. Hofstetter, M I. Bertoni, J. F. Lelièvre, C. del Cañizo, T. Buonassisi. "Synchrotron-based Microanalysis of Iron Distribution after Thermal Processing and Predictive Modeling of Resulting Solar Cell Efficiency," 35th IEEE Photovoltaics Specialist Conference, Honolulu, HI (2010).
5. D. P. Fenning, T. Buonassisi, "Engineering Metal Impurities in Silicon for High-Efficiency Industrial Solar Cells," Lab for Manufacturing & Productivity Seminar Series, MIT, May 2010.
4. J. Hofstetter, J. F. Lelièvre, D. P. Fenning, M.I. Bertoni, T. Buonassisi, A. Luque, C. del Cañizo, "Enhanced iron gettering by short, optimized low-temperature annealing after phosphorus emitter diffusion for industrial silicon solar cell processing," EMRS Spring Meeting, Strasbourg, France (2010).
3. D. P. Fenning, B. Newman, M. Bertoni, S. Bernardis, S. Hudelson, S. Fakra, M. Marcus, T. Buonassisi. "Local Melting of Metal-Silicide Precipitates in Silicon Matrix upon Cooling," Spring Meeting Materials Research Society (2010).
2. M. Bertoni, S. Hudelson, B. Newman, D. P. Fenning, S. Fakra, M. Marcus and T. Buonassisi. "Synchrotron-Based Investigations of Performance-limiting Defects in Solar Cell Materials," 216th Electrochemical Society Meeting, Vienna, Austria (2009).
1. D. G. Strickland, D. Fenning, S. Litster, J. G. Santiago, "In-situ Polymerized Wicks for Passive Water Management in PEM Fuel Cell Systems," in *ES2009: Proceedings of the ASME 3rd International Conference on Energy Sustainability*, vol. 1, pp. 325-326 (2009).

Poster Presentations

11. H. Laine, E. Magaña, V. Vähänissi, Z. Liu, K. Salo, H. Huang, A. Morishige, B. Lai, H. Savin, D. P. Fenning, "Evaluation of Iron Gettering Mechanisms in Boron-Implanted Emitters," Crystalline Silicon Solar Cells & Silicon Materials Joint Meeting, Tempe, AZ, October 2016. **Best Poster Award**
10. A. Morris, K. Rimpau, D. P. Fenning, "Implementation of Photoluminescence Saturation Current Density Measurement," 2016 SACNAS The National Diversity in STEM Conference, Long Beach, CA, October 2016.
9. M. Stuckelberger, B. West, B. Lai, J. Maser, V. Rose, D. P. Fenning, M. I. Bertoni, "X-ray Beam Induced Current for Nanoscale Engineering of Electronic Devices," X-ray Microscopy, Oxford, UK August 2016.
8. Y. Luo, S. Gamliel, S. Nijem, S. Elboher, M. Holt, B. Stripe, V. Rose, M. I. Bertoni, L. Etgar, D. P. Fenning, "Spatially Heterogeneous Chlorine Incorporation in Organic-Inorganic Perovskite Solar Cells," California Higher Education Sustainability Conference, Fullerton, CA, June 2016.
7. (invited) D. P. Fenning, "Understanding the Role of Defects and Heterogeneity in Efficient Organometal halide perovskite solar cells by X-ray Microscopy," Center for Nanoscale Materials Triennial DOE Review, Argonne National Lab, Argonne, IL, June 2016.
6. Y. Luo, S. Gamliel, S. Nijem, S. Elboher, M. Holt, B. Stripe, V. Rose, M. I. Bertoni, L. Etgar, D. P. Fenning, "Spatially Heterogeneous Chlorine Incorporation in Organic-Inorganic Perovskite Solar Cells," IEEE Photovoltaics Specialist Conference, Portland OR, June 2016.
5. H. S. Laine, V. Vhnissi, Z. Liu, H. Huang, E. Magaña, A. E. Morishige, N. Khelifati, T. U. Naerland, S. Husein, B. Lai, M. I. Bertoni, D. Bouhafs, T. Buonassisi, D. P. Fenning, H. Savin, "Finite- vs. infinite-source emitters in silicon photovoltaics: Effect on transition metal gettering," IEEE Photovoltaics Specialist Conference, Portland OR, June 2016. (*Best Poster Nominee*)
4. G. Hall, M. Stuckelberger, J. Werner, B. Niesen, C. Ballif, V. Rose, D. P. Fenning, M. I. Bertoni, "Perovskites under Pressure: Insights into the Reversibility of Solar Cell Performance," Spring MRS, Phoenix, AZ March 2016.
3. T. Nietzold, M. Stuckelberger, G. Hall, S. Nijem, L. Etgar, B. Niesen, C. Ballif, D. P. Fenning, M. I. Bertoni, "Degradation Kinetics of Perovskite Solar Cells: The Roles of Atmosphere and Light," Spring MRS, Phoenix, AZ, March 2016.
2. Y. Luo, S. Gamliel, S. Nijem, B. Stripe, M. Holt, V. Rose, M. I. Bertoni, Y. Shao-Horn, L. Etgar, D. P. Fenning, "Nanoscale Chemical Microscopy

of Perovskite Solar Cells via Synchrotron-Based X-Ray Fluorescence,” Fall MRS, Boston, MA, December 2015.

1. H. S. Laine, V. Vähänissi, A. E. Morishige, J. Hofstetter, B. Lai, A. Haarahiltunen, H. Savin, D. P. Fenning, ”Investigating Iron Gettering Mechanisms in Phosphorus-Implant Emitters,” 25th NREL Workshop on Crystalline Silicon Solar Cells & Modules, Keystone, CO July 2015.

32. H. Laine, V. Vähänissi, J. Hofstetter, A. E. Morishige, A. Haarahiltunen, D. P. Fenning, H. Savin, ”Simulating Iron Precipitation in Phosphorus-Implanted Solar Cells”, European Photovoltaics and Solar Energy Conference, Amsterdam, The Netherlands, September 2014.
31. D. P. Fenning, K. J. May, K. A. Stoerzinger, W. T. Hong, D. Lee, M. D. Biegalski, A. M. Kolpak, Y. Shao-Horn, ”Single-Nanometer Scale Thickness Dependence of Photoelectrochemical Water Splitting on Ultrathin Lanthanum Ferrite Films,” International Society of Electrochemistry 65th Annual Meeting, Lausanne, Switzerland, September 2014.
30. K. J. May, D. P. Fenning, A. M. Kolpak, Y. Shao-Horn, ”Band Alignment of LaFeO₃/Nb:SrTiO₃ Heterojunctions via Spectroscopic Ellipsometry, X-ray Photoelectron Spectroscopy and First-Principles Calculation” International Society of Electrochemistry 65th Annual Meeting, Lausanne, Switzerland, September 2014.
29. D. P. Fenning, J. Hofstetter, A. E. Morishige, M. Ann Jensen, M. I. Bertoni, B. Lai, J. Maser, V. Rose, T. Buonassisi, W. T. Hong, Y. Yacoby, Z. Feng, H. Zhou, M. Biegalski, H. M. Christen, Y. Shao-Horn, ”Investigating Silicon Solar Cell Impurities and Oxygen Catalyst Cation Distributions using Hard X-rays,” APS User Meeting, May 2014.
28. D. M. Powell, J. Hofstetter, D. P. Fenning, R. Hao, M. Ann Jensen, T. S. Ravi, and T. Buonassisi, ”High-Lifetime Kerfless Silicon Wafers,” 40th IEEE Photovoltaics Specialist Conference, Denver, CO, June 2014.
27. A. E. Morishige, D. P. Fenning, J. Hofstetter, M. Ann Jensen, S. Ramanathan, C. Wang, B. Lai, T. Buonassisi, ”Elucidating and Engineering Recombination-Active, Metal-Rich Precipitates in *n*-type Multicrystalline Silicon,” 40th IEEE Photovoltaics Specialist Conference, Denver, CO June 2014.
26. M. Ann Jensen, J. Hofstetter, D. P. Fenning, A. E. Morishige, G. Coletti, B. Lai, T. Buonassisi, ”The Distribution of Chromium in Multicrystalline Silicon,” 40th IEEE Photovoltaics Specialist Conference, Denver, CO, June 2014.

25. A. E. Morishige, J. Hofstetter, M. Ann Jensen, D. P. Fenning, S. Ramanathan, C. Wang, B. Lai, T. Buonassisi, "Engineering Metal-Rich Precipitates and Increasing Minority Carrier Lifetime in *n*-type Multicrystalline Silicon for Solar Cells," Quantum Energy and Sustainable Solar Technologies Site Visit, Tempe, AZ, May 2014.
24. J. Lindroos, D. P. Fenning, D. J. Backlund, E. Verlage, A. Gorgulla, S. K. Estreicher, H. Savin, T. Buonassisi, "Fast-Diffusing Interstitial Nickel in Silicon," 15th Gettering and Defect Engineering in Semiconductor Technology (GADEST 2013), Oxford, UK, September 2013.
23. D. P. Fenning, M. I. Bertoni, T. Buonassisi, "Hard X-ray Investigations of Trace Metal Impurities in Silicon Solar Cells," SUNCAT/Stanford Summer School: Heterogeneous Catalysis for Energy Transformations, Stanford, CA, August 2013.
22. M. I. Bertoni, D. P. Fenning, S. Gangam, B. Lai, J. Maser, T. Buonassisi, C. Honsberg, "*In-situ* Stage Development for High-Temperature X-ray Nanocharacterization of Defects in Solar Cells," 39th IEEE Photovoltaics Specialist Conference, Tampa, FL, June 2013.
21. A. E. Morishige, D. P. Fenning, J. Hofstetter, D. M. Powell, T. Buonassisi, "Simulated Co-optimization of Crystalline Silicon Solar Cell Efficiency and Throughput Using Continuously Ramping Phosphorus Diffusion Profiles," Lab for Manufacturing & Productivity: Manufacturing Summit/ASPE 2013 Spring Topical Meeting, Cambridge, MA, April 2013.
20. J. Hofstetter, D. P. Fenning, T. Buonassisi, "Correlation of Interstitial Iron Concentration and Recombination Strength of Dislocations in Multicrystalline Silicon," SiliconPV, Hamelin, Germany, March 2013.
19. J. Hofstetter, D. P. Fenning, A. E. Morishige, T. Buonassisi, "Toward Narrowing the Standard Deviation of Multicrystalline Silicon Solar Cell Efficiencies Through Customized Processing," MRS Fall Meeting, Boston, MA, November 2012.
18. A. E. Morishige, D. P. Fenning, J. Hofstetter, T. Buonassisi, "Co-optimizing Crystalline Silicon Solar Cell Throughput and Efficiency Using Continuously Ramping Phosphorus Diffusion Profiles," MRS Fall Meeting, Boston, MA November 2012.
17. J. Hofstetter, D. P. Fenning, A. E. Morishige, T. Buonassisi, "Customized P diffusion gettering tailored to as-grown silicon material quality" 6th International Workshop on Crystalline Silicon Solar Cells, Aix-les-bains, France, October 2012.
16. J. Hofstetter, D. P. Fenning, H. Choi, M. I. Bertoni, T. Buonassisi, "Metal-Dislocation Interaction in Multicrystalline Silicon," 22nd NREL Workshop on Crystalline Silicon Solar Cells & Modules, Vail, CO, July 2012.

15. A. E. Morishige, D. P. Fenning, J. Hofstetter, D. M. Powell, T. Buonassisi, "Simulated Co-Optimization of Crystalline Silicon Solar Cell Throughput and Efficiency Using Continuously Ramping Phosphorus Diffusion Profiles," 38th IEEE Photovoltaics Specialist Conference, Austin, TX, June 2012.
14. J. Schön, A. Haarahiltunen, D. Fenning, T. Buonassisi, W. Warta, M. C. Schubert, "Modeling the Size Distribution of Iron Precipitates in Multicrystalline Silicon," 38th IEEE Photovoltaics Specialist Conference, Austin, TX, June 2012.
13. D. P. Fenning, "Optimizing Phosphorus Diffusion for Silicon Solar Cells," Quantum Energy and Sustainable Solar Technologies First Annual Site Visit, Tempe, AZ, May 2012.
12. D. P. Fenning, M. I. Bertoni, T. Buonassisi. "Advancements in Synchrotron-Based Characterization of Metals in Silicon," 5th International Workshop on crystalline Silicon Solar Cells, Boston, MA, November 2011.
11. J. Hofstetter, J. F. Lelièvre, D. P. Fenning, Tonio Buonassisi, and C. del Cañizo. "Toward the tailoring of P diffusion gettering to as-grown silicon material properties," 5th International Workshop on crystalline Silicon Solar Cells, Boston, MA, November 2011.
10. A. E. Morishige, D. P. Fenning, J. Hofstetter, T. Buonassisi. "Co-optimizing the phosphorus diffusion time-temperature profile for gettering and throughput," 5th International Workshop on crystalline Silicon Solar Cells, Boston, MA, November 2011.
9. D. P. Fenning, J. Hofstetter, T. Buonassisi, "Optimizing Industrial Phosphorus Diffusion for Silicon Solar Cells", Gettering and Defect Engineering in Semiconductor Technology XIV, Loipersdorf, Austria, September 2011.
8. J. Hofstetter, J. F. Lelièvre, D. P. Fenning, M.I. Bertoni, A. E. Morishige, Tonio Buonassisi, and C. del Cañizo. "Towards the tailoring of P diffusion gettering to as-grown silicon material properties," 21st NREL Workshop on Crystalline Silicon Solar Cells & Modules: Materials and Processes, Breckenridge, CO , July 2011.
7. D. M. Powell, D. P. Fenning, T. Buonassisi, B. S. Conrad, J. Hofstetter, J. F. Lelièvre, Carlos del Cañizo. " Deployment of Impurity-to-Efficiency (I2E) Simulation Tool," 37th Photovoltaics Specialist Conference, Seattle, WA (2011).
6. D. P. Fenning, M. Bertoni, T. Buonassisi. "Predictive Modeling of the Optimal Phosphorus Diffusion Profile in Silicon Solar Cells," 24th European Photovoltaic Solar Energy Conference. Hamburg, Germany (2009).
5. J. Hofstetter, D. P. Fenning, J.F. Lelièvre, M. Bertoni, T. Buonassisi, C. del Cañizo. "Simulating the Evolution of the Iron Content and Distribution

during Solar Cell Processing,” 24th European Photovoltaic Solar Energy Conference. Hamburg, Germany (2009).

4. S. Bernardis, B. Newman, M. Di Sabatino, D. P. Fenning, S.C. Fakra, R.B. Larsen, S. Gaal, M. Tangstad, and T. Buonassisi. “Iron Impurities in Si-bearing Compounds for Metallurgical Grade Silicon Production,” Fall Meeting Materials Research Society, Boston, MA (2009).
3. D. P. Fenning, S. Hudelson, J. Sullivan, S. Bernardis, M. I. Bertoni, B. Newman, T. Buonassisi. “Synchrotron-Based Investigation of Metal Impurity Diffusion in Silicon Solar Cell Materials,” Optics and Photonics for Advanced Energy Technology Conference, Cambridge, MA (2009).
2. D. G. Strickland, D. P. Fenning, S. Litster, and J.G. Santiago, “In Situ Polymerized Wicks for Passive Water Management in PEM Fuel Cell Systems, Proceedings of Energy Sustainability 2009, American Society of Mechanical Engineering Conference, San Francisco, July 19-23, 2009.
1. D. G. Strickland, D. P. Fenning, S. E. Litster, and J. G. Santiago. “In-situ polymerized wicks for water management in large-scale PEM fuel cell systems.” Gordon Research Conference - Fuel Cells, Jul 20-25, 2008.