

SYMPOSIUM ES11

Advanced and Highly Efficient Photovoltaic Devices
April 18 - April 21, 2017

Symposium Organizers

N.J. Ekins-Daukes, Imperial College London
Louise Hirst, US Naval Research Laboratory
Richard King, Arizona State University
Bryce Richards, Karlsruhe Institute of Technology (KIT)

Proceedings Statement

All authors are invited to submit articles based on their 2017 MRS Spring Meeting presentations to the journals in the MRS portfolio (www.mrs.org/publications-news). Papers submitted and accepted for publication in MRS Advances (www.mrs.org/mrs-advances) will be available as symposium collections. Visit the MRS/Cambridge University Press Publications Booth #100 in the Exhibit Hall to learn more, including MRS Advances print options available at special rates during the meeting week only.

* Invited Paper

SESSION ES11.1: Hot Carrier Solar Cells I

Session Chairs: N.J. Ekins-Daukes and Stephen Goodnick
Tuesday Morning, April 18, 2017
PCC North, 200 Level, Room 221 AB

10:30 AM *ES11.1.01

Where is the Heat Gone? Recent Progress in Coupled Photovoltaic and Thermoelectric Conversion Using Hot Carriers [Jean Francois Guillemoles](#)^{1,2,3}; ¹CNRS, France; ²IPVF, France; ³NextPV, Japan.

11:00 AM *ES11.1.02

Solar Rectifying Antennas—A New Distinct Paradigm for Solar Power Conversion [Jeffrey Gordon](#); Ben-Gurion University of the Negev, Israel.

11:30 AM *ES11.1.03

Generating and Exploiting Hot Carriers in a Metallic Solar Cell [James Dimmock](#)^{1,2}; ¹Sharp Labs of Europe, United Kingdom; ²Imperial College London, United Kingdom.

SESSION ES11.2: Hot Carrier Solar Cells II

Session Chairs: James Dimmock and Louise Hirst
Tuesday Afternoon, April 18, 2017
PCC North, 200 Level, Room 221 AB

1:30 PM *ES11.2.01

Hot Carrier Cooling Mechanisms in Multiple Quantum Wells [Gavin Conibeer](#); University of New South Wales, Australia.

2:00 PM *ES11.2.02

Nonequilibrium Electron and Phonon Dynamics in Advanced Concept Solar Cells [Stephen M. Goodnick](#); Arizona State University, United States.

2:30 PM ES11.2.03

Type-II Quantum Well Absorbers—Candidate Systems for Hot Carrier Solar Cells [Hamidreza Esmailpour](#); University of Oklahoma, United States.

2:45 PM ES11.2.04

Influence of Hot Carrier Effects on Electrical Performance of a Quantum Well Solar Cell [Dac Trung Nguyen](#)^{1,2}; ¹Institut Photovoltaïque d'Île-de-France (IPVF), France; ²Institut de Recherche et Développement sur l'Énergie Photovoltaïque (IRDEP), France.

3:00 PM BREAK

SESSION ES11.3: Solar Cell Optics I
Session Chairs: Alexander Mellor and Bryce Richards
Tuesday Afternoon, April 18, 2017
PCC North, 200 Level, Room 221 AB

3:30 PM *ES11.3.01

Multi-Resonant Light-Trapping in Ultrathin Solar Cells [Stephane Collin](#); CNRS, France.

4:00 PM ES11.3.02

Durable Broadband Graded-Index Fluoropolymer Antireflection Coatings for Plastic Optics [Baomin Wang](#); Pennsylvania State University, United States.

4:15 PM ES11.3.03

High Concentration Planar Microtracking Photovoltaic System Exceeding 30% Power Conversion Efficiency [Jared S. Price](#); The Pennsylvania State University, United States.

4:30 PM ES11.3.04

Measuring and Exploiting Optical Anisotropies in Nanophotonic Photovoltaics [Jon A. Schuller](#); University of California, Santa Barbara, United States.

4:45 PM ES11.3.05

Dielectric Resonator-Based Antireflection Coatings [Dongheon Ha](#)^{1,2,3}; ¹National Institute of Standards and Technology, United States; ²University of Maryland, United States; ³University of Maryland, United States.

SESSION ES11.4: Poster Session I: Advanced PV Materials and Devices

Session Chairs: N.J. Ekins-Daukes and Masakazu Sugiyama
Tuesday Afternoon, April 18, 2017
8:00 PM - 10:00 PM
Sheraton, Third Level, Phoenix Ballroom

ES11.4.01

Alternative Low Cost Conductors for Photovoltaic Applications [Myong Jae Yoo](#); KETI, Korea (the Republic of).

ES11.4.02

Mathematical Modeling of Silicon Doping by Neutron Transmutation Doping Method for High Efficient Solar Cells [Sergey M. Karabanov](#); Ryazan State Radio Engineering University, Russian Federation.

ES11.4.03

Silver Coated Copper Paste for Low Cost Silicon Solar Cells [Sung Hyun Kim](#); Korea Electronics Technology Institute, Korea (the Republic of).

ES11.4.04

Low Temperature, Combustion Reacted Al Doped ZnO Coating on Ag Nanowire Transparent Electrode for Flexible Solar Cells [Min Kyu Park](#); KAIST, Korea (the Republic of).

ES11.4.05

Study of Electrical Properties Derived from Optical Constants for Transparent Composite Electrode [Aditya Yerramilli](#); Arizona State University, United States.

ES11.4.06

Hydrogenated Indium Oxide without Introduction of Water during Sputtering [Nathan Rodkey](#); Arizona State University, United States.

ES11.4.07

Reduction of Zn²⁺/dye Complex Formation by Controlled Soaking Time in Dye Solution [Kichang Jung](#); University of California, Riverside, United States.

ES11.4.08

Preventing Formation of Zn²⁺/dye Compound by Using CuO as a Protective Layer on ZnO Photoelectrode for Dye-Sensitized Solar Cells [Kichang Jung](#); University of California, Riverside, United States.

ES11.4.09

Three-Dimensional Compositional Analysis of III-V Alloys with Clustering Behavior for Implementation in High Efficiency Photovoltaics Nicole A. Kotulak; U.S. Naval Research Laboratory, United States.

ES11.4.10

Design and Modeling of InGaN-Based Concentrator Solar Cells under High Temperature Yi Fang; Arizona State University, United States.

ES11.4.11

The Band Gap Bowing of Thick InGaN Alloys for Photovoltaic Applications Alec M. Fischer; Arizona State University, United States.

ES11.4.12

Defect-Tolerant Bil₃ Films for Photovoltaic Applications Yoon Myung; Washington University in St. Louis, United States.

ES11.4.13

Fabrication of Three-Dimensional Hybrid Nanostructure-Embedded ITO and Its Application as a Transparent Electrode for High-Efficiency Solution Processable Organic Photovoltaic Device Jeong Won Kim; National NanoFab Center (NNFC), Korea (the Republic of).

ES11.4.14

High Efficiency Small Molecular Solar Cells with New Fullerene-Free Acceptor Min Jae Sung; Gyeongsang National University, Korea (the Republic of).

ES11.4.15

Enhancement of Power Conversion Efficiency for A-D-A Type NDI-Based Small Molecule as Non-Fullerene Acceptor for Solution-Processed Organic Photovoltaics Yeon Hee Ha; Gyeongsang National University, Korea (the Republic of).

ES11.4.16

Improvement of Open Circuit Voltage by Adding the Cascade Materials in Ternary Bulk Heterojunction Photovoltaic Cells Luyao Song; Huazhong University of Science and Technology, China.

ES11.4.17

Effect of Chlorination for Efficient Non-Fullerene Polymer Solar Cells Feng He; South University of Science and Technology of China, China.

ES11.4.18

Transparent Wide Bandgap Inorganic Halide Material for Hybrid Solar Cells Karunakara Moorthy Boopathi; Research Center for Applied Sciences, Academia Sinica, Taiwan.

ES11.4.19

Cation-Controlled Aggregation in Fluorene-Triarylamine Sulfonate Copolymers Meilin Li^{1,2}; ¹National University of Singapore, Singapore; ²Solar Energy Research Institute of Singapore, Singapore.

ES11.4.20

A PCBM-Assisted Perovskite Growth Process to Fabricate High Efficiency Semitransparent Solar Cells Chao Li^{1,2}; ¹University of Central Florida, United States; ²University of Central Florida, United States.

ES11.4.21

Investigation of Thermal Donors and Other Bulk Defects in n-Type Czochralski-Grown Si for High Efficiency Solar Cells Apoorva Srinivas; Arizona State University, United States.

ES11.4.22

Silicon Heterojunction Solar Cells with MoOx Hole Selective Contact Hisham Nasser^{1,3}; ¹The Center for Solar Energy Research and Applications GUNAM, Turkey; ³Middle East Technical University METU, Turkey.

SESSION ES11.5/ES14.5: Joint Session: Tandem Devices

Session Chairs: Richard King and Yaroslav Romanyuk

Wednesday Morning, April 19, 2017

PCC North, 200 Level, Room 221 ABC

8:00 AM *ES11.5.01/ES14.5.01

Efficiency Potential and Recent Activities of High Efficiency and Si Tandem Solar Cells Masafumi Yamaguchi; Toyota Technological Institute, Japan.

8:30 AM *ES11.5.02/ES14.5.02

Development of High Gap Ge- and Si-Based Kesterite-Like Solar Cells for Tandem Applications Guy Brammertz; imec - Division of IMOMECE, Belgium.

9:00 AM ES11.5.03/ES14.5.03

NIR-Transparent Perovskite Solar Cell for Flexible All-Thin-Film Tandem Devices Stefano Pisoni; EMPA, Switzerland.

9:15 AM ES11.5.04/ES14.5.04

Infrared-Tuned Silicon Bottom Cell for 23.6%-Efficient Perovskite/Silicon Tandem Zhengshan J. Yu; Arizona State University, United States.

9:30 AM ES11.5.05/ES14.5.05

Large-Area Scalable Perovskite/Silicon Multi-Junction Solar Modules Manoj Jaysankar; imec, Belgium.

9:45 AM ES11.5.06/ES14.5.06

Study of Polycrystalline Mg_xCd_{1-x}Te/Mg_yCd_{1-y}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 ES11.6: Solar Cell Optics II**

Session Chairs: Louise Hirst and Bryce Richards

Wednesday Morning, April 19, 2017

PCC North, 200 Level, Room 221 AB

10:30 AM *ES11.6.01

Nanophotonic Control of Thermal Emissivity and Its Implication for Energy Applications Shanhui Fan; Stanford University, United States.

11:00 AM ES11.6.02

The Radiative Emissivity of Silicon Solar Cells—What is It, Where Does It Come From and What Can We Do about It? Alexander Mellor; Imperial College London, United Kingdom.

11:15 AM ES11.6.03

Frequency Selective Thermal Extraction for High Efficiency Thermophotovoltaics Zoila Jurado; California Institute of Technology, United States.

11:30 AM ES11.6.04

Near Perfect Transmittance Arising from Waveguide Modes in Printed Nanocone Arrays Colton R. Bukowsky; California Inst of Technology, United States.

11:45 AM ES11.6.05

Microstructured Transparent Electrodes Utilizing Directed Total Internal Reflection Pieter G. Kik; University of Central Florida, United States.

SESSION ES11.7: III-V Rapid Deposition

Session Chairs: N.J. Ekins-Daukes and Mircea Guina

Wednesday Afternoon, April 19, 2017

PCC North, 200 Level, Room 221 AB

1:30 PM *ES11.7.01

III-V Nano-Epitaxial MOVPE for High-Efficiency and Low-Cost Solar Cells Masakazu Sugiyama; The University of Tokyo, Japan.

2:00 PM ES11.7.02

Toward High-Efficiency Scalable III-V Solar Devices Grown via Low-Cost Vapor Transport from a Solid Source [Shannon W. Boettcher](#); University of Oregon, United States.

2:15 PM ES11.7.03

Flexible III-V Solar Cells Using Single-Crystal-Like Materials Grown on Hastelloy Tapes [Sara Pouladi](#); University of Houston, United States.

2:30 PM BREAK

SESSION ES11.8: Thin-Film PV

Session Chairs: Gavin Conibeer and Jean Francois Guillemoles
Wednesday Afternoon, April 19, 2017
PCC North, 200 Level, Room 221 AB

3:30 PM ES11.8.01

Can “Photovoltaic” Halide-Perovskites be Ferroelectric? The Case of MAPbI₃ and MAPbBr₃ [Yevgeny Rakita](#); Weizmann Institute of Science, Israel.

3:45 PM ES11.8.02

Cu₂O/Si Heterojunction Based Carrier Selective Contact for Silicon Photovoltaics [Pramod Ravindra](#); Indian Institute of Science, India.

4:00 PM ES11.8.03

Selective Grain Boundary Etching to Improve on the Back-Contact of Polycrystalline CdTe Solar Cells [Sudhajt Misra](#); University of Utah, United States.

4:15 PM ES11.8.04

< 1g/W Solar Cells on Flexible Silicon Substrates [Andre Augusto](#); Arizona State University, United States.

4:30 PM ES11.8.05

Wearable All-Solid Photovoltaic Textile [Jun Chen](#); Georgia Institute of Technology, United States.

SESSION ES11.9: Poster Session II: Hybrid
Session Chairs: T. Grassman and Richard King
Wednesday Afternoon, April 19, 2017
8:00 PM - 10:00 PM
Sheraton, Third Level, Phoenix Ballroom

ES11.9.01

Partially Passivated Micro-Pyramidal Silicon/PEDOT:PSS Hybrid Solar Cells with High Efficiency [Inyoung Choi](#); Ulsan National Institute of Science and Technology (UNIST), Korea (the Republic of).

ES11.9.02

Broadband Light Absorption in Perovskite Solar Cell Using Metamaterial Cross Grating Structures [Omar A. Abdelraouf](#); The American University in Cairo, Egypt.

ES11.9.03

Fabrication and Analysis of c-Si Solar Cells with Micro and Nano Holes Prepared by Reactive Ion Etching [Hayriye S. Altinoluk](#)^{1,2}; ¹Mugla Sıtkı Kocman University, Turkey; ²Middle East Technical University, Turkey.

ES11.9.04

Theoretical Study of Heteroatom-Doped Carbon Nanomaterials as Effective Catalysts in Dye-Sensitized Solar Cells [Zhenghang Zhao](#); University of North Texas, United States.

ES11.9.05

Investigation of Deep-Level Defects Lateral Distribution in Active Layers of Multicrystalline Silicon Solar Cells [Sergey M. Karabanov](#); Ryazan State Radio Engineering University, Russian Federation.

ES11.9.06

Amine-Based Interfacial Molecules as Versatile Interlayer for Inverted Polymer-Based Optoelectronic Devices [Seungjin Lee](#); UNIST, Korea (the Republic of).

ES11.9.07

Ultrafast One-Step Deposition of Perovskite Thin Films by Atmospheric Plasma Curing—Towards a New Route of Synthesis for Efficient and Reliable Solar Cells [Florian Hilt](#); Stanford University, United States.

ES11.9.08

Multiscale Modeling of Silicon Heterojunction Solar Cells [Pradyumna Muralidharan](#); Arizona State University, United States.

ES11.9.09

Do Electron and Hole Transport Layers Contribute Equally to Surface Photovoltage? [Sunil Kumar Samji](#); Indian Institute of Technology (IIT B), India.

ES11.9.10

Three-Component Light Trapping Structure for Multi-Junction Solar Cells [Alexander Mellor](#); Imperial College London, United Kingdom.

ES11.9.11

Surface Defect Analysis on n-Type Substrates Using Spatially Resolved Photoluminescence Images and TIDLs for High Performance Devices [Pradeep Balaji](#); Arizona State University, United States.

ES11.9.12

High Performance of Perovskite Solar Cell with a High Temperature Annealing Process and Their Large Size Application [Dong Suk Kim](#); Korea Institute of Energy Research, Korea (the Republic of).

ES11.9.13

Comparison of Donor and Acceptor Doped TiO₂ Nanorods as a Mesoporous Scaffold of Perovskite Solar Cells [Fangda Yu](#); University of Pittsburgh, United States.

ES11.9.14

Correlation between Phase-Separated Morphology of Active Layer and Photovoltaic Properties in All-Polymer Solar Cells [Yuxiang Li](#)^{1,3}; ¹Pusan National University, Korea (the Republic of); ³Korea University, Korea (the Republic of).

ES11.9.15

Characterization of Titanium Nitride as Iron Diffusion Barrier for GaAs Thin Film Solar Cell on Steel [Saloni Chaurasia](#); Indian Institute of Science, India.

ES11.9.16

Surface Passivation Quality of Ozone and Water-Based Al₂O₃ Film Grown by Atomic Layer Deposition for Silicon Solar Cell [Hyo Sik Chang](#); Chungnam National University, Korea (the Republic of).

ES11.9.17

Effects of Columnar Grain Boundaries on Thin Film Polycrystalline GaAs Solar Cells [Khushboo Kumari](#); Indian Institute of Science Bangalore, India.

ES11.9.18

HIT Solar Cell with V₂O₅ Window Layer [Erenn Ore](#); University of Cambridge, United Kingdom.

ES11.9.19

Solution Process Synthesis of a TiO_x Passivation Layer for Silicon-PEDOT:PSS Solar Cell [Yuqiang Liu](#); University, China.

ES11.9.20

Optimization of Si Bottom Cell for High-Efficiency Si/III-V Integrated Solar Devices [Simone Bernardini](#); Arizona State University, United States.

ES11.9.21

Ultra-Thin SiO₂ Layers for Defect-Free Si/Oxide Carrier Selective Contacts [Rudra Mukherjee](#); Indian Institute of Science, India.

ES11.9.22

High Temperature InGaN Solar Cells for Full Spectrum Solar Energy Harvesting [Ehsan Vadiiee](#); Arizona State University, United States.

SESSION ES11.10: Singlet Fission and IBSC
Session Chairs: N.J. Ekins-Daukes and Timothy Schmidt
Thursday Morning, April 20, 2017
PCC North, 200 Level, Room 221 AB

8:15 AM *ES11.10.01

Beyond the Shockley–Queisser Limit with Singlet Exciton Fission [Akshay Rao](#); University of Cambridge, United Kingdom.

8:45 AM *ES11.10.02

Exploring Strategies for Charge or Energy Transfer from Molecules to Semiconductors after Singlet Fission [Justin Johnson](#); National Renewable Energy Laboratory, United States.

9:15 AM ES11.10.03

A Solid-State Organic Intermediate Band Solar Cell with Electrically Integrated Triplet-Triplet Annihilation Up Conversion [YunHui L. Lin](#); Princeton University, United States.

9:30 AM BREAK

SESSION ES11.11: Multi-Junction PV
Session Chairs: Diego Alonso Alvarez and Richard King
Thursday Morning, April 20, 2017
PCC North, 200 Level, Room 221 AB

10:00 AM *ES11.11.01

Dilute Nitride Solar Cells—Technology Developments towards 50% Efficiency [Mircea Guina](#); Tampere University of Technology, Finland.

10:30 AM *ES11.11.02

Development of Epitaxial III-V/Si Multijunction Solar Cells [T. Grassman](#); The Ohio State University, United States.

11:00 AM ES11.11.03

1-eV GaNAsSb Solar Cells Lattice-Matched to GaAs [Aymeric Maros](#); Arizona State University, United States.

11:15 AM ES11.11.04

Imaging Atomic Scale Clustering in III-V Semiconductor Alloys for Multi-Junction Photovoltaics [Louise C. Hirst](#); U.S. Naval Research Laboratory, United States.

11:30 AM ES11.11.05

Structural Properties of Si/GaAs Interfaces Fabricated by Surface-Activated Bonding at Room Temperature [Yutaka Ohno](#); Tohoku University, Japan.

11:45 AM ES11.11.06

The GaAs/GaAs/Si Two-Terminal Tandem Solar Cell—Current Matching for a Non-Ideal Bandgap Combination [Ian Marius Peters](#)^{1,2}; ¹Massachusetts Institute of Technology, United States; ²SMART, Singapore.

SESSION ES11.12: Intermediate Band PV
Session Chairs: Urs Aeberhard and Masakazu Sugiyama
Thursday Afternoon, April 20, 2017
PCC North, 200 Level, Room 221 AB

1:30 PM *ES11.12.01

Intermediate Band Solar Cells—Status and Future Directions [Jacob J. Krich](#); University of Ottawa, Canada.

2:00 PM *ES11.12.02

Multicolor Emission in Intermediate Band Solar Cell Materials [Wladyslaw Walukiewicz](#)^{1,2}; ¹Lawrence Berkeley National Lab, United States; ²University of California, Berkeley, United States.

2:30 PM ES11.12.03

Lead Halide Perovskite-Based Intermediate Band Absorbers [Alex Martinson](#); Argonne National Laboratory, United States.

2:45 PM BREAK

3:15 PM *ES11.12.04

Challenges and Progress on the Development of Quantum Dot Intermediate Band Solar Cells [Yoshitaka Okada](#); University of Tokyo, Japan.

3:45 PM *ES11.12.05

Control of Carrier Dynamics and Efficient Two-Step Photon Up-Conversion in Quantum-Dot Intermediate-Band Solar Cells [Takashi Kita](#); Kobe University, Japan.

4:15 PM ES11.12.06

High Efficiency “Quantum Ratchet” Intermediate Band Solar Cells [Anthony Vaquero-Stainer](#); Imperial College London, United Kingdom.

SESSION ES11.13: Nanostructured PV
Session Chairs: James Dimmock and Louise Hirst
Friday Morning, April 21, 2017
PCC North, 200 Level, Room 222C

8:30 AM *ES11.13.01

A Quantum-Kinetic Perspective on Photovoltaic Device Operation in Nanostructure-Based Solar Cells [Urs Aeberhard](#); Forschungszentrum Juelich GmbH, Germany.

9:00 AM ES11.13.02

Carrier Transport Suppression in Quantum Wire and Quantum Well Solar Cells [Diego Alonso Alvarez](#); Imperial College London, United Kingdom.

9:15 AM ES11.13.03

Demonstration of Non-Polar and Semipolar InGaN/GaN Multi-Quantum Well (MQW) Solar Cells [Xuanqi Huang](#); Arizona State Univ., United States.

9:30 AM ES11.13.04

Hybrid Photoelectrochemical Systems Based on Self-Organized TiO₂ Nanotubes Coated with Chalcogenides [Jan M. Macak](#); University of Pardubice, Czech Republic.

9:45 AM ES11.13.05

Silicon Nanowire/Polymer Hybrid Solar Cell-Supercapacitor—A Self-Charging Power Unit with a Total Efficiency of 10.5% [Ruiyuan Liu](#)^{1,2}; ¹Soochow Univ., China; ²Georgia Institute of Technology, United States.

10:00 AM BREAK

SESSION ES11.14: Selective and Heterojunction Contacts
Session Chairs: Diego Alonso Alvarez and James Dimmock
Friday Morning, April 21, 2017
PCC North, 200 Level, Room 222C

10:30 AM *ES11.14.01

Dopant Free Selective Contacts for Highly Efficient Si and III-V Solar Cells [Ali Javey](#); University of California, Berkeley, United States.

11:00 AM ES11.14.02

Carrier-Selective Materials for High Efficiency Silicon Solar Cells [James Bullock](#); University of California, Berkeley, United States.

11:15 AM ES11.14.03

Carrier Selective Contact GaP/Si Solar Cells [Chaomin Zhang](#); Arizona State University, United States.

11:30 AM ES11.14.04

Silicon Heterojunction Solar Cells with Silicon Nanoparticle Enabled Microcrystalline Silicon Thin Films [Joe V. Carpenter](#); Arizona State University, United States.

11:45 AM ES11.14.05

High Efficiency Heterojunction Si Solar Cells with Effectively Transparent Front Contacts [Rebecca Saive](#); California Institute of Technology, United States.