CALL FOR PAPERS

THE 39th IEEE PHOTOVOLTAIC SPECIALISTS CONFERENCE
June 16-21, 2013
Tampa Convention Center
Tampa, Florida, USA

www.ieee-pvsc.org

Sponsored by the IEEE Electron Devices Society

Technical Co-Sponsors
Invitation from the Chair

On behalf of the Organizing, Steering, Cherry and International Committees, it is my great honor to invite you to join the 39th IEEE Photovoltaic Specialist Conference (PVSC), June 16-21, 2013, at the Tampa Convention Center, Florida. Our commitment is to remain the premier technical conference covering all aspects of PV technology, from fundamental physics and basic material science to installed system performance. In addition to our conference proceedings, authors will also have the opportunity to submit their papers for peer-review publication in the IEEE Journal of Photovoltaics (J-PV).

We will also continue our Industrial Exhibition that provides a showcase for the new materials, services, and tools which support PV research, development, and manufacturing. This is your opportunity to see the latest commercial development of the products and services that are supporting our industry.

Finally, for those of you who are not familiar with Tampa you will be in for quite a treat. Tampa is one of the premiere vacation destinations in the U.S. It is located on the gulf coast of the “Sunshine State” of Florida and is host to a large number of cultural, sports, and entertainment venues.

I invite you to come and be part of THE photovoltaic conference event of the year!

Highlights include:

Strong Technical Program: Building off the record number of technical presentation at the 38th PVSC, we will continue with our ten (10) technical areas. In addition, we will be adding a new area devoted to the Science of PV Reliability. This area will be similar to other cross-cutting areas that have been added to the conference in recent years due to the continued growth and evolution of our field (i.e., PV Velocity Forum, PV Modules and Terrestrial Systems, and PV Characterization Methods). We anticipate having a number of joint sessions between our new and established area which can really get at the heart of the challenges and opportunities facing the PV industry today.

Full Day of Tutorials: We will have a full set of tutorials scheduled, consisting of half---day lectures taught by experts in the field. The topics will range from basic physics of solar cell operation to details about the latest trends in the industry that will be valuable to newcomers to PV as well as seasoned veterans.

Industrial Exhibition: Within the fantastic Tampa Convention Center, our exhibit space has been designed to bring together the commercial sector with photovoltaic technologists. Our focus will be on tools and services for testing, measurement, characterization, and processing for both R&D and manufacturing.

Student Participation: Our technical community’s future is only as vibrant as our student body, so we have created incentives to encourage students to attend and to be active participants in the conference, including reduced registration and tutorial fees, special
hotel rates, best student presentation awards in each technical area, and the opportunity to work as graduate student assistants to conference operations.

Hotel Accommodations: Special rates have been secured at the Marriott adjacent to the Convention Center as well as the Embassy Suites connected to the Convention Center. This is an extremely busy time in Tampa and nearby hotels are likely to be booked very early, so don't miss the opportunity to secure your accommodations at one of these conference hotels at reduced pre-negotiated rates.

Social Program: Continuing our theme of enhancing our PV Specialists community, our goal is to create relationships on a social as well as professional level amongst our attendees, families, and companions. From the Cherry Award Reception to the Conference Banquet to the daily sightseeing tours, the social program is going to be truly memorable. Plan to bring family members and arrive early and stay late!

We urge you to register for the meeting and make your hotel reservation well ahead of the deadline. The increased interest in PV and the Tampa venue are likely to lead to greatly increased attendance, and the hotel room block is limited. Please join us in Tampa and help to continue the excellence of the world’s first and still premier PV technical conference.

Ryne Raffaelle, General Chair, 39th PVSC
Call for Papers

On behalf of the Technical Program Committee, I am honored to invite you to submit an abstract on your latest achievements in photovoltaics research, development, and applications to the 39th IEEE PVSC. The PVSC endeavors to cover all aspects of photovoltaics technology, including the latest in device performance, new module encapsulation technologies, novel characterization techniques, knowledge gained from field experiences, or new PV material science. Basically if it's new and it's PV related, we encourage you to submit your work here. The chance to share and discuss these important PV developments in a timely and influential forum is what the PVSC is all about. Please contribute to the PVSC’s tradition as the premier international conference on the science and technology of photovoltaics.

For PVSC39, we have expanded the number of technical areas to eleven (11), adding a new cross-technology area focused on Reliability of PV, headed up by Dr. Sarah Kurtz of NREL (Area 10). As the PV industry has grown, it has become increasingly critical to have confidence in the long-term performance of the GWs of PV, representing enormous financial investment. This topic cuts across all PV technologies and throughout the supply chain.

To have your paper considered for presentation at the 39th PVSC, please submit a 3-page evaluation abstract, and a short abstract of no more than 300 words in length for display on the PVSC website. Evaluation abstracts are expected to be detailed enough to allow a competent technical review. A suggested format has been provided at the conference website for your convenience. The preferred way to submit your abstract is via the 39th PVSC website at www.ieee-pvsc.org. Log in with your user name and password and carefully follow the instructions provided to upload your abstract successfully.

Submission to the IEEE Journal of Photovoltaics (J-PV): We are continuing the very popular option of offering authors who submit particularly high quality PVSC review abstracts, as evaluated by the program committee, an opportunity to directly submit a manuscript to J-PV. This path allows authors to bring their peer reviewed journal quality research to the PVSC and enjoy both the PVSC conference experience as well as receiving a peer review citation from a highly regarded journal. Manuscripts accepted to J-PV will be published in J-PV as well as included in the conference proceedings DVD.

The deadline for electronic submission of the abstracts is February 4, 2013 at midnight Pacific Standard Time (UTC - 8 hours). Contributing authors will be notified of the acceptance status of their papers after March 25, 2013. For visa applications, an invitation letter will be issued at that time. We will also ask authors to confirm that they will be able to present their work at the conference and upload their manuscript by the due date of June 10, 2013 (1 week before the conference) for publication in the conference proceedings. Thank you for your participation in the PVSC!

David M. Wilt, Program Chair, 39th PVSC
Technical Areas

Area 1: Fundamentals and New Concepts for Future Technologies

Chair: Alex Freundlich, University of Houston, USA
Co-Chairs: Gavin Conibeer, University of New South Wales- Australia
Antonio Marti, Polytechnic University of Madrid, Spain
Masakazu Sugiyama, University of Tokyo, Japan

Sub-Area 1.1: Fundamental Conversion Mechanisms
   Sub-Area Chair: Seth Hubbard (RIT)

Sub-Area 1.2: Quantum-well, Nanowire, and Quantum Dot-Architected Devices
   Sub-Area Chair: Jessica Adams (Microlink Devices)

Sub-Area 1.3: Hybrid Organic/Inorganic Solar Cells
   Sub-Area Chair: Nicoleta Hickman (University of Central Florida)

Sub-Area 1.4: Advanced Light Management and Spectral Shaping
   Sub-Area Chair: Peichen Yu (National Chiao Tung University)

Sub-Area 1.5: Novel Material Systems
   Sub-Area Chair: Cory Cress (Naval Research Laboratory)

Papers are sought that describe basic research and breakthroughs in physical, chemical and optical phenomena, new materials and novel device concepts, which are essential to feed the innovation pipeline leading to future-generation PV technologies. General areas of interest include, but are not limited to, recent advances in understanding, simulation, demonstration and optimization of:

1. non-conventional PV conversion processes and devices, intermediate-band solar cells, multiple charge carrier generation, thermophotovoltaics, hot-carrier cells, and other emerging PV device concepts,
2. devices based on quantum wells, nanowires, and quantum dots as well as deciphering the science in photogeneration, recombination, and carrier transport in these devices,
3. cross-cutting hybrid devices that leverage on organic/inorganic materials and nanostructures,
4. advanced light management concepts and approaches: including new structures and materials for antireflection, light trapping, plasmonic coupling, spectral conversion, and light concentration,
5. novel material systems and associations for increasing performance, functionality, reliability and scalability of PV devices, including new pseudomorphic and metamorphic photovoltaic material systems, alternative inexpensive substrates, novel doping and defect passivation schemes, novel nanostructures, earth abundant thin films and TCO materials. Novel scalable nano/micro fabrication techniques and processes for synthesis of PV materials.
1.1: Fundamental Conversion Mechanisms
Sub-area 1.1 attempts to capture both experimental and theoretical work exploring new paradigms for photovoltaic energy conversion. Papers submitted to this sub-area would explore the fundamental physics or initial experimental demonstrations related to novel energy conversion mechanisms. In addition, papers on modeling and simulation of new device architectures to enable these conversion mechanisms are encouraged. Examples of new mechanisms of interest are non-conventional PV conversion processes based on, but not limited to, quantum confined or nanostructured concepts, intermediate band concepts, multiple exciton generation (MEG), thermophotonics or hot-carrier effects. Also of interest are concepts and demonstration of new materials and material science related to energy conversion. Finally, cross-cutting science approaches involving novel physics, innovative device structures, and modeling and simulation are solicited.

1.2: Quantum Well, Wire, and Dot-Architected Devices
Sub-area 1.2 focuses on the band-gap engineering of photovoltaic devices via the inclusion of quantum structures, and the science involved in the photogeneration, recombination and carrier transport mechanisms in these devices. This is a particularly exciting time in this technical area as these novel architectures are at the cutting edge of both photovoltaic research and commercial implementation. Such device designs offer a multitude of realistic technological paths to attaining solar cells with efficiency in excess of 50%. To continue the momentum in the field, papers are sought on both the theoretical and experimental progress in the development of quantum-structured materials and devices.

1.3: Hybrid Organic-Inorganic Solar Cells
Hybrid solar cells are designed to exploit the unique interfacial electronic properties at the organic-inorganic boundary. This class of devices is rooted in nanostructured TiO2 or ZnO integrated with conjugated polymers (P3HT), but is rapidly expanding to include many other organic and inorganic materials including single and polycrystalline Si and GaAs, organic small molecules, nanostructured carbon allotropes such as carbon nanotubes and graphene, as well as colloidal nanostructures including quantum wires, rods, and dots. Papers are sought which leverage the unique electronic and optical properties and functionality afforded by integrating organic and inorganic materials, and those which utilize quantum confined nanostructures to enhance charge transport and fine-tune the spectral sensitivity range.

1.4: Advanced Light Management and Spectral Shaping
Any effective solar cell technology requires some means for coupling light into the solar cell with minimum loss. This can take the form of a simple anti-reflection coating, textured light trapping surface, luminescent (fluorescence) concentrator system or advanced photonic or plasmonic structure. In addition, it is also desirable to modify the spectrum of the incident sunlight, using techniques such as up and down conversion either in planar layers or in waveguide structures. Papers submitted to this sub-area should address one or more of these themes and maybe be theoretical or experimental in nature.
1.5: Novel Material Systems
Sub-area 1.5 encompasses novel inorganic materials, novel combinations of materials, and novel materials processing techniques for improving the performance, functionality, reliability, and scalability of PV devices. Such materials, combinations, and processes may find application in single-crystalline, thin film, multijunction, and nanostructured PV devices or may enable entirely new device classes. Anticipated topics include (but are not limited to): experimental and theoretical PV materials discovery, materials displaying novel bandstructure or other exploitable properties, alternative inexpensive substrates, barrier layers, new pseudomorphic and metamorphic photovoltaic materials or growth, novel doping and defect passivation schemes, novel nanostructured architectures that lower material quality constraints, earth abundant photovoltaic or transparent conducting oxide materials, and scalable nano/micro techniques for the synthesis, deposition, or fabrication of PV materials and devices.
Area 2: Chalcogenide Thin Film Solar Cells and Related Materials

Chair: Sylvain Marsillac, Old Dominion University, USA
Co-Chairs: James Sites, Colorado State University, USA
Takashi Minemoto, Ritsumeikan University, Japan
Jean-Francois Guillemoles, IRDEP-CNRS, France

Subarea 2.1: Absorber Formation and Characterization
Harin Ullal (NREL), Ayodhya Tiwari (EMPA), Shigeru Niki (AIST)

Subarea 2.2: Substrates, Contacts, Buffer layers and TCO
Vikash Ranjan (Pilkington), Susanne Siebentritt (U. Luxembourg), Tokio Nakada (Aoyama University), Marika Edoff (Uppsala University)

Subarea 2.3: Device Properties, Modeling, Stability, and Defect Characterization
Robert Collins (University of Toledo), Daniel Abou Ras (Hemholtz center Berlin), Tetsuya Sakurai (University of Tsukuba), Mike Scarpulla (University of Utah)

Subarea 2.4: Manufacturing Issues: Performance, Metrology, Process Control, and Reliability
Markus Gloeckler (First Solar), Paul Mogensen (Avancis), Tadashi Iwakura (Honda Engineering)

Over the last ten years, chalcogenide thin-film modules have managed to capture more than 15% of the terrestrial PV market while the efficiency of the laboratory scale cells has surpassed the 20% landmark.

Beside the now more traditional CdTe and Cu(In,Ga)(S,Se)$_2$, new material systems are emerging, such as Cu$_2$ZnSn(S,Se)$_4$, which brings new technology challenges but also insight into the other material systems.

There is therefore still a need for understanding and developing the fundamental science and engineering of these chalcogenide thin films while pushing the limits of the industrial applications and solutions for these systems. Area 2 of the 39th IEEE PVSC invites contributions addressing recent progress in the fields of Absorber Formation and Characterization, Substrates, Contacts, Buffer layers and TCO, Device Properties, Modeling, Stability, and Defect Characterization, and all aspects of Manufacturing Issues, which include Performance, Metrology, Process Control, and Reliability.
Area 3: III-V and Concentrator Technologies

Chair: Scott Burroughs, Semprius, Inc., USA
Co-chair: Frank Dimroth, Fraunhofer ISE, Germany

Sub-Area 3.1: Materials and Devices
Daniel Aiken (Emcore) and Carlos Algora (UPM)

Sub-Area 3.2: Concentrator Receiver and Modules
Andreas Gombert (Soitec)

Sub-Area 3.3: High and Low Concentrator Systems
Damien Buie (EDF Renewable Energy)

This focus area of the IEEE Photovoltaic Specialists Conference covers the latest technical progress in concentrating photovoltaic (CPV) technology. CPV is proving to be a technology that offers very high efficiencies leading to very low LCOE. This area welcomes papers describing advances enabling higher efficiency, lower cost, or more reliable concentrator cells, modules and systems.

Sub Area 3.1: Concentrator Solar Cells
Solar cell devices are discussed for concentrator systems, including studies on high-efficiency cell materials and designs, their theoretical modeling, materials development, cell characterization, performance, long-term behavior, reliability, industrial manufacturing, and cost. The concentrator cells may include monolithic multi-junction III-V solar cells, low-cost silicon concentrator cells, stacked cells, new component cells, etc. Solar cell devices and their characteristics under high- and low concentration are discussed.

Sub Area 3.2: Concentrator Receivers and Modules
This sub-topic area presents the latest advances in receiver and module design, testing, manufacturability, and reliability. Testing and characterization relating to optical and electrical design, thermal management, and environmental factors are emphasized. Reliability of receivers and panels relating to cell protection, mounting and interconnecting, heat sinking, optics, anti-reflective and anti-soiling coatings, mechanical design, qualification testing, and other factors are covered. Performance modeling and characterization based upon environmental conditions are sought. Module cost analysis is also welcome.

Sub Area 3.3: Concentrator Systems
System integration of receivers and modules into tracking and non-tracking systems are important factors to overall system performance, cost, and reliability. This sub-topic area is intended to cover both high and low concentrator system designs utilizing III-V cells, Si cells, and other novel concentrator materials. Discussion topics include system cost, performance and operation, characterization, environmental factors, maintenance, soiling, and reliability. System components like trackers or inverters are covered as well as applications were CPV systems can address new markets. Field performance measurements and evaluation of concentrator projects to permit realistic evaluation of overall system performance, reliability, and design requirements that lead to revised and
better designs for improved cost and manufacturability are encouraged. Finally, financial aspects and large-scale integration of CPV into utility electricity supply are covered in this sub area.
Area 4: Crystalline Silicon Photovoltaics

Chair: Nathan Stoddard, Solarworld, USA
Co-chairs: Gianluca Coletti, IMEC
Zhigang-Rick Li, DuPont

4.1: Feedstock, Doping and Impurities
Roland Einhaus, Apollon Solar

4.2: Crystallization and Wafering
Noritake Usami, Tohoku University

4.3: Passivation and Advanced Devices
Giso Hahn, Univ. of Konstanz

4.4: Industrial Cell Processing
Ajay Upadhyaya, Georgia Tech

4.5: Fundamentals
Mariana Bertoni, Arizona State Univ

The downward trend in module prices worldwide continues to drive the need for improved technology in crystalline silicon to maintain competitiveness and meet the demands of a widening market. Refinements in fundamental understanding on topics such as crystallization techniques, defect control and surface passivation drive further improvement in performance. Advances in cell performance demand a difficult balance of performance and manufacturability. We invite papers reporting on all aspects of crystalline silicon technology, encompassing the value chain from feedstock through crystallization, wafer cutting, wafer handling and cell design, as well as the fundamental aspects of defect characterization, gettering, modeling and optics.
**Area 5: Thin Film Silicon Based PV Technologies**

**Chair:** Arno Smets, Delft University of Technology, the Netherlands  
**Co-chairs:** Ivan Gordon (IMEC, Belgium)  
Nikolas Podraza (University of Toledo, USA)

**Sub-Area 5.1 Fundamental properties of thin film silicon**  
Sub-Area Chair: Erik Johnson (Ecole Polytechnique, France)

**Sub-Area 5.2 Processing issues for thin silicon films and devices**  
Sub-Area Chair: Takuya Matsui (AIST, Japan)

**Sub-Area 5.3 Light management concepts in thin film silicon solar cell devices**  
Sub-Area Chair: Matthieu Despeisse (EPFL Neuchatel, Switzerland)

**Sub-Area 5.4 Novel concepts for thin film silicon solar cell devices**  
Sub-Area Chair: Vikram Dalal, (Iowa State University, USA)

**Sub-Area 5.5 Polycrystalline and epitaxial silicon technology**  
Sub-Area Chair: David Young, (NREL, USA)

**Sub-Area 5.6 Thin film silicon based solar cells, multijunctions and PV modules.**  
Sub-Area Chair: Bernd Stannowski (Helmholtz Zentrum Berlin, Germany)

Thin-film photovoltaics based on amorphous, nano/microcrystalline, polycrystalline and epitaxial silicon on non Si-substrates have matured through three decades of advances in the design and processing of high-quality materials, solar cells and modules. Despite these great advances, many fundamental and technological issues of great importance still remain in order to achieve further progress, like the further increase of the conversion efficiencies and the reduction of cost price of thin silicon film based solar cells. Detailed research studies and visionary papers addressing the entire spectrum of the subject are welcomed. These topics include, but are not limited to: material characterization concerning microstructure, light induced degradation, various silicon based alloy types such as SiGe:H, SiC:H, SiO:H, film oxidation, passivation at heterojunction interfaces; processing issues concerning large throughput, large area, high deposition rates, contamination issues, processing routes for polycrystalline and epitaxial silicon; light trapping using textured interfaces, multi-layers, intermediate reflective layers and new TCO materials or concepts; novel concepts for thin silicon solar cells concerning films with new functionalities, plasmonic approaches, spectral conversion; and all topics related to amorphous/microcrystalline/polycrystalline/epitaxial silicon film solar cells and modules such as multi-junction structures, high performance and long-term reliability.
Organic solar cells are rapidly advancing technologies that show potential for low-cost, light-weight, and flexible solar power generation. With efficiencies in organic photovoltaic (OPV) devices approaching or exceeding 11% through both single junction and tandem device architectures, these technologies represent scalable PV technologies that may soon demonstrate initial commercial viability. Despite this remarkable progress, there is a need to increase our understanding of the underlying processes in OPV devices both at the nanoscale and bulk as well as the chemistry, physics, and engineering issues behind OPV systems. Furthermore, commercial viability needs to be enabled to fully realize the advantages of OPV as a technology.

This symposium intends to address recent progress in devices and processing in a wide range of organic related photovoltaic technologies, including polymer solar cells, small molecule solar cells, organic-inorganic hybrid, and dye-sensitized solar cells. Novel interfacial and electrode materials, novel device concepts and architectures, device lifetime, active layer materials and characterization, and large-scale OPV device/module fabrication methods are important topics to be addressed. We especially encourage submissions describing the emerging strategy of using OPV as a low-cost efficiency enhancement layer in tandem with conventional inorganic photovoltaics. The symposium hopes to bring together efforts from a wide range of expertise to further facilitate the development of this technology.

The primary focus will in five main areas that combine many of the themes in the broad set of devices combining inorganic and organic materials to develop low-cost, stable, high-performance solar energy systems.
Area 7: Space Technologies

Chair: Philip P. Jenkins, Naval Research Laboratory, USA
Co-Chairs: Mitsuru Imaizumi, JAXA, Japan
           Carsten Baur, ESA, The Netherlands

Sub-Area 7.1: Space Devices and Materials
              David Scheiman (Naval Research Laboratory)
Sub-Area 7.2: Space Systems
              Brian Spence (Deployable Space Systems)
Sub-Area 7.3: Flight Performance and Environmental Effects
              Justin Likar (Lockheed Martin)

Advances in photovoltaic device performance for spacecraft applications over the past decade have been continuous and remarkable. However, spacecraft requirements of the power system continue to grow and power subsystems are still the most failure prone, thus there is much work to be done. Papers are sought that describe advancements in photovoltaic devices capable of high performance (efficiency, mass specific power, volumetric specific power, radiation stability, high temperature capability, LILT, low cost, etc) as well as solar array designs suitable for these advanced devices. Also of interest are papers concerning cell, array and power system reliability, space environmental effects, and advanced protective materials for the space environment. To span the spectrum from fundamental research to applied engineering, we welcome papers ranging from theoretical studies to applied experimental efforts, including characterization and qualification as well as flight experiments and missions.

Area 7 has been divided into three subareas, as presented below. Submission of papers on detailed scientific research studies and visionary papers addressing the full range of these fundamental issues and technological challenges in the field are invited, including:

7.1: Space Devices and Materials
This subarea focuses on novel photovoltaic device approaches and recent developments for achieving high performance photovoltaic devices for spacecraft applications. Submissions may include (but are not be limited to) next generation multijunction solar cells, quantum enhanced devices, advanced cell materials and the spin-on of terrestrial photovoltaics for spacecraft applications (ie. thin film PV, etc). In addition, novel environmental protection technologies that enable longer on-orbit capability, high voltage operation, etc., are sought. Papers on characterization, modeling, and qualification of high efficiency solar cells are also welcome.

7.2: Space Systems
This subarea focuses on technology developments associated with integrating space photovoltaic devices into high performance spacecraft power systems, including blanket/module technologies (cell interconnects, advanced harnessing, modularity schemes, etc.) and advanced solar array technologies.
7.3: Flight Performance and Environmental Effects

Analysis and results from on-orbit experimentation will be presented in this subarea. This includes behavioral data and analysis of high performance photovoltaic devices and systems exposed to the space environment as well as results from on-ground testing activities under realistic conditions. Papers examining solar cell degradation due to particle irradiation along with its modeling and flight prediction are encouraged. Topics relating to effects of spacecraft charging and electrostatic discharges on solar cell, or system design, are encouraged including basic mechanisms, flight experimentation, flight performance, ground laboratory results, mitigation techniques, qualification (ISO-11211 or otherwise), and combined effects. Also of interest are papers in which performance data is presented relevant to specific missions, such as near sun or deep space where solar cell performance has to be determined under extreme conditions (high intensity, high temperature and low intensity, low temperature, respectively).
Area 8: Characterization Methods

Chair: Gerald Siefer, Fraunhofer ISE, Germany
Co-chairs: Tonio Buonassisi, M.I.T, USA
Yoshihiro Hishikawa, AIST, Japan
Yanfa Yan, The University of Toledo, USA

Sub-Area 8.1: Defects in Photovoltaic Materials and Solar Cells
Sub-Area 8.2: Advanced Methods and Instruments for the Characterization of Solar Cells and Modules
Sub-Area 8.3: In-Situ Measurements, Process Control, Defect Monitoring.
Sub-Area 8.4: Challenges in the Characterization of Novel Solar Cell Devices
Sub-Area 8.5: Performance Testing and Standards

It is impossible to understand innovation in science without the support of measurements and characterization. Measurements are needed at all different levels of R&D and production - from the investigation of the operating principles of solar cells to the development of standards for the performance of installed PV systems. Understanding the relations between structure, physical properties, and the resulting PV performance is an exemplary problem in materials science and engineering. Reliable and precise determination of the efficiency and thus power of solar cells and PV modules is crucial for the successful widespread deployment of photovoltaics. Area 8 is intended for the presentation of the latest developments in the characterization of photovoltaics. We encourage members of the PV community to submit their contributions addressing the full range of scientific and technological challenges in the field of characterization, including the following topics:

8.1: Defects in Photovoltaic Materials and Solar Cells
The presence of defects often limits the performance of solar cells and process yield. Relevant to this subarea are all methods for the characterization of defects and their influence on the PV performance, including (opto)electronic measurements, structure, composition, stress fields, and mechanical properties. This subarea includes both intrinsic defects of the PV materials and manufacturing defects associated with yield.

8.2: Advanced Methods and Instruments for the Characterization of Solar Cells and Modules
In the last decade, improvements in methods and instrumentation in the field of the characterization of PV have been extraordinary. This subarea targets on novel characterization methods and characterization equipment. This involves both – laboratory based characterization as well as in-line high throughput characterization.

8.3: In-Situ Measurements, Process Control, Defect Monitoring
Process control typically requires continuous measurements integrated (and compatible) with the growth/manufacturing equipment. These measurements, often required to be non-contact and non-destructive, are essential to control manufacturing parameters and for yield and process performance optimization. In addition to this, it is important to
develop feedback methods by which a process is controlled. This subarea includes both, novel methods and the application of existing methods in selected environments.

8.4: Challenges in the Characterization of Novel Solar Cell Concepts
Novel solar cell concepts require an adaption of characterization techniques. Solar cells such as multi-junction devices, organic and dye sensitized solar cells as well as metastable devices cannot be characterized using standard measurement procedures. Issues related to the characterization of such devices are the topic of this subarea.

8.5: Performance Testing and Standards
Standardization of measurements for the determination of the performance of solar cells and PV modules and systems is increasingly important as the global installed PV power continues to expand. This involves also methods for estimating PV performance over time and measurements that are necessary to accomplish this task.
Area 9: PV Modules and Terrestrial Systems

Chair: Joshua Stein, Sandia National Laboratories, USA
Co-Chair: Osamu Onodera, NEDO, Japan

Sub-Area 9.1: Solar Resource Assessment
Steve Ransome (SRCL)

Alex Cronin (Univ. of Arizona)

Sub-Area 9.3: Inverters, Converters, Embedded Power Electrics, and BOS
Stephen Pisklak (Dow)

Sub-Area 9.4: PV Performance Modeling
Nate Blair (NREL)

Sub-Area 9.5: Interconnecting PV to the Grid
Robert Broderick (Sandia National Laboratories)

Sub-Area 9.6: Advanced PV Systems and Smart Grid
Brian Dougherty (NIST)

The amount of innovation in the area of PV modules and systems has been growing dramatically in recent years. The PV sector is moving quickly from being a very small part of the energy generation mix to becoming a major component of the electrical power system. This rapid growth is resulting in numerous challenges, including the need to reduce uncertainty in the available solar resource, the need to reduce manufacturing costs and increase performance and reliability by developing new module and BOS designs and materials, the need to increase system efficiency at all steps in the power conversion process, the need to streamline the interconnection process, and the need to design and operate PV systems to integrate with the “smart grid” of the future. We have divided this broad area into six sub-areas, which are described in more detail below. We welcome papers describing technical advances in PV modules and systems.

Due to the multidisciplinary nature of systems research, Area 9 may host joint sessions with other Areas, including Areas 3, 8, 10, and 11. Authors should submit to the area of their choice; abstracts that are relevant to two areas will be reviewed by both areas and will be considered for inclusion in all relevant sessions.

9.1: Solar Resource Assessment
Sub-area 9.1 concerns measurements, modeling and mapping of irradiance resources. The instantaneous power from PV systems depends on the irradiance intensity, spectral distribution, solar angle of incidence, and angular distribution. Papers and posters are requested concerning the following topics:

• Measurements with pyranometers, unfiltered or filtered reference cells of differing technologies, their angle of incidence and spectral dependence, calibration and drifts.
• Measurements in the horizontal plane, fixed, 1-D or 2-D tracking, direct vs. diffuse fraction, sky angular and spectral distributions, concentrator measurements.
• Remote sensing applications
• Variability by geographical location and interpolation between sites.
• Cloud effects, transients, cloud cover measurements.
• Databases and pseudo random stochastic time series generation
• Allowance and predictions of climate change

System designers are paying increasing attention to modules that offer excellent yield, efficiency, and lifetime. Sub-area 9.2 focuses on materials, designs, and practices that improve module-scale performance and reliability. This includes AR coatings, encapsulants, edge seals, frames, junction boxes, substring assembly, and bypass diodes, as well as thermal and mechanical management of module components.

9.3: Inverters, Converters, Embedded Power Electrics, and BOS
Technology to squeeze every available kWh of energy from an array continues to evolve and has branched into many forms: “grid-friendly” central inverters, yield optimizers, AC modules, “smart” combiner boxes, cloud-proof tracking methods, integrated battery backup systems, time-of-use storage, fault-protection schemes, and power conversion products that serve specialized applications. This sub-area is targeted to an audience that is interested in the latest developments in these technologies and trends for the future.

9.4: PV Performance Modeling
This sub-topic area presents the latest advances in system modeling, component modeling and validation of models. It’s anticipated that issues such as shading, derates and emerging technology modeling will be discussed. Papers regarding new models of components as well as the integration of component models into a system model are solicited. Papers reviewing model implementations (tools) and the validation of the models and tools are very welcome although papers simply describing the capabilities of a tool will likely be deemed too commercial. We look to receive papers regarding modeling across system-scale (residential to utility-scale) as well as at various transient scales as well.

9.5: Interconnecting PV to the Grid
High penetration of both distributed and utility-scale PV systems on the electrical power grid and the variability and unpredictability of PV output introduce a host of challenges for utilities to manage. This subarea focuses on novel solutions to (1) identify these challenges through screening, (2) analyze and predict system impacts, and (3) mitigate the impacts through new grid integration strategies and technologies.

9.6: Advanced PV Systems and Smart Grid
Thousands of electric power utilities around the world seek to more effectively integrate renewables into their distribution systems, especially as part of their overall efforts to transition to the evolving cyber-physical system dubbed the Smart Grid. Papers are sought that address and demonstrate ways that solar photovoltaic systems can contribute to the realization of the Smart Grid. Papers on advances in PV technologies and their deployment at the system level are also sought for this sub-area. Possible topics include system level advances with the solar array itself, the integration of local energy storage, the
implementation of system optimizing controls, and approaches for gaining improved interactions with centralized and micro grids.
Area 10: Reliability of PV

Chair: Sarah Kurtz, NREL, USA
Co-Chairs: Tony Sample, JRC, European Commission
Wei Zhou, Trina Solar, China

Subarea 10.1: Field Experience
Jeff Newmiller (BEW Engineering), Yuzuru Ueda (Tokyo Institute of Technology)

Subarea 10.2: Correlation of Accelerated Testing and Field Performance
John Wohlgemuth (NREL)

Subarea 10.3: Manufacturing Quality Assurance
Masaaki Yamamichi (AIST)

Subarea 10.4: PV Safety Issues
Joerg Althaus (TÜV Rheinland)

Subarea 10.5: Cell Level Reliability Issues
Allan Ward (First Solar), Kent Whitfield (Solaria)

Subarea 10.6: Reliability Techniques for Application to PV
Carole Graas (Colorado School of Mines), Glenn Alers (University of California, Santa Cruz), Vivek Gade (Jabil)

As the PV industry has grown, it has become increasingly critical to have confidence in the long-term performance of the GWs of PV, representing billions of dollars or euros investment. This topic cuts across all technologies and throughout the supply chain. Topics especially critical to the success of the PV industry include: an up-to-date understanding of what is being observed for deployed products, the physics behind observed degradation/failure modes, and the quantitative correlation between accelerated test results and outcomes seen in the field as a function of climate and installation in order to move toward statistical service life predictions. Submissions are invited for all types of PV technologies.

This area will host joint sessions with other Areas, including Areas 8, 9, and 11. Authors may choose to submit to the area of their choice; abstracts that are relevant to two areas will be reviewed by both areas. If appropriate abstracts are received, a joint session with the Velocity forum will be included: "Demonstrating Reliability to Satisfy the Investor/Customer/Insurance company."

Area 10 has been divided into five subareas, as presented below. Submission of papers on detailed scientific research studies and visionary papers addressing the full range of these topics are invited, including:

10.1: Field Experience
This subarea focuses on statistics of types of failures, analysis of mechanisms of observed degradation and failures, electrical and mechanical impacts of failures, degradation models, and long-term operation models of PV plants. Submissions may include (but are not limited to) observations and analysis of observations from deployments of all PV technologies, methods of analysis of such data, and models or reviews that paint the big
picture of what is happening in the field.

10.2: Correlation of Accelerated Testing and Field Performance
This subarea focuses on identification of failure modes observed in the field that can be duplicated using accelerated stress tests, quantitative determination of acceleration factors for those failure modes, modeling of failure rates and wear-out as functions of localized weather conditions and/or accelerated stress test conditions, and fundamental physics and chemistry studies that can lead to quantitative modeling of module and device reliability and durability.

10.3: Manufacturing Quality Assurance
This subarea focuses on qualification of materials and components including development of test methods and specifications, process control, in-line diagnostic techniques, product sampling/testing, warranty return experience, standardization, and other technical aspects of quality assurance programs that are needed to avoid PV product recalls/returns.

10.4: PV Safety Issues
This subarea focuses on fire prevention, arc detection/mitigation, shock hazards, ground faults, mechanical integrity, and inspection procedures and other safety issues. Submissions may address mitigating or testing for the full range of safety issues at the module and/or system level.

10.5: Cell Level Reliability Issues
This subarea will focus on the physics of metastabilities and degradation, including potential induced degradation, moisture susceptibility, diffusion, electromigration, as well as device reverse-bias behavior such as hot-spot formation and breakdown, etc. Submissions are solicited both for cell level issues that are independent of packaging and for issues that must be treated by studying both packaging and cell structure at the same time.

10.6: Reliability Techniques for Application to PV
This subarea will provide an opportunity for reliability engineers from other disciplines to share their techniques with the PV community. Emphasis will be on techniques that help understand the diversity of stresses and conditions that are experienced by PV modules and how these interact with both the packaging and the enclosed electrical systems and materials. Submissions are welcomed for the full range of component through system level testing, modeling, failure analysis, and metrology.
Area 11: PV Velocity Forum

Chair: Elaine Ulrich, U.S. Department of Energy, USA
Co-Chair: Kristen Ardani, NREL, USA

Sub-Area 11.1 Deployment: Analysis and Case Studies
Sub-Area 11.2 Technology and Business Support through Shared Resources
Sub-Area 11.3 Manufacturing

The PV Velocity Forum will address strategies to sustain or accelerate high growth rates and rapid cost reductions for PV technologies.

“Deployment: Analysis and Case Studies” will focus on deployment challenges at the local, national and international level. This area may include market, finance, Intellectual Property, business development, outreach, policy and regulatory studies. This may include workforce challenges with an emphasis on finding ways to effectively increase the breadth of expertise engaged in PV R&D, manufacturing, deployment and technology support.

“Technology and Business support through shared resources” will focus on the wide variety of R&D centers, consortia, facilities, road-mapping, and other activities and resources that can help you to access information and equipment you need to drive your technology and business forward in a cost-effective manner. This is an appropriate forum for showcasing the resources that may be offered by your organization. This is open (but not limited to) government programs, non-profits, advocacy organizations and for-profit facilities and services.

“Manufacturing” will explore the outlook for materials & equipment supply chains (from cradle to grave), manufacturing costs, environmental & safety impacts that must be addressed in order to drive emerging technologies into production.