ERIC JOHLIN

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CURRENT EMPLOYMENT

FOM Institute AMOLF, Amsterdam, Netherlands **2015-Present**

- Postdoctoral Researcher – Nanoscale Solar Cells, Advised by Dr. Erik Garnett

EDUCATIONAL HISTORY

Massachusetts Institute of Technology, Cambridge, MA (GPA - 4.8/5.0) **2009-2014**

- Ph.D. in Mechanical Engineering and Computation
  - Dissertation - Understanding and Improving Hole Transport in Hydrogenated Amorphous Silicon
  - Major Program - Nanoscale Fabrication and Measurement
  - Minor Program - Simulation and Computation
- M.S. in Mechanical Engineering
  - Thesis - Origins and Implications of Intrinsic Stress in Hydrogenated Amorphous Silicon Thin Films

California Institute of Technology, Pasadena, CA (GPA - 3.5/4.0) **2005-2009**

- B.S. in Mechanical Engineering with High Honors

SELECTED PUBLICATIONS

- E Johlin, J Solari, SA Mann, J Wang, TS Shimizu, EC Garnett. "Super-resolution imaging of light–matter interactions near single semiconductor nanowires." *Nature Communications* **7**, 13950 (2016)
- M de Goede, E Johlin, B Sciacca, F Boughorbel, EC Garnett. "3D multi-energy deconvolution electron microscopy." *Nanoscale* **9**, 684 (2017)
- E Johlin, A Al-Obeidi, G Nogay, M Stuckelberger, T Buonassisi, JC Grossman. "Nanohole Structuring for Improved Performance of Hydrogenated Amorphous Silicon Photovoltaics." *ACS Applied Materials & Interfaces* **8**, 15169 (2016)
- JP Mailoa, CD Bailie, E Johlin, ET Hoke, AJ Akey, WH Nguyen, MD McGehee, T Buonassisi. "A 2-terminal perovskite/silicon multijunction solar cell enabled by a silicon tunnel junction." *Applied Physics Letters* **106**, 121105 (2015)
- DA Strubbe, E Johlin, TR Kirkpatrick, T Buonassisi, JC Grossman. "Stress effects on the Raman spectrum of an amorphous material: Theory and experiment on a-Si:H." *Physical Review B* **92**, 241202 (2015)
- E Johlin, CB Simmons, T Buonassisi, JC Grossman. "Hole-mobility-limiting atomic structures in hydrogenated amorphous silicon." *Physical Review B* **90**, 104103 (2014)

- T Mueller, E Johlin, JC Grossman. "Origins of hole traps in hydrogenated nanocrystalline and amorphous silicon revealed through machine learning." *Physical Review B* **89**, 115202 (2014)
- R Raghunathan, E Johlin, JC Grossman. "Grain Boundary Engineering for Improved Thin Silicon Photovoltaics." *Nano Letters* **14**, 4943 (2014)
- E Johlin, LK Wagner, T Buonassisi, JC Grossman. "Origins of structural hole traps in hydrogenated amorphous silicon." *Physical Review Letters* **110**, 146805 (2013)
- E Johlin, N Tabet, S Castro-Galnares, A Abdallah, MI Bertoni, T Asafa, JC Grossman, S Said, T Buonassisi. "Structural origins of intrinsic stress in amorphous silicon thin films." *Physical Review B* **85**, 075202 (2012)

PATENTS

- JP Mailoa, CD Bailie, E Johlin, MD McGehee, T Buonassisi. "2-TERMINAL METAL HALIDE SEMICONDUCTOR/C-SILICON MULTIJUNCTION SOLAR CELL WITH TUNNEL JUNCTION" US Patent 20,160,163,904 (2016)

SELECTED ORAL PRESENTATIONS

- "Super-Resolution Imaging of Light-Matter Interactions in Single Nanowires." *NanoCity Conference*, Amsterdam, The Netherlands, 21 June 2016
- "Super-Resolution Measurements of Silicon Nanowires." *Fall MRS Meeting*, Boston, MA, 1 December 2015
- "Efficiency Improvements through Nanohole Structuring of Amorphous Silicon Photovoltaic Devices." *EMRS Spring Meeting*, Lille, France, 15 May 2015
- "Nanohole Structuring of Hydrogenated Amorphous Silicon for Photovoltaic Applications." *Spring MRS Meeting*, San Francisco, CA, 25 April 2014
- "Influence of Structural Phenomena on Time-of-flight Hole Mobility in Hydrogenated Amorphous Silicon Thin Films." *Fall MRS Meeting*, Boston, MA, 28 November 2012
- "Stress-Based Mitigation of Strong Hole Traps in Hydrogenated Amorphous Silicon." *Spring MRS Meeting*, San Francisco, CA, 10 April 2012
- "Stress Engineering in Amorphous Silicon Thin Films." *37th IEEE-PVSC*, Seattle, WA, 20 June 2011
- "Statistical Diagnosis and Mitigation of Structural Hole Traps in Hydrogenated Amorphous Silicon." *Spring MRS Meeting*, San Francisco, CA, 27 April 2011
- "Density Functional Theory Calculations of the Role of Defects in Amorphous Silicon Solar Cells." *APS March Meeting*, Portland, OR, 15 March 2010

RESEARCH EXPERIENCE

Doctoral Thesis Research - Massachusetts Institute of Technology, Cambridge, MA **2011-2014**
Advised by Profs. Jeffrey C. Grossman (Dept. Mat. Sci.), and Tonio Buonassisi (Dept. Mech. Eng.)

- **Improvement of Amorphous Silicon Photovoltaic Performance through Nanostructuring**

  Conventional planar hydrogenated amorphous silicon (a-Si:H) photovoltaic devices have been widely relegated to low-efficiency, low-cost applications. This poor efficiency is mainly attributed to the low hole mobility of the bulk amorphous material, limiting the device current collection. Nanostructuring of the material, however, holds promise of significantly improving carrier extraction without limiting the advantageous light absorption properties, deposition flexibility, and low cost of the material. In particular, we have fabricated nanohole devices with 150 nm diameter holes at a 300 nm period in 950 nm thick cells, utilizing a semi-conformal p-type layer and conformal AZO front contacts to achieve a 30% increase in current collection over planar devices. We are additionally exploring the potential of using these methods in heterostructure cells with improved photoconversion efficiency over planar devices.

- **Density Functional Theory Calculations on the Origins of Structural Hole Traps in Hydrogenated Amorphous Silicon**

  The inherently disordered nature of a-Si:H obfuscates the influence of atomic structure on the trapping of holes. To address this, we created six ensembles of over two thousand ab-initio structures of a-Si:H, spanning three stress states and two hydrogen contents. Using density-functional theory to analyze its properties, we explore the influence of geometric factors (coordination defects, atomic displacement, bond lengths and angles, etc.) on the formation of deep hole traps. Statistical analysis of the relative contribution of various structures to the trap distribution shows that floating bonds and ionization-induced atomic displacements correlate most strongly with deep traps in our ensemble.

- **Influence of Structural Phenomena on Hole Mobility in Hydrogenated Amorphous Silicon**

  Low hole mobility currently limits the efficiency of amorphous silicon photovoltaic devices. We explore three possible phenomena contributing to this low mobility - coordination defects, self-trapping ionization displacement defects, and lattice expansion allowing for hole wavefunction delocalization. By combining direct experimental measurements of film hole mobilites (through time-of-flight transient photocurrent measurements) with our previous analysis of theoretical models, we demonstrate the dependence of the relative prevalence of these defects on film stress and hydrogen content, and that the mobility of a film is governed by an interplay between these three (and potentially other) defect types.

Masters Thesis Research - Massachusetts Institute of Technology, Cambridge, MA **2009-2011**
Advised by Profs. Jeffrey C. Grossman (Dept. Mat. Sci.), and Tonio Buonassisi (Dept. Mech. Eng.)

- **Structural Origins of Intrinsic Stress in Hydrogenated Amorphous Silicon Thin Films**

  In this work, we synthesized and augmented several previous models of deposition phenomena and ion bombardment, developing a refined model correlating plasma-enhanced chemical vapor deposition conditions (pressure and discharge power and frequency) to the

development of intrinsic stress in amorphous silicon thin films. As predicted by the model we developed, we observe that film compressive stress varies nearly linearly with bombarding ion momentum and with a -1/4 power dependence on deposition pressure, that tensile stress is proportional to a reduction in film porosity, and the net film intrinsic stress results from a balance between these two forces. We observe the hydrogen-bonding configuration to evolve with increasing ion momentum, shifting from a void-dominated configuration to a silicon-monohydride configuration.

Undergraduate Research - California Institute of Technology, Pasadena, CA **2008-2009**
Advised by Dr. Kenneth A. Pickar (Visiting Professor of Mechanical Engineering, Caltech)

- **Design, Optimization, and Validation of a Novel Solar Water Distillation Device**
  Through a collaboration with a team of three students, two from the Art Center College of Design, and one from Caltech, we worked to create an experimentally optimized solar water distillation purification device for use in Guatemala. This work included theoretical calculations and experimental tests to determine optimal geometries and materials for the device design, performance testing of multiple functional prototypes, and purity testing of the produced water.

Undergraduate Research - NASA Jet Propulsion Laboratory, Pasadena, CA **2007, 2008**
Advised by Dr. Dan Goebel (Senior Research Scientist, NASA JPL)

- **Plasma Characterization and Analysis of High Frequency Oscillations in the Xenon Ion Propulsion System's Neutralizer Cathode**
  Ion thrusters are a highly efficient form of space propulsion, relying on the emission of heavy atoms at high speeds producing small thrusts that accumulate over long periods of operation. The multitude of possible failure modes present in modern thrusters requires a combination of theoretical modeling of the effects of the plasma on the thruster components, along with actual experimental lifetime tests. An array of plasma diagnostic measurements were taken to fully characterize the Xenon Ion Propulsion System's [XIPS] cathode to prepare it for lifetime testing, and for use in current modeling efforts. Furthermore, the effects of strong, high-frequency oscillations in the potential of the plasma at certain operating conditions were explored to determine their implications on the plasma properties used for this characterization, and future modeling efforts.

TEACHING EXPERIENCE

Teaching Assistant - *Massachusetts Institute of Technology*, Cambridge, MA **2009-2010**

- 2.626 - Fundamentals of Photovoltaics. Instructor: Prof. Tonio Buonassisi
  Assisted Professor Buonassisi with class operation and lab sessions, graded quizzes, homework assignments and tests, and held office hours to assist students with the course material.

Teaching Assistant - *California Institute of Technology*, Pasadena, CA **2008-2009**

- ME 96 - Mechanical Engineering Laboratory. Instructor: Dr. David Boyd

Taught and assisted students with laboratory experiments, graded laboratory reports and homework assignments. Maintained lab equipment and helped refine experiment procedures, requirements and grading.

TECHNICAL EXPERIENCE

Fabrication

- Chemical deposition (PECVD, ALD, LPCVD)
- Physical deposition (thermal & e-beam evaporation, sputtering)
- Etching (RIE, DRIE, ozone/plasma)
- Lithography (photo-, interference, soft/PDMS, e-beam)
- Wet bench processing, thermal and laser annealing

Characterization

- Optical ([micro]Raman spectroscopy, UV-Vis absorption/reflection/transmission spectroscopy, FTIR transmission spectroscopy, spectroscopic ellipsometry, curvature-stress measurement)
- Microscopy (SEM, STEM, AFM, profilometry)
- Electronic (Time-of-Flight mobility, solar simulator J-V device measurements, Suns-V_{OC}, 4 point probe)
- General Laser/Optical Bench Work

Technical Software

- Lumerical (FDTD), SIESTA (DFT), Igor, Solidworks, Autodesk AutoCAD & Inventor, LabVIEW, Grace, Inkscape/Illustrator

Programming Languages

- Julia, Perl, Mathematica, MATLAB, C, Basic, TeX