SYMPOSIUM ES14

Thin-Film Chalcogenide Semiconductor Photovoltaics
April 18 - April 21, 2017

Symposium Organizers
Shubhra Bansal, University of Nevada-Las Vegas
Ingrid Repins, National Renewable Energy Laboratory
Sascha Sadewasser, International Iberian Nanotechnology Laboratory
Edgardo Saucedo Silva, Catalan Institute for Energy Research (IREC)

Symposium Support
Dr. Eberl MBE-Komponenten GmbH
First Solar
International Iberian Nanotechnology Laboratory
National Renewable Energy Laboratory

Proceedings Statement
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* Invited Paper

TUTORIAL
Young Scientist Tutorial on Characterization Techniques for Thin-Film Solar Cells
Monday Morning, April 17, 2017
8:30 AM – 5:00 PM
PCC North, 200 Level, Room 229 B

8:30 AM - 8:35 AM
Welcome

8:35 AM - 9:50 AM
Part I: Thomas Paul Weiss
Device Characterization and Modeling

Basic concepts of electrical characterization using IV, QE, EBIC, C-V and C-f. Discussion of characteristic features of QE and I-V curves and how to extract the diode parameters using a 1-diode model. EBIC as a tool to access the carrier collection function and its connection to the device QE. Various contributions of a solar cell to its capacitance and how C-V and C-f measurements can be employed to extract doping densities, charge-carrier barriers and deep defect levels.

9:50 AM BREAK

10:20 AM – 11:35 AM
Part II: Matthias Maiberg
Characterization of Thin-Film Semiconductors by Time-Resolved Luminescence

Introduction to measurement and analysis of time-resolved luminescence (TRL) in photovoltaic thin-film semiconductors. Discussion of various techniques for measurement of TRL as well as advantages and disadvantages. Examples for luminescence decay curves from measurements on Cu(In,Ga)Se2 and Cu2ZnSnSe4. Classification of these luminescence transients and determination of material parameters using simulations.

11:35 AM LUNCH

12:45 PM - 2:00 PM
Part III: Michelle Mezher
Soft X-Ray and Electron Spectroscopy

Introduction to several soft x-ray characterization techniques, including x-ray and UV photoelectron spectroscopy, inverse photoemission spectroscopy and x-ray emission spectroscopy. Discussion includes how they can be used to determine the electronic and chemical structure of surfaces and interfaces in photovoltaic devices.

2:00 PM BREAK

2:30 PM - 3:45 PM
Part IV: Jacob Gruber and Jose J. Chavez
Introduction to Atomic Modeling for Materials Characterization

Introduction to atomistic modeling in general. Several example applications for the study of mechanical behaviors of materials while avoiding potential pitfalls. Along with post processing tools, application for the study of structure and behavior of defects, analysis of bulk properties from models of atomic interactions, as well as of synthesis processes for numerous materials systems.

3:45 PM - 5:00 PM
Part V: Tao Song
Device Design and Modeling of Thin-Film Photovoltaic Devices

Basic design principles of thin-film solar cells and techniques. Numerical simulation to support interpretation of experimental results. Examples to illustrate the importance of device modeling, including the impact of material parameters on cell performance, the energy band alignment and interface recombination, as well as the grain boundary and non-uniformity issues of thin-film solar cells.

5:00 PM
Closing Remarks

Instructors
Thomas Paul Weiss, Swiss Federal Laboratories for Materials Science and Technology (EMPA)
Matthias Maiberg, Martin Luther University of Halle-Wittenberg
Michelle Mezher, University of Nevada, Las Vegas
Jacob Gruber, Drexel University
Jose J. Chavez, Sandia National Laboratories
Tao Song, Colorado State University

SESSION ES14.1: Passivation

Session Chairs: Sascha Sadewasser and Edgardo Saucedo Silva
Tuesday Morning, April 18, 2017
PCC North, 200 Level, Room 229 B

10:30 AM **ES14.1.01
Improving the Open-Circuit Voltage of Cu2ZnSnSe4 Thin-Film Solar Cells via Interface Passivation Byungha Shin; KAIST, Korea (the Republic of).

11:00 AM ES14.1.02
Boosting the Open Circuit Voltage of Cu2ZnSnS4 Solar Cells by a Lattice-Matched CeO2 Layer and Theoretical Understanding of Interface Defects Andrea Croveto*; 1, 2, 3Technical University of Denmark, Denmark; 1University of New South Wales, Australia.

11:15 AM ES14.1.03
Understanding the Full Effects of Rear Contact Passivation in CIGS Solar Cells Pedro M. Salone; INL, Portugal.

11:30 AM ES14.1.04
Improved CdTe Solar-Cell Performance with An Evaporated Te Layer before the Back Contact Andrew Moore; Colorado State University, United States.

11:45 AM ES14.1.05
On the Effects of Chalcogen Excess for High Efficiency Kesterite Solar Cells Douglas M. Bishop; IBM T.J. Watson Research Center, United States.
SESSION ES14.2: Absorber Characterization
Session Chairs: Matthias Maiberg and Byungha Shin
Tuesday Afternoon, April 18, 2017
PCC North, 200 Level, Room 229 B

1:30 PM *ES14.2.01
Correlative Optical Microscopy of Charge Carrier Lifetimes, Mobilities and Space Charge Fields in Thin-Film Chalcopyrite Solar Cells
Darius Kocieneikas; National Renewable Energy Laboratory, United States.

2:00 PM ES14.2.02
Expanding the Theory of the Diode Factor from Devices towards Semiconductor Layers Using the Example of Cu(In,Ga)Se_2, Finn Babbe; University of Luxembourg, Luxembourg.

2:15 PM ES14.2.03
Structural Defects and Lateral Composition Inhomogeneities in Cu(In,Ga)Se_2 Layers Grown by Multistage Co-Evaporation
Enrico Avancini; Empa, Switzerland.

2:30 PM ES14.2.04
Interpreting Time-Resolved Photoluminescence for Chalcopyrite and Kesterite Absorbers and Devices
Charles Hages; Helmholtz Zentrum Berlin, Germany.

2:45 PM ES14.2.05
Origin of Band-Tails in Kesterite
Germain Rey; University of Luxembourg, Luxembourg.

3:00 PM BREAK

SESSION ES14.3: Interfaces and Contacts
Session Chairs: Sergio Giraldo and Clemens Heske
Tuesday Afternoon, April 18, 2017
PCC North, 200 Level, Room 229 B

3:30 PM *ES14.3.01
(Zn,Mg)O Transparent Electrode and Buffer Layer for Junction Control in Cu(In,Ga)(Se,S)_2 Solar Cells
Takashi Mingamoto; Ritsumeikan University, Japan.

4:00 PM ES14.3.02
Benefit of Textured CIGS Cells for Low Reflecting Nanogrid Application
Joon van Deelen; TNO, Netherlands.

4:15 PM ES14.3.03
Well-Controlled Dielectric Nanomeshes by Colloidal Nanosphere Lithography for Opto-Electronic Enhancement of Ultrathin Cu(In,Ga)Se_2 Solar Cells
Guanchao Yin; Helmholtz Zentrum Berlin, Germany.

4:30 PM *ES14.3.04
Alternative Buffer and Front Contact Layers for Thin-Film Chalcopyride Cells
Yaroslav E. Romanyuk; EMPA, Switzerland.

SESSION ES14.4: Poster Session I: Passivation, Absorber and Advanced Characterization, Interfaces and Contacts
Session Chairs: Ingrid Repins and Edgardo Saucedo Silva
Tuesday Afternoon, April 18, 2017
8:00 PM - 10:00 PM
Sheraton, Third Level, Phoenix Ballroom

ES14.4.01
Mapping Disordered Nanodomains in Cu_(Zn,Sn)S_x and Cu_(Zn,Sn)Se_y S_z
Dennis S. Prozans; University of Utah, United States.

ES14.4.02
Nondestructive High-Power-High-Temperature Raman Spectroscopy for Probing Microscopic Structural Variations in CZTSe Alloys
Qiong Chen; University of North Carolina at Charlotte, United States.

ES14.4.03
Effects of CdCl_2 Treatment and Br_/MeOH Etching on the Absorption of CdTe Thin Films as Measured by Photothermal Deflection Spectroscopy
Jordan J. Andrews; University of British Columbia Okanagan, Canada; University of British Columbia, Canada.

ES14.4.04
Simulation Study of Photoluminescence Lifetime and Device Efficiency of Cu(In,Ga)Se_2 Thin Film Solar Cells
Jose Fabio Lopez Salas; University of Oldenburg, Germany.

ES14.4.05
High Fidelity Polycrystalline CdTe/CdS Heterostructures via Molecular Dynamics
Rodolfo Aguirre; The University of Texas at El Paso, United States.

ES14.4.06
Charged Grain Boundaries Reduce the Open Circuit Voltage of Polycrystalline Solar Cells—An Analytic Description
Benoit Gaury; National Institute of Standards and Technology, United States; University of Maryland, United States.

ES14.4.07
Admittance-Spectroscopy Model of CIGS-Based Solar Cells
Kazimierz J. Plucinski; Military University of Technology, Poland.

ES14.4.08
XESCA—X-Ray Emission Spectroscopy for Chemical Analysis
Sang Jun Lee; SLAC, United States; Stanford University, United States.

ES14.4.09
Surface Phases in (Ag,Cu)(In,Ga)Se_2 Semiconductors Determined by Ultraviolet and X-Ray Photoemission Spectroscopy
Kevin Jones; University of Delaware, United States.

ES14.4.10
Evaluation of Electrical Characteristics of Cu(In,Ga)(S,Se)_2 Thin Films Prepared by a Two-Step Sputtering/Anealing Large-Scale Fabrication Process
Hwan Kim; Ewha Womans University, Korea (the Republic of).

ES14.4.11
Surface and Local Electronic Properties of (Ag,Cu)ZnSn(S,Se)_2 Photovoltaic Absorbers Grown by 2-Step Processes
Hwan Kim; Ewha Womans University, Korea (the Republic of).

ES14.4.12
Revisiting Thin-Film Absorption Coefficient Measurement from Photoluminescence
Germain Rey; University of Luxembourg, Luxembourg.

ES14.4.13
Role of Defects in Cu(In,Ga)Se_2 Solar Cells with CdS and Zn(1-x)Sn(x) O(y) Buffer Layers—Microscopy and Photoluminescence Study
Jennifer P. Teixeira; Unive de Aveiro, Portugal.

ES14.4.14
Effect of Varying the Cu Content on Cu(In,Ga)Se_2 Solar Cells
Jennifer P. Teixeira; Unive de Aveiro, Portugal.

ES14.4.15
Characterization of CIGS Solar Cells through Glow Discharge Optical Emission Spectroscopy and Differential Interferometry Profiling
Matthieu Chausseau; HORIBA Scientific, United States.

ES14.4.16
Luminescence Detection of the 0.8eV Defect
Conrad Spindler; University of Luxembourg, Luxembourg.

ES14.4.17
Role of Pre-Layer Mo Films in Microstructural and Morphological Properties of Over-Layer CIGS Films
Hamda Al-Thani; National Energy & Water Research Center (NEWRC), United Arab Emirates.

ES14.4.18
Compositional Influence of the Cationic Solution in CZTS Thin Films Deposited by SILAR for Solar Cells Applications
Shadi Lu Gu Lored; Centro de Investigación en Materiales Avanzados S. C. Unidad Monterrey, Mexico.
ES14.4.19 Photoconductive Properties of Nano-Flakes Assembled Porous Microspheres CuInS2 CdTe V- Thin Films via Hydrothermal Method on Spray Seed Coated Substrates K. Sethuraman 1, 3; 3University of Alabama, United States; 3Madurai Kamaraj University, India.

ES14.4.20 Evaporated CdInS2 Buffer Layer for Kesterite Solar Cells Leo Choubry; Institut des Matériaux Jean Rouxel (IMN), Université de Nantes, France.

ES14.4.21 Back Contact Functionalization by Transition Metal Oxides for Kesterite Solar Cells Sergio Giraldo; Catalonia Institute for Energy Research (IREC), Spain.

ES14.4.22 Electronic Structure of Cu(In,Ga)(S,Se) Surface and CdS/Cu(In,Ga) (S,Se) Interface Suehiro Kawamura; Kagoshima University, Japan.


ES14.4.24 CuZnSn(S,Se)2 Surface Modification by Epitaxial Growth of Al(OH) Nanolayers—Impact on the Devices Efficiency Edgardo Suández Silva; IREC, Spain.

ES14.4.25 Zn1-xSn xO2/Cu2ZnSnS4 Interface and Its Chemical Structure Studied by Soft X-Ray Spectroscopies Bridget Eizman; University of Nevada, Las Vegas, United States.

ES14.4.26 Bi-Facial CdTe Thin Film Solar Cells Using Nanowire Back Contact for Flexible Applications Yongbeom Kwon; Korea University, Korea (the Republic of).

ES14.4.27 From Bandstructure to Bandalignment—A Study on Chalcopyrite Surfaces Christian Pottenkofer; Helmholtz-Zentrum Berlin, Germany.

ES14.4.28 Cadmium Tin Oxide and Zinc Magnesium Oxide Prepared by Hollow Cathode Sputtering for CdTe Photovoltaics Alan F. Deblieck; CNBM New Energy Materials Research Center, Department of Physics, New Jersey Institute of Technology, United States.

ES14.4.29 ALD of ZnO, S Buffer Layer Films Samuel Wilson; University of Florida, United States.

ES14.4.30 DFT Calculations and XPS Analysis of the Adsorption of Transition Metal-Citrate Complexes on a CdS Surface for the Deposition of Cu2ZnSnS4 Thin Films Raquel Garza Hernandez; Centro de Investigación en Materiales Avanzados S. C. Unidad Monterrey, Mexico.

ES14.4.31 A Comparative Study of CdTe/CdS Junction Activation Using MgCl, and CdCl3 Xavier Mathew; Instituto de Energías Renovables, Universidad Nacional Autónoma de México, Mexico.

ES14.4.32 Structural and Optical Properties of CdS Se Thin-Film Chalcopyride Glass Pawan Kumar 1, 3; 1University of Puerto Rico San Juan, United States; 3Garukula Kangri University Haridwar, India.

ES14.4.33 Deposition Kinetics of Zinc Oxide Thin Films by Magnetron Sputtering Yifei Sun; Macalester College, United States.

ES14.4.34 Effects of Gas Flow Rate on the Properties of SnO2 Thin Films Deposited by RF Sputtering Muntaser Al-Mansoori; Masdar Institute of Science and Technology, United Arab Emirates.

ES14.4.35 Micropatterned Oxide Layers for Front Contact Passivation in CdTe-Based Thin-Film Photovoltaics Jason M. Keplarh; Colorado State University, United States.

ES14.4.36 CIGS Performance Enhancement by Texturisation Joop van Deelen; TNO, Netherlands.

ES14.4.37 Investigation of Crystal Growth Mechanisms of the CuGaSe2 - CuAlSe2 Single Crystals Grown by Chemical Vapor Transport B V. Korzun; The City University of New York, Borough of Manhattan Community College, United States.

ES14.4.38 Mössbauer Studies of the CuFeO4_2-x Thin Films System B V. Korzun; The City University of New York, Borough of Manhattan Community College, United States.

8:30 AM *ES14.5.01/ES11.5.01 Efficiency Potential and Recent Activities of High Efficiency and Si Tandem Solar Cells Masafumi Yamauchi; Toyota Technological Institute, Japan.

8:30 AM *ES14.5.02/ES11.5.02 Development of High Gap Ge- and Si-Based Kesterite-Like Solar Cells for Tandem Applications Guy Brammertz; imec - Division of IMOMEC, Belgium.

9:00 AM ES14.5.03/ES11.5.03 NIR-Transparent Perovskite Solar Cell for Flexible All-Thin-Film Tandem Devices Stefano Pisoni; EMPA, Switzerland.

9:15 AM ES14.5.04/ES11.5.04 Infrared-Tuned Silicon Bottom Cell for 23.6%-Efficient Perovskite/Silicon Tandem Zhengshan J. Yu; Arizona State University, United States.

9:30 AM ES14.5.05/ES11.5.05 Large-Area Scalable Perovskite/Silicon Multi-Junction Solar Modules Manoj Javanskar; imec, Belgium.

9:45 AM ES14.5.06/ES11.5.06 Study of Polycrystalline Mg,Cd1-x Te/Mg Cd1-x Te Double Heterostructures for Tandem Solar Cell Applications Calli M. Campbell 1, 2; 1Arizona State University, United States; 2Arizona State University, United States.

10:00 AM BREAK

SESSION ES14.6: Buffer Layer and Alkali Treatments Session Chairs: Michelle Mezher and Pedro Salome Wednesday Morning, April 19, 2017 PCC North, 200 Level, Room 229 B

10:30 AM *ES14.6.01 Design of Optimal Buffer Layers for CIGS Thin-Film Solar Cells Vincenzo Lordi; Lawrence Livermore National Laboratory, United States.

11:00 AM *ES14.6.02 Highly Efficient Solar Cells Based on Full PVD Processed CIGSe/CdIn2S4 Heterojunction Nicolas Barreca; Universität de Nantes, France.

11:30 AM ES14.6.03 Impact of the Heavy Alkali Fluoride Post-Deposition Treatment on the Electronic Structure of the CdS/Cu(In,Ga)Se Interface in High-Efficiency Thin-Film Solar Cells Dirk Hauschild 1, 2; 1Karlsruhe Institute of Technology (KIT), Germany; 2Karlsruhe Institute of Technology (KIT), Germany; 1University of Würzburg, Germany.
Comparison of the Interface Formation of Cu(In,Ga)Se₂ with RbF Post-Deposition Treatment and CdS and ZnS Buffer Layers

Nicoleta Nicoara
International Iberian Nanotechnology Laboratory, Portugal.

11:45 AM ES14.6.04

SESSION ES14.7: Defects and Disorder
Session Chairs: Shubhra Bansal and Stephan Lany
Wednesday Afternoon, April 19, 2017
PCC North, 200 Level, Room 229 B

1:30 PM ES14.7.01
Optical Properties and Band Structures of Cu-Deficient Phases, Cu(In,Ga)₂Se₃, and Cu(In,Ga)₄Se₅ in Cu-Poor Cu₂Se-(In,Ga)₃Se₅ Pseudo-Binary System
Takahiro Wada; Ryukoku Univ, Japan.

1:45 PM ES14.7.02
Investigation of Carrier Transport in CuInGaSe₂ by Highly Spatially, Spectrally and Time Resolved Cathodoluminescence Microscopy
Matthias Mueller; Otto-von-Guericke-University, Germany.

2:00 PM ES14.7.03
Optoelectronic Properties of Bulk Single-Crystal Ag,Cu,ZnSnSe,Alloys
Michael A. Lloyd; University of Delaware, United States; ¹Institute of Energy Conversion, United States.

2:15 PM ES14.7.04
Role of Nanoscale Disordering in Photovoltaics
Jeffrey A. Aguiar; ¹Idaho National Laboratory, United States; ²University of Utah, United States.

2:30 PM BREAK

SESSION ES14.8: Alkali Incorporation
Session Chairs: Nicolas Barreau and Stefan Haass
Wednesday Afternoon, April 19, 2017
PCC North, 200 Level, Room 229 B

3:30 PM *ES14.8.01
Thermodynamic Limitations for Alkali Metals in Cu(In,Ga)₂Se₃
Dimitrios Haridakis; Zentrum für Sonnenergie- und Wasserstoff-Forschung Baden-Württemberg, Germany.

4:00 PM ES14.8.02
KF Post-Deposition Treatment of Intermediate Cu(In,Ga)(S,Se) Thin-Film Surfaces—Modifying the Chemical and Electronic Structure
Michelle Mezher; University of Nevada, Las Vegas, United States.

4:15 PM ES14.8.03
Na-Diffusion Enhanced p-Type Conductivity in Cu(In,Ga)₂Se₃: A New Mechanism for Efficient Doping in Semiconductors
Shiyou Chen; East China Normal University, China.

4:30 PM ES14.8.04
Impact of Different Alkali Post Deposition Treatments on the Formation of the Zn(O,S)/Cu(In,Ga)₂Se₃ Interface
Thomas Kunze; Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany.

4:45 PM ES14.8.05
Improvement of Open Circuit Voltage in Cu₂ZnSnSe₄ Solar Cells by Surface Treatment
Hitoshi Tamagi; National Institute of Advanced Industrial Science and Technology, Japan.

SESSION ES14.9: Poster Session II: Defects, Degradation and Stability, Chalcopyrite Growth, Tandem Devices and Alkali Incorporation
Session Chairs: Shubhra Bansal and Ingrid Repins
Wednesday Afternoon, April 19, 2017
8:00 PM - 10:00 PM
Sheraton, Third Level, Phoenix Ballroom

ES14.9.01
Using Diffusion-Reaction Simulation to Study Light Soaking Effect in CdTe Solar Cells
Da Guo; Arizona State University, United States.

ES14.9.02
Alkali Doping in Solution Processed Kesterite Solar Cells
Stefan G. Haass; Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Thin Films and Photovoltaics, Switzerland.

ES14.9.03
Analysis of Waiting Times between CIGS and CdS and In-Diffusion of Na on the Properties of Cu(In,Ga)Se₂, Materials and Solar Cells
Pedro M. Salome; INL, Portugal.

ES14.9.04
Na-Assisted Grain Growth in Cu₂ZnSnS₄ Nanoparticle Thin Films for Solar Cell Applications
Sara Engberg; Technical University of Denmark, Denmark.

ES14.9.05
In-Ga Interdiffusion in CIGS—The Roles of Potassium and Selenium
Diego Colomba; Université du Luxembourg, Luxembourg.

ES14.9.06
Enhanced Performance of Cu₂ZnSn(S,Se)₄ Solar Cells with Introducing Interfacial Alkali Fluoride Layers
Cheng-Ying Chen; National Taiwan University, Taiwan; ¹Institute of Atomic and Molecular Science, Academia Sinica, Taiwan.

ES14.9.07
Composition Dependent Cation Ordering Characteristics of Thin-Film CZTS
Katharina Rudisch; Uppsala University, Sweden.

ES14.9.08
Antisite Defects in Cu₂ZnSn(S,Se)₄—Local and Long Range Order
Michael F. Toney; SLAC National Laboratory, United States.

ES14.9.09
Can Deep Defects Limit the Open Circuit Voltage of Cu(In,Ga)Se₂ Solar Cells?
Conrad Spindler; University of Luxembourg, Luxembourg.

ES14.9.10
Atomic-Scale Study of Grain Boundaries in CdTe
Fai G. Sen; Argonne National Laboratory, United States.

ES14.9.11
Molecular Dynamics Study of Grain Boundaries within CdTe Thin Films Grown on CdS Substrates
Jose J. Chavez; Sandia National Laboratories, United States.

ES14.9.12
Structural Trends in Chalcopyrite Based Intermediate Band Absorber Materials
Julien Marquardt; ²Freie Universität Berlin, Germany.

ES14.9.13
Defects in Copper Indium Gallium Aluminum Diselenide (CIAGS) Films and Their Impact on Photovoltaic Device Performance
Stephen Campbell; University of Minnesota, United States.

ES14.9.14
Electronic Transitions in Highly Doped and Compensated Chalcopyrites and Kesterites
Jennifer P. Teixeira; ¹Institute of Atomic and Molecular Science, Academia Sinica, Taiwan; ²University of Delaware, United States.

ES14.9.15
The Defects Generated in Magnetron Sputtered Thin-Film CdTe Solar Cells that Limit Performance and Cause Delamination
John M. Walls; Loughborough University, United Kingdom.
A Review—Metastability, Potential Induced and Damp Heat Degradation and Recovery in CIGS Solar Cells

Shubhra Bansal; University of Nevada, Las Vegas, United States.

ES14.9.17
Anomalous Reverse Breakdown of CIGS Devices—Theory and Simulation

Marco Nardone; Bowling Green State University, United States.

ES14.9.18
Clarification of Proton- and Electron-Irradiated Degradation Mechanism of Cu2ZnSnS4 Solar Cells

Mutsumi Sugiyama; Tokyo University of Science, Japan.

ES14.9.19
Compare Corrosion Resistance of Aluminum-Doped Zinc Oxide (AZO) and Gallium-Doped Zinc Oxide (GZO) Films Depending on the Hydrogen Content

Soo Ho S. Cho; Koreatech, Korea (the Republic of).

ES14.9.20
Low Band Gap Cu(In,Ga)Se2 Absorber Layers for Current Matched Perovskite/CIGS Tandem Solar Cells

Thomas Feurer; Empa, Switzerland.

ES14.9.21
Comparison of Low Bandgap CuInSe2, Alloys for Tandem Solar Cells

Nicholas H. Valdez1, 2; Institute of Energy Conversion, United States; 1University of Delaware, United States.

ES14.9.22
Cu(In,Ga)Se2-Based Monolithic Tandem Solar Cell with Open-Circuit Voltage over 1 V

Jae-Hyung W; Electronics and Telecommunications Research Institute (ETRI), Korea (the Republic of).

ES14.9.23
Textured CIGS/Perovskite Tandem Cells

Joop van Deelen; TNO, Netherlands.

ES14.9.24
Understanding the Effect of Stainless Steel Substrates on Flexible CIGS Solar Cell Performance

Tara Nietzold; Arizona State University, United States.

ES14.9.25
Predicting Ga and Cu Profiles in Co-Evaporated Cu(In,Ga)Se2 Using Modified Diffusion Equations and a Spreadsheet

Ingrid Repins; National Renewable Energy Laboratory, United States.

ES14.9.26
CIGS and CIS Solar Cells Processed from Environmental Benign and Stable Molecular Inks

Hao Xin; Nanjing University of Posts & Telecommunications, China.

ES14.9.27
Photovoltaic Assessment of Single Solution Derived CuIn(S,Se)x Films and Devices

Devendra Tiwari; University of Bristol, United Kingdom.

ES14.9.28
Pulsed Laser Deposition (PLD) of the CZTS Absorber Material for Solar Cells with up to 5.2% Efficiency

Jorgen Schou; TU Denmark, Denmark.

ES14.9.29
Pulsed Laser Deposition of Thin Films of Chalcogenides

Stela Candescu; Technical University of Denmark, Denmark.

ES14.9.30
Cu(In,Ga)Se2 Solar Cell Fabrication and Characterization

Yasir I. Alrikabi; University of Arkansas at Little Rock, United States.

ES14.9.31
Photoluminescence Study of Pentanary Ag-Containing Chalcopyrite Solar Cells

Abhinav Chikhalkar; Arizona State University, United States.

ES14.9.32
Monolithic Tandem Devices Demonstrating over 1.2 V Voc Using a Wide-Bandgap Chalcopyrite Absorber

Kim Horsley; Hawaii Natural Energy Institute, United States.

SESSION ES14.10: Advanced Characterization

Session Chairs: Daniel Abou-Ras and Thomas Kunze

Thursday Morning, April 20, 2017

PCC North, 200 Level, Room 229 B

8:30 AM *ES14.10.01
Alternative Buffer Materials and Their Electronic and Chemical Properties in Cu(In,Ga)(S,Se)2 and CdTe Thin-Film Solar Cells

Clemens Heske; 1University of Nevada Las Vegas (UNLV), United States; 2Karlsruhe Institute of Technology (KIT), Germany.

9:00 AM ES14.10.02
Synchrotron-Based In Situ Characterization of CuInGaSe2 Solar Cells—Nanoscale Performance under Operating Conditions

Michael Stuckelberger; Arizona State University, United States.

9:15 AM ES14.10.03
In Situ Nano Elemental Mapping to Visualize the Growth of Cu(In,Ga)Se2 Thin Films

Bradley West; Arizona State University, United States.

9:30 AM ES14.10.04
Nanoscale Photovoltaic Performance throughout 3-Dimensions in CdTe Solar Cells via Topographic AFM

Bryan D. Huey; University of Connecticut, United States.

9:45 AM ES14.10.05
Studies of Atom Disorder in Cu2ZnSnSSe4 and Ag2ZnSnSSe4 Alloys

David Cherns; University of Bristol, United Kingdom.

10:00 AM BREAK

SESSION ES14.11: Defects

Session Chairs: Igor Sankin and Dragica Vasileska

Thursday Morning, April 20, 2017

PCC North, 200 Level, Room 229 B

10:30 AM ES14.11.01
Three-Dimensional Lifetime Tomography Reveals How CdCl2 Improves Recombination throughout CdTe Solar Cells

Edward S. Barnard; Lawrence Berkeley National Lab, United States.

10:45 AM ES14.11.02
Correlations of Grain-Boundary Character with Electrical and Optoelectronic Properties of CuInSe2 Thin Films

David Cherns, University of Bristol, United Kingdom.

11:00 AM ES14.11.03
Phosphorus, Arsenic and Antimony Diffusion and Doping in Polycrystalline CdTe

Eric Colegrove; National Renewable Energy Laboratory (NREL), United States.

11:15 AM ES14.11.04
Influence of Defects Interactions on the Properties of CdTe:Cl,Cu Solar Cell Absorber

Dmitry Kraikov; First Solar Inc, United States.

11:30 AM ES14.11.05
Voltage Dependent Admittance Spectroscopy for the Detection of near Interface Defect States and the Extraction of the Doping Density

Thomas P. Weiss; Empa - Swiss Federal Laboratories for Materials Science and Technology, Switzerland.

11:45 AM ES14.11.06
Structural and Compositional Dependence of the CdTe Se2 Alloy Layer Photoactivity in CdTe-Based Solar Cells

Jonathan Poplawsky; Oak Ridge National Laboratory, United States.

11:00 AM
SESSION ES14.12: Degradation, Stability and Modules
Session Chairs: Da Guo and Lars Stolt
Thursday Afternoon, April 20, 2017
PCC North, 200 Level, Room 229 B

1:30 PM *ES14.12.01

2:00 PM *ES14.12.02
Metastability and Reliability of CdTe Solar Cells Dragica Vasileska; Arizona State University, United States.

2:30 PM ES14.12.03
Reduced Degradation of Cu(In,Ga)Se₂ Devices through Modification of ZnO:Al Surfaces Lorelle M. Mansfield; National Renewable Energy Lab, United States.

2:45 PM ES14.12.04
Study of Time-Resolved Photoluminescence on Cu(In,Ga)Se₂ Absorbers with Varying Cu-Content Matthias Maiberg; Martin Luther University Halle-Wittenberg, Germany.

3:00 PM BREAK

SESSION ES14.13: Industry
Session Chairs: Dmitriy Krasikov and Lorelle Mansfield
Thursday Afternoon, April 20, 2017
PCC North, 200 Level, Room 229 B

3:30 PM *ES14.13.01
Comprehensive Solution for Defect Chemistry in II-VI Photovoltaics Igor Sankin; First Solar, Inc, United States.

4:00 PM *ES14.13.02

4:30 PM ES14.13.03
In-Line Alkali Post-Deposition Treatment for Flexible CIGS Solar Cell Manufacturing JinWoo Lee; Global Solar Energy, United States.

4:45 PM ES14.13.04
Alkali Element Interdependence in CIGS Relating to Depth Distribution of Na/K and Ga/(Ga+In) Lars F. Stolt; 1, 2 Solibro Research AB, Sweden; 1Uppsala University, Sweden.

Session Chairs: Sascha Sadewasser and Edgardo Saucedo Silva
Thursday Afternoon, April 20, 2017
8:00 PM - 10:00 PM
Sheraton, Third Level, Phoenix Ballroom

ES14.14.01
Effect of Mg Incorporation on Solution-Processed Kesterite Solar Cells Raquel Caballero; Univ Autonoma-Madrid, Spain.

ES14.14.02

ES14.14.03
Exploring the Role of Ge in the Synthesis of Cu₂ZnSnS₄:Ge Kesterite Absorbers Sergio Giraldo; Catalonia Institute for Energy Research (IREC), Spain.

ES14.14.04
Ge Incorporated CZTSe Thin-Film Solar Cell with a Conversion Efficiency of 12.3% Hitoshi Tampo; National Institute of Advanced Industrial Science and Technology, Japan.

ES14.14.05
Reaction Kinetics of Cu₂ZnSnS₄, and Cu₂SnS₃ Formation from Cu₂S, ZnS and SnS, Precursors Studied Using Differential Scanning Calorimetry Elizabeth A. Pogue; University of Illinois, United States.

ES14.14.06
Tuning of Stoichiometry and Band Gap of Solution-Processed Cu₂ZnGe₂Se₅ Absorbers for Thin-Film Solar Cells Thomas Schnabel; Zentrum fur Sonnenergie- und Wasserstoff-Forschung, Germany.

ES14.14.07
The Influence of Synthesis Conditions upon the Single-Phase Region in Cu₂ZnSnS₄ Thin Films Alexandra Davydova; Uppsala University, Sweden.

ES14.14.08
Insights into the Chemistry of Amine-Thiol Solution Processing and Implications for Solution Processing of Chalcogenide Optoelectronic Devices Caleb K. Miskin; Purdue University, United States.

ES14.14.09
Atmospheric Variations on Close Spaced Vapor Transport Deposited SnS Thin Films—Air vs Argon Jacob A. Andrade-Arviz; Escuela Superior de Fisica y Matematicas - Instituto Politencial Nacional (ESFM-IPN), Mexico.

ES14.14.10
Engineering the Crystal Phase and Morphology of Chalcogenide Nanomaterials for the Next Generation Thin-Film Solar Cells Xiaoyan Zhang; Nanjing Tech University, China.

ES14.14.11
Efficient Planar Antimony Sulfide Thin-Film Photovoltaics Haisheng Song; Huazhong University of Science and Technology, China.

Chemically Deposited Solar Cells of Orthorhombic and Cubic Tin Sulfide—An Overview Ana Rosa Garcia Angelmo; Universidad Nacional Autonoma de Mexico, Mexico.

Cubic Phase Tin Sulfide Thin Film Obtained by Atomic Layer Deposition and Its Application to Solar Cells Xizhu Zhao; Harvard University, United States.

ES14.14.14
Emitter/Absorber Interface Formation in SnS-Based Thin-Film Solar Cells Leonardo Kochler; Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany.

ES14.14.15
Ultrasonic Spray Pyrolysis Deposition of Sb₂S₃ for Extremely Thin Absorber Solar Cells Erki Karbec; 1, 2 Tallinn University of Technology, Estonia; 1University of Nevada, Las Vegas (UNLV), United States.

ES14.14.16
Perspectives on Antimony Sulfide-Selenide Thin-Film Solar Cells Fabiola De Bray Sanchez; Universidad Nacional Autonoma de Mexico, Mexico.

ES14.14.17
Aqueous Spray Pyrolyzed ZnO as Orientation Induced Buffer Layer for SnS₂, Photovoltaics of Improved Stability Liang Wang; Huazhong University of Science and Technology, China.

ES14.14.18
Synthesis and Characterization of Sn₄(SₓSe₁₋ₓ)₄, Ternary Alloy Thin Films for Photovoltaic Applications Joshua J. Fox; 1, 2 The Pennsylvania State University, United States; 1Materials Research Institute, United States.

ES14.14.19
Towards the Improvement of the Antimony Sulfide-Selenide Sensitized Solar Cells—Effect of Mesoporous TiO₂ Annealing and CdS Interlayer Araceli Hernandez-Granados; UAEM, Mexico.
SESSION ES14.15: Novel Chalcogenide Absorber Materials
Session Chairs: Gilles Dennler and Joop van Deelen
Friday Morning, April 21, 2017
PCC North, 200 Level, Room 229 B

8:15 AM ES14.15.01 Potential Resolution to the “Doping Puzzle” in Pyrite FeSe₂: Carrier Type Determination by Hall Effect and Thermopower
Chris Leighton; University of Minnesota, United States.

8:30 AM ES14.15.02 Binary and Ternary Sb-Based Chalcogenide Thin-Film Solar Cells
Jing Tang; Huazhong University of Science and Technology, China.

8:45 AM ES14.15.03 Should KCN Etching be Performed when Cu₂SnₓGe₁₋ₓSe Thin Films are Processed into Solar Cells?
Erika Robert; University of Luxembourg, Luxembourg.

9:00 AM ES14.15.04 Metastable Cubic SnS, SnSe and Their Alloys as Photovoltaic Materials
Stephan Lamy; National Renewable Energy Laboratory, United States.

9:15 AM ES14.15.05 Cu₂BaSn(S,Se)₄—Earth-Abundant Chalcogenides for Solar Energy Conversion Applications
Dempheun Shin; Duke University, United States.

9:30 AM ES14.15.06 Reduced Secondary Phase Formation and Doping in Cu₂SnₓSe₄ by Alloying with Ag to be Used for Solar Cell Applications
Jessica de Wild; Luxembourg Univ, Luxembourg.

9:45 AM BREAK

SESSION ES14.16: Kesterite Absorber Growth and Devices
Session Chairs: Raquel Caballero and James Clark
Friday Morning, April 21, 2017
PCC North, 200 Level, Room 229 B

10:15 AM *ES14.16.01 11.5% CZTSSe Devices Spray Coated from a Water-Ethanol Ink—Current Limitations and Ways Forward
Gilles Dennler; IMRA, France.

10:45 AM ES14.16.02 Cu₂ZnSnS₄ Solar Cell with over 700 mV Open Circuit Voltage from High Sulfur Partial Pressure during the Annealing Process
Yi Ren; Uppsala University, Sweden.

11:00 AM ES14.16.03 Thermal Annealing Effect on Layer Morphology and Performance of Kesterite Solar Cells
Samira Khelifi; Gent University, Belgium.

11:15 AM ES14.16.04 High Voltage CZTSSe Devices with High Efficiencies
Richard Haight; IBM T.J. Watson Research Ctr, United States.

11:30 AM ES14.16.05 Cu₂ZnSnS₄ Solar Cell with 11.5% Efficiency Achieved by Sputtering from Quaternary Target
Rujun Sun; Tsinghua University, China.

11:45 AM ES14.16.06 Cu₂ZnSnS₄ Thin Films from a Single Precursor Solution—Effect of Na and Sb Doping on Device Performance
David J. Fermin; University of Bristol, United Kingdom.