

Sunday, June 25, 2017

Registration

7:30 - 8:30 AM

Convention Registration Desk

Registration Opens

Break

12:00 - 1:30 PM

Ballroom Foyer

Lunch On Own

Social Activity

6:00 - 10:00 PM

Mellow Mushroom (Adams Morgan)

Students and Young Professional Mixer

Monday, June 26, 2017

Registration

7:30 - 8:30 AM

Convention Registration Desk

Registration Opens

Area 4 - Plenary

8:30 - 9:00 AM

Marriott Ballroom

Plenary

Chair(s): Pierre Verlinden, Giso Hahn, Bram Hoex

8:30 High-Performance p-Type Multi-Crystalline Silicon Material: its Characterization and Projected Performance in Different Solar Cell Configuration

Pietro P. Altermatt¹, Zhen Xiong¹, Weiwei Deng¹, AnYao Liu², Daniel H. Macdonald², Tabea Luka³, Christian Hagendorf³, Annika Zuschlag⁴, Barbara Terheiden⁴, Giso Hahn⁴, Otwin Breitenstein⁵, Erin E. Looney⁶, Tonio Buonassisi⁶, Aaron R. Arehart⁷, Steven A. Ringel⁷, Pierre J. Verlinden¹

¹Trina Solar, Changzhou, China, ²The Australian National University, Canberra, Australia, ³Fraunhofer CSP, Halle, Germany, ⁴University of Konstanz, Konstanz, Germany, ⁵Max-Planck-Institute of Microstructure Physics, Halle, Germany, ⁶MIT, Cambridge, MA, United States, ⁷Ohio State University, Columbus, OH, United States

Area 5 - Plenary

9:00 - 9:30 AM

Marriott Ballroom

Plenary

Chair(s): Marina Leite, Laurent Lombez

9:00 **Probing Nanoscale Heterogeneity in Thin Film PV: Perovskites to Polymers**

David S. Ginger

University of Washington, Seattle, WA, United States

Area 7 - Plenary

9:30 - 10:00 AM

Marriott Ballroom

Plenary

Chair(s): Claus Zimmermann, Mitsuru Imaizumi, Jeremiah McNatt

9:30 **Low cost applied to large constellations**

Christophe C. Allaud

Break

10:00 - 10:30 AM

Ballroom Foyer

Coffee Break

Keynote

10:30 - 12:00 PM

Marriott Ballroom

Opening Keynote Session

10:30 **Welcome to IEEE PVSC-44 and General Announcements**

Angèle Reinders

10:35 **Presentation by Keynote Speaker**

Charlie Gay

11:05 **Public Announcement of the Young Professional Awardee**

Geoff Bradshaw, Weiwei Deng (Awardee)

11:10 **IEEE Fellow Ceremony**

Samar Saha, Richard King (Candidate)

11:20 **Public Announcement of the William Cherry Awardee Including Ceremonial Issuing of Plaque**

Samar Saha, Ron Sinton, Eli Yablonovitch (Awardee)

11:25 **Personal Introduction to the William Cherry Awardee**

Ron Sinton

11:35 **Presentation by William Cherry Awardee**

Eli Yablonovitch

Break

12:00 - 1:30 PM

Ballroom Foyer

Lunch On Own

Area 1 - Oral

1:30 - 3:00 PM

Maryland A

Quantum Dot and Intermediate Band Solar Cells

Chair(s): Louise Hirst, Matt Doty

1:30 Effect of Cl-doping in ZnTeO on Photoluminescence and Photovoltaic Properties of ZnTeO-based Intermediate Band Solar CellsTooru Tanaka¹, Shuji Tsutsumi¹, Yuuki Okano¹, Kento Matsuo¹, Katsuhiko Saito¹, Qixin Guo¹, Mitsuhiro Nishio¹, Takeshi Tayagaki², Kin M Yu³, Wladek Walukiewicz^{4,5}¹*Department of Electrical and Electronic Engineering, Saga University, Saga, Japan*, ²*Research Center for Photovoltaics, National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan*, ³*Department of Physics and Materials Science, City University of Hong Kong, Kowloon, Hong Kong*, ⁴*Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, United States*, ⁵*Department of Materials Science and Engineering, University of California at Berkeley, Berkeley, CA, United States***1:45 Toward Lead Halide Perovskite-Based Intermediate Band Absorbers**Matthew D Sampson, Ji-Sang Park, Richard Schaller, Maria Chan, Alex B F Martinson
*Argonne National Laboratory, Lemont, IL, United States***2:00 Type-II Quantum Dots for Application to Photon Ratchet Intermediate Band Solar Cells**Ryo Tamaki, Yasushi Shoji, Yoshitaka Okada
*Research Center for Advanced Science and Technology (RCAST), The University of Tokyo, Tokyo, Japan***2:15 Best Student Presentation Award Finalist****An investigation of the role of recombination processes in InAs/GaAs_{1-x}Sb_x quantum dot solar cells**Yang Cheng¹, Anthony J. Meleco¹, Alison J. Roeth¹, Vincent R. Whiteside¹, Mukul C. Debnath¹, Michael B. Santos¹, Tetsuya D. Mishima¹, Sabina Hatch², Huiyun Liu², Ian R. Sellers¹¹*Homer L. Dodge Department of Physics and Astronomy, The University of Oklahoma, Norman, OK, United States*, ²*Department of Electrical & Electronic Engineering, University College London, London, United Kingdom***2:30 Temperature and voltage bias dependent two step photon absorption in InAs/GaAs/Al_{0.3}GaAs quantum dot in a well solar cells**Yushuai Dai, Brittany L Smith, Micheal A Slocum, Zachary S Bittner, Hyun Kum, Seth M Hubbard
*Rochester Institute of Technology, Rochester, NY, United States***2:45 Increasing Current Generation by Photon Up-conversion in a Single-Junction Solar Cell with a Hetero-interface**Shigeo Asahi, Kazuki Kusaki, Toshiyuki Kaizu, Takashi Kita
*Kobe University, Kobe City, Japan***Area 2 - Oral**

1:30 - 3:00 PM

Marriott Ballroom Salon 3

Advances in CIGSe I

Chair(s): James Sites, Takuya Kato

- 1:30 **High V_{oc} in (Cu,Ag)(In,Ga)Se₂ solar cells**
 Marika Edoff¹, Erik Wallin², Nina Shariati-Nilsson¹, Tobias Jarmar², Daniel Högström², Olof Stolt¹,
 Olle Lundberg², William Shafarman³, Lars Stolt^{1,2}
¹Angström Solar Center, Department of Engineering Sciences, Uppsala University, Uppsala, Sweden, ²Solibro Research AB, Uppsala, Sweden, ³Institute of Energy Conversion, University of Delaware, Newark, DE, United States
- 2:00 **RTP-assisted Ex-situ Analysis of (Ag,Cu)(In,Ga)Se₂ Formation using Selenization**
 Sina Soltanmohammad^{1,2}, William Shafarman^{1,2}
¹Institute of Energy Conversion, Newark, DE, United States, ²Department of Materials Science & Engineering, Newark, DE, United States
- 2:15 **Role of E_V+0.98 eV trap in light soaking-induced short circuit current instability in CIGS solar cells**
 Pran K. Paul¹, Tobias Jarmar², Lars Stolt², Angus A. Rockett³, Steven A. Ringel^{1,4}, Aaron R. Arehart¹
¹Electrical and Computer Engineering, The Ohio State University, Columbus, OH, United States, ²Solibro Research AB, Uppsala, Sweden, ³Department of Metallurgical and Materials Engineering, Colorado School of Mines, Golden, CO, United States, ⁴Institute for Materials Research, The Ohio State University, Columbus, OH, United States
- 2:30 **Study of Defect Properties in CuGaSe₂ Thin-film Solar-cells Using Admittance Spectroscopy**
 Muhammad M. Islam^{1,2}, Shogo Ishizuka³, Hajime Shibata³, Shigeru Niki³, Katsuhiro Akimoto¹,
 Takeaki Sakurai¹
¹Division of Applied Physics, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan, ²Alliance for Research on North Africa (ARENA), Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan, ³Research Center for Photovoltaics, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan
- 2:45 **Solution-Processed Cu(In,Ga)(S,Se)₂ Solar Cell with Active Area 17% Efficiency**
 Alexander Eeles¹, Panagiota Arnou¹, Jake Bowers¹, John M Walls¹, Stephen Whitelegg², Paul Kirkham², Cary Allen², Stuart Stubbs², Zugang Liu², Ombretta Masala², Christopher Newman²,
 Nigel Pickett²
¹Loughborough University, Loughborough, United Kingdom, ²Nanoco Technologies Ltd, Manchester, United Kingdom

Area 3 - Oral

1:30 - 3:00 PM

Virginia A

III-V PV: New Areas and Applications

Chair(s): Kensuke Nishioka, Stephanie Tomasulo

- 1:30 **New opportunities in III-V semiconductor solar cells: Achieving high efficiency at affordable costs**
 Stephen Forrest
 University of Michigan, Ann Arbor, MI, United States
- 2:00 **Best Student Presentation Award Finalist**
Transmissive Spectrum-Splitting Concentrator Photovoltaic Cells and Modules
 Yaping Ji¹, Qi Xu^{1,2}, Brian Riggs¹, John Robertson¹, Kazi Islam¹, Vince Romanin³, Dimitri Krut⁴,
 James Ermer⁴, Matthew Escarra¹
¹Tulane University, New Orleans, LA, United States, ²Stion Corp., San Jose, CA, United States,
³Otherlab, San Francisco, CA, United States, ⁴Boeing-Spectrolab Inc., Sylmar, CA, United States

2:15 AlGaInP/GaAs Tandem Solar Cells For Power Conversion At 400°C And 1000X Concentration

Myles A. Steiner¹, Emmett E. Perl¹, John Simon¹, Daniel J. Friedman¹, Nikhil Jain¹, Paul Sharps², Claiborne McPheeters², Minjoo L. Lee³

¹National Renewable Energy Laboratory, Golden, CO, United States, ²SolAero Technologies Corp., Albuquerque, NM, United States, ³University of Illinois at Urbana-Champaign, Urbana, IL, United States

2:30 GaInAsP Solar Cells Grown by Hydride Vapor Phase Epitaxy for One- Sun & Low-Concentration III-V/Si Photovoltaics

Nikhil Jain¹, John Simon¹, Kevin L. Schulte¹, David R. Diercks², Corinne E. Packard², David L. Young¹, Aaron J. Ptak¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States

2:45 Photo-Electrochemical Hydrogen Generation from Inverted Metamorphic Multijunction III-Vs

Todd G. Deutsch¹, James L. Young¹, Myles A. Steiner¹, Henning Döscher^{1,2}, Ryan M. France¹, John A. Turner¹

¹NREL, Golden, CO, United States, ²Philipps-Universität Marburg, Marburg, Germany

Area 4 - Oral

1:30 - 3:00 PM

Marriott Ballroom Salon 2

Passivated Contacts, Low Temperature

Chair(s): Christophe Ballif, Ajeet Rohatgi

1:30 Record-breaking Efficiency Back-contact Heterojunction Crystalline Si Solar Cell and Module

Kunta Yoshikawa, Daisuke Adachi, Wataru Yoshida, Toru Irie, Katsunori Konishi, Takahisa Fujimoto, Hayato Kawasaki, Masanori Kanematsu, Toshihiko Uto, Yuji Takahashi, Toru Terashita, Shinya Omoto, Gensuke Koizumi, Naoaki Nakanishi, Masashi Yoshimi, Kenji Yamamoto
KANEKA Corporation, Settsu, Japan

2:00 Best Student Presentation Award Finalist

N-type nanocrystalline silicon oxide front contacts for silicon heterojunction solar cells: Photocurrent enhancement on planar and textured wafers

Luana Mazzarella, Simon Kirner, Max Hendrichs, Anna B. Morales-Vilches, Lars Korte, Rutger Schlatmann, Bernd Stannowski
Helmholtz Zentrum Berlin, Berlin, Germany

2:15 Advanced Silicon Thin Films for High-Efficiency Silicon Heterojunction-Based Solar Cells

Antoine Descoeurdes¹, Christophe Allebé¹, Nicolas Badel¹, Loris Barraud¹, Gabriel Christmann¹, Fabien Debrot¹, Antonin Faes¹, Jonas Geissbühler¹, Jörg Horzel¹, Jacques Levrat¹, Silvia Martin de Nicolas¹, Sylvain Nicolay¹, Bertrand Paviet-Salomon¹, Andrea Tomasi², Christophe Ballif^{1,2}, Matthieu Despeisse¹

¹CSEM, Neuchâtel, Switzerland, ²EPFL, Neuchâtel, Switzerland

2:30 MoO_x and WO_x based hole selective contacts for dopant free wafer-based Si solar cells

Stephanie Essig¹, Evgeny Zamburg¹, Jérémie Werner¹, Mathias Mews², Davide Sacchetto³, Rucavado Rucavado¹, Lars Korte², Monica Morales-Masis¹, Jonas Geissbühler³, Sylvain Nicolay³, Takashi Koida⁴, Mathieu Boccard¹, Stefaan De Wolf⁵, Christophe Ballif^{1,3}

¹École Polytechnique Fédérale de Lausanne (EPFL), Neuchâtel, Switzerland, ²Helmholtz-Zentrum Berlin for Materials and Energy (HZB), Berlin, Germany, ³CSEM, PV-center, Neuchâtel,

Switzerland, ⁴National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, ⁵King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia

- 2:45 **Stability of low temperature, dopant-free, selective contacts for crystalline silicon solar cells**
James Bullock¹, Xu Zhaoran¹, Mark Hettick¹, Stephanie Essig², Harry Qian³, Yimao Wan³, Andrew Thomson³, Andres Cuevas³, Ali Javey¹

¹Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, CA, United States, ²École Polytechnique Fédérale de Lausanne (EPFL), Photovoltaics and Thin Film Electronic Laboratory (PVLab), Neuchatel, Switzerland, ³Research School of Engineering, The Australian National University (ANU), Canberra, Australia

Area 5 - Oral

1:30 - 3:00 PM

Maryland B&C

Characterization of Solar Cells

Chair(s): Laurent Lombez, Thorsten Trupke

- 1:30 **Characterization of photovoltaic materials and devices from the atomistic to the module level**

Uwe Rau, Beatrix Blank, Yael Augarten, Thomas Kirchartz
IEK5-Photovoltaik, Forschungszentrum Jülich, Jülich, Germany

- 2:00 **Best Student Presentation Award Finalist**

Near-Field Transport Imaging Application of Photovoltaic Materials

Chuanxiao Xiao^{1,2}, Chun-Sheng Jiang¹, John Moseley¹, John Simon¹, Kevin Schulte¹, Aaron Ptak¹, Steve Johnston¹, Brian Gorman², Mowafak Al-Jassim¹, Nancy M. Haegel¹, Helio Moutinho¹
¹National Renewable Energy Laboratory, golden, CO, United States, ²Colorado School of Mines, golden, CO, United States

- 2:15 **Applications of DMD-based Inhomogeneous Illumination Photoluminescence Imaging for Silicon Wafers and Solar Cells**

Yan ZHU, Mattias Klaus Juhl, Thorsten Trupke, Ziv Hameiri
University of New South Wales, Sydney, Australia

- 2:30 **Numerical model to extract materials properties map from spectrally resolved luminescence images**

Nicolas Paul¹, Vincent Le Guen¹, Daniel Ory^{1,2}, Laurent Lombez^{2,3}
¹EDF R&D, 6 quai Watier, Chatou, France, ²Institute of Research and Development on Photovoltaic Energy (IRDEP), UMR 7174 CNRS-EDF- Chimie ParisTech, Chatou, France, ³Institut Photovoltaïque d'Ile-de-France (IPVF), 8 rue de la Renaissance, Antony, France

- 2:45 **Non-Destructive Contact Resistivity Measurements on Solar Cells Using the Circular Transmission Line Method**

Andrew M. Gabor¹, Geoffrey S. Gregory², Rob Janoch¹, Andrew Anselmo¹, Kristopher O. Davis²
¹BrightSpot Automation, Westford, MA, United States, ²Florida Solar Energy Center, Orlando, FL, United States

Area 7 - Oral

1:30 - 3:00 PM

Delaware B

Space systems and component technologies

Chair(s): Scott Billets, Mikael Thibaudeau

- 1:30 **Radiation Resistance of Low Cost High Efficiency Triple Junction solar cells**
Roberta Campesato¹, Erminio Greco¹, Giuseppe Gabetta¹, Mariacristina Casale¹, Gabriele Gori¹, M Sankaran², B.R. Uma², Suresh Puthanveetil², DR.M. Ravindra², Sheeja Krishnan³
¹CESI S.p.A, Milan, Italy, ²ISRO, Bangalore, India, ³Shree Devi Institute of Technology, Mangalore, India
- 1:45 **Amorphous Silicon Carbide Rear-Side Passivation and Reflector Layer Stacks for Multi-Junction Space Solar Cells based on Germanium Substrates**
Stefan Janz¹, Charlotte Weiss¹, Rufi Kurstjens², Bruno Boizot³, Bianca Fuhrmann⁴, Victor Khorenko⁴
¹Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany, ²Umicore Electro-optic Materials, Olen, Belgium, ³Laboratoire des Solides Irradiés, Paris, France, ⁴AZUR SPACE Solar Power GmbH, Heilbronn, Germany
- 2:00 **Integration of Crack-Tolerant Composite Gridlines on Triple Junction Photovoltaic Cells**
Omar K Abudayyeh¹, Geoffrey K Bradshaw², Steven Whipple³, David M Wilt², Sang M Han¹
¹University of New Mexico, Albuquerque, NM, United States, ²Air Force Research Laboratory, Albuquerque, NM, United States, ³SolAero Technologies, Albuquerque, NM, United States
- 2:15 **Subcell Light Current-Voltage Characterization of Irradiated Multijunction Solar Cell**
Don Walker, John Nocerino, Yao Yue, Colin J. Mann, Simon H. Liu
The Aerospace Corporation, El Segundo, CA, United States
- 2:30 **Evaluating the Emissivity of Pseudomorphic Glass**
Ryan Beauchemin¹, David Wilt²
¹Applied Technology Associates, Albuquerque, NM, United States, ²US Air Force Research Lab, Albuquerque, NM, United States
- 2:45 **Analytical Method for Predicting Spacecraft Power Generation on Partially Shaded Solar Panels**
Gordon Wu, Bao Hoang
Space Systems/Loral, Palo Alto, CA, United States

Area 11 - Oral

1:30 - 3:00 PM

Delaware A

Solar Resource Measurement and Applications for PV

Chair(s): Tom Stoffel, Kelsey Yates

- 1:30 **Best Student Presentation Award Finalist**
Characterizing the Impact of Solar Spectral Irradiance on PV Module Output
Markus Schweiger, Werner Herrmann
TÜV Rheinland Energy GmbH, Cologne, Germany
- 1:45 **Use of Measured Aerosol Optical Depth and Precipitable Water to Model Clear Sky Irradiance**
Mark A. Mikofski¹, Clifford W. Hansen², William F. Holmgren³, Gregory M. Kimball¹
¹SunPower Corporation, Richmond, CA, United States, ²Sandia National Laboratories, Albuquerque, NM, United States, ³University of Arizona, Tucson, AZ, United States

2:00 **Recent Advancements in the Numerical Simulation of Surface Irradiance for Solar Energy Applications**

Yu Xie, Manajit Sengupta, Chris Deline

National Renewable Energy Laboratory, Golden, CO, United States

2:15 **Optimal Irradiance Sensor Placement for Photovoltaic Systems Using Mutual Information Based Greedy Algorithm in Gaussian Process**

Lianlian Jiang¹, Srivatsan Ramasubramanian¹, Douglas L Maskell²

¹*Energy Research Institute @ NTU, Singapore, Singapore*, ²*School of computer Science and Engineering, Nanyang Technological University, Singapore, Singapore*

2:30 **Best Student Presentation Award Finalist**

Evaluating different upscaling approaches to derive the actual power of distributed PV systems

Sven Killinger^{1,2}, Björn Müller¹, Bernhard Wille-Haussmann¹, Russell McKenna²

¹*Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany*, ²*Chair for Energy Economics, Karlsruhe, Germany*

2:45 **Advances in long-term solar energy prediction and project risk assessment methodology**

Alemu Tadesse¹, Adam Kankiewicz¹, Alex Kubinieć¹, Tom Hoff¹, Skip Dise¹, Richard Perez²

¹*Clean Power Research, Kirkland, WA, United States*, ²*SUNY, Albany, NY, United States*

Break	
3:00 - 3:30 PM	Ballroom Foyer
Coffee Break	

Area 2 - Poster	
3:30 - 5:00 PM	Exhibit Hall D
Progress in Absorber, Buffer, and Window Layers	

Chair(s): Aaron Arehart, Amit Munshi, Heayoung Yoon

ePoster **Decoupling Thin Film CdTe Growth from Packaging: Toward Record Specific Power in Low Cost Polycrystalline PV**

Deborah L Clayton-Warwick^{1,2}, Matthew S Dabney¹, Teresa M Barnes¹, Michael D Kempe¹, Colin A Wolden², Matthew O Reese¹

¹*National Renewable Energy Laboratory, Golden, CO, United States*, ²*Colorado School of Mines, Golden, CO, United States*

A30 **Non-vacuum Process of Ga-doped ZnO Films using Diethylzinc Solution**

Kenji Yoshino¹, Himeka Tominaga¹, Shigeru Ikeda², Takashi Minemoto³

¹*University of Miyazaki, Miyazaki, Japan*, ²*Osaka University, Osaka, Japan*, ³*Ritsumeikan University, Shiga, Japan*

A2 **Junction Activation of CdTe/CdS Solar Cell Using MgCl₂**

Gonzalo Angeles-Ordóñez, Eulises Regalado-Pérez, Martin G Reyes-Banda, Nini R Mathews, Xavier Mathew

Instituto de Energías Renovables, Universidad Nacional Autónoma de México, Temixco Morelos, Mexico

- A4 **Variation of Cu Content of Sprayed Cu(In,Ga)(S,Se)₂ Solar Cells Based on a Thiol-Amine Solvent Mixture**
Panagiota Arnou¹, Soňa Uličná¹, Alexander Eeles¹, Mustafa Togay¹, Lewis D. Wright¹, Andrei V. Malkov², John M. Walls¹, Jake W. Bowers¹
¹CREST, Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, United Kingdom, ²Department of Chemistry, Loughborough University, Loughborough, United Kingdom
- A6 **CuInSe₂ absorber layer grown under copper excess with a copper poor surface formed by a KF post deposition treatment**
Finn Babbe, Hossam Elanzeery, Michele Melchiorre, Susanne Siebentritt
University of Luxembourg, Belvaux, Luxembourg
- A8 **Cu₂ZnSnSe₄ Solar Cells onto Polyimide Substrates Fabricated at Low Temperature**
Ignacio Becerril-Romero, Simón López-Marino, Moisés Espíndola-Rodríguez, Laura Acebo, Markus Neuschitzer, Yudania Sánchez, Edgardo Saucedo, Paul Pistor
Catalonia Institute for Energy Research, Sant Adrià del Besòs - Barcelona, Spain
- A10 **Above 9 % Efficient Earth-abundant Cu₂ZnSn(S,Se)₄ Solar Cells with Introducing Interfacial Alkali Fluoride Layers**
Cheng-Ying Chen¹, Wei-Chao Chen¹, Bandiyah Sri Aprillia^{1,2,3}, Naili Saidatin^{1,2,3}, Kuei-Hsien Chen³, Li-Chyong Chen¹
¹Center for Condensed Matter Sciences, National Taiwan University, Taipei, Taiwan, ²Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taipei, Taiwan, ³Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei, Taiwan
- A12 **An optimized photolithography recipe for Cu(In_{1-x}Ga_x)(S_ySe_{1-y})₂ (CIGS_{Se}) solar cells**
Xia Hao¹, Shenghao Wang^{*1}, Katsuhiko Akimoto¹, Takuya Kato², Hiroki Sugimoto², Takeaki Sakurai¹
¹Institute of Applied Physics, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan, ²Atsugi Research Center, Solar Frontier K. K., Atsugi, Kanagawa, 243-0206, Japan
- A14 **Effects of CdCl₂ Passivation on Thin CdTe Absorbers Fabricated by Close Space Sublimation**
Alexandra M. Huss, Anna Wojtowicz, Jennifer A. Drayton, James R. Sites
Colorado State University Department of Physics, Fort Collins, CO, United States
- A16 **CdS_{1-x}Se_x Window Layer for CdTe Prepared by the Exchange of S with Se in CdS Films**
Geethika K. Liyanage, Adam B. Phillips, Zhaoning Song, Suneth C. Waththage, Ramez H. Ahangharnejhad, Michael J. Heben
Wright Center for Photovoltaics Innovation and Commercialization, Department of Physics and Astronomy, University of Toledo, Toledo, OH, United States
- A18 **Effect of Illumination on Thermal Chlorine Treatment of CdTe**
Sudhajit Misra¹, Carina E. Hahn¹, Vasilios Palekis², Christos Ferekides², Michael A Scarpulla¹
¹University of Utah, Salt Lake City, UT, United States, ²University of South Florida, Tampa, FL, United States
- A20 **Challenges in the industrial production of CZTS monograin solar cells**
Gerhard Peharz¹, Valentin Satzinger¹, Sandra Pötzt², Gernot Oreski², Theodoros Dimopoulos³, Stefan Edinger³, Wolfgang Hackl⁴, Hannes Starkl⁴, Parichehr Esfandiari⁵, Peter Krabb⁵, Lukas Plessing⁵, Stefan Gahr⁵, Dieter Meissner^{5,6}
¹JOANNEUM RESEARCH, Weiz, Austria, ²PCCL, Leoben, Austria, ³AIT, Vienna, Austria, ⁴Forster FF, Waidhofen, Austria, ⁵crystalsol, Vienna, Austria, ⁶Tallinn University of Technology, Tallin, Estonia

- A26 Cation/Anion Doped Nanoparticles: Ink to Nanostructured Films**
 Rekha Yadav¹, Balakrishna Ananthoju², Prof. Mohammad Aslam³
¹1, Mumbai, India, ²2, Mumbai, India, ³3, Mumbai, India
- A28 Growth and properties of epitaxial Cu(In, Ga)Se₂ thin films deposited by the three-stage process for solar cells**
 Takeru Yamagami¹, Yuta Ando¹, Ishwor khatri², Mutsumi Sugiyama^{1,2}, Tokio Nakada²
¹Faculty of Science and Technology Tokyo university of science, Noda, Japan, ²Research Institute for Science and Technology Tokyo university of science, Noda, Japan
- A31 Improvement of CIS Solar Cells with KF Postdeposition Following a Simple Two-Step Selenization Process**
 Yang Zhang, Robert E. Bartolo, Sang Jik Kwon, Mario Dagenais
 University of Maryland, College Park, MD, United States
- B1 The Twins Structure, Electrical Properties and Cell Performance of Magnetron Sputtering Deposited Chlorine Doped CdTe**
 Ziyao Zhu^{1,2}, Xiangxin Liu^{1,2}, Fu-Kuo Chiang³, Zhongming Du^{1,2}, Yufeng Zhang^{1,2}
¹The Key Laboratory of Solar Thermal Energy and Photovoltaic System, Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing, China, ²University of Chinese Academy of Sciences, Beijing, China, ³National Institute of Clean and Low Carbon Energy, Beijing, China
- A22 Understanding Instabilities and Degradation due to Moisture Ingress in Cu(In,Ga)Se₂ Solar Cells**
 Grace Rajan¹, Shankar Karki¹, Isaac Butt¹, Krishna Aryal¹, Tyler Grassman^{3,4}, Angus Rockett², Sylvain Marsillac¹
¹Virginia Institute of Photovoltaic, Old Dominion University, Norfolk, VA, United States,
²Metallurgical and Material Engineering, Colorado School of Mines, Golden, CO, United States,
³Department of Materials Science and Engineering, The Ohio State University, Columbus, OH, United States, ⁴Department of Electrical and Computer Engineering, The Ohio State University, Columbus, OH, United States
- A24 Control of MoSe₂ formation in hydrazine-free solution-processed CIS/CIGS thin film solar cells**
 Sona Ulicna¹, Panagiota Arnou¹, Alexander Eeles¹, Mustafa Togay¹, Lewis D. Wright¹, Ali Abbas¹, Andrei V. Malkov², John M. Walls¹, Jake W. Bowers¹
¹CREST, Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, United Kingdom, ²Department of Chemistry, Loughborough University, Loughborough, United Kingdom

Area 3 - Poster

3:30 - 5:00 PM

Exhibit Hall E

III-V Cells

Chair(s): John Geisz, Karin Hinzer, Ivan Garcia

- B8 Comparative Study of >2 eV Lattice-Matched and Metamorphic (Al)GaInP Materials and Solar Cells Grown by MOCVD**
 Daniel J. Chmielewski, Christine Jackson, Jacob Boyer, Daniel Lepkowski, John A. Carlin, Aaron R. Arehart, Tyler J. Grassman, Steven A. Ringel
 The Ohio State University, Columbus, OH, United States

- B10 Multi Junction Solar Cells Under Current Matching Conditions: Genetic Algorithm Approach for 50% Efficiency**
Slobodan Cicic, Stanko Tomic
University of Salford, Manchester, United Kingdom
- B45 35.1% Efficient Dual-Junction Solar Cells Optimized for Direct Hydrogen Generation**
Jens Ohlmann, David Lackner, Juan Francisco Sanchez, Mario Zedda, Alexander Wekkeli, Marc Steiner, Arne Fallisch, Frank Dimroth
Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany
- C1 Simulation of the performances of multijunction solar cells with improved voltage by transfer and scattering matrix methods**
Gianluca Timò^{1,2}, Lucio Andreani²
¹*RSE, Piacenza, Italy*, ²*University of Pavia, Pavia, Italy*
- B24 Evaluation of Tandem efficiencies: Dilute nitride p-i-n (bulk or MQWs) in conjunction with practical Si Solar cells.**
Khim Kharel, Alexandre Freundlich
University of Houston, Houston, TX, United States
- B4 Detailed Characterization for TCAD Simulations of GaAs_{0.76}P_{0.24}/Si_{1-y}Ge_y/Si Single Junction Solar Cells**
Sabina Abdul Hadi¹, Timothy Milakovich², Eugene A. Fitzgerald², Ammar Nayfeh¹
¹*Masdar Institute of Science and Technology, Abu Dhabi, United Arab Emirates*, ²*Massachusetts Institute of Technology, Cambridge, MA, United States*
- B6 Fabrication of InGaAsP Solar Cells for Concentrator Applications**
Mitchell F. Bennett^{1,2}, Matthew P. Lumb^{1,3}, Kenneth J. Schmieder¹, Brent Fisher⁴, Eric A. Armour⁵, Robert J. Walters¹
¹*Naval Research Laboratory, Washington, DC, United States*, ²*Sotera Defense Solutions, Annapolis, MD, United States*, ³*George Washington University, Washington, DC, United States*, ⁴*Semprius Inc., Durham, NC, United States*, ⁵*Veeco MOCVD, Somerset, NJ, United States*
- B12 Performance of GaSb Photovoltaics with Graphene Coating**
Benjamin P Conlon¹, Daniel J Herrera¹, Shaimaa A Abdallah¹, Jonathan O Okafor², Luke F Lester¹
¹*Virginia Polytechnic Institute and State University, Blacksburg, VA, United States*, ²*Norfolk State University, Norfolk, VA, United States*
- B14 Over 30% efficiency single-junction photovoltaic devices under low intensity light illumination**
Yushuai Dai, Hyun Kum, Micheal A Slocum, Seth M Hubbard
Rochester Institute of Technology, Rochester, NY, United States
- B16 Radiation resistant of upright metamorphic GaInP/GaInAs/Ge triple junction solar cells for space use**
Liang Fang¹, Abuduwayiti Aierken², Zhen Pan¹, Qiming Zhang², Zhanhang Li¹, Heini Maliya², Wei Gao¹, Hui Gao¹, Ronghua Wan¹, Bao Zhang¹, He Wang¹, Qi Guo²
¹*Tianjin Institute of Power Sources, Tianjin, China*, ²*Xinjiang Technical Institute of Phys. & Chem., Chinese Academy of Sciences, Urumqi, China*
- B18 High Efficiency Glass Waveguiding Solar Concentrator**
Chehao hu, Yusuf Dogan, Matthew Morrison, Arnab Nanda, Dangang Ma, Robert Robert, Christi K. Madsen
Texas A&M University, college station, TX, United States

- B20 Highly thermal robust InGaN/GaN Multi-Quantum Well (MQW) Solar Cells**
 Xuanqi Huang, Houqiang Fu, Hong Chen, Zhijian Lu, Jossue Montes, Yuji Zhao
School of Electrical, Computer & Energy Engineering, Arizona State University, TEMPE, AZ, United States
- B22 GaInAsP/GaInAs Tandem Solar Cell with 32.6% One-Sun Efficiency**
 Nikhil Jain, Kevin L. Schulte, John F. Geisz, Ryan M. France, Myles A. Steiner
National Renewable Energy Laboratory, Golden, CO, United States
- B26 Gallium Phosphide nanostructure on Silicon by Silica nanospheres lithography and Metal Assisted Chemical Etching**
 Sangpyeong Kim, Chaomin Zhang, Som Dahal, Stuart Bowden, Christiana Honsberg
Arizona State University, Tempe, AZ, United States
- B28 Efficiency Enhancement of InGaP/InGaAs/Ge Solar Cells with Gradually Doped P-N Junction Active Layers**
 Youngjo Kim¹, Sang Hyun Jung¹, Chang Zoo Kim¹, Kangho Kim^{1,2}, Hyun-Beom Shin¹, Kyung Ho Park¹, Won-Kyu Park¹, Jaejin Lee², Ho Kwan Kang¹
¹*Korea Advanced Nano Fab Center, Suwon, South Korea, ²Ajou University, Suwon, South Korea*
- B30 Analysis of InGaP Oxide Growth Rate at High Temperatures and Ambient Conditions for Terrestrial Photovoltaic Applications**
 Nicole A. Kotulak¹, Matthew P. Lumb^{2,3}, Raymond Hoheisel^{2,3}, Erin Cleveland³, Mitchell Bennett⁴, Phillip P. Jenkins³, Robert J. Walters³
¹*NRC Postdoctoral Associate at U.S. Naval Research Laboratory, Washington, DC, United States, ²George Washington University, Washington, DC, United States, ³U.S. Naval Research Laboratory, Washington, DC, United States, ⁴Sotera Defense Solutions, Inc., Herndon, VA, United States*
- B32 Grain boundaries in Thin-Film Polycrystalline GaAs Solar Cells: A Simulation Study**
 Khushboo Kumari¹, Sushobhan Avasthi¹
¹*Centre for nanoscience and Engineering, Indian Institute of Science Bangalore, Bengaluru, India, ²Centre for nanoscience and Engineering, Indian Institute of Science Bangalore, Bengaluru, India*
- B34 Time-resolved PL measurements in the growth of high voltage (Al)GaInP/GaAs solar cells**
 Xinyi Li, Hongbo Lu, Wei Zhang
State Key Lab for Space Power Technology, Shanghai, China
- B36 Investigation of Direct MOCVD Epitaxial Growth Time of III-V Alloys on Mo for Low Cost PV Applications**
 Marlene L Lichty¹, Sean J Babcock¹, Tasnuva Ashrafee¹, Grace Rajan¹, Sylvain Marsillac¹, Seth M Hubbard², Elisabeth L McClure², Christopher G Bailey¹
¹*Old Dominion University, Norfolk, VA, United States, ²Rochester Institute of Technology, Rochester, NY, United States*
- B38 Low-Resistance and Highly-Transparent GaSb-based Tunnel Junctions**
 Matthew P Lumb^{1,2}, Shawn Mack², Maria Gonzalez^{3,2}, Kenneth J Schmieder², Mitchell F Bennett^{3,2}, Chaffra A Affouda², James E Moore^{1,2}, Robert J Walters²
¹*The George Washington University, Washington, DC, United States, ²US Naval Research Laboratory, Washington, DC, United States, ³Sotera Defense Solutions, Annapolis Junction, MD, United States*
- B39 Modulated Photocurrent Measurements in Double Junction Solar Cells**
 Nicolas S. Marquez Peraca, Behrang H. Hamadani
National Institute of Standards and Technology, Gaithersburg, MD, United States

B41 Effect of Atmospheric Absorption Bands on the Optimal Design of Multijunction Solar Cells

William E. McMahon, Daniel J. Friedman, John F. Geisz
National Renewable Energy Laboratory, Golden, CO, United States

ePoster **Investigation and Mitigation of Shunts for Higher Efficiency Epitaxial GaSb/GaSb and GaSb/GaAs Solar Cells**

George T Nelson¹, Bor-Chau Juang², Steve Johnston³, Michael A Slocum¹, Zachary S Bittner¹, Ramesh B Lagumavarapu², Diana Huffaker², Seth M Hubbard¹

¹*Rochester Institute of Technology, Rochester, NY, United States*, ²*University of California, Los Angeles, Los Angeles, CA, United States*, ³*National Renewable Energy Labs, Golden, CO, United States*

B47 "Numerical simulation of defects in GaAs PV cells: the effect of voltage bias and doping concentration"

Vasiliki Paraskeva, Constantinos Lazarou, Andreas Livera, Venizelos Venizelou, Maria Hadjipanayi, George Georgiou
University of Cyprus, Nicosia, Cyprus

B49 Improvement of open-circuit voltage in metamorphic GaSb cells grown on GaAs substrates by using an interfacial misfit array and an AlSb blocking layer

Emma J. Renteria, Sadhvikas J. Addamane, Darryl M. Shima, Ahmad Mansoori, Amy L. Soudachanh, Ganesh Balakrishnan
Center for High Technology Materials, University of New Mexico, Albuquerque, NM, United States

ePoster **Development of GaSb solar cells on GaAs by MOVPE via interface misfit technique**

Michael A Slocum, Alessandro Giussani, George T. Nelson, Emily Kessler, Seth M. Hubbard
Rochester Institute of Technology, Rochester, NY, United States

B51 Energy yield evaluation for field operation of solar cells in Singapore: GaAs/GaAs tandem vs. GaAs single-junction solar cells

Maung Thway^{1,2}, Zekun Ren³, Kevin Nay Yaung³, Liu Haohui¹, Liu Zhe¹, Samuel Raj¹, Soo Jin Chua², Amrin G. Aberle^{1,2}, Tonio Buonassisi^{3,4}, Ian Marius Peters⁴, Fen Lin¹

¹*Solar Energy Research Institute of Singapore (SERIS), National University of Singapore, 7 Engineering Drive 1, 117574, Singapore, Singapore*, ²*Department of Electrical and Computer Engineering, National University of Singapore, 4 Engineering Drive 3, 117583, Singapore, Singapore*, ³*Singapore-MIT Alliance for Research and Technology (SMART), 1 CREATE Way, 138602, Singapore, Singapore*, ⁴*Massachusetts Institute of Technology (MIT), 77 Massachusetts Avenue, Cambridge, MA 02139, Boston, MA, United States*

C3 Optimized Design of Back-Contact Thin-Film GaAs Solar Cells

Jia-Ling Tsai¹, Chung-Yu Hong^{1,3}, Tien-Chien Zhan¹, Yuh-Renn Wu², Albert Lin⁴, Peichen Yu¹
¹*Department of Photonic & Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan*, ²*Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan*, ³*Arima Photovoltaic & Optical Corporation, Hsinchu, Taiwan*, ⁴*Department of Electronics Engineering, National Chiao Tung University, Hsinchu, Taiwan*

C5 Design consideration on GaInNAs solar cells with back surface reflectors

Antti Tukiainen, Arto Aho, Timo Aho, Ville Polojärvi, Mircea Guina
Optoelectronics Research Centre, Tampere University of Technology, Tampere, Finland

C7 Quantitative Electroluminescence Analysis of Triple Junction Solar Cells to Determine Subcell Voltage-Temperature Coefficients

Kevin D Tyler¹, Geoffrey K Bradshaw², Sam Wilt³, David M Wilt², Richard R King¹

¹*Arizona State University, Tempe, AZ, United States*, ²*United States Air Force Research Laboratory, Albuquerque, NM, United States*, ³*University of New Mexico, Albuquerque, NM, United States*

- C9 Progress Towards High Efficiency Double-Junction InGaN Solar Cell**
 Ehsan Vadiee¹, Heather McFavilen³, Alec Fischer¹, Evan A. Clinton², Yi Fang¹, Joshua Williams¹,
 Christiana B. Honsberg¹, William A. Doolittle², Stephen Goodnick¹
¹Arizona State University, Tempe, AZ, United States, ²Georgia Institute of Technology, Atlanta,
 GA, United States, ³Photonitride Devices Inc., Tempe, AZ, United States
- C11 Broadband Ta₂O₅ Moth-eye Antireflection Coatings for Tandem Solar Cells on Si**
 Bo Yuan¹, Brian Thibeault², David.N. Payne³, James Mutitu⁴, Ivan Perez-Wurfl³, Kevin Dobson⁴,
 Brianna Conrad³, Allen Barnett³, Robert.L. Opila^{1,5}
¹Department of Chemistry and Biochemistry, University of Delaware, Newark, DE, United States,
²Department of Electrical and Computer Engineering, University of California Santa Barbara, Santa
 Barbara, CA, United States, ³School of Photovoltaic and Renewable Energy Engineering,
 University of New South Wales, Sydney, Australia, ⁴Institute of Energy Conversion, University of
 Delaware, Newark, DE, United States, ⁵Department of Materials Science and Engineering,
 University of Delaware, Newark, DE, United States
- B43 Effects of Contact Configuration and Perimeter Recombination on Optimal Cell Size for High
 Concentration Photovoltaics**
 James E Moore^{1,2}, Matthew Lumb^{1,2}, Ken Schmieder², Robert J Walters², Brent Fisher³, Matt
 Meitl³, Scott Burroughs³
¹The George Washington University, Washington, DC, United States, ²U.S. Naval Research
 Laboratory, Washington, DC, United States, ³Semprius Inc., Durham, NC, United States

Area 4 - Poster

3:30 - 5:00 PM

Exhibit Hall A

Modeling, Light Management and Passivation

Chair(s): Marius Peters, Sachit Grover, Bram Hoex

- C45 SiN_x thin films with appropriate antireflection and shift-conversion properties for silicon
 solar cells**
 Elis Mon-Pérez¹, Jenifer Salazar¹, Ateet Dutt¹, Jaime Santoyo-Salazar², Guillermo Santana¹
¹Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México. A.P. 70-
 360, Coyoacán, C.P. 04510, Mexico City, Mexico, ²Departamento de Física, CINVESTAV-IPN, A.
 P. 14-740, C. P. 07000, Mexico City, Mexico
- C49 Interdigitated Back Contact Silicon Solar Cell with Perovskite layer for Front Surface
 Passivation and Ultraviolet Radiation Stability**
 Rahul Pandey, Shivam Gupta, Trijul Khatri, Rishu Chaujar
 Delhi Technological University, New Delhi, India
- C15 Improving Silicon Surface Passivation with a Silicon Oxide Layer Grown via Ozonated
 Deionized Water**
 Sara Bakhshi^{1,2}, Kristopher Davis^{1,2}, Ngwe Zin^{1,2}, Marshall Wilson³, Winston Schoenfeld^{1,2}
¹University of Central Florida, Orlando, FL, United States, ²Florida solar energy center, Orlando,
 FL, United States, ³SemilabSDI, Tampa, FL, United States
- C17 Ultrathin epitaxial silicon solar cells with inverted nanopyramid arrays for efficient light
 trapping**
 Andrea Cattoni¹, Alexandre Gaucher¹, Christophe Dupuis¹, Wanghua Chen², Romain Cariou²,
 Martin Foldyna², Loïc Lalouat³, Emmanuel Drouard³, Christian Seassal³, Pere Roca i Cabarrocas²,
 Stéphane Collin¹
¹Centre de Nanosciences et de Nanotechnologies (C2N), CNRS, Université Paris-Sud, Université

Paris-Saclay, Marcoussis, France, ²LPICM, CNRS, Ecole Polytechnique, Université Paris-Saclay, Palaiseau, France, ³Institut des Nanotechnologies de Lyon (INL), Université de Lyon, UMR5270, CNRS-INSA-ECL-UCBL, Ecole Centrale de Lyon,, Ecully, France

- C19 Deposition of SiOC by plasma-free ultra-low-temperature ALD (ULT-ALD) and its passivation on p-type silicon**
Meixi Chen¹, Naoto Noda², Raphael Rochat², Abhishek Iyer¹, James H. Hack¹, Changhee Ko², Christian Dussarrat², Robert L. Opila¹
¹University of Delaware, Newark, DE, United States, ²K.K. Air Liquide Laboratories, Tsukuba, Japan
- C21 A Method for Quantitatively Investigating the Rear-Side Passivation Performance of PERC cells**
Tsung-Cheng Chen, Yung-Sheng Lin, Chen-Hao Ku, Ting-Wei Kuo, Cheng-Shun Hu, Ching-Chang Wen
E-ton Solar Tech, Tainan, Taiwan
- C23 Field-Effect Passivation by Negative Charge on Boron Emitter and Boron-doped Surfaces by a Novel Low-cost Plasma Charge Injection**
Eunhwan Cho¹, Young-Woo Ok¹, James Hwang², Aditi Jain¹, Vijay D. Upadhyaya¹, John Keith Tate¹, Ajeet Rohatgi¹
¹Georgia Institute of Technology, Atlanta, GA, United States, ²Amtech Systems Inc., Tempe, AZ, United States
- C25 Industry Relevant RIE Texturing for Mc-Si Diamond Wire or Direct Wafer® Product: Optimized Reflectivity, Uniformity, and Throughput**
Jose L. Cruz-Campa, Ray Fraser, Rob Steeman, John Linton
1366 Technologies, Bedford, MA, United States
- C27 Short-Circuit Current-Density Enhancement of Silicon Solar Cells Using Plasmonics Antireflective Coating and Luminescent Downshifting**
Sheng-Kai Feng, Wen-Jeng Ho, Guan-Yi Li, Jheng-Jie Liu, Hao-Yu Yang, Ta-Wei Chuang
National Taipei University of Technology, Taipei, Taiwan
- C29 Extremely Low Reflectivity Nanoporous Black Silicon Surface by Copper Catalyzed Etching for Efficient Solar Cells**
K A S M Ehteshamul Haque, Wenqi Duan, Fatima Toor
Department of Electrical and Computer Engineering, University of Iowa, Iowa City, IA, United States
- C31 Impact of front side pyramid size on the light trapping performance of wafer based silicon solar cells and modules**
Oliver Höhn, Nico Tucher, Benedikt Bläsi
Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany
- C33 A Study of Blister Control of Al₂O₃ Thin Film Deposited by Plasma-assisted Atomic Layer Deposition after Firing Process**
Min Gu Kang¹, Jeong In Lee¹, Hee-eun Song¹, Myeong Sang Jeong¹, Kyung Taek Jeong¹, Hyo Sik Chang²
¹Korea Institute of Energy Research, Daejeon, South Korea, ²Chungnam National University, Daejeon, South Korea
- C35 Plasma Texturing of Silicon Solar Cells for Mass Production and its Self-Masking Process**
Dominik Lausch^{1,2}, Jens Hirsch², Maria Gaudig², Volker Naumann¹, Stephan Großer¹, Norbert Bernhard²

¹Fraunhofer Center for Silicon Photovoltaics CSP, Halle (Saale), Germany, ²Anhalt University of Applied Sciences, Köthen, Germany

C39 Improvement in Surface Passivation of c-Si Using Gradient-Layered a-Si:H Film for High Efficiency Silicon Heterojunction Solar Cells

Soonil Lee¹, Leo Mathew², Rajesh Rao², Jae Hyun Kim¹, Edward T. Yu¹

¹Microelectronics Research Center, University of Texas at Austin, Austin, TX, United States,

²Applied Novel Devices Inc., Austin, TX, United States

C41 Photovoltaic Performance Enhancement of Textured Silicon Solar Cells Using Luminescent Down-Shifting Methylammonium Lead Tribromide Perovskite Nanophosphors

Guan-Yi Li¹, Wen-Jeng Ho¹, Sheng-Kai Feng¹, Jheng-Jie Liu¹, Hao-Yu Yang¹, Ta-Wei Chuang¹, Bang-Jin You¹, Zong-Xian Lin¹, Zong-Liang Tseng¹, Lung-Chien Chen¹

¹National Taipei University of Technology, Taipei, Taiwan, ²National Taipei University of Technology, Taipei, Taiwan

C47 Numerical Simulation of Crystalline Silicon Solar Cells with Full Area Metal Oxide Rear Contacts

James E Moore^{1,2}, Woojun Yoon², Phillip P Jenkins², Robert J Walters²

¹The George Washington University, Washington, DC, United States, ²U.S. Naval Research Laboratory, Washington, DC, United States

C51 Potential of a-Si:H/c-Si heterojunction solar cells with very thin wafers

Hitoshi Sai^{1,2}, Hiroshi Umishio^{1,3}, Takuya Matsui^{1,2}, Shota Nunomura^{1,2}, Tomoyuki Kawatsu⁴, Hidetaka Takato², Koji Matsubara^{1,2}

¹RCPV, AIST, Tsukuba, Japan, ²FREA, AIST, Koriyama, Japan, ³Tsukuba Univ., Tsukuba, Japan,

⁴Komatsu NTC Ltd., Nanto, Japan

C53 Manipulating Fixed Charges in ZrO₂ by Doping for Passivation and Antireflection on Wafer-Si Solar Cells

Woo Jung Shin¹, Laidong Wang², Wen-Hsi Huang², Meng Tao²

¹School for Engineering of Matter, Transport and Energy, Arizona State University, Tempe, AZ, United States, ²School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, United States

C55 Low temperature antireflection coating for Silicon Solar cells

Onkar S Shinde^{1,2}, Eric J Schneller¹, Neelkanth Dhere¹, Subhash V Ghaisas³

¹Florida Solar Energy Centre, University of central Florida, Orlando, FL, United States, ²Department of Electronics Science, Savitribai Phule Pune University, Pune, India, ³Indian Institute of Bombay, Mumbai, India

D3 A New Low-Cost and Low-Temperature Chemical Passivation Process for Large Area Industrial Single Crystalline Silicon Wafers

Tarun S. Yadav^{1,2}, Sandeep K.¹, Ashok K. Sharma¹, Spandana B.¹, K.L. Narasimhan^{1,2}, B.M. Arora^{1,2}, Anil Kottantharayil^{1,2}, Prabir K. Basu¹

¹National Centre for Photovoltaics for Research and Education (NCPRE), Indian Institute of Technology Bombay, Mumbai, India, ²Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, India

D5 Evaluation of ALD Passivation Layers for Industrial PERC Process

Chang Youn Yoo, Keunkee Hong, Jisun Kim, Eunjoo Lee, Dong Seop Kim

Technical Research Center, Shinsung Solar Energy Co., Ltd., Gyeonggi-do, Korea

C14 Carrier transport in polycrystalline silicon at high optical injection: transient photoconductance vs. numerical modeling

Uchechi Anyanwu, Christian Harris, Andrey Semichaevsky
Lincoln University (PA), Lincoln University, PA, United States

C37 Pypvcell: An Open-Source Solar Cell Modeling Library in Python

Kan-Hua Lee, Kenji Araki, Omar Elleuch, Nobuaki Kojima, Masafumi Yamaguchi
Toyota Technological Institute, Nagoya, Japan

C43 Physical Device Simulation of Partial-Dopant-Free Asymmetric Silicon Heterostructure Solar Cell (P-DASH) based on Hole-selective Molybdenum Oxide (MoO_x) with Crystalline Silicon (cSi)

Haris Mehmood¹, Hisham Nasser², Engin Özkol², Tauseef Tauqeer³, Shahzad Hussain⁴, Raşit Turan²

¹School of Electrical Engineering and Computer Science (SEECs), National University of Sciences and Technology (NUST), Islamabad, Pakistan, ²Centre for Solar Energy Research and Applications (GÜNAM), Middle East Technical University (METU), Ankara, Turkey, ³Information Technology University, Lahore, Pakistan, ⁴School of Chemical and Materials Engineering (SCME), National University of Sciences and Technology (NUST), Islamabad, Pakistan

ePoster A Physics-Based Simulation Tool for Leakage Currents in c-Si PV Modules

John M Waddle, Saroj Dahal, Marco Nardone
Bowling Green State University, Bowling Green, OH, United States

D1 Relationship between Power Loss and Voltage Applied to Solar Cells in PID-affected Solar Modules

Fumei Wang¹, Baosong Duan², Wenshuang He¹, He Wang¹, Hong Yang¹, Chengfeng Su³, Bojie Su⁴, Xue Zhang⁴, Yunxue Cao⁵, Hui Zhao⁵

¹Xi'an Jiaotong University, Xi'an, China, ²Xi'an Communications Institute, Xi'an, China, ³Taizhou Chisolar Co., Ltd., Taizhou, China, ⁴China Quality Certification Center, Beijing, China, ⁵SPIC Power Plant Operation Technology Co., Ltd, Beijing, China

D7 Gap passivation structure for scalable n-type interdigitated all back contact silicon hetero-junction solar cell

Lei Zhang^{1,2}, Ujjwal K Das², Steven S Hegedus^{1,2}

¹Department of Electrical and Computer Engineering, University of Delaware, Newark, DE, United States, ²Institute of Energy Conversion, University of Delaware, Newark, DE, United States

Area 5 - Poster

3:30 - 5:00 PM

Exhibit Hall F

Characterization I

Chair(s): Marina Leite, Greg Kimball, Helio Moutinho

D14 Photoexcited Carriers, Phonons, and their Scattering Measured in Semiconductor Junctions by Transient Extreme Ultraviolet Spectroscopy

Scott K. Cushing^{1,2}, Brett M. Marsh¹, Mihai E. Vaida¹, Lucas M. Carneiro¹, Ilana J. Porter¹, Angela Lee¹, Stephen R. Leone^{1,2,3}

¹Department of Chemistry, UC Berkeley, Berkeley, CA, United States, ²Chemical Sciences Division, Lawrence Berkeley National Labs, Berkeley, CA, United States, ³Department of Physics, UC Berkeley, Berkeley, CA, United States

D17 High Resolution 3D Chemical Characterisation of a Cadmium Telluride Solar Cell by Dynamic SIMS

Thomas Fiducia¹, Kexue Li², Chris Grovenor², Kurt Barth³, Walajabad Sampath³, Michael Walls¹

¹Loughborough University, Loughborough, United Kingdom, ²Oxford University, Oxford, United Kingdom, ³Colorado State University, Fort Collins, CO, United States

D27 Extended linear interpolation/extrapolation procedure for accurate and versatile translation of the I-V curves of PV cells and modules

Yoshihiro HISHIKAWA, Hironori OHSHIMA, Michiya HIGA, Kengo YAMAGOE, Takakazu TAKENOUCHI, Takuya DOI
AIST, Tsukuba, Japan

D49 Non-contact Voltage Measurement of Solar Cell with Electrostatic Voltmeter

Sakutaro Miyajima¹, Kensuke Nishioka¹, Yoshihiro Hishikawa²
¹University of Miyazaki, Miyazaki, Japan, ²National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan

D10 Proposal of the Bandgap Design Using the Sun Height of the Culmination on the Winter Solstice

Kenji Araki, Kan-Hua Lee, Masafumi Yamaguchi
Toyota Technological Institute, Nagoya, Japan

ePoster **Quantitative analysis of electroluminescence and infrared thermal images for aged monocrystalline silicon photovoltaic modules**

Irene Berardone¹, Marco Paggi¹, Juan L. Garcia²
¹IMT School for Advanced Studies, Lucca, Italy, ²European Commission, DG JRC, Institute for Energy and Transport, ISPRA, Italy

D12 Non-destructive measurement of water ingress in photovoltaic module encapsulants

Mihail Bora, Vincenzo Lordi, Joel B. Varley
Lawrence Livermore National Laboratory, Livermore, CA, United States

D16 On The Use of Voltage Measurements For Determining Carrier Lifetime at High Illumination Intensity

Robert Dumbrell, Mattias K Juhl, Thorsten Trupke, Ziv Hameiri
University of New South Wales, Sydney, Australia

D19 Evaluation Setup and First Power Production Results for Si Mini-Modules Covered by Eu³⁺-Based Down Converters in Extreme Outdoor Conditions

Benjamín González-Díaz¹, Carlos Montes¹, Joaquín Sanchiz³, Luis Ocaña², Carlos Quinto², Óscar González², Guillermo M. Bertolomeu², Miguel Á. Padrón-González², Cecilio Hernández-Rodríguez³, Mari P. Friend², Manuel Cendagorta-Galarza², David Cañadillas⁴, Ricardo Guerrero-Lemus⁴
¹Departamento de Ingeniería Industrial. Universidad de La Laguna. Avenida Astrofísico Francisco Sánchez S/N 38206, San Antonio, TX, United States, ²Instituto Tecnológico y de Energías Renovables, S. A. (ITER), Pol. Industrial de Granadilla, s/n., Granadilla, Spain, ³Departamento de Física. Universidad de La Laguna. Avenida Astrofísico Francisco Sánchez S/N 38206, San Cristóbal de La Laguna, Spain, ⁴Departamento de Química. Universidad de La Laguna. Avenida Astrofísico Francisco Sánchez S/N 38206, San Cristóbal de La Laguna, Spain

D21 Study Of Micro-Structural Properties Of ZnO And TiO₂ Thin Films Grown By Spray Pyrolysis

Gerardo Gordillo, John Correa, Asdrubal Ramirez, Edwin Ramirez
Universidad Nacional de Colombia, Bogota, Columbia

D23 Nonlinear Response of Silicon Solar Cells

Behrang H Hamadani¹, Andrew Shore¹, Howard W Yoon¹, Mark Campanelli²
¹National Institute of Standards and Technology, Gaithersburg, MD, United States, ²Intelligent Measurement Systems, Bozeman, MT, United States

- D25 Material Based Mathematical Modeling of a Non-Ideal PV Cell**
Lili He, P. L. Uditha Dulinda Perera
San Jose State University, San Jose, CA, United States
- D29 Severity Test with Uneven Load due to Wind Action on Photovoltaic Module**
Shu-Tsung Hsu
ITRI, Hinchu, Taiwan
- D31 Standardized Durability Test for Organic Photovoltaic and Dye Sensitized Solar Cell**
Shu-Tsung Hsu¹, Yean-San Long², Teng-Chun Wu³
¹ITRI, Hinchu, Taiwan, ²ITRI, Hinchu, Taiwan, ³ITRI, Hinchu, Taiwan
- D33 Spatial Thickness Uniformity and Structural Evaluation of RF Sputtered ZnO Thin Films for Solar Cell**
Babar Hussain^{1,2}, Thiara Ortiz¹
¹University of North Carolina at Charlotte, Charlotte, NC, United States, ²National Institute of Lasers and Optronics, Islamabad, Pakistan
- D35 Local Measurements of Surface Capacitance by Electrostatic Force Microscopy on Cu(In,Ga)Se₂ Materials**
Tomoaki Ishii¹, Takashi Minemoto², Takuji Takahashi¹
¹the University of Tokyo, Tokyo, Japan, ²Ritsumeikan University, Shiga, Japan
- D37 use of a transformed diode equation for characterization of the ideality factor and series resistance of crystalline silicon solar cells based on light I-V curves**
Sujeong Jeong¹, Soo Min Kim², Yoonmook Kang³, Hae-seok Lee³, Donghwan Kim¹
¹Korea University, Seoul, Korea, ²Gumi Electronics & Information Technology Research Institute, Gumi, Korea, ³KU KIST green school, Seoul, Korea
- D39 A Comparison of Si-based Cameras for Imaging Luminescence from Photovoltaic Materials and Devices**
Steve Johnston
National Renewable Energy Laboratory, Golden, CO, United States
- D41 Blistering of Al₂O₃/a-SiN_x:H stacks: analysis of the submerged part of the iceberg by colored picosecond acoustic microscopy**
Fabien Lebreton^{1,2,3}, Arnaud Devos⁴, Etienne Drahi^{1,3}, Patricia de Coux¹, François Silva^{2,3}, Sergej Filonovich^{1,3}, Pere Roca i Cabarrocas^{2,3}
¹Total – GRP, Paris, France, ²LPICM, CNRS, Ecole Polytechnique, Université Paris-Saclay, Palaiseau, France, ³Institut Photovoltaïque d'Ile-de-France (IPVF), Antony, France, ⁴IEMN UMR 8520, Dpt ISEN, Lille, France
- D43 Self-Reference Procedure to Reduce Uncertainty in Module Calibration**
Dean Levi, Carl Osterwald, Steve Rummel, Larry Ottoson, Allan Anderberg
National Renewable Energy Laboratory, Golden, CO, United States
- D45 Uncertainty Evaluation of Primary Reference Photovoltaic Cell Calibration under Outdoor Condition in Tibet**
Haitao Liu¹, Shiyu Sang¹, Guomin Zhou², Yonghui Zhai¹
¹Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing, China, ²Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing, China, ³Tibet New Energy Research and Demonstration Centre, Lhasa, China, ⁴Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing, China
- D47 Requirement of Artificial Lighting Simulator for Evaluation Emerging PV Performance Rating under Indoor Environment**

Yean-San Long, Shu-Tsung Hsu, Teng-Chun Wu
1, Hsinchu, Taiwan

D51 NREL's Cell and Module Performance group's asymptotic Pmax protocol for perovskite devices.

Thomas E. Moriarty, Dean H. Levi
NREL, Golden, CO, United States

D53 Outdoor Operating Temperature Modeling of Photovoltaic Modules including Transient Effect

Soo-Young Oh¹, Min-Soo Kim¹, Won-Shup So¹, Woo Kyoung Kim¹, Jae Hak Jung¹, Chin Ho Park¹, Benazzouz Aboubakr², Ikken Badr², Naimi Zakaria², Benlarabi Ahmed²
¹Yeungnam University, Gyeongsan, Korea, ²IRESEN, Benguerir, Morocco

D55 Primary Reference Cell Calibrations with Reduced Measurement Uncertainty

Carl R. Osterwald, Larry Ottoson, Rafell Williams, Charles Mack, Tom Moriarty, Keith Emery, Dean Levi
National Renewable Energy Laboratory, Golden, CO, United States

E1 Implementation of novel pin connection and test routine for improved accuracy in I-V measurements

Samuel Raj¹, Johnson Kai Chi Wong¹, Mohan Krishan Bhan³, Evan Palmer³, Jian Wei HO¹, Sumukh Ramprasad¹, Junci Wang², Thomas Mueller¹, Armin Aberle^{1,2}
¹Solar Energy Research Institute of Singapore (SERIS), National University of Singapore, Singapore, Singapore, Singapore, ²Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Singapore, Singapore, ³OAI-Optical Associates, INC. 685 River Oaks Parkway, San Jose, CA 95134 USA, San Jose, CA, United States

E3 A new method to quantify Contact Resistance using Localized-illumination Photoluminescence technique in a Solar Cell

Amit Singh Rajput^{1,2}, Samuel Raj², Johnson Wong², Armin G. Aberle^{1,2}
¹Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Singapore, ²Solar Energy Research Institute of Singapore (SERIS), Singapore, Singapore

E5 Improvement of the properties of CZTS thin films prepared by spray pyrolysis using DMSO in acetone as solvent

Edwin Ramirez, Gerardo Gordillo, Asdrubal Ramirez
Universidad Nacional de Colombia, Bogota, Columbia

E7 Assessment of Carrier Lifetimes and Surface Recombination Velocity through Spectral Measurements

John F Roller, Behrang H Hamadani
NIST, Gaithersburg, MD, United States

E9 Extracting dielectric fixed charge density on highly doped c-Si surfaces using photoconductance measurements

Alexander To¹, Jie Cui², Bram Hoex¹
¹UNSW, Sydney, Australia, ²Australian National University, Canberra, Australia

Area 7 - Poster

3:30 - 5:00 PM

Exhibit Hall B

Space and Specialty Technologies

Chair(s): Emilio Fernandez, Phil Jenknins, Takeshi Ohshima

E25 Effect of luminescence coupling between InGaP and GaAs subcells to external quantum efficiency in triple-junction solar cells

Mitsunobu Sugai¹, Mitsuru Imaizumi², Tetsuya Nakamura², Takeshi Ohshima³

¹Advanced Engineering Services Co., Ltd., Tsukuba, Japan, ²Japan Aerospace Exploration Agency, Tsukuba, Japan, ³National Institute for Quantum Science and Technology, Takasaki, Japan

ePoster Simulation of Light Trapping Structures for Enhancing Radiation Hardness in Space Solar Cells

Nizami Z. Vagidov, Kyle H. Montgomery, Geoffrey K. Bradshaw, David M. Wilt

Space Vehicles Directorate, Air Force Research Laboratory, Kirtland AFB, Albuquerque, NM, United States

E27 Carbon Fiber Mirrors for Solar Applications

Nina Vaidya¹, Michael D Kelzenberg¹, Pilar Espinet-Gonzalez¹, Tatiana Vinogradova^{1,2,3}, Christophe Leclerc¹, Ali Naqavi¹, Ali Hajimiri¹, Sergio Pellegrino¹, Harry A Atwater¹

¹California Institute of Technology, Pasadena, CA, United States, ²Northrop Grumman Aerospace Systems, Azusa, CA, United States, ³Visiting Associate, California Institute of Technology, Pasadena, CA, United States

E29 GaAs Solar Cells on V-Grooved Silicon via Selective Area Growth

Michelle Vaisman^{1,2}, Nikhil Jain¹, Qiang Li³, Kei May Lau³, Adele C Tamboli¹, Emily L Warren¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Yale University, New Haven, CT, United States, ³Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

E31 Development of a High Capacity MOCVD Tool for the Production of Low Cost III-V Solar Cells

Lori Washington, Khurshed Sorabji, Gregg Higashi, Alex Lerner, Vladimir Galbut, Abe Cabrerros, David Ishikawa, Brian Burrows, Brian Brown, Gang He

Alta Devices, Sunnyvale, CA, United States

E33 High Temperature Annealing of In_{1-x}Ga_xN MQW Solar Cells

Joshua J Williams¹, Heather McFavilen², Steven Young², Christiana B Honsberg¹, Stephen M Goodnick¹

¹Arizona State University, Tempe, AZ, United States, ²Photonitride Devices, Inc., Tempe, AZ, United States

E35 Solar Probe Plus Array Reliability

Anton G Yanchilin, Edward M Gaddy

E12 An Alternative Method for Solar Cell Integration

Jessica L Buckner¹, Tracy Davis², Eric Muskovin³, Bernard Carpenter⁴

¹Air Force Research Lab, Kirtland AFB, NM, United States, ²Applied Technology Associates, Albuquerque, NM, United States, ³Missouri University of Science and Technology, Rolla, MO, United States, ⁴The Aerospace Corporation, Albuquerque, NM, United States

E14 NIEL DOSE Analysis on Triple Junction cells 30% efficient and related single junctions

Roberta Campesato¹, Erminio Greco¹, Mariacristina Casale¹, Massimo Gervasi², Mauro Tacconi², Pier Giorgio Rancoita², Davide Rozza², Enos Gombia³, Aldo Kingma³, Carsten Baur⁴

¹CESI S.p.A., Milan, Italy, ²INFN University Milano Bicocca, Milan, Italy, ³CNR, Bologna, Italy, ⁴ESA, Noordwijk, Netherlands

E16 Thin and Flexible Triple Junction cells 30% efficient: qualification results and future space applications

Roberta Campesato¹, Mariacristina Casale¹, Giuseppe Gabetta¹, Emilio Fernandez Lisbona²,

Laurent D'Abrigeon³

¹CESI S.p.A., Milan, Italy, ²ESA, Noordwijk, Netherlands, ³Thales Alenia Space, Cannes, France

ePoster Impact of Space Radiation Environment on Concentrator Photovoltaic Systems

Pilar Espinet-Gonzalez¹, Tatiana Vinogradova^{2,3}, Michael D. Kelzenberg¹, Alexander Messer^{2,3},
Chris Peterson², Emily Warmann¹, Nina Vaidya¹, Ali Naqavi¹, Samuel Loke¹, Jing-Shun Huang¹,
Ali Hajimiri¹, Sergio Pellegrino¹, Harry A. Atwater¹

¹California Institute of Technology, Pasadena, CA, United States, ²Northrop Grumman Aerospace
Systems, Azusa, CA, United States, ³Visiting Associate, California Institute of Technology,
Pasadena, CA, United States

**E18 Printed Assemblies of Microscale Triple-Junction (3J) Inverted Metamorphic (IMM)
GaInP/GaAs/InGaAs Solar Cells**

Boju Gai¹, John Geisz³, Daniel Friedman³, Jongseung Yoon^{1,2}

¹Department of Chemical Engineering and Materials Science, University of Southern California,
Los Angeles, CA, United States, ²Department of Electrical Engineering, University of Southern
California, Los Angeles, CA, United States, ³National Renewable Energy Laboratory, Golden, CO,
United States

**E20 Comparative Study on Nonradiative Recombination Centers in Proton Irradiated InAs/GaAs
Quantum Dot Structure by Two Wavelength Excited Photoluminescence**

M. D. Haque¹, N. Kamata¹, S-I. Sato², S. M. Hubbard³

¹Department of Functional Materials Science, Saitama University, Saitama 338-8570, Japan,
²Quantum Beam Research Directorate, National Institutes for Quantum and Radiological Science
and Technology, Takasaki 370-1292, Japan, ³NanoPower Research Labs. Rochester Institute of
Technology, Rochester 14623, NY, United States

E22 Design and Prototyping Efforts for the Space Solar Power Initiative

Michael D Kelzenberg¹, Pilar Espinet Gonzalez¹, Nina Vaidya¹, Tatiana A. Roy¹, Emily C.
Warmann¹, Ali Naqavi¹, Samuel P. Loke¹, Jing-Shun Huang¹, Tatiana G. Vinogradova^{1,2}, Alexander
J. Messer^{1,2}, Christophe Leclerc¹, Ali Hajimiri¹, Sergio Pellegrino¹, Harry A. Atwater¹

¹California Institute of Technology, Pasadena, CA, United States, ²Northrop Grumman Aerospace
Systems, Azusa, CA, United States

**ePoster Near-unity ultra-wideband thermal infrared emission in polaritonic metasurfaces for space
solar power radiative cooling**

Ali Naqavi, Samuel Loke, Michael D. Kelzenberg, Emily C. Warmann, Pilar Espinet-González,
Nina Vaidya, Jing-Shun Huang, Alexander J. Messer, Tatiana G. Vinogradova, Ali Hajimir, Sergio
Pellegrino, Harry A. Atwater

**ePoster Line-Focus and Point-Focus Space Photovoltaic Concentrators Using Robust Fresnel
Lenses, 4-Junction Cells, & Graphene Radiators**

Mark O'Neill¹, Michael Piszczor², Matt Myers², A.J. McDanal¹, Paul Sharps³, Claiborne
McPheeters³, Jeff Steinfeldt³

¹Mark O'Neill, LLC, Keller, TX, United States, ²NASA Glenn Research Center, Cleveland, OH,
United States, ³SolAero Technologies, Albuquerque, NM, United States

**E23 Defect Characterization of III-V Quantum Structure Solar Cells Using Photo-Induced Current
Transient Spectroscopy**

Shin-ichiro Sato¹, Takeyoshi Sugaya², Tetsuya Nakamura³, Takeshi Ohshima¹

¹National Institutes for Quantum and Radiological Science and Technology, Takasaki, Japan,
²National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan, ³Japan
Aerospace Exploration Agency, Tsukuba, Japan

Area 8 - Poster

3:30 - 5:00 PM

Exhibit Hall C

PV Module and System Modeling

Chair(s): Ralph Gottschalg, Jessica Forbess, Michael Deceglie

E39 A New Photovoltaic System Topology Through Load Management

Joseph A. Azzolini, Meng Tao
Arizona State University, Tempe, AZ, United States

E41 First step for power generation amount estimation of solar matching system

Kazuya Hosokawa¹, Toshiaki Yachi¹, Yoichi Hirata², Yasuyuki Watanabe²
¹*Tokyo University of Science, Tokyo, Japan*, ²*Suwa Tokyo University of Science, Suwa, Japan*

E37 INTEGRABILITY COMPARISON BETWEEN BIPV AND BAPV IN TROPICAL CONDITIONS: A BANGALORE CASE-STUDY

Gayathri Aaditya, Roshan R Rao, Monto Mani
Indian Institute of Science, Bangalore, India

ePoster **Photovoltaic Temperature Estimation Model for Rapid Irradiance change conditions in Tropical Regions using Heuristic Algorithms**

Srivatsan Ramasubramanian¹, Lianlian Jiang¹, Douglas L Maskell²
¹*Energy Research Institute @ NTU, Singapore, Singapore*, ²*School of Computer Science and Engineering, Nanyang Technological University, Singapore, Singapore*

E43 Irradiance and temperature distributions at high latitudes: Design implications for photovoltaic systems

Anne Gerd Imenes^{1,2}, Josefine Selj^{3,4}
¹*Teknova AS, Kristiansand, Norway*, ²*University of Agder, Grimstad, Norway*, ³*Institute for Energy Technology, Kjeller, Norway*, ⁴*University of Oslo, Dept. Technology Systems, Kjeller, Norway*

ePoster **Accuracy of CdTe PV Energy Predictions Using Spectral Corrections**

Mitchell V Lee, Kendra L Passow, Paul J Wolffersdorff
First Solar, San Francisco, CA, United States

E47 Open Circuit Voltage Calculations Using Temperature and Irradiance

Andrew J Melvin
SunEdison, Belmont, CA, United States

F7 Comparison of Physical and Electrical Equivalent Circuits of Solar Cells

Michael Slonim
Ben-Gurion University, Beersheva, Israel

F5 How to Choose the best Empirical Model for Optimum Energy Yield Predictions

Steven J Ransome
SRCL, Kingston upon Thames, United Kingdom

ePoster **PlantPredict: Solar Performance Modeling Made Simple**

Kendra Passow, Lauren Ngan, Stephen Kaplan, Mitchell Lee
First Solar, San Francisco, CA, United States

F1 Study of Photovoltaic Systems Monitoring Methods

Eneko Ortega¹, Gerardo Aranguren¹, Maria J Saenz², Ruben Gutierrez², Juan C Jimeno²
¹*Electronic Design Group. University of the Basque Country, Bilbao, Spain*, ²*Technological Institute of Microelectronics. University of the Basque Country, Bilbao, Spain*

- F3 Global Design Aspects of Persistent and Autonomous PV Powered Systems**
 Ian Marius Peters¹, Sterling Watson¹, Nasim Sahraei², Tonio Buonassisi¹
¹Massachusetts Institute of Technology, Cambridge, MA, United States, ²Singapore MIT Alliance for Research and Technology, Singapore, Singapore
- E45 Performance comparisons of a PV system by monitoring Solar irradiance with different pyranometers**
 Yasuhiro Matsumoto¹, J. Antonio Urbano¹, Ramón Peña¹, Maria de la Luz Olvera¹, Nun Pitalúa², René Asomoza¹
¹Centro de Investigacion y de Estudios Avanzados, Mexico City, Mexico, ²Universidad de Sonora, Hermosillo, Mexico
- F9 Modeling and Analysis of Photovoltaic Electrochemical System using Module-Level Power Electronics**
 Gowri M. Sriramagiri^{1,2}, Nuha M. Ahmed^{1,2}, Kevin D. Dobson¹, Steven S. Hegedus^{1,2}, Robert W. Birkmire¹
¹Institute of Energy Conversion, University of Delaware, Newark, DE, United States, ²Department of Electrical and Computer Engineering, University of Delaware, Newark, DE, United States
- E51 Financial Analysis of a Grid-connected Photovoltaic System in South Florida**
 Hadis Moradi
 Florida Atlantic University, Boca Raton, FL, United States
- E49 Step-by-step evaluation of photovoltaic module performance related to outdoor parameters: evaluation of the uncertainty**
 Anne Migan Dubois¹, Jordi Badosa², Fausto Calderón-Obaldía^{1,2}, Olivier Atlan², Vincent Bourdin³, Marko Pavlov², Dae Young Kim², Yvan Bonnassieux⁴
¹GeePs, Gif-sur-Yvette, France, ²LMD, Palaiseau, France, ³LIMSI, Orsay, France, ⁴LPICM, Palaiseau, France

Exhibition	
5:00 - 8:00 PM	Exhibit Hall A
Opening Reception/Exhibits	

Tuesday, June 27, 2017

Registration	
8:00 - 8:30 AM	Convention Registration Desk
Registration Opens	

Area 1 - Plenary	
8:30 - 9:00 AM	Marriott Ballroom
Plenary	

Chair(s): Peichen Yu, Jeremy Munday

Hot Carrier Solar Cells: Myths and Realities

Jean-François Guillemoles

IRDEP, French National Centre for Scientific Research (CNRS), Chatou, France

Area 6 - Plenary		
9:00 - 9:30 AM		Marriott Ballroom
	Plenary	

Chair(s): Woojun Yoon

Making Perovskite Tandem Solar Cells Efficient and Stable Enough to be a Gamechanger

Michael D. McGehee

Stanford University, Stanford, CA, United States

Area 11 - Plenary		
9:30 - 10:00 AM		Marriott Ballroom
	Plenary	

Chair(s): Skip Dize, Barry Mather

Distribution Grid Innovation Driven by PV Solar Integration

Steve J Steffel

Break		
10:00 - 10:30 AM		Exhibit Hall A
	Coffee Break	

Area 1 - Poster		
10:30 - 12:00 PM		Exhibit Hall F
	Quantum Confined Materials and Avant Guard Concepts	

Chair(s): Gavin Conibeer, Masakazu Sugiyama, Jean-François Guillemoles

A3 **Minimum entropy principle-based solar cell operation without a pn-junction and a thin CdS layer to extract the holes from the emitter**

Karl W. Böer

University of Delaware, Newark, DE, United States

A1 **Multi-objective optimization for color-tunability and transparency in colloidal quantum dot solar cells**

Ebuka S. Arinze, Botong Qiu, Nathan Palmquist, Yan Cheng, Yida Lin, Gabrielle Nyirjesy, Gary Qian, Susanna M. Thon

Johns Hopkins University, Baltimore, MD, United States

A5 **Cubic phase $\text{In}_x\text{Ga}_{1-x}\text{N}/\text{GaN}$ Quantum Wells for their application to Tandem Solar Cells**

C. A. Hernandez¹, Y. L. Casallas-Moreno², D. Cardona², Yu. Kudriavtsev³, A. Morales-Acevedo³,

G. Santana-Rodríguez⁴, M. López-López²

¹Programa de Doctorado en Nanociencias y Nanotecnología, D.F., Mexico, ²Departamento Física, D.F., Mexico, ³Departamento Ingeniería Eléctrica – SEES, D.F., Mexico, ⁴Universidad Nacional Autónoma de México, D.F., Mexico

A7 Modeling of p-i-n GaAsPN/GaP MQWs solar cell: towards lattice matched III-V/Si tandem

Khim Kharel, Alexandre Freundlich
University of Houston, Houston, TX, United States

A9 Type-II InP Quantum Dots Grown by MOCVD for Intermediate Band Solar Cell Applications

Hyun Kum, Michael Slocum, Yushuai Dai, Zachary Bittner, Seth Hubbard
Rochester Institute of Technology, Rochester, NY, United States

A11 Modified Limiting Efficiency of Multiple Exciton Generation Solar Cells

Jongwon Lee, Christiana B. Honsberg
School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, United States

A13 A Simple Monte Carlo Model of a Hot Carrier Cell

Tor O Saetre
University of Agder, Grimstad, Norway

A15 Optimization of Semiconductor Quantum Dots for Luminescent Solar Concentrators: Minimizing Reabsorption Losses

Anatoli I. Shkrebtii¹, Anatoliy V. Sachenko², Igor O. Sokolovskiy², Vitaliy P. Kostylyov², Mykola R. Kulish², Denis V. Khomenko²
¹University of Ontario Institute of Technology, Oshawa, ON, Canada, ²V. Lashkaryov Institute of Semiconductor Physics, Kiev, Ukrenia

A17 Development of absorber and energy selective contacts for hot carrier solar cells

Santosh Shrestha, Simon Chung, Yuanxun Liao, Wenkai Cao, Neeti Gupta, Yi Zhang, Xiaoming Wen, Gavin Conibeer
UNSW Sydney, Sydney, Australia

A19 Hot Carrier Transportation Dynamics in InAs/GaAs Quantum Dot Solar Cell

Tomah Sogabe^{1,2,3}, Kohdai Nii², Katsuyoshi Sakamoto², Koichi Yamaguchi^{1,2}, Yoshitaka Okada³
¹i-Powered Energy Research Center (i-PERC), The University of Electro-Communications, Tokyo, Japan, ²Department of Engineering Science, The University of Electro-Communications, Tokyo, Japan, ³Research Center for Advanced Science and Technology (RCAST), The University of Tokyo, Tokyo, Japan

ePoster Betavoltaic generation function in silicon

Igor O. Sokolovskiy^{1,2}, Anatoliy V. Sachenko², Mykhaylo Evstigneev¹
¹Department of Physics and Physical Oceanography, Memorial University of Newfoundland, St. John's, NL, Canada, ²V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine, Kiev, Ukrenia

A21 GaAsBi Devices for Thermal Energy Conversion

Margaret Stevens, Abigail Licht, Nicole Pfiester, Emily Carlson, Kevin Grossklaus, Thomas E Vanderveelde
Department of Electrical and Computer Engineering, Tufts University, Medford, MA, United States

A23 Analytic JV-Characteristics of Ideal Impurity PV-Cells

Rune Strandberg
University of Agder, Grimstad, Norway

- A25 Photoluminescence Properties of In-Plane Ultrahigh-Density InAs Quantum Dots on GaAsSb/GaAs(001) for Solar Cell Applications**
Ryo Sugiyama, Naoki Akimoto, Tomah Sogabe, Koichi Yamaguchi
The University of Electro-Communications, Tokyo, Japan
- A27 Carrier Selective Back Contact (CSBC) Solar Cell using Transition Metal Oxides**
Astha Tyagi¹, Kunal Ghosh², Anil Kottantharayil¹, Saurabh Lodha¹
¹*Indian Institute of Technology Bombay, Mumbai, India,* ²*Indian Institute of Technology Mandi, Mandi, India*
- A29 Analysis of open-circuit voltage and conversion efficiency in quantum-dot solar cells via detailed-balance-limit theory**
Lin Zhu¹, Hidefumi Akiyama¹, Yoshihiko Kanemitsu²
¹*Institute for Solid State Physics, University of Tokyo, Kashiwa, Chiba, Japan,* ²*Institute for Chemical Research, Kyoto University, Uji, Kyoto, Japan*

Area 2 - Poster

10:30 - 12:00 PM

Exhibit Hall E

Progress in ARC, TCO, Window, Buffer, Interface, and Contact Layers

Chair(s): William Shafarman, Tao Song, Rouin Farshchi

- A32 Use of Single Wall Carbon Nanotube films doped with Triethyloxonium Hexachlorantimonate as a Transparent Back Contact for CdTe Solar Cells**
Fadhil K. Alfadhili, Jacob M. Gibbs, Geethika K. Liyanage, Patrick W Krantz, Suneth C Waththage, Zhaoning Song, Adam B. Phillips, Michael J Heben
Wright Center for Photovoltaics Innovation and Commercialization, University of Toledo, Toledo, OH, United States
- B2 Grain and Grain Boundary Geometrical Shape Considerations on Sodium and Potassium Diffusion Through Molybdenum Films**
Orlando Ayala, Chinedum Akwari, Tasnuva Ashrafee, Shankar Karki, Grace Rajan, Sylvain Marsillac
Virginia Institute of Photovoltaics, Old Dominion University, Norfolk, VA, United States
- B3 Use of CdS:O and CdSe as Window Layers for CdTe Photovoltaics**
Tom Baines, Ken Durose, Jonathan Major
University of Liverpool, Liverpool, United Kingdom
- B5 Solution-Processed Nickel-Alloyed Iron Pyrite Thin Film as Hole Transport Layer in Cadmium Telluride Solar Cells**
Ebin Bastola, Khagendra P. Bhandari, Randy J. Ellingson
Wright Center for Photovoltaics Innovation and Commercialization (PVIC), Department of Physics and Astronomy, University of Toledo, Toledo, OH, United States
- B7 Applications of Hybrid Organic-Inorganic Metal Halide Perovskite Thin Film as a Hole Transport Layer in CdTe Thin Film Solar Cells**
Khagendra P. Bhandari, Suneth C. Waththage, Zhaoning Song, Adam Phillips, Michael J. Heben, Randy J. Ellingson
Wright Center for Photovoltaics Innovation and Commercialization, Department of Physics and Astronomy, University of Toledo, 2801 W. Bancroft Street, TOLEDO, OH, United States
- B9 Magnesium-doped Zinc Oxide as a High Resistance Transparent layer for thin film CdS/CdTe solar cells**

Francesco Bittau¹, Elisa Artegiani², Daniele Menossi², Jake W. Bowers¹, John M. Walls¹, Alessandro Romeo²

¹Centre for Renewable Energy Systems Technology (CREST), Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, United Kingdom, ²Laboratory for Applied Physics, Department of Computer Science, Univ. Verona, Strada Le Grazie 15, 37134, Verona, Italy

B11 Investigation of Zn_{1-x}Mg_xO:Al film by Ratio Frequency Magnetron Co-Sputtering as Transparent Conductive Oxide layer

Jakapan Chantana, Yuya Ishino, Takashi Minemoto
Ritsumeikan University, Kusatsu, Japan

B13 A New TCO/window-buffer Front Stack for CdTe Solar Cells and its Implementation

Alan E. Delahoy¹, Xuehai Tan¹, Akash Saraf¹, Payal Patra², Surya Manda¹, Yunfei Chen¹, Shou Peng^{3,4}, Ken K. Chin¹, Krishnakumar Velappan⁵, Bastian Siepchen⁵

¹New Jersey Institute of Technology, Newark, NJ, United States, ²New Jersey Innovation Institute, Newark, NJ, United States, ³Bengbu Design and Research Institute for Glass Industry, Bengbu, China, ⁴China Triumph International Engineering Co. Ltd., Shanghai, China, ⁵CTF Solar GmbH, Dresden, Germany

B15 Synthesis of High-Quality AZO Polycrystalline Films via Target Bias Radio Frequency Magnetron Sputtering

Zhongming Du^{1,2}, Xiangxin Liu^{1,2}, Yufeng Zhang^{1,2}

¹The Key Laboratory of Solar Thermal and Photovoltaic System, Institute of Electrical Engineering, CAS, Beijing, China, ²University of Chinese Academy of Sciences, Beijing, China

B17 Close-Space Sublimated CdTe Solar Cells with Co-Sputtered CdS_xSe_{1-x} Alloy Window Layers

Corey R. Grice¹, Maxwell M. Junda¹, Alex Archer¹, Jian Li², Yanfa Yan¹

¹University of Toledo, Toledo, OH, United States, ²Texas State University, San Marcos, TX, United States

B19 Effects of graphene oxide barrier on Cu₂ZnSnS_xSe_{4-x} thin film solar cells

Woo-Lim Jeong^{1,2}, Jung-Hong Min^{1,2}, In-Young Kim^{1,2}, Hae-Sun Kim^{1,2}, Jin-Hyeok Kim³, Dong-Seon Lee^{1,2}

¹Gwangju Institute of Science and Technology, Gwangju, South Korea, ²Research Institute for Solar and Sustainable Energies, Gwangju, South Korea, ³Chonnam National University, Gwangju, South Korea

B21 13% CdS/CdTe Solar Cell Using a Nanocomposite (CuS)_x(ZnS)_{1-x} Thin Film Hole Transport Layer

Kamala Khanal Subedi, Khagendra P Bhandari, Ebin Bastola, Randy J Ellingson
Wright Center for Photovoltaic Innovation and Commercialization, Department of Physics and Astronomy, The University of Toledo, Toledo, OH, United States

B23 Molybdenum Oxide and Molybdenum Nitride Back Contacts for Thin Film CdTe Solar Cells

Anna E Kindvall, Jason M Kephart, Walajabad S Sampath
Colorado State University, Fort Collins, CO, United States

B25 Investigation and optimization of Cd-free buffer layers In₂S₃ and Zn(O,S) for Cu₂ZnSn(S,Se)₄-based solar cells

Willi Kogler, Thomas Schnabel, Andreas Bauer, Stefanie Spiering, Erik Ahlswede, Michael Powalla
Centre for Solar Energy and Hydrogen Research Baden-Wuerttemberg, Stuttgart, Germany

B27 Rear Contact Passivation for High Band Gap Cu(In,Ga)Se₂ Solar Cells with Varying Absorber Thickness and Flat Ga Profile

Dorothea Ledinek¹, Pedro Salome², Carl Högglund¹, Marika Edoff¹

¹Uppsala University, Uppsala, Sweden, ²International Iberian Nanotechnology Laboratory, Braga, Portugal

ePoster Zinc Selenide Surface Passivation Layer for Single-Crystalline CZTSe Solar Cells

Michael A. Lloyd^{1,2}, Douglas Bishop³, Brian E. McCandless², Robert Birkmire^{1,2}

¹University of Delaware, Newark, DE, United States, ²Institute of Energy Conversion, Newark, DE, United States, ³IBM T.J. Watson Research Center, Yorktown Heights, NY, United States

B29 Laser Annealed Back Contacts for CdTe Solar Cells

Vasilios Palekis¹, Shamara Collins¹, Imran Khan¹, Vamsi Evani¹, Sudhajit Misra², Michael Scarpulla², Mark Lonergan³, Don Morel¹, Chris Ferekides¹

¹University of South Florida, Tampa, FL, United States, ²University of Utah, Salt Lake City, UT, United States, ³University of Oregon, Eugene, OR, United States

B31 Enhanced Anti-reflective Coating for Thin Film Solar Cells

Grace Rajan¹, Shankar Karki¹, Robert W Collins², Sylvain Marsillac¹

¹Virginia Institute of Photovoltaic, Old Dominion University, Norfolk, VA, United States, ²Department of Physics and Astronomy, The University of Toledo, Toledo, OH, United States

B33 Influence of AGS Layer Insertion at Absorber/TCO Interface on Structural and Photovoltaic Properties of Ultrathin Cu(In,Ga)Se₂ Solar Cells

Muhammad Saifullah^{1,2}, Jihye Gwak^{1,2}, Kihwan Kim¹, Junsik Cho^{1,2}, Jae Ho Yun^{1,2}

¹Korea Institute of Energy Research (KIER), Daejeon, South Korea, ²University of Science and Technology (UST), Daejeon, South Korea

B35 Novel, Facile Back Surface Treatment for CdTe Solar Cells

Suneth C Watthage, Geethika K Liyanage, Zhaoning Song, Fadhil K Alfadhili, Rabee B Alkhatay, Khagendra P Bhandari, Randy J Ellingson, Adam B Phillips, Michael J Heben

University of Toledo, Toledo, OH, United States

B37 Optimizing CdS buffer layer for CIGS based thin film solar cell

Weijie Zhang, Geordie Zapalac, Korhan Demirkan, David Spaulding, Neil Mackie, Jochen Titus

Area 3 - Poster

10:30 - 12:00 PM

Exhibit Hall G

III-V Low Cost

Chair(s): Emily Warren, Tom Vandervelde, Kyle Montgomery

B52 Ultrathin Silicon-on-Insulator(SOI) Wafer for Compliant Substrate

Shinyoung Noh, Anita Ho-Baillie, Stephen Bremner, Martin A. Green, Xiaojing Hao, Ziheng Liu
University of New South Wales, Sydney, Australia

C6 Reduced defect density in single-crystalline-like GaAs thin film on flexible metal substrates by using superlattice structures

Monika Rathi¹, Pavel Dutta¹, Devendra Khatiwada¹, Nan Zheng², yao yao¹, Ying Gao¹, Sicong Sun¹, Yongkaun Li¹, Sara Pouladi¹, Phil Ahrenkiel², Sara Reed¹, Ali Khadimallah¹, Jae-Hyun Ryou¹, Venkat Selvamamickam¹

¹Department of Mechanical Engineering, Advanced Superconductor Manufacturing Institute, Texas Center for Superconductivity, University of Houston, Houston, TX, United States, ²South Dakota School of Mines and Technology, Rapid City, SD, United States

B40 Development of Aluminum Epilayers as Buffers for GaInAs

Phil Ahrenkiel¹, Nathan Smaglik¹, Nikhil Pokharel¹, Alessandro Giussani², Michael Slocum², Seth M. Hubbard²

¹South Dakota School of Mines & Technology, Rapid City, SD, United States, ²Rochester Institute of Technology, Rochester, NY, United States

B42 Laser Crystallization of Amorphous Germanium on Titanium Nitride-Coated Steel for Low-Cost GaAs Solar-Cells

Saloni Chaurasia¹, Srinivasan Raghavan², Sushobhan Avasthi³

¹Indian Institute of Science, Bangalore, India, ²Indian Institute of Science, Bangalore, India, ³Indian Institute of Science, Bangalore, India

B44 High Quality Epitaxial Germanium on Si (100) for low -cost III-V Solar-Cells

Saloni Chaurasia¹, Srinivasan Raghavan², Sushobhan Avasthi³

¹Indian Institute of Science, Bangalore, India, ²Indian Institute of Science, Bangalore, India, ³Indian Institute of Science, Bangalore, India

ePoster Investigation of InP defect characteristics grown using novel TF-VLS technique

Abhinav Chikhalkar¹, Alec Fischer¹, Mark Hettick², Ali Javey², Richard King¹

¹Arizona State University, Tempe, AZ, United States, ²University of California, Berkeley, CA, United States

B46 High efficiency GaInP/GaAs double junction Solar cell on Si substrate assisted by the electron beam treatment

Hyo Jin Kim¹, Yong Whan Kim²

¹Research center for ICT and Photonics Energy, Korea Photonics Technology Institute, Gwangju, Korea, ²Research and Development Team, Infovion Incorporation, Seoul, Korea

ePoster Defect Density Reduction in Mismatched Ge Hetero-epitaxy by Laser Treatment, towards a Cost-effective Substrate for High Efficiency III-V Solar Cells

Ziheng Liu, Xiaojing Hao, Jialiang Huang, Anita Ho-Baillie, Martin A. Green

UNSW, Sydney, Australia

B48 Crystallinity Control in Low-Temperature Growth of Poly-Crystalline Ge by Ion Beam Deposition

S Maximenko¹, N Mahadik¹, E McClure², C Bailey³, S Hubbard², P Jenkins¹, R Walters¹

¹Naval Research Laboratory, Washington, DC, United States, ²Rochester Institute of Technology, Rochester, NY, United States, ³Old Dominion University, Norfolk, VA, United States

B50 Analysis of Deposited Residues and Its Cleaning Process on GaAs Substrate after Epitaxial Lift-Off

Tatsuya Nakata¹, Kentaroh Watanabe², Hassanet Sodabanlu², Daiki Kimura¹, Naoya Miyashita², Yoshitaka Okada^{1,2}, Yoshiaki Nakano^{1,2}, Masakazu Sugiyama¹

¹School of Engineering, The University of Tokyo, Bunkyo-ku, Japan, ²Research Center for Advanced Science and Technology, Meguro-ku, Japan

C2 Characterization of GaAs solar cells grown by hydride vapor phase epitaxy in a horizontal reactor

Ryuji Oshima¹, Kikuo Makita¹, Akinori Ubukata², Takeyoshi Sugaya¹

¹National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan, ²Taiyo Nippon Sanso Corporation, Tsukuba, Japan

C4 Flexible GaAs Single-Junction Solar Cells Based on Single-Crystal-Like Thin-Film Materials Directly Grown on Metal Tapes

Sara Pouladi, Monika Rathi, Mojtaba Asadirad, Pavel Dutta, Seung Kyu Oh, Devendra Khatiwada,

Shahab Shervin, Yao Yao, Venkat Selvamanickam, Jae Hyoun Ryou
University of Houston, Houston, TX, United States

C8 Economic Analysis of Transfer Printed III-V Virtual Substrates

Kenneth J Schmieder¹, Matthew P Lumb^{2,1}, Michael K Yakes¹, Shawn Mack¹, Mitchell F Bennett^{3,1}, Sergey I Maximenko¹, Laura B Ruppalt¹, Michael A Meeker¹, Chase T Ellis¹, Matthew Meitl⁴, Joseph G Tischler¹, Robert J Walters¹

¹*US Naval Research Laboratory, Washington, DC, United States*, ²*George Washington University, Washington, DC, United States*, ³*Sotera Defense Solutions, Annapolis Junction, MD, United States*, ⁴*Semprius Inc., Durham, NC, United States*

C10 Thin Films of Zinc-Doped GaAs by RF Magnetron Sputtering for Use in Photovoltaic Devices

Kirby H Simon, Nishit J Shetty, Elijah J Thimsen, Kyle P Cepeda
Washington University in St. Louis, St. Louis, MO, United States

C12 Wet Etching Process for Incoherent Back Reflector on III-V Photovoltaic

Wei Wang, Alex Freundlich
Center for Advanced Materials, Houston, TX, United States

C13 Au-Assisted Ge and SixGe1-x Heteroepitaxial Growth on Silicon Nanopillars

Saleem zaidi¹, Ayu Azhari², Kamaruzzaman Sopian¹

¹*Solar Energy Research Institute, Universiti Kebangsaan Malaysia, Bangi, Malaysia*, ²*Universiti Malaysia Perlis, Perlis, Malaysia*

ePoster **Investigation of Fast Growth GaAs-based Solar Cell on Reusable Substrate by Metalorganic Chemical Vapor Deposition**

Chaomin Zhang¹, Eric Armour², Yeongho Kim³, Abhinav Chikhalkar¹, Ehsan Vadiiee¹, Richard King¹, Christiana Honsberg¹

¹*Arizona State University, Tempe, AZ, United States*, ²*Veeco Instruments Inc., MOCVD Operations, Somersret, NJ, United States*, ³*Korea Research Institute Standards and Science, Yuseong-gu, South Korea*

Area 4 - Poster

10:30 - 12:00 PM

Exhibit Hall C

Crystalline Silicon Solar Cell Technology

Chair(s): Stefan Glunz, Giso Hahn, Stuart Bowden

C24 Mitigation of Potential-Induced Degradation

Orry M Faur, Maria Faur
Specmat, North Olmsted, OH, United States

C32 Plasma Immersion Ion Implantation for Emitter and BSF Doping in N-type PERT Solar Cells with a Single Activation Annealing

Adeline Lanterne^{1,2}, Jean-François Lerat^{1,2}, Thomas Michel⁴, Thibaut Desrues^{1,2}, Marianne Coig^{1,3}, Frédéric Milesi^{1,3}, Frédéric Mazen^{1,3}, Yannick Veschetti^{1,2}, Laurent Roux⁴, Sébastien Dubois^{1,2}

¹*Univ. Grenoble Alpes, Grenoble, France*, ²*CEA, LITEN, INES, Le Bourget-du-Lac, France*, ³*CEA, LETI, Grenoble, France*, ⁴*IBS, Peynier, France*

C38 Influneces of annealing and defect limitation on p-type silicon solar cell

Yu-Hsuan Lin, Sung-Yu Chen, Kuen-Yi Wu, Chien-Hsun Chen, Chen-Hsun Du, Chun-Ming Yeh
Industrial Technology Research Institute, Hsinchu, Taiwan

- C50 Mechanistic Studies for the Development of Thin Si Microwire Solar Cells for Wearable Electronics**
 Yun Goo Ro¹, Renjie Chen¹, Ahmed T. El-Thakeb¹, Ren Liu¹, Shadi A. Dayeh^{1,2,3}
¹Department of Electrical and Computer Engineering, University of California San Diego, La Jolla, CA, United States, ²Graduate Program of Materials Science and Engineering, University of California San Diego, La Jolla, CA, United States, ³Department of NanoEngineering, University of California San Diego, La Jolla, CA, United States
- C54 The silver contact and formation mechanism of the boron emitter and the current flow mechanism of the solar cell electrode**
 Seunghyun Shin, Soohyun Bae, Sungeun Park, Yoonmook Kang, Hae-seok Lee, Donghwan Kim
 korea university, seoul, South Korea
- C18 >20% Efficiency Industry Screen Printed Bi-Facial PERC Solar Cells**
 Keng Siew Chan, Peiting Zheng, Jiaping Xu, Haijie Sun, Fan Zhang, Yao Guo, Hongyin Pan, Xinyu Zhang, Hao Jin
 R&D Center, JinkoSolar, Haining, China
- C20 Exploiting the Potentials of the Front Surface Field (FSF) Industrial Silicon Solar Cell**
 Ahrar Ahmed Chowdhury, Yu-Chen Hsu, Veysel Unsur, Abasifreke Ebong
 University of North Carolina at Charlotte, Charlotte, NC, United States
- C22 Photovoltaic Performance of Silicon Solar Cells Enhanced by Plasmonic Silver Nanoparticles of Various Dimensions Depositing Through Anodic Aluminum Oxide Template**
 Ta-Wei Chuang¹, Wen-Jeng Ho¹, Sheng-Kai Feng¹, Jheng-Jie Liu¹, Guan-Yi Li¹, Hao-Yu Yang¹, Yun-Chie Yang¹, Cho-Chun Chiang¹, Yao-Hui Chen¹
¹National Taipei University of Technology, Taipei, Taiwan, ²National Taipei University of Technology, Taipei, Taiwan
- C28 Effect of Si content in Al paste on Local Al Rear Contacts in PERC Cell**
 Supawan Joonwichien, Katsuhiko Shirasawa, Satoshi Utsunomiya, Hidetaka Takato
 National Institute of Advanced Industrial Science and Technology (AIST), Koriyama, Fukushima, Japan
- C42 BSF Islands For Reduced Recombination In IBC Cells**
 Agnes A. Mewe, Nicolas Guillevin, Ilkay Cesar, Antonius R. Burgers
 ECN Solar Energy, Petten, Netherlands
- C44 Thermal Stability of Hydrogenated Boron Emitters**
 Khaja H. Mohammed¹, Larry C. Cousar¹, Sergiu C. Pop³, Philip A. McMeans¹, Garrett Z. Evans¹, Hameed A. Naseem², Douglas A. Hutchings¹
¹Picasolar, Inc., Fayetteville, AR, United States, ²University of Arkansas, Department of Electrical Engineering, Fayetteville, AR, United States, ³Yingli Green Energy Americas, San Francisco, CA, United States
- C48 Optimization of Boron Doping by BCl₃ for n-type Bifacial c-Si Solar Cell**
 Efe ORHAN¹, Fırat ES², Raşit TURAN³
¹Efe ORHAN, ANKARA, Turkey, ²Fırat ES, ANKARA, Turkey, ³Raşit TURAN, ANKARA, Turkey
- C56 Laser Annealing to Enhance Performance of All-Laser-Based Silicon Back Contact Solar Cells**
 Zeming Sun, Mool C Gupta
 University of Virginia, Charlottesville, VA, United States

- D2 Large Area N-type Selective Emitter cells using Laser Doping through Boron Doped Screen Printed Paste**
Ajay Upadhyaya, Vijaykumar Upadhyaya, Brian Rounsaville, Keeya Madani, Ajeet Rohatgi
Georgia Institute of Technology, Atlanta, GA, United States
- D8 Low Temperature Rear Surface Metallization of Multicrystalline Silicon Solar Cells for Improved Bulk Lifetime**
Ned J Western, Stephen P Bremner
University of New South Wales, Sydney, Australia
- D9 19.9% Monocrystalline Silicon Solar Cell by Inline Diffusion**
Ying Xu^{1,2}, Wentao Hu¹, Xiaowei Li¹, Guoyi Dong¹, Yaohua Mai¹
¹*Hebei University, BAODING, China, ²Juli New Energy Co.Ltd., Xushui, China*
- D15 Constructing submicron-texture on diamond-wire-sawn multi-crystalline silicon solar cells via copper catalyzed chemical etching**
Jiawei Zha, Ting Wang, Chengfeng Pan, Kexun Chen, Fenqin Hu, Xiaodong Su
Soochow University, Suzhou, China
- C16 How to realize solar cells with laser structured plated Ni-Cu-Contacts with Excellent Adhesion and High Fill-Factors without parasitic plating**
Andreas Büchler, Sven Kluska, Jonas Bartsch, Benjamin Grübel, Andreas A Brand, Simon Gutscher, Markus Glatthaar
Fraunhofer Institute for Solar Energy, Freiburg, Germany
- C30 Formation of Low Resistance Emitter Contact Using Screen-Printed Etching Resist and Copper Paste**
Yuji Kurimoto¹, Tetsuya Fukuda¹, Tomohiro Saito², Daisuke Ando^{1,2}, Yuji Sutou^{1,2}, Katsuhiko Shirasawa², Junichi Koike^{1,2}
¹*Material Concept, Inc., Sendai, Japan, ²Tohoku University, Sendai, Japan*
- C34 Low cost metallization of Ni/Cu plated silicon solar cells**
Li-Yu Li^{1,2}, Chien-Kai Peng¹, Peichen Yu², Chen-Hsun Du¹
¹*Green Energy & Environment Research Lab., Industrial Technology Research Institute, Hsinchu, Taiwan, ²Department of Photonics and Institute of Electro-Optical Engineering, National Chiao-Tung University, Hsinchu, Taiwan*
- C36 New Silver Paste Metallization Approach on p+ Diffusion Zones of Silicon Solar cells**
Yunjun Li, Mohshi Yang, Igor Pavlovsky, Guoping Zeng
13010 Research Blvd, Suite 225, Austin, TX, United States
- C40 Reduced Temperature Silver Paste with Low Contact Resistance for Advanced Solar Cell Applications**
Ryan W Mayberry, Daniel Holzmann, Gerd Schulz, Lindsey Karpowich, Mark Naylor, Matthias Hoerteis
Heraeus Precious Metals North America Conshohocken LLC, West Conshohocken, PA, United States
- C46 Light Induced Plating of Silicon Solar Cells Using Boric Acid Free Nickel Chemistry**
Krystal Munoz¹, Lynne Michaelson¹, Joseph Karas², Tom Tyson¹, James Rand³, Stuart Bowden²
¹*Technic Inc, Cranston, RI, United States, ²Ira A. Fulton Schools of Engineering, Arizona State University, Tempe, AZ, United States, ³Core Energy Works, Newark, DE, United States*
- C52 Baking temperature dependence of Cu paste on Al-BSF cell properties**
Tomohiro Saito¹, Hoang Tri Hai¹, Daisuke Ando¹, Yuji Sutou¹, Junichi Koike¹, Tetsuya Fukuda²,

Yuji Kurimoto²

¹Tohoku University, Sendai, Japan, ²Material Concept, Inc., Sendai, Japan

C26 Electrodeposition of Si-layer Through Reduction of Diatomaceous Earth for the Application of Solar-Cells

Muhammad M. Islam^{1,2}, Imane Abdellaoui¹, Takeaki Sakurai¹, Saad Hamzaoui³, Katsuhiro Akimoto¹

¹Division of Applied Physics, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan, ²Alliance for Research on North Africa (ARENA), Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan, ³Laboratory of Electronic Microscopic and Materials Sciences, Faculty of Electrical Engineering, Oran University, Oran, Algeria

ePoster Self-Aligned Aluminum Selective Emitter for n-type Si Cells

San Theingi^{1,2}, Robert C. Reedy¹, Vincenzo LaSalvia¹, Paul Stradins¹, Benjamin G. Lee¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States

D4 Light Induced Electroless Nickel and Silicide Formation for Crystalline Silicon Solar Cell Metallization

Ashkan Vakiliipour Takaloo¹, Firat Es², Rasit Turan², Seung Ki Joo¹

¹Department of Materials Science and Engineering, Research Center and the Research Institute of Advanced Materials (RIAM) . Seoul National University, Seoul 151-742, Republic of Korea, Seoul, Korea, ²b. Department of Physic, Middle East Technical University, 06800, Ankara, Turkey. Center for solar Cell Research and applications (GUNAM), Middle East Technical University.06800, Ankara, Turkey, Ankara, Turkey

D6 Metallized Boron-Doped Black Silicon Emitters For Front-Contact Solar Cells

Guillaume von Gastrow¹, Eric Calle², Pablo Ortega², Ramón Alcubilla², Andreana Daniil³, Anna Fontcuberta i Morral³, Sebastian Husein⁴, Tara Nietzold⁴, Mariana Bertoni⁴, Hele Savin¹

¹Aalto University, Espoo, Finland, ²Universitat Politècnica de Catalunya, Barcelona, Spain, ³École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, ⁴Arizona State University, Tempe, AZ, United States

D11 Contact Resistance Measurement for Thermally Diffused Point Contacting by Localized Dielectric Breakdown Solar Cells

Qilin Ye, Ned J Western, Anqi Liao, Stephen P Bremner
UNSW, Sydney, Australia

D13 An In-Depth Investigation of Screen-Printed Ag and Al Contacts with TLM and EDX Techniques

Saleem zaidi, Samir Ahmad, Cheow Siu Leong, Kamaruzzam Sopian
Solar Energy Research Institute, Universiti Kebangsaan Malaysia, Bangi, Malaysia

Area 6 - Poster

10:30 - 12:00 PM

Exhibit Hall D

Perovskite and Organic Solar Cells

Chair(s): Woojun Yoon, Yasuhiro Shirai, Giles Eperon

D18 Enhanced Perovskite Solar Cell Performance Using Full Space Device Optimization

Ahmer AB Baloch¹, Shahzada P. Aly¹, Mohammad I. Hossain², Raka Jovanovic², Nouar Tabet^{1,2}, Fahhad H. Alharbi^{1,2}

¹College of Science and Engineering, Hamad bin Khalifa University, Doha, Qatar, ²Qatar Environment & Energy Research Institute, Hamad bin Khalifa University, Doha, Qatar

- D20 Measuring Optical Absorption in Organic Photovoltaics with Nanometer Scale Spatial Resolution**
 Jessica Alexander¹, Frank Scheltens¹, Lawrence Drummy², Michael Durstock², James Gilchrist³, Sandrine Heutz³, David McComb¹
¹The Ohio State University, Columbus, OH, United States, ²Air Force Research Laboratory, Wright-Patterson Air Force Base, OH, United States, ³Imperial College London, London, United Kingdom
- D22 Advanced Deposition of Photo-catalytic TiO₂ Film by Atmospheric SPPS for Dye Sensitized Solar Cells**
 Ifeanacho. Anyadiiegwu, Dickson. Kindole, Geoffrey. K Ronoh, Yasutaka Ando, Yoshimasa Noda
 Ashikaga Institute of Technology, Ashikaga, Japan
- D24 Iron Pyrite (FeS₂) Inexpensive Hybrid Solar Cell**
 Ayana Bhaduri¹, Partha Pratim Ray², Chandan Banerjee³
¹Amity University Gurgaon, Gurgaon, India, ²Jadavpur University, Kolkata, India, ³National Institute for Solar Energy, Gurgaon, India
- D26 Performance recovery of photo-degraded polymer solar cells by post degradation thermal anneal using thermally stable device**
 Joydeep Bhattacharya¹, Pranav H Joshi¹, Rana Biswas^{1,2,3}, Vikram L Dalal^{1,2}
¹Iowa State University, Ames, IA, United States, ²Microelectronics Research Center, Ames, IA, United States, ³Ames Laboratory, Ames, IA, United States
- D28 CH₃NH₃PbI_{3-x}Br_x perovskite solar cells via spray assisted two-step deposition: influence of bromide on the device performance**
 Gaoda Chai, Shiqiang Luo, Shizhen Wang, Hang Zhou
 Peking University ShenZhen Graduate School, Shenzhen, China
- D30 Acceptor moiety modification of a D-A-A' molecule for C₇₀ based small molecule organic solar cells**
 Chia-Hsun Chen¹, Ken-Tsung Wong², Tien-Lung Chiu³, Chi-Feng Lin⁴, Jiun-Haw Lee¹
¹Graduate Institute of Photonics and Optoelectronics and Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan, ²Department of Chemistry, National Taiwan University, Taipei, Taiwan, ³Department of Photonics Engineering, Yuan Ze University, Taiwan, Taoyuan, Taiwan, ⁴Department of Electro-Optical Engineering, National United University, Taiwan, Miaoli, Taiwan
- D32 Modulated Structure to Maximize the Open-Circuit Voltage with Moderate Band-gap of Small Molecule Organic Solar Cells-DFT Approach**
 Saravanan Chinnusamy¹, Amit Munshi², Walajabad Sampath², Milind Dangate¹
¹Department of Chemistry, Amrita Vishwa Vidyapeetham, Amrita University, Amritapuri, India, ²Department of Mechanical Engineering, Fort Collins, CO, United States
- D34 Perovskite Grain Size modulation by annealing in Methyl-Amine Environment**
 Arun Singh Chouhan¹, Naga Prathibha Jasti¹, Shreyash Hadke², Srinivasan Raghavan¹, Sushobhan Avasthi¹
¹Centre for Nanoscience and Engineering, Indian Institute of Science, Bangalore, India, ²Energy Research Institute, Nanyang technological University, Singapore, Singapore
- D36 Fe₂O₃ as an Electron Transport Material for Organic-Metal Halide Perovskite Solar Cells**
 Tara P Dhakal, Pravakar Rajbhandari, Dallas A Fisher
 Binghamton University, Binghamton, NY, United States
- D38 Optical Evaluation of Perovskite Films in and for Solar Cell Device Structures**
 Kiran Ghimire, Dewei Zhao, Changlei Wang, Yanfa Yan, Nikolas Podraza

Wright Center for Photovoltaics Innovation and Commercialization & Department of Physics and Astronomy, University of Toledo, TOLEDO, OH, United States

ePoster Investigation of High Performance Perovskite-based Solar Cells Grown by Hybrid Chemical Vapor Deposition Technique

Huseyin C Gokkaya, Qian Shen, Zhiwei Ren, Annie Ng, Charles Surya
Department of Electronic and Information Engineering, The Hong Kong Polytechnic University, Hong Kong, China

D40 Hybrid Organic-Inorganic Solar Cells with a Benzoquinone Passivating Layer

James Hack, Abhishek Iyer, Meixi Chen, Nicole Kotulak, Akirt Sridharan, Robert Opila
University of Delaware, Newark, DE, United States

D42 Precise I-V Curve Measurement Procedure for Perovskite Solar Cells: Application to Various Types of Devices

Yoshihiro HISHIKAWA, Masahiro YOSHITA, Haruya SHIMURA, Ayumi SASAKI, Takashi UEDA
AIST, Tsukuba, Japan

D44 Understanding the Recrystallization Mechanism of MAPbI₃ Under Methylamine Atmosphere to Form Large-Grained Thin Films

Daniel L. Jacobs, Ling Zang
Department of Materials Science and Engineering, University of Utah, Salt Lake City, UT, United States

D46 Enhancing the Crystalline of Planar-Structure CH₃NH₃PbI₃ Perovskite Solar Cells via Sandwich Evaporation Technique

Po-Tsun Kuo¹, Shang-Pang Lin¹, Cheng-Shian Lin¹, Ching-Fuh Lin^{1,2,3,4}
¹*Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan,*
²*Graduate Institute of Electronics Engineering, National Taiwan University, Taipei, Taiwan,*
³*Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan,* ⁴*Innovative Photonics Advanced Research Center, National Taiwan University, Taipei, Taiwan*

D48 Toward High Performance Organic-Silicon Hybrid Solar Cells

Yi Lai¹, Hong-Jhang Syu¹, Ching-Fuh Lin^{1,2,3,4}
¹*Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan,*
²*Graduate Institute of Electronics Engineering, National Taiwan University, Taipei, Taiwan,*
³*Department of Electrical Engineering, National Taiwan University, Taipei, Taipei, Taiwan,*
⁴*Innovative Photonics Advanced Research Center, National Taiwan University, Taipei, Taiwan*

D50 Nickel Oxide Thin Films by Radio Frequency Sputter for Inverted Perovskite Solar Cells

Hyeonseok Lee, Yu-Ting Huang, Shien-Ping Feng
the University of Hong Kong, Hong Kong, Hong Kong

D52 Anharmonicity in Hybrid and Inorganic Perovskite Materials used for Photovoltaics Applications

Arthur Marronnier¹, Heejae Lee¹, Denis Tondelier¹, Bernard Geffroy^{1,2}, Jean-Eric Bourée¹, Yvan Bonnassieux¹, Guido Roma³
¹*LPICM, CNRS, Ecole Polytechnique, Paris-Saclay University, Palaiseau, France,* ²*LCSEN, NIMBE, CEA, Paris-Saclay University, Saclay, France,* ³*SRMP, CEA, Paris-Saclay University, Saclay, France*

D54 Anomalous Efficiency Scaling with Dark Current in Perovskite Solar Cells

Vikas Nandal, Pradeep R. Nair
Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, India

- D56 Numerical simulation and performance optimization of perovskite solar cell**
Sai Naga R. Nanduri, Mahbube K. Siddiki, Ghulam M. Chaudhry, Yahya Z. Alharthi
Department of Computer Science and Electrical Engineering, University of Missouri-Kansas City, Kansas city, MO, United States
- E2 Performance Prediction for Large Area Perovskite Solar Cells**
Yojak B. Raote, Hitarth Choubisa, Pradeep R. Nair
Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, India
- E4 Photoconversion Efficiency Modeling in Perovskite Solar Cells**
Anatoliy V. Sachenko¹, Vitaliy P. Kostylyov¹, Alexander V. Bobyl², Viktor M. Vlasiuk¹, Igor O. Sokolovsky^{1,3}, Eugen I. Terukov^{2,4}, Mykhaylo Evstigneev³
¹*V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine, Kiev, Ukrenia*, ²*Ioffe Institute RAS, St.-Petersburg, Russia*, ³*Department of Physics and Physical Oceanography, Memorial University of Newfoundland, St. John's, NL, Canada*, ⁴*TFTC Ioffe R&D Center, St.-Petersburg, Russia*
- E6 Influence of Mono- and Di-valent Metal Additives on Morphology and Charge Carrier Dynamics of CH₃NH₃PbI₃ Perovskite**
Niraj Shrestha, Suneth C. Waththage, Zhaoning Song, Paul J. Roland, Adam B. Phillips, Michael J. Heben, Randall J. Ellingson
Department of Physics and Astronomy, and Wright Center for Photovoltaics Innovation and Commercialization, Toledo, OH, United States
- E8 Effect of Dual Cathode Buffer Layer on Ternary Organic Solar Cell**
Ashish Singh¹, T. Bhim Raju², Anamika Dey^{1,2}, Ritesh Kant Gupta¹, Parameswar K. Iyer^{1,2}
¹*Centre for Nanotechnology, Indian Institute of Technology Guwahati, Guwahati, India*, ²*Department of chemistry, Indian Institute of Technology Guwahati, Guwahati, India*
- E10 Copper Plated Top Electrode for an Inverted Organic Photovoltaic**
Malia Steward, Zhan Shi, Kyoung-Tae Kim, Seungkeun Choi
University of Washington Bothell, Bothell, WA, United States
- E11 Interface Band Gap and Charge Trapping in Bulk Heterojunction Solar Cells**
Marian B Tzolov, Maxwell McIntyre
Lock Haven University of PA, Lock Haven, PA, United States
- E13 Analysis of burn-in loss of power conversion efficiency in inverted organic solar cells**
Ashraf Uddin, Mushfika Baishakhi Upama, Matthew Wright, Naveen Elumalai, Md Arafat Mahmud, Dian Wang, Faiazul Haque, Cheng Xu
The University of New South Wales, Sydney, Australia
- E15 Fabrication of Efficient CH₃NH₃PbI₃ Solar Cells in Ambient Air**
Feng Wang^{1,2}, Zhongbiao Ye^{1,2}, Hojjatollah Sarvari¹, Somin Park³, Kenneth Graham³, Yuetao Zhao^{1,2}, Zhi David Chen^{1,2}
¹*Department of Electrical & Computer Engineering, and Center for Nanoscale Science & Engineering, University of Kentucky, Lexington, KY, United States*, ²*School of Optoelectronic Information, University of Electronic Science and Technology of China, Chengdu, China*, ³*Department of Chemistry, University of Kentucky, Lexington, KY, United States*
- E17 Interfacial Modification of Sol-Gel-Derived ZnO/AZO Bilayer as Highly Efficient Electron Transport Layer for Perovskite Solar Cells**
Shang-Hsuan Wu¹, Ming-Yi Lin², Sheng-Hao Chang², Wei-Chen Tu², Chi-Wei Chu¹, Yia-Chung Chang¹
¹*Research Center for Applied Sciences, Academia Sinica, Taipei, Taiwan*, ²*Department of Electronic Engineering, Chung Yuan Christian University, Taoyuan, Taiwan*

E19 High Efficiency Perovskite Solar Cells by a Modified Low-Temperature Solution Process Inter-Diffusion Method

Yangyi Yao, Wei-Lun Hsu, Mario Dagenais
University of Maryland, College Park, MD, United States

E21 Highly Conductive ChargeNE-Transport Thin Films for Efficient Hybrid Perovskite Solar Cells Fabricated by Scalable Substrate Vibration-Assisted Drop Casting (SVADC)

Fatemeh Zabih², Qianli Chen¹, Morteza Eslamian¹
¹*University of Michigan-Shanghai Jiao Tong University Joint Institute, Shanghai 200240, China, Shanghai, 200240, China,* ²*State Key Laboratory for Modification of Chemical Fibers and Polymer Materials, College of Materials, Shanghai, 201620, China*

Area 8 - Poster

10:30 - 12:00 PM

Exhibit Hall B

Bifacial, Partly Shaded PV Performance, Characterization/ Field Analysis

Chair(s): Roger French, Kendra Passow, Christoph Mayr

E24 Performance Assessment of Stand Alone Bifacial Solar Panel Under Real Time Conditions

Ahmer AB Baloch¹, Maher Armoush², Basel Hindi², Abdelkader Bouselham³, Nouar Tabet^{1,3}
¹*College of Science and Engineering, Hamad bin Khalifa University, Doha, Qatar,* ²*Mechanical Engineering Program, Texas A&M University at Qatar, Doha, Qatar,* ³*Qatar Environment & Energy Research Institute, Hamad bin Khalifa University, Doha, Qatar*

E32 Requirements for Measurements of Bifacial Modules and Some Factors Affecting the Simulation of Energy Generation by Bifacial PV Systems

Lev Kreinin¹, Asher Karsenti², Dov Grobgeld², Naftali Eisenberg²
¹*SolAround, Jerusalem, Israel,* ²*Academic Center Lev (JCT), Jerusalem, Israel*

E34 APPLICATION OF SHAPED REFLECTORS TO INCREASE THE ENERGY HARVEST OF BIFACIAL PV SYSTEMS - ANALYZED WITH A MINIATURIZED TEST ARRAY

Hartmut Nussbaumer, Markus Klenk, Nico Keller, Dominic Heller, Remo Käslin, Thomas Baumann, Franz Baumgartner
Zurich University of Applied Science, Winterthur, Switzerland

ePoster The Potential of Bifacial Photovoltaics: A Global Perspective

Xingshu Sun¹, Mohammad R. Khan¹, Amir Hanna², Muhammad M. Hussain², Muhammad A. Alam¹
¹*Network of Photovoltaic Technology, Purdue University, West Lafayette, IN, United States,* ²*Integrated Nanotechnology and IDEA Lab, King Abdullah University of Science and Technology, Thuwal, Saudi Arabia*

E44 Bifacial Photovoltaic Module Energy Yield Calculation and Analysis

Christopher E. Valdivia¹, Chu Tu Li¹, Annie Russell¹, Joan E. Haysom¹, Rui Li², David Lekx², Mohsen M. Sepeher², Dan Henes², Karin Hinzer¹, Henry P. Schriemer¹
¹*SUNLAB, Centre for Research in Photonics, University of Ottawa, Ottawa, ON, Canada,* ²*Celestica Inc., Toronto, ON, Canada*

E46 Advantages of Bifacial PV Modules

Bas B. Van Aken¹, Sergiu C. Pop²
¹*ECN - Solar Energy, Petten, Netherlands,* ²*Yingli Green Energy Americas, San Francisco, CA, United States*

E42 Data analysis for effective monitoring of partially shaded photovoltaic systems

Odysseas Tsafarakis, Kostas Sinapis, Wilfried G.J.H.M. van Sark
, *Utrecht, Netherlands*

E40 Partial Shading Abatement Through Cascaded H-Bridge Topology

Steven M Tidwell, Joseph W Latham, Michael McIntyre
University of Louisville, Louisville, KY, United States

E36 Towards a new PV module concept for linear shading response

Kostas Sinapis¹, Tom Rooijackers¹, Lenneke H. Sloof², Lars A.G. Okel², Mark J. Jansen², Anna J. Carr²

¹*Solar Energy Application Centre (SEAC), Eindhoven, Netherlands*, ²*Energy research Centre of the Netherlands (ECN), Petten, Netherlands*

E30 Predicting Module Mismatch Loss in Utility-Scale Photovoltaic Systems

Stephen Kaplan, Kendra Passow
First Solar, Inc., San Francisco, CA, United States

E28 A Novel Multilevel Solar Panel System: Implementation and Verification

Tanmoy Debnath, Syed Nafiz Imtiaz, Syed Fakir Nawaz, Abdullah Al Mahmud, Md Mosaddequr Rahman
Dept of Electrical & Electronic Engineering., BRAC University, Dhaka, Bangladesh

ePoster Methodology to Analyze Performance of Photovoltaic Systems Based on Location and Weather Conditions

Bridget V Boland, Sandra Schujman, Jonathan Mann, David Metacarpa, Pradeep Haldar
US Photovoltaic Manufacturing Consortium (PVMC), SUNY Polytechnic Institute, Albany, NY, United States

E26 New analysis approach to characterize grid-connected PV systems applied to PV systems in operation in South Maui

Severine Busquet, Jonathan Kobayashi, Richard E. Rocheleau
UH-HNEI, Honolulu, HI, United States

E38 Effects of Bypass Diode Configurations to the Maximum Power of Photovoltaic Module

J. C. Teo¹, Rodney H. G. Tan¹, V. H. Mok¹

¹*UCSI University, Kuala Lumpur, Malaysia*, ²*UCSI University, Kuala Lumpur, Malaysia*, ³*UCSI University, Kuala Lumpur, Malaysia*

E48 Design and Development of a Solar Photovoltaic Module Detection Control System based on PLC

Yiwang wang^{1,2,3}, Jili zhang¹, Kanglin liu², Houjun Tang³, Hui Pan⁴, Yan Lin⁵, Peter Yang⁶, Rui wang⁷

¹*Jiangsu Engineering Research Center for Photovoltaic Generation, Suzhou, China*, ²*Shanghai Jiaotong University, Shanghai, China*, ³*The University of Tennessee, Knoxville, TN, United States*, ⁴*Suzhou Tianye Electric Appliance Co.,Ltd, Suzhou, China*, ⁵*Luxen Solar Energy Co.,Ltd, Suzhou, China*, ⁶*Suzhou Smagix Energy Technology Co.,Ltd, Suzhou, China*, ⁷*Suzhou KSTN New Energy Technology Co.,Ltd, Suzhou, China*

Area 11 - Poster

10:30 - 12:00 PM

Exhibit Hall A

Solar Resource for PV and Forecasting

Chair(s): Skip Dise, Justin Robinson, Matthew Lave

E50 Performance of Solar Resource Monitoring Stations in Hot Climate Regions

Yahya ALharthi, Mahbube Siddiki, Ghulam Chaudhry, Saad Muaddi, Ahmed Alahmed
¹UMKC, kansas city, MO, United States, ²UMKC, kansas city, MO, United States, ³UMKC, kansas city, MO, United States, ⁴UMKC, kansas city, MO, United States, ⁵UMKC, kansas city, MO, United States

E52 First Results of a Low Cost All-Sky Imager for Cloud Tracking and Intra-Hour Irradiance Forecasting serving a PV-based Smart Grid in La Graciosa Island

David Cañadillas¹, Walter Richardson², Benjamín González-Díaz³, Les E. Shephard⁴, Ricardo Guerrero-Lemus¹
¹Departamento de Física. Universidad de La Laguna. Avenida Astrofísico Francisco Sánchez S/N 38206, San Antonio, TX, United States, ²Department of Mathematics. University of Texas at San Antonio, One UTSA Circle, San Antonio, TX, United States, ³Departamento de Ingeniería Industrial. Universidad de La Laguna. Avenida Astrofísico Francisco Sánchez S/N 38206, San Cristóbal de La Laguna, Spain, ⁴Department of Civil Engineering. University of Texas at San Antonio, One UTSA Circle, San Antonio, TX, United States

F4 Statistical Analysis of PV Insolation Data

Abdulmunim H Guwaeder¹, Rama K Ramakumar²
¹Oklahoma State University, Stillwater, OK, United States, ²Oklahoma State University, Stillwater, OK, United States

F6 A Comparison of PV Power Forecasts Using PVLIB-Python

William F Holmgren¹, Antonio T Lorenzo², Clifford Hansen³
¹Department of Hydrology and Atmospheric Sciences, University of Arizona, Tucson, AZ, United States, ²College of Optical Sciences, University of Arizona, Tucson, AZ, United States, ³Sandia National Laboratories, Albuquerque, NM, United States

F8 Comparing the Typical GHI Year vs Typical Power Year

Alex Kubiniec, Adam Kankiewicz, Alemu Tadesse
Clean Power Research, Kirkland, WA, United States

F10 Mapping of the potential capacity of grid-connected PV systems in Indonesia: A comparison of two methods

Kun Kunaifi^{1,2}, A.H.M.E Reinders¹
¹University of Twente, Faculty of Engineering Technology, Department of Design, Production and Management, Enschede, Netherlands, ²UIN Suska Riau University, Faculty of Science and Technology, Pekanbaru, Indonesia

F11 The Holy Grail of Resource Assessment: Low Cost Ground-Based Measurements with Good Accuracy

Bill Marion¹, Benjamin Smith²
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Enphase Energy, Inc., Petaluma, CA, United States

ePoster **Detecting Calibration Drift at Ground Truth Stations -- A Demonstration of Satellite Irradiance Models' Accuracy**

Richard Perez¹, James Schlemmer¹, Adam Kankiewicz², John Dise², Alemu Tadesse², Thomas Hoff²
¹State University of New York, Albany, NY, United States, ²Clean Power Research, Kirkland, WA, United States

F12 Global Comparison of the Impact of Temperature and Humidity on CdTe and Silicon Solar Cells

Ian Marius Peters¹, Haohui Liu², Thomas Reindl², Tonio Buonassisi¹

¹Massachusetts Institute of Technology, Cambridge, MA, United States, ²Solar Energy Research Institute of Singapore, Singapore, Singapore

- F13 Research on Environmental Parameters to identify their effects on mono-crystalline Photovoltaic cell**
Masud Rana Rashed^{1,2}, Andre Albion^{1,2}, Md. Tofael Ahmed^{1,2}, Jannatul Rifath³, Ana Catarina das Neves Foles^{1,2}, Teresa C. F Goncalves^{1,2}, Mouhaydine Tlemcani^{1,2}
¹University of Évora, Évora, Portugal, ²Institute of Earth Science, Portugal, Portugal, ³Shahjalal university of science and technology, sylhet, Bangladesh
- F14 Estimation of mean monthly global solar radiation using model based on sunshine hours for Colombia**
Diego Julián Rodríguez¹, Ovidio Simbaqueva², Johann Hernández¹
¹Universidad Distrital FJDC, Bogotá, Columbia, ²Fundación Universitaria Los Libertadores, Bogotá, Columbia
- F15 Implementation of Solar Diffuse CIE Model in Ray Tracing Program for Irradiance Calculations**
Liliana Ruiz Diaz, Pierre-Alexandre Blanche, Robert A. Norwood
College of Optical Sciences, The University of Arizona, Tucson, AZ, United States
- F16 Investigation of City-Level Site-Pair Correlations of Solar Variability using Empirical Satellite Data**
Rhythm Singh^{1,2}, Rangan Banerjee²
¹National Institute of Construction Management and Research, Pune, India, ²Indian Institute of Technology Bombay, Mumbai, India
- F17 Ultra-short-term Photovoltaic Power Forecasting Model Based on Adaboost Clustering and Markov Chain**
Jin Tan, Changhong Deng
Wuhan University, Wuhan, China
- F18 Daily Solar Irradiance Profile Characterization and Ramp Rate Analysis at Different Time Resolutions**
Spyros Theocharides, Venizelos Venizelou, George Makrides, George E. Georghiou
University of Cyprus, Nicosia, Cyprus
- F19 A Sky Image Analysis System for Sub-minute PV Prediction**
Rodrigo Verschae¹, Li Li¹, Shohej Nobuhara¹, Takekazu Kato^{1,2}
¹Kyoto University, Kyoto, Japan, ²Shizuoka Institute of Science and Technology, Fukuroi, Japan
- F20 Comparison and Analysis of Instruments Measuring Plane of Array Irradiance for One Axis Tracking PV Systems**
Frank Vignola¹, Chun-Yu Chiu¹, Josh Peterson¹, Michael Dooraghi², Manajit Sengupta²
¹University of Oregon, Eugene, OR, United States, ²NREL, Golden, CO, United States
- F21 Statistical Analysis of Prediction Error for Photovoltaic Power**
Pei Xia, Changhong Deng, Gongchen Wang
Department of Electrical Engineering, Wuhan University, Wuhan, China
- F2 Combine deep neural network and tree based machine learning models using stacked generalization to forecast hourly solar irradiance for tropical regions**
Zibo Dong, Lu Zhao, Wilfred M. Walsh, Thomas Reindl
Solar Energy Research Institute of Singapore, Singapore, Singapore

Break	
12:00 - 1:30 PM	Ballroom Foyer
Lunch On Own	

Area 1 - Oral	
1:30 - 3:00 PM	Maryland A
Light Management and Spectral Splitting	

Chair(s): Tom Vandervelde, Chien-chung Lin

1:30 **Best Student Presentation Award Finalist**

Large Area Nanostructure Integration for Broad-Spectrum, Omnidirectional Antireflection Improvements on Polymer Packaged, Mechanically Flexible, Epitaxial Lift-Off III-V Solar Cells

Gabriel Cossio¹, Jihwan Lee¹, Gautham Rangunathan², Andre Wibowo², Sudersena R. Tatavarti², Kimberly A. Sablon³, Edward T. Yu¹

¹University of Texas at Austin, Austin, TX, United States, ²Microlink Devices Inc, Niles, IL, United States, ³U.S. Army Research Laboratory, Adelphi, MD, United States

1:45 **Ultra-thin Resonant Cavity Enhanced Amorphous Germanium Solar Cells on ZnO Honeycomb Electrodes**

Colleen Lattyak, Regina-Elisabeth Ravekes, Volker Steenhoff, Martin Vehse, Carsten Agert
NEXT ENERGY – EWE Research Centre for Energy Technology, Oldenburg, Germany

2:00 **Best Student Presentation Award Finalist**

Experimental Results for Tailored Spectrum Splitting Metallic Nanofluids for c-Si, GaAs, and Ge Solar Cells

Natasha E Hjerrild, Felipe Crisostomo, Robert Lee Chin, Jason A. Scott, Rose Amal, Robert A. Taylor

University of New South Wales, Sydney, Australia

2:15 **Diffraction Volume Optics for Advanced Light Management in PV Modules**

Gerhard Peharz, Ladislav Kuna
JOANNEUM RESEARCH, Weiz, Austria

2:30 **Development of Back Surface Texture for Light Management in Epitaxial Lift Off (ELO) Quantum Dot Solar Cells**

Seth M Hubbard¹, Brittany Smith¹, George Nelson¹, Yushuai Dai¹, Michael Slocum¹, Andree Wibowo², Rao Tatavarti²

¹Rochester Institute of Technology, Rochester, NY, United States, ²Microlink Devices, Inc., Niles, IL, United States

2:45 **Enabling high-efficiency InAs/GaAs Quantum Dot Solar Cells by Epitaxial Lift-Off and Light Management**

Federica Cappelluti¹, Ariel Pablo Cedola¹, Arastoo Khalili¹, Farid Elsehrawy¹, Gerard Bauhuis², Peter Mulder², John Schermer², Gunther Bissels³, Timo Aho⁴, Tapio Niemi⁴, Mircea Guina⁴, Donyoung Kim⁵, Jiang Wu⁵, Huiyun Liu⁵

¹Department of Electronics and Telecommunications, Politecnico di Torino, Torino, Italy, ²Institute for Molecules and Materials, Radboud University, Nijmegen, Netherlands, ³tf2 devices B.V., Nijmegen, Netherlands, ⁴Optoelectronics Research Centre, Tampere University of Technology, Tampere, Finland, ⁵Department of Electronic and Electrical Engineering, University College London, London, United Kingdom

Area 2 - Oral

1:30 - 3:00 PM

Marriott Ballroom Salon 3

Advances in CdTe I

Chair(s): Chris Ferekides, Xiangxin Liu

1:30 Improving CdTe for Photovoltaics

Wyatt K Metzger¹, Joel Duenow¹, Eric Colegrove¹, David Albin¹, Matthew Reese¹, Mahisha Amarasinghe¹, Teresa Barnes¹, James Burst¹, Darius Kuciauskas¹, Santosh Swain², Kelvin Lynn², Brian McCandless³, Moseley John¹, Moutinho Helio¹, Chun-Sheng Jiang¹, Al-Jassim Mowafak¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Washington State University, Pullman, WA, United States, ³Institute of Energy Conversion, Newark, DE, United States

2:00 Characterization of Arsenic Doped CdTe Layers and Solar Cells

Sachit Grover, Xiaoping Li, Wei Zhang, Ming Yu, Gang Xiong, Markus Gloeckler, Roger Malik
First Solar Inc., Santa Clara, CA, United States

2:15 Enhancing p-type Doping in Polycrystalline CdTe Films

Brian E McCandless¹, Wayne A Buchanan¹, Gowri Sriramagiri¹, Christopher P Thompson¹, Joel Duenow², David Albin², Soren Jensen², John Moseley², Wyatt K Metzger²
¹University of Delaware, Newark, DE, United States, ²National Renewable Energy Laboratory, Golden, CO, United States

2:30 Best Student Presentation Award Finalist**Influence of CdTe Deposition Temperature and Window Thickness on CdTe Grain Size and Lifetime After CdCl₂ Recrystallization**

Mahisha Amarasinghe¹, Eric Colegrove², Helio R. Moutinho², David S. Albin², Joel N. Duenow², Steve Johnston², Jason M. Kephart³, Walajabad S. Sampath³, Mowafak M. Al-Jassim², Sivalingam Sivananthan¹, Wyatt K. Metzger²
¹University of Illinois, Chicago, IL, United States, ²National Renewable Energy Laboratory, Golden, CO, United States, ³Colorado State University, Fort Collins, CO, United States

2:45 Best Student Presentation Award Finalist**Polycrystalline CdSeTe/CdTe Absorber Cells with 28 mA/cm² Short-Circuit Current**

Amit Munshi¹, Ali Abbas², Jason Kephart¹, John Raguse³, Jean-Nicolas Beaudry⁴, Kurt Barth¹, James Sites³, John Walls², Walajabad Sampath¹
¹Department of Mechanical Engineering, Colorado State University, Fort Collins, CO, United States, ²CREST, Loughborough University, Loughborough, United Kingdom, ³Department of Physics, Colorado State University, Fort Collins, CO, United States, ⁴5N Plus Inc., Montreal, QC, Canada

Area 3 - Oral

1:30 - 3:00 PM

Virginia A

III-V PV: Materials and Multijunctions

Chair(s): Ryan France, Won-Kyu Park

1:30 Building a Six Junction Inverted Metamorphic Concentrator Solar Cell

John F. Geisz, Myles A. Steiner, Nikhil Jain, Kevin L. Schulte, Ryan M. France, William E.

McMahon, Emmett E. Perl, Kelsey A. Horowitz, Daniel J. Friedman
NREL, Golden, CO, United States

2:00 **Spectral and Concentration Sensitivity of Multijunction Solar Cells at High Temperature**

Daniel J. Friedman, Myles A. Steiner, Emmett E. Perl, John Simon
National Renewable Energy Laboratory, Golden, CO, United States

2:15 **On the use of transparent conductive oxides in high concentrator III-V multijunction solar cells**

Ignacio Rey-Stolle^{1,2}, Yeonbae Lee¹, Ivan Garcia², Kin Man Yu³, Carlos Algora², Wladek Walukiewicz¹

¹Lawrence Berkeley National Lab, Berkeley, CA, United States, ²Universidad Politécnica de Madrid, Madrid, Spain, ³City University of Hong Kong, Hong Kong, Hong Kong

2:30 **Component Integration Effects in 4-junction Solar Cells with Dilute Nitride 1eV Subcell**

Ivan Garcia¹, Mario Ochoa¹, Ivan Lombardero¹, Luis Cifuentes¹, Ignacio Rey-Stolle¹, Carlos Algora¹, Andrew D. Johnson², J. Iwan Davies², Tan Kian Hua³, Loke Wan Khai³, Satrio Wicaksono³, Soon Fat Yoon³

¹Universidad Politécnica de Madrid, Madrid, Spain, ²IQE PLC, Cardiff, United Kingdom, ³Nanyang Technological University, Singapore, Singapore

2:45 **Best Student Presentation Award Finalist**

Bismuth Surfactant-Mediated Growth of GaNAsSb(Bi) Solar Cells

Aymeric Maros¹, Chaomin Zhang¹, Nikolai Faleev¹, Christiana B. Honsberg¹, Richard R. King¹, Jongwon Lee¹, Hongfeng Wang², Stephen Bremner²

¹Arizona State University, TEMPE, AZ, United States, ²University of New South Wales, Sydney, Australia

Area 4 - Oral

1:30 - 3:00 PM

Marriott Ballroom Salon 2

Surface Passivation and Light Management

Chair(s): Zachary Holman, Marius Peters

1:30 **Amorphous silicon carbide for silicon surface passivation in carrier-selective contact devices**

Mathieu Boccard¹, Zachary Holman², Christophe Ballif¹

¹EPFL, PVlab, Neuchâtel, Switzerland, ²ASU, Tempe, AZ, United States

1:45 **Surface passivation of boron diffused junctions by borosilicate glass and in situ grown silicon dioxide interface layer**

Valentin D. Mihailetchi, Haifeng Chu, Jan Lossen, Radovan Kopecek
ISC Konstanz e.V., Konstanz, Germany

2:00 **Optical Performance Enhancement of Flat Silicon Solar Cells and their Tandems with PDMS Scattering Layers**

Salman Manzoor¹, Zhengshan J. Yu¹, Asad Ali¹, Waqar Ali¹, Kevin A. Bush², Axel F. Palmstrom², Stacey F. Bent², Michael D. McGehee², Zachary C. Holman¹

¹School of Electrical, Computer, and Energy Engineering, Arizona State University, Tempe, AZ, United States, ²Stanford University, Stanford, CA, United States

2:15 **Damage-free laser ablation for emitter patterning of silicon heterojunction interdigitated back-contact solar cells**

Menglei Xu^{1,2}, Twan Bearda², Miha Filipic², Hariharsudan Sivaramakrishnan Rad², Maarten

Debucquoy², Ivan Gordon², Jozef Szlufcik², Jef Poortmans^{1,2,3}

¹KU Leuven, Leuven, Belgium, ²IMEC, Leuven, Belgium, ³Universiteit Hasselt, Hasselt, Belgium

- 2:30 **Benefits of a thermal drift during atomic layer deposition of Al₂O₃ for c-Si passivation**
Fabien Lebreton^{1,2,3}, Andy Zauner^{4,3}, Pavel Bulkin^{2,3}, François Silva^{2,3}, Sergej Filonovich^{1,3}, Pere Roca i Cabarrocas^{2,3}

¹Total – GRP, Paris, France, ²LPICM, CNRS, Ecole Polytechnique, Université Paris-Saclay, Palaiseau, France, ³Institut Photovoltaïque d'Île-de-France (IPVF), Antony, France, ⁴Air Liquide Paris-Saclay Research Center, Les Loges-en-Josas, France

- 2:45 **Growth Difference of amorphous silicon between plasma enhanced and catalytic CVD based on silicon heterojunction solar cells**

Liping Zhang¹, Renfang Chen¹, Chenguang Sun², Zhuopeng Wu¹, Jinning Liu¹, Fanying Meng¹, Zhengxin Liu¹

¹Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Shanghai, China, ²State Key Laboratory of PV Science and Technology, Trina Solar, Changzhou, China

Area 6 - Oral

1:30 - 3:00 PM

Maryland B&C

Perovskite Materials and Solar Cells

Chair(s): Giles Eperon, Yasuhiro Shirai

- 1:30 **Developing an understanding-based selection of hybrid-perovskite compounds and the Cu-In hybrid perovskite (CHIPs) Family**

alex Zunger

University of Colorado, boulder, CO, United States

- 2:00 **Effects of Electron and Proton Radiation on Perovskite Solar Cells for Space Solar Power Application**

Jing-Shun Huang¹, Michael D Kelzenberg¹, Colin J Mann², Don Walker², Harry A Atwater¹

¹CalTech, Pasadena, CA, United States, ²Aerospace Corporation, El Segundo, CA, United States

- 2:15 **Towards Perovskite Silicon Tandem Solar Cells with Optimized Optical Properties**

Jan Christoph Goldschmidt¹, Alexander J. Bett¹, Patricia S. Schulze¹, Nico Tucher¹, Martin Bivour¹, Markus Kohlstädt¹, Seunghun Lee¹, Simone Mastroianni¹, Laura Mundt¹, Markus Mundus¹, Paul Ndione², Karl Wienands¹, Kristina Winkler¹, Uli Würfel¹, Martin Hermle¹, Stefan W. Glunz^{1,3}

¹Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany, ²National Renewable Energy Laboratory, Golden, CO, United States, ³Albert-Ludwigs-University, Freiburg, Germany

- 2:30 **First-principles density functional theory calculation of metal-substituted lead halide perovskite**

Maria K. Y. Chan¹, Ji-Sang Park¹, Matthew D. Sampson², Alex B. F. Martinson²

¹Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL, United States,

²Materials Science Division, Argonne National Laboratory, Argonne, IL, United States

- 2:45 **Enhancement of efficiency for perovskite solar cells consisting of Sn**

Kongo Hamada¹, Yuhei Ogomi¹, Daisuke Hirotani¹, Daiki Yamasuso¹, ayumu Yonaha¹, Erina Yamaguchi¹, Shen Qing², Taro Yoyoda², Kenji Yoshino³, Takshi Minemoto⁴, Shuzi Hayase¹

¹Kyushu Institute of Technology, Kitakyushu, Japan, ²University of Electro-communication, Chofu, Japan, ³Miyazaki University, Miyazaki, Japan, ⁴Ritsumeikan University, Ohtsu, Japan

Area 8 - Oral

1:30 - 3:00 PM

Delaware A

Module Materials, Design, Manufacture, and Production

Chair(s): Michael Kempe, David Meakin

1:30 **19.86% Aperture Efficient World Record P-type Multi-crystalline Module with 20.59% Efficient PERC Solar Cells**

Shu Zhang, Yang Yang, Weiwei Deng, Hongwei Huang, Yeyi Jin, Pietro P. Altermatt, Jianmei Xu, Zhiqiang Feng, Pierre J. Verlinden
State Key Laboratory of PV Science and Technology, Changzhou Trina Solar Energy Co., Ltd., changzhou, China

2:00 **Best Student Presentation Award Finalist**

Manufacturable Multiwire Stringing and Cell Interconnection for Silicon Cells and Modules

Luke T. Meyer, Sarah Wiegold, Ashley E. Morishige, Emanuel Sachs, Tonio Buonassisi
Massachusetts Institute of Technology, Cambridge, MA, United States

2:15 **Reducing Operating Temperature in Photovoltaic Modules**

Timothy J Silverman, Michael G. Deceglie, Ingrid Repins
National Renewable Energy Laboratory, Golden, CO, United States

2:30 **Estimating the Effects of Module Area on Thin-Film Photovoltaic System Costs**

Kelsey A. W. Horowitz¹, Ran Fu¹, Xingshu Sun², Tim Silverman¹, Muhammad A. Alam²
¹*National Renewable Energy Laboratory (NREL), Golden, CO, United States*, ²*Purdue University, West Lafayette, IN, United States*

2:45 **Best Student Presentation Award Finalist**

Cost Analysis of Tandem Modules

Sarah E. Sofia¹, Jonathan P. Mailoa¹, Dirk N. Weiss², Tonio Buonassisi¹, Ian M. Peters¹
¹*Massachusetts Institute of Technology, Cambridge, MA, United States*, ²*First Solar, Inc., Santa Clara, CA, United States*

Area 9 - Oral

1:30 - 3:00 PM

Delaware B

Field Reliability, Systems, and Safety

Chair(s): Greg Ball, Jeff Newmiller, Markus Schweiger

1:30 **Comparison of PV Module Performance Before and After 11, 20, and 25.5 Years of Field Exposure**

Jacob Rada^{1,2}, Charles Chamberlin^{1,2}, Peter Lehman^{1,2}, Arne Jacobson^{1,2}
¹*Humboldt State University, Arcata, CA, United States*, ²*Schatz Energy Research Center, Arcata, CA, United States*

1:45 **Robust PV Degradation Methodology and Application**

Dirk C. Jordan¹, Chris Deline¹, Sarah R. Kurtz¹, Greg Kimball², Mike Anderson²
¹*NREL, Golden, CO, United States*, ²*Sunpower, Rio Robles, CA, United States*

2:00 **Detecting photovoltaic module failures in the field during daytime with ultraviolet fluorescence module inspection**

Arnaud Morlier¹, Michael Siebert¹, Iris Kunze¹, Gerhard Mathiak², Marc Köntges¹
¹ISFH, Emmerthal, Germany, ²TÜV Rheinland Energy, Cologne, Germany

2:15 Cause of Current-Collection Failure Observed in I_{sc} -Reduction Phase of PV Cells and Modules Exposed to Acetic Acid

Tadanori Tanahashi, Norihiko Sakamoto, Hajime Shibata, Atsushi Masuda
National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan

2:30 Marrying Quality Assurance with Design Engineering - A Winning Partnership! but a Cultural Clash?

Sarah Kurtz¹, Govind Ramu³, Robert Cornell⁴, Sumanth Lokanath⁴, Edward Hsi⁵, Tony Sample⁶, Masaaki Yamamichi⁷, George Kelly⁸, Ted Spooner⁹, Jonathan Previtali¹⁰, John Wohlgemuth²
¹National Renewable Energy Laboratory, Golden, CO, United States, ²PowerLight, Camarillo, CA, United States, ³SunPower Corporation, San Jose, CA, United States, ⁴First Solar, Tempe, AZ, United States, ⁵Swiss Reinsurance Company, Hong Kong, China, ⁶European Commission, JRC, Ispra, Italy, ⁷AIST, Tsukuba, Japan, ⁸Sunset Technology, Mount Airy, MD, United States, ⁹UNSW, Sydney, Australia, ¹⁰Wells Fargo, San Francisco, CA, United States

2:45 Updated Evaluation of Shock Hazards to Firefighters Working in Proximity of PV Systems.

Olga Lavrova, Jimmy Quiroz, Jack Flicker, Renee Gooding
Sandia National Laboratories, Albuquerque, NM, United States

Break	
3:00 - 3:30 PM	Exhibit Hall A
Coffee Break	

Area 1 - Oral	
3:30 - 5:00 PM	Maryland A
Nanowire Photovoltaics	

Chair(s): Ian Sellers, Peichen Yu

3:30 From basic nanowire science to opportunities in photovoltaics

Lars Samuelson^{1,2}
¹Lund University, NanoLund & Solid State Physics, Lund, Sweden, ²Sol Voltaics AB, Lund, Sweden

4:00 Best Student Presentation Award Finalist

Growth and optimization of GaInP/InP Nanowire Tunnel Diodes

Xulu Zeng, Gaute Otnes, Magnus Heurlin, Magnus T Borgström
Solid State Physics, NanoLund, Lund University, Lund, Sweden

4:15 Cathodoluminescence mapping for the determination of n-type doping in single GaAs nanowires

Hung-Ling Chen¹, Chalermchai Himwas¹, Andrea Scaccabarozzi², Pierre Rale¹, Fabrice Oehler¹, Aristide Lemaître¹, Laurent Lombez^{2,3}, Jean-François Guillemoles^{2,3}, Maria Tchernycheva¹, Jean-Christophe Harmand¹, Andrea Cattoni¹, Stéphane Collin^{1,2}
¹Centre of Nanoscience et de Nanotechnology, Marcoussis, France, ²Institut Photovoltaïque d'Île-de-France, Antony, France, ³Institut de Recherche et Développement sur l'Énergie Photovoltaïque, Chatou, France

4:30 Optical Optimization of Passivated GaAs Nanowire Solar Cells

Kyle W Robertson¹, Ray R LaPierre³, Jacob J Krich^{1,2}

¹Department of Physics, University of Ottawa, Ottawa, ON, Canada, ²School of Electrical Engineering and Computer Science, University of Ottawa, Ottawa, ON, Canada, ³Department of Engineering Physics, McMaster University, Hamilton, ON, Canada

4:45 High efficiency GaN nanowire/Si solar cell photocathode for photoelectrochemical water splitting

Srinivas Vanka¹, Sheng Chu¹, Yichen Wang¹, Ishiang Shih¹, Hong Guo², Zetian Mi^{1,3}

¹Department of Electrical and Computer Engineering, McGill University, Montreal, QC, Canada, ²Department of Physics, McGill University, Montreal, QC, Canada, ³Department of Electrical Engineering and Computer Science, Centre for Photonics and Multiscale Nanomaterials, University of Michigan, Ann Arbor, MI, United States

Area 2 - Oral

3:30 - 5:00 PM

Marriott Ballroom Salon 3

Advances in Characterization, Analysis, Theory, and Modeling

Chair(s): Dragica Vasileska, Angus Rockett

3:30 Analytic description of the impact of grain boundaries on Voc (invited)

Paul M Haney¹, Benoit Gaury^{1,2}

¹National Institute for Standards and Technology, Gaithersburg, MD, United States, ²University of Maryland, College Park, MD, United States

4:00 How Does CIGS Performance Depend on Temperature at the Nanoscale?

Michael E. Stuckelberger¹, Tara Nietzold¹, Bradley West¹, Rouin Farshchi², Dmitry Poplavskyy², Jeff Bailey², Barry Lai³, Jörg M. Maser³, Mariana I. Bertoni¹

¹Defect Lab, School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, United States, ²MiaSole Hi-Tech Corp., Santa Clara, CA, United States, ³Advanced Photon Source, Argonne National Laboratory, Argonne, IL, United States

4:15 Role of Tellurium Buffer Layer on CdTe Solar Cells' Absorber/Back-Contact Interface

Tao Song, James R. Sites

Department of Physics, Colorado State University, Fort Collins, CO, United States

4:30 Bandgap Fluctuations Observed by EL in CIGS PV Modules

Matevù Bokalič¹, Andreas Gerber², Bart E. Pieters², Uwe Rau², Marko Topič¹

¹University of Ljubljana, Faculty of Electrical Engineering, Ljubljana, Slovenia, ²Forschungszentrum Jülich, IEK-5 Photovoltaik, Jülich, Germany

4:45 Simultaneous Examination of Grain-Boundary Potential, Recombination, and Photocurrent in CdTe Solar Cells Using Diverse Nanometer-Scale Imaging

C.-S. Jiang, H.R. Moutinho, J. Moseley, A. Kanevce, J.N. Duenow, E. Colegrove, W.K. Metzger, M.M. Al-Jassim

national Renewable Energy Laboratory, Golden, CO, United States

Area 4 - Oral

3:30 - 5:00 PM

Marriott Ballroom Salon 2

Light Management and Thin-Film Silicon

Chair(s): Arno Smets, Jozef Szlufcik

3:30 Low-Refractive-Index Nanoparticle Interlayers To Reduce Parasitic Absorption In Metallic Rear Reflectors Of Solar Cells

Mathieu Boccard¹, Peter Firth^{1,2}, Zhengshan J. Yu¹, Kathryn C. Fisher¹, Mehdi Leilaieoun¹, Salman Manzoor¹, Zachary C. Holman^{1,2}

¹Arizona State University, Tempe, AZ, United States, ²Swift Coat, Inc., Peoria, AZ, United States

3:45 Absorption in each layer of a silicon heterojunction solar cell

Keith R McIntosh¹, Malcolm D Abbott¹, Benjamin A Sudbury¹, Salman Manzoor², Jason Yu², Mehdi Leilaieoun², Jianwei Shi², Zachary C Holman²

¹PV Lighthouse, Coledale, Australia, ²Arizona State University, Tempe, AZ, United States

4:00 Investigations on Plasmonic Color Tuning Coating on c-Si Solar Cells

Gerhard Peharz¹, Wolfgang Waldhauser¹, Christine Prietl¹, Bettina Großschläd¹, Martin Schuber², Bernhard Michl²

¹JOANNEUM RESEARCH, Weiz, Austria, ²Fraunhofer ISE, Freiburg, Germany

4:15 Properties and potential of PECVD passivation layers for liquid-phase crystallized silicon on glass

Natalie Preissler^{1,2}, Daniel Amkreutz², Daniel Abou-Ras³, Paul Sonntag², Martina Trahms², Cham Thi Trinh², Rutger Schlatmann¹, Bernd Rech²

¹PVcomB / Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany, ²Institute for Silicon Photovoltaics / Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany, ³Department Nanoscale Structures and Microscopic Analysis / Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany

4:30 Investigation of Interface and Bulk Localized States in a-Si:H Solar Cells

Adrien Bidiville, Takuya Matsui, Hitoshi Sai, Koji Matsubara
AIST, Tsukuba, Japan

4:45 Experimental and theoretical study of the infrared emissivity of crystalline silicon solar cells

Alberto Riverola¹, Alexander Mellor², Diego Alonso Alvarez², Lourdes Ferre Llin³, Ilaria Guarracino⁴, Christos N. Markides⁴, Douglas Paul³, Daniel Chemisana¹, Ned Ekins-Daukes²

¹Applied Physics Section of the Environmental Science Department, University of Lleida, Lleida, Spain, ²Department of Physics, Imperial College London, London, United Kingdom, ³School of Engineering, University of Glasgow, Glasgow, United Kingdom, ⁴Department of Chemical Engineering, Imperial College London, London, United Kingdom

Area 6 - Oral

3:30 - 5:00 PM

Maryland B&C

Organic Photovoltaics

Chair(s): Nicole Kotulak, Chittibabu Kethinni

3:30 High Performance Molecular Donors For Organic Solar Cells, Materials Design And Device Optimization

David J Jones, Paul Geraghty, Calvin Lee, Jegadesan Subbiah, Haotian Wang
University of Melbourne, Melbourne, Australia

4:00 Advanced Optical Modelling of Micro-Textured Solution-Processed Solar Cells with Consideration of Small-Area Effects

Benjamin Lipovsek¹, Marko Jost¹, Andrej Campa¹, Fei Guo², Christoph J Brabec², Karen Forberich², Janez Krc¹, Marko Topic¹

¹University of Ljubljana, Faculty of Electrical Engineering, Ljubljana, Slovenia, ²Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

4:15 **Identification of Degradation Pathways of Organic Solar Cells using Infrared Spectroscopy**

Satvik Shah¹, Rana Biswas^{1,2}, Thomas Koschny², Vikram Dalal¹

¹Iowa State University, Ames, IA, United States, ²Ames Laboratory, Ames, IA, United States

4:30 **A Device-Independent Screening Technique for Rapidly Identifying Next Generation OPV Materials**

Bryon W Larson, Andrew J Ferguson, Bertrand Tremolet de Villers, Ross E Larsen
National Renewable Energy Laboratory, Golden, CO, United States

4:45 **Novel Anthanthrone and Anthanthrene Co-polymers As p-Type Conjugated Semiconductors for Organic Photovoltaics**

Suru V. John^{1,2}, Patrick Denk², Christoph Ulbricht^{2,3}, Herwig Heilbrunner², Jean-Benoit Giguère⁴, Antoine Lafleur-Lambert⁴, Jean-Francois Morin⁴, Emmanuel Iwuoha¹, Daniel A. M. Egbe^{2,3}

¹SensorLab, Department of Chemistry, University of Western Cape, Robert Sobukwe Road, P. Bag X17, Bellville, 7535, Cape Town, South Africa, ²Linz Institute for Organic Solar Cells (LIOS), Johannes Kepler University, Altenbergerstr. 69, 4040, Linz, Austria, ³Institute of Polymeric Materials and Testing (IPMT), Johannes Kepler University, Altenbergerstr. 69, 4040, Linz, Austria, ⁴Department of Chemistry, Faculty of Science and Engineering, Pavillon Alexandre-Vachon, Local 1250b, Université Laval, (Québec), G1V 0A6, Québec, QC, Canada

Area 9 - Oral

3:30 - 5:00 PM

Delaware B

Device Reliability and Accelerated Testing

Chair(s): Max Koentopp, Peter Hacke

3:30 **Best Student Presentation Award Finalist**

Reducing UV induced degradation losses of solar modules with c-Si solar cells featuring dielectric passivation layers

Robert Witteck¹, Henning Schulte-Huxel¹, Boris Veith-Wolf¹, Malte Ruben Vogt¹, Fabian Kiefer¹, Marc Köntges¹, Robby Peibst^{1,2}, Rolf Brendel^{1,3}

¹Institute for Solar Energy Research Hamelin (ISFH), Emmerthal, Germany, ²Institute of Electronic Materials and Devices (MBE), Leibniz Universität Hannover, Hanover, Germany, ³Institute for Solid State Physics, Leibniz Universität Hannover, Hanover, Germany

3:45 **Best Student Presentation Award Finalist**

Large-Area Junction Damage in Potential-Induced Degradation of c-Si Solar Modules

Chuanxiao Xiao^{1,2}, Chun-Sheng Jiang¹, Steve Johnston¹, Peter Hacke¹, Brian Gorman², Mowafak Al-Jassim¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States

4:00 **Search for Microstructural Defects as Nuclei for PID-Shunts in Silicon Solar Cells**

Volker Naumann¹, Otwin Breitenstein², Jan Bauer², Christian Hagendorf¹

¹Fraunhofer Center for Silicon Photovoltaics CSP, Halle (Saale), Germany, ²Max-Planck-Institute for Microstructure Physics, Halle (Saale), Germany

4:15 **Investigating PID Shunting in Polycrystalline Silicon Modules via Multi-Scale, Multi-Technique Characterization**

Steven P. Harvey¹, John Moseley¹, Adam Stokes², Andrew Norman¹, Brian Gorman², Peter Hacke¹, Steve Johnston¹, Mowafak Al-Jassim¹
¹NREL, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States

4:30 Potential-induced degradation of a Si nitride/crystalline Si interface observed through minority carrier lifetime measurement

Naoyuki Nishikawa, Seira Yamaguchi, Keisuke Ohdaira
Japan Advanced Institute of Science and Technology, Nomi, Ishikawa, Japan

4:45 Preventing Potential Induced Degradation in Crystalline Silicon PV Modules: Relationship Between Degradation and Bill of Material

Alessandro Virtuani, Eleonora annigoni, Christophe Ballif
EPFL, Neuchatel, Switzerland

Joint Area Session - Oral

3:30 - 5:00 PM

Delaware A

Characterization Techniques for PV Modules and Systems

Chair(s): Bruce King, Kyumin Lee

3:30 Field Inspection of PV Modules: Quantification of EVA Browning Level using an Image Processing Tool

Sushanth Gudla, GovindaSamy TamizhMani
Arizona State University Photovoltaic Reliability Lab (ASU-PRL), Mesa, AZ, United States

3:45 Identifying Reverse-bias Breakdown Sites in $\text{CuIn}_x\text{Ga}_{(1-x)}\text{Se}_2$ Photovoltaic Modules

Steve Johnston¹, Elizabeth Palmiotti², Andreas Gerber³, Lorelle Mansfield¹, Timothy J. Silverman¹, Mowafak Al-Jassim¹, Angus Rockett²
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States, ³IEK5-Photovoltaics, Forschungszentrum Julich GmbH, Julich, Germany

4:00 Historical Analysis of Champion PV Module Efficiencies

Sarah Kurtz¹, Stuart Bowden², Pierre Verlinden³, Susan Huang⁴, Keith Emery¹, Lawrence Kazmerski¹, Ian Tappan¹, Dean Levi¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Arizona State University, Tempe, AZ, United States, ³State Key Laboratory of PV Science and Technology, Trina Solar, Changzhou, China, ⁴Department of Energy, Washington DC, DC, United States

4:15 Reduced Measurement Uncertainty in PV Module Batch Testing

Blagovest Mihaylov¹, Bengt Jaeckel², Juergen Arp³, Ralph Gottschalg¹
¹CREST, Loughborough University, Loughborough, United Kingdom, ²UL International GmbH, Neu-Isenburg, Germany, ³PV LAB Germany GmbH, Potsdam, Germany

4:30 Automatic Detection of Inactive Solar Cell Cracks in Electroluminescence Images

Sergiu V. Spataru¹, Peter Hacke², Dezso Sera¹
¹Aalborg University, Aalborg, Denmark, ²National Renewable Energy Laboratory, Golden, CO, United States

4:45 Thermal Characteristics of PID-affected Monocrystalline Silicon Solar Modules under Illuminated and Dark Conditions

Pan Zhao¹, Shuwen Guo¹, He Wang¹, Hong Yang¹, Dengyuan Song², Shiyu Sang³, Bojie Su⁴, Xue Zhang⁴, Yunxue Cao⁵, Hui Zhao⁵
¹Xi'an Jiaotong University, Xi'an, China, ²Yingli Group Co., Ltd., Baoding, China, ³Institute of

Electrical Engineering of the Chinese Academy of Sciences, Beijing, China, ⁴China Quality Certification Center, Beijing, China, ⁵SPIC Power Plant Operation Technology Co., Ltd, Beijing, China

Joint Area Session - Oral		
3:30 - 5:00 PM		Virginia A
Solar Forecasting for Grid Integration of PV		

Chair(s): Skip Dise, Gerd Heilscher, Barry Mather

3:30 Challenges in funding Solar Forecasting RD&D

Tassos Golnas
United States Department of Energy, Washington, DC, United States

4:00 Himawari 8 enabled real-time distributed PV simulations for distribution networks

Nicholas A Engerer¹, Jamie M Bright¹, Sven Killinger^{1,2}
¹*Fenner School of Environment and Society, The Australian National University, Canberra, Australia,* ²*Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany*

4:15 Cloud Motion Identification Algorithms Based on All-Sky Images to Support Solar Irradiance Forecast

Lydie Magnone, Fabrizio Sossan, Enrica Scolari, Mario Paolone
EPFL, Lausanne, Switzerland

4:30 Applying Spatial Downscaling and Smart Persistence to Provide an Improved Solar Forecast to Reduce Commercial Demand Charges

Alex Kubinieć¹, Ted Belanger², Adam Kankiewicz¹, Skip Dise¹, Nate Glasgow², Alemu Tadesse¹
¹*Clean Power Research, Kirkland, WA, United States,* ²*EdgePower, Aspen, CO, United States*

4:45 Targeted Evaluation of Utility-Scale and Distributed Solar Forecasting

Matthew Lave¹, Robert J Broderick², Laurie Burnham²
¹*Sandia National Laboratories, Livermore, CA, United States,* ²*Sandia National Laboratories, Albuquerque, NM, United States*

Social Activity		
6:00 - 8:00 PM		Marriott Ballroom Salon 1 & 2
Cherry Reception		

Wednesday, June 28, 2017

Registration		
8:00 - 8:30 AM		Convention Registration Desk
Registration Opens		

Area 2 - Plenary		
8:30 - 9:00 AM		Marriott Ballroom

Plenary

Chair(s): Mike Scarpulla, Jim Sites

8:30 **The Adolescence of Cadmium Telluride PV**
Markus Gloeckler
First Solar, Inc., Perrysburg, OH, United States

Area 12 - Plenary

9:00 - 9:30 AM

Marriott Ballroom

Plenary

Chair(s): Michael Woodhouse, Chinho Park

9:00 **SunShot 2030**
Becca Jones-Albertus
U.S. Department of Energy, Washington, DC, United States

Area 8 - Plenary

9:30 - 10:00 AM

Marriott Ballroom

Plenary

Chair(s): Anton Driesse, Cliff Hansen

9:30 **Novel designs and materials for durable PV modules: applications on the ground, in cities and in the air**
Christophe Ballif^{1,2}
¹EPFL, IMT, PV-lab, Neuchâtel, , Switzerland, ²CSEM PV-center, Neuchâtel, , Switzerland

Break

10:00 - 10:30 AM

Exhibit Hall A

Coffee Break

Area 1 - Oral

10:30 - 12:00 PM

Maryland A

Advances in Novel PV Absorbers

Chair(s): Michael Yakes, Susan Huang

10:30 **Record Efficiencies for Selenium Photovoltaics and Application to Indoor Solar Cells**
Douglas M Bishop, Teodor Todorov, Yun S Lee, Oki Gunawan, Richard Haight
IBM TJ Watson Research Institute, Yorktown Heights, NY, United States

11:00 **ZnSnN₂ as a solar cell absorber: effect of the band edges position on the device performance.**
Elisabetta Arca¹, Angela N. Fioretti^{1,2}, Stephan Lany¹, Adele C. Tamboli^{1,2}, Celeste Melamed^{1,2}, Jie

Pan¹, Eric S. Toberer^{1,2}, Andriy Zakutayev¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States

11:15 Close-Spaced Sublimation for Sb₂Se₃ Solar Cells

Laurie J Phillips¹, Peter Yates¹, Olliver S Hutter¹, Thomas Baines¹, Leon Bowen², Ken Durose¹, Jonathon D Major¹

¹University of Liverpool, Liverpool, United Kingdom, ²Durham University, Durham, United Kingdom

11:30 Best Student Presentation Award Finalist

Fabrication of Copper Arsenic Sulfide Thin Films from Nanoparticles for Application in Solar Cells

Scott A McClary¹, Joseph Andler², Carol A Handwerker², Rakesh Agrawal¹

¹Davidson School of Chemical Engineering, Purdue University, West Lafayette, IN, United States,

²School of Materials Engineering, Purdue University, West Lafayette, IN, United States

11:45 Orientation Controlled Ge Thin Films on Glass by AI-Induced Crystallization

Kaveh Shervin, Khim Kharel, Alexandre Freundlich

University of Houston, Houston, TX, United States

Area 2 - Oral

10:30 - 12:00 PM

Marriott Ballroom Salon 3

Advances in Manufacturing and Commercialization

Chair(s): Sachit Grover, Marko Topic

10:30 CIGS PV module technology at 17 % efficiency and beyond

Lars Stolt¹, Philipp Kratzert², Olle Lundberg¹

¹Solibro Research AB, Uppsala, Sweden, ²Solibro Hi-Tech GmbH, Bitterfeld-Wolfen, Germany

11:00 In-line Potassium Fluoride Treatment of CIGS Absorbers Deposited on Flexible Substrates in a Production-Scale Process Tool

Ryan Kaczynski, JinWoo Lee, Jane van Alsborg, Baosheng Sang, Urs Schoop, Jeffrey Britt

Global Solar Energy, Tucson, AZ, United States

11:15 Commercialization of Polycrystalline CdTe Thin-Film Solar Cell Technology in ASP

Xuanzhi Wu

Advance Solar Power (ASP), Hangzhou, China

11:45 Light-Soak and Dark-Heat Induced Changes in Cu(In,Ga)Se₂ Solar Cells: A Macroscopic to Microscopic Study

Rouin Farshchi, Benjamin Hickey, Dmitry Poplavskyy

MiaSole Hi-Tech Corp, Santa Clara, CA, United States

Area 3 - Oral

10:30 - 12:00 PM

Virginia A

Micro and Trackerless CPV

Chair(s): Ken Schmieder, Ray Lin, Stefan Myrskog

10:30 Can Micro-CPV Technology Change the Paradigm of Flat-Plate PV?

Michael W Haney

U. S. Department of Energy/ARPA-E, Washington, DC, United States

10:45 A New Model to Determine Installed System Cost and LCOE for ARPA-E's MOSAIC Micro-concentrator PV Program

Ran Fu¹, Kelsey A.W. Horowitz¹, Daniel W. Cunningham², James Zahler²

¹*National Renewable Energy Laboratory (NREL), Golden, CO, United States*, ²*Advanced Research Projects Agency – Energy (ARPA-E), Washington, D.C. , DC, United States*

11:00 Fixed-tilt 660× Concentrating Photovoltaic System with 30% Efficiency

Alex J. Grede¹, Jared S. Price¹, Baomin Wang¹, Micheal V. Lipski¹, Brent Fisher², Kyu-Tae Lee³, Junwen He⁴, Xiaokun Ma⁵, Scott Burroughs², Christopher D. Rahn⁵, Ralph G. Nuzzo⁴, John A. Rogers³, Noel C. Giebink¹

¹*Department of Electrical Engineering, The Pennsylvania State University, University Park, PA, United States*, ²*Semprius Inc., Durham, NC, United States*, ³*Department of Materials Science and Engineering, University of Illinois at Urbana-Champaign, Urbana, IL, United States*, ⁴*Department of Chemistry, University of Illinois at Urbana-Champaign, Urbana, IL, United States*, ⁵*Department of Mechanical and Nuclear Engineering, The Pennsylvania State University, University Park, PA, United States*

11:15 Wafer Integrated Micro-scale Concentrating Photovoltaics

Tian Gu¹, Duanhui Li¹, Lan Li¹, Bradley Jared², Gordon Keeler², Bill Miller², William Sweatt², Scott Paap², Michael Saavedra², Ujjwal Das³, Steve Hegedus³, Anna Tauke-Pedretti², Juejun Hu¹

¹*Massachusetts Institute for Technology, Cambridge, MA, United States*, ²*Sandia National Laboratories, Albuquerque, NM, United States*, ³*University of Delaware, Newark, DE, United States*

11:30 Toward Stationary Concentrator Photovoltaic Panels

Peter Kozodoy, Christopher Gladden, Michael Pavilonis, Chadwick Casper, Kevin Schneider
Glint Photonics, Inc., Burlingame, CA, United States

11:45 CPV Technologies Not Relying on Perfection of Trackers

Kenji Araki¹, Yasuyuki Ota², Kan-Hua Lee¹, Kensuke Nishioka², Masafumi Yamaguchi¹

¹*Toyota Technological Institute, Nagoya, Japan*, ²*University of Miyazaki, Miyazaki, Japan*

Area 4 - Oral

10:30 - 12:00 PM

Marriott Ballroom Salon 2

Silicon Material and Wafer Technology I

Chair(s): Pietro Altermatt

10:30 The gettering effect of dielectric films for silicon solar cells

AnYao Liu¹, Chang Sun¹, Vladimir P Markevich², Anthony R Peaker², John D Murphy³, Daniel Macdonald¹

¹*Research School of Engineering, Australian National University, Canberra, Australia*, ²*Photon Science Institute, University of Manchester, Manchester, United Kingdom*, ³*School of Engineering, University of Warwick, Coventry, United Kingdom*

10:45 Best Student Presentation Award Finalist

Tabula Rasa: Mitigating performance-limiting oxygen precipitates through rapid high temperature processing

Erin E. Looney¹, Hannu S. Laine^{1,2}, Mallory A. Jensen¹, Amanda Youssef¹, Tonio Buonassisi¹

¹*Massachusetts Institute of Technology, Cambridge, MA, United States*, ²*Aalto University, Aalto, Finland*

11:00 **Is it possible to unambiguously assess the presence of two defects by temperature and injection dependent lifetime spectroscopy?**

Tine U Naerland, Simone Bernardini, Mariana Bertoni
Arizona State University, Tempe, AZ, United States

11:15 **Toward Effective Gettering in Boron-Implanted Silicon Solar Cells**

Hannu S Laine¹, Ville Vähänissi¹, Zhengjun Liu¹, Ernesto Magaña², Ashley E Morishige³, Jan Krügener⁴, Kristian Salo¹, Barry Lai⁵, Hele Savin¹, David P Fenning²
¹*Aalto University, Espoo, Finland*, ²*University of California San Diego, La Jolla, CA, United States*,
³*Massachusetts Institute of Technology, Cambridge, United States*, ⁴*Leibniz Universität Hannover, Hannover, Germany*, ⁵*Argonne National Laboratory, Argonne, IL, United States*

11:30 **Effect of Carbon Concentration and Growth Conditions on Oxygen Precipitation Behavior in n-type Cz-Si**

Takuto Kojima¹, Ryota Suzuki¹, Kosuke Kinoshita¹, Kyotaro Nakamura¹, Atsushi Ogura¹, Yoshio Oshita², Isao Masada³, Shoji Tachibana³
¹*Meiji University, Kawasaki, Japan*, ²*Toyota Technological Institute, Nagoya, Japan*, ³*Tokuyama Corporation, Shunan, Japan*

11:45 **Best Student Presentation Award Finalist**

Impact of the initial growth interface on the grain structure in HPMC-Si ingot

Giri W Alam^{1,2,3}, Etienne Pihan¹, Marie Benoit¹, Nathalie Mangelinck-Noël²
¹*CEA-INES, Le Bourget du Lac, France*, ²*Aix-Marseille University, CNRS, IM2NP, UMR CNRS 7334, Marseille, France*, ³*Centre of Technology for Materials, Agency for the Assessment and Application of Technology, South Tangerang, Indonesia*

Area 5 - Oral

10:30 - 12:00 PM

Maryland B&C

Scanning Probe Microscopy Methods

Chair(s): Angus Rockett, Mowafak Al-Jassim

10:30 **Nanoscale electronic properties of Cu(In,Ga)Se₂ absorber surfaces and absorber/buffer interfaces after alkali post-deposition treatments**

Nicoleta Nicoara¹, Philip Jackson², Dimitrios Hariskos², Thomas Lepetit³, Sylvie Harel³, Ludovic Arzel³, Wolfram Witte², Nicolas Barreau³, Sascha Sadewasser¹
¹*International Iberian Nanotechnology Laboratory (INL), Braga, Portugal*, ²*Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW), Stuttgart, Germany*, ³*Institut des Matériaux Jean Rouxel (IMN), Nantes, France*

11:00 **Best Student Presentation Award Finalist**

Nano-imaging of Performance in Photovoltaics

Elizabeth M. Tennyson^{1,2}, Marina S. Leite^{1,2}
¹*Department of Materials Science and Engineering, Univ. of Maryland, College Park, MD, United States*, ²*Institute for Research in Electronics and Applied Physics, Univ. of Maryland, College Park, MD, United States*

11:15 **Implications of conductive grain boundaries in Chlorine-treated CdTe solar cells**

Mohit Tuteja^{1,2}, Vasilios Palekis³, Allen Hall², Scott MacLaren², Christos S. Ferekides³, Angus Rockett²
¹*University of Maryland, College Park, MD, United States*, ²*University of Illinois, Urbana-Champaign, IL, United States*, ³*University of South Florida, Tampa, FL, United States*

11:30 Imaging the Multi-Temporal Photo-Carrier Dynamics at the Nanometer Scale in Organic and Inorganic Solar Cells

Pablo A. Fernández Garrillo^{1,2,3}, Lukasz Borowik^{1,2}, Florent Caffy³, Renaud Demadrille³, Benjamin Grévin³

¹Université Grenoble Alpes, Grenoble, France, ²CEA, LETI, MINATEC Campus, Grenoble, France, ³INAC-SPRAM, CEA, CNRS, Université Grenoble Alpes, Grenoble, France

11:45 Nanoscale Tomographic Charge Transport in Polycrystalline Chalcogenide Absorbers: CdTe versus CIGS

Justin Luria¹, Andrew Moore², Sun Yu¹, Mark Aindow¹, Bryan Huey¹

¹University of Connecticut, Storrs, CT, United States, ²Colorado State University, Ft. Collins, CO, United States

Area 8 - Oral

10:30 - 12:00 PM

Delaware A

Modeling of System Components

Chair(s): Joshua Stein, Steve Ransome

10:30 Significant Improvement in PV Module Performance Prediction Accuracy Using a New Model Based on IEC-61853 Data

Aron Dobos

National Renewable Energy Laboratory, Golden, CO, United States

10:45 Improving the PV Module Single-Diode Model Accuracy with the Temperature Dependence of the Series Resistance

Kyumin Lee

CFV Solar Test Laboratory, Albuquerque, NM, United States

11:00 Cell-to-Module (CTM) Analysis for Photovoltaic Modules with Shingled Solar Sells

Max Mittag¹, Johann Rüdiger², Tobias Zech¹, Martin Wiese¹, Matthieu Ebert¹, Ulrich Eitner¹

¹Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany, ²none, Dresden, Germany

11:15 A Practical Irradiance Model for Bifacial PV Modules

Bill Marion¹, Sara MacAlpine¹, Chris Deline¹, Amir Asgharzadeh², Fatima Toor², Daniel Riley³, Joshua Stein³, Clifford Hansen³

¹National Renewable Energy Laboratory, Golden, CO, United States, ²The University of Iowa, Iowa City, IA, United States, ³Sandia National Laboratories, Albuquerque, NM, United States

11:30 A Detailed Model of Rear-Side Irradiance for Bifacial PV Modules

Clifford W Hansen¹, Renee L Gooding¹, Nathan G Guay¹, Johnson J Kallickal¹, Donald E Ellibee¹, Daniel M Riley¹, Amir Asgharzadeh², Bill Marion³, Fatima Toor², Joshua S Stein¹

¹Sandia National Laboratories, Albuquerque, NM, United States, ²The University of Iowa, Iowa City, IA, United States, ³National Renewable Energy Laboratory, Golden, CO, United States

11:45 View Factor Model and Validation for Bifacial PV and Diffuse Shade on Single-Axis Trackers

Marc Abou Anoma¹, Jonathan A Scholl¹, Ben C Bourne¹, David Jacob¹, Daniel M Riley², Clifford W Hansen²

¹SunPower Corporation, San Jose, CA, United States, ²Sandia National Laboratories, Albuquerque, NM, United States

Area 10 - Oral

10:30 - 12:00 PM

Delaware B

Advanced Distribution System Analysis for PV

Chair(s): Tom Key, Robert Broderick

10:45 Best Student Presentation Award Finalist

A Fast Quasi-Static Time Series (QSTS) Simulation Method for PV Impact Studies Using Voltage Sensitivities of Controllable Elements

Xiaochen Zhang¹, Santiago Grijalva¹, Matthew J. Reno², Jeremiah Deboever¹, Robert J. Broderick²
¹Georgia Institute of Technology, Atlanta, GA, United States, ²Sandia National Laboratories, Albuquerque, NM, United States

11:00 Fast Determination of Distribution-Connected PV Impacts Using a Variable Time-Step Quasi-Static Time-Series Approach

Barry Mather

National Renewable Energy Laboratory, Golden, CO, United States

11:15 Best Student Presentation Award Finalist

Scalability of the Vector Quantization Approach for Fast QSTS Simulation for PV Impact Studies

Jeremiah Deboever¹, Santiago Grijalva¹, Matthew J. Reno², Xiaochen Zhang¹, Robert J. Broderick²
¹Georgia Institute of Technology, Atlanta, GA, United States, ²Sandia National Laboratories, Albuquerque, NM, United States

11:30 Machine Learning for Rapid QSTS Simulations using Neural Networks

Matthew J. Reno¹, Robert J. Broderick¹, Logan Blakely²

¹Sandia National Laboratories, Albuquerque, NM, United States, ²Portland State University, Portland, OR, United States

11:45 Algorithmic Aspects of a Commercial-Grade Distribution System Load Flow Engine

Francis Therrien¹, Marc Belletête¹, Jean-Sébastien Lacroix¹, Matthew J. Reno²

¹CYME International T&D, St-Bruno, QC, Canada, ²Sandia National Laboratories, Albuquerque, NM, United States

Area 1 - Poster

12:45 - 2:15 PM

Exhibit Hall F

Light Management

Chair(s): Stephen J Polly, Deirdre O'Carroll, Lars Samuelson

G1 CdSe(Te)/CdS/CdSe Rods vs. CdTe/CdS/CdSe Spheres: Morphology-Dependent Carrier Dynamics for Photon Upconversion

Eric Y. Chen, Zhuohui Li, Christopher C. Milleville, Kyle R. Lennon, Matthew F. Doty
Department of Materials Science and Engineering, University of Delaware, Newark, DE, United States

G3 Drift-Diffusion InGaN/GaN Solar Cell Simulator with Optical Management

Yi Fang, Da Guo, Alec Fischer, Ehsan Vadiiee, Joshua Williams, Chaomin Zhang, Steve Goodnick, Dragica Vasileska
Arizona State University, Tempe, AZ, United States

ePoster Resonant and non-resonant dielectric coatings for high efficiency solar cells

Dongheon Ha^{1,2,3}, Chen Gong^{2,4}, Marina S. Leite^{2,4}, Jeremy N. Munday^{2,3}

¹Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, MD, United States, ²Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, MD, United States, ³Department of Electrical and Computer Engineering, University of Maryland, College Park, MD, United States, ⁴Department of Materials Science and Engineering, University of Maryland, College Park, MD, United States

G5 Efficient solar energy harvesting using optimized nanocone array

Xu Han^{1,2}, Kebo He², Tao Tang¹, Hang Zhou¹, Yijian Chen¹, Zhaoyu Zhang²

¹School of Electronic and Computer Engineering, Peking University, Shenzhen, China, ²School of Science and Engineering, The Chinese University of Hong Kong, Shenzhen, China

G7 Performance Enhancement of A GaAs Solar Cell with Colloidal Quantum Dots Embedded in Trenches

Chia Jhe Hsu¹, Yu Ming Huang², Shun Chieh Hsu¹, Chien Chung Lin¹, Jinn Kong Shu³, Pei chen Yu⁴, Yung Jr Hung⁵, Jia-Lin Tsai⁴

¹Institute of Photonic System, National Chiao-Tung University, Tainan, Taiwan, ²Institute of Imaging and Biomedical Photonic, National Chiao-Tung University, Tainan, 711, Taiwan, Tainan, Taiwan, ³Department of Photonics, National Cheng-Kung University, Tainan, Taiwan, ⁴Department of Photonics, National Chiao-Tung University, Hsinchu, Taiwan, ⁵Department of Photonics, National Sun Yat-sen University, Kaohsiung, Taiwan

G9 Enhanced Photoresponse of InN Devices Using Indium-Tin Oxide Nanorods

Lung-Hsing Hsu¹, Yuh-Jen Cheng², Peichen Yu³, Hao-Chung Kuo³, Chien-Chung Lin⁴

¹Institute of Lighting and Energy Photonics, National Chiao Tung University, Tainan, Taiwan, ²Research Center for Applied Sciences, Academia Sinica, Taipei, Taiwan, ³Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan, ⁴Institute of Photonic System, National Chiao Tung University, Tainan, Taiwan

G11 Light-trapping Metallic Nanostructures for Improved Perovskite Photovoltaic Performance

Arul varman Kesavan, Arun D Rao, Praveen C Ramamurthy

Department of Materials Engineering, Indian Institute of Science, Bangalore, India

G13 Quantum cutting luminescent PMMA films containing Ce³⁺-Yb³⁺ co-doped YAG phosphor for Si concentrator solar cells

Lu Li^{1,2}, Chaogang Lou¹, Huihui Cao¹

¹Southeast University, Nanjing, China, ²Sanjiang University, Nanjing, China

G15 Down Shifted Conversion for Enhanced HIT Solar Cell Efficiency

Albert S. Lin¹, Parag Parashar¹, Wei-Ming Huang¹, Yi-Wen Huang¹, Ding-Rung Jian¹, Ming-Hsuan Kao², Shi-Wei Chen², Chang-Hong Shen², Jia-Min Shieh², Tzu-Yu Chen³, Chien-Chung Lin⁴, Hao-Chung Kuo³

¹Dept. of Electronics Engineering, National Chiao Tung University, Hsinchu, Taiwan, ²National Nano Device Laboratories, Hsinchu, Taiwan, ³Dept. of Photonics, National Chiao Tung University, Hsinchu, Taiwan, ⁴Institute of Photonic System, College of Photonics, National Chiao-Tung University, Tainan, Taiwan

G17 Numerical Evaluation on the Nano-rod Array on a N-side-up Thin-film GaAs Solar Cells

Yan-Zhang Lin, Shun-Chieh Hsu, Po-Ching Wu, Chien-Chung Lin, Chia-Jhe Hsu

Institute of Photonic System, National Chiao-Tung University, Tainan, 711, Taiwan, Tainan, Taiwan

G19 The Planar Thermophotovoltaic Selective Nearly-Perfect Absorbers/Emitters

Parag Parashar, Ding-Rung Jian, Weiming Huang, Yi-Wen Huang, Albert Lin

Department of Electronic Engineering, National Chiao-Tung University, Hsinchu, Taiwan

G21 Evolutionary Computer Optimization of Nanostructures in Photovoltaic Devices

Eliad Peretz^{1,2}, Benjamin Treml¹, Yinnon Sanders¹, Tobias Hanrath¹

¹Cornell University, Ithaca, NY, United States, ²NASA GSFC, Greenbelt, MD, United States

ePoster **Enhanced Light Trapping in Thin Silicon using Effectively Transparent Contacts (ETCs)**

Rebecca Saive¹, André Augusto², Stuart Bowden², Harry Atwater¹

¹California Institute of Technology, Pasadena, CA, United States, ²Arizona State University, Tempe, AZ, United States

G23 Hybrid PEDOT:PSS-Silicon Solar Cells with Pencil-shaped Radial Junction Structure

Ruei-Ying Wu¹, Liang-Chian You¹, Chun-Chi Chen², Hsin-Fei Meng¹, Peichen Yu¹

¹National Chiao-Tung University, Hsinchu, Taiwan, ²National Nano Device Laboratories, Hsinchu, Taiwan

ePoster **Enhanced Power Conversion Efficiency in Single Nanowire Devices through Symmetry Breaking Design**

Jian Zhou, Yonggang Wu, Zihuan Xia, Xuefei qin, Zongyi Zhang

Tongji University, Shanghai, China

Area 2 - Poster

12:45 - 2:15 PM

Exhibit Hall D

Progress in Absorber Layers

Chair(s): Wyatt Metzger, Colin Wolden, Kuo-Jui Hsiao

H8 Earth-abundant CZTSSe thin film solar cells on flexible stainless steel foil substrates

Hae-Sun Kim^{1,2}, Woo-Lim Jeong^{1,2}, Dong-Seon Lee^{1,2}

¹School of Electrical Engineering and Computer Science, Gwangju Institute of Science and Technology (GIST), Gwangju 61005, South Korea, ²Research Institute for Solar and Sustainable Energies (RISE), Gwangju 61005, South Korea

H33 Non-vacuum Process of CuInS₂ Thin Films at Low Temperature from Metal Xanthate Precursors

Kenji Yoshino¹, Himeka Tominaga¹, Yuhei Ogomi², Shyam Pandey², Qing Shen³, Taro Toyoda³, Shuzi Hayase²

¹University of Miyazaki, Miyazaki, Japan, ²University of Electro-Communications, Tokyo, Japan, ³Kyushu Institute of Technology, Kitakyushu, Japan

H10 Surface modification of Na and K incorporated Cu(In,Ga)Se₂ absorbers investigated by synchrotron based spectroscopies

Isheta Majumdar^{1,2,3}, Bünyamin Ümsür^{1,2}, Binoy Chacko^{1,2}, Vladimir Parvan¹, Dieter Greiner¹, Martha Ch. Lux-Steiner², Rutger Schlatmann¹, Iver Lauermann¹

¹PVcomB / Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany, ²Freie Universität Berlin, Berlin, Germany, ³Indian Institute of Technology Bombay, Mumbai, India

G26 PL Study of Phosphorous-Doped CdTe Thin Films Deposited by EVT

S.P. Collins, M.D. Khan, V. Evani, C.A. Hsu, V. Palekis, C. Ferekides

University of South Florida, Tampa, FL, United States

G28 Growth of p-type CdZnTe Thin Films as an Prospective Absorber Layer for Photovoltaic Application

F M Tahzib Enam¹, Kazi S Rahman¹, Md Akhtaruzzaman², Kamaruzzaman Sopian², Nowshad Amin^{1,2}

¹Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering and Built

Environment, The National University of Malaysia, Bangi, Malaysia, ²Solar Energy Research Institute, The National University of Malaysia, Bangi, Malaysia

- G30 Characterization of Single-Source Deposited Close-Space Sublimation CdTe_xSe_{1-x} Thin Film Solar Cells**
Corey R. Grice¹, Jian Li², Yanfa Yan¹
¹University of Toledo, Toledo, OH, United States, ²Texas State University, San Marcos, TX, United States
- G32 The Influence of the Cu-rich/Cu-poor sequence on the properties of Cu(In,Ga)Se₂ films deposited by in-line co-evaporation process**
Wang He, Yang Yi Tong, Yao Li You, Gao Peng, Sun Qiang
Tianjin Institute of Power Sources, Tianjin, China
- H2 Determination of Injection Dependent Series Resistance in CIGS Solar Cells**
Vito Huhn, Bart E. Pieters, Andreas Gerber, Yael Augarten, Uwe Rau
Forschungszentrum Jülich IEK-5 Photovoltaics, Jülich, Germany
- H4 Large grain growth in Cu₂ZnSnS₄ thin films in the absence of Na using rapid thermal annealing**
Jeffrey L Johnson¹, Ashish Bhatia², Joseph G. Bolke², Michael A. Scarpulla^{1,2}
¹ECE Department, University of Utah, Salt Lake City, UT, United States, ²MSE Department, University of Utah, Salt Lake City, UT, United States
- H6 Cu₂ZnSnS₄ thin films synthesized by cosputtering and rapid thermal annealing: Effects of composition and temperature**
Jeffrey L. Johnson¹, Win Maw Hlaing Oo², Makarand Karmarkar², Michael A. Scarpulla^{1,2}
¹Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT, United States, ²Department of Materials Science and Engineering, Salt Lake City, UT, United States
- H12 Comparison of MgCl₂ and CdCl₂ activation treatment for CdTe solar cells: Recrystallization and Defects**
Daniele Menossi¹, Elisa Artegiani¹, Ivan Rimmaudo⁴, Alessia Le Donne², Simona Binetti², Juan L. Pena⁴, Fabio Piccinelli³, Alessandro Romeo¹
¹Department of Computer Science, University of Verona, Verona, Italy, ²Department of Material Science, University of Milano Bicocca, Milano, Italy, ³Department of Biotechnology, University of Verona, Verona, Italy, ⁴Cinvestav, Merida, Mexico
- H14 Characterization of CdTe Photovoltaic Devices Passivated Using Hydrogen Plasma**
Amit Munshi¹, Piotr Kaminski², Ali Abbas², Shiva Tarun Chenna^{1,3}, Sreeram Chandralal^{1,4}, John Walls², Walajabad Sampath¹
¹Next Generation Photovoltaic Center (NGPV), Department of Mechanical Engineering, Colorado State University, Fort Collins, CO, United States, ²CREST (Center for Renewable Energy Systems Technology), Loughborough University, Loughborough, United Kingdom, ³Department of Electronics and Communication Engineering, Amrita University, Amritapuri, India, ⁴Department of Mechanical Engineering, Amritapuri, India
- H16 Group-V doping impact on Cd-rich CdTe single crystals grown by traveling-heater method**
Akira Nagaoka^{1,3}, Kenji Yoshino², Yoshitaro Nose³, Darius Kuciauskas⁴, Michael A. Scarpulla¹
¹University of Utah, Salt Lake City, UT, United States, ²University of Miyazaki, Miyazaki, Japan, ³Kyoto University, Kyoto, Japan, ⁴National Renewable Energy Laboratory, Golden, CO, United States
- H18 Band-Gap Engineering in Cu₂ZnSn(S,Se)₄ Solar Cells by Post-Sulphurization of Selenized Absorber Layers**
Markus Neuwirth¹, Elisabeth Seydel¹, Heinz Kalt¹, Michael Hetterich²

¹Institute of Applied Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany, ²Light Technology Institute, Karlsruhe Institute of Technology, Karlsruhe, Germany

H20 Multi-layer strategy to enhance the grain size of CIGS thin film fabricating by single quaternary CIGS target

Xiao Peng, Ming Zhao, Daming Zhuang
Tsinghua University, Beijing, China

H22 Impact of Ga/III Profile on Voltage-dependent Collection Losses in CIGS Solar Cells

Dmitry Poplavskyy, Jeff Bailey, Rouin Farshchi, David Spaulding
MiaSole Hi-Tech, Santa Clara, CA, United States

H24 CI Diffusion in CdTe Solar Cells Activated by Gaseous CHCl₃ Atmosphere

Ivan Rimmaudo¹, Ricardo Mis-Fernandez¹, Victor Rejon¹, Ali Abbas², John M. Walls², Juan L. Peña¹
¹CINVESTAV Unidad Merida, Merida, Mexico, ²CREST, Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, United Kingdom

H26 Stability of Cd_{1-x}Zn_xTe Alloys Under CdTe Processing Conditions

Yegor Samoilenko, Colin A. Wolden
Colorado School of Mines, Golden, CO, United States

H27 CIGS absorber preparation : an alternative to H₂Se

Onkar S Shinde¹, Eric.J. Schneller¹, Subhash Ghaisas², Neelkanth G Dhere¹
¹Florida Solar Energy Centre, University of central Florida, Orlando, FL, United States, ²Indian Institute Bombay, Mumbai, India

H29 Charge controlled sequential electrodeposition for Synthesis of Cu₂ZnSnS₄ on Mo-coated glass substrate

Ashish Kumar Singh¹, Rajiv Dubey², Manoj Neergat¹, Balasubramaniam R. Kavaipatti¹
¹Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Mumbai-400076, India, ²Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai-400076, India

H31 Cd-doping Cu₂ZnSnSe₄ solar cells with 11.2% efficiency based on quaternary target sputtering

Rujun Sun¹, Daming Zhuang¹, Ming Zhao¹, Michael A. Scarpulla², Qianming Gong¹, Liangqi Ouyang¹, Li Guo¹, Mingjie Cao¹, Yaowei Wei¹, Leng Zhang¹, Shilu Zhan¹, Xunyan Lv¹, Xiao Peng¹
¹Tsinghua University, Beijing, China, ²University of Utah, Salt Lake City, UT, United States

H35 Effect of deposited pressure on the CdTe thin films by closed space sublimation method

Yufeng Zhang^{1,2}, Xiangxin Liu^{1,2}, Zhongming Du^{1,2}
¹The Key Laboratory of Solar Thermal and Photovoltaic System, Institute of Electrical Engineering, CAS, Beijing, China, ²University of Chinese Academy of Sciences, Beijing, China

Area 3 - Poster

12:45 - 2:15 PM

Exhibit Hall G

CPV Modules and Systems

Chair(s): Christopher Valdivia, Kyu-Tae Lee, Drew Cardwell

H40 Optical design for 2-terminal III-V/Si SMAC module

Masaaki Baba¹, Kikuo Makita², Hidenori Mizuno³, Hidetaka Takato³, Takeyoshi Sugaya², Noboru Yamada¹

¹Nagaoka University of Technology, Nagaoka, Japan, ²National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan, ³National Institute of Advanced Industrial Science and Technology, Koriyama, Japan

H52 Design and Evaluation of Partial Concentration III-V/Si Module with Enhanced Diffuse Sunlight Transmission

Daisuke Sato¹, Noboru Yamada¹, Kan-Hua Lee², Kenji Araki², Masafumi Yamaguchi²
¹Nagaoka University of Technology, Nagaoka, Japan, ²Toyota Technological Institute, Nagoya, Japan

H38 Generalized Numerical Design of Axially-asymmetrical and Grid- arranged Static CPV array for Maximizing Annual Energy Generation

Kenji Araki, Kan-Hua Lee, Masafumi Yamaguchi
Toyota Technological Institute, Nagoya, Japan

H42 Spectral Transmittance Analysis of Liquids for High Concentration III-V Photovoltaic Immersion Cooling Applications

Xinyue Han, Yongjie Guo
School of Energy and Power Engineering, Jiangsu University, Zhenjiang, China

ePoster Analyzing the Cost Reduction Potential of III-V/Si Hybrid Concentrator Photovoltaic Systems

Kan-Hua Lee, Kenji Araki, Masafumi Yamaguchi
Toyota Technological Institute, Nagoya, Japan

H44 Design of Optical Elements for Low Profile CPV Panel with Sun Tracking for Rooftop Installation

Xinbing Liu, Zhou Lu, Riccardo Leto, Carlton Brule, Nanu Brates
Panasonic Boston Laboratory, Newton, MA, United States

H46 Micro Chiplet Printer Development For MOSAIC Program

Patrick Y. Maeda¹, Yunda D. Wang¹, Sourabh Raychaudhuri¹, Jamie Kalb¹, David K. Biegelsen¹, Rene Lujan¹, Qian Wang¹, Yu Wang¹, Julie Bert¹, Brad Rupp¹, Ion Matei¹, Lara Crawford¹, Anne Plochowitz¹, Eugene M. Chow¹, JengPing Lu¹, Vipin Gupta²
¹PARC, a Xerox company, Palo Alto, CA, United States, ²Sandia National Laboratories, Albuquerque, NM, United States

H48 Micro-optical Tandem Luminescent Solar Concentrator

David R. Needell¹, Zach Nett², Ognjen Ilic¹, Colton R. Bukowsky¹, Junwen He⁴, Lu Xu⁴, Ralph G. Nuzzo⁴, Benjamin G. Lee³, John F. Geisz³, A. Paul Alivisatos², Harry A. Atwater²
¹California Institute of Technology, Pasadena, CA, United States, ²University of California, Berkeley, CA, United States, ³National Renewable Energy Laboratory, Golden, CO, United States, ⁴University of Illinois, Urbana-Champaign, IL, United States

H50 Increase in Maximum Power of a-Si, c-Si and GaAs_{0.76}P_{0.24} Solar Cells Under Low Concentration

Hiba Riaz, Sabina Abdul Hadi, Ammar Nayfeh
Masdar Institute of Science and Technology, Abu Dhabi, United Arab Emirates

12 Simulation of a secondary optical element for a concentrated photovoltaic module

G.S. Zeng¹, Eric Chen¹, David Dai², Erin Lin², Eric Wang², Ray Y Lin^{2,3}
¹National Central University, Chungli, Taoyuan, Taiwan, ²TaiCrystal International Technologies, Chungli, Taoyuan, Taiwan, ³University of Cincinnati, Cincinnati, OH, United States

Area 4 - Poster

12:45 - 2:15 PM

Exhibit Hall C

Passivated Contacts

Chair(s): Andres Cuevas, Giso Hahn, Jozef Szlufcik

14 **Experimental and Simulation studies on TiO₂/Silicon Heterojunction diodes**

Swasti Bhatia¹, Neha Raorane², Nimisha Sreekumar², Pradeep Nair¹, Aldrin Antony³

¹Department of Electrical Engineering, IIT Bombay, Mumbai, India, ²Centre of Excellence in Nanoelectronics, IIT Bombay, Mumbai, India, ³Department of Energy Science and Engineering, IIT Bombay, Mumbai, India

16 **Fabrication and characterization of >20%-efficient silicon heterojunction solar cells with direct rear aluminum metallization**

Jonathan L Bryan, Zhengshan J Yu, Jianwei Shi, Will Weigand, Kathryn C Fisher, Zachary C Holman

Arizona State University, Tempe, AZ, United States

18 **The influence of flow ratio and annealing temperature to n and p poly-Si contacts**

Chun-Heng Chen^{1,2}, Chien-Hsun Chen², Chao-Cheng Lin², Chun-Ming Yeh², Chen-Hsun Du², Peichen Yu¹

¹Department of Photonics and Institute of Electro-Optical Engineering, National Chiao-Tung University, 30010, Hsinchu, Taiwan, ²Department of Silicon Solar Cell and Photovoltaic Technology Division, Green Energy and Environment Research Laboratories, Industrial Technology Research Institute, 31040, Hsinchu, Taiwan

110 **A Study on Blister Formation and Electrical Properties under Various Annealing Condition for Tunneling Oxide Passivation Layer**

Sungjin Choi^{1,2}, Ka-Hyun Kim¹, Min Gu Kang¹, Jeong In Lee¹, Donghwan Kim², Hee-eun Song¹

¹Korea Institute of Energy Research, Daejeon, Korea, ²Korea University, Seoul, Korea

ePoster **Contamination control challenges on SHJ solar cell processing**

Giuseppe Condorelli¹, Anna Battaglia¹, Pietro Rotoli¹, Andrea Canino¹, Wilfried Favre², Anne-Sophie Ozanne², Adnan Moustafa², Adrien Danel², Delfina Muñoz², Pierre-Jean Ribeyron², Cosimo Gerardi³

¹3SUN, Catania, Italy, ²CEA, LITEN, Department of Solar Technologies, Le Bourget du Lac, France, ³Enel Green Power, Catania, Italy

112 **Processing Approaches and Challenges of Interdigitated Back Contact Si Solar Cells**

Ujjwal Das, Lei Zhang, Steven Hegedus

Institute of Energy Conversion, University of Delaware, Newark, DE, United States

114 **Fabrication of Cu/a-Si:H/c-Si Structure for Application to Hole-selective Contacts of Heterojunction Si Solar Cells**

Kazuhiro Gotoh¹, Min Cui¹, Nguyen Cong Thanh², Koichi Koyama², Isao Takahashi¹, Yasuyoshi Kurokawa¹, Hideki Matsumura², Noritaka Usami¹

¹Nagoya University, Nagoya, Japan, ²Japan Advanced Institute of Science and Technology, Ishikawa, Japan

116 **Characteristics of Thin Crystalline Silicon Solar Cells with Rib Structure**

Yukimi Ichikawa^{1,2}, Shuhei Yoshida¹, Masakazu Hirai¹, Makoto Konagai²

¹Japan Science and Technology Agency, Koriyama, Japan, ²Tokyo City University, Tokyo, Japan

118 **Measurement of TiO₂/p-Si Selective Contact Performance using a Heterojunction Bipolar Transistor with a Selective Contact Emitter**

Janam Jhaveri, Alexander H. Berg, Sigurd Wagner, James C. Sturm
Department of Electrical Engineering and the Princeton Institute for the Science and Technology of Materials, Princeton University, Princeton, NJ, United States

- I20 **The Influences of Intrinsic Amorphous Silicon Layer's Thickness and Bandgap to the Performances of Heterojunction Interdigitated Back-contact (HBC) Solar Cell**
Rui Jia, Ke Tao, Qiang Li, Hengchao Sun, Xiaowan Dai, Xinyun Liu, Zhi Jin
Institute of Microelectronics of Chinese Academy of Sciences,, Beijing, China
- I22 **Effect of growth and post-oxidation annealing temperature of thermally grown tunneling SiO_x on the implied V_{oc} of passivated contacts for c-Si based solar cells**
Abhijit Kale¹, William Nemeth², Matthew Page², Sumit Agarwal¹, Paul Stradins²
¹Colorado School of Mines, Golden, CO, United States, ²National Renewable Energy Laboratory, Golden, CO, United States
- I24 **Partially contacted surfaces with contact size in the 1 μm range for c-Si PERC solar cells.**
Rasha Khoury¹, Isidro Martin², Gema Lopez², Chen Jin², Juan Miguel López-González², Li Zeyu¹, Pavel Bulkin¹, Erik V. Johnson¹, Ramon Alcubilla²
¹Laboratoire de Physique des Interfaces et des Couches Minces (UMR 7647) LPICM-CNRS. Ecole Polytechnique, Université Paris Saclay, palaiseau, France, ²Departament d'Enginyeria Electrònica, Universitat Politècnica de Catalunya, Gran Capità s/n, Mòdul C4, Barcelona, Spain
- I26 **Entrance of Low Cost Fabrication of Back-Contact Hetero-Junction Solar Cells by Using Plasma Ion-Implantation**
Koichi Koyama, Keisuke Ohdaira, Hideki Matsumura
Japan Advanced Institute of Science and Technology, Nomi, Japan
- I28 **Contact resistance of the p-type amorphous silicon hole contact in silicon heterojunction solar cells**
Mehdi Leilaieoun, William Weigand, Pradyumna Muralidharan, Mathieu Boccard, Dragica Vasileska, Stephen Goodnick, Zachary Holman
Arizona State University, Tempe, AZ, United States
- I30 **Solar Cells Application of p-type poly-Si Thin Film by Aluminum Induced Crystallization**
Shota Masuda¹, Kazuhiro Gotoh¹, Isao Takahashi¹, Kyotaro Nakamura², Yoshio Ohshita³, Noritaka Usami¹
¹Graduate School of Engineering, Nagoya University, Nagoya, Japan, ²Meiji University, Kawasaki, Japan, ³Toyota Technological Institute, Nagoya, Japan
- I32 **A Self-Consistently Coupled Drift Diffusion and Monte Carlo Simulator to Model Silicon Heterojunction Solar Cells**
Pradyumna Muralidharan, Stuart Bowden, Stephen M Goodnick, Dragica Vasileska
Arizona State University, Tempe, AZ, United States
- I34 **Dopant Patterning by PECVD and Mechanical Masking for Passivated Tunneling Contact IBC Cell Architectures**
William Nemeth¹, Vincenzo LaSalvia¹, Benjamin G. Lee¹, Abhijit Kale², Paul Stradins¹
¹NREL, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States
- I38 **Screen Printed, Large Area Bifacial N-PERT cells with Tunnel Oxide Passivated Back Contact**
Young-Woo Ok¹, Ajay D Upadhyaya¹, Brian Rounsaville¹, Ying-Yuan Huang¹, Vijaykumar D Upadhyaya¹, Ajeet Rohatgi^{1,2}
¹Georgia Institute of Technology, Atlanta, GA, United States, ²Suniva Inc., Norcross, GA, United States

- I40 Correlation between Electroluminescence and Photoconversion Efficiency in a-Si:H/c-Si Heterojunction Solar Cells**
 Anatoliy V. Sachenko¹, Alexander V. Bobyl², Vasiliy N. Verbickiy², Viktor M. Vlasiuk¹, Denis M. Zhigunov³, Vitaliy P. Kostilyov¹, Igor O. Sokolovskiy^{1,4}, Eugeny I. Terukov^{2,5}, Pavel A. Forsh³, Mykhaylo Evstigneev⁴
¹V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine, Kiev, Ukrenia, ²Ioffe Institute RAS, St. Petersburg, Russia, ³M. Lomonosov Moscow State University, Moscow, Russia, ⁴Department of Physics and Physical Oceanography, Memorial University of Newfoundland, St. John's, NL, Canada, ⁵TFTC Ioffe R&D Center, St. Petersburg, Russia
- I42 An Isotope Study of Hydrogen Passivation of poly-Si/SiO_x Passivated Contacts for Si Solar Cells**
 Manuel Schnabel¹, William Nemeth¹, Bas W.H. van de Loo², Bart Macco², W.M.M. Kessels², Pauls Stradins¹, David Young¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Department of Applied Physics, Eindhoven University of Technology, Eindhoven, Netherlands
- I44 Alleviating hydrogen plasma damage to amorphous/crystalline silicon interface passivation**
 Jianwei Shi, Zachary C. Holman
 School of Electrical, Computer and Energy Engineering, Ira A. Fulton Schools of Engineering, Arizona State University, Tempe, Arizona, 85287, USA, Tempe, AZ, United States
- I46 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**
 Anishkumar Soman¹, Ugochukwu Nsofor^{1,2}, Lei Zhang^{1,2}, Ujjwal Das², Tingyi Gu¹, Steven Hegedus^{1,2}
¹Department of Electrical and Computer Engineering, University of Delaware, Newark, DE, United States, ²Institute of Energy Conversion, University of Delaware, Newark, DE, United States
- I48 Large-area n-type TOPCon Cells with Screen-printed Contact on Selective Boron Emitter Formed by Wet Chemical Etch-back**
 Yuguo Tao¹, Felix Book², Barbara Terheiden², Vijaykumar Upadhyaya¹, Keeya Madani¹, Brian Rounsaville¹, Eunhwan Cho¹, Ajeet Rohatgi^{1,3}
¹Georgia Institute of Technology, Atlanta, GA, United States, ²University of Konstanz, Konstanz, Germany, ³Suniva Inc., Norcross, GA, United States
- I50 Measuring Diode Resistivity of Passivated Contacts**
 San Theingi^{1,2}, William Nemeth¹, David L. Young¹, Paul Stradins¹, Benjamin G. Lee¹
¹National Renewable Energy Lab, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States
- I51 Band Bending in Titanium Dioxide Based Electron-Selective Contacts to p-type Silicon**
 Daniel Vössing, Karim M. Gad, Leonhard M. Reindl, Martin Kasemann
 Department of Microsystems Engineering, University of Freiburg, Freiburg, Germany
- I53 Ultra-Thin Crystalline Silicon Solar Cells with Nickel Oxide Interlayer as Hole-selective Contact**
 Muyu Xue¹, Yusi Chen², Raisul Islam², Junyan Chen³, Ching-Ying Lu², Zheng Lyu², Kai Zang², Jieyang Jia², Huiyang Deng², Yijie Huo², Ted Kamins², Krishna Saraswat^{1,2}, James Harris^{1,2}
¹Department of Materials Science and Engineering, Stanford University, Stanford, CA, United States, ²Department of Electrical Engineering, Stanford University, Stanford, CA, United States, ³School of Physics, Peking University, Beijing, China
- I55 Crystalline Si Solar Cells with Hole-selective Metal Oxide Contacts**
 Woojun Yoon¹, James Moore², David Scheiman¹, Eunhwan Cho³, Young-Woo Ok³, Nicole

Kotulak⁴, Phillip Jenkins¹, Ajeet Rohatgi³, Robert Walters¹

¹U.S. Naval Research Laboratory, Washington, DC, United States, ²The George Washington University, Washington, DC, United States, ³Georgia Institute of Technology, Atlanta, GA, United States, ⁴NRC Postdoctoral Research Associate residing at the U.S. Naval Research Laboratory, Washington, DC, United States

J1 GaP/Si Heterojunction Solar Cells Grown by MBE

Chaomin Zhang, Ehsan Vadiiee, Richard King, Christiana Honsberg
Arizona State University, Tempe, AZ, United States

J3 Spin Coated Nickel and Vanadium Oxide Layers on Silicon for a Carrier Selective Contact Solar Cell

Jing Zhao, Fa-Jun Ma, Anita Ho-Baillie, Stephen Bremner
University of New South Wales, Sydney, Australia

ePoster >23% Silicon heterojunction solar cells in Meyer Burger's Demo line: Results of pilot production on mass production tools

Jun Zhao¹, Marcel König¹, Yu Yao², Thomas Söderström²

¹Meyer Burger Germany AG, Hohenstein-Ernstthal, Germany, ²Meyer Burger AG, Thun, Switzerland

I36 ALD Aluminum oxide as a hole selective tunneling contact for crystalline silicon solar cells.

Kortan Ögütman^{1,3}, Kristopher O. Davis^{1,3}, Winston V. Schoenfeld^{1,2,3}, Michael Haslinger⁴, Sofie Robert⁴, Emanuele Cornagliotti⁴, Joachim John^{4,5}

¹Florida Solar Energy Center, Cocoa, FL, United States, ²CREOL, the College of Optics and Photonics, Orlando, FL, United States, ³Dept. of Electrical Engineering and Computer Science, University of Central Florida, Orlando, FL, United States, ⁴IMEC, Leuven, Belgium, ⁵EnergieVille, Genk, Belgium

Area 8 - Poster

12:45 - 2:15 PM

Exhibit Hall A

Module Design & Manufacture, BIPV, Novel Applications

Chair(s): Wilfried van Sark, Kimberly Sablon, Kurt Barth

J6 Spalling Analysis of Flexible Ge and Si Layers

Ibrahim Alhomoudi, Abdulrahman Albadri

King Abdulaziz City for Science and Technology (KACST), Riyadh, Saudi Arabia

J14 High Efficiency Anti-Reflective Coating for PV Module Glass

Brennen M. Freiburger¹, Robert A. Fleming¹, Corey S. Thompson¹, Douglas A. Hutchings¹, Sergiu C. Pop²

¹WattGlass, Fayetteville, AR, United States, ²Yingli Green Energy Americas, San Francisco, CA, United States

J16 Investigation of Efficiency for PID-affected Solar Module at Non-standard Test Conditions

Shuwen Guo¹, Pan Zhao¹, Weijing Huang², Jipeng Chang¹, He Wang¹, Hong Yang¹, Chengfeng Su³, Bojie Su⁴, Xue Zhang⁴, Yunxue Cao⁵, Hui Zhao⁵

¹Xi'an Jiaotong University, Xi'an, China, ²Xi'an Huanghe Photovoltaic Technology Co, Ltd, Xi'an, China, ³Taizhou Chisolar Co., Ltd., Xi'an, China, ⁴dChina Quality Certification Center, Beijing, China, ⁵eSPIC Power Plant Operation Technology Co., Ltd, Beijing, China

- J20 Thermal Uniformity Mapping of PV Modules and Plants**
Ashwini Pavgi, Jaewon Oh, Joseph Kuitche, Sai Tatapudi, GovindaSamy TamizhMani
Arizona State University Photovoltaic Reliability Lab (ASU-PRL), Mesa, AZ, United States
- J22 Climate-specific Thermal Model Coefficients for c-Si and Thin-Film PV Modules**
Ashwini Pavgi, Joseph Kuitche, Jaewon Oh, GovindaSamy TamizhMani
Arizona State University Photovoltaic Reliability Lab (ASU-PRL), Mesa, AZ, United States
- J10 Field Inspection of PV Modules: Quantitative Determination of Performance Loss due to Cell Cracks using EL Images**
Carlos A. Rodríguez Castañeda¹, Shashwata Chattopadhyay², Jaewon Oh³, Sai Tatapudi³, GovindaSamy TamizhMani³, Hailin Hu¹
¹*Universidad Nacional Autónoma de México, Instituto de Energías Renovables (IER-UNAM), Temixco, Mexico*, ²*National Centre for Photovoltaic Research and Education, Indian Institute of Technology Bombay, Mumbai, India*, ³*Arizona State University Photovoltaic Reliability Lab (ASU-PRL), Mesa, AZ, United States*
- ePoster Quantification of PV Module Discoloration using Visual Image Analysis**
Shashwata Chattopadhyay¹, Chetan Singh Solanki¹, Anil Kottantharayil¹, K.L. Narasimhan¹, Juzer Vasi¹, Sai Tatapudi², Govindasamy TamizhMani²
¹*National Centre for Photovoltaic Research & Education, IIT Bombay, MUMBAI, India*, ²*Arizona State University Photovoltaics Reliability Lab, MESA, AZ, United States*
- J24 Effect of the thermophysical properties of a phase change material on the electrical output of a concentrated photovoltaic system**
Jawad Sarwar, Ahmed E. Abbas, Konstantinos E. Kakosimos
Texas A&M University at Qatar, Doha, Qatar
- J18 The low PV/T system: design and test**
Alena Okhorzina¹, Alexey Yurchenko^{1,2}, Alexander Bikbulatov¹, Norbert Bernhard³
¹*Tomsk Polytechnic University, Tomsk, Russia*, ²*Tomsk State University, Tomsk, Russia*, ³*Anhalt University of Applied Sciences, Köthen, Germany*
- J12 Scale Up Designs for Hand-Held Light-Weight TPV Generator**
Lewis Fraas¹, James Avery¹, Leonid Minkin¹, Hui She¹, Luke Ferguson²
¹*JX Crystals Inc, Issaquah, WA, United States*, ²*C12 Materials LLC, Everett, WA, United States*
- J28 The Water-Solar nexus: PV for desalination - issues and opportunity with a case study**
Andy Skumanich¹, Paula Mints²
¹*SolarVision Co, Los Gatos, CA, United States*, ²*SPV, San Jose, CA, United States*
- J30 Modified Maximum Power Extraction technique for rapidly changing NUI and dynamic loads**
Aswani Uppada¹, Siddhartha Prakash Dutttagupta¹, Eldho T I², Venkata Rao Basam³
¹*PhD scholar, Electrical Engineering, IIT Bombay, Mumbai, India*, ²*Associate Professor, Electrical Engineering, Electrical Engineering, IIT Bombay, Mumbai, India*, ³*Professor, Civil Engineering, IIT Bombay, Mumbai, India*, ⁴*Scientist, Naval Science and Technological Laboratory, Visakhapatnam, India*
- J8 Temperature and Power Study of Adhered and Racked Double Glass Photovoltaic Modules**
Volker Beutner, Rubina Singh, Cameron Stark
Fraunhofer USA, Albuquerque, NM, United States
- J26 Passive Cooling of Photovoltaics with Desiccants**
Lin J. Simpson¹, Jason Woods², Nicolas Valderrama³, Alex Hill⁴, Nina Vincent⁵, Timothy Silverman⁶
¹*National Renewable Energy Laboratory, Golden, CO, United States*, ²*National Renewable Energy Laboratory, Golden, CO, United States*, ³*University of Florida, Gainesville, FL, United States*,

⁴University of Denver, Denver, CO, United States, ⁵Scripps College, Claremont, CA, United States,
⁶National Renewable Energy Laboratory, Golden, CO, United States

Area 9 - Poster

12:45 - 2:15 PM

Exhibit Hall B

Reliability Field Experience, and Reliability and Safety of Power Electronics and PV Systems

Chair(s): Dirk Jordan, Olga Lavrova, Keisuke Ohdaira

J32 Photovoltaic Module Durability and Reliability: Analysis of a 23-Year Old Array Operating in Quebec, Canada

Christopher Baldus-Jeursen¹, Alexandre Côté¹, Tanya Deer², Yves Poissant¹
¹CanmetENERGY, Varennes, QC, Canada, ²RelSol Inc, Vaughan, ON, Canada

J34 Are E-W trackers a better option for future investments in PV sector- A detailed Techno-Commercial Study

Rakesh Bohra, Ramesh Rame Gowda, Mani R Krishnan

J36 Experimental Evaluation of the Performance of Crystalline-Si PV Module Degradation after 15-Years of Field Exposure

Denio A. Cassini^{1,2}, Marcelo M. Viana³, Michele C.C. Oliveira³, Vanessa de F. Lins³, Roberto Zilles⁴, Lawrence L. Kazmerski⁵, Antonia Sonia A.C. Diniz¹
¹PUC Minas, Belo Horizonte, Brazil, ²CEMIG, Belo Horizonte, Brazil, ³UFMG, Belo Horizonte, Brazil, ⁴USP, São Paulo, Brazil, ⁵NREL, Golden, CO, United States

J38 Field investigations of potential-induced degradation (PID) for crystalline silicon PV panels in different climates

Yifeng Chen¹, Peter Hacke², Kaitlyn VanSant³, Yong Sheng Khoo⁴, Zigang Wang¹, Wei Luo⁴, Jing Chai⁴, Chris Deline², Sarah Kurtz², Admin Abele⁴, Zhiqiang Feng¹, Pierre J. Verlinden¹
¹State Key Laboratory of PV Science and Technology, Trina Solar, Changzhou, China, ²National Renewable Energy Laboratory (NREL), Golden, CO, United States, ³Colorado School of Mines, Golden, CO, United States, ⁴Solar Energy Research Institute of Singapore (SERIS), Singapore, Singapore

J40 Determining the Power Change Rate of 373 Plant Inverters' Time-series Data Across Multiple Climate Zones, Using a Month-by-Month Data Science Analysis

Alan J Curran, Yang Hu, Rojiar Haddadian, Jennifer L Braid, David Meakin, Timothy J Peshek, Roger H French

J42 Photovoltaic Array Differential Backside Exposure Conditions: Backsheet Degradation and Site Design

Andrew Fairbrother¹, Julien Avenet¹, Yadong Lyu¹, Matt Boyd¹, Scott Julien², Kai-Tak Wan², Liang Ji³, Kenneth Boyce³, Sebastien Merzlic⁴, Amy Lefebvre⁴, Greg O'Brien⁴, Yu Wang⁵, Laura Bruckman⁵, Roger French⁵, Michael Kempe⁶, Xiaohong Gu¹
¹National Institute of Standards and Technology, Gaithersburg, MD, United States, ²Northeastern University, Boston, MA, United States, ³Underwriters Laboratories, Northbrook, IL, United States, ⁴Arkema, King of Prussia, PA, United States, ⁵Case Western Reserve University, Cleveland, OH, United States, ⁶National Renewable Energy Laboratory, Golden, CO, United States

J44 Potential Induced Degradation (PID) Power Loss Correlation to Leakage and Reverse Bias Currents

Michalis A. Florides, Georgios Konstantinou, Venizelos Venizelou, George Makrides, George E. Georghiou

FOSS Research Centre for Sustainable Energy, PV Technology, Department of Electrical and Computer Engineering, University of Cyprus, 75 Kallipoleos Street, 1678, Nicosia, Cyprus

- J46 Study on Random Failure of Crystalline Silicon Solar Modules in the Field**
Xuefang Jiang^{1,2}, Fumei Wang¹, Ao Wang¹, Hong Yang¹, He Wang¹, Jie Ding³, Junjun Zhang³, Jingsheng Huang³
¹*Xi'an Jiaotong University, Xi'an, China*, ²*Xi'an Polytechnic University, Xi'an, China*, ³*China electric power research institute, Nanjing, China*
- J48 Performance Study of Various PV Module Technologies in Desert Conditions**
Jim J John, Ammar Elnosh, Anwar Almheiri, Wadhah Alzahmi, Marco Stefancich, Pedro Banda
Dubai Electricity and Water Authority, Dubai, United Arab Emirates
- J50 High-Speed Measurements of Generated Power and its Relationship to Weather Observations at Yoshinogari Mega Solar Power Plant**
Makoto Kasu, Shigeomi Hara, Takumi Uematsu
Saga University, Saga, Japan
- J52 Impact of Missing Data on the Estimation of Photovoltaic System Degradation Rate**
Andreas Livera, Alexander Phinikarides, George Makrides, George E. Georghiou
University of Cyprus, Nicosia, Cyprus
- ePoster Considerations and Structured Approach for Selecting and Deploying Climate Specific Polymeric Wire Management Means**
Sumanth Varma Lokanath¹, Bryan Skarbek¹, Ramanathan Muruganathan², Gurneet Kaur¹, Peter Seidel³
¹*First Solar Inc, Mesa, AZ, United States*, ²*First Solar Inc, Mesa, AZ, United States*, ³*First Solar Inc, Perrysburg, OH, United States*, ⁴*First Solar Inc, Mesa, AZ, United States*, ⁵*First Solar Inc, Mainz, Germany*
- J54 Field Degradation and Failures of Crystalline Silicon PV Modules in Mexico**
Dalia Martínez Escobar¹, Pedro Andrés Sánchez Pérez¹, José Ortega Cruz¹, Rocío de la Luz Santos Magdaleno¹, Sai Tatapudi², Aaron Sánchez Juárez¹, GovindaSamy TamizhMani²
¹*Instituto de Energías Renovables, Universidad Nacional Autónoma de México, Temixco, Mexico*, ²*Photovoltaic Reliability Laboratory, Arizona State University, Mesa, AZ, United States*
- J56 Rapid Shutdown with Panel Level Electronics - A suitable safety measure?**
Christopher Merz, Gerd Bettenwort, Markus Hopf, Hannes Knopf, Joachim Laschinski
SMA Solar Technology AG, Niestetal, Germany
- K2 Investigating a New Operating Point For PV Panels Seeking Maximum Life Span**
Bechara F. Nehme^{1,2}, Nacer K. MSirdi¹, Tilda R. Akiki²
¹*Aix Marseille Université, CNRS, ENSAM, Université de Toulon, LSIS UMR 7296, 13397, Marseille, France*, ²*Department of Electrical and Electronics Engineering Faculty of Engineering, Holy Spirit University of Kaslik (USEK), Jounieh, Lebanon*
- K4 Power Generation Evaluation of Large-scale Photovoltaic Systems Located on Inclined Plane**
Naotaka Oka¹, Yasuhito Takahashi¹, Koji Fujiwara¹, Kazuyuki Hidaka², Hiroshi Morita²
¹*Doshisha University, Kyoto, Japan*, ²*Kinden Corporation, Kyoto, Japan*
- K6 INVESTIGATING THE IMPACT OF SOLAR CELLS' PARTIAL SHADING ON PHOTOVOLTAIC MODULES BY THERMOGRAPHY**
David Pera, José A. Silva, Sara Costa, João M. Serra
Instituto Dom Luiz - Faculdade de Ciências Universidade de Lisboa, Lisboa (Lisbon, Portugal), Portugal

K8 Annual Degradation Rate and its Linearity Analysis using Metered kWh Data
Chris Raupp, Govindasamy Tamizhmani
Arizona State University Photovoltaic Reliability Lab (ASU-PRL), Mesa, AZ, United States

K10 Electrical Performance Analysis of a 27 kW Grid-Connected PV System with Soiling and Shading in Morelos, Mexico.
Pedro Andrés Sánchez Pérez, Dalia Martínez Escobar, Edson Osvaldo Ángel Ruiz, José Ortega Cruz, Rocío Santos Magdaleno, Aarón Sánchez Juárez
Instituto de Energías Renovables Universidad Nacional Autónoma de México, Temico, Mexico

K12 Modified STC Correction Procedure for Assessing PV Module Degradation in Field Surveys
Hemant Kumar Singh, Rajiv Dubey, Sachin Zachariah, K. L. Narasimhan, B. M. Arora, Anil Kottantharayil, Juzer Vasi
National Centre for Photovoltaic Research and Education (NCPRE), Department of Electrical Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, India

ePoster **Real-time Monitoring of Photovoltaic Reliability Only Using Maximum Power Point – the Suns-Vmp Method**
Xingshu Sun, Haejun Chung, Raghu Vamsi Krishna Chavali, Peter Bermel, Muhammad Ashraf Alam
Network of Photovoltaic Technology, Purdue University, WEST LAFAYETTE, IN, United States

K14 Degradation Models of Photovoltaic Module Backsheets Exposed to Diverse Real World Conditions
Yu Wang¹, Sebastien Merzlic², Andrew Fairbrother³, Lucas Fridman¹, Scott Julien⁴, Amy Lefebvre², Xiaohong Gu³, Michael Kempe⁶, Kai-tak Wan⁴, Liang Ji⁵, Kenneth P. Boyce⁵, Roger H. French¹, Laura S. Bruckman¹
¹Case Western Reserve University, Cleveland, OH, United States, ²Arkema Inc, King of Prussia, PA, United States, ³National Institute of Standards and Technology, Gaithersburg, MD, United States, ⁴Northeastern University, Boston, MA, United States, ⁵UL LLC, Northbrook, IL, United States, ⁶National Renewable Energy Laboratory, Golden, CO, United States

Area 12 - Poster

12:45 - 2:15 PM

Exhibit Hall E

PV Deployment and Sustainability

Chair(s): Annick Anctil, Robert Margolis, Michael Woodhouse

K16 "Photovoltaic Smart Home System - Dubai Case Study"
Marwa S ALJaziri, Maitha M ALBalooshi, Gharibah E Masoud, Hassa M ALBalooshi, Ammar N Natsheh
Higher Colleges of Technology, Duabi, United Arab Emirates

K32 Analysis of Light Environment under Solar Panels and Crop Layout
Deng Wang¹, Yaojie Sun¹, Yandan Lin¹, Yuan Gao²
¹Fudan University, Shanghai, China, ²Delft University of Technology, Delft, Netherlands

K18 Direct Drive Photovoltaic Milk Chilling Experience in Kenya
Robert E. Foster¹, Brian Jensen², Brian Dugdill³, Bruce J. Knight⁴
¹Winrock International, Arlington, VA, United States, ²SunDanzer, Tucson, AZ, United States, ³Winrock International, N. Yorkshire, United Kingdom, ⁴Winrock International, Naivasha, Kenya

- K20 Cost Optimization of Decommissioning and Recycling CdTe PV Power Plants**
 Vasilis Fthenakis¹, Zhuoran Zhang¹, Jun-Ki Choi²
¹Columbia University, New York, NY, United States, ²University of Dayton, Dayton, OH, United States
- K22 Challenges for decision makers when feed in tariff schemes change to incentives dependent of a high share of self-consumed electricity**
 Mattias Gustafsson
 University of Gävle, Gävle, Sweden
- K24 Procedures to Make Projects about Renewable Energy Generation Connected to the grid in Colombia**
 Johann Hernández¹, Carlos Arredondo², Diego Julián Rodríguez¹
¹Universidad Distrital FJDC, Bogotá, Columbia, ²Universidad de Medellín, Medellín, Columbia
- K26 A Critical Analysis on the Thin Crystalline Silicon PV Module of the Lightweight PV System**
 Abhishek Iyer², Meixi Chen¹, Robert Opila¹, Cheng-Hao Shih³, Lado Kurdgelashvili³
¹University of Delaware, Newark, DE, United States, ²University of Delaware, Newark, DE, United States, ³University of Delaware, Newark, DE, United States, ⁴University of Delaware, Newark, DE, United States, ⁵University of Delaware, Newark, DE, United States
- K28 Photovoltaic Module Manufacturing Costs, Average Prices and Industry Balance 2006-2016**
 Paula J Mints¹, Zhengshan J Yu²
¹SPV Market Research, San Jose, CA, United States, ²Arizona State University, Phoenix, AZ, United States
- K30 Solar Cell and Wind Energy Replacement of Power Plants Globally**
 Larry D. Partain^{1,2}, Shirley Hansen², Dirk Bennett², Richard Hansen², Allan Newlands², Lewis M. Fraas³
¹Solar Cell Electricity, Los Altos, CA, United States, ²BridgePoint Consortium, Los Altos, CA, United States, ³JX Crystals Inc., Issaquah, WA, United States
- ePoster Addressing Hot Spots in the Product Environmental Footprint of CdTe Photovoltaics**
 Parikhit Sinha¹, Andreas Wade²
¹First Solar, Tempe, AZ, United States, ²First Solar, Mainz, Germany

Area 2 - Oral	
2:30 - 4:00 PM	Marriott Ballroom Salon 3
Advances in CIGSe II	

Chair(s): Aaron Arehart, Lars Stolt

- 2:30 Enhanced Efficiency of Cd-free Cu(In,Ga)(Se,S)₂ Minimodule via (Zn,Mg)O Second Buffer Layer and Alkali Post Treatment**
 Takuya Kato, Atsushi Handa, Takeshi Yagioka, Tetsuya Matsuura, Kentarou Yamamoto, Shougo Higashi, Jyh-Lih Wu, Kong Fai Tai, Homare Hiroi, Takashi Yoshiyama, Tetsuya Sakai, Hiroki Sugimoto
 Solar Frontier K.K., Atsugi, Kanagawa, Japan
- 2:45 Interface effects of alkali treatment on Cu-rich thin film solar cells**
 Hossam Elanzeery, Finn Babbe, Anastasiya Zelenina, Michele Melchiorre, Susanne Siebentritt
 Laboratory for Photovoltaics, University of Luxembourg, Belvaux, Luxembourg

- 3:00 **Interfacial Engineering for Lifetime Enhancement of CIGS Devices**
 Ina T Martin¹, Maria Y Kim¹, Elizabeth J Hodges¹, Lorelle M Mansfield², Roger H French¹, Timothy J Peshek¹
¹Case Western Reserve University, Cleveland, OH, United States, ²The National Renewable Energy Laboratory, Golden, CO, United States
- 3:15 **Influence of sodium and rubidium post-deposition treatment on the quasi-Fermi level splitting of Cu(In,Ga)Se₂ thin films**
 Max H. Wolter¹, Benjamin Bissig², Enrico Avancini², Romain Carron², Stephan Buecheler², Philip Jackson³, Susanne Siebentritt¹
¹University of Luxembourg, Physics and Materials Science Research Unit, Laboratory for Photovoltaics, 41, rue du Brill, 4422 Belvaux, Luxembourg, ²Laboratory for Thin Films and Photovoltaics, Empa - Swiss Federal Laboratories for Materials Science and Technology, Überlandstr. 129, 8600 Dübendorf, Switzerland, ³Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), 70565 Stuttgart, Germany
- 3:30 **Increased V_{OC} and FF in ZnO_{1-x}S_x-buffered CuIn_{1-x}Ga_xSe₂ Solar Cells by Cadmium Partial Electrolyte Treatment**
 Andreas Bauer, Dimitrios Hariskos, Wiltraud Wischmann
 ZSW, Stuttgart, Germany
- 3:45 **Best Student Presentation Award Finalist**
"First-principles modeling of alkali metal post deposition treatment effect in CIGS solar cells."
 Maria Fedina, Hannu-Pekka Komsa, Ville Havu, Martti Puska
 Aalto university, Espoo, Finland

Area 4 - Oral	
2:30 - 4:00 PM	Marriott Ballroom Salon 2
Passivated Contacts, High Temperature	

Chair(s): Andres Cuevas, Monica Aleman

- 2:30 **Passivating and Carrier-selective Contacts – Basic Requirements and Implementation**
 Stefan W. Glunz, Martin Bivour, Frank Feldmann, Ralph Müller, Christian Reichel, Armin Richter, Jan Benick, Martin Hermle
 Fraunhofer ISE, Freiburg, Germany
- 3:00 **Exploring silicon carbide- and silicon oxide-based layer stacks for passivating contacts to silicon solar cells**
 Philipp Löper¹, Gizem Nogay¹, Philippe Wyss¹, Matej Hyvl², Paul Procel³, Josua Stuckelberger¹, Andrea Ingenito¹, Quentin Jeangros¹, Martin Ledinsky², Antonin Fejfar², Christophe Allebe⁴, Jörg Horzel⁴, Matthieu Despeisse⁴, Felice Crupi³, Franz-Josef Haug¹, Christophe Ballif¹
¹École Polytechnique Fédérale de Lausanne, Neuchâtel, Switzerland, ²Academy of Sciences of the Czech Republic, Prague, Czech Republic, ³Department of Computer Engineering, Modeling, Electronics and Systems Engineering, University of Calabria, Rende, Italy, ⁴CSEM SA, PV-Center, Neuchâtel, Switzerland
- 3:15 **Perimeter recombination in 25 %-efficient IBC solar cells with passivating POLO contacts for both polarities**
 Felix Haase¹, Sören Schäfer¹, Fabian Kiefer¹, Jan Krügener^{2,3}, Rolf Brendel^{1,2,4}, Robby Peibst^{1,2}
¹Institute for Solar Energy Research Hamelin (ISFH), Emmerthal, Germany, ²Institute of Electronic Materials and Devices, Leibniz Universität Hannover, Hannover, Germany, ³Laboratory of Nano

and Quantum Engineering (LNQE), Leibniz Universität Hannover, Hannover, Germany, ⁴Institute for Solid State Physics, Leibniz Universität Hannover, Hannover, Germany

- 3:30 **Gallium doped polySi:Ga/SiO₂ passivated emitters to n-Cz wafers with $iV_{oc} > 730$ mV**
David L. Young, Benjamin G. Lee, Derek Fogel, William Nemeth, Vincenzo LaSalvia, San Theingi, Matthew Page, Matthew Young, Craig Perkins, Paul Stradins
National Renewable Energy Laboratory, Golden, CO, United States
- 3:45 **Efficient electron contacts for n-type silicon solar cells using Magnesium metal, oxide, and fluoride**
Yimao Wan¹, Chris Samundsett¹, James Bullock², Di Yan¹, Thomas Allen¹, Jun Peng¹, Jie Cui¹, Mark Hettick², Ali Javey², Andres Cuevas¹
¹*Research School of Engineering, Canberra, Australia*, ²*Electrical Engineering and Computer Science, Berkeley, CA, United States*

Area 7 - Oral

2:30 - 4:00 PM

Maryland A

Space Solar Cell Concepts

Chair(s): Bao Hoang, Mitsuru Imaizumi

- 2:30 **Best Student Presentation Award Finalist**
Graded (Al_zGa_{1-z})_xIn_{1-x}P Window-Emitter Structures for Improved Short-Wavelength Response
Jacob T. Boyer, Daniel J. Chmielewski, Steven A. Ringel, Tyler J. Grassman
Ohio State University, Columbus, OH, United States
- 2:45 **Best Student Presentation Award Finalist**
Integration of Quantum Dots and Quantum Wells into InGaAs Metamorphic Subcell for Radiation Hard 3-J ELO IMM Photovoltaics
Zachary S. Bittner¹, Hyun Kum¹, Michael A. Slocum¹, George T. Nelson¹, Rao Tatavarti², Andree Wibowo², Seth M. Hubbard¹
¹*Rochester Institute of Technology, Rochester, NY, United States*, ²*Microlink Devices, Niles, IL, United States*
- 3:00 **Best Student Presentation Award Finalist**
Proton Irradiation of 3J Solar Cells at Low Temperature
Seonyong Park¹, Jacques C. Bourgoin¹, Olivier Cavani¹, Sandrine Picard², Jérôme Bourcois², Victor Khorenko³, Carsten Baur⁴, Bruno Boizot¹
¹*Laboratoire des Solides Irradiés, CNRS-UMR 7642, CEA-DRF-IRAMIS, Ecole Polytechnique, Université Paris-Saclay, Palaiseau, France*, ²*CSNSM, Université Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France*, ³*AZUR SPACE Solar Power GmbH, Heilbronn, Germany*, ⁴*European Space Agency, Noordwijk, Netherlands*
- 3:15 **Ultra-thin GaAs solar cells: radiation tolerance and space applications**
Louise C Hirst¹, Michael K Yakes¹, Jeffery H Warner¹, Mitchell F Bennett², Kenneth J Schmieder¹, Stephanie Tomasulo¹, Erin Cleveland¹, Sergey Maximenko¹, James E Moore³, Robert J Walters¹, Phillip P Jenkins¹
¹*U.S. Naval Research Laboratory, Washington, DC, United States*, ²*Sotera Defense Solutions, Inc., Annapolis Junction, MD, United States*, ³*The George Washington University, Washington, DC, United States*
- 3:30 **Large Area Multijunction III/V Space Solar Cells Over 31% Efficiency**
Xing Q. Liu, Chris M. Fetzer, Philip T. Chiu, Moran Haddad, Xiaobo Zhang, Rob Cravens, Daniel C.

Law, James H. Ermer, Jeffrey P. Krogen, Surya K. Sharma, James P. Hanley
Spectrolab, Sylmar, CA, United States

3:45 Advanced-Architecture High-Efficiency Solar Cells for Low Irradiance Low Temperature (LILT) Applications

Andreea Boca¹, Jonathan Grandidier¹, Claiborne McPheeters², Paul Sharps², Philip Chiu³, Xing-Quan Liu³, James Ermer³

¹*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States,*

²*SolAero Technologies Corp., Albuquerque, NM, United States,* ³*Boeing Spectrolab Inc., Sylmar, CA, United States*

Area 8 - Oral

2:30 - 4:00 PM

Delaware A

PV for Buildings and Novel Applications

Chair(s): Christoph Mayr, Pierluigi Bonomo

2:30 Ultra-Lightweight PV module design for Building Integrated Photovoltaics

Ana C. Martins¹, Valentin Chapuis¹, Alessandro Virtuani¹, Christophe Ballif^{1,2}

¹*École Polytechnique Fédérale de Lausanne (EPFL), Neuchâtel, Switzerland,* ²*CSEM (PV-center), Neuchâtel, Switzerland*

2:45 Design it with LSCs; an exploration of applications for Luminescent Solar Concentrator PV technologies.

Wouter Eggink, Angèle Reinders

University of Twente, Enschede, Netherlands

3:00 Investigating PV-battery 3-terminal Integration Concept as a Self-sustaining Power Solution

Solomon.N Agbo, Oleksandr Astakhov, Uwe Rau, Tsvetelina Merdzhanova

Institute of Energy and Climate Research (IEK-5)- Photovoltaics, Forschungszentrum Julich GmbH, Julich, Germany

3:15 Performance assessment of a BIPV Roofing Tile in outdoor testing

Cristina S. Polo Lopez, Pierluigi Bonomo, Francesco Frontini, Lorenzo Nespoli, Vasco Medici

SUPSI, Canobbio, Switzerland

3:30 Life cycle assessment of transparent organic photovoltaic for window and portable electronic applications

Annick Anctil, Jack H Stephan, Anjali R Munasinghe, Eunsang Lee, Richard R Lunt

Michigan State University, East Lansing, MI, United States

Area 10 - Oral

2:30 - 4:00 PM

Delaware B

PV Inverters: Operation, Reliability and Security

Chair(s): Barry Mather, Brian Lydic

2:30 A Reduced Order Model for a TOV Study in a Solar PV Project

Ahmad Abdullah, Billy Yancey

Electric Power Engineers, Inc., Austin, TX, United States

- 2:45 **Cyber Security Assessment of a Residential PV Inverter**
Cedric Carter, Ifeoma Onunkwo, Patricia Cordeiro, Jay Johnson
Sandia National Laboratories, Albuquerque, NM, United States
- 3:00 **Evaluation of Fast-Frequency Support Functions in High Penetration Isolated Power Systems**
Mohamed Elkhatab, Jason Neely, Jay Johnson
Sandia National Laboratories, Albuquerque, NM, United States
- 3:15 **Loss of Utility Detection Capabilities for Today's Utility Interconnected Photovoltaic Inverters**
Sigifredo Gonzalez¹, Greg Kern², Michael Ropp³
¹*Sandia National Laboratories, Albuquerque, NM, United States*, ²*SunPower Corporation, Austin, TX, United States*, ³*Northern Plains Power Technologies, Brookings, SD, United States*
- 3:30 **Best Student Presentation Award Finalist**
Parametric PV Grid-Support Function Characterization for Simulation Environments
JAVIER HERNANDEZ-ALVIDREZ, JAY JOHNSON
- 3:45 **Response of Grid Interconnected Solar PV to Transmission System Faults**
David M Piper, Daniel L Donaldson
Southern California Edison, Rosemead, CA, United States

Area 12 - Oral

2:30 - 4:00 PM

Virginia A

International Markets and Potential for Growth

Chair(s): Robert Margolis, Dirk Weiss, Dana Olson

- 2:30 **Recent Developments in Korean PV R&D and Market**
Chinho Park
Korean Ministry of Trade, Industry & Energy (MOTIE), Sejong City, South Korea
- 3:00 **Cost analysis and cost reduction opportunities of residential PV system in the Japan**
Izumi KAIZUKA, Takashi OHIGASHI, Risa Kurihara, Haruki YAMAYA, Osamu IKKI
RTS Corporation, Tokyo, Japan
- 3:15 **Supply and Demand Constraints on Future PV Power in the USA**
Paul A. Basore¹, Wesley J. Cole²
¹*U.S. Department of Energy, Washington, DC, United States*, ²*National Renewable Energy Laboratory, Golden, CO, United States*
- 3:30 **Residential Photovoltaic Electricity Generation in the European Union 2017 - Opportunities and Challenges**
Arnulf Jäger-Waldau, Thomas Huld, Sandor Szabo
European Commission, Ispra, Italy
- 3:45 **Recent developments of solar photovoltaic systems in India**
SARAVANAN VASUDEVAN¹, ARUMUGAM MURUGESAN²
¹*Arunai Engineering College, Tiruvannamalai, India*, ²*Arunai Engineering College, Tiruvannamalai, India*

Characterization of Perovskites

Chair(s): Marina Leite, David Ginger

2:30 Anticorrelation Between Local Photoluminescence and Photocurrent Suggests Variability in Contact to Active Layer in Perovskite Solar Cells

Giles E Eperon, David Moerman, David Ginger
University of Washington, Seattle, WA, United States

2:45 Investigating Nanoscale Determinants of Charge Collection in Quasi-2D Perovskite Solar Cells

Yanqi Luo¹, Bat-El Cohen², Xueying Li¹, Barry Lai³, Lioz Etgar², David Fenning¹
¹*University of California San Diego, La Jolla, CA, United States*, ²*The Hebrew University of Jerusalem, Jerusalem, Israel*, ³*Argonne National Laboratory, Argonne, IL, United States*

3:00 Best Student Presentation Award Finalist

Distribution and charge state of iron impurities in intentionally contaminated lead halide perovskites

Jeremy R. Poindexter¹, Mallory A. Jensen¹, Ashley E. Morishige¹, Erin E. Looney¹, Amanda Youssef¹, Juan-Pablo Correa Baena¹, Sarah Wieghold¹, Volker Rose², Barry Lai³, Zhonghou Cai³, Tonio Buonassisi¹
¹*Massachusetts Institute of Technology, Cambridge, MA, United States*, ²*Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL, United States*, ³*X-Ray Science Division, Argonne National Laboratory, Argonne, IL, United States*

3:15 Operando X-Ray Diffraction for Characterization of Photovoltaic Materials

Laura T. Schelhas¹, Jeffrey A. Christians², Joseph J. Berry², Michael F. Toney¹, Christopher J. Tassone¹, Kevin H. Stone¹
¹*SLAC National Accelerator Laboratory, Menlo Park, CA, United States*, ²*National Renewable Energy Laboratory, Golden, CO, United States*

3:30 Imaging the Spatial Evolution of Degradation in Perovskite/Si Tandem Solar Cells after Exposure to Humid Air

Zhaoning Song¹, Jérémie Werner², Suneth C. Wathage¹, Florent Sahli², Niraj Shrestha¹, Stefaan De Wolf^{2,3}, Björn Niesen^{2,4}, Adam B. Phillips¹, Christophe Ballif^{2,4}, Randy J. Ellingson¹, Michael J. Heben¹
¹*University of Toledo, Wright Center for Photovoltaics Innovation and Commercialization, Department of Physics and Astronomy, Toledo, OH, United States*, ²*Ecole Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering (IMT), Photovoltaics and Thin-Film Electronics Laboratory (PV-Lab), Neuchâtel, Switzerland*, ³*King Abdullah University of Science and Technology (KAUST), KAUST Solar Center (KSC), Thuwal, Saudi Arabia*, ⁴*CSEM, PV-Center, Neuchâtel, Switzerland*

3:45 Correlative X-Ray Microscopy: Methods to Investigate the Roles of Inhomogeneities in Perovskite Solar Cells

Michael E. Stuckelberger¹, Tara Nietzold¹, Bradley West¹, Genevieve N. Hall¹, Jérémie Werner², Arnaud Walter³, Bjoern Niesen^{2,3}, Barry Lai⁴, Jörg M. Maser⁴, Volker Rose^{4,5}, Christophe Ballif^{2,3}, Mariana I. Bertoni¹
¹*Defect Lab, School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, United States*, ²*Photovoltaics and Thin-Film Electronics Laboratory, Institute of Microengineering, Ecole Polytechnique Fédérale de Lausanne, Neuchâtel, Switzerland*, ³*CSEM, Neuchâtel, Switzerland*, ⁴*Advanced Photon Source, Argonne National Laboratory, Argonne, IL*,

United States, ⁵Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL, United States

Break	
4:00 - 4:30 PM	Exhibit Hall A
Coffee Break	

Area 1 - Oral	
4:30 - 6:00 PM	Maryland A
Hot Carrier Solar Cells and New Concepts	

Chair(s): Jacob Krich , Ian Sellers

- 4:30 **Electro-Luminescent Refrigeration Enabled by Highly Efficient Photovoltaics**
T. Patrick Xiao¹, Kaifeng Chen², Parthiban Santhanam², Shanhui Fan², Eli Yablonovitch¹
¹University of California, Berkeley, Berkeley, CA, United States, ²Stanford University, Stanford, CA, United States
- 5:00 **Multiple quantum wells as slowed hot carrier cooling absorbers in hot carrier cells**
Gavin Conibeer, Yi Zhang, Simon Chung, Yuanxun Liao, Stephen Bremner, Santosh Shrestha
University of New South Wales, Sydney, Australia
- 5:15 **Quantitative optoelectronic measurements of carrier thermodynamics properties in quantum well hot carrier solar cell**
Dac-Trung Nguyen^{1,2}, Laurent Lombez^{1,2}, François Gibelli², Soline Boyer-Richard³, Alain Le Corre³, Olivier Durand^{1,3}, Jean-François Guillemoles^{1,2}
¹Institut photovoltaïque d'Île-de-France (IPVF), Antony, France, ²Institut de Recherche et Développement sur l'Energie Photovoltaïque (IRDEP), UMR 7174 CNRS-EDF-Chimie ParisTech, Chatou, France, ³FOTON-OHM, UMR 6082 CNRS-INSA, Rennes, France
- 5:30 **Best Student Presentation Award Finalist**
Absorption Enhancement in InGaAsP/InGaP Quantum Well Solar Cells
Islam E. Sayed^{1,2}, Nikhil Jain², Myles A. Steiner², John F. Geisz², Salah M. Bedair¹
¹North Carolina State University, Raleigh, NC, United States, ²National Renewable Energy Laboratory, Golden, CO, United States
- 5:45 **Carrier Collection Model and Design Rule for Quantum Well Solar Cells**
Kasidit Toprasertpong, Boram Kim, Yoshiaki Nakano, Masakazu Sugiyama
School of Engineering, the University of Tokyo, Tokyo, Japan

Area 2 - Oral	
4:30 - 6:00 PM	Marriott Ballroom Salon 3
Advances in Window, Buffer, and Interface Layers	

Chair(s): Walajabad Sampath, Sascha Sadewasser

- 2:30 **Use of new organic complexing and buffer agent for Zn(S,O) deposition for high efficiency Cu(In,Ga)Se₂-based solar cells**
Thibaud Hildebrandt^{1,2}, Nicolas Loones^{1,2}, Muriel Bouttemy³, Jackie Vigneron³, Arnaud Etcheberry³,

Daniel Lincot^{2,4}, Negar Naghavi^{2,4}

¹EDF R&D, Chatou, France, ²IPVF, Antony, France, ³ILV, Versailles, France, ⁴CNRS, Chatou, France

2:45 Influence of conduction band offsets at window/buffer and buffer/absorber interfaces on the roll-over of J-V curves of CIGS solar cells

Giovanna Sozzi¹, Simone Di Napoli¹, Roberto Menozzi¹, Florian Werner², Susanne Siebentritt², Philip Jackson³, Wolfram Witte³

¹Department of Engineering and Architecture, University of Parma, Parma, Italy, ²Laboratory for Photovoltaics, University of Luxembourg, Belvaux, Luxembourg, ³Zentrum für Sonnenenergie und Wasserstoff-Forschung Baden-Württemberg (ZSW), Stuttgart, Germany

3:00 Overview of surface passivation schemes for thin film solar cells

Bart Vermang^{1,2}, Ratan Kotipalli³

¹Imec, Leuven, Belgium, ²UHasselt, Diepenbeek, Belgium, ³UCL, Louvain-La-Neuve, Belgium

3:15 Best Student Presentation Award Finalist

Towards 10% State-of-the-Art Pure Sulfide Cu₂ZnSnS₄ Solar Cell by modifying the Interface Chemistry

Kaiwen Sun¹, Jialiang Huang¹, Steve Johnston², Chang Yan¹, Fangyang Liu¹, Xiaojing Hao¹, Martin Green¹

¹School of Photovoltaic and Renewable Energy Engineering, University of New South Wales (UNSW), Sydney, Australia, ²National Renewable Energy Laboratory (NREL), Golden, CO, United States

3:30 Sputter-deposited Oxides for Interface Passivation of CdTe Photovoltaics

Jason M. Kephart¹, Anna Kindvall¹, Desiree Williams¹, Darius Kuciauskas², Pat Dippo², Amit Munshi¹, Walajabad S. Sampath¹

¹Colorado State University, Fort Collins, CO, United States, ²National Renewable Energy Laboratory, Golden, CO, United States

3:45 Band Gap Changes of the CdS Buffer Induced by Post-Annealing of Cu₂ZnSn(S,Se)₄ Solar Cells

Mario Lang¹, Nicolas Schäfer¹, Christian Huber¹, Thomas Schnabel², Heinz Kalt¹, Michael Hetterich^{1,3}

¹Institute of Applied Physics, Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Str. 1, 76131, Karlsruhe, Germany, ²Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), Industriestr. 6, 70565, Stuttgart, Germany, ³Light Technology Institute, KIT, Engesserstr. 13, 76131, Karlsruhe, Germany

Area 4 - Oral

4:30 - 6:00 PM

Marriott Ballroom Salon 2

Crystalline Silicon Solar Cells

Chair(s): Stefan Glunz, Mathieu Boccard

4:30 22.61% Efficient Fully Screen Printed PERC Solar Cell

Weiwei Deng, Feng Ye, Ruimin Liu, Yunpeng Li, Haiyan Chen, Zhen Xiong, Yang Yang, Yifeng Chen, Yongqian Wang, Pietro P. Altermatt, Zhiqiang Feng, Pierre J. Verlinden
State Key Laboratory of PV Science and Technology, Trina Solar, Changzhou, China

5:00 How to achieve 23% efficient large-area Cu plated n-PERT cells?

Monica Aleman¹, Angel Uruena^{1,2}, Emanuele Cornagliotti¹, Loic Tous¹, Wen-Cheng Sun¹, Richard

Russell¹, Filip Duerinckx¹, Jozef Szlufcik¹
¹Imec, Leuven, Belgium, ²now with Kaneka, Westerlo-Oevel, Belgium

5:15 **Best Student Presentation Award Finalist**

Rear side Cu precipitation and LID kinetics of mc-PERC solar cells

Tabea Luka^{1,2}, Marko Turek¹, Stephan Großer¹, Christian Hagendorf¹
¹Fraunhofer Center for Silicon-Photovoltaics CSP, Halle (Saale), Germany, ²Anhalt University of Applied Sciences, Köthen (Anhalt), Germany

5:30 **Thermodynamic Efficiency Limit of Bifacial Solar Cells for Various Spectral Albedos**

Thomas Russell, Rebecca Saive, Harry Atwater
California Institute of technology, Pasadena, CA, United States

5:45 **Process-Induced Degradation Resistant n-Cz Wafers through *Tabula Rasa* Defect Engineering**

Vincenzo LaSalvia¹, William Nemeth¹, Matthew Page¹, Wooseok Nam², Youngsik Han², Sungsun Baik², Amanda Youssef³, Tonio Buonassisi³, Paul Stradins¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Woongjin Energy Co. Ltd., Daejeon, South Korea, ³Massachusetts Institute of Technology, Cambridge, MA, United States

Area 6 - Oral

4:30 - 6:00 PM

Maryland B&C

Perovskite Stability

Chair(s): Yasuhiro SHIRAI, Chittibabu Kethinni

4:30 **Closing the Cell-To-Module Efficiency Gap: A Fully Laser Scribed Perovskite Mini-Module with 16% Steady-State Aperture Area Efficiency**

Arnaud Walter¹, Soo-Jin Moon¹, Brett Akira Kamino¹, Linus Löfgren¹, Davide Sacchetto¹, Jérémie Werner², Matthias Wolfgang Bräuninger², Florent Sahli², Fabio Matteocci³, Babak Taheri³, Björn Niesen^{1,2}, Julien Bailat¹, Aldo Di Carlo³, Christophe Ballif^{1,2}, Sylvain Nicolay¹
¹CSEM, Neuchâtel, Switzerland, ²EPFL, Neuchâtel, Switzerland, ³Centre for Hybrid and Organic Solar Energy (CHOSE), University of Rome "Tor Vergata", Rome, Italy

5:00 **Detector of A Shifting Bromine Concentration in Hybrid Perovskites By X-ray Fluorescence Microscopy**

Yanqi Luo¹, Parisa Khoram², Sarah Brittman², Barry Lai³, Erik Garnett², David Fenning¹
¹University of California San Diego, La Jolla, CA, United States, ²FOM institute AMOLF, Amsterdam, Netherlands, ³Argonne National Laboratory, Argonne, IL, United States

5:15 **Influence of Grain Size and Interfaces on Photo-Stability of Perovskite Solar Cells**

Vikram Dalal, Istiaque Hossain, Liang Zhang, Ranjith Kottokkaran, Mohamed El-Henaway, Max Noack
Iowa State University, Ames, IA, United States

5:30 **Cold Thoughts on Perovskite Fever**

Tao Xu
Department of Chemistry and Biochemistry, Northern Illinois University, DeKalb, IL, United States

5:45 **LBIC Analysis of Perovskite Based Solar Cells Stability**

Carmen M. Ruiz¹, Javier Ramos², Richard Garuz¹, Damien Barakel¹, Jean Rousset³, Judikaël LE Rouzo¹
¹Aix Marseille Université, CNRS, IM2NP, Marseille, France, ²Institut Photovoltaïque d'Ile de

France , Antony, France, ³Institute of Research and Development on Photovoltaic Energy , Chatou, France

Area 12 - Oral

4:30 - 6:00 PM

Virginia A

PV Industry Sustainability Issues

Chair(s): Annick Anctil , Michael Woodhouse

4:30 Global Policy on PV End of Life Care

Sinha Parikhit

First Solar, Tempe, AZ, United States

5:00 Assessing Job Creation Rates in the US PV Industry

Brion Bob

SunShot Initiative, Department of Energy, Washington, DC, United States

5:15 Ensuring the Reliability of Photovoltaic Power Systems Using International Standards and the IECRE Conformity Assessment System

George Kelly¹, Adrian Häring², Edward Spooner³, Greg Ball⁴, Sarah Kurtz⁵, Matthias Heinze⁶, Masaaki Yamamichi⁷, Govind Ramu⁸

¹Sunset Technology, Mount Airy, MD, United States, ²SolarEdge, Niestetal, Germany, ³UNSW, Sydney, Australia, ⁴SolarCity, San Rafael, CA, United States, ⁵NREL, Golden, CO, United States, ⁶TUV Rheinland, Pleasanton, CA, United States, ⁷AIST, Tsukuba, Japan, ⁸SunPower, San Jose, CA, United States

5:30 A Framework to Calculate Uncertainties for Lifetime Energy Yield Predictions of PV Systems

Björn Müller¹, Peter Bostock², Boris Farnung¹, Christian Reise¹

¹Fraunhofer ISE, Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany, ²VDE Americas, San José, CA, United States

5:45 Integrated PV-Recycling - More Efficient, More Effective

Wolfram Palitzsch, Ulrich Loser

Loser Chemie GmbH, Zwickau, Germany

Joint Area Session - Oral

4:30 - 6:00 PM

Delaware A

Low Cost III-V PV

Chair(s): Chris Bailey, Roberta Campesato

4:30 GaInP Solar Cells Grown by Hydride Vapor Phase Epitaxy

Kevin L Schulte¹, John Simon¹, John Mangum², Corinne E Packard², Brian Gorman², Nikhil Jain¹, Aaron J Ptak¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Department of Metallurgical and Materials Engineering, Colorado School of Mines, Golden, CO, United States

4:45 Extremely high-speed GaAs growth by MOVPE for low-cost PV application

Hassanet Sodabanlu¹, Kentaroh Watanabe¹, Akinori Ubukata², Takeyoshi Sugaya³, Masakazu Sugiyama⁴, Yoshiaki Nakano⁴

¹Research Center for Advanced Science and Technology, Tokyo, Japan, ²Compound

Semiconductor Division, Taiyo Nippon Sanso, Ibaraki, Japan, ³National Institute of Advanced Industrial Science and Technology, Ibaraki, Japan, ⁴School of Engineering, the University of Tokyo, Tokyo, Japan

5:00 **Tunnel Junction Development Using Hydride Vapor Phase Epitaxy**

Aaron J. Ptak, John Simon, Kevin L. Schulte, Nikhil Jain
National Renewable Energy Laboratory, Golden, CO, United States

5:15 **Best Student Presentation Award Finalist**

Multilayer-Grown Ultrathin Nanostructured GaAs Solar Cells

Boju Gai¹, Yukun Sun³, Minjoo Lee³, Jongseung Yoon^{1,2}

¹Department of Chemical Engineering and Materials Science, Los Angeles, CA, United States,

²Department of Electrical Engineering, Los Angeles, CA, United States, ³Department of Electrical and Computer Engineering, Urbana, IL, United States

5:30 **Best Student Presentation Award Finalist**

Virtual Substrates for Low-Cost High Efficiency III-V Photovoltaics

Sean J. Babcock¹, Marlene L. Lichty¹, Shankar Karki¹, Grace Rajan¹, Sylvain Marsillac¹, Seth M. Hubbard², Christopher G. Bailey¹

¹Old Dominion University, Norfolk, VA, United States, ²Rochester Institute of Technology, Rochester, NY, United States

5:45 **III-V Solar Cells Grown on Reusable Spalled Ge Substrate**

Nikhil Jain¹, Dustin Crouse², John Simon¹, Steve Johnston¹, Sebastian Siol¹, Kevin Schulte¹, Corinne Packard², David L. Young¹, Aaron J. Ptak¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States

Joint Area Session - Oral

4:30 - 6:00 PM

Delaware B

Soiling

Chair(s): Alan Lyons, Ben Figgis, Jim John

4:30 **Best Student Presentation Award Finalist**

Anti-reflective and anti-soiling properties of KleanBoost(TM) a superhydrophobic nano-textured coating for solar glass

Ilyia Nayshevsky^{1,2}, QianFeng Xu^{1,3}, Gil Barahman¹, Alan M. Lyons^{1,2,3}

¹College of Staten Island, Staten Island, NY, United States, ²Graduate Center of the City University of New York, New York, NY, United States, ³ARL Designs LLC, New York, NY, United States

4:45 **Best Student Presentation Award Finalist**

Comparing Indoor and Outdoor Soiling Experiments for Different Glass Coatings and Microstructural Analysis of Particle Caking Processes

Klemens K. Ilse^{1,2,3}, Jorge Rabanal^{4,5}, Lukas Schönleber¹, Muhammad Z. Khan¹, Volker Naumann¹, Christian Hagendorf¹, Jörg Bagdahn²

¹Fraunhofer Center for Silicon-Photovoltaics CSP, Halle, Germany, ²Anhalt University of Applied Sciences, Köthen, Germany, ³Department of Physics, Martin Luther University Halle-Wittenberg, Halle, Germany, ⁴International Solar Energy Research Center - ISC Konstanz, Konstanz, Germany, ⁵Centro de Desarrollo Energético Antofagasta, Universidad de Antofagasta, Antofagasta, Chile

5:00 **Investigation of Adhesion Forces Between Dust Particles and Solar Glass**

Helio R. Moutinho, Chun-Sheng Jiang, Bobby To, Craig Perkins, Matt Muller, Mowafak M. Al-

Jassim, Lin Simpson
National Renewable Energy Laboratory, Golden, CO, United States

5:15 Laboratory studies of particle cementation and PV module soiling

Craig L. Perkins, Matthew Muller, Lin Simpson
NREL, Golden, CO, United States

5:30 Seasonal trends of soiling on PV systems

Leonardo Micheli^{1,2}, Matthew Muller¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Department of Chemistry, Colorado School of Mines, Golden, CO, United States

5:45 Interrelationships Among Non-Uniform Soiling Distributions and PV Module Performance Parameters, Climate Conditions, and Soiling Particle and Module Surface Properties

Lawrence L. Kazmerski^{1,2}, Antonia Sonia A.C. Diniz², Cristiana Brasil Maia², Marcelo M. Viana³, Daniel S. Costa², Suellen C. Costa², Pedro P. Brito², Claudio D. Campos², Sergio Harriot², Leila R. Cruz⁴
¹University of Colorado Boulder, Boulder, CO, United States, ²Pontificia Universidade Católica de Minas Gerais (PUCMinas), Belo Horizonte, Brazil, ³Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, Brazil, ⁴Instituto Militar de Engenharia (IME), Rio de Janeiro, Brazil

Social Activity

8:00 - 10:00 PM

Marriott Ballroom Salon 3

Late Night Open Mic Competition

Thursday, June 29, 2017

Registration

8:00 - 8:30 AM

Convention Registration Desk

Registration Opens

Area 3 - Plenary

8:30 - 9:00 AM

Marriott Ballroom

Plenary

Chair(s): Tyler Grassman, Frank Dimroth, Kenji Araki

8:30 Beyond Fresnel Lenses: Low-Profile, Solid CPV Modules Using Total Internal Reflection

Stefan H. Myrskog, John Paul Morgan, Brett Barnes, Stephen Caelers, Philip M. Chang, Joel K. Slonetsky
Morgan Solar Inc., Toronto, ON, Canada

Area 10 - Plenary

9:00 - 9:30 AM

Marriott Ballroom

Plenary

Chair(s): Barry Mather, Olivier Stalter

9:00 The Role of Power Electronics in Mitigating Intermittent Renewables

Thomas O. Bialek

San Diego Gas & Electric Co., San Diego, CA, United States

Area 9 - Plenary		
9:30 - 10:00 AM		Marriott Ballroom
	Plenary	

Chair(s): Kent Whitfield, Sarah Kurtz

9:30 PV Module Durability - connecting field results, accelerated testing, and materials.

T. John Trout¹, William J. Gambogi¹, Thomas C. Felder¹, Yushi Heta², Lucie Garreau-Iles³,
Katherine M. Stika¹

¹*DuPont Photovoltaic Solutions, Wilmington, DE, United States*, ²*DuPont KK, Utsonomiya-shi, Japan*, ³*Du Pont de Nemours International S.A., Geneva, Switzerland*

Break		
10:00 - 10:30 AM		Exhibit Hall A
	Coffee Break	

Area 1 - Poster		
10:30 - 12:00 PM		Exhibit Hall D
	Novel Material and Processing	

Chair(s): Ching-Fuf Lin, Phil Ahrenkiel, Monika Rathi

G16 Molybdenum oxide thin films for heterojunction solar cells

Ariel Domínguez¹, Ateet Dutt¹, Osvaldo De Melo², Guillermo Santana¹

¹*Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México. A.P. 70-360, Coyoacán, C.P. 04510, México, D.F, Mexico*, ²*Departamento de Física, Universidad de la Habana 27 y J. Plaza de la Revolución. , La Habana, Cuba*

G2 Growth of MoS₂ Thin Films With Microdome Texture As Omnidirectional Light Trap For Solar Cell Applications

Hussain Abouelkhair¹, Nina Orlovskaya², Robert Peale¹

¹*Department of Physics, University of Central Florida, Orlando, FL, United States*, ²*Department of Mechanical & Aerospace Engineering, University of Central Florida, Orlando, FL, United States*

G4 Study of spatial distribution of electrical, optical and structural properties of magnetron sputtered AZO thin films

Mohit Agarwal¹, Rajiv O Dusane²

¹*Department of Electronics and Communication Engineering, Patila, India*, ²*Indian Institute of technology Bombay, Mumbai, India*

G6 Multiband Formation in Cr doped CuGaS₂ Thin Films Synthesized by Chemical Spray Pyrolysis

Nazmul Ahsan¹, Sivaperuman Kalainathan², Naoya Miyashita¹, Takuya Hoshii³, Yoshitaka Okada¹
¹The University of Tokyo, Tokyo, Japan, ²VIT University, Vellore, India, ³Tokyo Institute of Technology, Tokyo, Japan

G8 Effects of Annealing and Substrate Temperature for Sn-S Thin Films

Yoji Akaki¹, Kazuya Iwasaki¹, Hideaki Araki², Shigeyuki Nakamura³
¹National Institute of Technology, Miyakonojo College, Miyazaki, Japan, ²National Institute of Technology, Nagaoka College, Niigata, Japan, ³National Institute of Technology, Tsuyama College, Okayama, Japan

G10 A new solar cell without a pn Junction but a layer of CdS attached that extracts all holes created by sunlight.

Karl W. Boer
University of Delaware, Newark, DE, United States

G12 Application of the Luminescent Solar Concentrator in the Built Environment: the Roadside Noise Barrier

Michael G Debije¹, Michallis Kanellis¹, Lenneke Slooff², Minne De Jong³
¹Eindhoven University of Technology, Eindhoven, Netherlands, ²ECN, Petten, Netherlands, ³SEAC, Eindhoven, Netherlands

G14 Boron-doped p-BaSi₂/n-Si Solar Cells Formed On Textured n-Si(001) With A Pyramid Structure Consisting of (111) Facets

tianguo deng¹, ryota takabe¹, zhihao xu¹, suguru yachi¹, yudai yamashita¹, kaoru toko¹, kazuhiko gotoh², noritaka usami², takashi suemasu¹
¹Institute of Applied physics, University of Tsukuba, Tsukuba, Japan, ²Graduate school of engineering, Nagoya University, Nagoya, Japan

G18 Dual ion beam sputtered TCO thin films: Sputter-instigated plasmonic features for ultrathin photovoltaics

Vivek Garg¹, Brajendra S. Sengar¹, Vishnu Awasthi¹, Shailendra Kumar², Shaibal Mukherjee¹
¹Hybrid Nanodevice Research Group (HNRG), Electrical Engineering, Indian Institute of Technology (IIT) Indore, Indore, India, ²Raja Ramanna Center for Advanced Technology, Indore, India

G20 Combinatorial study of Sn-Ti-W-O transparent conducting oxide thin films for photovoltaic applications

Michael N Gona, Patrick J M Isherwood, Jake W Bowers, John M Walls
1, Loughborough, United Kingdom

G22 Bandgap and Electron Affinity Optimization of Zinc Oxide for n-ZnO/p-Si Single Heterojunction Solar Cell

Babar Hussain^{1,2}
¹University of North Carolina at Charlotte, Charlotte, NC, United States, ²National Institute of Lasers and Optronics, Islamabad, Pakistan

G24 Modeling and Optimizing the Efficiency of a ZnO/ZnTe Solar Cell Using SCAPS Software

Amal A. Kaban, Sam Roy
Bucknell University, Lewisburg, PA, United States

G25 Ternary phosphide semiconductor in Mg/Zn₃P₂ solar cells

Ryoji Katsube, Kenji Kazumi, Yoshitaro Nose
Kyoto University, Kyoto, Japan

- G27 Numerical modeling of WSe₂ solar cells**
Hrachya Kyureghian, Matthew Hilfiker, Aaron Ediger, Vojislav Medic, Natale Ianno
Univ of Nebraska, Lincoln, NE, United States
- G29 Biaxial-textured Titanium Nitride thin films on low cost, flexible metal substrate as a conductive buffer layer for thin film solar cells**
Yongkuan Li, Yao Yao, Ying Gao, Sicong Sun, Pavel Dutta, Monika Rathi, Jae-Hyun Ryou, Venkat Selvamani
Department of Mechanical Engineering, Advanced Manufacturing Institute & Texas Center for Superconductivity, University of Houston, Houston, TX, United States
- G31 SnS by Ionized Jet Deposition for photovoltaic applications**
Daniele Menossi¹, Simone Di Mare¹, Ivan Rimmaudo⁴, Elisa Artegiani¹, Giampiero Tedeschi², Juan L. Pena⁴, Fabio Piccinelli³, Alessandro Romeo¹
¹*Department of Computer Science, University of Verona, Verona, Italy*, ²*Noivion S.r.l., Rovereto (TN), Italy*, ³*Department of Biotechnology, University of Verona, Verona, Italy*, ⁴*Cinvestav, Merida, Mexico*
- H1 Effect of valence band splitting on the absorption spectra of monolayer MoS₂ in presence of sulphur vacancies**
Himani Mishra, Sitangshu Bhattacharya
- H3 Influence of hetero-interfaces on photovoltaic performance in solar cells based on ZnSnP₂ bulk crystal**
Shigeru Nakatsuka¹, Shunsuke Akari², Jakapan Chantana², Takashi Minemoto², Yoshitaro Nose¹
¹*Kyoto University, Kyoto, Japan*, ²*Ritsumeikan University, Shiga, Japan*
- H5 The Study of Some Materials as Buffer Layer in Copper Antimony Sulphide (CuSbS₂) Solar Cell Using SCAPS 1-D**
Muteeu A. Olopade, Adeyinka D. Adewoyin, Michael A. Chendo, Bolaji Adewumi
- H7 Junction by Diffusion of Elemental Sodium Alone into Bridgman Cu(In,Ga)Se₂**
Sunyoung Park¹, C.H. Champness¹, Ishiang Shih¹, Srinivas Vanka¹, Zetian Mi^{1,2}
¹*Electrical and Computer Engineering Department, McGill University, Montreal, QC, Canada*, ²*Department of Electrical Engineering and Computer Science, Centre for Photonics and Multiscale Nanomaterials, Ann Arbor, MI, United States*
- H9 Oxygen substitution and sulfur vacancies in NaBiS₂: a Pb-free candidate for solution processable solar cells**
Robert J Patterson, Hongze Xia, Long Hu, Bo Wang, Zhilong Zhang, Lin Yuan, Jianfeng Yang, Weijian Chen, Zihan Chen, Yijun Gao, Yicong Hu, Binesh P Veetil, John A Stride, Gavin Conibeer, Shujuan Huang
University of New South Wales, Sydney, Australia
- ePoster Double Heterojunction Silicon Solar Cell by NiO/Si and Si/TiO₂ Interfaces**
Zingway Pei^{1,2}, Yu-Tsu Lee¹, Wei-Hua Huang¹
¹*Department of Electrical Engineering and Graduate of Optoelectronic Engineering, National Chung Hsing University, Taichung, Taiwan*, ²*Research Center for Sustainable Energy and Nanotechnology, National Chung Hsing University, Taichung, Taiwan*
- H11 Synthesis and Characterization of Bismuth Ferrite/ Silver oxide for all oxide solar photovoltaics**
Tata Kondala Rao¹, Y.L.N. Murthy²
¹*professor, Sri Sivani College of Engineering, SRIKAKULAM, INDIA, India*, ²*professor, Department of Chemistry, Andhra University, Visakhapatnam, INDIA, India*

- H13 Deposition of Tungsten Disulfide (WS₂) Thin Films for Photovoltaic Application**
 Haroon Rashid¹, Khan Sobayel¹, Kazi S Rahman¹, Mohammad I Hossain³, Fahhad H Alharbi^{3,4},
 Nouar Tabet^{3,4}, Nowshad Amin^{1,2}
¹Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering and Built Environment, The National University of Malaysia, Bangi, Malaysia, ²Solar Energy Research Institute, The National University of Malaysia, Bangi, Malaysia, ³Qatar Environment and Energy Research Institute, Hamad Bin Khalifa University, Doha, Qatar, ⁴College of Science and Engineering, Hamad Bin Khalifa University, Doha, Qatar
- H15 Effect of Annealing on Performance of Solar Cell with New Oxide Absorber Mn₂V₂O₇**
 Pramod Ravindra¹, Eashwer Athresh², Rajeev Ranjan³, Srinivasan Raghavan¹, Sushobhan Avasthi¹
¹Centre for Nanoscience and Engineering, Indian Institute of Science, Bangalore, India, ²Interdisciplinary Centre for Energy Research, Indian Institute of Science, Bangalore, India, ³Department of Materials Engineering, Indian Institute of Science, Bangalore, India
- H17 Electro-optical Properties of Zn₂Mo₃O₈ Thin-Films: A Novel Low-Bandgap Solar Absorber**
 Pramod Ravindra¹, Eashwer Athresh², Rajeev Ranjan³, Srinivasan Raghavan¹, Sushobhan Avasthi¹
¹Centre for Nanoscience and Engineering, Indian Institute of Science, Bangalore, India, ²Interdisciplinary Centre for Energy Research, Indian Institute of Science, Bangalore, India, ³Department of Materials Engineering, Indian Institute of Science, Bangalore, India
- H19 Functionalized Two-Dimensional Nanomaterials for Solar Cell Applications: Structure, Stability and Characterization**
 Anatoli I. Shkrebtii¹, Bernardo S Mendoza², Michael Rohlfing³
¹University of Ontario Institute of Technology, Oshawa, ON, Canada, ²Centro de Investigaciones en Óptica, León, Mexico, ³Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Münster, Germany
- H21 Low temperature solution process for random high aspect ratio silver nanowire as promising transparent conductive layer**
 Arastoo Teymouri, Supriya Pillai, Zi Ouyang, Xiaojing Hao, Martin Green
- H23 Oxygen Incorporation into Si Nanocrystal/SiC Multilayers**
 Charlotte Weiss, Stefan Janz
 Fraunhofer ISE, Freiburg, Germany
- ePoster Femtosecond vs Nanosecond: An Analysis on the Laser Ablation Properties of Dielectric Layers for Solar Cells**
 Jaffar Moideen Yacob Ali^{1,2}, Vinodh Shanmugam¹, Carlos David Rodríguez-Gallegos^{1,2}, Bianca Lim¹, Armin Aberle^{1,2}, Thomas Mueller¹
¹Solar Energy Research Institute of Singapore, Singapore, Singapore, ²Department of ECE, National University of Singapore, Singapore, Singapore
- H25 Design of Cascaded Heterostructured p-i-i-n CdS/CdSe Low Cost Solar Cell**
 Mukhammaddin Zinaddinov, Sam Mil'shtein
 ECE Dept. UMass, Lowell, MA, United States

Area 2 - Poster

10:30 - 12:00 PM

Exhibit Hall G

Progress in Characterization, Analysis, Theory, and Modeling

Chair(s): James Sites, Drew Swanson, Matevz Bokalic

- H28 Crystal Growth Phenomena in Polycrystalline (Cu)ZnTe/CdTe/CdS Via Molecular Dynamics**
Rodolfo Aguirre¹, Jose Juan Chavez², Xiaowang Zhou², David Zubia¹
¹University of Texas at El Paso, El Paso, TX, United States, ²Sandia National Laboratories, Livermore, CA, United States
- H30 Observation of Off-Stoichiometric Cu₂ZnSnS₄ Crystal Structures Using X-Ray Anomalous Scattering**
Christopher J. Bosson¹, Max T. Birch¹, Douglas P. Halliday¹, Chiu C. Tang², Peter D. Hatton¹
¹Department of Physics, The University of Durham, Durham, United Kingdom, ²Diamond Light Source, Harwell Science and Innovation Campus, Didcot, United Kingdom
- H32 Simulation of ZnMgO as the window layer for CdTe Solar Cells**
Yunfei Chen¹, Shou Peng², Xin Cao³, Alan E. Delahoy¹, Ken K. Chin¹
¹Department of Physics and CNBM New Energy Materials Research Center, New Jersey Institute of Technology, Newark, NJ, United States, ²China Triumph International Engineering Co., Ltd, Shanghai, China, ³Bengbu Design & Research Institute for Glass Industry, Bengbu, China
- H34 Modeling Effect of Defects on Efficiency of Nanowire CdS-CdTe Solar Cells**
Hongmei Dang¹, Esther Ososanya², Nian Zhang³, Xiaohui Wang⁴, Hojjatollah Sarvari⁵, Vijan Singh⁶
¹University of the District of Columbia, DC, DC, United States, ²University of the District of Columbia, DC, DC, United States, ³University of the District of Columbia, DC, DC, United States, ⁴University of Kentucky, Lexington, KY, United States, ⁵University of Kentucky, Lexington, KY, United States, ⁶University of Kentucky, Lexington, KY, United States
- H36 Analytical description of charged grain boundaries in polycrystalline thin film solar cells**
Benoit H Gaury^{1,2}, Paul M Haney¹
¹Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, MD, United States, ²Maryland NanoCenter, University of Maryland, College Park, MD, United States
- H37 Imaging the Effect of CdSe Window Layers in CdTe Photovoltaics**
John M. Howard^{1,2}, Elizabeth M. Tennyson^{1,2}, William B. Gunnarsson^{1,3}, Nauba R. Paudel^{4,5}, Yanfa Yan^{4,5}, Marina S. Leite^{1,2}
¹Department of Materials Science and Engineering, University of Maryland, College Park, MD, United States, ²Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, MD, United States, ³Department of Electrical and Computer Engineering, University of Maryland, College Park, MD, United States, ⁴Department of Physics and Astronomy, University of Toledo, Toledo, OH, United States, ⁵Wright Center for Photovoltaics Innovation and Commercialization, University of Toledo, Toledo, OH, United States
- H39 Investigation of traps density and position in alkali treated Cu(In,Ga)Se₂ thin films and solar cells**
Shankar Karki¹, Pran K. Paul², Grace Rajan¹, Chinedum Akwari¹, Angus Rockett³, Steven A. Ringel², Aaron R. Arehart², Sylvain Marsillac¹
¹Virginia Institute of Photovoltaics, Old Dominion University, Norfolk, VA, United States, ²Dept. of Electrical & Computer Engineering, The Ohio State University, Columbus, OH, United States, ³Dept. of Metallurgical and Materials Engineering, Colorado School of Mines, Golden, CO, United States
- H41 The Effect of Deposition Stoichiometry and Post-deposition Treatments on Deep Defects in CdTe**
Imran S. Khan, Vamsi Evani, Shamara Collins, Chih A. Hsu, Vasilis Palekis, Chris Ferekides
University of South Florida, Tampa, FL, United States
- H43 Testing the limits of mechanically-scribed CIGS microcells**
Ombline Lafont¹, Nicolas Vandamme¹, Leia Ruffini¹, Jia Yu¹, Philip Jackson², Jose Alvarez³, Daniel

Lincot^{1,4}

¹Institut de Recherche et Développement sur l'Energie Photovoltaïque, IRDEP - CNRS /EDF/Chimie ParisTech, 6 quai Watier, 78401, Chatou, France, ²Zentrum für Sonnenenergie - und Wasserstoff - Forschung Baden - Württemberg (ZSW), Industriestr. 6, D - 70565, Stuttgart, Germany, ³Laboratoire de Génie électrique et électronique de Paris, GeePs, UMR CNRS 8507, Centrale-Supélec, Univ. Paris-Sud, Université Paris-Saclay, Sorbonne Universités, UPMC Univ. Paris 06, 11 rue Joliot-Curie, Plateau de Moulon, 91192, Gif-sur-Yvette, France, ⁴Institut Photovoltaïque d'Ile-de-France, IPVF, 8 rue de la Renaissance, 92160, Antony, France

H45 Application of New Simulation Software to the Modelling of Cu₂ZnSnS₄ Solar Cells

Xiaolei Liu¹, Hongtao Cui², Fangyang Liu², Xiaojing Hao², Shujuan Huang², Gavin Conibeer²

¹University College London, London, United Kingdom, ²University of New South Wales, Sydney, Australia

ePoster Fast C-V method to mitigate effects of deep levels in CIGS doping profiles

Pran K. Paul¹, Jeff Bailey², Geordie Zapalac², Steven A. Ringel^{1,3}, Aaron R. Arehart¹

¹Electrical and Computer Engineering, The Ohio State University, Columbus, OH, United States,

²MiaSolé Hi-Tech Corp., Santa Clara, CA, United States, ³Institute for Materials Research, The Ohio State University, Columbus, OH, United States

H47 PL imaging analysis of doping in thin film CdS and CdS/CdTe devices

Christos Potamialis¹, Fabiana Lisco¹, Biancamaria Maniscalco¹, Mustafa Togay¹, Ali Abbas¹, Jake W. Bowers¹, John M. Walls¹, Ivan Rimmaudo², Ricardo Mis- Fernández², Victor Rejon², Juan L. Peña²

¹CREST, Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, United Kingdom, ²Cinvestav, Unidad Merida, Merida, Mexico

H49 Application of Mapping Spectroscopic Ellipsometry for CdSe/CdTe and CdS/CdSe/CdTe Solar Cells: Optimization of Low-Temperature Processed Devices with All-Sputtered Semiconductors

Mohammed A. Razooqi, Adam B. Phillips, Geethika K. Liyanage, Fadhil K. Al-Fadhili, Maxwell M. Junda, Nikolas J. Podraza, Michael J. Heben, Robert W. Collins, Prakash Koirala
Wright Center for Photovoltaics Innovation & Commercialization and Department of Physics & Astronomy, University of Toledo, Toledo, OH, United States

H51 Assessing the Validity and Accuracy of 1D Device Simulation Models for Polycrystalline Solar Cells

Yubo Sun¹, Allison Perna¹, Benoit H. Gaury², Sudhajit Misra³, Michael A. Scarpulla³, Paul M. Haney², Peter Bermel¹

¹Purdue University, West Lafayette, IN, United States, ²National Institute of Standards and Technology, Gaithersburg, MD, United States, ³University of Utah, Salt Lake City, UT, United States

I1 Characterizing recombination in CdTe-based solar cells by the temperature and excitation dependence of open-circuit voltage and photoluminescence

Craig H. Swartz^{1,2}, Sanjoy Paul¹, Corey R. Grice³, Yanfa Yan³, Lorelle Mansfield⁴, Sachit Grover⁵, Gang Xiong⁵, Jian V. Li^{1,2}

¹Department of Physics, Texas State University, San Marcos, TX, United States, ²Materials Science, Engineering, and Commercialization Program, Texas State University, San Marcos, TX, United States, ³Department of Physics, University of Toledo, Toledo, OH, United States, ⁴National Renewable Energy Laboratory, Golden, CO, United States, ⁵First Solar, Inc., Santa Clara, CA, United States

I3 Experimental Evidence For CdS-related Transport Barrier in Thin Film Solar Cells and Its Impact on Admittance Spectroscopy

Florian Werner, Anastasiya Zelenina, Susanne Siebentritt
University of Luxembourg, Belvaux, Luxembourg

Area 3 - Poster

10:30 - 12:00 PM

Exhibit Hall E

Hybrid Tandems

Chair(s): Larry Lee, Michael McGegee, Ignacio Rey-Stolle

- 15 **Design Arithmetic of the Lateral III-V / Si Hybrid Module**
Kenji Araki¹, Kyotaro nakamura², Yu-Cian Wang¹, Nobuaki Kojima¹, Atsushi Ogura², Yoshio Ohshita¹, Masafumi Yamaguchi¹
¹Toyota Technological Institute, Nagoya, Japan, ²Meiji University, Kawasaki, Japan
- 17 **Wide Band Gap Cu(In,Ga)S₂ Absorber for Application in Tandem Solar Cells with Si**
Matteo Balestrieri^{1,2}, Karima Bouras^{1,2}, Corentin Berthier^{1,2,3}, Jorge Posada^{1,2}, Romain Bodeux^{1,2,3}
¹IPVF, Antony, France, ²IRDEP, Chatou, France, ³EDF, Chatou, France
- 19 **GaAsP Nanowire Solar Cell Development Towards Nanowire/Si Tandem Applications**
Enrique Barrigon, Yang Chen, Gaute Otnes, Vilgaile Dageyte, Nicklas Anttu, Lars Samuelson, Magnus Borgström
Division of Solid State Physics and NanoLund, Lund University, Lund, Sweden
- 111 **GaInP₂/Si Voltage Matched Tandem Solar Cells**
David C. Bobela¹, Kirstin Alberi¹, Kenneth J. Schmieder², Leo Matthew³, Rajesh Rao³, Matthew P. Lumb^{2,4}, James E. Moore^{2,4}, Eric A. Armour⁵, Robert J Walters²
¹National Renewable Energy Laboratory, Golden, CO, United States, ²U.S. Naval Research Laboratory, Washington D.C., DC, United States, ³Applied Novel Devices, Austin, TX, United States, ⁴George Washington University, Washington D.C., DC, United States, ⁵Veeco MOCVD, Somerset, NJ, United States
- 113 **Wafer Bonded III-V on Silicon Multi-Junction Cell with Efficiency beyond 31%**
Romain Cariou¹, Jan Benick¹, Paul Beutel¹, Nico Tucher¹, Martin Graf¹, David Lackner¹, Martin Hermle¹, Andreas W. Bett¹, Stefan W. Glunz^{1,2}, Frank Dimroth¹
¹Fraunhofer Institute for Solar Energy Systems, Heidenhofstraße 2, 79110 Freiburg, Germany, ²Laboratory for Photovoltaic Energy Conversion, University of Freiburg, 79110 Freiburg, Germany
- 115 **3-Terminal Monolithically Integrated Silicon Tandems**
Maxwell Cotton, Aymeric Maros, Yongjie Zou, Chaomin Zhang, Stuart Bowden, Richard King, Stephen Goodnick, Christiana Honsberg
Arizona State University, Temoe, AZ, United States
- 117 **Design and Performance Modeling of Hybrid Diffuse + CPV Technology**
Brent R. Fisher¹, Matthew P. Lumb^{2,3}, Kenneth J. Schmieder³, Michael Dooraghi⁴
¹Semprius, Durham, NC, United States, ²George Washington University, Washington, D.C., DC, United States, ³Naval Research Laboratory, Washington, D.C., DC, United States, ⁴National Renewable Energy Laboratory, Golden, CO, United States
- 119 **Development of In_{0.18}Ga_{0.82}As metamorphic grade structures for low-cost III-V photovoltaics**
Alessandro Giussani¹, Michael A. Slocum¹, Seth M. Hubbard¹, Nathan Smaglik², Nikhil Pokharel², S. Phillip Ahrenkiel²
¹Rochester Institute of Technology, Rochester, NY, United States, ²South Dakota School of Mines and Technology, Rapid City, SD, United States

I21 Temperature Dependent Characteristics of GaInP/GaAs/GaInNAsSb Solar Cell Under Simulated AM0 Spectra

Riku Isoaho, Arto Aho, Antti Tukiainen, Mircea Guina

Optoelectronics Research Centre, Tampere University of Technology, Tampere, Finland

I23 Efficiency of GaAsP/Si Two-junction Solar Cells with Multi-Quantum Wells: a Realistic Modeling with Carrier Collection Efficiency

Boram Kim¹, Kasidit Toprasertpong¹, Oliver Supplie², Agnieszka Paszuk², Thomas Hannappel², Yoshiaki Nakano¹, Masakazu Sugiyama¹

¹*the University of Tokyo, Tokyo, Japan*, ²*Technical University Ilmenau, Ilmenau, Germany*

ePoster Transparent Conductive Adhesives for Tandem Solar Cells

Talysa R Klein, Benjamin G Lee, Manuel Schnabel, Emily L Warren, Pauls Stradins, Adele C Tamboli, Maikel F A M van Hest

National Renewable Energy Laboratory, Golden, CO, United States

I25 Inverse Metamorphic III-V/epi-SiGe Tandem Solar Cell Performance Assessed by Optical and Electrical Modeling

Raphaël Lachaume^{1,5}, Martin Foldyna², Gwénaëlle Hamon^{2,3}, Nicolas Vaissière², Jean Decobert⁴, Romain Cariou^{2,4}, Pere Roca i Cabarrocas², José Alvarez¹, Jean-Paul Kleider¹

¹*GeePs CNRS UMR 8507 CentraleSupélec Univ Paris-Sud Sorbonne Universités-UPMC Univ Paris 06, Gif-Sur-Yvette, France*, ²*LPICM, CNRS, Ecole Polytechnique, Université Paris-Saclay, Palaiseau, France*, ³*TOTAL New Energies, Paris La Défense, France*, ⁴*III-V Lab, Palaiseau, France*, ⁵*Institut Photovoltaïque d'Île-de-France (IPVF), Antony, France*

I27 Towards Monolithically Integrated GaAs on Si Tandem Solar Cell

Zhe Liu¹, Zekun Ren², Haohui Liu¹, Tonio Buonassisi^{2,3}, Ian Marius Peters^{2,3}

¹*Solar Energy Research Institute of Singapore, SINGAPORE, Singapore*, ²*Singapore MIT Alliance for Research and Technology, SINGAPORE, Singapore*, ³*Massachusetts Institute of Technology, SINGAPORE, Singapore*

I29 ZnSiP₂ Thin Film Growth for Si-Based Tandem Photovoltaics

Aaron D. Martinez^{1,2}, Elisa M. Miller², Andrew G. Norman², Paul Stradins^{1,2}, Eric S. Toberer^{1,2}, Adele C. Tamboli^{1,2}

¹*Colorado School of Mines, Golden, CO, United States*, ²*National Renewable Energy Laboratory, Golden, CO, United States*

I31 *In situ* control over the sublattice orientation of heteroepitaxially grown single-domain GaP/Si:As virtual substrates for tandem absorbers

Agnieszka Paszuk¹, Oliver Supplie¹, Sebastian Brückner², Matthias M. May³, Anja Dobrich¹, Andreas Nägelein¹, Boram Kim⁴, Yoshiaki Nakano⁴, Masakazu Sugiyama⁴, Peter Kleinschmidt¹, Thomas Hannappel¹

¹*Institute of Physics, Department for Photovoltaics, Ilmenau University of Technology, Ilmenau, Germany*, ²*Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg, Germany*, ³*Chemistry Department, University of Cambridge, England, United Kingdom*, ⁴*School of Engineering, the University of Tokyo, Bunkyo-ku, Tokyo, Japan*

I33 III-V/Si Tandem Modules – Comparison Between Current And Voltage Matched Interconnection

Henning Schulte-Huxel, Emily L. Warren, Manuel Schnabel, Paul Stradins, Daniel Friedman, Adele C. Tamboli

National Renewable Energy Laboratory, Golden, CO, United States

I35 InGaP/GaAs/ITO/Si Hybrid Triple-Junction Cells with GaAs/ITO Bonding Interfaces

Naoteru Shigekawa¹, Tomoya Hara¹, Tomoki Ogawa¹, Jianbo Liang¹, Takafumi Kamioka², Kenji

Araki², Masafumi Yamaguchi²

¹Osaka City University, Osaka, Japan, ²Toyota Technological Institute, Nagoya, Japan

I37 Measurements of Potentials at Tap Contacts and Estimation of Resistance across Bonding Interfaces in InGaP/GaAs/Si Hybrid Triple-Junction Cells

Naoteru Shigekawa, Jianbo Liang
Osaka City Univ., Osaka, Japan

I39 Development of an Optimized GaAsP Cell for Implementation in a III-V/Si Tandem Structure

Amber C. Silvaggio, Daniel J. Chmielewski, Jacob T. Boyer, Daniel L. Lepkowski, Steven A. Ringel, Tyler J. Grassman
The Ohio State University, Columbus, OH, United States

I41 Theoretical Design of Perovskite/CdTe Four-terminal Tandem Solar Cells

Tao Tang¹, Huan Zhang¹, Xingzhi Du¹, Yiming Liu², Hang Zhou¹
¹Peking University Shenzhen Graduate School, Shenzhen, China, ²University of Southern Denmark, Shenzhen, China

ePoster Wafer bonding approaches for III-V on Si multi-junction solar cells

Laura Vauche^{1,2}, Elias Veinberg Vidal^{1,2}, Clément Weick^{1,2}, Christophe Morales^{1,2}, Vincent Larrey^{1,2}, Christophe Lecouvey^{1,2}, Mickaël Martin^{1,2}, Jérémy Da Fonseca^{1,2}, Christophe Jany^{1,2}, Thibaut Desrues^{1,3}, Céline Brughera^{1,2}, Philippe Voarino^{1,2}, Thierry Salvétat^{1,2}, Frank Fournel^{1,2}, Mathieu Baudrit^{1,2}, Cécilia Dupré^{1,2}
¹Univ. Grenoble Alpes, Grenoble, France, ²CEA, LETI, Grenoble, France, ³CEA, LITEN, INES, Grenoble, France

I43 Wafer-Bonded AlGaAs/Si Dual-Junction Solar Cells

Elias Veinberg-Vidal^{1,2}, Laura Vauche^{1,2}, Clément Weick^{1,3}, Jérémy Da Fonseca^{1,2}, Christophe Jany^{1,2}, Christophe Morales^{1,2}, Christophe Lecouvey^{1,2}, Thibaut Desrues^{1,3}, Philippe Voarino^{1,3}, Frank Fournel^{1,2}, Anne Kaminski-Cachopo¹, Alejandro Datas⁴, Pablo Garcia-Linares⁴, Mathieu Baudrit^{1,3}, Pierre Mur^{1,2}, Cécilia Dupré^{1,2}
¹Université Grenoble Alpes, Grenoble, France, ²CEA, LETI, MINATEC Campus, Grenoble, France, ³CEA, LITEN, INES, Le Bourget du lac, France, ⁴IES-UPM, Madrid, Spain

I45 Enhancement of Si Photovoltaic Module by Introducing III-V/Si Hybrid Configurations and Cost Evaluations under Various Cost Ratios of III-V/Si Photovoltaics

Yu-Cian Wang¹, Kenji Araki¹, Kyotaro Nakamura², Kan-Hua Lee¹, Takefumi Kamioka¹, Nobuaki Kojima¹, Yoshio Ohshita¹, Masafumi Yamaguchi¹
¹Toyota Technological Institute, Nagoya, Japan, ²Meiji University, Kawasaki, Japan

ePoster Modeling Three Terminal III/V-Si Tandem Solar Cells

Emily L. Warren, Michael G. Deceglie, Pauls Stradins, Adele C. Tamboli
National Renewable Energy Laboratory, Golden, CO, United States

I47 Numerical Simulation and loss analysis of PERL Silicon cell for III-V/Si Tandem Devices

Chuqi Yi, Fajun Ma, Anita Ho-Baillie, Stephen P Bremner
UNSW, Sydney, Australia

I49 Epitaxial GaP Layers Grown on Si Substrates using Migration Enhanced and Molecular Beam Epitaxy

Chaomin Zhang¹, Allison Boley², Nikolai N Faleev¹, David J. Smith², Christiana B. Honsberg¹
¹Arizona State University, Ira Fulton School, Solar Power Lab, Tempe, AZ, United States, ²Arizona State University, Physics Department, Tempe, AZ, United States

Area 4 - Poster

10:30 - 12:00 PM

Exhibit Hall B

Silicon Material, Wafer Technology and Thin-Film Silicon

Chair(s): Arno Smets, Nikolas Podraza, Pierre Verlinden

J17 Characterization of Microcrystalline Silicon Thin Film Solar Cells Prepared by High Working Pressure Plasma-enhanced Chemical Vapor Deposition

Jung-Dae Kwon¹, Dong-Ho Kim¹, Ji-Hoon Lee¹, Myungkwan Song¹, Myunghun Shin²

¹Korea Institute of Materials Science, Changwon, South Korea, ²Korea Aerospace University, Goyang, South Korea

I56 Characterization of defects on n-type Si after saw damage removal using spatially resolved photoluminescence

Pradeep Balaji, Andre Augusto, Stuart Bowden

Arizona State University, Tempe, AZ, United States

ePoster Investigation of Carrier-Induced Defect Behavior in p-type Multi-Crystalline Silicon

Catherine E Chan, Tsun H Fung, Alison M Ciesla, David N R Payne, Malcolm D Abbott, Daniel Chen, Ran chen, Brett J Hallam, Stuart R Wenham
University of New South Wales, Sydney, Australia

J2 Laser Hydrogenation on Heavily Dislocated Cast-Mono Silicon Cells

Alison M Ciesla, Catherine E Chan, Sisi Wang, Malcolm D Abbott, Stuart R Wenham
UNSW, Sydney, Australia

J5 Low temperature spalling of silicon: A crack propagation study

Pablo Guimera Coll¹, Tine Uberg Naerland¹, Nathan Stoddard², Mariana Bertoni¹

¹Arizona State University, Tempe, AZ, United States, ²Solar World, Hillsboro, OR, United States

J9 Study of PV module degradation rate prediction through correlation of field-aged and accelerated-aged module degradation data

Babak, T Hamzavy¹, William, J. Grieco¹, Brian, J. Fields¹, Cara S. Libby², William, B. Hobbs³, Olga Lavrova⁴, Jones, C. Birk⁴

¹Southern Research Institute, Birmingham, AL, United States, ²EPRI, Palo Alto, CA, United States, ³Southern Company Services, Inc., Birmingham, AL, United States, ⁴Sandia National Laboratories, Albuquerque, NM, United States

J13 Advanced Analysis of Multi Wire Wafering Processes

Ringo Koepge¹, Samuel Brinnig¹, Felix Kaule¹, Stephan Schoenfelder^{1,2}, Hartmut Schwabe¹

¹Fraunhofer Center for Silicon Photovoltaics CSP, Halle (Saale), Germany, ²Leipzig University of Applied Science, Leipzig, Germany

J15 Consideration on open-circuit voltage of Si heterojunction solar cells under low concentration condition

Makoto Konagai

Tokyo City University, Tokyo, Japan

J23 A Novel Defect Passivation Method for Multicrystalline Si Wafer by H₂S Reaction

Hsiang-Yu Liu, Ujjwal K. Das, Robert W. Birkmire

Institute of Energy Conversion, University of Delaware, Newark, DE, United States

J25 Removal of the major impurities for silicon based solar cell recycling by steam plasma and EMCCM

BYUNG-MOON MOON¹, SU-HYUN BAEK^{1,2}, HYUN-DO JUNG², DONGJOON MIN¹

¹Korea Institute of Industrial Technology, CHEONAN-si, Korea, ²Yonsei University, SEOUL-si, Korea

ePoster **High quality and thin silicon wafer for next generation solar cells**

Yoshio Ohshita¹, Takuto Kojima², Ryota Suzuki², Kosuke Kinoshita², Tomoyuki Kawatsu³, Kyotaro Nakamura², Atsushi Ogura²

¹Toyota Technological Institute, Nagoya, Japan, ²Meiji University, Kawasaki, Japan, ³Komatsu NTC Ltd., Nanto, Japan

J27 **Carrier Transportation at Novel Silver Paste Contact**

Yoshio Ohshita¹, Takefumi Kamioka¹, Satoshi Kameyama¹, Kazuo Muramatsu², Aki Tanaka², Naotaka Iwata¹, Kyotaro Nakamura³, Atsushi Ogura³

¹Toyota Technological Institute, Nagoya, Japan, ²NAMICS Corporation, Nigorigawa, Japan, ³Meiji University, Kawasaki, Japan

J31 **Minority Carrier Lifetime Variations in Multicrystalline Silicon Wafers with Temperature and Ingot Position**

Sissel T. Søndergaard¹, Jan O. Odden², Rune Strandberg¹

¹University of Agder, Department of Engineering Sciences, Grimstad, Norway, ²Elkem Solar AS, Kristiansand, Norway

J35 **The Effect of Chemical Composition on Porous Etching for Epi and Lift-off Wafer Process**

Teng-Yu Wang¹, Peng-Wei Chen^{1,2}, Han-Wen Liu²

¹Industrial Technology Research Institute, Hsinchu, Taiwan, ²National Chung Hsing University, Taichung, Taiwan

J37 **Electrical and Optical Performance of Silicon Solar Cells Using Plasmonics Indium Nanoparticles Layer Embedded in SiO₂ Antireflective Coating**

Hao-Yu Yang, Wen-Jeng Ho, Sheng-Kai Feng, Jheng-Jie Liu, Ta-Wei Chuang, Guan-Yi Li, Yun-Chie Yang, Cho-Chun Chiang, Yao-Hui Chen

National Taipei University of Technology, Taipei, Taiwan

I52 **Magnetron Sputtered Hydrogenated Silicon Thin Films: Assessment for Application in Photovoltaics**

Dipendra Adhikari¹, Maxwell M. Junda¹, Sylvain X. Marsillac², Robert W. Collins¹, Nikolas J. Podraza¹

¹Wright Center for Photovoltaics Innovation and Commercialization & Department of Physics and Astronomy, University of Toledo, Toledo, OH, United States, ²Virginia Institute of Photovoltaics, Old Dominion University, Norfolk, VA, United States

I54 **First Demonstration of Radial Junction Silicon Nanowire Solar Mini-Modules Prepared by PECVD and Laser Scribing**

Mutaz Al-Ghzaiwat¹, Martin Foldyna¹, Takashi Fuyuki¹, Wanghua Chen¹, Erik V. Johnson¹, Jacques Meot², Pere Roca i Cabarrocas¹

¹LPICM, CNRS, Ecole Polytechnique, Université Paris-Saclay, 91128, Palaiseau, France, ²SOLEMS, 3 rue Léon Blum, 91120, Palaiseau, France

J4 **Performance Optimization of Semi-Transparent Thin-Film Amorphous Silicon Solar Cells**

Yuan Gao^{1,2,3}, Fai Tong Si¹, Olindo Isabella¹, Rudi Santbergen¹, Guangtao Yang¹, Jianfei Dong^{2,3}, Guoqi Zhang⁴, Miro Zeman¹

¹Photovoltaic Materials and Devices, Delft University of Technology, Delft, Netherlands, ²Beijing Research Center, Delft University of Technology, Beijing, China, ³Suzhou Institute of Biomedical Engineering and Technology, Chinese Academy of Sciences, Suzhou, China, ⁴Department of Microelectronics, Delft University of Technology, Delft, Netherlands

- J7 New Findings of Thermal Effect on pm-Si:H Solar Cells Optoelectronic Properties**
Leon Hamui^{1,2}, Luis A. Gomez-Gonzalez², Guillermo Santana²
¹Universidad Anahuac, Mexico, Mexico, ²IIM-UNAM, Mexico, Mexico
- J11 Low temperature synthesis of silicon nanocrystals and growth of nanocrystalline thin films for photovoltaic application**
Ka-Hyun Kim^{1,2}, Erik V. Johnson², Andrey G. Kazanskii³, Mark V. Khenkin³, Pere Roca i Cabarrocas²
¹KIER-UNIST Advanced Center for Energy, Korea Institute of Energy Research, 44919 Ulsan, Korea, ²LPICM, CNRS, Ecole Polytechnique, Université Paris-Saclay, 91128 Palaiseau, France, ³Faculty of Physics, Moscow State University, 119991 Moscow, Russia
- J19 Characterization of Microcrystalline Silicon Thin Film Solar Cells Prepared by High Working Pressure Plasma-enhanced Chemical Vapor Deposition**
JUNG-DAE KWON¹, DONG-HO KIM¹, JI-HOON LEE¹, MYUNGKWAN SONG¹, MYUNGHUN SHIN²
¹Korea Institute of Materials Science, Changwon, South Korea, ²School of Electronics and Information Engineering, Korea Aerospace University, Goyang, South Korea
- J21 Atomic-layer-deposited V₂O_{5-x} Films as a Highly-efficient p-type Layer for Thin Film a-Si Solar Cells**
Ji-Hoon Lee, Myungkwon Song, Dong-Ho Kim, Jung-Dae Kwon
Korea Institute of Materials Science (KIMS), Changwon, Gyeongnam, South Korea
- J29 Influence of Deposition Parameters on Silicon Thin Films Deposited by Magnetron Sputtering**
Grace Rajan¹, Tejaswini Miryala¹, Shankar Karki¹, Robert W Collins², Nikolas Podraza², Sylvain Marsillac¹
¹Virginia Institute of Photovoltaic, Old Dominion University, Norfolk, VA, United States, ²Department of Physics and Astronomy, The University of Toledo, Toledo, OH, United States
- J33 CuO nanowires-based Radial hetero-junction thin film silicon solar cells with a high open-circuit voltage**
XIAOLIN SUN^{1,2}, linwei YU¹
¹NANJING UNIVERSITY, NANJING, China, ²SANJIANG UNIVERSITY, NANJING, China

Area 5 - Poster

10:30 - 12:00 PM

Exhibit Hall F

Characterization II

Chair(s): Mariana Bertoni, Nicole Kotulak, Chun Sheng Jian

- J39 Electroluminescence Analysis For Separation of Series Resistance From Recombination Effects in Silicon Solar Cells with Interdigitated Back Contact Design**
Nuha M Ahmed^{1,2}, Lei R Zhang^{1,2}, Ujjwal K Das¹, Steven S Hegedus^{1,2}
¹Institute of Energy Conversion, Newark, DE, United States, ²Department of Electrical and Computer Engineering, Newark, DE, United States
- J41 Indoor Measurement of Angle Resolved Light Absorption by Black Silicon**
Mekbib W. Amdemeskel¹, Beniamino Iandolo², Rasmus S. Davidsen², Ole Hansen², Gisele A. Benatto¹, Nicholas Riedel¹, Peter B. Poulsen¹, Sune Thorsteinsson¹, Anders Thorseth¹, Carsten Dam-Hansen¹
¹Department of Photonics Engineering, Technical University of Denmark, Roskilde, Denmark,

²*Department of Micro- and Nanotechnology, Technical University of Denmark, Kongens Lyngby, Denmark*

- J43 Impact of non-flat photogeneration and carrier profiles in the luminescent emission and detection of silicon solar cells**
Nekane Azkona, Federico Recart, Pedro Rodríguez, Juan C. Jimeno
TiM - UPV/EHU, Bilbao, Spain
- J45 Development of outdoor luminescence imaging for drone-based PV array inspection**
Gisele A. Benatto¹, Sune Thorsteinsson¹, Nicholas Riedel¹, Peter B. Poulsen¹, Anders Thorseth¹, Carsten Dam-Hansen¹, Claire Mantel¹, Søren Forchhammer¹, Kenn H. Frederiksen², Jan Vedde³, Michael Petersen⁴, Henrik Voss⁵, Michael Messerschmidt⁵, Harsh Parikh⁶, Sergiu Spataru⁶, Dezso Sera⁶
¹*Department of Photonics Engineering, Technical University of Denmark, Roskilde, Denmark,* ²*Kenergy, Horsens, Denmark,* ³*SiCon Silicon & PV consulting, Birkerød, Denmark,* ⁴*Skive Kommune, Skive, Denmark,* ⁵*Sky-Watch, Støvring, Denmark,* ⁶*Aalborg University, Aalborg, Denmark*
- J47 Climbing Drum Peel (CDP) Test Method for Characterizing Adhesion in Flexible PV Modules**
Venkata Bheemreddy, Kedar Hardikar
MiaSole Hi-Tech Corp., Santa Clara, CA, United States
- J49 3D Stress Characterization for Photovoltaic Si Ingots.**
Charly Collin¹, Hubert Seigneur^{1,2}, Winston Schoenfeld^{1,2}
¹*University of Central Florida, Orlando, FL, United States,* ²*c-Si Division, U.S. Photovoltaic Manufacturing Consortium, Orlando, FL, United States*
- J51 Modeling of Polarized Reflection of Wafers for Defect Detection**
Charly Collin¹, Hubert Seigneur^{1,2}, Winston Schoenfeld^{1,2}
¹*University of Central Florida, Orlando, FL, United States,* ²*c-Si Division, U.S. Photovoltaic Manufacturing Consortium, Orlando, FL, United States*
- J53 Accuracy of Solar Simulator Spectral Determination Using Band-Pass Filtering Method**
Weston A Dobson¹, Ronald A Sinton¹, Harrison Wilterdink¹, Adrienne Blum¹, Justin Dinger¹, Cassidy Sainsbury¹, Karsten Bothe², David Hinken², Martin Wolf²
¹*Sinton Instruments, Boulder, CO, United States,* ²*Institute for Solar Energy Research Hamelin (ISFH), Hamelin, Germany*
- J55 Correlation of I-V Curve Parameters with Module-Level Electroluminescent Image Data Over 3000 Hours Damp-Heat Exposure**
Justin S. Fada¹, Andrew Loach¹, Alan J. Curran¹, Jennifer L. Braid¹, Shuying Yang², Timothy J. Peshek¹, Roger H. French¹
¹*SDLE Research Center, Cleveland, OH, United States,* ²*SunEdison Inc., Belmont, CA, United States*
- K1 A comparison between Quasi-Steady State and Transient Photo Conductance lifetime measurements on silicon ingots**
Mohsen Goodarzi¹, Ronald Sinton², Daniel Chung³, Bernhard Mitchell³, Thorsten Trupke³, Daniel Macdonald¹
¹*Research School of Engineering, The Australian National University, Canberra, Australia,* ²*Sinton Instruments Inc, Boulder, CO, United States,* ³*School of Photovoltaic and Renewable Energy Engineering, UNSW, Sydney, Australia*
- K3 A Novel Method to Investigate Stoichiometry and Performance of Buried Passivated Contacts Utilizing Time-of-Flight SIMS**

Steven P. Harvey¹, William Nemeth¹, Jeff Aguiar², Craig Perkins¹, Pauls Stradins¹
¹NREL, Golden, CO, United States, ²Idaho National Laboratory, Idaho Falls, ID, United States

- K5 New development in Glow Discharge Optical Emission Spectroscopy for the characterization and the thickness measurement of layers for photovoltaic applications**
Philippe Hunault¹, Matthieu Chausseau¹, Sofia Gaiaschi², Patrick Chapon², Anais Loubat³, Muriel Bouttemy⁴, Arnaud Etcheberry⁴
¹HORIBA Scientific, Edison, NJ, United States, ²HORIBA Scientific, Longjumeau, France, ³Institut Photovoltaïque d'Ile-de-France (IPVF), Antony, France, ⁴Institut Lavoisier de Versailles (ILV), UMR 8180 CNRS-UVSQ, Versailles, France
- K7 Deep level transient spectroscopy measurements of silicon heterojunction cells**
Sanchit S. Khatavkar¹, C. V. Kannan², Vijay Kumar², Pradeep R. Nair¹, Brij M. Arora¹
¹Dept. of Electrical Engineering, IIT Bombay, Mumbai, India, ²Moser Baer Photovoltaic Pvt. Ltd., Greater Noida, India
- K9 Characterization of Modules and Arrays with SunsVoc**
Alexander Killam, Maxwell Cotton, Stuart Bowden
Arizona State University, Tempe, AZ, United States
- K11 A Study of Performance Characterization with Rear Light Source in Conventional Bifacial Solar Cells**
Soo Min Kim¹, Sang Hoon Jung¹, Hae-won Choi¹, Yong Bae Kim¹, Min Gu Kang², Hee-Eun Song², Gyu-seok Choi¹
¹Gumi Electronics & Information Technology Research Institute, Gumi, South Korea, ²Korea Institute of Energy Research, Daejeon, South Korea
- K13 Electrical characterization of the carrier transport properties in a Cu(In,Ga)Se₂ solar cell**
Roberto Lopez¹, Sanjoy Paul¹, Ingrid Repins², Jian V. Li^{1,3}
¹Department of physics, Texas State University, San Marcos, TX, United States, ²National Renewable Energy Lab, Golden, CO, United States, ³Materials Science, Engineering and Commercialization, Texas State University, San Marcos, TX, United States
- K15 Systematic Thermalphotovoltaic Solar Cell Optimization**
Zheng Lyu¹, Muyu Xue², Junyan Chen³, Jieyang Jia¹, Shanhui Fan¹, James Harris^{1,2}
¹Stanford University, Stanford, CA, United States, ²Stanford University, Stanford, CA, United States, ³Peking University, Beijing, China, ⁴Stanford University, Stanford, CA, United States, ⁵Stanford University, Stanford, CA, United States, ⁶Stanford University, Stanford, CA, United States
- K17 Characterization of Tellurium as a Back Contact for CdTe Solar Cells**
Christina E Moffett, Drew E Swanson, Andrew Moore, Jennifer A Drayton, Walajabad S Sampath
Colorado State University, Fort Collins, CO, United States
- K19 On the Different Explanations of the Recombination Currents with High Ideality Factor in Silicon Solar Cells**
Alona Otaegi
TiM, University of the Basque Country, Bilbao, Spain
- K21 Identification and mitigation of shunts in a monolithic multijunction GaAs/GaAs device by spectrometric characterization**
Felipe Oviedo^{1,2}, Zhe Liu³, Zekun Ren², Thway Maung^{3,4}, Haohui Liu³, Tonio Buonassisi^{1,2}, Ian Marius Peters^{1,2}
¹Massachusetts Institute of Technology (MIT), Cambridge, MA, United States, ²Singapore-MIT Alliance for Research and Technology, Singapore, Singapore, ³Solar Energy Research Institute of Singapore (SERIS), Singapore, Singapore, ⁴National University of Singapore, Singapore, Singapore

- K23 A Simulation Study on Radiative Recombination Analysis in CIGS Solar Cells**
Sanjoy Paul^{1,2}, Roberto Lopez¹, Md. Dalim Mia², Craig H. Swartz², Jian V. Li^{1,2}
¹Physics Department, Texas State University, San Marcos, TX, United States, ²Materials Science, Engineering, and Commercialization Program, Texas State University, San Marcos, TX, United States
- K25 Simulation and Spectroscopy of Carrier Relaxation in GaSb and GaAs**
Adam Scofield¹, Andrew Hudson¹, Baolai Liang², Bor-Chau Juang², Diana Huffaker², Seth Hubbard³, William Lotshaw¹
¹The Aerospace Corporation, El Segundo, CA, United States, ²University of California Los Angeles, Los Angeles, CA, United States, ³Rochester Institute of Technology, Rochester, NY, United States
- K27 Computational Design of Dopants in CdTe Grain Boundaries for Efficient Photovoltaics**
Fatih G. Sen¹, Tadas Paulauskas², Ce Sun³, Moon Kim³, Robert F. Klie², Maria Chan²
¹Argonne National Laboratory, Lemont, IL, United States, ²University of Illinois at Chicago, Chicago, IL, United States, ³University of Texas at Dallas, Richardson, TX, United States
- K29 Analyses of Photovoltaic Power Plant Performance Estimates Based on Detailed Laboratory Module Characterizations and Typical Real-World Input Data Sources**
Rajeev Singh¹, John L. R. Watts¹, Kellen Gillispie²
¹DNV GL PVEL, Berkeley, CA, United States, ²Stratasense, Oakland, CA, United States
- K31 Critical Evaluation of the Foundations of Solar Simulator Standards**
Ronald A Sinton, Harrison Wilterdink, Justin Dinger, Adrienne L Blum, Weston Dobson, Cassidy Sainsbury
- K33 Impact of Infrared Optical Properties on Crystalline Si and Thin Film CdTe Solar Cells**
Indra Subedi¹, Timothy J Silverman², Michael Deceglie², Nikolas J Podraza¹
¹Department of Physics & Astronomy and Wright Center for Photovoltaics Innovation & Commercialization, University of Toledo, Toledo, OH, United States, ²National Renewable Energy Laboratory, Golden, CO, United States
- K34 The Impact of Impurities on the Relative Efficiencies of Solar Cells from different Silicon Feedstocks**
Muhammad Tayyib¹, Muhammad Nadeem Akram¹, Aleksandr Dobroliubov¹, Jan Ove Odde²
¹University College of Southeast Norway, Borre, Norway, ²Elkem Solar AS, Kristiansand, Norway
- K35 Accuracy evaluation of absolute electroluminescence-efficiency measurements of solar cells using a sensitivity-calibrated-photodetector contact method**
Masahiro Yoshita¹, Yoshihiro Hishikawa¹, Yoshihiko Kanemitsu², Hidefumi Akiyama³
¹RCPV, AIST, Tsukuba, Japan, ²ICR, Kyoto Univ., Uji, Japan, ³ISSP, Univ. of Tokyo, Kashiwa, Japan

Area 9 - Poster

10:30 - 12:00 PM

Exhibit Hall C

Soiling; Device, Panel, and Materials Durability and Accelerated Testing

Chair(s): Michael Kempe, Lawrence Kazmerski, John Trout

- K50 Statistical Analysis of Degradation Data for c-Si modules observed in India in 2016**
Chiranjibi Mahapatra¹, Rajiv Dubey², Shashwata Chattopadhyay³, Sachin Zachariah², Sanjeev Sabnis¹
¹Department of Mathematics, Indian Institute of Technology Bombay, Mumbai, India, ²Department

of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, India, ³Department of Energy Science & Engineering, Indian Institute of Technology Bombay, Mumbai, India

- K52 A unified global investigation on the spectral effects of soiling losses of PV glass substrates: preliminary results**
Leonardo Micheli^{1,2}, Eduardo F. Fernández³, Greg P. Smestad⁴, Hameed Alrashidi⁵, Nabin Sarmah⁶, Nazmi Sellami⁷, Ibrahim A. I. Hassan⁸, Amal Kasry⁹, Gustavo Nofuentes³, Neeru Sood¹⁰, Bala Pesala^{11,12}, S. Senthilarasu⁵, Florencia Almonacid³, K.S. Reddy¹³, Matthew Muller¹, Tapas Mallick⁵
¹NREL, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States, ³University of Jaén, Jaén, Spain, ⁴Sol Ideas Technology Development, San José, CA, United States, ⁵University of Exeter, Exeter, United Kingdom, ⁶Tezpur University, Tezpur, India, ⁷Robert Gordon University, Aberdeen, United Kingdom, ⁸South Valley University, Qena, Egypt, ⁹British University in Egypt, El Sherouk City, Egypt, ¹⁰BITS Pilani, Dubai, United Arab Emirates, ¹¹Academy of Scientific and Innovative Research, Chennai, India, ¹²CSIR-Central Electronics Engineering Research Institute, Chennai, India, ¹³Indian Institute of Technology Madras, Chennai, India
- K36 Modeling Potential-Induced Degradation (PID) of Field-Exposed Crystalline Silicon Solar PV Modules: Focus on a Regeneration Term**
Eleonora Annigoni¹, Alessandro Virtuani¹, Fanny Sculati-Meillaud¹, Christophe Ballif^{1,2}
¹École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, ²CSEM, Neuchâtel, Switzerland
- K37 DuraMat: The Durable Module Materials National Lab Consortium**
Teresa M Barnes¹, Margaret Gordon², David Ginley¹, Anubhav Jain³, Randy Schunk², Mark van Benthem², Mike Toney⁴, Peter Hacke¹, Bruce King², Mike Woodhouse¹, Sarah Kurtz¹
¹NREL, Golden, CO, United States, ²Sandia, Albuquerque, NM, United States, ³LBL, Berkeley, CA, United States, ⁴SLAC, Stanford, CA, United States
- K38 Soiling loss on PV modules at two locations in India studied using a water based artificial soiling method**
Sonali Bhaduri¹, Sachin Zachariah², Lawrence L. Kazmerski², Balasubramaniam Kavaipatti¹, Anil Kottantharayil²
¹Indian Institute of Technology Bombay, Department of Energy Science and Engineering, Mumbai, India, ²Indian Institute of Technology Bombay, Department of Electrical Engineering, Mumbai, India, ³National Renewable Energy Laboratory, Golden, CO, United States
- K39 Quantifying Year-to-Year Variations in Solar Panel Soiling from PV Energy-Production Data**
Michael G Deceglie¹, Leonardo Micheli^{1,2}, Matthew Muller¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Department of Chemistry, Colorado School of Mines, Golden, CO, United States
- K40 Performance of Monocrystalline Silicon solar cell – Influence of dust on Ultra-Violet and Visible region during early stage of deposition**
Hemaprabha Elangovan¹, Upasna Ranjan¹, Jagdish A K², Praveen C Ramamurthy^{1,2}, Kamanio Chattopadhyay^{1,2}
¹Interdisciplinary Centre for Energy Research, Indian Institute of Science, Bangalore, India, ²Department of Materials Engineering, Indian Institute of Science, Bangalore, India
- K41 Accurately Measuring PV Soiling Losses with Soiling Station Employing PV Module Power Measurements**
Michael Gostein¹, Bill Stueve¹, Mandy Chan²
¹Atonometrics, Austin, TX, United States, ²E.ON Climate & Renewables North America, San Francisco, CA, United States

- K42 A Comprehensive Study of Light Soaking Effect in CdTe Solar Cells**
Da Guo¹, Andrew Moore², Dmitry Krasikov³, Igor Sankin³, Dragica Vasileska¹
¹Arizona State University, Tempe, AZ, United States, ²Colorado State University, Fort Collins, CO, United States, ³First Solar Inc, Perrysburg, OH, United States
- K43 Paradigm Change for Accelerated Stress Testing of Thin-Film Modules**
Peter Hacke¹, Sergiu Spataru², Steve Johnston¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Aalborg University, Aalborg, Denmark, ³National Renewable Energy Laboratory, Golden, CO, United States
- K44 A Fine Model of Power Degradation for Crystalline Silicon Solar Modules**
Wenshuang He¹, Baosong Duan², Fumei Wang¹, Ao Wang¹, Jipeng Chang¹, He Wang¹, Hong Yang¹, Jie Ding³, Junjun Zhang³, Jingsheng Huang³
¹Xi'an Jiaotong University, Xi'an, China, ²Xi'an Communications Institute, Xi'an, China, ³China electric power research institute, Nanjing, China
- K45 Test Methods for Hydrophobic Coatings on Solar Cover Glass**
Kenan Isbilir, Biancamaria Maniscalco, Ralph Gottschalg, John M Walls
CREST, Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU, United Kingdom
- ePoster**Nanometer-Scale Carrier Imaging of Potential-Induced Degradation in c-Si Solar Cells**
C.-S. Jiang¹, C. Xiao¹, H.R. Moutinho¹, S. Johnston¹, M.M. Al-Jassim¹, X. Yang², Y. Chen², J. Ye³
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Trina Solar Inc., Changzhuo, China, ³Ningbo Institute of Industrial Technology, Chinese Academy of Science, Ningbo, China
- K46 Impact of degradation rates on Solar PV project financing for projects in the United States**
Rounak Kharait¹, John Graff², Larry McClung³, Alex Schneider¹, Phil Stiles¹
¹Leidos, Denver, CO, United States, ²Leidos, Boston, MA, United States, ³Leidos, Ottawa, ON, Canada
- K47 Analysis of wind direction and wind speed measurements in an arid region - a site evaluation using data with low temporal resolution**
Elisabeth Klimm, Felix Guischar, Karl-Anders Weiß
Fraunhofer ISE, Freiburg, Germany
- K48 Forecasting Environmental Degradation Power Loss in Solar Panels with a Predictive Crack Opening Test**
Jason L. Lincoln¹, Andrew M. Gabor², Eric J. Schneller¹, Hubert Seigneur¹, Joseph Walters¹, Rob Janoch², Andrew Anselmo², Victor Huayamave³, Winston Schoenfeld¹
¹Florida Solar Energy Center, University of Central Florida, Cocoa, FL, United States, ²BrightSpot Automation LLC, Westford, MA, United States, ³Department of Mechanical Engineering, Embry-Riddle Aeronautical University, Daytona Beach, FL, United States
- K49 Fluorescence Imaging on the Cross-section of Degraded Photovoltaic Laminates**
Yadong Lyu, Jae Hyun Kim, Xiaohong Gu
National Institute of Standards and Technology, Gaithersburg, MD, United States
- K51 Process Induced Deflection and Stress on Encapsulated Solar Cells**
Xiaodong Meng¹, Michael Stuckelberger¹, Peter Hacke², Mariana Berton¹
¹Arizona State University, Tempe, AZ, United States, ²National Renewable Energy Laboratory, Golden, CO, United States
- L1 The Development of a DC Breakdown Voltage Test for Photovoltaic Insulating Materials**
David C. Miller¹, Bernt Åke-Sultan², Axel Borne³, Rene Eugen⁴, Bradley L. Givot⁵, Jürgen Jung⁶,

Steven W. MacMaster⁷, Byron K. McDanold¹, Ulf H. Nilsson², Nancy H. Phillips⁷, Ian A. Tappan¹, Nick S. Bosco¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Borealis AB, Stenungsund, Sweden, ³DuPont Photovoltaic and Advanced Materials, Meyrin, Switzerland, ⁴Isovoltaic AG, Lebring, Austria, ⁵The 3M Company, St. Paul, MN, United States, ⁶Agfa-Gevaert NV, Mortsel, Belgium, ⁷DuPont Photovoltaic Solutions, Wilmington, DE, United States

L2 Field-Evaluation of Electrodynamic Screens for Maintaining High Optical Efficiency Operation of Solar Collectors

Cristian M Morales¹, Annie Bernard¹, Ryan Eriksen¹, Julius Yellowhair², Sean Garner³, Ricci La Centra¹, Alecia Griffin¹, Alexis Lloyd¹, Yujie Gao¹, Ramakrishnan Lakshmanan¹, Mark Horenstein¹, Malay Mazumder¹

¹Boston University, Boston, MA, United States, ²Sandia National Laboratory, Albuquerque, NM, United States, ³Corning Research & Development Center, Corning, NY, United States

L3 Effect of Reverse Biases on CIGS Solar Cells

S Mortazavi¹, K Bakker², G Amorim Soares¹, H Steijvers¹, M Theelen¹

¹TNO Solliance, Thin Film Technology, Eindhoven, Netherlands, ²ECN Solliance, Thin Film Photovoltaics, Eindhoven, Netherlands

L4 A Method to Extract Soiling Loss Data From Soiling Stations with Imperfect Cleaning Schedules

Matthew T. Muller¹, Leonardo Micheli^{1,2}, Alfredo A. Martinez-Morales³

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States, ³University of California, Riverside, Riverside, CA, United States

L5 Analytical (S)TEM Studies of Defects Associated with PID in Stressed Si PV Modules

Andrew G Norman¹, Adam Stokes², John Moseley¹, Steven P Harvey¹, Steve Johnston¹, Mowafak M Al-Jassim¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States

L6 Performance of Anti-soiling and Anti-reflection Coated Photovoltaic Modules

Wonwook Oh¹, Nochang Park¹, Sun Choi², Soyeon Kang¹, Woojun Yoon³, Phillip Jenkins³, Heon Hwang², Sung-Il Chan¹

¹Korea Electronics Technology Institute, Seongnam 13509, Korea, ²Sung Kyun Kwan University, Suwon 16419, Korea, ³Naval Research Laboratory, Washington, DC, United States

L7 Design, Development and Evaluation of Electrodynamic Screens for Self-Cleaning Solar Panels and Concentrating Mirrors

Annie Rabi Bernard¹, Ryan Eriksen¹, Hung Yi Lin², Julius Yellowhair³, Sean Garner⁴, Arash Sayyah¹, Alecia Griffin¹, Alexis Lloyd¹, Yujie Gao¹, Ricci La Centra¹, Cristian Morales¹, Ramakrishnan Lakshmanan¹, Mark Horenstein¹, Malay Mazumder¹

¹Boston University, Boston, MA, United States, ²Industrial Technology Research Institute, Hsinchu, Taiwan, ³Sandia National Lab, Albuquerque, NM, United States, ⁴Corning Research & Development Center, Corning, NY, United States

L8 Evaluating Solar Cell Fracture as a Function of Module Mechanical Loading Conditions

Eric J. Schneller¹, Andrew M. Gabor², Jason L. Lincoln¹, Rob Janoch², Andrew Anselmo², Joseph Walters¹, Hubert Seigneur¹

¹Florida Solar Energy Center, University of Central Florida, Cocoa, FL, United States, ²BrightSpot Automation, Westford, MA, United States

L9 Computational study of the effect of photovoltaic (PV) module parameters on stress development in silicon under static loading

Saurabh Sethia, Karan Shishir Yadav, Aparna Singh, Sudharm Rathore, Abhishek Shubhrant

Department of Metallurgical Engineering and Materials Science, Indian Institute of Technology
Bombay, Mumbai-400076, India, Mumbai, India

L10 Accelerated Testing of Photovoltaic Modules in Extreme Climates

Narendra Shiradkar, Vivek Gade, Jared Opalewski, Shesh Vaishnav
Jabil Circuit Inc, St Petersburg, FL, United States

ePoster NREL Efforts to Address Soiling on PV Modules

Lin J. Simpson¹, Matthew Miller¹, Michael Deceglie¹, Helio Moutinho¹, Craig Jensen¹, Chun Sheng
Jiang¹, David C. Miller¹, Leonardo Micheli^{1,2}, Gavindasamy Tamizhmani³, Sai Ravi Vasista
Tatapudi³, Mowafak Al-Jassim¹, Sarah Toth¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines,
Golden, CO, United States, ³Arizona State University, Tempe, AZ, United States

L11 A Simple Method for Measuring Solar Radiation Intensity by Image Analyses

Akiko Takahashi, Akinori Moriki, Nobuyuki Yamada, Jun Imai, Shigeyuki Funabiki
Okayama University, Okayama, Japan

L12 Degradation of Solder Bonds in Field Aged PV Modules: Correlation with Series Resistance Increase

Abhishiktha Tummala, Jaewon Oh, Sai Tatapudi, GovindaSamy TamizhMani
Arizona State University Photovoltaic Reliability Lab (ASU-PRL), Mesa, AZ, United States

L13 Performance of Light and Dark Current-Voltage Characteristics for PID-affected Monocrystalline Silicon Solar Modules

He Wang¹, Pan Zhao¹, Shuwen Guo¹, Hong Yang¹, WeiJing Huang², Shiyu Sang³, Bojie Su⁴, Xue
Zhang⁴, Yunxue Cao⁵, Hui Zhao⁵
¹School of science, Xi'an Jiaotong University, Xi'an, China, ²Xi'an Huanghe Photovoltaic
Technology Co., Ltd, Xi'an, China, ³Institute of Electrical Engineering of the Chinese Academy of
Sciences, Beijing, China, ⁴China Quality Certification Center, Beijing, China, ⁵SPIC Power Plant
Operation Technology Co., Ltd, Beijing, China

L14 Soiling Rates of PV Modules vs. Thermopile Pyranometers

Martin Waters¹, Michael Gostein², Tejas Tirumalai¹, Bill Stueve²
¹Recurrent Energy, San Francisco, CA, United States, ²Atonometrics, Austin, TX, United States

L15 Temperature Dependent Evaluation and Simulation of c-/a-Si, CdTe and CIGS Photovoltaics Modules

Saleem zaidi¹, cheow Siu Leong¹, Kamaruzzaman Sopian¹, Adnan Ali²
¹Solar Energy Research Institute, Universiti Kebangsaan Malaysia, Bangi, Malaysia, ²Government
College University Faisalabad, Faisalabad, Pakistan

Area 10 - Poster

10:30 - 12:00 PM

Exhibit Hall A

Grid Integration and Power Electronics

Chair(s): Sigifredo Gonzalez, Hariharan Krishnaswami?, Barry Mather

L16 Interconnection Study Of Distributed PV Systems By Interfacing Matlab With OpenDSS and GIS.

Joseph A. Ahamioje, Hariharan Krishnaswami

L18 >80% Reduction in Grid-Buy Electricity and Elimination of Evening & Morning Energy Peaks by Optimizing Energy Usage and Integration of Self-Supply Rooftop Solar Systems (PV &

Hot Water) with Battery Storage: A Case Study for Residential Hawaii

John O Borland¹, Jay Moore², Corpuz Poncho², Takahiro Tanaka³, Harumi McClure³
¹*J.O.B. Technologies, Aiea, HI, United States*, ²*Poncho's Solar, Honolulu, HI, United States*,
³*Tabuchi Electric, San Jose, CA, United States*

L19 A Single-Stage Ćuk-based Transformerless Inverter for 1- ϕ Grid-Connected PV Systems

phanikumar chamarthi¹, Amit kumar Gupta¹, Madhuwanthi Joshi², Vivek Agarwal¹
¹*Indian Institute of Technology, Mumbai, India*, ²*Integra Power LLC, Edison, NJ, United States*

L20 A State Space Average Model for Dynamic Microgrid Based Space Station Simulation

Rachid Darbali-Zamora, Eduardo I. Ortiz-Rivera
University of Puerto Rico-Mayagüez, Mayagüez, PR, United States

L23 Virtual Power Plant Feedback Control Design for Fast and Reliable Contingency Reserve Dispatch

Mohamed Elkhatib, Jay Johnson, David Schoenwald
Sandia National Laboratories, Albuquerque, NM, United States

L24 Intelligent Sampling of Periods for Reduced Computational Time of Time Series Analysis of PV Impacts on the Distribution System

Jason A Galtieri, Matthew J
Sandia, Albuquerque, NM, United States

L25 A PWM Scheme to Realise Two Times Effective Switching Frequency with Constant Common Mode Voltage and Reactive Power Capability in 1- ϕ Grid-Tied Transformerless H6 PV Inverter

Amit Kumar Gupta¹, Madhuwanti Joshi², Vivek Agarwal¹
¹*Indian Institute of Technology, Bombay, Mumbai, India*, ²*Integra Power LLC, Edison, NJ, United States*

L29 Evaluation of PV Hosting Capacity of Distribution Grids Considering a Solar Roof Potential Analysis - Comparison of Different Algorithms

Gerd Heilscher¹, Falko Ebe¹, Basem Idlbi¹, Jeromie Morris¹, Florian Meier²
¹*Ulm University of Applied Sciences, Ulm, Germany*, ²*Stadtwerke Ulm/Neu-Ulm, Ulm, Germany*

L30 Model-Free Decentralized Distribution Circuit Optimization with PV Inverters using Extremum Seeking Control

Jay Johnson¹, Sigifredo Gonzalez¹, Daniel Arnold²
¹*Sandia National Laboratories, Albuquerque, NM, United States*, ²*Lawrence Berkeley National Laboratory, Berkeley, CA, United States*

L32 Spatial Analysis of Residential Combined Photovoltaic and Battery Potential: Case Study Utrecht

Bala Bhavya Kausika, Geert Litjens, Wilfried van Sark
Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, Netherlands

L33 Power Balance Requirements for Sustained Islanding of Inverter Based Distributed Generation

Gregory A Kern¹, Michael Ropp², Sigifredo Gonzalez³
¹*SunPower, Austin, TX, United States*, ²*Northern Plains Power Technologies, Brookings, SD, United States*, ³*Sandia National Laboratories, Albuquerque, NM, United States*

L34 Full-Scale Demonstration of Distribution System Parameter Estimation to Improve Low-Voltage Circuit Models

Matthew Lave¹, Matthew J. Reno¹, Robert J. Broderick¹, Jouni Peppanen²

¹Sandia National Laboratories, Albuquerque, NM, United States, ²EPRI, Knoxville, TN, United States

L35 Creation and Value of Synthetic High-Frequency Solar Simulations for Distribution System QSTS Simulations

Matthew Lave¹, Matthew J. Reno², Robert J. Broderick²

¹Sandia National Laboratories, Livermore, CA, United States, ²Sandia National Laboratories, Albuquerque, NM, United States

L37 "Passivity Based Controller for Photovoltaic Modules Using ZETA Converter"

Daniel Merced^{1,2}, Rachid Darbali-Zamora², Eduardo I. Ortiz-Rivera²

¹University of Tennessee, Knoxville, TN, United States, ²University of Puerto Rico, Mayaguez, PR, United States

L38 SiC Switch based Single-Stage Buck-Boost Transformerless Mini Inverter with Low Leakage Current and Negligible DC Injection

Soumya Ranjan Mohapatra¹, Amit Kumar Gupta¹, Madhuwanti Joshi², Vivek Agarwal¹

¹Indian Institute of Technology, Mumbai, India, ²Integra Power LLC, Edison, NJ, United States

L40 An autocorrelation-based copula model for producing realistic clear-sky index and photovoltaic power generation time-series

Joakim Munkhammar, Joakim Widen

Built Environment Energy Systems Group, Dept. Engineering Sciences, Uppsala University, Uppsala, Sweden

L41 Maximum Power Point Tracking of PV Module Based on New Explicit I-V Relation

Tejeswar Nukala, A.K. Panchal

Sardar Vallabhbhai National Institute of Technology, SURAT, India

L42 Dynamic Response of Maximum Power Point Tracking using Perturb and Observe Algorithm with Momentum Term

Gautam A. Raiker

NIT Goa, Farmagudi, Goa, India

ePoster Grid Integration of Building Systems and 1 MW Photovoltaic Array Using VOLTTRON

David M. Raker^{1,3}, Andrew Sellers², Roshan Kini², Michael Green³, Thomas Stuart², Randall Ellingson^{1,3}, Raghav Khanna², Michael Heben^{1,3}

¹School for Solar and Advanced Renewable Energy, Department of Physics and Astronomy, The University of Toledo, Toledo, OH, United States, ²Department of Electrical Engineering and Computer Science, The University of Toledo, Toledo, OH, United States, ³Wright Center for Photovoltaics Innovation and Commercialization, The University of Toledo, Toledo, OH, United States

L43 A Framework for Comparing the Economic Performance and Associated Emissions of Grid-connected Battery Storage Systems in Existing Building Stock: a NYISO Case Study

Julian D Ricardo, Vasilis Fthenakis

Center for Life Cycle Analysis, Dept. of Earth and Environmental Engineering, Columbia University, New York, NY, United States

L44 Improving Any Arbitrary MPPT Hill Climber with ANN Estimations

Jesse T Roberts, Indranil Bhattacharya

L45 Increasing Solar Photovoltaic Penetration Using Thermal Energy Storage

Alexander F. Routhier, Christiana Honsberg

Arizona State University, Tempe, AZ, United States

L46 Model Predictive Control of Grid Connected Modular Multilevel Converter for Integration of Photovoltaic Power Systems

Amir Shahirinia¹, Amin Hajizadeh²

¹University of the District of Columbia, Washington DC, WA, United States, ²Aalborg University, Esbjerg, Denmark

L47 Maximization of Self-Sufficiency with Grid Constraints: PV Generators, Wind Turbines and Storage to Feed Tertiary Sector Users

Filippo Spertino, Jawad Ahmad, Alessandro Ciocia, Paolo Di Leo, Francesco Giordano
POLITECNICO DI TORINO, Torino, Italy

L48 Switches Controlling to Implement Adaptive Multilevel Inverter on PV System

Hadi Suhana¹, Ngapuli Irmea Sinisuka², Muhammad Nurdin³, Yvon Besanger⁴, Vincent Debusschere⁵

¹Bandung Institute of Technology, Bandung, Indonesia, ²Bandung Institute of Technology, Bandung, Indonesia, ³Bandung Institute of Technology, Bandung, Indonesia, ⁴G2ELab, Grenoble, France, ⁵G2ELab, Grenoble, France

L49 Demand response for the promotion of photovoltaic penetration

Venizelos Venizelou, Spyros Theocharides, George Makrides, Venizelos Efthymiou, George E Georghiou

University of Cyprus, Nicosia, Cyprus

ePoster Probabilistic Load Flow for Power Grids with High PV Penetrations using Copula-Based Modeling of Spatially Correlated Solar Irradiance

Joakim Widén, Mahmoud Shepero, Joakim Munkhammar
Uppsala University, Uppsala, Sweden

L50 High Performance Flow Battery Design for GRID-Scale Energy Storage Applications

Rachid Zaffou¹, Michael Perry¹

¹Qatar Environment and Energy Research Institute, Hamad Ben Khalifa University, Doha, DE, Qatar, ²United Technologies Research Center, East Hartford, CT, United States

L17 Modeling a Grid-connected PV/Battery Microgrid System With MPPT Controller

Genesis B. Alvarez, Hadis Moradi

Florida Atlantic University, BOCA RATON, FL, United States

L21 Buck Converter and SEPIC Based Electronic Power Supply Design with MPPT and Voltage Regulation for Small Satellite Applications

Rachid Darbali-Zamora¹, Nicolás Cobo-Yepes¹, John E. Salazar-Duque¹, Eduardo I. Ortiz-Rivera¹, Amilcar A. Rincon-Charris²

¹University of Puerto Rico-Mayagüez, Mayagüez, PR, United States, ²Inter American University of Puerto Rico-Bayamon, Bayamon, PR, United States

L22 Voltage Stability for a Photovoltaic System Connected to Grid by Using Genetic Algorithm Technique

A.Elrheem E.A. Mostafa¹, Naglaa K. Bahgaat², Mohamed Ebrahim El sayed³, El-Said A. Othman⁴

¹Al-Azhar University, Cairo, ID, Egypt, ²Canadian International College (CIC), Cairo, ID, Egypt, ³Al-Azhar University, Cairo, ID, Egypt, ⁴Al-Azhar University, Cairo, ID, Egypt

L26 A Solar PV Retrofit Solution for Residential Battery Inverters

Amit Kumar Gupta¹, Vaibhav Pawar¹, Madhuwanti S Joshi², Vivek Agarwal¹, Deepak Chandran³

¹Indian Institute of Technology, Mumbai, India, ²Integra Power LLC, Edison, NJ, United States, ³IRIS Energy LLC, Monmouth Junction, NJ, United States

L28 Systematic Voltage Rise Mitigation in Residential Networks with High PV Penetration

Maryam Hasheminamin
UNSW, Sydney, Australia

L31 Demand Response of Electric Hot Water Heaters for Increased Integration of Solar PV

C Birk Jones, Matthew Lave, Jay Johnson, Robert Broderick
Sandia National Lab, Albuquerque, NM, United States

ePoster **Novel MPPT Algorithm for Active Power Control of Multi-Level Dual-Active Bridge PV Converter Implemented in NI myRIO**

Shilpa Marti, Hariharan Krishnaswami
University of Texas at San Antonio, San Antonio, TX, United States

L36 A Direct Maximum Power Point Search Using Current-Voltage Based Power-Law Relation for Photovoltaic System under Uniform Irradiance

Hitesh K Mehta¹, Ashish K Panchal²
¹Sardar Vallabhbhai National Institute of Technology, Surat, India, ²Sardar Vallabhbhai National Institute of Technology, Surat, India

L39 Open Source Tools for High Performance Quasi-Static-Time-Series Simulation Using Parallel Processing

Davis Montenegro¹, Roger C. Dugan¹, Matthew J. Reno²
¹EPRI, Knoxville, TN, United States, ²Sandia National Laboratories, Albuquerque, NM, United States

L27 Cost Benefit and Alternatives Analysis of Distribution Systems with Energy Storage System

Tom Harris¹, Adarsh Nagarajan¹, Murali Baggu¹, Tom Bialek²
¹National Renewable Energy Laboratory, Golden, CO, United States, ²San Diego Gas & Electric, San Diego, CA, United States

Event	
12:00 - 1:30 PM	Virginia A&B
Women in PV Lunch	
Break	
12:00 - 1:30 PM	Ballroom Foyer
Lunch On Own	
Area 4 - Oral	
1:30 - 3:00 PM	Marriott Ballroom Salon 3
Modeling	

Chair(s): Keith McIntosh, Bram Hoex

1:30 Griddler AI: New Paradigm in Luminescence Image Analysis Using Automated Finite Element Methods

Johnson Wong¹, Percis Teena¹, Daniel Inns²
¹Solar Energy Research Institute of Singapore, Singapore, Singapore, ²DuPont Silicon Valley Technology Center, Sunnyvale, CA, United States

2:00 **Modeling Thermo-Mechanical Stresses, Strains, and Displacements During Solar Cell and Module Fabrication**

Eduardo Divo^{1,2}, Victor Huayamave^{1,2}, Andres Ceballos^{1,3}, Ron Eaglin^{1,3}, Adam Payne⁴, Vijay Yelundur⁴, Hubert Seigneur^{5,6}

¹Central Technological Corporation, Altamonte Springs, FL, United States, ²Embry-Riddle Aeronautical University, Daytona Beach, FL, United States, ³University of Central Florida, Department of Mechanical and Aerospace Engineering, Orlando, FL, United States, ⁴Suniva, Norcross, GA, United States, ⁵University of Central Florida, Florida Solar Energy Center, Cocoa, FL, United States, ⁶c-Si Photovoltaic Manufacturing Consortium, Orlando, FL, United States

2:15 **Big Data Analytics in PV Manufacturing - A Glimpse Into The Future**

Rhett Evans^{1,2}

¹Solinno Pty. Ltd., Bulli, Australia, ²School of Photovoltaic and Renewable Energy Engineering, UNSW,, Sydney, Australia

2:30 **Interaction of O₂i Dimers with Ga in Si and Implications for a Comprehensive Model of Light-Induced Degradation**

Yu Jin, Scott Dunham

University of Washington, Seattle, WA, United States

2:45 **Numerical Simulation of EBIC for Analysis of Extended Defects**

Marco Nardone¹, John Moseley², Saroj Dahal¹, Anuja V. Parikh¹, John M. Waddle¹

¹Bowling Green State University, Bowling Green, OH, United States, ²National Renewable Energy Laboratory, Golden, CO, United States

Area 5 - Oral

1:30 - 3:00 PM

Maryland B&C

Advanced Characterization Methods

Chair(s): David Fenning, Marina Leite

1:30 **Best Student Presentation Award Finalist**

Colloidal Quantum Dot Solar Cell Electrical Parameter Imaging Using Camera-based High-frequency Heterodyne Lock-in Carrierography

Lilei Hu¹, Mengxia Liu², Andreas Mandelis^{1,2}, Alexander Melnikov¹, Qiming Sun¹, Edward H. Sargent²

¹Center for Advanced Diffusion-Wave and Photoacoustic Technologies (CADIPT), Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, ON, Canada, ²Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto, Toronto, ON, Canada

1:45 **Best Student Presentation Award Finalist**

A New Perspective on Potential-Induced Degradation of the Shunting Type by Micro Raman-Spectroscopy and Micro Light-Beam-Induced Current

Andreas Büchler¹, Henning Nagel¹, Matthias Breitwieser², Sven Kluska¹, Friedemann D. Heinz¹, Martin C. Schubert¹, Markus Glatthaar¹, Stefan Glunz¹

¹Fraunhofer Institute for Solar Energy, Freiburg, Germany, ²Hahn-Schickard Gesellschaft, Freiburg, Germany

2:00 **Nanoscale Detection of Deep Levels in CIGS using Electron Energy Loss Spectroscopy**

Julia I Deitz¹, Pran K. Paul¹, Aaron R. Arehart¹, Sylvain Marsillac², David W. McComb¹, Tyler G. Grassman¹

¹The Ohio State University, Columbus, OH, United States, ²Old Dominion University, Norfolk, VA, United States

2:15 **Measurement of Carrier Dynamics in Photovoltaic CZTSe by Time-Resolved Terahertz Spectroscopy**

Siming Li¹, Michael L. Lloyd², Andrew A. Golembeski³, Brian E. McCandless², Jason B. Baxter¹
¹Drexel University, Philadelphia, PA, United States, ²University of Delaware, Newark, DE, United States, ³University of Rochester, Rochester, NY, United States

2:30 **Decoupling grain-boundary, grain-interior, and surface recombination with cathodoluminescence**

John Moseley¹, Pierre Rale², Stéphane Collin², Ana Kanevce¹, Eric Colegrove¹, Joel Duenow¹, Søren Jensen¹, Wyatt K. Metzger¹, Mowafak M. Al-Jassim¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Centre de Nanoscience et de Nanotechnology, CNRS, Marcoussis, France

2:45 **High resolution THz scanning for optimization of dielectric layer opening process on doped Si surfaces**

Pierpaolo Spinelli¹, Pi Danzi¹, Dimitrios Deligiannis^{1,2}, Nicolas Guillemin¹, Antonius R. Burgers¹, Simon Sawallich³, Michael Nagel³, Ilkay Cesar¹
¹Energy Research Centre of the Netherlands (ECN), Petten, Netherlands, ²Delft University of Technology, Delft, Netherlands, ³Protomics GmbH, Aachen, Germany

Area 8 - Oral

1:30 - 3:00 PM

Delaware A

Measurement, Analysis and Rating of System Performance

Chair(s): David Moser, Kenneth Sauer

1:30 **Degradation Assessment of Fielded CIGS Photovoltaic Arrays**

Bruce H. King, Joshua S. Stein, Daniel Riley, C. Birk Jones, Charles D. Robinson
Sandia National Labs, Albuquerque, NM, United States

1:45 **Application of IEC 61724 Standards to Analyze PV System Performance in Different Climates**

Katherine A. Klise¹, Joshua S. Stein¹, Joseph Cunningham²
¹Sandia National Laboratories, Albuquerque, NM, United States, ²Sunny Energy, Tempe, AZ, United States

2:00 **Effects of Urban Environment on Solar PV Performance**

Panagiotis Moraitis¹, Bala Bhavya Kausika², Wilfried van Sark³
¹Copernicus Institute Utrecht University, Utrecht, Netherlands, ²Copernicus Institute Utrecht University, Utrecht, Netherlands, ³Copernicus Institute Utrecht University, Utrecht, Netherlands

2:15 **Irradiance measurement considerations for system performance assessment when managing fleets of photovoltaic assets across Asia**

André M. Nobre, Shravan Karthik, Chenxi Liu, Rohit Jaswal, Rupesh Baker, Raghav Malhotra, Alan Khor
Cleantech Energy Corporation, Singapore, Singapore

2:30 **Machine Learning in PV Fault Detection, Diagnostics and Prognostics: A Review**

Sandy Rodrigues^{1,3}, Helena Geirinhas Ramos³, Fernando Morgado-Dias^{1,2}
¹Madeira Interactive Technologies Institute, Funchal, Portugal, ²Universidade da Madeira, Funchal,

Portugal, ³Telecommunications Institute from the Superior Technical Institute of the University of Lisbon, Lisbon, Portugal

2:45 Outdoor Field Performance from Bifacial Photovoltaic Modules and Systems

Joshua S Stein¹, Daniel Riley¹, Matthew Lave¹, Chris Deline², Fatima Toor³

¹Sandia National Laboratories, Albuquerque, NM, United States, ²National Renewable Energy Laboratory, Golden, CO, United States, ³The University of Iowa, Iowa City, IA, United States

Area 9 - Oral

1:30 - 3:00 PM

Marriott Ballroom Salon 2

Panels and Materials Durability and Accelerated Testing

Chair(s): Tadanori Tanahashi, Volker Naumann, Karl-Anders Weiss

1:30 Best Student Presentation Award Finalist

Influence of Viscoelastic Properties of Encapsulation Materials on the Thermomechanical Behavior of Photovoltaic Modules

Michael Owen-Bellini, Daniel Montiel-Chicharro, Jiang Zhu, Thomas R. Betts, Ralph Gottschalg
CREST, Loughborough University, Loughborough, United Kingdom

1:45 Defining Threshold Values of Encapsulant and Backsheet Adhesion for PV Module Reliability

Nick Bosco¹, Sarah Kurtz¹, Jared Tracy², Reinhold H. Dauskardt²

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Stanford University, Stanford, CA, United States

2:00 Evaluation of Encapsulant Adhesion to Surface Metallization of Photovoltaic Cells

Jared Tracy¹, Nick Bosco², Reinhold Dauskardt¹

¹Stanford University, Stanford, CA, United States, ²National Renewable Energy Laboratory, Golden, CO, United States

2:15 Characterizations of aged Glass/Ethylene Vinyl Acetate/Glass using spectroscopic and nanoindentation techniques

Jae Hyun Kim¹, Yadong Lyu¹, David C. Miller², Xiaohong Gu¹

¹National Institute of Standards and Technology, Gaithersburg, MD, United States, ²National Renewable Energy Laboratory, Golden, CO, United States

2:30 Impact of UV Light Intensity on Photodegradation of PV Backsheets

Xiaohong Gu, Li-Chieh Yu, Yadong Lyu, Jae Hyun Kim, Andrew Fairbrother, Tinh Nguyen
National Institute of Standards and Technology, Gaithersburg, MD, United States

2:45 Survey of Mechanical Durability of PV Backsheets

Michael Kempe¹, David Miller¹, Allen Zielnik², Daniel Montiel-Chicharro³, Jiang Zhu³, Ralph Gottschalg³

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Atlas Material Testing Technology LLC, Mount Prospect, IL, United States, ³Loughborough University, Leicestershire, United Kingdom

Area 10 - Oral

1:30 - 3:00 PM

Delaware B

PV Power Electronic Design and Control

Chair(s): Jay Johnson, Matt Reno

1:30 **Advances in Utility-Scale PV Plants: Key Lessons Learned**

Mahesh Morjaria

First Solar Inc., Tempe, AZ, United States

2:00 **Best Student Presentation Award Finalist**

Solar Variability Reduction Using Off-Maximum Power Point Tracking and Battery Storage

Jason A Galtieri, Philip T. Krein

University of Illinois, Urbana, IL, United States

2:15 **Best Student Presentation Award Finalist**

Integration of Electrochemical Capacitors on Silicon Photovoltaic Modules for Rapid-Response Power Buffering

Yu Jiang¹, Xuanyi Shi¹, Derwin Lau¹, Da-Wei Wang², Zi Ouyang¹, Alison Lennon¹

¹*School of Photovoltaics and Renewable Energy Engineering, University of New South Wales, Sydney, Australia,* ²*School of Chemical Engineering, University of New South Wales, Sydney, Australia*

2:30 **Design & Evaluation of a Hybrid Switched Capacitor Circuit with Wide-Bandgap Devices for Compact MVDC PV Power Conversion**

Joshua Stewart^{1,2}, Jarod Delhotal¹, James Richards^{1,2}, Jason Neely¹, Lee Rashkin¹, Jack Flicker¹, Robert Kaplar¹, Sigifredo Gonzalez¹, Jane M Lehr²

¹*Sandia National Labs, Albuquerque, NM, United States,* ²*University of New Mexico, Albuquerque, NM, United States*

2:45 **Design and Evaluation of SunSpec-Compliant Smart Grid Controller with an Automated Hardware-in-the-Loop Testbed**

Jay Johnson¹, Ron Ablinger², Roland Bruendlinger², Bob Fox³, Jack Flicker¹

¹*Sandia National Laboratories, Albuquerque, NM, United States,* ²*Austrian Institute of Technology, Vienna, Austria,* ³*SunSpec Alliance, San Jose, CA, United States*

Area 12 - Oral

1:30 - 3:00 PM

Maryland A

PV Lifecycle Analysis and Applications

Chair(s): Dana Olson, Dirk Weiss, Mike Woodhouse

1:30 **Solar Energy for Clean and Affordable Water Desalination**

Vasilis Fthenakis

Center for Life Cycle Analysis, Columbia University, New York, NY, United States

2:00 **Best Student Presentation Award Finalist**

Global Residential Air-Conditioning Sector as a Driver for Photovoltaic Industry Growth during the 21st Century

Hannu S Laine^{1,2}, Jyri Salpakari³, Marius Peters², Erin E Looney², Ashley E Morishige², Hele Savin¹, Gregory Wilson⁴, Tonio Buonassisi²

¹*Department of Electronics and Nanoengineering, Aalto University, Espoo, Finland,*

²*Massachusetts Institute of Technology, Cambridge, MA, United States,* ³*New Energy*

Technologies Group, Department of Applied Physics, Aalto University, Espoo, Finland, ⁴*National Center for Photovoltaics, National Renewable Energy Laboratory, Golden, CO, United States*

2:15 **Best Student Presentation Award Finalist**

Energy Pay-Back Time of Perovskite Tandem Photovoltaic Solar Cells

ilke Celik¹, Song Zhaoning², Yanfa Yan³, Randy Ellingson⁴, Michael Heben⁵, Defne Apul⁶

¹University of Toledo, Toledo, OH, United States, ²University of Toledo, Toledo, OH, United States,

³University of Toledo, Toledo, OH, United States, ⁴University of Toledo, Toledo, OH, United States,

⁵University of Toledo, Toledo, OH, United States, ⁶University of Toledo, Toledo, OH, United States

2:30 **Solar photovoltaic technology and self-consumption: Measures to remove economic non-market failure and institutional barriers that restrict their use in Spain**

Enrique Rosales-Asensio¹, Juan A. Méndez², Benjamín González-Díaz³, David Cañadillas¹, Ricardo Guerrero-Lemus¹

¹Departamento de Física. Universidad de La Laguna. Avenida Astrofísico Francisco Sánchez S/N

38206, San Cristóbal de La Laguna, Spain, ²Departamento de Ingeniería Informática y Sistemas.

Universidad de La Laguna. Avenida Astrofísico Francisco Sánchez S/N 38206, San Cristóbal de La

Laguna, Spain, ³Departamento de Ingeniería Industrial. Universidad de La Laguna. Avenida

Astrofísico Francisco Sánchez S/N 38206, San Cristóbal de La Laguna, Spain

2:45 **Cost Competitive Concentrator Photovoltaics for Solar Thermal Applications**

Brian C Riggs¹, Richard Biedenharn¹, Chris Dougher², Yaping Vera Ji¹, Qi Xu¹, Vince Romanin³, Daniel S Codd⁴, James M Zahler⁵, Matthew D Escarra¹

¹Tulane University, New Orleans, LA, United States, ²Duke University, Durham, NC, United States,

³Otherlab, San Fransisco, CA, United States, ⁴University of San Diego, San Diego, CA, United

States, ⁵Department of Energy, Washington, D.C., DC, United States

Joint Area Session - Oral

1:30 - 3:00 PM

Marriott Ballroom Salon 1

Si-Based Tandems: Battle Royale

Chair(s): Adele Tamboli, Mariana Bertoni, Michael McGehee

1:30 **2-terminal III-V/Si Tandem Solar Cells with > 30 % AM1.5g Efficiency**

Frank Dimroth¹, Jan Benick¹, Markus Feifel¹, Romain Cariou¹, Ryan M. France², Jens Ohlmann¹, Paul Beutel¹, Nico Tucher¹, David Lackner¹, Martin Hermle¹, Stefan Janz¹, Andreas W. Bett¹, Stefan W. Glunz¹

¹Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany, ²NREL, Golden, CO, United States

2:00 **23.6%-Efficient Monolithic Perovskite/Silicon Tandem Cell**

Zhengshan J. Yu¹, Kevin A. Bush², Axel F. Palmstrom², Stacey F. Bent², Michael D. McGehee², Zachary C. Holman¹

¹Arizona State University, Tempe, AZ, United States, ²Stanford University, Stanford, CA, United States

2:30 **32% efficient III-V/Si dual-junction solar cells and their challenging path towards cost competitiveness**

Stephanie Essig¹, Christophe Allebé², Timothy Remo³, John F. Geisz³, Myles A. Steiner³, Loris Barraud², J. Scott Ward³, Kelsey Horowitz³, Manuel Schnabel³, Antoine Descoedres², David L. Young³, Michael Woodhouse³, Matthieu Despeisse², Christophe Ballif^{1,2}, Adele Tamboli³

¹École Polytechnique Fédérale de Lausanne (EPFL), Neuchâtel, Switzerland, ²Swiss Center for Electronics and Microtechnology (CSEM), Neuchâtel, Switzerland, ³National Renewable Energy Laboratory (NREL), Golden, CO, United States

2:45 **Best Student Presentation Award Finalist**

Perovskite/Silicon Tandem Solar Cells: Challenges Towards High-Efficiency in 4-Terminal

and Monolithic Devices

Jeremie Werner¹, Brett Kamino², Florent Sahli¹, Davide Sacchetto², Matthias Bräuninger¹, Arnaud Walter², Soo-Jin Moon², Loris Barraud², Bertrand Paviet-Salomon², Jonas Geissbuehler², Christophe Allebé², Stefaan De Wolf¹, Matthieu Despeisse², Sylvain Nicolay², Bjoern Niesen^{1,2}, Christophe Ballif^{1,2}

¹*Ecole Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering (IMT) Photovoltaics and Thin-Film Electronics Laboratory (PV-Lab), Rue de la Maladière 71b, Neuchâtel, Switzerland,* ²*CSEM, PV-Center, Neuchâtel, Switzerland*

Break	
3:00 - 3:30 PM	Ballroom Foyer
Coffee Break	

Joint Area Session - Plenary	
3:30 - 5:00 PM	Marriott Ballroom
International Cooperation Session: Role of Photovoltaics in Creating a "Smart Mobility Society"	

Chair(s): Angele Reinders, Masafumi Yamaguchi, Larry Kazmerski

3:30 Opening Statement

Masafumi Yamaguchi
Toyota Tech. Inst

3:40 Bright Future of a Society with Smart Mobility Enabled by Solar Energy

Akinori Satou
Toyota Motor

3:55 Panel discussion: Short Presentations by Each Panelist

Akinori Satou¹, Charlie Gay², Arnulf Jaeger-Waldau³, Hiroyuki Yamada⁴
¹*Toyota Motor*, ²*DOE*, ³*EC-JRC*, ⁴*NEDO*

4:20 Discussion Among Panelists

4:35 Questions and Comments From Audience

4:55 Summary and Wrap Up

Sarah Kurtz
NREL

Joint Area Session - Oral	
3:30 - 5:00 PM	Maryland A
Thermophotovoltaic (TPV) Workshop	

Chair(s): Myles Steiner, Lewis Fraas

3:30 Overview of TPV Applications

Lew Fraas

- 3:50 **Record setting portable TPV generator: Enabling efficient heat-to-electricity generation at the mesoscale**
Ivan Celanovic
- 4:05 **Solar thermophotovoltaics: state-of-the-art and future prospects**
Peter Bermel
- 4:20 **TPV for UAVs & drones**
Eli Yablonovitch
- 4:35 **Development of GaSb IR solar cells on GaSb and GaAs by Vapor Phase Epitaxy**
Seth Hubbard
- 4:50 **Open Discussion**

Joint Area Session - Oral	
3:30 - 5:00 PM	Delaware B
Multi-national Collaboration on Photovoltaic Grid Integration	

Chair(s): Barry Mather

- 3:30 **Introduction to IEA PVPS Task 14 – High-Penetration of PV in Electricity Grids**
Christoph Mayr
AIT
- 3:45 **Transmission-Level Integration of Renewables: Best Practices and Latest Status in Japan**
Kazuhiko Ogimoto
University of Tokyo
- 4:00 **High-Penetration PV Integration on the Distribution System: Best Practices in Modeling, Operation, and Interconnection**
Barry Mather
NREL
- 4:15 **Integration of Smart Inverters into a Secure Energy Information System**
Gerd Heilscher
Integration of Smart Inverters into a Secure Energy Information System
- 4:30 **Developments on Grid Codes: Coordination and Gaps**
Roland Brundlinger
AIT
- 4:45 **Open Discussion**

Social Activity	
7:00 - 11:00 PM	Smithsonian Air & Space Museum
Conference Dinner (ticket required)	

Friday, June 30, 2017

Registration

8:00 - 8:30 AM

Convention Registration Desk

Registration Opens

Area 2 - Oral

8:30 - 10:00 AM

Marriott Ballroom Salon 3

Advances in CZTSSe

Chair(s): Florian Werner, Rakesh Agrawal

8:30 **The outcome of replacing Sn completely by Ge in Kesterite $\text{Cu}_2\text{ZnSnSe}_4$ solar cells**

Sylvester Sahayaraj^{1,2,4}, Guy Brammertz^{1,2}, Bart Vermang^{3,4}, Thomas Schnabel⁷, Erik Ahlswede⁷, Zijian Hunag^{1,2,5}, Samaneh Ranjbar^{1,2,6}, Marc Meuris^{1,2}, Jef Vleugels⁸, Jef Poortmans^{3,4}
¹imec division IMOMECE - partner in Solliance, Wetenschapspark 1, 3590, Diepenbeek,, Belgium, ²Institute for Material Research (IMO) Hasselt University – partner in Solliance, Wetenschapspark 1, 3590, Diepenbeek,, Belgium, ³imec –partner in Solliance, Kapeldreef 75, 3001, Leuven, Belgium, ⁴Department of Electrical Engineering, KU Leuven, Kasteelpark Arenberg 10, 3001, Heverlee, Belgium, ⁵Laboratory for photovoltaics, University of Luxembourg, rue du Brill 41, 4422 Belvaux,, Belvaux, Luxembourg, ⁶I3N - Departamento de Física, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal, ⁷Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, 70565, Stuttgart, Germany, ⁸Department of Material Engineering, KU Leuven Kasteelpark Arenberg 44, 3001, Heverlee, Belgium

8:45 **Transition Metal Oxides Nano-Layers as Efficient Back Electron Reflectors For $\text{Cu}_2\text{ZnSnSe}_4$ Solar Cells**

Sergio Giraldo¹, Moisés Espíndola-Rodríguez¹, Florian Oliva¹, Víctor Izquierdo-Roca¹, Alejandro Pérez-Rodríguez^{1,2}, Edgardo Saucedo¹
¹Catalonia Institute for Energy Research (IREC), Sant Adrià de Besòs (Barcelona), Spain, ²IN2UB, Departament d'Electrònica, Universitat de Barcelona, Barcelona, Spain

9:00 **Mixed sulfur and selenium annealing study of compound-sputtered bilayer $\text{Cu}_2\text{ZnSnS}_4$ / $\text{Cu}_2\text{ZnSnSe}_4$ precursors**

Nils Ross^{1,2}, Sigbjorn Grini¹, Lasse Vines¹, Charlotte Platzer-Björkman²
¹University of Oslo, Oslo, Norway, ²Uppsala University, Uppsala, Sweden

9:15 **Revealing the Role of Mn Incorporation in $\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$ Photovoltaic Absorber Layer**

Stener Lie¹, Joel M. R. Tan¹, Wenjie Li¹, Shin W. Leow¹, Oki Gunawan², Doug Bishop², Lydia H. Wong¹
¹Nanyang Technological University, Singapore, Singapore, ²IBM T.J. Watson Research Center, Yorktown Heights, NY, United States

9:30 **Non-Vacuum Single Step Synthesis of Large-Grain Size CZTS Photo Absorber for Thin Film Solar Cells by Flux Assisted Chemical Spray**

Ratheesh R. Thankalekshmi, Navjot K. Sidhu, A. C. Rastogi
Electrical and Computer Engineering Department & Center for Autonomous Solar Power, Binghamton University, State University of New York, Binghamton, NY, United States

9:45 **Raman scattering assessment of point defects in kesterite semiconductors: UV resonant Raman characterization for advanced photovoltaics**

Florian OLIVA¹, Sergio Giraldo¹, Mirjana Dimitrievska^{1,2,3}, Paul Pistor¹, Alejandro Martínez-Pérez¹, Lorenzo Calvo-Barrio⁴, Edgardo Saucedo¹, Alejandro Pérez-Rodríguez^{1,5}, Victor Izquierdo-Roca¹
¹Catalonia Institute for Energy Research (IREC), Barcelona, Spain, ²NIST Center for Neutron Research, National Institute of Standards and Technology, Gaithersburg, CO, United States, ³National Renewable Energy Laboratory, Golden, CO, United States, ⁴Centres Científics i Tecnològics de la Universitat de Barcelona (CCiTUB), Barcelona, Spain, ⁵Centres Científics i Tecnològics de la Universitat de Barcelona (CCiTUB), Departament d'Electrònica, Universitat de Barcelona i Tecnològics de la Universitat de Barcelona (CCiTUB), Barcelona, Spain

Area 4 - Oral

8:30 - 10:00 AM

Maryland B&C

Silicon Material and Wafer Technology II

Chair(s): Ron Sinton, Martin Schubert

- 8:30 **Assessing the defect responsible for LeTID: temperature- and injection-dependent lifetime spectroscopy**
Mallory A. Jensen¹, Yan Zhu², Erin E. Looney¹, Ashley E. Morishige¹, Carlos Vargas², Ziv Hameiri², Tonio Buonassisi¹
¹Massachusetts Institute of Technology, Cambridge, MA, United States, ²University of New South Wales, Sydney, Australia
- 8:45 **Microscopic Distribution of Luminescence from Dislocation Clusters in Multicrystalline Silicon Wafers**
Hieu T Nguyen¹, Mallory A Jensen², Lily Li³, Christian Samundsett¹, Hang C Sio¹, Barry Lai⁴, Tonio Buonassisi², Daniel Macdonald¹
¹Research School of Engineering, The Australian National University, Canberra, Australia, ²Massachusetts Institute of Technology, Cambridge, MA, United States, ³Australian National Fabrication Facility, The Australian National University, Canberra, Australia, ⁴Advanced Photon Source, Argonne National Laboratory, Argonne, IL, United States
- 9:00 **Degradation of Surface Passivation and its Impact on Light Induced Degradation Experiments**
David Sperber, Alexander Graf, Daniel Skorka, Axel Herguth, Giso Hahn
University of Konstanz, Konstanz, Germany
- 9:15 **Cross-Validation of Photoluminescence Detected Lifetime and Iron Concentration Measurements on Silicon Bricks and Wafers**
Daniel Chung¹, Bernhard Mitchell¹, Mohsen Goodarzi², Ronald A Sinton³, Daniel Macdonald², Thorsten Trupke¹
¹School of Photovoltaics and Renewable Energy Engineering, University of New South Wales, Sydney, Australia, ²Research School of Engineering, Australian National University, Canberra, Australia, ³Sinton Instruments, Boulder, CO, United States
- 9:30 **Best Student Presentation Award Finalist**
Do grain boundaries matter? Electrical and elemental identification at grain boundaries in LeTID-affected p-type multicrystalline silicon
Mallory A. Jensen¹, Ashley E. Morishige¹, Sagnik Chakraborty², Romika Sharma², Hang C. Sio³, Chang Sun³, Barry Lai⁴, Volker Rose^{4,5}, Amanda Youssef¹, Erin E. Looney¹, Sarah Wieghold¹, Jeremy Poindexter¹, Juan-Pablo Correa-Baena¹, Daniel Macdonald³, Joel B. Li², Tonio Buonassisi¹
¹Massachusetts Institute of Technology, Cambridge, MA, United States, ²Solar Energy Research Institute of Singapore, Singapore, Singapore, ³Australian National University, Canberra, Australia, ⁴Advanced Photon Source, Argonne National Laboratory, Argonne, IL, United States, ⁵Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL, United States

9:45 **Correlations between Industrial PERC Solar Cell Performance and Ingot Level Metrology Data**

Bernhard Mitchell¹, Daniel Chung¹, Quixiang He², Hua Zhang², Zhen Xiong², Pietro P. Altermatt², Rhett Evans¹, Thorsten Trupke¹

¹*Australian Centre for Advanced Photovoltaics, University of New South Wales, Sydney, Australia,*

²*State Key Laboratory of PV Science and Technology, Trina Solar, Changzhou, China*

Area 5 - Oral

8:30 - 10:00 AM

Delaware B

Emerging Characterization Methods

Chair(s): Sarah Wieghold, Sascha Sadewasser

8:30 **Best Student Presentation Award Finalist**

Machine Learning and Correlative Microscopy: How 'Big Data' Techniques Can Benefit Thin Film Solar Cell Characterization

Bradley M. West¹, Michael Stuckelberger¹, Shannon Wojcik², Lei Chen³, Barry Lai⁴, Jörg Maser⁴, Mariana I. Bertoni¹

¹*Arizona State University, Tempe, AZ, United States,* ²*Stanford University, Stanford, CA, United States,* ³*Institute of Energy Conversion, University of Delaware, Newark, DE, United States,*

⁴*Advanced Photon Source, Argonne National Laboratory, Lemont, IL, United States*

8:45 **Photoluminescence-imaging-based Evaluation of Non-uniform CdTe Degradation**

Steve Johnston, David Albin, Peter Hacke, Steven P. Harvey, Helio Moutinho, Mowafak Al-Jassim, Wyatt K. Metzger

National Renewable Energy Laboratory, Golden, CO, United States

9:00 **Metal Induced Contact Recombination Measured By Quasi-steady-state Photoluminescence**

Robert Dumbrell¹, Mattias K Juhl¹, Mengjie Li², Thorsten Trupke¹, Ziv Hameiri¹

¹*University of New South Wales, Sydney, Australia,* ²*Solar Energy Research Institute of Singapore, Singapore, Singapore*

9:15 **Utilizing Time-of-Flight SIMS to Investigate Group V Dopant Distribution in CdTe**

Steven P. Harvey¹, Eric Colegrove¹, Brian McCandless², Dave Albin¹, Mowafak Al-Jassim¹, Wyatt Metzger¹

¹*NREL, Golden, CO, United States,* ²*university of delaware, newark, DE, United States*

9:30 **Quantitative Analysis of Active Dopant Distribution and Estimation of Effective Diffusivity in Phosphorus-Implanted Emitter of Si Solar Cell Using Scanning Nonlinear Dielectric Microscopy**

Kotaro Hirose¹, Katsuto Tanahashi², Hidetaka Takato², Yasuo Cho¹

¹*Tohoku University, Sendai, Japan,* ²*Institute, National Institute of Advanced Industrial Science and Technology, Koriyama, Japan*

9:45 **Simulation of drive-level capacitance profiling to interpret measurements on Cu(In,Ga)Se₂Schottky devices**

Geordie Zapalac, Jeff Bailey

MiaSole Hi-Tech, Santa Clara, CA, United States

Area 8 - Oral

8:30 - 10:00 AM

Delaware A

Simulation and Optimization of Systems

Chair(s): Jessica Forbess, Bodo Littmann

8:30 Analysis of the Impact of Installation Parameters and System Size on Bifacial Gain and Energy Yield of PV Systems

Amir Asgharzadeh¹, Tomas Lubenow¹, Joseph Sink¹, Bill Marion², Chris Deline², Clifford Hansen³, Joshua Stein³, Fatima Toor¹

¹Electrical and Computer Engineering Department, The University of Iowa, Iowa City, IA, United States, ²National Renewable Energy Laboratory, Golden, CO, United States, ³Sandia National Laboratories, Albuquerque, NM, United States

8:45 Dependence of String Power on its Height in the Array in Yoshinogari Mega Solar Power Plant

Shigeomi Hara¹, Makoto Kasu¹, Yasuki Masutomi²

¹Saga University, Saga, Japan, ²Saga Yoshinogari Solar LLC, Kanzaki, Japan

9:00 A bottom-up energy simulation framework to accurately compare PV module topologies under non-uniform and dynamic operating conditions

Patrizio Manganiello^{1,2}, Maro Baka³, Hans Goverde¹, Tom Borgers¹, Jonathan Govaerts¹, Arvid van der Heide¹, Eszter Voroshazi¹, Francky Catthoor^{1,2}

¹imec, Heverlee, Belgium, ²KU Leuven, Heverlee, Belgium, ³National Technical University of Athens, Athens, Greece

9:15 A Performance Model for Bifacial PV Modules

Daniel M Riley¹, Clifford W Hansen¹, Joshua S Stein¹, Matthew Lave¹, Johnson J Kallickal¹, Bill Marion², Fatima Toor³

¹Sandia National Laboratories, Albuquerque, NM, United States, ²National Renewable Energy Laboratory, Golden, CO, United States, ³University of Iowa, Iowa City, IA, United States

9:30 Best Student Presentation Award Finalist

Accurate Modeling of Partially Shaded PV Arrays

Bennet E Meyers¹, Mark A Mikofski²

¹Department of Electrical Engineering, Stanford University, Palo Alto, CA, United States,

²SunPower Corporation, Richmond, CA, United States

9:45 Evaluation of uncertainty in PV project design: definition of scenarios and impact on energy yield predictions

Giorgio Belluardo¹, Magnus Herz², Ulrike Jahn², Mauricio Richter³, David Moser¹

¹Institute for Renewable Energy - EURAC Research, Bolzano, Italy, ²TÜV Rheinland Energy, Cologne, Germany, ³3E sa, Brussels, Belgium

Joint Area Session - Oral

8:30 - 10:00 AM

Virginia A

Si-Based Tandems: III-Vs and II-VIs

Chair(s): Ammar Nayfeh, Stephen Bremner

8:30 Best Student Presentation Award Finalist

Monocrystalline 1.7 eV MgCdTe double-heterostructure subcell for high-efficiency II-VI/Si tandem device applications

Calli M. Campbell^{1,2}, Xin-Hao Zhao^{1,2}, Yuan Zhao^{1,3}, Mathieu Boccard³, Cheng-Ying Tsai^{1,3}, Jacob

J. Becker^{1,3}, Zachary Holman³, Yong-Hang Zhang^{1,3}

¹Center for Photonics Innovation, Arizona State University, Tempe, AZ, United States, ²School for the Engineering of Matter, Transport and Energy, Arizona State University, Tempe, AZ, United States, ³School of Engineering of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, United States

8:45 **Best Student Presentation Award Finalist**

MBE growth of 1.7eV Al_{0.2}Ga_{0.8}As and 1.42eV GaAs solar cells on Si using dislocations filters: an alternative pathway toward III-V/Si solar cells architectures

Arthur Onno¹, Mingchu Tang¹, Mu Wang¹, Yuri Maidaniuk², Mourad Benamara², Yuriy I. Mazur², Gregory J. Salamo², Lars Oberbeck³, Jiang Wu¹, Huiyun Liu¹

¹University College London, London, United Kingdom, ²University of Arkansas, Lafayette, AR, United States, ³Total Gas, Renewables & Power, Paris La Défense, France

9:00 **III-V/Si Tandem Cells Utilizing Interdigitated Back Contact Si Cells and Varying Terminal Configurations**

Manuel Schnabel¹, Michael Rienäcker², Agnes Merkle², Talysa R. Klein¹, Nikhil Jain¹, Stephanie Essig^{1*}, Maikel F.A.M. van Hest¹, John Geisz¹, Jan Schmidt², Rolf Brendel², Robby Peibst², Paul Stradins¹, Adele Tamboli¹

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Institute for Solar Energy Research Hamelin, Emmerthal, Germany

9:15 **Towards High-Efficiency GaAsP/Si Tandem Cells**

Shizhao Fan¹, Michelle Vaisman^{2,3}, Kevin N. Yaung², Emmett Perl³, Diego Martín-Martín⁴, Mehdi Leilaouioun⁵, Zachary Holman⁵, Minjoo L. Lee^{1,2}

¹University of Illinois at Urbana and Champaign, Urbana, IL, United States, ²Yale University, New Haven, CT, United States, ³National Renewable Energy Laboratory, Golden, CO, United States, ⁴Universidad Rey Juan Carlos, Madrid, Spain, ⁵Arizona State University, Tempe, AZ, United States

9:30 **Cost Competitive CdTe/Silicon Tandem Solar Cells**

David C. Bobela, Ana Kanevce, Timothy Remo, Kirstin Alberi, Michael Woodhouse, Adele C. Tamboli

National Renewable Energy Laboratory, Golden, CO, United States

9:45 **Characterization of Heteroepitaxial GaAs Films Grown on Si using Selective Area Nucleation**

Emily L. Warren¹, Emily A. Makoutz^{1,2}, Michelle Vaisman^{1,3}, Benjamin F. Bachman^{1,4}, William E. McMahon², Jeremy A. Zimmerman¹, Adele C. Tamboli⁴

¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States, ³Yale University, New Haven, CT, United States, ⁴University of Oregon, Eugene, OR, United States

Break

10:00 - 10:30 AM

Ballroom Foyer

Coffee Break

Area 1 - Oral

10:30 - 12:00 PM

Maryland A

Novel Materials and Processing

Chair(s): Dongheon Ha, Ching-Fuh Lin

- 10:30 **Efficient Photon Upconversion in Semiconductor Nanostructures: Constraints and Opportunities**
 Matthew F. Doty¹, Eric Y. Chen¹, Jing Zhang², Diane G. Sellers¹, Zhuohui Li¹, Christopher C. Milleville¹, Kyle Lennon³, Joshua M. O. Zide¹
¹*Department of Materials Science and Engineering, University of Delaware, Newark, DE, United States*, ²*Department of Chemistry, University of Delaware, Newark, DE, United States*, ³*Department of Chemical and Biomolecular Engineering, University of Delaware, Newark, DE, United States*
- 10:45 **Enhanced Ultra-Thin a-Ge:H Solar Cells by Plasmonic Nanoparticles Embedded in the Optical Resonant Cavity**
 Brendan Brady¹, Volker Steenhoff², Benedikt Nickel², Martin Vehse², Alexandre Brolo¹
¹*University of Victoria - Centre for Advanced Materials and Related Technology, Victoria, BC, Canada*, ²*NEXT ENERGY - University of Oldenburg, Oldenburg, Germany*
- 11:00 **Native-Metal-Oxide Coated Plasmonic Electrodes for Nanophotonic Light Trapping and Efficient Charge Collection.**
 Deirdre M. O'Carroll^{1,2}, Christopher E. Petoukhoff¹, Zhongkai Cheng², Zeqing Shen², Catrice Carter¹
¹*Rutgers University, Dept. of Materials Science and Engineering, Piscataway, NJ, United States*, ²*Rutgers University, Dept. of Chemistry, Piscataway, NJ, United States*
- 11:15 **In-Ga precursor islands for CIGSe micro-concentrator solar cells.**
 Katharina Eylers¹, Franziska Ringleb¹, Berit Heidmann^{2,3}, Sergiu Levenco², Thomas Unold², Hagen W. Klemm⁴, Gina Peschel⁴, Alexander Fuhrich⁴, Thomas Teubner¹, Thomas Schmidt⁴, Martina Schmid⁵, Torsten Boeck¹
¹*Leibniz institute for crystal growth, Berlin, Germany*, ²*Helmholtz-Zentrum Berlin, Berlin, Germany*, ³*Department of physics, Freie Universität Berlin, Berlin, Germany*, ⁴*Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany*, ⁵*Universität Duisburg-Essen, Duisburg, Germany*
- 11:30 **Advances in silicon surface texturization by metal assisted chemical etching for photovoltaic applications**
 S Le Gall¹, R Lachaume¹, E Torralba², M Halbwx³, V Magnin³, T El Assimi², M Fouchier³, J Harari³, J-P Vilcot³, C Cachet-Vivier², S Bastide²
¹*Génie Electrique et Electronique de Paris, Gif sur Yvette, France*, ²*Institut de Chimie et des Matériaux Paris-Est, Thiais, France*, ³*Institut d'Electronique, Microélectronique et Nanotechnologies, Villeneuve d'Ascq, France*
- 11:45 **Single Crystalline Substrates for III-V Growth via Exfoliation of Bulk Single Crystals**
 Celeste L. Melamed^{1,2}, Brenden R. Ortiz², Aaron Martinez^{1,2}, Adele C. Tamboli^{1,2}, Andrew Norman¹, Eric S. Toberer^{1,2}
¹*National Renewable Energy Laboratory, Golden, CO, United States*, ²*Colorado School of Mines, Golden, CO, United States*

Area 2 - Oral

10:30 - 12:00 PM

Marriott Ballroom Salon 3

Advances in CdTe II

Chair(s): Brian McCandless, Jason Kephart

- 10:30 **CuZnS hole contacts on monocrystalline CdTe solar cells**
 Jacob Becker^{1,2}, Xiaojie Xu⁴, Rachel Woods-Robinson⁴, Calli M. Campbell^{1,3}, Maxwell Lassise^{1,2}, Joel Ager⁴, Yong-Hang Zhang^{1,2}
¹*Center for Photonics Innovation, Arizona State University, Tempe, AZ, United States*, ²*School of*

Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, United States, ³School for Engineering of Matter, Transport and Energy, Tempe, AZ, United States, ⁴Material Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, United States

10:45 The Effect of the CdCl₂ Heat Treatment on CdSe_xTe_{1-x} Solar Cells

Chih An Hsu, Vasilios Palekis, Imran Khan, Shamara Collin, Don Morel, Chris Ferekides
University of South Florida, Tampa, FL, United States

11:00 Point Defects in CdTe Bulk Single Crystals Grown in Cd-rich Conditions

Tursun Ablekim, Santosh K. Swain, Kelvin G. Lynn
Center for Materials Research, The School of Mechanical and Materials Engineering, Pullman, WA, United States

11:15 Effects of CdCl₂ treatment on the local electronic properties of polycrystalline CdTe measured with photoemission electron microscopy

Morgann E Berg^{1,2}, Jason M Kephart³, Walajabad S. Sampath³, Taisuke Ohta^{1,2}, Calvin C Chan¹
¹Sandia National Laboratories, Albuquerque, NM, United States, ²Center for Integrated Nanotechnologies, Albuquerque, NM, United States, ³Colorado State University, Fort Collins, CO, United States

11:30 Optical Properties of CdSe_{1-x}S_x and CdSe_{1-y}Te_y Alloys and Their Application for CdTe Photovoltaics

Maxwell M. Junda^{1,2}, Corey R. Grice^{1,2}, Prakash Koirala^{1,2}, Robert W. Collins^{1,2}, Yanfa Yan^{1,2}, Nikolas J. Podraza^{1,2}
¹University of Toledo Department of Physics & Astronomy, Toledo, OH, United States, ²The Wright Center for Photovoltaics Innovation & Commercialization, Toledo, OH, United States

11:45 Blistering of magnetron sputtered thin film CdTe devices

John M Walls, Piotr M Kaminski, Sibel Yilmaz, Ali Abbas, Francesco Bittau, Jake W Bowers, Rachael C Greenhalgh
Loughborough University, Loughborough, United Kingdom

Area 4 - Oral

10:30 - 12:00 PM

Maryland B&C

Metallization, Contact Formation and Module Integration

Chair(s): Radovan Kopecek, Hartmut Nussbaumer

10:30 Novel Positive-Masked Plating Process for Silicon Heterojunction Solar Cell Metallization

Markus Glatthaar, Rukmangada Rohit, Andreas Rodofili, Yitzhak J. Snow, Jan Nekarda, Jonas Bartsch
Fraunhofer Institute for Solar Energysystems ISE, Freiburg, Germany

10:45 Energy Yield of Silicon Modules in Various Climates: Impact of Solar Cell Architecture and Cell Interconnection

Jan Haschke¹, Johannes P. Seif¹, Yannick Riesen¹, Loïc Tous², Patrick Choulat², Monica Aleman², Jonathan Champlaud³, Jacques Levrat³, Amir A. Abdallah⁴, Brahim Aïssa⁴, Nouar Tabet⁴, Nicolas Wyrsh¹, Matthieu Despeisse³, Jozef Szlufcik², Stefaan De Wolf^{1,5}, Christophe Ballif^{1,3}
¹Ecole Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering (IMT), Photovoltaics and Thin-Film Electronics Laboratory (PV-lab), Neuchâtel, Switzerland, ²Interuniversity Microelectronics Center (imec), Leuven, Belgium, ³Swiss Center for Electronics and Microtechnology (CSEM), PV-center, Neuchâtel, Switzerland, ⁴Qatar Environment and Energy Research Institute (QEERI), Hamad bin Khalifa University, Doha, Qatar, ⁵Now with: King Abdullah University of Science and Technology (KAUST), KAUST Solar Center (KSC), Thuwal, Saudi Arabia

11:00 **Structuring of Metal Layers by Electrochemical Screen Printing for Back Contact Solar Cells**
Mathias Kamp¹, Raphael Efinger¹, Katharina Gensowski¹, Sebastian Bechmann², Jonas Bartsch¹
¹Fraunhofer Institute for Solar Energy Systems, Freiburg im Breisgau, Germany, ²Christian Koenen GmbH, Ottobrunn-Riemerling, Germany

11:15 **High Efficiency Copper Paste Al-BSF Cells with 19% Efficiency**
Tetsuya Fukuda¹, Yuji Kurimoto¹, Tomohiro Saito², Daisuke Ando^{1,2}, Yuji Sutou^{1,2}, Katsuhiko Shirasawa², Junichi Koike^{1,2}
¹Material Concept, Inc., Sendai, Japan, ²Tohoku University, Sendai, Japan

11:30 **Novel Rear Side Metallization Route for Si Solar Cells Using a Transparent Conducting Adhesive**
Manuel Schnabel, Talysa R. Klein, Benjamin G. Lee, William Nemeth, Vincenzo LaSalvia, Maikel F.A.M. van Hest, Paul Stradins
National Renewable Energy Laboratory, Golden, CO, United States

11:45 **Multilayer Foil Metallization for All Back Contact Cells**
David H Levy¹, David E Carlson²
¹Natcore Technology, Rochester, NY, United States, ²CarlsonPV, Williamsburg, VA, United States

Area 5 - Oral

10:30 - 12:00 PM

Delaware A

Non-Destructive Characterization Methods

Chair(s): Sarah Wieghold, Harvey Guthrey

10:30 **Electroluminescence Excitation Spectroscopy: A Novel Approach to Non-Contact Quantum Efficiency Measurements**
Kristopher O. Davis¹, Greg S. Horner², Joshua B. Gallon², Leonid A. Vasilyev², Kyle B. Lu², Antonius B. Dirriwachter², Terry B. Rigdon², Eric J. Schneller¹, Kortan Ögütman³, Richard K. Ahrenkiel⁴
¹Florida Solar Energy Center, University of Central Florida, Cocoa, FL, United States, ²Tau Science Corporation, Hillsboro, OR, United States, ³Dept. of Electrical Engineering and Computer Science, University of Central Florida, Orlando, FL, United States, ⁴Ahrenkiel Consulting, Lakewood, CO, United States

10:45 **Illuminated Outdoor Luminescence Imaging of Photovoltaic Modules**
Timothy J Silverman¹, Michael G. Deceglie¹, Kaitlyn VanSant², Steve Johnston¹, Ingrid Repins¹
¹National Renewable Energy Laboratory, Golden, CO, United States, ²Colorado School of Mines, Golden, CO, United States

11:00 **Electroluminescent Image Processing and Cell Degradation Type Classification via Computer Vision and Statistical Learning Methodologies**
Justin S. Fada¹, Mohammad A. Hossain¹, Jennifer L. Braid¹, Shuying Yang², Timothy J. Peshek¹, Roger H. French¹
¹SDLE Research Center, Cleveland, OH, United States, ²SunEdison Inc., Belmont, CA, United States

11:15 **Towards Developing a Standard for Testing Bifacial PV Modules: Single-Side versus Double-Side Illumination Method I-V Measurements Under Different Irradiances and Temperatures**
Stefan Roest¹, Witek Nawara¹, Bas B. Van Aken², Elias Garcia Goma¹
¹Eternal Sun Group, Den Haag, Netherlands, ²ECN Solar, Petten, Netherlands

11:30 **Electrical Transport Properties from Long Wavelength Ellipsometry**
Prakash Uprety¹, Indra Subedi¹, Maxwell M. Junda¹, Michael A. Slocum², David V. Forbes², Seth M. Hubbard², Nikolas J. Podraza¹
¹*Wright Center for Photovoltaics Innovation and Commercialization & Department of Physics and Astronomy, University of Toledo, Toledo, OH, United States*, ²*NanoPower Research Laboratory, Rochester Institute of Technology, Rochester, NY, United States*

11:45 **In Situ Raman Monitoring of Kesterite Cu₂ZnSnS₄ Phase Formation from Sulfurization of Sol-gel Oxide Precursors**
Osama M Awadallah, Joseph D Hernandez, Andriy Durygin, Zhe Cheng
Florida International University, Miami, FL, United States

Area 9 - Oral	
10:30 - 12:00 PM	Delaware B
Field Reliability	

Chair(s): David Meakin, Anil Kottantharayil, Ralph Gottschalg

10:30 **Performance of Field-Aged PV Modules in India: Results from 2016 All India Survey of PV Module Reliability**
Rajiv Dubey¹, Sachin Zachariah¹, Shashwata Chattopadhyay¹, Vivek Kuthanazhi¹, Sugguna Rambabu¹, Sonali Bhaduri², Hemant K. Singh¹, Archana Sinha¹, Chetan S. Solanki^{1,2}, Anil Kottantharayil¹, Brij M. Arora¹, K. L. Narasimhan¹, Juzer Vasi¹, Birinchi Bora³, Rajesh Kumar³, O. S. Sastry³
¹*National Centre for Photovoltaic Research and Education, Indian Institute of Technology Bombay, Mumbai, India*, ²*Energy Science and Engineering Department, Institute of Technology Bombay, Mumbai, India*, ³*National Institute for Solar Energy, Ministry of New and Renewable Energy, New Delhi, New Delhi, India*

10:45 **Inferring the Performance Ratio of PV systems distributed in an region: a real-case study in South Tyrol**
Marco Pierro^{1,2}, Giorgio Belluardo¹, Cristina Cornaro², David Moser¹
¹*Institute for Renewable Energy - EURAC Research, Bolzano, Italy*, ²*Department of Enterprise Engineering - University of Rome Tor Vergata, Roma, Italy*

11:00 **Silicon Heterostructure PV System Field Performance**
Dirk C. Jordan, Steve Johnston, Steve Rummel, Bill Sekulic, Peter Hacke, Chris Deline, Sarah Kurtz
NREL, Golden, CO, United States

11:15 **Quantify PV Module Degradation based on Model Coefficients Extracted from an Embedded Data Acquisition Devices**
C Birk Jones, Bruce H. King, Joshua S. Stein, Olga Lavrova
Sandia National Lab, Albuquerque, NM, United States

11:30 **Simulating PV System Performance with Component Reliability Distributions**
Geoffrey T Klise¹, Janine M Freeman², Olga Lavrova¹
¹*Sandia National Laboratories, Albuquerque, NM, United States*, ²*National Renewable Energy Laboratory, Golden, CO, United States*

11:45 **Lifetime and Degradation of Pre-damaged PV-Modules – Field study and lab testing**
Claudia Buerhop¹, Sven Wirsching¹, Simon Gehre¹, Tobias Pickel¹, Thilo Winkler¹, Andreas Bemm², Julia Mergheim³, Christian Camus¹, Jens Hauch¹, Christoph J. Brabec⁴

¹ZAE Bayern, Erlangen, Germany, ²AZT, München, Germany, ³LTM, Erlangen, Germany, ⁴i-MEET, Erlangen, Germany

Joint Area Session - Oral	
10:30 - 12:00 PM	Virginia A
Mobile PV	

Chair(s): Rao Tatavarti, Wolfgang Guter

10:30 IMM Triple-junction Solar Cells and Modules optimized for Space and Terrestrial Conditions

Tatsuya Takamoto¹, Hiroyuki Juso¹, Kohsuke Ueda¹, Hidetoshi Washio¹, Hiroshi Yamaguchi¹, Mitsuru Imaizumi², Taishi Sumita², Tetsuya Nakamura²
¹Sharp Corporation, Nara, GA, Japan, ²JAXA, Tsukuba, , Japan

10:45 Very High Specific Power ELO Solar Cells (>3 kW/kg) for UAV, Space, and Portable Power Applications

Drew Cardwell, Alex Kirk, Christopher Stender, Andree Wibowo, Francis Tuminello, Martin Drees, Ray Chan, Mark Osowski, Noren Pan
MicroLink Devices Inc., Niles, IL, United States

11:00 Enhanced Endurance of a Unmanned Aerial Vehicles Using High Efficiency Si and III-V Solar Cells

David A Scheiman¹, Raymond Hoheisel², Daniel J Edwards¹, Andrew Paulsen³, Justin Lorentzen¹, Steve Carruthers¹, Sam Carter⁴, Matthew Kelly¹, Phillip P Jenkins¹, Robert Walters¹
¹Naval Reseach Laboratory, Washington, DC, United States, ²George Washington University, Washington, DC, United States, ³Packet Digital, Fargo, ND, United States, ⁴Envisioneering, Alexandria, VA, United States

11:15 Lightweight, Flexible GaAs Solar Arrays for Space and Near Space Applications

Aarohi Vijh, Robert C Parenti
Alta Devices, Inc., Sunnyvale, CA, United States

11:30 Through-Epitaxial Via Back-Contact Multi-Junction Solar Cells Fabricated Using Epitaxial Lift-Off

Rekha Reddy, Christopher L Stender, Christopher Youtsey
MicroLink Devices, Inc., Niles, IL, United States

11:45 Design of InGaP/GaAs/InGaAs multi-junction cells with reduced layer thicknesses using light-trapping rear texture

Lin Zhu¹, Anurag Reddy², Kentaroh Watanabe², Masakazu Sugiyama², Yoshiaki Nakano², Hidefumi Akiyama¹
¹Institute for Solid State Physics, University of Tokyo and JST-CREST, Kashiwa, Chiba, Japan, ²School of Engineering and RCAST, the University of Tokyo, Tokyo, Japan

Keynote	
12:00 - 1:00 PM	Marriott Ballroom
Closing/Award Cermony	

12:00 Opening Remarks

Angèle Reinders

12:10 PVSC Napkin Award Presentation

Geoff Bradshaw

12:15 Student Awards

Geoff Bradshaw

12:35 Technical Highlights

Seth Hubbard

12:45 Announcement of Future Conferences

Masafumi Yamaguchi, Arno Smets, Alex Freundlich

12:55 Closing of the Conference

Angèle Reinders