PROGRAM

38th IEEE PHOTOVOLTAIC SPECIALISTS CONFERENCE

Austin Convention Center
Austin, Texas

June 3-8, 2012

IEEE

IEEE ELECTRON DEVICES SOCIETY

IEEE photonics SOCIETY formerly LEOS

IEEE PES Power & Energy Society®

MARK YOUR CALENDARS

June 16-21, 2013, Tampa, Florida
39th IEEE Photovoltaic Specialists Conference

June 8-13, 2014, Denver, Colorado
40th IEEE Photovoltaic Specialists Conference

PVSC 38 REGISTRATION DESK HOURS

1st Floor, Exhibit Hall 4 Foyer, Austin Convention Center

Saturday	4:00 PM - 8:00 PM
Sunday	7:00 AM - 8:00 PM
Monday	7:00 AM - 5:30 PM
Tuesday	8:00 AM - 5:30 PM
Wednesday	8:00 AM - 5:30 PM
Thursday	8:00 AM - 5:30 PM
Friday	8:00 AM - 1:00 PM

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Sponsored by the Electron Devices Society of the Institute of Electrical and Electronics Engineers

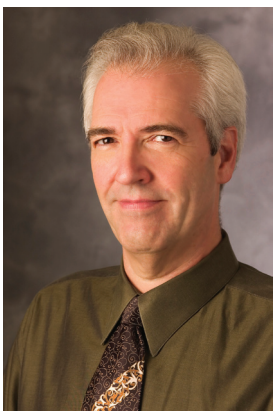
CHAIRMAN'S MESSAGE

Welcome to the 38th IEEE PV Specialists Conference, the pre-eminent global technical conference in photovoltaics that is sponsored by the world's largest professional association for the advancement of technology, the Institute of Electrical and Electronic Engineers.

The 38th PVSC marks the beginning of the Conference's second half century, and is expected to host about a thousand presentations. Its ten topical technical focus areas range across fundamentals, characterization, new concepts, all of the major commercial and next generation technologies, space and terrestrial applications, and policy and finance developments that can drive the velocity of market penetration as much as technological and manufacturing advances. The highest quality papers will be eligible for inclusion in the IEEE Journal of Photovoltaics, a newly commissioned, peer-reviewed, archival publication reporting original and significant research results that advance the field of photovoltaics. This year's technical program includes a special focus in the terrestrial PV systems area on recent developments in smart grid and module technologies that may play an important role in the future of system design for distributed generation.

The conference exhibits will be in the Austin Convention Center, a modern state-of-the-art venue, providing an ideal opportunity to access the world's leading researchers in photovoltaics. Austin is the Texas state capital, renowned for its high-tech entrepreneurial business environment, dynamic night-life and music scene, outstanding restaurants, scenic lakes and rivers, and as a gateway to the Central Texas Hill Country.

We invite you to Austin, Texas where the 2012 conference will be held June 3-8. Join thousands of the world's leading scientists and engineers, policy-makers and financiers, exhibitors and students at this time of massive transformation of the PV industry. After decades of sustained doubling of global production every two to three years, inexorable price reduction is driving the cost of solar PV generated electricity to grid parity in ever-expanding regions of the world. Environmental, climate change, and energy security concerns must be addressed with greater availability of clean energy to support continued global economic growth. Clearly, photovoltaics can be part of the solution, and public awareness is growing that photovoltaics can shape energy use patterns for generations. Join us in Austin and participate in the creation of this future.



Dr. Billy J. Stanbery
Chief Science Officer, HelioVolt Corporation
Conference General Chairperson

GENERAL INFORMATION

DATES

The 38th IEEE Photovoltaic Specialists Conference begins Sunday, June 3rd, with a day of tutorials. The technical program begins Monday, June 4th, and concludes Friday, June 8th, 2012.

CONFERENCE VENUE

Austin Convention Center
500 E. Cesar Chavez Street
Austin, TX 78701
Ph: 512.404.4000

REGISTRATION INFORMATION

Name badges and final programs will be distributed at the Registration Desk which is located on the 1st Floor, Exhibit Hall 4 Foyer, Austin Convention Center. The Registration Desk will be open during the following hours:

Saturday	4:00 PM - 8:00 PM
Sunday	7:00 AM - 8:00 PM
Monday	7:00 AM - 5:30 PM
Tuesday	8:00 AM - 5:30 PM
Wednesday	8:00 AM - 5:30 PM
Thursday	8:00 AM - 5:30 PM
Friday	8:00 AM - 1:00 PM

SPEAKER READY ROOM

The speaker ready room will be available to all oral presenters for required previewing and optional editing of your presentation(s). The speaker ready room is located in MR 13B and will be open during the following hours:

Sunday-Thursday	7:00 AM - 5:00 PM
Friday	7:00 AM - 10:00 AM

INTERNET ACCESS

The Austin Convention Center provides free access to their WiFi network.

NO PHOTOGRAPHY POLICY

The Organizing Committee has decided that photography is not allowed except for official conference photographers.

CONFERENCE MESSAGE CENTER

An information and message center will be located in the registration area.

AUTHOR'S BREAKFAST

All poster and oral presenters are required to attend the Author's Breakfast at 7:00 AM the morning of (each of) your presentation(s) for instructions, to meet your session chair, and to be sure all your materials have uploaded correctly. Breakfast will be in Ballroom EF.

COFFEE BREAKS

Coffee and soda breaks will be available each morning and afternoon. Please see below for locations:

8 AM Breaks

Monday - 4th Floor Foyer
Tuesday - 4th Floor Foyer
Wednesday - 4th Floor Foyer
Thursday - 4th Floor Foyer
Friday - 4th Floor Foyer

10 AM Breaks

Monday - 4th Floor Foyer
Tuesday - Exhibit Hall 4
Wednesday - Exhibit Hall 4
Thursday - Exhibit Hall 4
Friday - 4th Floor Foyer

3 PM Breaks

Monday - 4th Floor Foyer
Tuesday - Exhibit Hall 4
Wednesday - Exhibit Hall 4
Thursday - 4th Floor Foyer

EXHIBITS

The exhibit hall is located on the 1st floor of the Convention Center in Exhibit Hall 4 and will be open during the following hours:

Monday	5:30 PM - 8:30 PM
Tuesday	10:00 AM - 5:00 PM
Wednesday	10:00 AM - 5:30 PM
Thursday	10:00 AM - 3:00 PM

IEEE ELECTRON DEVICES SOCIETY - MEMBERSHIP PROMOTIONS FOR 38 PVSC ATTENDEES

IEEE Members: If you're not currently a member of the Electron Devices Society, don't worry. Your registration fee includes a half-year membership in EDS. Members also enjoy free online access to the new IEEE Journal of Photovoltaics! See the EDS membership table onsite for more info. Please note if you are currently a member of EDS, you cannot use this offer to renew your membership for 2012. For more information, please visit www.ieee.org/eds.

Non-IEEE Member: Use the Credit Voucher in your registration bag to receive a $25 credit towards IEEE membership and Free EDS membership for one half-year.

Affiliate Member: If you are a member of another scientific/technical society, you will receive FREE EDS membership for one-half year. By joining IEEE as an Affiliate Member you enjoy all the benefits of being an EDS member.

Student: If you registered and paid for the conference at the student, non-member rate you will receive one half-year of FREE IEEE and EDS.

EDS membership credit vouchers will also be available at the IEEE Exhibit located in the main PVSC Expo Hall.

HELIOVOLT WELCOMES ATTENDEES

to the

38TH IEEE PV SPECIALISTS CONFERENCE

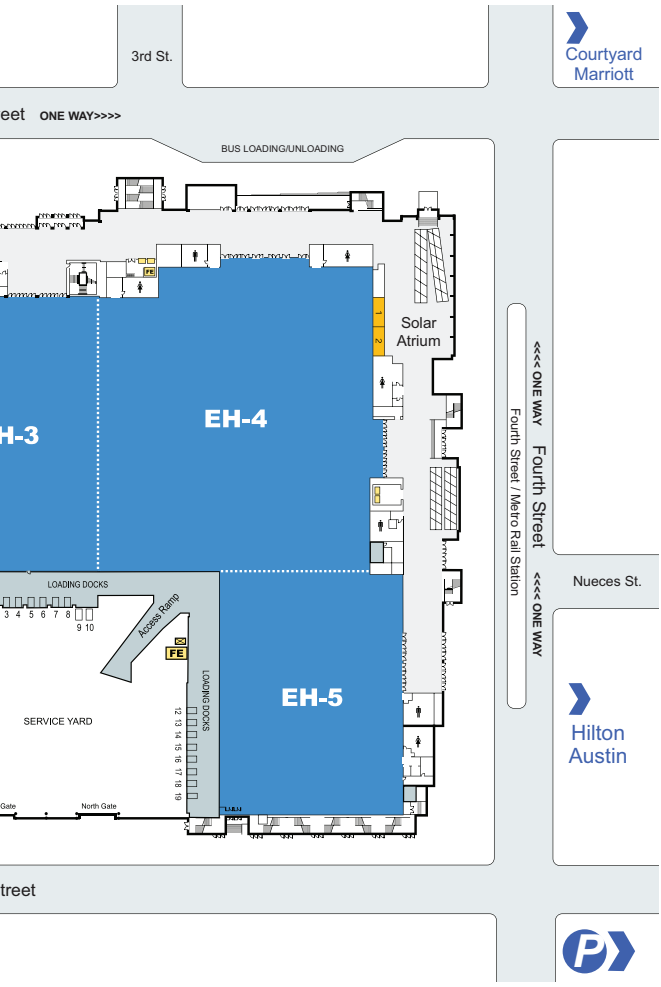
Founded in Austin in 2001, HelioVolt has built a world class manufacturing and research and development center that continues to advance thin-film CIGS technology and processes.

Visit us at **BOOTH #215** to learn about our newest high efficiency modules and speak with our employees about exciting career opportunities at HelioVolt!

LEARN MORE AT WWW.HELIOVOLT.COM

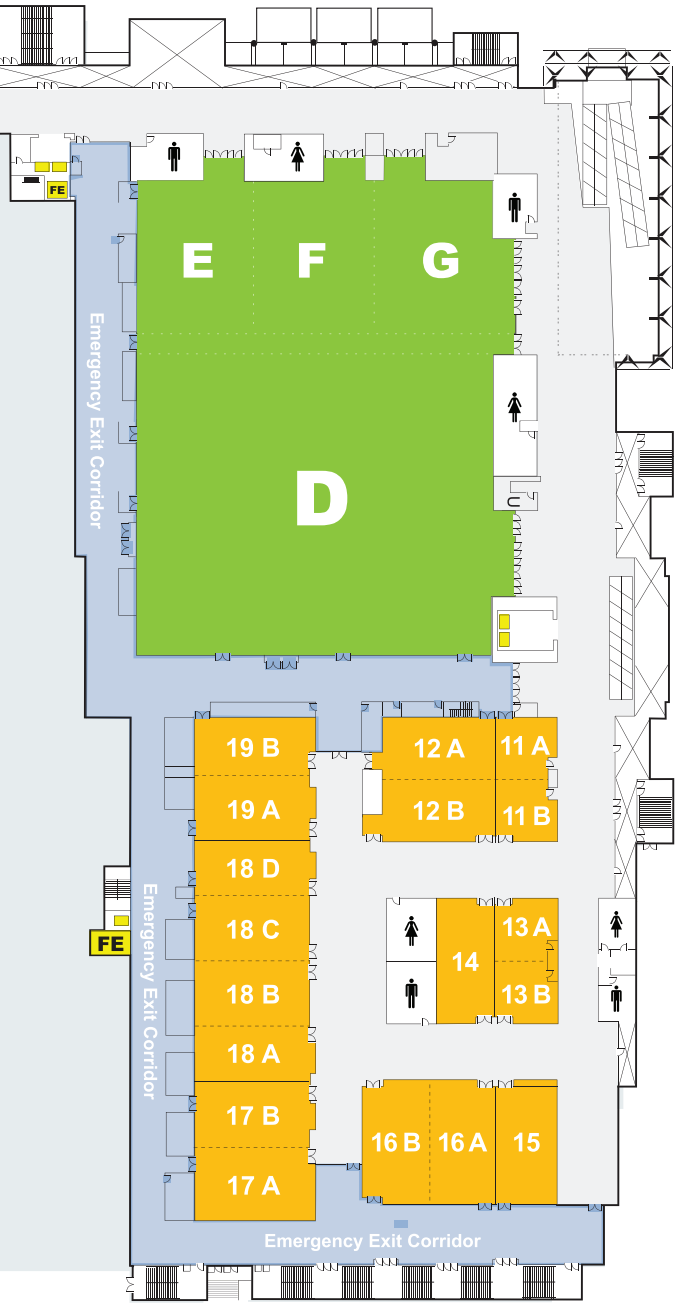
VENUE MAP - LEVEL 1

VENUE MAP - LEVEL 1



VENUE MAP - LEVEL 4

VENUE MAP - LEVEL 4



WILLIAM R. CHERRY AWARD

This award is named in honor of William R. Cherry, a founder of the photovoltaic community. In the 1950's, he was instrumental in establishing solar cells as the ideal power source for space satellites and for recognizing, advocating, and nurturing the use of photovoltaic systems for terrestrial applications. The William R. Cherry award was instituted in l980, shortly after his death. The purpose of the award is to recognize an individual engineer or scientist who devoted a part of his/her professional life to the advancement of the science and technology of photovoltaic energy conversion. The nominee must have made significant contributions to the science and/or technology of PV energy conversion, with dissemination by substantial publications and presentations. Professional society activities, promotional and/or organizational efforts and achievements are not considerations in the election for the award.

This award is presented at each IEEE Photovoltaic Specialists Conference. The recipient is selected by the William R. Cherry Committee, which is composed of past PVSC conference chairpersons and past recipients of the award. Those nominated for the award do not participate in the process.

To be eligible for the award, the nominee must currently be active in the science and technology of PV conversion. He/she must have been active in the field for an extended period with the expectation of continued activity. Short-term activities in the field, and/or single outstanding contributions are not sufficient to make a person eligible for the award.

To make a nomination, please submit a completed electronic nomination form and accompanying materials at: http://www.ieee-pvsc.org/ePVSC/cherry/form.php. The information required on the electronic form is listed below:

1. The name of your nominee, and his/her current affiliation and contact information.
2. A rationale (less than 150 words) of the nominee's contributions to the advancement of the PV field.
3. A citation (less that 40 words) listing the nominee's specific contributions to make them deserving of the award.
4. A list of the nominee's activities in the field.
5. A current CV for the nominee.
6. Nominator's name, address, phone number and e-mail address.

The deadline for Cherry Award nominations to be considered for the next IEEE PVSC is January 10 of each year.

Previous Cherry Award Recepients

Dr. Paul Rappaport	1980
Dr. Joseph L. Loferski	1981
Prof. Martin Wolf	1982
Dr. Henry W. Brandhorst	1984
Mr. Eugene L. Ralph	1985
Dr. Charles E. Backus	1987
Dr. David E. Carlson	1988
Dr. Martin A. Green	1990
Mr. Peter A. Iles	1991
Dr. Lawrence L. Kazmerski	1993
Prof. Yoshihiro Hamakawa	1994
Dr. Allen M. Barnett	1996
Dr. Adolf Goetzberger	1997
Dr. Richard J. Schwartz	1998
Dr. Christopher R. Wronski	2000
Dr. Richard M. Swanson	2002
Dr. Ajeet Rohatgi	2003
Dr. Timothy J. Coutts	2005
Dr. Antonio Luque	2006
Dr. Masafumi Yamaguchi	2008
Dr. Stuart Wenham	2009
Dr. Richard King	2010
Dr. Jerry M. Olson	2011

THIS YEAR THE WILLIAM R. CHERRY AWARD WILL BE PRESENTED TO:

DR. SARAH KURTZ

Dr. Sarah Kurtz is currently a Principal Scientist and Manager of the Module Reliability and Systems Engineering Group at the National Renewable Energy Laboratory (NREL). She has collaborated with others at NREL and around the world researching high-efficiency cells and PV reliability, with special emphasis on concentrator PV (CPV).

Dr. Kurtz received her PhD in Chemical Physics at Harvard University in 1985, working with Roy Gordon on the growth of amorphous silicon solar cells, and continued studying amorphous silicon as a post doc at the Solar Energy Research Institute (SERI, now NREL). In 1986, she joined Jerry Olson (at SERI) to implement Dr. Olson's invention of the GaInP/GaAs solar cell. In addition to the device fabrication and optimization, scientific studies included: effects of ordering of the group III sublattice on the optical properties, dilute-nitride materials and devices, dopant diffusion driven by non-equilibrium point-defect concentrations, multi-junction solar cell measurement techniques, and spectral effects on multi-junction cell performance. In 2004, she worked to implement Mark Wanlass's invention of the inverted metamorphic GaInP/GaAs/GaInAs cell, setting a world record with an efficiency of 37.9%, a record that was surpassed about a month later by a cell from Spectrolab. When the cell efficiencies approached 40%, Dr. Kurtz moved from studying the cells to studying the reliability issues associated with implementing these into complete systems. She now manages a group that attempts to put scientific rigor behind PV module reliability testing. In the last year, she helped to form the International PV Quality Assurance Task Force to develop comparative test standards for PV modules, with the goal of eventually enabling application-specific lifetime prediction for both flat-plate and CPV modules. She is recognized worldwide as an expert on CPV technology and has received numerous awards both as an individual and as part of a team including the Dan David Prize (in 2007, with Jerry Olson), Energy100 Award by the Department of Energy, and R&D 100 Awards.

Stuart Wenham
2012 William R. Cherry Award Chair

SOCIAL PROGRAM

WELCOME FROM THE SOCIAL PROGRAM CHAIR

Hi, my name is Ann Schneider and I am the Social Program Chair for the 38th Photovoltaic Specialists Conference. I'm pleased to invite you to join the fun and festivities planned for this year's conference!

Throughout the week we'll be offering a variety of organized and self-directed tours and social events, for which we have negotiated the best rates possible. Most of the tours, events and receptions are family friendly and you are welcome to join in all or as many as you wish. We know that we will create great memories among our community of Photovoltaic Specialists, families, and friends.

I look forward to meeting you in Austin and having a wonderful time together in this beautiful and unique city. Welcome to the Heart of Texas!

Warm regards,
Ann Schneider

COMPANION ROOM (AVAILABLE DAILY)

Because we are special, we have a dedicated space at the hotel to rendezvous, socialize, and be merry. Start each morning here with a complimetary continental breakfast. Companions are encouraged to make full use of this room. PLEASE NOTE that only companions with badges will be allowed in the companion's room for our continental breakfasts.

Monday - Thursday 7:30 am - 9:00 am
Hilton Hotel, Meeting Room 400

MONDAY, JUNE 4TH

AUSTIN: BY LAND AND BY SEA
10:00 am - 12:30 pm

We invite you to take an amphibious tour of Austin's surf and turf in an unsinkable, U.S. Coast Guard-inspected, Hydra Terra vehicle. The Duck Tour is a 75-minute sightseeing adventure that cruises past Historic Sixth Street, the State Capitol Building, Bob Bullock State History Museum, the Governor's Mansion and Lake Austin. The tour departs directly from the Hilton Austin. Bottled water will be provided.

Early Registration until May 1:
$42.00 per adult (minimum of 30 adult guests, maximum 129 total guests)
$20.00 per child (age 4-12 years old, 3 and under free)

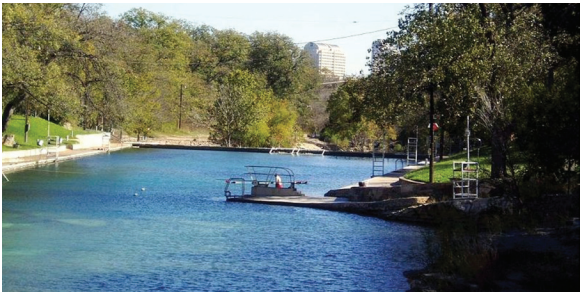
After May 2:
$52.00 per adult (minimum of 30 adult guests, maximum 129 total guests)
$30.00 per child (age 4-12 years old, 3 and under free)

MONDAY, JUNE 4TH

ZILKER BOTANICAL GARDENS AND BARTON SPRINGS POOL
1:00 pm - 5:00 pm

Zilker Botanical Garden - located on 30 acres of Zilker Park - has been called “the jewel in the heart of Austin.” Theme gardens, such as the rose, herb and Japanese gardens, are interspersed with flowing streams, gorgeous waterfalls and Koi-filled ponds. The Hartman Prehistoric Garden even recreates a local dinosaur habitat.

The garden is a unique collaboration between the City of Austin Parks & Recreation Department (PARD) and the Austin Area Garden Council (AAGC). As you explore the gardens, you will observe the diverse topography on the south bank of Austin’s Lady Bird Lake, which provides an ideal habitat for an array of native, hybrid and exotic plants.



In addition to touring the gardens, guests are invited to enjoy the other attractions of Zilker Park - Barton Springs pool, The Zilker Zephyr miniature train, Zilker Hillside Theater, Umlauf Sculpture Garden, the Nature Center and numerous historical markers and sites, concession stands and picnic areas.

Guests of all ages will delight in swimming in Barton Springs Pool, so remember to bring your swimsuit and towel. Three acres in size, the pool is fed from underground springs and maintains an average water temperature of 68 degrees year round. Enjoy the refreshing water and time to relax around the pool.

Round trip transportation via coach from the Austin Hilton and bottled water will be provided.

Early Registration until May 1:
$27.00 per adult (minimum of 35 adult guests)
$10.00 per child (age 12 years old and under)

After May 2:
$37.00 per adult (minimum of 35 guests)
$15.00 per child (age 12 and under)

TUESDAY, JUNE 5TH

TEXAS HILL COUNTRY!
9:00 am - 4:00 pm

Board your comfortable coach today from the Hilton Austin for a pleasant drive into the beautiful Texas Hill Country. Your journey begins in the town of Fredericksburg, named in 1846 after Prince Frederick of Prussia. Nestled in the Perdenales Valley, “fritz town,” as it is affectionately called, offers a glimpse into the German Chapter of Texas history, not to mention a variety of culinary delights and shopping that threatens credit card meltdown. Fredericksburg is also the home of the Admiral Nimitz State Historical Park, featuring the Pacific War Museum. From hand-made jewelry, preserves, home-made salsa, clothing, Texas-themed items and hand crafted dulcimers, there is something for everyone in Old Fritztown.

After exploring and shopping, we’ll head to Stonewall, TX -- the home of Becker Vineyards and Lavender Fields, for a private lunch, tour and wine tasting. Established in 1992, the vineyard was planted on a site of native Mustang grapes prized for winemaking by their German neighbors and ancestors. Also on the site is a three acre lavender field reminiscent of the wine country of Provence, France. We’re in luck, as lavender blooming season is typically in May and June. Several different lavender varietals bloom alongside the vineyard’s 46 acres of French Vinifera vines, generating eight different grape varietals.

Must be 21 years of age or older to participate in this tour

Early Registration until May 1:
$116.00 (minimum of 30 guests, maximum of 90 guests)

After May 1:
$126.00 (minimum of 30 guests, maximum of 90 guests)

WEDNESDAY, JUNE 6TH

SUN RUN
6:15 AM

The 2012 IEEE PVSC Sun Run will be held Wednesday, June 6th, during the 38th IEEE Photovoltaic Specialists Conference. This event was initiated in 1980 and has graced every IEEE PVSC since. The Seattle run will be held along Elliot Bay Trail (in Myrtle Edwards Park). We will have to bus our runners to and from the start of this event--and the buses will leave from the Sheraton Hotel at 6:15 a.m. This is an event for serious and more recreational runners! Awards will be made in several age categories and again, our special "Corporate Run" will be highlighted. To qualify for the Corporate Run, you need 3 runners (at least) to represent your company, university, government agency, or other organization. The times are handicapped by age and sex, using the long-proven Arvizu-Kazmerski adjustment system which adjusts your time to that of a 20-year-old runner. The fee is $25 and includes a most tasteful T-shirt and many other commemorative items. Registration can be made at the PVSC in the registration area (South Lobby, Level 4 of the convention center).

Cost:
$25.00

WEDNESDAY, JUNE 6TH

AUSTIN THROUGH HISTORY AND ART
9:30 am - 2:30 pm

The Blanton Museum of Art at The University of Texas is one of the foremost university art museums in the country, with the largest and most comprehensive collection of art in Central Texas. The Blanton collection comprises over 17,000 works of art, with particular depth in Western European art from the fourteenth through twentieth centuries and modern and contemporary art of the Americas. Your tour will pass through the Modern and Contemporary Art Galleries, European Paintings Galleries, and Print and Drawing Galleries, and will feature inspiring works spanning the Italian Renaissance to the cutting-edge contemporary art of North America and Latin America.

Following your tour, enjoy a gourmet boxed lunch in the museum's covered loggia or outdoor plaza here at the "cultural gateway" between University of Texas and the Austin community.

Round trip transportation via coach is provided from the Hilton Austin.

Early Registration until May 1:
$61.00 per adult (minimum of 30 adult guests, maximum 100 guests)
$50.00 per youth (age 12-17 years)
$20.00 per child (age 8-11, not recommended under age 8)

After May 2:
$71.00 per adult (minimum of 30 adult guests, maximum 100 guests)
$65.00 per youth (age 12-17 years)
$25.00 per child (age 8-11, not recommended under age 8)

WEDNESDAY, JUNE 6TH

LONE STAR RIVERBOAT BAT CRUISE
6:00 pm - 9:00 pm

In a two-hour sunset excursion on a Lone Star Riverboat, experience the exhilaration of the outdoors, the abundant wildlife, the ever-changing city skyline and the natural beauty that is Austin. Cruise under city bridges, around the mouth of Barton Creek and Zilker Park, past limestone cliffs, huge bald cypress and native pecan trees, waterfowl and great blue herons -- all in the heart of town. The pinnacle of the evening will be observing the world famous Mexican free tail bats as these nocturnal creatures emerge from the Congress Avenue Bridge they call home. The largest urban bat colony in North America, nearly 1.5 million bats reside in vertical crevices beneath the bridge roadway from mid-March to early November. There is no better seat in town from which to watch their evening antics than aboard the all-electric Lone Star Riverboat.

An appetizer and dessert buffet along with unlimited non-alcoholic beverages will be provided. Wines from the Texas-based Becker Vineyards and Shiner Bock Beer will also accompany this picturesque tour.

Round trip transportation via coach from the Hilton Austin is included.

Early Registration until May 1:
$111.00 per adult (minimum of 50 adult guests, maximum 147 guests)
$50.00 per child (aged 3-11)

After May 2:
$121.00 per adult (minimum of 50 adult guests, maximum 147 guests)
$55.00 per child (aged 3-11)

THURSDAY, JUNE 7TH

SAN MARCOS PREMIUM OUTLETS
9:30 am - 3:00 pm

Bargain hunters can save a fortune scouring the myriad of manufacturer and designer shops spread throughout the San Marcos Premium Outlets. From Coach, J. Crew and Pottery Barn Furniture to Bose, Brooks Brothers and Crate & Barrel, there are more shops than most can manage in a day (140!) so it's smart to plan ahead before hitting the pavement. Let the VIP Coupon Book (provided upon your arrival) be your guide to those in-the-moment special deals. Round trip transportation via coach from the Hilton Austin and bottled water will be provided. Enjoy lunch on your own at one of the many choices at the mall.

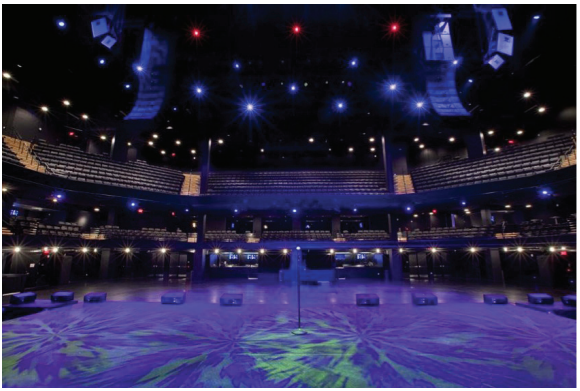
Early Registration until May 1:
$29.00 per adult (minimum of 40 adult guests)
$12.00 per child/youth (age 9-18 years old)

After May 2:
$39.00 per adult (minimum of 40 adult guests)
$17.00 per child/youth (age 9-18 years old)

THURSDAY, JUNE 7TH

PVSC BANQUET - AUSTIN CITY LIMITS AT MOODY THEATER
6:30 pm - 10:00 pm

Become immersed in the history of the longest running music television series, Austin City Limits, from the moment you walk down the red carpet and step inside ACL Live at the Moody Theater. The theater is the premier destination in Austin for live performance and private events. Green screen photography and corn hole toss will provide entertainment on the Music Porch. Tour the 3rd floor Gallery featuring the iconic ACL photographs of past legendary performers.



Savor the delicious Salt Lick BBQ - brisket, pork ribs, sausage, chicken, potato salad, coleslaw, beans, Vegetarian Creole with baked rice. Finish your meal with another Austin original, Amy's Ice Cream. Then sit back and enjoy a live music performance by Austin native and internationally renowned guitarist Eric Johnson. Though he is best known for his success in the instrumental rock format, Johnson regularly incorporates jazz, fusion, gospel and country and western music into his recordings. Johnson also composes and plays vocal pieces, and is an accomplished pianist.

Guitar Player magazine has called Johnson "one of the most respected guitarists on the planet." Johnson's stylistic diversity and technical proficiency with the guitar have been praised by Bill Hicks. His critically acclaimed, platinum-selling 1990 recording Ah Via Musicom produced the single "Cliffs of Dover", for which Johnson won the 1991 Grammy Award for Best Rock Instrumental Performance.
Price:

$80.00 per adult (maximum 900 guests)
$40.00 per child (aged 5-15)
No charge for children under 4 years

SELF-DIRECTED TOUR OPPORTUNITIES

In addition to the companion events, Austin offers many other sights to explore on your own.

Things to Do in Austin
www.thingstodoinAustin.com

Texas State Capital
www.tspb.state.tx.us/spb/capitol/texcap.htm

South Congress Avenue (SoCo)
www.austinchronicle.com/gyrobase/Guides/SoCo

Segway Tours
www.segcity.com/austin

Whole Foods Cooking Classes
wholefoodsmarket.com/stores/lamar-culinarycenter

6th Street
www.6street.com

Bob Bullock Texas State History Museum
www.thestoryoftexas.com

Austin Museum of Art
www.amoa.org

Austin Bike Tours and Rentals
www.austinbiketoursandrentals.com

Ladybird Johnson Wildflower Center
www.wildflower.org

Lyndon Baines Johnson Library and Museum
www.lbjlibrary.org

Austin Children's Museum
www.austinkids.org

Austin Zoo and Animal Sanctuary
www.austinzoo.org

Austin Nature and Science Center
www.ci.austin.tx.us/ansc

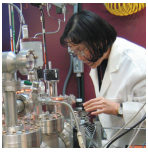
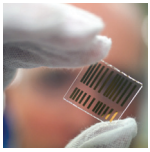
Lake Travis
www.laketravis.com/main_about.htm

Texas Hill Country Wineries
www.texaswinetrail.com

University of Texas at Austin
www.utexas.edu

SOLAR DAY/HIGH SCHOOL PHOTOVOLTAIC DESIGN COMPETITION

For the second year, Solar Day will kick off the IEEE PVSC. The purpose of Austin Solar Day is to showcase to the general public the benefits of PV by putting them in front of the experts who know it best - free of charge. Attendees will learn the basics of PV through educational sessions led by solar industry leaders; interact with representatives from local solar companies in our vibrant exhibit hall; and view the innovative ideas of Austin's young solar scientists, on display as part of our High School Photovoltaic Design Competition. We hope to see you there!

SunShot
U.S. Department of Energy

Revitalizing American Solar Competitiveness

DOE's SunShot Initiative seeks to reduce the total costs of solar energy by 75% within the decade making solar cost-competitive with conventional forms of electricity.

SUNSHOT GRAND CHALLENGE

Summit and Technology Forum

Join the best and brightest minds in government, industry, and academia in Denver, June 13 and 14 to address the scientific, technological, and market barriers to achieving breakthroughs in solar energy.

www.sunshotgrandchallenge.energy.gov

Visit us here in booth #307 and learn more about SunShot and how you can support work with DOE to reach the SunShot goals.

www.energy.gov/sunshot

ORGANIZING COMMITTEE

CONFERENCE CHAIR
BJ Stanbery
HelioVolt Corporation

PAST-CHAIR
David Wilt
AFRL/RVSV

DEPUTY CONFERENCE CHAIR/SECRETARY
Ryne Raffaelle
Rochester Institute of Technology

TREASURER
Richard R. King
Spectrolab

OPERATIONS
Steve Ringel
The Ohio State University

DEPUTY OPERATIONS
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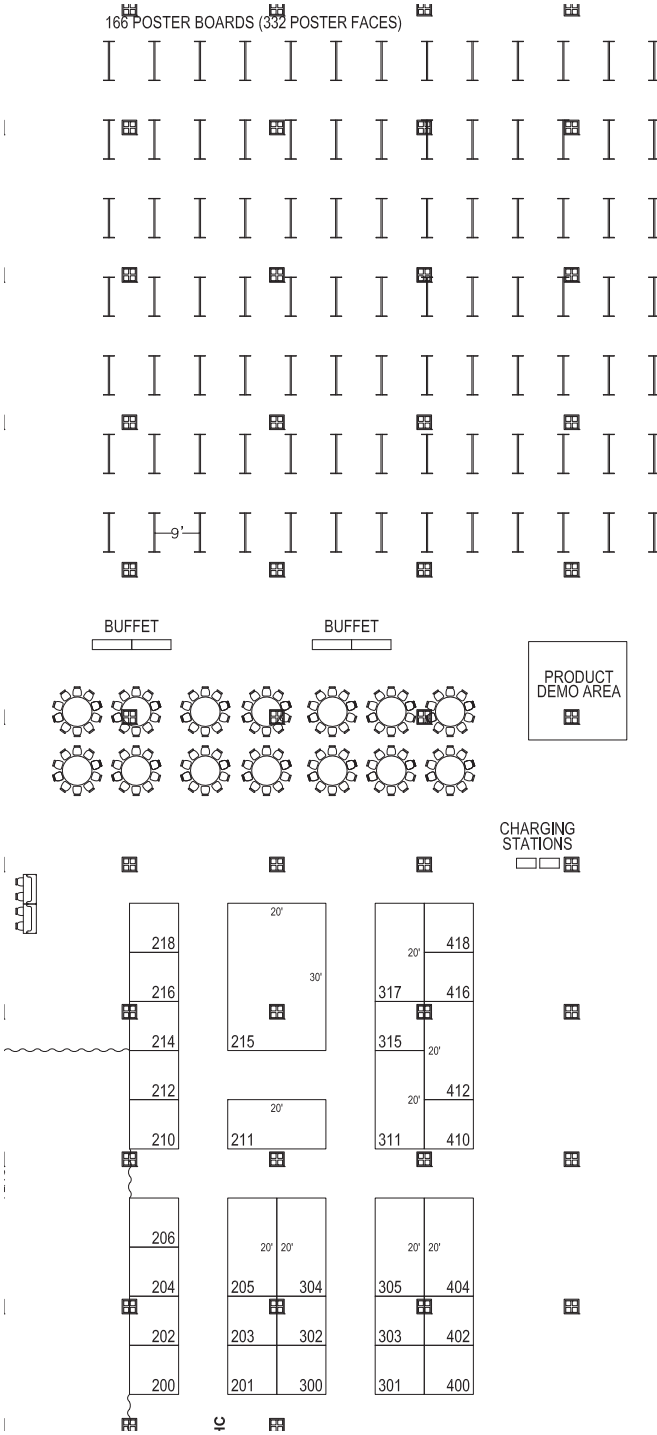

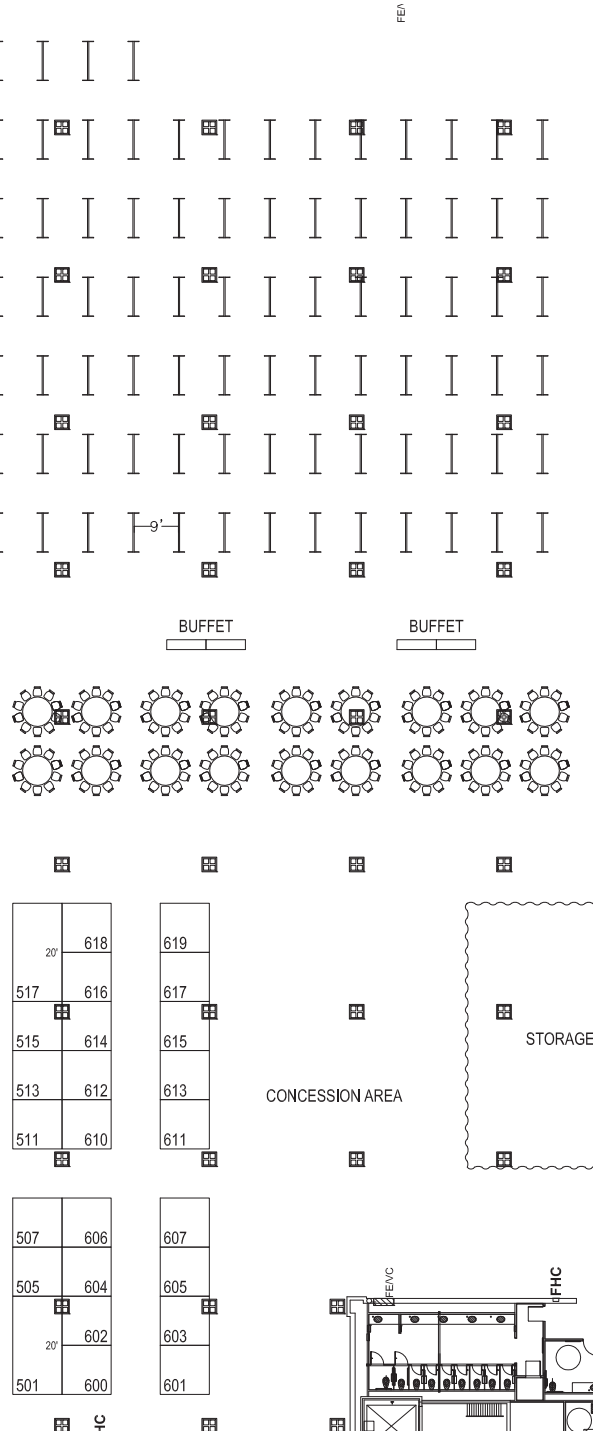
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Agilent Technologies
212
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Black Photon Instruments GmbH
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The IEEE Electron Devices Society (EDS), the sponsor of the 38th IEEE Photovoltaics Specialists Conference, is one of the technical societies of the IEEE; the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE and its members inspire a global community through IEEE's highly cited publications, conferences, technology standards, and professional and educational activities.

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315
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www.nrel.gov/pv
The National Center for Photovoltaics (NCPV) within the National Renewable Energy Laboratory performs research on wide range of PV materials including c-Si, thin-film silicon, CIGS, CdTe, III-V-based high efficiency devices, and organic PV. The NCPV provides standard performance measurements of PV cells and modules, as well as reliability testing. The Process Development and Integration Laboratory is a unique facility where collaborators can work closely with NREL scientists. Stop by the booth for a schedule of times to visit and “meet the PV experts.”

Naval Research Laboratory
211
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The Naval Research Laboratory (NRL) operates as the Navy's full-spectrum corporate laboratory, conducting a broadly based multidisciplinary program of scientific research and advanced technological development directed toward maritime applications of new and improved materials, techniques, equipment, systems and ocean, atmospheric, space sciences and related technologies. The Laboratory, with a total complement of nearly 2,500 personnel, is located in southwest Washington, DC, with other major sites at the Stennis Space Center, MS; and Monterey, CA.

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The Institute of Energy Conversion (IEC), established at the University of Delaware in 1972, is a laboratory devoted to research and development of thin-film photovoltaic solar cells and other photonic devices. IEC was designated a University Center of Excellence for Photovoltaic Research and Education by the Department of Energy and the National Renewable Energy Laboratory in 1992. IEC's mission is to develop the fundamental science and engineering base required to improve photovoltaic device performance and processing technologies and effectively transfer these laboratory results to large-scale manufacturing.

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PV Jobs At the Conference

The PV Jobs service offers the following during the conference:

- On-site interviews. We have an on-line scheduling system and private rooms available for conducting interviews. Prospective employers and employees may schedule interviews through the PV Jobs Portal (www.ieee-pvsc.org)
- Scrolling job announcements. Active job postings will be scrolled on the oral presentation room screens during breaks
- Job Fair. We will hold a job fair on Wednesday, June 6th from 3:30-5:00pm in the Exhibit Hall. Organizations with active job postings will be given a table in a sectioned off area to mingle with prospective job applicants.

INSTRUCTIONS TO ORAL PRESENTERS

Thank you for participating in the IEEE PVSC as an Oral Presenter! **As an Oral Presenter, the following lists your responsibilities:**

- Be sure to upload your manuscript, following the guidelines on the PVSC website, by May 21, 2012.
- Electronically sign the Copyright form and BRING A COPY WITH YOU
- Upload your presentation at least 24 hours prior to your presentation following the guidelines on the A/V company's website (see below). Bring your presentation on CD-ROM, Compact flash card, Memory Stick, Multi-media card, SD Card, and/or a laptop for transfer.
- Even if you upload your presentation prior to the conference, be sure to check that it uploaded correctly by reviewing it in the Speaker Ready Room at the conference. Bring your presentation on CD-ROM, Compact flash card, Memory Stick, Multi-media card, SD Card, and/or a laptop as a backup.
- Attend the Author's Breakfast on the morning of (each of) your presentation(s) for instructions, to meet your session chair, and to be sure all your materials have uploaded correctly. Author's Breakfast will be at 7:00 AM in Ballroom EF.
- Please arrive at your session at least 15 minutes before the scheduled start to coordinate with the session chairs, check that the presentation will display properly, and become familiar with the audio-visual equipment in your room.

REMEMBER: No Paper, No Podium

If your manuscript has not been uploaded, you will not be allowed to present. If you (or a co-author) do not give your presentation, the manuscript will not be included in the proceedings.

Be sure to check the online program to confirm your presentation time and length!

Guidelines for Computer Generated Presentations

Checking in to the Speaker Ready Room (MR 13B) is the single most important action you will take to ensure your presentation is a success. All speakers are required to check into the Speaker Ready Room at least 24 hours before their presentation. The Speaker Ready Room will be open daily during the meeting.

When reviewing your presentation, you should make sure all fonts appear as expected and all sound/video clips are working properly. You will also be able to edit your presentation at this time, if needed. The file will then be transferred to the computer network at the meeting. When the presentation is to be given, the file will be accessed via the conference menu on the computer provided in the meeting room. Once the presentation is launched, you (the speaker) will control the program from the podium using a computer mouse. At the end of the meeting, all files will be destroyed, and the computer hard drives will be reformatted.

We recommend PowerPoint for all users. A web browser (Internet Explorer) with typical plug-ins will also be available. If you plan to use something besides Flash, Shockwave or Windows Media Player, and for a comprehensive overview of our guidelines, please check with our Presentation Guidelines: http://www.prgpresenters.com/files/presentguidelines.pdf to be sure your presentation will work properly.

The computers in the presentation rooms will be Windows-based PCs with Microsoft Power Point 2007 installed. All videos should be .avi or .mpg (not .mov) format, so they will run properly on the computers provided. Presentations should be reviewed to be certain the fonts are displayed correctly.

For additional information on creating Power Point 2007 presentations or earlier versions, please see the Power Point Help website at http://office.microsoft.com/en-us/powerpoint/CH102247801033.aspx.

Supported Media

We recommend you bring at least 2 copies of your presentation to the meeting in case there is a problem with one of them. CD-R, CD-RW, Compact flash card, Memory Stick, Multi-media card or SD Card will be supported.

Ability to Edit PowerPoint Files in Speaker Ready Room

All PowerPoint presentations can be reviewed and edited in the Speaker Ready Room (MR 13B). For those who made changes to their presentations after the required 24-hour advanced presentation upload and check-in, the final version must be in place no less than two hours prior to the beginning of the session in which you are presenting.

Security

· Floppy drives and USB ports on the computers in the presentations rooms are disabled so no presentations can be copied.

· Cameras and video equipment are not permitted in the Speaker Ready Room.

· All files on the computers are deleted at the end of the conference and the hard drives will be reformatted.

Fonts: We can only supply fonts that are included in the base installation of Windows. Any font other than these will need to be embedded into your PowerPoint presentation. For information on embedding fonts see the conference website under Author Central, Oral Presentations. We suggest using the fonts such as Times New Roman, Arial and Tahoma. Use of fonts not included in Windows can lead to words that bleed into graphics or bullets that may be the wrong style.

INSTRUCTIONS TO POSTER PRESENTERS

Congratulations on being chosen to present a poster at the 38th PVSC! Poster sessions are critical to the success of the conference, contributing to both the breadth and the depth of coverage in photovoltaic technology. Poster papers make it possible for a large number of important developments in the field of photovoltaics to be presented. In addition, the poster sessions allow authors the opportunity to personally interact and network with interested parties, and discuss research results at a level of detail that cannot be approached in formal questions following an oral presentation.

As a Poster Presenter, the following lists your responsibilities:

- Manuscripts are required for all poster presentations in Areas 1-9. Manuscripts are accepted for poster presentations in Area 10, but are not required. Be sure to upload your manuscript (Manuscript Instruction), following the guidelines on the PVSC website, by May 21, 2012. We value ALL your contributions and expect each to be represented in the Proceedings.
- Electronically sign the Copyright form and BRING A COPY WITH YOU
- Prepare your poster following the guidelines below:
- **Poster Size** - The area available for the poster is limited to a rectangle 40 inches tall by 42 inches wide (101 cm by 106 cm). THE POSTER CHAIR RESERVES THE RIGHT TO TRIM ANY POSTERS LARGER THAN THE ALLOCATED SIZE TO THE ALLOCATED SIZE!!! Tables in front of poster boards are PROHIBITED.
- **Poster Format** - Poster materials must be legible from a distance of two meters. Lettering in text and figures should be at least 5 mm, and the headings should be at least 10 mm. The title of the paper, the authors, and their affiliations should appear near the top of the poster in letters approximately 25 mm high.
- **Poster Mounting** - The surface of the mounting board is pushpin friendly. Posters must be mounted to the boards with pushpins. Pushpins will NOT be available at the conference; you must bring your own. We also recommend that you attach an envelope near the bottom of the poster for people to leave business cards for reprints, etc. Please do not leave reprints of the paper on the floor.

- Poster boards will be available for mounting beginning on Sunday, June 3, 2012, from 8:00 AM - 5:00 PM. The posters will remain on display for most of the week, through the morning poster sessions on Thursday. Posters must be removed from the poster boards by 3:00 PM on Thursday, June 7, 2012. Any posters not removed on time will be removed and discarded.
- Present your poster in person at the designed time. The posters will all be displayed in the exhibit hall. All posters will be displayed from Monday through Thursday. Poster boards will be arranged with letters designating each aisle and numbered poster position on each aisle. Specific locations for your poster will be available on this website in June.
- **Poster Check-in**: You are required to check-in at the poster registration desk immediately before your poster session time. The poster registration desk will be located in the exhibit hall near the front of the poster area. If you do not check in, your poster will be recorded as not presented and your manuscript will not be published.
- Please be sure to attend the Author's Breakfast on the morning of (each of) your presentation(s) for instructions, to meet your session chair, and to be sure all your materials have uploaded correctly. Author's Breakfast will be at 7:00 a.m. in Ballroom EF.

REMEMBER: No Paper, No Podium

If your manuscript has not been uploaded, you will not be allowed to present your poster. If you (or a co-author) do not check-in at the poster registration and present your poster in person, the manuscript will not be included in the proceedings.

Be sure to check the online program to confirm your poster session time and length.

BEST POSTER AWARD

As a poster presenter, you are automatically eligible to win the Best Poster Award. The posters will be reviewed in three stages:

1. **Prior to the conference:** Poster session chairs will familiarize themselves with the poster content and review technical content.
2. **After the posters are hung:** Poster session chairs will select the top three to four posters as finalists for best poster; a star will be placed on these posters to indicate their selection.
3. **During the poster session:** The session chairs will listen to the poster presenter's summary.

The poster session chairs will judge the posters based on **Clarity of Presentation, Technical Merit, Impact and Oral Presentation.** These categories are described in more detail below. One winner will be selected at every poster session and the winner will receive a certificate.

Poster Reviewing Criteria

Clarity of Presentation
- Organized to guide observer through information in a logical order; provides the motivation/objectives and approach of the research, summarizes the key results and highlights the impact of the work.
- Proper use of graphics, figures, text and white space to allow for easy viewing.
- Proper text scaling for comfortable viewing.
- Efficient use of graphics to convey complex information.

Technical Merit
- Research is novel (e.g., discusses novel material development, novel device design, novel conversion mechanism, novel theoretical approach, novel characterization method, etc.).
- Research addresses a critical gap in PV technology.
- Systematic analysis conducted to arrive at results.
- Conclusions are fully supported by data.

Impact
- Results represent a significant advancement over the current status of the field or provide a critical breakthrough that will allow such advancement.

Oral Presentation
- An organized and concise summary of the work is presented, emphasizing the motivation/objectives, approach, key results, and impact of findings.
- Presenter is knowledgeable in all aspects of poster and able to address specific questions about the presented research.
- Presenter understands the broader impact of the work and can suggest potential methods for extending the research.

TUTORIAL PROGRAM

AM TUTORIALS (8:30 AM – 12:00 PM)

AM1. PHOTOVOLTAICS 101/201 (ROOM 18 AB)

Instructor: Dr. Angus Rockett, University of Illinois
Synopsis: An introductory tutorial in photovoltaic principles and devices. Basic semiconductor physics will be covered, with an emphasis on semiconductor junctions. The basic current-voltage relationship for a solar cell will be derived. Performance optimization and various loss mechanisms for the general solar cell will be discussed. The course is designed for those with a background in physics, chemistry, and/or engineering, but not yet having a strong background in semiconductor devices.

AM2. THIN FILM SOLAR CELLS (ROOM 16 AB)

Instructors: Dr. Tim Anderson (Univeristy of Florida)) and Brian McCandless and Steve Hegadus
Synopsis: The tutorial will provide a background of the present state of thin-film photovoltaic (PV) solar cell technologies and markets within the context of expected national and global future energy requirements. The technologies discussed will be those in present worldwide production, focusing on amorphous Silicon (a-Si), Copper Indium Gallium Diselenide (CIGS), and Cadmium Telluride (CdTe). For each technology, discussion will include historical development, present advantages and limitation, and possible future directions for improved devices and modules. A very condensed discussion of PV device physics will be provided to establish an appreciation of material parameters that are important to related device operation. The tutorial will also discuss advancements in related technologies that may be critical for accelerating deployment of thin-film PV products. Examples of this include development of thin-film PV specific glass and device-specific transparent conducting oxides and buffer layers.

AM3. POWER ELECTRONICS BALANCE-OF-SYSTEM REQUIREMENTS FOR NON-PLANAR PHOTOVOLTAIC SYSTEMS (ROOM 17 A)

Instructor: Dr. Robert Balog, Univerity of Texas A&M
Synopsis: To present design considerations for photovoltaic systems Installed in or on non-planar surfaces and their associate power conditioning architectures. The tutorial begins with a review of traditional planar PV systems, cell electrical models, and thermal models to predict the operating temperature of the module. The tutorial then explores the power electronics needed to interface the PV to the ac utility system. The electrical models previously developed are used to illustrate the

phenomenon of maximum power point tracking (MPPT) and explore the operation of series-connected strings of PV cells and modules under partial shading conditions. The second part of the tutorial introduced emerging applications of non-planar PV. Detailed analysis is presented for estimating the available electrical power and electrical energy harvest potential for PV systems installed on arbitrarily non-planar curved surface. By way of example, it will be shown that a) conventional "string" PV architectures in which PV modules are connected in series/parallel to a central DC-AC inverter and b) module integrated micro-inverters are not optimal for PV systems installed on curved or irregular surfaces. Several new approaches are then reviewed for extracting maximum power along with possible interconnection of module-integrated converters with PV cells. The concept of a "smart PV pixel" is presented and designs

AM4. HIGH EFFICIENCY MULTI-JUNCTION CELL TECHNOLOGY
(ROOM 18 CD)

Instructors: Dr. Vijit Sabnis, Solar Junction and Dr. Geoff Kinsey, Amonix
Synopsis: This tutorial will cover the physics of high-efficiency multijunction solar cells and provide a summary of state-of-the art technological approaches. The principles of multijunction solar cell operation and design tradeoffs for integration into high-concentration CPV systems will be discussed along with an overview of cell manufacturing and performance testing. A survey of technologies under development for achieving cell efficiencies exceeding 40% will be presented. Additionally, will provide an overview of the state of the art and future prospects for high-concentration CPV systems. The design considerations that lead to a given system configuration will be outlined, including choice of concentration level, system size, refractive vs. reflective optical elements, thermal management tradeoffs, and system lifetime. A survey of deployed system designs will be presented, as well as analysis of field data of solar power plants deployed by Amonix to date.

AM5. RATING PV POWER AND ENERGY: CELL, MODULE, AND SYSTEM MEASUREMENTS
(ROOM 17 B)

Instructor: Keith Emery, National Renewable Energy Laboratory
Synopsis: The tutorial will cover the state-of-the-art in theory, standards, procedures, and hardware used to determine the power and energy of PV cells, modules and systems. The measurement theory for evaluating the PV power for flat-plate or concentrating single- or multi-junction PV is discussed. Applicable ASTM, IEC and ISO standards are described along with a discussion on the plethora of sources of uncertainty in the measurements. Merits and limitations of the standards and current practices in predicting the PV delivered are described.

TUTORIAL PROGRAM

AM TUTORIALS (8:30 AM – 12:00 PM)

PM1. RELIABILITY: FROM PV CELL TO MODULE TO SYSTEM (ROOM 18 AB)

Instructor: Dr. Ramesh Dhere, FSEC
Synopsis: Photovoltaic module reliability and durability course provides attendees with a basic working knowledge of photovoltaic (PV) module reliability and durability. It presents history of PV module field failures and describes the utilization of field experience to develop more reliable modules and accelerated stress tests for more rapid evaluation of module performance. Then it introduces the concept of qualification testing outlining its usefulness and limitations. Typical module configurations are presented along with a discussion of the criteria utilized for component selection within these configurations. A number of examples based on commercial module construction are used to illustrate these points. Finally the long-term reliability, degradation rates and lifetime for the present day commercial modules are discussed.

PM2. SILICON SOLAR CELL TECHNOLOGY (ROOM 16 AB)

Instructor: Dr. Ron Sinton, Sinton Instruments
Synopsis: This tutorial will look at various aspects of crystalline silicon technologies, from the silicon bricks and ingots through sawing, solar cell production, cell test, and module test. The interactions between the various stages from feedstock to the module testing will be discussed. An emphasis will be placed on device physics as well as test and measurement strategies that are used to optimize the cell and module design and provide real-time feedback for process control at each stage of production.

PM3. COSTING AND ANALYSIS OF PHOTOVOLTAICS CELLS AND SYSTEMS
(ROOM 17 B)

Instructor: Alan Goodrich and Ted James (NREL)
Synopsis: The industry's predicable rate of cost reduction, captured by the historic module-price learning curve has been disrupted in recent years by the unavoidable supply-demand imbalances that characterize a nascent but burgeoning industry. In 2008, polysilicon feedstock prices reached a crescendo - driven by too little supply; today, module prices have fallen, by some accounts below costs - driven by a global oversupply situation. It is very difficult to predict what the future holds for the solar PV supply chain, given the full range of macroeconomic, policy, and technology-cost factors involved. From a research perspective, the cost of making decisions based on temporary market noise can be quite high. What is the real cost goal for a new technology that is five or more years from commercial production? As the market matures, the volatile swings that emblematic today should dampen to a 'steady state' - a minimum sustainable price. In this tutorial, NREL presents a cost analysis methodology that enables researchers to relate technology features to costs, and provides an objective perspective on tomorrow's cost goals. Case studies, including information from NREL's technology road maps for c-Si, CIGS, and CdTe are presented. A fourth case study demonstrates how to go about building up a reliable cost estimate for a lab scale technology, for which commercial equipment and volumetric-raw material sources may not exist.

PM4. NOVEL PV APPROACHES - ORGANICS, THIRD WAVE AND BEYOND
(ROOM 18 CD)

Instructors: Dr. Andrew Fergusen, Dr. Joey Luther (NREL), Dr. Sean Shaheen (University of Denver)
Synopsis: The drive toward low cost solar energy conversion has spurred research into photovoltaic (PV) technologies that are fabricated largely from chemical solutions, offering the possibility of high speed, roll-to-roll deposition of materials. Two active-layer technologies with immense potential in this respect are organic photovoltaic (OPV) and semiconductor quantum dot (QD) solar cells. The field of organic photovoltaics (OPV) has grown in the last several decades from being a laboratory novelty, with unique and interesting science but little commercial relevance, to the point now of niche consumer products entering the market. Steady growth around the world in the last few years has resulted in certified AM1.5 efficiencies exceeding 8% at numerous laboratories and record efficiencies now exceeding 10%. Likewise, recent developments in semiconductor QD solar cells have seen significant improvements in the performance of laboratory-scale devices, culminating in certified AM1.5 efficiencies exceeding 5% and the first observation of an external quantum efficiency greater than 100%, due to photocurrent resulting from multiple exciton generation, in a working PV device.

This course aims to provide an overview of the current state of OPV and semiconductor QD Solar cells, including materials design and development, mechanisms of device physics, and recent findings on charge generation, recombination, and transport. Basic models for the operation of the devices and thermodynamic pathways to higher efficiencies will be analyzed. Progress in understanding and mitigating material and device degradation pathways will be discussed, as will processing methods and issues for high throughput manufacturing. Importantly, these devices include some of the first true demonstrations of 3rd generation photovoltaic principles, and special attention will be paid to these topics in the course. An overview will be provided of (i) multiple exciton generation (MEG) in semiconductor QDs and the molecular analogue singlet fission (SF), (ii) triplet-triplet annihilation-assisted photon upconversion (UC), and (iii) quantum coherent pathways in multichromophoric systems. The course will include discussions of the photophysical mechanisms, factors affecting the efficiencies of these processes, and the issues associated with exploiting these novel processes for solar energy conversion.

PM5. ENVIRONMENTAL HEALTH & SAFETY (EHS) CHALLENGES IN PHOTOVOLTAICS (ROOM 17 A)

Instructors: John Visty, Salus Engineering; Eugene Ngai, Chemically Speaking LLC, Fthenakis, Vasilis, BNL; Troy McCuskey, NREL

Synopsis: This EHS tutorial is designed to assist the EHS PV Specialist by identifying key regulations and hazard areas that need focused attention in order for your company to comply with regulatory requirements and control potential hazards. The tutorial presentations will guide the attendee through various applicable regulations covering key points and providing reference to additional resources that can be accessed once the session is over. Standards, codes and industry practices that will be reviewed include:

- International Fire Code (IFC)
- International Building Code (IBC)
- National Fire Protection Association (NFPA)
- SEMI (Semiconductor Equipment & Materials International)
- Occupational Safety & Health Administration (OSHA - 29 Code of Federal Register - CFR)
- Environmental Protection Agency(EPA - 40 CFR)
- Compressed Gas Association (CGA)
- PV Industry Best Practices

Presenters are from the PV and high technology industry with in-depth experience in EHS and hazard control.

In addition to the presentations for the above topics time will be allotted to answer questions from the audience.

TECHNICAL PROGRAM

On behalf of the 2012 IEEE Photovoltaic Specialists Conference Program Committee I welcome you to Austin and thank you for attending this year's PVSC. We have an excellent program this year, thanks to all of the attendees who submitted outstanding research to the conference this year. We have assembled a program of over 1045 papers from 43 countries around the world. 47% of the papers are from outside of the United States with over 280 from Asia, over 160 from Europe, 25 from the Americas outside the US, and six from Africa. All of us on the program committee are delighted with the strength of the international participation this year, and hope it continues to grow in future conferences. The overall strength of the conference in the face of strong global economic pressures is a testimony to the great work our attendees are doing and the importance of the field to the future of the world and its people. To those of you presenting at the conference we congratulate you on your excellent work and contributions to the field. To those of you attending we hope you find the work presented as exciting as the program committee found it and that you enjoy learning about the latest and greatest science and technology in the field of photovoltaics.

This year's program will be presented in nine oral session programs and four poster sessions. Each oral program will include seven parallel oral sessions except the two on Friday, which only have six parallel sessions. This is a significant increase in the number of oral presentations relative to last year, which had only six parallel oral sessions in each time slot. We hope that the additional oral presentations will be appealing to audience members. However, we also have excellent papers in the poster sessions. As always at the PVSC, the posters are expected to be just as good as the oral presentations and with even more opportunity for dialogue, so don't miss out on the poster sessions.

Several changes have been made to the schedule this year. In particular we have added an additional hour of plenary talks on Monday morning focusing on terrestrial PV systems as a way of connecting with the strong renewable energy community in the Austin and Southwest US areas. This will include talks on residential PV and smart grid activities, issues in high-penetration PV, large system control and utility integration, and battery storage for the grid. These talks all connect very well with the conference keynote presentation by Samuel Baldwin of the US Department of Energy, Office of Energy Efficiency and Renewable Energy, who will be speaking on how much of our power renewables can supply. You will find Monday morning

highly informative and will it will give an excellent perspective on the scale up of PV to very high levels of grid penetration, which we all look forward to as part of the future of photovoltaics worldwide.

The opening keynote talks on Monday morning also fit with an exceptionally strong program this year in Area 9 on PV modules and systems. Jennifer Granata and her team have gathered together so many papers that we have programmed two parallel Area 9 oral sessions on Friday morning and one in every other session time period. At the same time Area 10, focusing on public policy provides an outstanding complementary perspective on financial and regulatory issues related to large-scale PV. These are just two of the many topical areas that you might be interested in. The worst part of the program will be deciding which excellent talk or poster to see next!

One of the changes to the PVSC which began with the Seattle conference last year and has grown this year is the invitation for selected authors of papers judged to be the most exciting to provide a full archival manuscript to the Journal of Photovoltaics. This year a number of papers were selected for this honor and can be expected to appear in JPV. The remainder of the conference papers will be published in the PVSC proceedings as usual. Be sure to check out the JPV portion of the proceedings as well as the classic PVSC proceedings papers.

In addition to the regular technical program we have an outstanding selection of tutorial lectures on Sunday prior to the meeting. The tutorials are intended for a broad audience ranging from those new to PV to seasoned professionals. Martha Symko-Davies has organized a group of outstanding lecturers, expert in the field of their tutorial, to give presentations on each topic. These include an introduction to the basics of photovoltaic operation and more advanced topics in the Photovoltaics 101/201 tutorial and topics strongly related to selected topical areas of the conference such as tutorials on Thin Film Solar Cells, Silicon Solar Cell Technology, Costing and Analysis of PV Cells and Systems, PV Environemental Health and Safety, Reliability from Cell to Module to System, Novel Approaches to PV, Power Electronics Balance of System Requirements for Non-planar PV, Rating PV Power and Energy, and High Efficiency Multijunction Cell Technology. I always find the tutorials excellent opportunities to brush up on specific topics or to learn about an area of PV about which I should know more but have not had the time to learn in detail. I think you will find them outstanding as well.

While you are in town we hope that you will also enjoy the excitement that Austin has to offer in the evenings and before and after the conference. This is a city of

music and night life. Don't have too much fun though – we want to see you in the sessions getting everything you can from the speakers' talks and posters.

It has been fun organizing the program this year and I hope you will enjoy it as much as I will. When the conference is over I also hope you will look forward to 2013 when we will be reconvening in Tampa Florida for the next PVSC. Don't forget to submit your best work again for that meeting.

As the overall Program Chair, I need to take a moment to thank my Area Chairs and their committees, which included a diverse group of individuals from around the world, for their hard work and prompt attention to the program planning needs. Their visionary leadership and knowledge of the community allowed them to identify the best work and the leaders in the field. Planning the program is a team effort and my team was outstanding. I thank each and every one of them. I also extend many thanks to Adam Kohm and Brent Nelson who were key contributors to the program planning process. Finally, I thank BJ Stanbery for getting me involved as Program Chair and all of the other organizers of the PVSC this year. It has been a pleasure working with all of them.

On behalf of the Program Committee

Angus Rockett
2012 PVSC Program Chair

AREA 1 OVERVIEW

AREA 1: FUNDAMENTALS AND NEW CONCEPTS FOR FUTURE TECHNOLOGIES

Chair
Ryne Raffaelle, Rochester Inst. Of Tech., USA

Co-Chairs
Ned Elkins-Daukes, Imperial College, UK
Yoshitaka Okada, Univ. Tokyo, Japan

Sub-Areas & Chairs
1.1: Fundamental Conversion Mechanisms - Martha Symko-Davies (NREL)
1.2: Quantum Dots, Nanowires, and Quantum Wells - Seth Hubbard (Rochester Inst. Of Technology)
1.3: Novel Materials Systems - Pete Sheldon (NREL)

The development of the photovoltaic industry over the past decade has been truly remarkable. However, much work remains if we are to be able to sustain this type of growth over the decades to come. Papers sought for Area 1 should describe basic research 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.

Area 1 is devoted to recent work on photovoltaic fundamentals and new concepts, which have been categorized in the four subareas presented below. We encourage authors to submit papers on detailed scientific research studies and visionary papers addressing the full range of fundamental materials and technological challenges for the future of our field, including:

Sub-area 1.1: Fundamental Conversion Mechanisms

Recently, a variety of new paradigms for photovoltaic conversion have been proposed. Sub-area 1.1 attempts to capture the best experimental and theoretical work exploring these new approaches. Examples of new mechanisms of interest are non-conventional PV conversion processes based on quantum confinement and nanostructured concepts, intermediate-band solar cells, multiple charge generation, up/down converters, thermophotonics, hot-carrier cells, and other concepts. Also, new device structures that incorporate such things as quantum dots, wires, and wells, highly metamorphic materials, and new materials systems are also of interest. Finally, cross-cutting science approaches which may involve heretofore unexplored materials, such as new hybrid organic/inorganic molecules, or innovative devices structures, such as luminescent concentrator designs, are solicited.

AREA 1 OVERVIEW (CONTINUED)

Sub-area 1.2: Quantum Dots, Nanowires, and Quantum Wells

The use of quantum confined materials has great potential for exploitation in future photovoltaic conversion systems. Sub-area 1.2 will cover the synthesis, characterization and modeling of these low-dimensional materials and devices. This includes developmental studies on both colloidal and epitaxial new quantum dot systems and their use in devices. Papers on the theoretical and experimental progress on the development of intermediate band solar cells are anticipated. New results are solicited on the growth and use of nanowires and nanotubes for a variety of photovoltaic applications, such as light-trapping antireflection coatings and as absorber materials. Finally, the use multiple quantum wells and other means of bandgap engineering for new multi-layer and concentrator solar cells are included in this sub-area.

Sub-area 1.3: Novel Materials Systems

Sub-area 1.3 covers progress on the development of new materials for photovoltaic applications. This includes the theoretical and experimental development of new compound semiconductors based on more abundant or less toxic replacements for current state-of-the-art materials. Materials with improved physical properties, such as absorption coefficients, carrier mobilities, or bandgaps, are also included. Also, advances in coatings, such as oxygen and moisture barriers or transparent conductors, are of interest. New and better antireflection coatings and materials used selective filters are solicited.

AREA 2 OVERVIEW

AREA 2: THIN FILM POLYCRYSTALLINE PHOTOVOLTAICS

Chair
Markus Beck, First Solar, USA

Sub-Areas & Chairs
2.1: Absorber Formation and Characterization - Chris Ferekides, University of South Florida, USA; Tokio Nakada, Tokyo University, Japan; Daniel Abou-Ras, HZB, Germany
2.2: Alternate Substrates, Back Contact Materials, Buffer Compounds, and TCOs - Ingrid Repins, NREL, USA; Clemens Heske, University of Nevada, Las Vegas, USA
2.3: Device Properties, Modeling, Stability and Defect Characterization -- Susanne Siebentritt, University of Luxembourg; Ralph Gottschlag, Loughborough University, UK
2.4: High Volume Manufacturing, Performance, Metrology, Process Control and Reliability - Ayodhya Tiwari, ETH, Germany; John Kessler, Universiti de Nantes, France

Over the past decade, thin-film compound semiconductor-based photovoltaic devices, in particular CdTe and Cu(In,Ga)(S,Se)2, managed to transition from the laboratory into high volume manufacturing capturing close to 20 percent of the terrestrial PV market while new material systems, such as Cu2ZnSn(S,Se)4, are demonstrating potential to follow suite. Despite the significant progress for the various material systems, a multitude of challenges remain and there continues to be a need for fundamental as well as applied research. Area 2 of the 38th IEEE PVSC invites contributions addressing recent progress in this field, spanning the range of material formation and characterization, device measurements and modeling, as well as module manufacturing and process metrology. Additional aspects encompass device stability and module reliability, alternate substrates, back contact and buffer materials as well as transparent conductive oxides. Contributions should address the fundamental science and engineering issues of thin-film deposition, characterization of structural, optical, electrical and interface properties, modeling, the role of defects and impurities, the effect of interfaces and buffer layers, as well as device stability and module reliability.

AREA 3 OVERVIEW

AREA 3: III-V AND CONCENTRATOR TECHNOLOGIES

Chair
Mark Stan, Emcore, USA

Co-Chairs
Carlos Algora, UPM, Spain
Kenji Araki, Daido Steel Corp., Japan
Frank Dimroth, Fraunhofer, Germany
Scott Burroughs, Semprius, Inc., USA

Sub-Areas
3.1: Materials and Devices
3.2: Concentrator Receiver and Modules
3.3: High and Low Concentrator Systems

This focus area of the IEEE Photovoltaic Specialists Conference covers the latest technical progress in concentrating photovoltaic technology. The area welcomes papers describing advances enabling higher efficiency, lower cost, or more reliable concentrator modules and systems.

Sub-area 3.1: Materials and Devices
Solar cell devices are discussed for concentrator systems, including studies on high-efficiency cell materials and designs, their characterization, special measurement requirements, performance, long-term behavior, reliability and cost. The concentrator cells may include monolithic multijunction III-V solar cells, low-cost silicon concentrator cells, stacked cells, new component cells, etc.

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, mechanical design, qualification testing, and other factors are covered. Performance modeling and characterization based upon environmental conditions are sought.

Sub-area 3.3: High and Low 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, and reliability. 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.

AREA 4 OVERVIEW

AREA 4: CRYSTALLINE SILICON PHOTOVOLTAICS

Chair
Nathan Stoddard, SolarWorld, USA

Co-Chairs
Paul von Dollen, University of California Santa Barbara, USA
Gianluca Coletti, ECN, The Netherlands

Sub-Areas & Chairs
4.1: Feedstock - Roland Einhaus, Apollon Solar, France
4.2: Crystallization and Wafering - Jinggang Lu, Suntech
4.3: Passivation and Advanced Devices - Giso Hahn, University of Konstanz, Germany
4.4: Advances in Industrial Cell Processing - Zhigang Rick Li, Dupont, USA
4.5: Fundamentals (Modeling, Characterization, Gettering, Defects) - Mariana Bertoni, 1366 Technologies, USA

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 OVERVIEW

AREA 5: THIN FILM SILICON BASED PV TECHNOLOGIES

Chair
Arno Smets, Delft University of Technology, The Netherlands

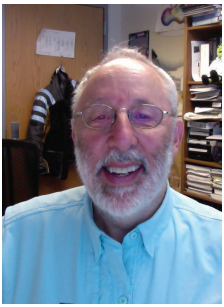
Co-Chairs
David Young, NREL, USA
Aad Gordijn, Forschungszentrum Julich, Germany
Hitoshi Sai, AIST, Japan

Sub-Areas & Chairs
5.1: Fundamental Properties of Thin Film Silicon - Nikolas Podraza, University of Toledo, USA
5.2: Processing Issues for Thin Silicon Films and Devices - Yasushi Sobajima, Osaka University, Japan
5.3: Light Management Concepts in Thin Film Silicon Solar Cell Devices - Franz-Jozef Haug, EPFL Neuchatel, Switzerland
5.4: Novel Concepts for Thin Film Silicon Solar Cell Devices - Vikram Dalal, Iowa State University, USA
5.5: Polycrystalline and Epitaxial Silicon Technology - Ivan Gordon, IMEC, Belgium
5.6: Thin Film Silicon Based Solar Cells, Multijunctions and PV Modules - 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 advances, many fundamental and technological issues of great importance still remain in order to achieve further progress, including the further increase of the conversion efficiencies and the reduction of cost in 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.

AREA 6 OVERVIEW

AREA 6: ORGANIC PHOTOVOLTAICS



Chair
David Ginley, NREL, USA

Co-Chairs
Ivgenny Katz, Ben-Gurion University of the Negev, Israel
Yang Yang, University of California Los Angeles, USA
Barry Rand, IMEC, Belgium

Sub-Areas & Chairs
6.1: New Organic Materials -- Gui Bazan, UCSB, USA; Seth Marder, Georgia Institute of Technology, USA
6.2: Device Concepts/Interfacial Science & Engineering -- Dana Olson, NREL, USA; Neal Armstrong, University of Arizona, USA
6.3: Lifetime and Scale up of OPV and Related Devices -- Darin Laird, Plextronics, USA; Matt Lloyd, NREL, USA

Organic, hybrid inorganic/organic, and dye-sensitized solar cells are rapidly advancing technologies that are beginning to demonstrate initial commercial viability. With efficiencies in OPV and DSSC approaching or exceeding 10 percent and new tandem devices approaching 9 percent, these technologies may represent scalable PV technologies capable of achieving DOE cost goals. The flexibility to model and produce different donor/acceptor combinations, including both organic small molecule and polymer as well as nanostructured inorganic materials, stimulates a large diversity of possible approaches to realize the promise of efficient and highly stable devices. Many of the devices are excitonic in nature, necessitating new models and understanding of the critical interfaces in the bulk heterojunction and the contacts. The symposium will focus on the examination of many of the key areas evolving in this diverse approach to solar energy. The primary focus will be in three primary areas that crosscut many of the themes in the broad set of devices combining inorganic and organic materials to developed high performance solar energy convertors with stability and low cost.

New materials synthesis - this includes the topic of first principles design of new donor/acceptor materials, active absorbers and the enhancement of PV properties with QD and related inorganic materials. Themes are design and synthesis for increased red response, for tandem devices, and for stability. Device design and interfacial science and engineering - as materials evolve, so must the overall device structure and the interface to the outside world. This combination of device structure and interface design and characterization, crossing the boundaries of organic and inorganic materials, is unique to this area.Lifetime and scale-up - while OPV devices have demonstrated encouraging lifetimes, it is clear that to reach large scale production, new processes, module designs and packaging will be need to be developed. As market penetration is aimed at building integrated PV and power generation, this may require specific evolution for these applications. Key is establishing and predicting lifetime with a constantly changing set of materials.

AREA 7 OVERVIEW

AREA 7: SPACE TECHNOLOGIES

Chair
David Wilt, AFRL, USA

Co-Chairs
Mitsuru Imaizumi, JAXA, Japan
Steven Taylor, ESA, The Netherlands

Sub-Areas & Chairs
7.1: Space Devices and Materials - Daniel Law (Spectrolab) and Pravin Patel (Emcore)
7.2: Space Systems - Claus Zimmerman (EADS Astrium) and Scott Billets (Lockheed Martin)
7.3: Flight Performance and Environmental Effects - Scott Messenger (NRL) and Bao Hoang (Loral)

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 fromtheoretical 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:

Sub-area 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.

AREA 7 OVERVIEW (CONTINUED)

Sub-area 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.

Sub-area 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. 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). Finally, an emphasis will be placed on papers addressing photovoltaic device/array reliability.

AREA 8 OVERVIEW

AREA 8: CHARACTERIZATION METHODS

Chair
Gerald Siefer, Fraunhofer ISE, Germany

Co-Chairs
Yoshihiro Hishikawa, AIST, Japan
Daniel Macdonald, ANU, Australia
Manuel Romero, NREL, USA

Sub-Areas & Chairs
8.1: Defects in Photovoltaic Materials and Solar Cells
8.2: Advanced Methods and Instruments for the Characterization of Solar Cells and Modules
8.3: Characterization Methods for the Photovoltaic Industry: In-Situ Measurements, Process Control, Defect Monitoring
8.4: Challenges in the Characterization of Multi-Junction PV Devices
8.5: Performance, Reliability Testing, and Standards

It is difficult to understand innovation in photovoltaics without the support of measurements and characterization. Measurements are needed at all different levels of R&D, from the investigation of the operating principles of solar cells to 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 and, in our opinion, one of the most critical to the development of the next generation of PV. 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, 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 sub-area 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 sub-area is targeted to an audience that is interested in getting a better understanding of the most recent developments in characterization methods and the capabilities offered by

AREA 8 OVERVIEW (CONTINUED)

the latest generation of instruments available to the PV community and how their research can be assisted by these new capabilities.

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

8.4: Challenges in the Characterization of Multi-Junction PV Devices
The concept of using more than one pn junction is one possible pathway to increase photovoltaic conversion efficiencies. It is successfully used in thin film photovoltaics as well as in III-V based solar cells. The internal series connection of several subcells, that cannot be accessed individually, adds complexity to the characterization. In addition spectral variations show a higher impact on the performance of these devices. Issues related to the characterization of multi-junction based photovoltaic devices are the topic of this subarea.

8.5: Performance, Reliability Testing, and Standards
Standardization of measurements for the determination of the performance, reliability and lifetime of PV modules and systems is increasingly important as the global installed PV power continues to expand exponentially. Of particular importance is the standardization of accelerated lifetime tests to estimate the PV performance over time. This subarea encompasses all such testing methods and standards as well as topics related to system components such as inverters, mounting hardware, resistance to harsh environmental conditions, and other issues.

AREA 9 OVERVIEW

AREA 9: PV MODULES AND TERRESTRIAL SYSTEMS

Chair
Jennifer Granata, Sandia National Laboratories, USA

Co-Chairs
Wilfried van Sark, Utrecht Univ., The Netherlands
Yuzuru Ueda, Tokyo Inst. Of Tech, Japan

Sub-Areas & Chairs
9.1: Irradiance Resources - Steve Ransome, SRCL, UK
9.2: PV Module Materials, Durability, and Performance - Peter Hacke, NREL, USA
9.3: Inverters, Batteries, and other BOS Components - Mike Fife, Advanced Energy Ind., USA
9.4: Grid Connected Systems and Smart Grids - Greg Ball, BEW, USA
9.5: Stand Alone Applications and PV Products - Robert Foster, New Mexico State University, USA
9.6: PV Modeling - Joshua Stein, Sandia National Laboratories, USA

In recent years, we have seen expansive growth in the number, size and locations of PV installations worldwide. This growth challenges the existing capabilities in resource, performance and reliability modeling; our understanding of module, inverter and BOS component lifetime and failure mechanisms; and the interactions of PV with the grid at high penetration levels. In 2012, we invite you to share your expertise, your research, your accomplishments and the advancements in your technology with the PV community in these research areas. In addition, we will be adding a special session on how PV could be an essential part of the future, particularly with interactions with smart grid concepts.

AREA 10 OVERVIEW

AREA 10: PV VELOCITY FORUM

Chair
Elaine Ulrich, U.S. Department of Energy, USA

Co-Chairs
John Benner, Stanford University, USA
Ardeth Barnhardt, University of Arizona, USA\
Robert Margolis, NREL, USA

Sub-Areas & Chairs
10.1: Manufacturing and Scaling Challenges -- John Benner, Stanford University, USA
10.2: Deployment Challenges -- Robert Margolis, NREL, USA
10.3: The PV Workforce Challenge -- Ardeth Barnhardt, University of Arizona, USA
10.4: PV ESH Challenges - Brent Nelson, NREL

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

“Manufacturing and Scaling Challenges” will explore the outlook for materials and equipment supply chains (from cradle to grave), manufacturing costs, environmental and safety impacts, and Intellectual Property (IP) considerations that must be addressed in order to drive emerging technologies into production. In addition, insights, opportunities for collaboration, and lessons learned from related industries like LED lighting, flexible display and from successful market players will be highlighted. “Deployment Challenges” will focus on the growing solar market, including finance, bankability, validation, siting and environmental issues, regulatory and policy engagement and governmental programs and projects. “The PV Workforce Challenge” will offer a forum for discussing the skills and expertise required to transform and grow the PV workforce as the industry and technologies mature, with an emphasis on finding ways to effectively increase the breadth of expertise engaged in PV R&D, manufacturing and technology support. Finally, the “PV EHS Challenges” will focus on environmental, safety, and health challenges to keep PV technologies safe and environmentally responsible from R&D, through manufacturing, to deployment.

AREA 1 PROGRAM SUMMARY

Monday, June 4
Fundamentals and New Concepts: Plenary
09:30 - 10:00 AM (Blrm D)

Fundamentals and New Concepts: Session 1 (Posters)
01:30 - 03:00 PM (EH4-A)

Fundamentals and New Concepts: Intermediate-Band Solar Cells (Orals)
03:30 - 05:00 PM (18AB)

Tuesday, June 5
Fundamentals and New Concepts: Session 2 (Posters)
10:30 - 12:00 PM (EH4-A)

Fundamentals and New Concepts: Quantum Well Solar Cells (Orals)
01:30 - 03:00 PM (18AB)

Fundamentals and New Concepts: Light Concentration and Light Trapping 1 (Orals)
03:30 - 05:00 PM (18AB)

Wednesday, June 6
Fundamentals and New Concepts: Simulation and Modeling of Advanced Concept Solar Cells (Orals)
10:30 - 12:00 PM (18AB)

Fundamentals and New Concepts: Quantum Dot Solar Cells (Orals)
01:30 - 03:00 PM (18AB)

SCREAM Workshop
03:00 - 04:00 PM (19B)

Fundamentals and New Concepts: Session 3 (Posters)
03:30 - 05:00 PM (EH4-A)

Thursday, June 7
Fundamentals and New Concepts: Session 4 (Posters)
10:30 - 12:00 PM (EH4-A)

Fundamentals and New Concepts: Advanced Approaches for Photoconversion (Orals)
01:30 - 03:00 PM (18AB)

Fundamentals and New Concepts: Novel Materials 1 (Orals)
03:30 - 05:00 PM (18AB)

Friday, June 8
Fundamentals and New Concepts: Novel Materials 2 (Orals)
08:30 - 10:00 AM (18AB)

Fundamentals and New Concepts: Light Concentration and Light Trapping 2 (Orals)
10:30 - 12:00 PM (18AB)

AREA 2 PROGRAM SUMMARY

Monday, June 4
Polycrystalline Thin Films: Absorber Formation and Characterization 1 (Posters)
01:30 - 03:00 PM (EH4-B)

Polycrystalline Thin Films: Wide Bandgap Devices (Orals)
03:30 - 05:00 PM (18CD)

Tuesday, June 5
Polycrystalline Thin Films: Device Properties, Modeling, Stability, and Defect Characterization (Posters)
10:30 - 12:00 PM (EH4-B)

Polycrystalline Thin Films: Absorber and Device Modeling (Orals)
01:30 - 03:00 PM (18CD)

Polycrystalline Thin Films: Junctions and Device Stability (Orals)
03:30 - 05:00 PM (18CD)

Wednesday, June 6
Polycrystalline Thin Films: Window Layers and Flexible Devices (Orals)
10:30 - 12:00 PM (18CD)

Polycrystalline Thin Films: Thin-Film Manufacturing (Orals)
01:30 - 03:00 PM (18CD)

Polycrystalline Thin Films: Alternate Substrates, Back Contact Materials, Buffer Compounds, TCOs, Manufacturing, Metrology, Process Control, and Reliability (Posters)
03:30 - 05:00 PM (EH4-B)

Thursday, June 7
Polycrystalline Thin Films: Plenary
08:30 - 09:00 AM (Blrm D)

Polycrystalline Thin Films: Absorber Formation and Characterization 2 (Posters)
10:30 - 12:00 PM (EH4-B)

Polycrystalline Thin Films: Kesterites (Orals)
01:30 - 03:00 PM (18CD)

Polycrystalline Thin Films: CIGS Absorber Processing (Orals)
03:30 - 05:00 PM (18CD)

Friday, June 8
Polycrystalline Thin Films: CdTe Processing & Devices (Orals)
08:30 - 10:00 AM (18CD)

Polycrystalline Thin Films: CIGS Processing & Devices (Orals)
10:30 - 12:00 PM (18CD)

AREA 3 PROGRAM SUMMARY

Tuesday, June 5
III-V's and Concentrators: Cells, Modules, and Systems 1 (Posters)
10:30 - 12:00 PM (EH4-C)

Wednesday, June 6
III-V's and Concentrators: Plenary
09:30 - 10:15 AM (Blrm D)

III-V's and Concentrators: Cells (Orals)
10:30 - 12:00 PM (17B)

III-V's and Concentrators: Modules and Systems (Orals)
01:30 - 03:00 PM (17B)

III-V's and Concentrators: Cells, Modules, and Systems 2 (Posters)
03:30 - 05:00 PM (EH4-C)

Thursday, June 7
III-V's and Concentrators: High-Efficiency Cells (Orals)
01:30 - 03:00 PM (17B)

AREA 4 PROGRAM SUMMARY

Monday, June 4
Crystalline Silicon: Fundamentals (Posters)
01:30 - 03:00 PM (EH4-C)

Crystalline Silicon: New Device Concepts (Orals)
03:30 - 05:00 PM (Blrm G)

Tuesday, June 5
Crystalline Silicon: Plenary
08:30 - 09:00 AM (Blrm D)

Crystalline Silicon: Passivation and Advanced Devices (Posters)
10:30 - 12:00 PM (EH4-D)

Crystalline Silicon: Fundamentals (Orals)
01:30 - 03:00 PM (Blrm G)

Crystalline Silicon: Advanced Devices (Orals)
03:30 - 05:00 PM (Blrm G)

Wednesday, June 6
Crystalline Silicon: Passivation (Orals)
10:30 - 12:00 PM (Blrm G)

Crystalline Silicon: Crystallization and Wafering (Orals)
01:30 - 03:00 PM (Blrm G)

Crystalline Silicon: Industrial Cell Technology (Posters)
03:30 - 05:00 PM (EH4-D)

Thursday, June 7
Crystalline Silicon: Feedstock, Crystallization, and Wafering (Posters)
10:30 - 12:00 PM (EH4-C)

Crystalline Silicon: Texture, Emitter, and ARC (Orals)
01:30 - 03:00 PM (Blrm G)

Crystalline Silicon: Discussion and Harumph (Workshop)
03:30 - 05:00 PM (Blrm G)

Friday, June 8
Crystalline Silicon: Feedstock (Orals)
08:30 - 10:00 AM (Blrm G)

Crystalline Silicon: Metallization (Orals)
10:30 - 12:00 PM (Blrm G)

AREA 5 PROGRAM SUMMARY

Monday, June 4
Thin-Film Silicon: Solar Cells: Fundamentals, Processing, and Light Trapping (Posters)
01:30 - 03:00 PM (EH4-D)

Thin-Film Silicon: Light Trapping in Solar Cells 1 (Orals)
03:30 - 05:00 PM (19A)

Tuesday, June 5
Thin-Film Silicon: Solar Cells, Novel Concepts, Thin Crystalline Silicon Film, Solar Cells and Modules (Posters)
10:30 - 12:00 PM (EH4-E)

Thin-Film Silicon: Solar Cells and Modules (Orals)
01:30 - 03:00 PM (19A)

Thin-Film Silicon: Novel Concepts: Hybrid, Plasmonics and Diagnostic Tools (Orals)
03:30 - 05:00 PM (19A)

Wednesday, June 6
Thin-Film Silicon: Plenary
08:30 - 09:00 AM (Blrm D)

Thin-Film Silicon: Thin-Crystalline Silicon Technology (Orals)
01:30 - 03:00 PM (19A)

Thursday, June 7
Thin-Film Silicon: Light Trapping in Solar Cells 2 (Orals)
01:30 - 03:00 PM (19A)

Thin-Film Silicon: Fundamentals and Defects in Solar Cells (Orals)
03:30 - 05:00 PM (19A)

AREA 6 PROGRAM SUMMARY

Wednesday, June 6
Organic Photovoltaics: Contacts and Dye Cells (Posters)
03:30 - 05:00 PM (EH4-E)

Thursday, June 7
Organic Photovoltaics: Plenary
09:00 - 09:30 AM (Blrm D)

Organic Photovoltaics: OPV Materials and Devices (Posters)
10:30 - 12:00 PM (EH4-D)

Organic Photovoltaics: New Organic and Interface Materials (Orals)
01:30 - 03:00 PM (17A)

Organic Photovoltaics: Device Concepts (Orals)
03:30 - 05:00 PM (17A)

Friday, June 8
Organic Photovoltaics: Lifetime Processing and Reliability (Orals)
08:30 - 10:00 AM (17A)

Organic Photovoltaics: OPV Modeling and Inorganic Hybrids (Orals)
10:30 - 12:00 PM (17A)

AREA 7 PROGRAM SUMMARY

Wednesday, June 6
Space Technologies: Plenary
09:00 - 09:30 AM (Blrm D)

Thursday, June 7
Space Technologies: Space PV Technologies (Posters)
10:30 - 12:00 PM (EH4-E)

Space Technologies: High Performance PV for Space Applications (Orals)
03:30 - 05:00 PM (17B)

Friday, June 8
Space Technologies: Testing and Design of Space PV Technologies (Orals)
08:30 - 10:00 AM (17B)

AREA 8 PROGRAM SUMMARY

Monday, June 4
PV Characterization: Session 1 (Posters)
01:30 - 03:00 PM (EH4-E)

PV Characterization: PV Modules: Testing and Standards (Orals)
03:30 - 05:00 PM (17A)

Tuesday, June 5
PV Characterization: Plenary
09:00 - 09:30 AM (Blrm D)

PV Characterization: Session 2 (Posters)
10:30 - 12:00 PM (EH4-F)

PV Characterization: Challenges in Characterization of Multijunction Devices (Orals)
01:30 - 03:00 PM (17A)

PV Characterization: Defects in PV Materials and Solar Cells (Orals)
03:30 - 05:00 PM (17A)

Wednesday, June 6
PV Characterization: Characterization of Thin Films (Orals)
10:30 - 12:00 PM (17A)

PV Characterization: Advanced Characterization Methods and Instruments (Orals)
01:30 - 03:00 PM (17A)

AREA 9 PROGRAM SUMMARY

Monday, June 4
Modules and Systems: Grid-Tied Systems (Posters)
01:30 - 03:00 PM (EH4-F)

Modules and Systems: Utility Scale and High Penetration (Orals)
03:30 - 05:00 PM (16AB)

Tuesday, June 5
Modules and Systems: Inverters, Balance-of-System Devices, and Module Shading (Posters)
10:30 - 12:00 PM (EH4-G)

Modules and Systems: Systems Design, Control, and Performance (Orals)
01:30 - 03:00 PM (16AB)

Modules and Systems: Inverters and Balance-of-System Devices (Orals)
03:30 - 05:00 PM (16AB)

Wednesday, June 6
Modules and Systems: PV Reliability (Orals)
10:30 - 12:00 PM (16AB)

Modules and Systems: Module Materials, Durability, and Performance 1 (Orals)
01:30 - 03:00 PM (16AB)

Modules and Systems: Module Materials, Durability, and Performance (Posters)
03:30 - 05:00 PM (EH4-F)

Thursday, June 7
Modules and Systems: Plenary
09:30 - 10:00 AM (Blrm D)

Modules and Systems: Irradiance Resources, PV Modeling, and Off-Grid Applications (Posters)
10:30 - 12:00 PM (EH4-F)

Modules and Systems: PV Performance Modeling Collaborative (Orals)
01:30 - 03:00 PM (16AB)

Modules and Systems: Module Materials, Durability, and Performance 2 (Orals)
03:30 - 05:00 PM (16AB)

Friday, June 8
Modules and Systems: Irradiance Resources (Orals)
08:30 - 10:00 AM (16AB)

Modules and Systems: Off-Grid Applications (Orals)
08:30 - 10:00 AM (19A)

Modules and Systems: Performance Modeling (Orals)
10:30 - 12:00 PM (16AB)

AREA 10 PROGRAM SUMMARY

Monday, June 4
PV Velocity Forum: Equipment-Related PV ESH (Orals)
01:30 - 03:00 PM (19B)

PV Velocity Forum: Sustainability and PV EHS (Orals)
03:30 - 05:00 PM (19B)

Tuesday, June 5
PV Velocity Forum: Plenary
09:30 - 10:00 AM (Blrm D)

PV Velocity Forum: PV Executive Forum
10:30 - 12:00 PM (19B)

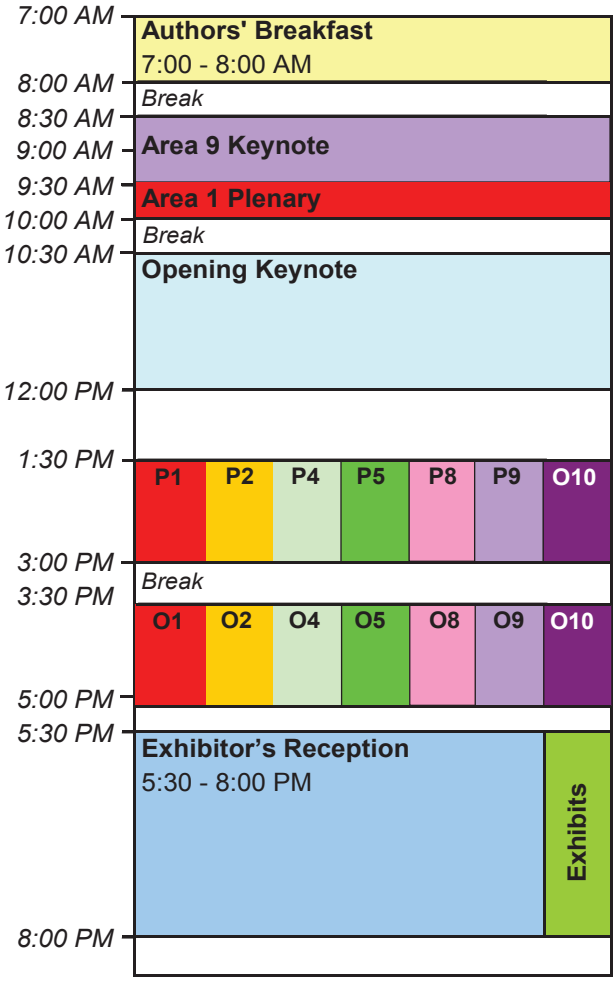
PV Velocity Forum: National Programs (Orals)
01:30 - 03:10 PM (19B)

PV Velocity Forum: Markets and Scalability (Orals)
03:30 - 05:00 PM (19B)

Wednesday, June 6
PV Velocity Forum: Models and Markets (Orals)
10:30 - 12:00 PM (19B)

PV Velocity Forum: Session (Posters)
03:30 - 05:00 PM (EH4-G)

MONDAY PROGRAM SUMMARY



AREA LEGEND

- Area 1: Fundamentals and New Concepts for Future Technologies
- Area 2: Thin Film Polycrystalline Photovoltaics
- Area 3: III-V and Concentrator Technologies
- Area 4: Crystalline Silicon Photovoltaics
- Area 5: Thin Film Silicon Based PV Technologies
- Area 6: Organic Photovoltaics
- Area 7: Space Technologies
- Area 8: Characterization Methods
- Area 9: PV Modules and Terrestrial Systems
- Area 10: PV Velocity Forum

O = Oral Session P = Poster Session

8:00 - 8:30 AM **4th Floor Foyer**

Coffee Break

8:30 - 9:30 AM **Blrm D**

Area 9: Modules and Systems: Keynote

Chair(s): Greg Ball, Barry Mather

1 **Residential PV and Smart Grid Activities**
Scott Hinson
Pecan Street Project

2 **High-Penetration PV Deployment in the Arizona Public Service System, Phase 1 Update**
David Narang[1], Joshua Hambrick[2]
[1]Arizona Public Service, Pheonix, AZ, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

3 **Large PV System Control and Utility Integration Strategies**
Robert Johnson
SunPower Corporation

4 **Battery Storage for PV and Smart Grid Applications**
Richard Fioravanti
DNV KEMA

9:30 - 10:00 AM **Blrm D**

Area 1: Fundamentals and New Concepts: Plenary

Chair(s): Ryne Raffaelle, Yoshitaka Okada

9:30 5 **High-Performance Photovoltaics from Earth-Abundant Thin-Film Absorbers**
David B. Mitzi
IBM T. J. Watson Research Center, Yorktown Heights, NY, USA

10:00 - 10:30 AM **4th Floor Foyer**

Coffee Break

10:30 - 12:00 PM **Blrm D**

Welcoming Session and Keynotes

Chair(s): BJ Stanbery, Angus Rocket

10:30 6 **Opening Remarks**
BJ Stanbery
PVSC 38 General Chair

10:45 7 **Cherry Award Presentation**
Stuart Wenham
Cherry Award Chair

10:50 8 **Cherry Award Acceptance Speech:**
Persistence in the Face of Skepticism. Our Response When the World Says "It Can't Be Done".
Sarah Kurtz
National Renewable Energy Laboratory

11:20 9 **Renewable Electricity Futures: How Much of Our Power Can Renewables Supply?**
Samuel Baldwin
EERE US DOE, Washington, DC, USA

1:30 - 3:00 PM **EH4-A**

Area 1: Fundamentals and New Concepts: Session 1 (Posters)

Chair(s): Annick Anctil, Chris Bailey, Seth Hubbard

A1 10 **Thin-Film a-Si/c-Si$_{1-x}$Ge$_x$/c-Si Heterojunction Solar Cells with Ge Content Up To 56%**
Sabina Abdul Hadi[1], Pouya Hashemi[2], Nicole DiLello[2], Ammar Nayfeh[1], Judy Hoyt[2]
[1]Masdar Institute of Science and Technology, Abu Dhabi, United Arab Emirates, [2]MIT Microsystems Technology Laboratories, Cambridge, MA, USA

A5 11 **Luminescent Down-Shifting: A Review of Dyes and Simulation of Performance**
Diego Alonso-Álvarez, David Ross, Bryce Richards
School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, United Kingdom

A9 12 **Optical Analysis of a CPC-Based CPV/T System**
Hasan Baig, Tapas Kumar Mallick
Mechanical Engineering Department, Heriot Watt University, Edinburgh, United Kingdom

A13 13 **Plasmonic Effect in Dye-Sensitized Solar Cells**
Marko Berginc[1], Ursa Opara Krasovec[1], Etienne Quesnel[2], Marko Topic[1]
[1]University of Ljubljana, Faculty of Elec Eng, Ljubljana, Slovenia, [2]CEA, LITEN, Grenoble, France

A17 14 **Intermediate-Band Solar Cell with Non-Ideal Band Structure Under AM1.5 Spectrum**
Stephen P. Bremner
University of New South Wales, Sydney, Australia

A21 15 **The Steady State Occupancy and Effective Fermi Level of p-n Junction**
Zimeng Cheng, Ken K. Chin
Apollo CdTe Solar Energy Research Center, NJIT, Newark, NJ, USA

A25 16 **High-Efficiency Nanostructured Photovoltaic Cell**
David Choi, Kyu H Choi
Qsolar Technology, Inc, Cupertino, CA, USA

B1 17 **Hot-Carrier Solar Cell Absorbers: Superstructures, Materials and Mechanisms for Slowed Carrier Cooling**
Gavin Conibeer, Santosh Shrestha, Shujuan Huang, Robert Patterson, Pasquale Aliberti, Hongze Xia, Yu Feng, Neeti Gupta, Suntrana Smyth, Yuanxun Liao
Photovoltaics Centre of Excellence, University of New South Wales, Sydney, Australia

B5 18 **Raman Measurements on GaN Thin-Films for PV Purposes***

G. Contreras-Puente[1], A. Cantarero[2], J. M. Recio[2], O. de Melo[1,3], E. Hernandez-Cruz[1], N. Campos-Rivera[1], R. Mendoza-Perez[4], G. Santana-Rodriguez[5], J. Aguilar-Hernandez[1], M. Lopez-Lopez[6], L. Zamora[7], A. Escamilla-Esquivel[1]
[1]Escuela Superior de Física y Matemáticas del IPN, Mexico, Mexico, [2]Materials Science Institute, University of Valencia, Valencia, Spain, [3]Facultad de Física de la Universidad de La Habana, La Habana, Cuba, [4]Universidad Autónoma de la Ciudad de México, Mexico, Mexico, [5]Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México, Mexico, Mexico, [6]Centro de Investigación y de Estudios Avanzados del IPN, Mexico, Mexico, [7]Centro de Investigaciones en Micro- y Nanotecnología, Universidad Veracruzana, Veracruz, Mexico

B9 19 **Investigation of Carrier Escape Mechanism in InAs/GaAs Quantum Dot Solar Cells**

Yushuai Dai[1], Christopher G Bailey[2], Chris Kerestes[1], David V Forbes[1], Seth M Hubbard[1]
[1]NanoPower Research Laboratory, Rochester Institute of Technology, Rochester, NY, USA, [2]Naval Reasearch Laboratory, Washington, DC, USA

B13 20 **Intermediate-Band Solar Cells Using In-Plane Ultrahigh Density InAs/GaAsSb Quantum Dot Sheets**

Yousuke Eguchi, Miyuki Shiokawa, Katsuyoshi Sakamoto, Koichi Yamaguchi
University of Electro-Communications, Tokyo, Japan

B17 21 **Modeling Down-Conversion and Down-Shifting for Photovoltaic Applications**

Ahmed M Gabr[1], Richard M Beal[1], Alex Walker[1], Jeffrey F Wheeldon[1], Justin Sacks[2], Rachel M Savidge[2], Trever J Hall[1], Rafael N Kleiman[2], Karin Hinzer[1]
[1]University of Ottawa, Ottawa, ON, Canada, [2]McMaster University, Hamilton, ON, Canada

B21 22 **Fabrication and Characterization of c-Si Solar Cells Integrated with Ordered Metallic Nanostructure Arrays**

Liang Huang[1,2], Husam Hamza Abu-Safe[1,3], Matthew Young[1,2], Seth Shumate[2], Benjamin Newton[2], Hameed Naseem[1], Shui-Qing Yu[1]
[1]Department of Electrical Engineering, University of Arkansas, Fayetteville, AR, USA, [2]Microelectronics and Photonics Program, University of Arkansas, Fayetteville, AR, USA, [3]Natural Science Division, Lebanese American University, Lebanon, Byblos, Lebanon

B25 23 **Hydrogenated Amorphous Silicon (a-Si:H) and Single-Wall Carbon Nanotube (SWNT) Heterojunction Solar Cell**
Rajendra R Khanal, Adam B Phillips, Zhiquan Huang, Lila R Dahal, Nikolas podraza, Robert W Collins, Michael.J Heben
Department of Physics & Astronomy and Wright Center for Photovoltaics Innovation and Commercialization, University of Toledo, Toledo, OH, USA

C1 24 **Limiting Efficiencies Over 50% Using Multijunction Solar Cells with Multiple Exciton Generation**
Jongwon Lee, Christiana B. Honsberg
Arizona State University, Tempe, AZ, USA

C5 25 **Theoretical Analysis for Intermediate-Band and Tandem Hybrid Solar Cell Materials**
Jongwon Lee, Som Dahal, Christiana B Honsberg
Arizona State University, Tempe, AZ, USA

C9 26 **Insight into Electronic Loss in Cu(In,Ga)Se_2 Solar Cells**
Yu-Kuang Liao[1, 4], Shou-Yi Kuo[3], Min-An Tsai[5], Tung-Po Hsieh[4], Hao-Chung Kuo[2]
[1]Department of Electro-Physics, National Chiao-Tung University, Hsinchu, Taiwan, [2]Department of Photonics and Institute of Electro-Optical Engineering, National Chiao-Tung University, Hsinchu, Taiwan, [3]Department of Electronic Engineering, Chang Gung University, Taoyuan, Taiwan, [4]Compound Semiconductor Solar Cell Department, Next Generation Solar Cell Division, Green Energy and Environment Research Laboratories, Industrial Technology Research Institute (ITRI), Hsinchu, Taiwan, [5]Photovoltaic Metrology Laboratory, Energy & Environment Metrology Division, Center for Measurement Standards, Industrial Technology Research Insitute (ITRI), Hsinchu, Taiwan

C13 27 **Decoupling Spectral Overlap of Intermediate-Band Solar Cells Using Low-High State Filling**
Albert Lin[1], Jamie Phillips[2]
[1]National Chiao-Tung University, Hsinchu, Taiwan, [2]University of Michigan, Ann Arbor, Ann Arbor, MI, USA

C17 28 **A Unified Mathematical Framework for Intermediate-Band Solar Cells**
Albert S Lin[1], Sze-Ming Fu[1], Yan-Kai Chung[2]
[1]Institute of Electronic Engineering, National Chiao-Tung University, Hsinchu, Taiwan, [2]Department of Electro-Physics, National Chiao-Tung University, Hsinchu, Taiwan

C21 29 **Junction Investigation of Graphene/Silicon Schottky Diode**
Muatez Z. Mohammed, Tar-pin Chen, Zhongrui Li, Jingbiao Cui
University of Arkansas at Little Rock and Arkansas GREEN Solar Cell Research Center, Little Rock, AR, USA

C24 30 **Analysis of the Energy Structure of Nitrogen Delta-Doped GaAs Superlattices for High-Efficiency Intermediate-Band Solar Cells**
Shunsuke Noguchi[1], Shuhei Yagi[1], Yasuto Hijikata[1], Shigeyuki Kuboya[2], Kentaro Onabe[2], Hiroyuki Yaguchi[1]
[1]Graduate School of Science and Engineering, Saitama University, Saitama, Japan, [2]Department of Advanced Materials Science, The University of Tokyo, Chiba, Japan

C27 31 **Optical Design of Selectively Scattering Nanostructures for Angle-Sensitive Semi-Transparent Photovoltaics**
Brian Roberts[1], Michael Boyd[2], P.-C. Ku[1]
[1]Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI, USA, [2]Department of Chemical Engineering, University of Michigan, Ann Arbor, MI, USA

D2 32 **Quantum Efficiency Measurements of Down-Shifting Using Silicon Nanocrystals for Photovoltaic Applications**
Justin Sacks[1], Rachel M. Savidge[1], Ahmed Gabr[2], Alex Walker[2], Richard Beal[2], Jeff Wheeldon[2], Andrew P. Knights[1], Peter Mascher[1], Karin Hinzer[2], Rafael N. Kleiman[1]
[1]McMaster University, Hamilton, ON, Canada, [2]University of Ottawa, Ottawa, ON, Canada

D5 33 **Study of Temperature and Illumination Dependence on c-Si Homojunction and Heterojunction Solar Cell Performance, and Determination of Conduction Mechanism in Silicon Heterojunction Solar Cells**
Abhishek Sharan, Raveesh Kumar, Basudev Prasad, Sudip Bhattacharya
BHEL-ASSCP, Siri fort, New Delhi, India

D8 34 **Theoretical Efficiency of Intermediate-Band Solar Cells with Overlapping Absorption Coefficients for Various Combinations of Bandgaps**
Rune Strandberg
Teknova AS, Kristiansand, Norway

D11 35 **Conversion of Light Propagation Direction for Highly-Efficient Thin-Film Solar Cells**
Ikuo Suemune
Hokkaido University, Sapporo, Japan

D13 36 **Carrier Multiplications in a Close Proximity of Surfactant-Free Silicon Nanocrystals Produced by 3D-Surface Engineering in Liquid Medium**
Vladimir Svrcek[1], Davide Mariotti[2], Koji Matsubara[1], Michio Kondo[1]
[1]Research Center for Photovoltaic Technologies, National Institute of Advanced Industrial Science and Technology (AIST), Tsukiba, Japan, [2]Nanotechnology & Integrated Bio-Engineering Centre (NIBEC), University of Ulster, Ulster, United Kingdom

D15 37 **Thin-Film InAs/GaAs Quantum Dot Solar Cells Layer-Transferred onto Si Substrates and Flexible Plastic Films**
Katsuaki Tanabe, Katsuyuki Watanabe, Yasuhiko Arakawa
University of Tokyo, Tokyo, Japan

D17 38 **Synthesis and Optical Properties of $ZnTe_{1-x}O_x$ Highly Mismatched Alloys for Intermediate-Band Solar Cells**
Tooru Tanaka[1,2], Tomohiro Mochinaga[1], Katsuhiko Saito[1], Qixin Guo[1], Mitsuhiro Nishio[1], Kin M. Yu[3], Wladek Walukiewicz[3]
[1]Department of Electrical and Electronic Engineering, Saga University, Saga, Japan, [2]PRESTO, Japan Science and Technology Agency, Kawaguchi, Japan, [3]Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA

D19 39 **Very-High Efficient Solar System by Current Matched Partitions**
Donald Wagner[1], Lili He[2]
[1]Sol Solution, Inc., Los Gatos, CA, USA, [2]San Jose State University, San Jose, CA, USA

D21 40 **Numerical Study of the Characterization with Polarization Effects of c-Facet p-InGaN /i-InGaN /n-GaN Solar Cell**
Hsun-Wen Wang[2], Pei-Chen Yu[1], Shiuan-Huei Lin[2], Hao-Chung Kuo[1]
[1]Department of Photonics & Institute of Electro-Optical Engineering, National Chiao-Tung University, Hsinchu, Taiwan, [2]Department of Electrophysics, National Chiao Tung University, Hsinchu, Taiwan

D23 41 **Light-Trapping Structure with Backside Scatterer for Enhanced Photo-Absorption by Quantum Structures**

Kentaroh Watanabe[1], Boram Kim[1,2], Hassanet Sodabanlu[1], Masanao Goto[3], Keisuke Nakayama[3], Shinya Hayashi[3], Masakazu Sugiyama[1,2], Kenjiro Miyano[1], Yoshiaki Nakano[1,2]

[1]Research Center for Advanced Science and Technology, The University of Tokyo, Tokyo, Japan, [2]Department of Electrical Engineering and Information Systems, School of Engineering, The University of Tokyo, Tokyo, Japan, [3]Central Technical Research Laboratory, JX Nippon Oil & Energy Corporation, Yokohama, Japan

D25 42 **Creating Value for Utilities: Emerging Strategies for PV Adoption Across Customer Segments**

Simon Watson, Andy Skumanich

SolarVision Consulting, Los Gatos, CA, USA

D27 43 **Stability and Electronic Structures of Cu_xS Solar Cell Absorbers**

Su-Huai Wei, Qiang Xu, Bing Huang, Yufeng Zhao, Yanfa Yan, Rommel Noufi

National Renewable Energy Laboratory, Golden, CO, USA

E1 44 **The Impacts of Emitter and Base-Carrier Density on Si-Chalcopyrite Heterojunction Solar Cells Using AMPS-1D**

Jian Wu[1,2], Xusheng Wang[2], Lingjun Zhang[2], Wenzhong Shen[1]

[1]Institute of Solar Cell, Physics Department, Shanghai Jiao Tong University, Shanghai, China, [2]Canadian Solar Inc., Suzhou, China

E3 45 **Direct Near-Field Mapping of Photoelectric Response Induced by Localized Surface Plasmon of Silver Nano-Islands on a Silicon Solar Cell**

Cheng-Ying Yang[1], Ting-Gang Chen[1], Chien-Lang Chiang[1], Yi-Ying Liou[2], Wen-Che Tsai[2], Pei-chen Yu[1], Wen-Hao Chang[2]

[1]Department of Photonic & Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan, [2]Department of Electrophysics, National Chiao Tung University, Hsinchu, Taiwan

1:30 - 3:00 PM **EH4-B**

Area 2: Polycrystalline Thin Films: Absorber Formation and Characterization 1 (Posters)

Chair(s): Tim Gessert, Chris Ferekides, Bernhard Dimmler

E6 46 **Effect of Substrate Bias on Growth of RF-Sputtered CdTe Films**
Hui Li, Xiangxin Liu, Fang Huang
The Key Laboratory of Solar Thermal Energy and Photovoltaic System, Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing, China

E10 47 **The Effect of Cadmium Chloride Treatment on Close Spaced Sublimated Cadmium Telluride Thin-Film Solar Cells**
Ali Abbas[1,2], Geoff West[1], Paul Rowley[2], Jake Bowers[2], Biancamaria Maniscalco[2], John M. Walls[2], Keegan Barricklow[3,4], W.S. Sampath[3], Kurt L. Barth[3,4]
[1]Department of Materials, Loughborough University, Loughborough, United Kingdom, [2]CREST (Centre for Renewable Energy Systems and Technology), Loughborough, United Kingdom, [3]NSF I/UCRC for Next Generation Photovoltaics, Colorado State University, Fort Collins, CO, USA, [4]Abound Solar, Loveland, CO, USA

E14 48 **Fabrication of Thin-Film Solar Cells with Indium-Doped CdTe Crystals**
Tursunjan Ablekim, Kelvin G. Lynn
Center for Materials Research, Washington State University, Pullman, WA, USA

E18 49 **Real Time and Post-Deposition Optical Analysis of Interfaces in CdTe Solar Cells**
Prakash Koirala, Naba Paudel, Jie Chen, Dinesh Attygalle, Yanfa Yan, Robert W Collins
The University of Toledo, Toledo, OH, USA

E22 50 **Correlation Between Roughness and Performance of Sputtered CdTe Solar Cells**
DoHyoung Kwon, Yunsic Shim, Kristopher A Wieland, Alvin D. Compaan
Dept. of Physics and Astronomy, The University of Toledo, Toledo, OH, USA

E26 51 **The Oxygen Effect on CdS/CdTe Solar Cell Activated with $CHClF_2$**
Victor Rejon, Oscar Ares, Juan M. Camacho, Araceli Rios-Flores, Juan Luis Peña
Applied Physics Department, CINVESTAV-IPN, Mérida, Yucatán, Mexico

F2 52 **Eleminating Pinholes in CSS-Deposited CdS Films**
Mohammed A. Tashkandi, W.S. Sampath
Materials Eng NSF I/UCRC for Next Generation Photovoltaics, Colorado State University, Fort Collins, CO, USA

F6 53 **CdS Thin-Film Grown by Aerosol Assisted Deposition Method**
Guogen Liu[1,2], Zimeng Cheng[1], George E. Georgiou[1], Jingong Pan[3], Ken Chin[1], Alan Delahoy[1], Robert B. Barat[2]
[1]Apollo CdTe Solar Energy Research Center, Newark, NJ, USA, [2]Chemical, Biological and Pharmaceutical Engineering, Newark, NJ, USA, [3]Apollo Solar Energy, Inc., Chengdu, China

F10 54 **Effects of Thermal Annealing on Structural and Optical Properties of Sputtered CdS Thin Films for Photovoltaic Application**
M. Aminul Islam[1], M. Sharafat Hossain[1], M. Mannir Aliyu[1], Jamilah Husna[1], M. Rezaul Karim[3], Kamaruzzaman Sopian[2], Nowshad Amin[1,2,3]
[1]Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia, [2]Solar Energy Research Institute, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia, [3]CEREM, College of Engineering, King Saud University, Riyadh, Saudi Arabia

F14 55 **An Analysis on Structural and Optical Properties of $Zn_xCd_{1-x}S$ Thin Film Deposited by RF Magnetron Sputtering**
M. Sharafat Hossain[1], M. Aminul Islam[1], M. Mannir Aliyu[1], Saleem H. Zaidi[2], Takhir Razykov[2], Kamaruzzaman Sopian[2], Nowshad Amin[1,2]
[1]Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia, [2]Solar Energy Research Institute, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia

F18 56 **Growth and Characterization of $Cd_{1-x}Mg_xTe$ Thin Films for Possible Application in High-Efficiency Solar Cells**
Pavel S. Kobyakov, Russell Geisthardt, Tyler Cote, W.S. Sampath
NSF I/UCRC for Next Generation Photovoltaics, Colorado State University, Fort Collins, CO, USA

F22 57 **Investigation of the Absorption Properties of Sputtered Tin-Sulfide Thin Films for Photovoltaic Absorber Layers**
Rona E. Banai[1], Hyeonseok Lee[1], Matthew A. Lewinsohn[1], Michael A. Motyka[1], Ramprasad Chandrasekharan[1], Nikolas J. Podraza[2], Jeffrey R.S. Brownson[1], Mark W. Horn[1]
[1]The Pennsylvania State University, University Park, PA, USA, [2]The University of Toledo, Toledo, OH, USA

F26 58 **Atmospheric-Pressure Chemical Vapor Deposition of Iron-Pyrite Thin Films**
Nicholas E. Berry[1], Ming Cheng[2], Craig L. Perkins[3], John C. Hemminger[2], Matt Law[2]
[1]Department of Physics, University of California, Irvine, Irvine, CA, USA, [2]Department of Chemistry, University of California, Irvine, Irvine, CA, USA, [3]National Renewable Energy Laboratory, Golden, CO, USA

G2 59 **Ink-Based FeS_2 Thin-Film Absorber Formed by Annealing**
Tara P. Dhakal, Lakshmi K. Ganta, Charles R. Westgate
Center for Autonomous Solar Power (CASP), SUNY-Binghamton, Binghamton, NY, USA

G6 60 **Effect of Sulphur Variation in $AgInS_2$ Thin Films Prepared by Chemical Spray Pyrolysis**
Anantha Sunil Maligi, Deepa K.G., Nagaraju Jampana
Indian Institute of Science, Bangalore, India

G10 61 **Fabrication and Characterization of Improved p-GaTe/n-InSe Heterojunction Solar Cells**
Krishna C. Mandal, Sandip Das
University of South Carolina, Columbia, SC, USA

G14 62 **Study of $CuInS_2$-Based Solar Cells with Chemically-Deposited ZnS and In_2S_3 Buffer Layers**
Clara L. Calderón[1], Johana S. Oyola[1], Pascual Bartolo[2], Gerardo Gordillo[1]
[1]Departamento de Física, Universidad Nacional de Colombia, Bogotá, Columbia, [2]Departamento de Física Aplicada, CINVESTAV- IPN, Mérida, Mexico

G18 63 **Characterization of $(AgCu)(InGa)Se_2$ Absorb Layer Fabricated by Selenization Process from Metal Precursor**
Yuki Tauchi[1,3], Kihwan Kim[1], Hyeonwook Park[1,4], William Shafarman[1,2]
[1]Institute of Energy Conversion, University of Delaware, Newark, DE, USA, [2]Department of Materials Science and Engineering, University of Delaware, Newark, DE, USA, [3]Electric Research Laboratory, Kobe Steel, LTD., Kobe, Japan, [4]School of Display and Chem. Eng., Yeungnam University, Gyeongsan, South Korea

G22 64 **Preparation of $CuInSe_2$ Thin Films by Post-Deposition Selenization of Sputter-Deposited $CuInO_x$ Films**

Emre Yassitepe[1], William N. Shafarman[1,2], S. Ismat Shah[1,3]
[1]Materials Science and Engineering, University of Delaware, Newark, DE, USA, [2]Institute of Energy Conversion, University of Delaware, Newark, DE, USA, [3]Department of Physics and Astronomy, University of Delaware, Newark, DE, USA

G26 65 **Reaction Between Sodium and Selenium in Bridgman-Grown $CuInSe_2$**

Hadley F. Myers, Clifford H. Champness, Ishiang Shih
McGill University, Montreal, QC, Canada

H2 66 **The Effect of Na Implantation on the Polycrystalline $CuIn_{1-x}Ga_xSe_2$**

Wan-Yao Wu[1], Chia-Hsiang Chen[1], Chia-Hao Hsu[1], Chien-Hsu Chen[2], Yun-Chung Wu[1], Tian-Jue Hong[1], Huan Niu[4], Chih-Huang Lai[1,3]
[1]Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan, [2]Center for Nano Science and Technology, National Chiao Tung University, Hsinchu, Taiwan, [3]Low Carbon Energy Research Center, National Tsing Hua University, Hsinchu, Taiwan, [4]Nuclear Science and Technology Development Center, National Tsing Hua University, Hsinchu, Taiwan

H5 67 **Effect of CdTe Growth Temperature and ZnTe:Cu Contacting Conditions on CdTe Device Performance**

James M. Burst[1], William L. Rance[1], Matthew O. Reese[1], Teresa M. Barnes[1], Myles A. Steiner[1], Timothy A. Gessert[1], Kan Zhang[2], Kim Fuller[2], Charles Hamilton[2], Carlo A. Kosik Williams[2], Darius Kuciauskas[1], Jian V. Li[1]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Corning, Inc., Corning, NY, USA

1:30 - 3:00 PM **EH4-C**

Area 4: Crystalline Silicon: Fundamentals (Posters)

Chair(s): Hele Savin

I24 68 **Industrially Fabricated Bifacial Si Solar Cells with n^+-p-p^+ Structure**
Galina Grigorieva[1], Kira Zviagina[1], Marlen Kagan[1], Lev Kreinin[2], Nelli Bordin[2], Jacob Broder[2], Naftali Eisenberg[2]
[1]KVANT Research and Production Enterprise, Moscow, Russia, [2]Jerusalem College of Technology, Jerusalem, Israel

I28 69 **Modeling Isotextured Silicon Solar Cells**
Simeon C. Baker-Finch[1], Keith R. McIntosh[2], Mason L. Terry[3]
[1]Australian National University, Canberra, ACT, Australia, [2]PV Lighthouse, Coledale, NSW, Australia, [3]Dupont Innovalight, Sunnyvale, CA, USA

J4 70 **Modeling Recombination at the Si–Al_2O_3 Interface**
Lachlan E. Black[1], Keith R. McIntosh[2]
[1]Centre for Sustainable Energy Systems, Australian National University, Canberra, Australia, [2]PV Lighthouse, Coledale, NSW, Australia

J8 71 **Impact of Si Surface Topography on the Glass Layer Resulting from Screen-Printed Ag-Paste Solar Cell Contacts**
Enrique Cabrera[1], Sara Olibet[1], Dominik Rudolph[1], Joachim Glatz-Reichenbach[1], Radovan Kopecek[1], Daniel Reinke[2], Anne Götz[2], Gunnar Schubert[2]
[1]International Solar Energy Research Center (ISC) Konstanz, Konstanz, Germany, [2]Sunways AG, Konstanz, Germany

J12 72 **Study of the Effect of Different Hole Sizes on Mechanical Strength of Wafers for Back Contact Solar Cells**
Eneko Cereceda[1], Josu Barredo[2], Jose Rubén Gutiérrez[1], Juan Carlos Jimeno[1], Alberto Fraile[3], Lutz Hermanns[3]
[1]Technological Institute of Microelectronics (TiM), University of the Basque Country, Zamudio, Spain, [2]Centre for Modeling in Mechanical Engineering (CEMIM-F2I2), Madrid, Spain, [3]Department of Structural Mechanics and Industrial Constructions, UPM, Madrid, Spain

J16 73 **Understanding Coupled Oxide Growth and Phosphorus Diffusion in $POCl_3$ Deposition for Control of Phosphorus Emitter Diffusion**
Renyu Chen[1], Hannes Wagner[2], Amir Dastgheib-Shirazi[3], Michael Kessler[4], Zihua Zhu[5], Pietro Altermatt[2], Scott Dunham[1]
[1]Department of Electrical Engineering, University of Washington, Seattle, WA, USA, [2]Dep. Solar Energy, Inst. Solid-State Physics, Leibniz University of Hannover, Hannover, Germany, [3]Div. Photovoltaics, Dep. of Physics, University of Konstanz, Konstanz, Germany, [4]Institute for Solar Energy Research Hamelin (ISFH), Emmerthal, Germany, [5]Environmental Molecular Sciences Lab, Pacific Northwest National Lab, Richland, WA, USA

J20 74 **Revisiting Models for Lifetime Degradation in Si Due to B/O Complexes**
Scott T. Dunham, Renyu Chen, Bart Tryznadlowski
Department of Electrical Engineering, University of Washington, Seattle, WA, USA

J24 75 **Coupled Modeling of Evolutuion of Impurity/Defect Distribution and Cell Performance**
Scott T. Dunham, Bart Tryznadlowski, Armin Yazdani, Renyu Chen
Department of Electrical Engineering, University of Washington, Seattle, WA, USA

J28 76 **Effect of Band Bending and Band Offset in the Transport of Minority Carriers Across the Ordered/Disordered Interface of a-Si/c-Si Heterojunction Solar Cell**
Kunal Ghosh, Clarence Tracy, Stephen Goodnick, Stuart Bowden
Arizona State university, Tempe, AZ, USA

K4 77 **Defect Band Luminescence Intensity Reversal as Related to Application of Antireflection Coating on mc-Si PV Cells**
Harvey L. Guthrey[1,2], Steve W. Johnston[2], Fei Yan[2], Brian P. Gorman[1], Mowafak M. Al-Jassim[2]
[1]Colorado School of Mines, Golden, CO, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

K8 78 **Study of the Sintering Behavior of Silver Front Side Metallization Pastes**
Andre Kalio, Steve Olweya, Markus Glatthaar
Fraunhofer ISE, Freiburg, Germany

K12 79 **Using Electroluminescence Imaging Under Reverse Bias to Understand Junction Breakdown Phenomena in Crystalline Si Solar Cell: Substrate Quality Perspective**
Chinna Venkadasamy Kannan, Ramu Maddu, Ivan Saha
MoserBaer Photovoltaic Ltd, Greater Noida, U.P, India

K16 80 **Challenges of Lowering Solar Cell Production Costs by Reducing Silver Usage in Back-Contact Metallization Pastes**
Eric Kurtz, Lindsey Karpowich, Markus Koenig, Weiming Zhang
Heraeus Precious Metals North America Conshohocken LLC, West Conshohocken, PA, USA

K20 81 **Novel Framework for Metal Wrap Through Solar Cell Top Contact Design Optimization**
Chao-Hu Li, Albert W. Lu, Kuo-Ling Chiang
Topcell Solar International Co., Ltd., Taoyuan County, Taiwan

K24 82 **Investigation of the Influence of Sintering Process on Silicon Solar Cells**
Zhonglan Li[1], Yifeng Chen[2], Yang Yang[1], Zhiqiang Feng[1], Qiang Huang[1]
[1]State Key Lab of PV Science and Technology, Trina Solar Limited Company, Changzhou, China, [2]Institute for Solar Energy Systems, Sun Yat-sen University, Guangzhou, China

K27 83 **Modeling Internal Gettering of Iron at Grain Boundaries in Multicrystalline Silicon Measured via Photoluminescence Imaging**
AnYao Liu, Daniel Walter, Sieu Pheng Phang, Daniel Macdonald
Research School of Engineering, Australian National University, Canberra, Australia

L2 84 **Effect of Geometry and Edge Defects on the Mechanical Strength of Silicon Wafers for Solar Cell**
Linyan Liu[1], Jianting Gao[2], Liyuan Sun[3], Tao Zhang[1], Xiaojuan Cheng[1]
[1]LDK Solar, Xinyu, China, [2]LDK Solar, Sunnyvale, CA, USA, [3]LDK Solar, Nanchang, China

L5 85 **Influence of Temperature on Photovoltaic Cells Spectral Response**
Maibi A. Malape, Michael Simon, Edson E. Meyer
Fort Hare Institute of Technology, Alice, Eastern Cape, South Africa

L8 86 **Towards Cost-Effective Antireflectve Coating and Surface-Texturing**
Yasuhiro Matsumoto, Gabriel Romero
Centro de Investigacion y de Estudios Avanzados del IPN, Mexico, Mexico

L11 87 **OPAL 2.0: Rapid Optical Simulation of Practical Silicon Solar Cells**
Keith R. Mcintosh[1], Simeon C. Baker-Finch[2]
[1]PV Lighthouse, Coledale, Australia, [2]Australian National University, Canberra, Australia

L14 88 **Behaviors of Fe and Ni at Crystal Defects in Multicrystalline Silicon by Intentional Contamination and Phosphorus Gettering**
Naoto Miyzaki[1], Yuki Tsuchiya[1], Takashi Sameshima[1], Tomihisa Tachibana[1], Takuto Kojima[2], Yoshio Ohshita[2], Koji Arafune[3], Atsushi Ogura[1]
[1]Meiji Univ., Kawasaki, Japan, [2]Toyota Tech. Inst., Nagoya, Japan, [3]Univ. of Hyogo, Himeji, Japan

L17 89 **An Investigation of Silicon Boride Surface Layer Resulting from Boron Diffusion in Silicon**
Karthick Murukesan[1], D.V. Sridhara Rao[2], Muraleedharan K.[2], Ashok Kumar Kapoor[3], Anuradha Dhaul[3], Brajesh Singh Yadav[3], Brij Mohan Arora[1]
[1]NCPRE, Department of Electrical Engineering, IIT Bombay, Mumbai, India, [2]Defence Metallurgical Research Laboratory, Kanchanbagh, Hyderabad, India, [3]Solid State Physics Laboratory, Lucknow Road, Delhi, India

L20 90 **Laser-Transferred Contacts: Modeling of the Transfer Process**
Tobias C. Röder, Jügen R. Köhler
Institute of Photovoltaics, University of Stuttgart, Stuttgart, Germany

L23 91 **Modeling Distribution and Impact of Efficiency-Limiting Metallic Impurities in Silicon Solar Cells**
Martin C. Schubert, Jonas Schön, Bernhard Michl, Alireza Abdollahinia, Wilhelm Warta
Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany

L26 92 **Modeling the Size Distribution of Iron Precipitates in Multicrystalline Silicon**
Jonas Schön[1], Antti Haarahiltunen[2], David Fenning[3], Tonio Bounassisi[3], Wilhelm Warta[1], Martin C. Schubert[1]
[1]Fraunhofer Institute for Solar Energy Systems (ISE), Freiburg, Germany, [2]Aalto University, Aalto, Finland, [3]Massachusetts Institute of Technology, Cambridge, MA, USA

M1 93 **Bow Analysis After Soldering Process for Silicon Solar Cell with Special Bus Bar Pattern Design**
Pin-Hsueh Tsai, Yu-Ning Chang, Chien-Wen Chen, Wen-Pin Chen, Chih-Hsyong Wu
Motech Industries, Inc., Tainan, Taiwan

M4 94 **Correlation Between Carbon Incorporation and Defect Formation in Quasi-Single Crystalline Silicon**
Yuki Tsuchiya[1], Hiroki Kusunoki[1,2], Naoto Miyazaki[1], Takashi Sameshima[1], Tomihisa Tachibana[1], Takuto Kojima[3], Koji Arafune[4], Yoshio Ohshita[3], Haruhiko Ono[2], Atsushi Ogura[1]
[1]Meiji University, Kawasaki, Japan, [2]Kanagawa Industrial Technology Center, Ebina, Japan, [3]Toyota Technological Institute, Nagoya, Japan, [4]University of Hyogo, Himeji, Japan

M7 95 **Mapping of the Dopant Compensation Effects on the Reverse and Forward Characteristics of Solar Cells**
J. Andrew Veirman, S. Dubois, N. Enjalbert, T. Desrues
CEA, LITEN, INES, 50 av du Lac Léman, F-73377, Le Bourget-du-Lac, France

M10 96 **Contrast Enhancement of Luminescence Images via Point-Spread Deconvolution**
Daniel C. Walter[1], Anyao Liu[1], Evan Franklin[1], Daniel Macdonald[1], Bernhard Mitchell[2], Thorsten Trupke[2,3]
[1]Centre for Sustainable Energy Systems, Australian National University, Canberra, Australia, [2]School of Photovoltaic and Renewable Energy Engineering, University of New South Wales, Sydney, Australia, [3]BT Imaging, Sydney, Australia

M13 97 **Analyzing emitter dopant inhomogeneities at textured Si surfaces by using 3D process and device simulations in combination with SEM imaging**
Hannes Wagner[1], Silke Steingrube[1], Bettina Wolpensinger[2], Renyu Chen[3], Scott Dunham[3], Pietro Altermatt[1]
[1]Dep. Solar Energy, Inst. Solid-State Physics, Leibniz University of Hannover, Appelstr. 2, 30167 30167 Hannover, Germany, Hannover, Germany, [2]Institute for Solar Energy Research Hamelin (ISFH), 31860, Emmerthal, Germany, [3]Electrical Engineering Department, University of Washington, Seattle, WA, USA

M16 98 **The Spot-Like Defect on Aluminum Oxide Passivation Layer for Crystalline Silicon Wafer**
Teng-Yu Wang[1], Cheng-Chi Liu[1,2], Chien-Hsiung Hon[1,2], Chen-Hsun Du[1,3], Chung-Yuan Kung[2], Jeng-Lang Lue[4], Chi-Chun Li[4]
[1]Green Energy and Environment Research Labs, Industrial Technology Research Institute, Hsinchu, Taiwan, [2]Department of Electrical Engineering, National Chung-Hsing University, Taichung, Taiwan, [3]Institute of NanoEngineering and MicroSystems, National Tsing Hua University, Hsinchu, Taiwan, [4]Motech Industries, Inc., Tainan, Taiwan

1:30 - 3:00 PM **EH4-D**

Area 5: Thin-Film Silicon: Solar Cells: Fundamentals, Processing, and Light Trapping (Posters)

Chair(s): X Niu, Nieuwenhuysen

O3 99 **Thinner Absorber Layers and Improved Relative Stability of a-Si:H p-i-n Junctions Using n-Doped µc-SiO_x:H Reflector Layers**
Pavel Babal, Ravi Vasudevan, Johan Blanker, Arno H.M. Smets, Miro Zeman
TU Delft, Delft, Netherlands

O5 100 **Large-Area Imprinted-Surface Textures for Omnidirectional Conformal AR Coatings on Flexible Amorphous Silicon Solar Cells**
Arvinder M. Chadha[1], Eric D. Cline[2], Meng Tao[3], Weidong Zhou[1]
[1]University of Texas at Arlington, Arlington, TX, USA, [2]ZT Solar Inc, Dallas, TX, USA, [3]Arizona State University, Tempe, AZ, USA

O7 101 **Amorphous Silicon Solar Cell on Block-Textured Glass**
Keum Chang Min[1], Moon Seung Jae[1], Kim Beom jun[2], Lee Jong Mo[2], Bae Byung Seung[1,2]
[1]New it Engineering, Hoseo University, Asan, Chungnam, South Korea, [2]Dep. of Semiconductor and Display Engineering, Hoseo University, Asan, Chungnam, South Korea

O9 102 **Monolithic Thin-Film Photovoltaic Device with Enhanced Output Voltage**
Boris Gilman
CoolSol R&C, Mountain View, CA, USA

O11 103 **Solvent-Induced Growth of Crystalline Silicon on Glass**
Robert Heimburger, Roman Bansen, Thomas Teubner, Torsten Boeck
Leibniz Institute for Crystal Growth, Berlin, Germany

O13 104 **Blazed Pyramidal Gratings for Enhanced Light Trapping In Very-Thin-Film Solar Cells**
Liming Ji[1], Matthew Allan Thomas[2], Jingbiao Cui[2], Vasundara Varadan[1]
[1]University of Arkansas, Fayetteville, AR, USA, [2]University of Arkansas at Little Rock, Little Rock, AR, USA

O15 105 **Structural Properties of p-Type Polycrystalline Silicon Seed Layer by Electron Beam Annealing Method**
Changheon Kim[1,2], Sangwoo Lim[2], Jin Hyeok Kim[3], Chaehwan Jeong[1]
[1]Applied Optics & Energy Research Group, Korea Institute of Industrial Technology, Gwangju, South Korea, [2]Department of Chemical and Biomolecular Engineering, Yonsei University 262 Seongsanno Seodaemun-gu, Seoul, South Korea, [3]Department of Materials Science Engineering, Chonnam National University, Gwangju, South Korea

O17 106 **Crystallization of a-Si Thin-Film Using an Ultrathin n+ Poly-Si Seed Layer for Solar Cell Applications**
Yue Kuo[1], Chi-Chou Lin [1], Stanislav Verkhoturov[2]
[1]Thin Film Nano & Microelectronics Research Laboratory, Texas A&M University, College Station, TX, USA, [2]Department of Chemistry, College Station, TX, USA

O19 107 **Layer Transfer of Crystalline Si Thin Film by Metal-Assisted Chemical Etching Concerning Different H_2O_2/HF Ratios**
Tzu-Ching Lin[1], Shu-Chia Shiu[2], Keng-Lam Pun[2], Hong-Jhang Syu[2], Ching-Fuh Lin[1,2,3]
[1]Graduate Institute of Electronics Engineering, National Taiwan University, Taipei, Taiwan, [2]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan, [3]Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan

O21 108 **Non-Metallic, Manufacturable Arrays for High-Performance Single-Junction Thin-Film nc-Si Solar Cells**

Wook Jun Nam[1,2], Stephen Fonash[1,2], Liming Ji[3], Vasundara Varadan[3]
[1]Solarity LLC, State College, PA, USA, [2]Center for Nanotechnology Education and Utilization, The Pennsylvania State University, University Park, PA, USA, [3]Department of Electrical Engineering, University of Arkansas, Fayetteville, AR, USA

O23 109 **Optical Characterization of Structurally-Graded $Si_{1-x}Ge_x$:H Thin Films**

Nikolas J. Podraza[1], David B. Saint John[2]
[1]Department of Physics and Astronomy, University of Toledo, Toledo, OH, USA, [2]Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA, USA

O25 110 **Plasmon-Enhanced Optical Absorption in Silicon Nanohole Array for Thin-Film Solar Cells Application**

Pushpa Raj Pudasaini, Arturo A. Ayon
University of Texas at San Antonio, San Antonio, TX, USA

O27 111 **Raman Study of Localized Recrystallization of Amorphous Silicon Induced by Laser Beam**

Nouar A. Tabet[1], Abduljabar Q. Sayoud[2], Seyed A. Said[2], A. Seyed[3], X. Yang[3], Y. Yang[3], E. Diallo[3], Z. Wang [3], X. Wang[3], Eric Johlin[4], Christie Simmons[4], Tonio Buonassisi[4]
[1]KFUPM-MIT Center of Research for Clean Water and Clean Energy, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, [2]Center of Research Excellence in Renewable Energy, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, [3]Nanofabrication Core Laboratory, King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia, [4]Massachusetts Institute of Technology, Cambridge, MA, USA

P1 112 **Numerical Simulation of Multijunction Thin-Film Silicon Solar Cells: From Single-Junction to Triple-Junction Solar Cells**

Karsten von Maydell, Stefan Geißendörfer, Jürgen Lacombe, Thilo Kilper, Oleg Sergeev, Kambulakwao Chakanga
EWE Forschungszentrum für Energietechnologie - NEXT ENERGY, Oldenburg, Germany

P3 113 **Large-Grain Polysilicon Seed Layers on Glass for Epitaxial Silicon Solar Cells**
Seth D. Shumate[1,2], Mohammed K. Hafeezuddin[2], Douglas A. Hutchings[2], Hameed A. Naseem[3]
[1]Microelectronics-Photonics, University of Arkansas, Fayetteville, AR, USA, [2]Silicon Solar Solutions, Fayetteville, AR, USA, [3]Department of Electrical Engineering, University of Arkansas, Fayetteville, AR, USA

1:30 - 3:00 PM **EH4-E**

Area 8: PV Characterization: Session 1 (Posters)

Chair(s): Manuel Romero, Yoshihiro Hishikawa, Gerald Siefer

Q20 114 **Tracking Cell Parameters in Fully Packaged Modules After Stress Testing**
Glann Alers[1], Abaham Ishihara[2], Jeremy Olson[3], Nathan Green[3]
[1]Uinversity of California, Santa Cruz, CA, USA, [2]Carnegie Mellon, Mountain View, CA, USA, [3]APV Research, Mountain View, CA, USA

Q22 115 **Through-the-Glass Optical Metrology for Mapping 60 cm x 120 cm CdTe Photovoltaic Panels in Off-Line and Online Configurations**
Jie Chen[1], Prakash Koirala[1], Carl Salupo[1], Robert W. Collins[1], Sylvain Marsillac[2], Kenneth R. Kormanyos[3], Blaine D. Johs[4], Jeffrey S. Hale[4], Galen L. Pfeiffer[4]
[1]Center for Photovoltaics Innovation & Commercialization and Department of Physics & Astronomy, University of Toledo, Toledo, OH, USA, [2]Department of Electrical and Computer Engineering, Old Dominion University, Norfolk, VA, USA, [3]Calyxo USA Inc., Perrysburg, OH, USA, [4]J. A. Woollam Co., Lincoln, NE, USA

Q24 116 **Characterization of ZnS Films Deposited by ALD for CIGS Solar Cells**
Yunus Erkaya[1], Nitin Hegde[1], Krishna Aryal[1], Grace Rajan[1], Patrick Boland[1], Vikash Ranjan[1], Helmut Baumgart[1], Robert W. Collins[2], Sylvain Marsillac[1]
[1]Old Dominion University, Norfolk, VA, USA, [2]The University of Toledo, Toledo, OH, USA

R2 117 **ARXPS Analysis of a GaAs/GaInP Heterointerface with Application in III-V Multijunction Solar Cells**

Mercedes Gabás[1], M. Cruz López-Escalante[1], Carlos Algora[2], Ignacio Rey-Stolle[2], Beatriz Galiana[2], Santiago Palanco[1], José R. Ramos-Barrado[1]

[1]Dpto. de Física Aplicada I, Lab. de Materiales y Superficies, Universidad de Málaga, Málaga, Spain, [2]Instituto de Energía Solar-Universidad Politécnica de Madrid, Madrid, Spain

R4 118 **Uncertainty in Photoluminescence-Based Effective Minority Carrier Lifetime Measurements**

Ziv Hameiri[1], Keith McIntosh[2], Thorsten Trupke[3]

[1]SERIS, Singapore, Singapore, [2]PV Lighthouse, Coledale, Australia, [3]UNSW, Sydney, Australia

R6 119 **Photoemission Study of CdTe Surfaces After Low-Energy Ion Treatments**

Douglas Hanks[1], Micheal Weir[1], Kimberly Horsley[1], Timo Hofmann[1], Lothar Weinhardt[1,2], Keegan Barricklow[3], Pavel Kobyakov[3], Walajabad Sampath[3], Clemens Heske[1,2]

[1]University of Nevada, LasVegas (UNLV), Las Vegas, NV, USA, [2]Institute for Synchrotron Radiation, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, [3]Colorado State University (CSU), Fort Collins, CO, USA

R8 120 **Chemical Surface and Interface Properties of Differently-Stressed (Au/Cu/)CdTe/CdS Thin-Film Solar Cell Structures**

Kimberly A. Horsley[1], Regan G. Wilks[2], Douglas Hanks[1], Monika Blum[1,3], Naba Paudel[4], Alvin Compaan[4], Wanli Yang[3], Marcus Baer[1,2,5], Lothar Weinhardt[1,6], Clemens Heske[1,6]

[1]Dept. of Chemistry, University of Nevada, Las Vegas, Las Vegas, NV, USA, [2]Solar Energy Research, Helmholtz-Zentrum Berlin fuer Materialien und Energie GmbH, Berlin, Germany, [3]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA, USA, [4]Dept. of Physics and Astronomy, University of Toledo, Toledo, OH, USA, [5]Institut fuer Physik und Chemie, Brandenburgische Technische Universitaet Cottbus, Cottbus, Germany, [6]Institute for Synchrotron Radiation, Karlsruhe Institute of Technology, Karlsruhe, Germany

R10 121 **Real-Time Parameter Estimation for Characterization of Cell Level Degradation Using a Polymer Dispersed Liquid Crystal Active Shading Screen**

Abraham K. Ishihara

Carnegie Mellon University, Moffett Field, CA, USA

R12 122 **Quality Characterization of Silicon Bricks Using Photoluminescence Imaging and Photoconductive Decay**
Steven W. Johnston[1], Fei Yan[1], Katherine Zaunbrecher[1,2], Mowafak Al-Jassim[1], Omar Sidelkheir[3], Kamel Ounadjela[3]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Colorado State University, Fort Collins, CO, USA, [3]Calisolar, Sunnyvale, CA, USA

R14 123 **Measurement of Internal Optical Reflection Characteristics of Solar Cell Back Reflectors**
Henner Kampwerth, Yang Yang, Martin A. Green
Photovoltaics Centre of Excellence - University of New South Wales, Sydney, Australia

R16 124 **Electronic and Structural Properties of Copper Selenide ($Cu_{2-x}Se$) Thin Films as Determined by *In Situ* Real-Time and *Ex Situ* Characterization**
Himal Khatri[1], Krishna Aryal[2], Robert W. Collins[1], Sylvain Marsillac[2]
[1]The University of Toledo, Toledo, OH, USA, [2]Old Dominion University, Norfolk, VA, USA

R18 125 **Combined Thin-Film Thickness Measurement and Surface Metrology of Photovoltaic Thin Films Using Coherence Correlation Interferometry**
Biancamaria Maniscalco, Piotr M. Kaminski, John M. Walls
Loughborough University, Loughborough, United Kingdom

R20 126 **Photoluminescence Excitation Spectroscopy of p-GaAs Surfaces and AlGaAs/GaAs Interfaces Supported by Numerical Modeling**
Kyle H. Montgomery[1], Dionisis Berdebes[1], Jayprakash Bhosale[2], Mark S. Lundstrom[1], Jerry M. Woodall[1]
[1]School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, USA, [2]Department of Physics, Purdue University, West Lafayette, IN, USA

R22 127 **Highly-Conductive Ga-Doped ZnO Thin Films Deposited onto Si Wafers: Interface Characterization**
Efraín Ochoa[1], Mercedes Gabás[1], Shanti Bijani[1], Santiago Palanco[1], Angel R. Landa-Cánovas[2], Pilar Herrero[2], Fernando Agulló-Rueda[2], Pilar Díaz-Carrasco[1], José R. Ramos-Barrado[1]
[1]Dpto. de Física Aplicada I, Lab. de Materiales y Superficies, Univ. de Málaga, Málaga, Spain, [2]Instituto de Ciencia de Materiales de Madrid, (ICMM-CSIC), Madrid, Spain

R24
128 **Open-Atmosphere Structural Depth Profiling of Multilayer Samples of Photovoltaic Interest Using Laser-Induced Plasma Spectrometry**
Santiago Palanco[1], Mercedes Gabás[1], Shanti Bijani[1], Ignacio Rey-Stolle[2], Enrique Barrigón[2], Carlos Algora[2], José R. Ramos-Barrado[1]
[1]Departamento de Física Aplicada, Univeridad de Málaga, Málaga, Spain, [2]Instituto de Energía Solar-Universidad Politécnica de Madrid, Madrid, Spain

S2
129 **Identification of Metal Impurities in Crystalline Silicon Wafers**
Bijaya B. Paudyal[1], Francisco Machuca[3], David Cornwell[2], Phil Shaw[2]
[1]MKS Instruments, San Jose, CA, USA, [2]MKS Instruments UK Ltd. Spectra Products, Crewe, Cheshire, United Kingdom, [3]Pure Crystal Solutions, Mountain View, CA, USA

S4
130 **Detection of Defect Densities in Raw Silicon Wafers Using a Transmission Polarimeter**
Matthew P. Peloso
Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Singapore

S6
131 **Residual and Bending Stress Measurements by X-Ray Diffraction and Synchrotron Diffraction Analysis in Silicon Solar Cells**
V.A. Popovich[1], M. Janssen[1], I.J. Bennett[2], I.M. Richardson[1]
[1]Delft University of Technology, Department of Materials Science & Engineering, Delft, Netherlands, [2]Energy Research Centre of the Netherlands, Solar Energy, PV Module Technology, Petten, Netherlands

S8
132 **Electroluminescence System for Analysis of Defects in CdTe Cells and Modules**
John M. Raguse, J. Tyler McGoffin, James R. Sites
Colorado State University, Fort Collins, CO, USA

S10
133 **Real-Time Analysis of Ultrathin CIGS Thin-Film Deposition**
Vikash Ranjan[1], Krishna Aryal[1], Scott Little[2], Yunus Erkaya[1], Grace Rajan[1], Patrick Boland[1], Dinesh Attygalle[2], Puruswottam Aryal[2], Puja Pradhan[2], Robert W. Collins[2], Sylvain Marsillac[1]
[1]Old Dominion University, Norfolk, VA, USA, [2]The University of Toledo, Toledo, OH, USA

S12
134 **Developing Raman Scattering as Quality Control Technique: Correlation with Presence of Electronic Defects in CIGS-Based Devices**
Carmen M. Ruiz[1], Xavier Fontané[2], Andrew Fairbrother[2], Victor Izquierdo-Roca[2], Cedric Broussillou[1], Sylvie Bodnar[1], Alejandro Perez-Rodriguez[2,3], Veronica Bermudez[1]
[1]NEXCIS, Rousset, France, [2]IREC, Barcelona, Spain, [3]Universitat Barcelona, Barcelona, Spain

S14 135 **A New Generation of Compact Solar Simulators**
Harvey Serreze, Jason Burns, Martin Stein, Nanditha Chandrasekhar
Spire Solar, Inc., Bedford, MA, USA

S16 136 **Detection of Increased Series Losses in PV Arrays Using Fuzzy Inference Systems**
Sergiu V. Spataru, Dezso Sera, Tamas Kerekes, Remus Teodorescu
Aalborg University, Aalborg, Denmark

S18 137 **Transparent Conductive Oxide / Encapsulant Interface Characterization Following Damp Heat Exposure**
Katherine Stika[1], Segolene Pelisset[2], Silvia Schreiber[3], Frederic de Borman Chautems[3], Petros Dafniotis[3], Laure-Emmanuelle Perret-Aebi[2], Christophe Ballif[2]
[1]E.I.DuPont de Nemours & Co., Wilmington, DE, USA, [2]Ecole Polytechnique Federale de Lausanne, Institute of Microengineering, Neuchatel, Switzerland, [3]DuPont de Nemours International, Geneva, Switzerland

S20 138 **Integrated Electrical and Optical Characterization of Large-Area Thin-Film Photovoltaic Materials**
Geza Szitasi, Ferenc Korsos, Dario Quintavalle, Miklos Tallian, Aron Pap, Laurent Kitzinger, Andrew Findlay, Marshall Wilson
Semilab Semiconductor Physics Laboratory Co. Ltd., Budapest, Hungary

S22 139 **Stand Test Solution for Photovoltaic Thermal Hybrid Solar Collector Devices Under Real Operating Conditions**
Luca Tenconi[1], Cristina S. Polo Lopez[1,2], Fabio Lo Castro[1], Stefano Brambillasca[1]
[1]IRcCOS S.c.a r.l. - Research and certification Institute for Sustainable Construction, Legnano, Italy, [2]Institute of Applied Sustainability to the Built Environment (ISAAC) - Swiss BiPV Competence Centre, University of Applied Sciences and Arts of Southern Switzerland (SUPSI), Cannobio, Switzerland

S24 140 **Non-Contact Microcrack Detection from as-cut Wafer to Finished Solar Cell**
Matthias Trautmann[1], Marc Hemsendorf[2], Christopher Berge[1], Christian Probst[2], Eric Rueland[1]
[1]GP Solar GmbH, Konstanz, Germany, [2]GP Inspect GmbH, Neuried, Germany

T2 141 **Automated Process Metrology in Solar Cell Manufacturing**
Vamsi M. Velidandla[1], Ben Garland[1], Fred Cheung[2]
[1]Zeta Instruments, San Jose, CA, USA, [2]TetraSun, Milpitas, CA, USA

T4 142 **A Fast and Accurate Method for the Performance Testing of High-Efficiency c-Si PV Modules Using a 10-ms Single-Pulse Solar Simulator**
Alessandro Virtuani[1], Pierre Beljean[2], Giorgio Rigamonti[1], Gabi Friesen[1], Domenico Chianese[1]
[1]Supsi, Canobbio, Switzerland, [2]Pasan, Neuchatel, Switzerland

T5 143 **Series Resistance Modeling of Complex Metallization Geometries of Solar Cells Using Conductive Line Decomposition**
Johnson Wong[1], Ranjani Sridharan[1], Xueling Zhang[2], Yang Yang[2], Zhiqiang Feng[2], Qiang Huang[2], Armin G. Aberle[1], Thomas Mueller[1]
[1]Solar Energy Research Institute of Singapore, Singapore, Singapore, [2]Trina Solar Limited, Changzhou, China

T6 144 **Equivalent Cell Temperature Calculation for PV Modules with Variable Ideality Factors**
Georgi Hristov Yordanov[1,2], Ole-Morten Midtgård[1,2], Tor Oskar Saetre[1]
[1]University of Agder (UiA), Grimstad, Norway, [2]Norwegian University of Science and Technology (NTNU), Trondheim, Norway

T7 145 **Specific Contact Resistance Measurements on c-Si Solar Cells by TLM Method**
Fei Zeng, Zongcun Liang, Yuan Feng, Hui Shen
Institute for Solar Energy System, School of Physics and Engineering, State Key Laboratory of Optoelectronic Materials and Technologies, Sun Yat-Sen University, Guangzhou, China

1:30 - 3:00 PM **EH4-F**

Area 9: Modules and Systems: Grid-Tied Systems (Posters)

Chair(s): Robert Johnson, Angele Reinders, Greg Ball

T8 146 **Floating Tracking Cooling Concentrating (FTCC) Systems**
Raniero Cazzaniga[1], Marco Rosa-Clot[2], Paolo Rosa-Clot[2], Giuseppe M. Tina[3]
[1]Koiné Multimedia, Pisa, Italy, [2]Scienza Industria Tecnologia srl, Pisa, Italy, [3]DIEEI - University of Catania, Catania, Italy

T12 147 **Low-X Single-Axis Solar Louver Tracking System for Residential Rooftop Applications**
Edoardo Sarda[1], Brad Starks[1], Nikolai Dowd[1], Justin Lacroix[1], Paul Weber[1], Tim Hebrink[2]
[1]Lake Superior State University, School of Engineering and Technology, Sault Ste Marie, MI, USA, [2]3M Company, Corporate Research Laboratory, St. Paul, MN, USA

T16 148 **Evaluation of Four Geomembrane Mounted PV Systems for Land Reclamation in Southern Arizona**
Adria E. Brooks[1,2], Nathan Allen[3], Vincent P. Lonij[1], Alexander D. Cronin[1]
[1]University of Arizona, Department of Physics, Tucson, AZ, USA, [2]Arizona Research Institute for Solar Energy, Tucson, AZ, USA, [3]University of Arizona, Biosphere 2, Tucson, AZ, USA

T20 149 **Development of a PV System as a Way to Promote the Technology**
Izete Zanesco, Adriano Moehlecke, Sergio Boscato Garcia, Filipe Sehn Febras, Airton Cabral de Andrade
PUCRS-Catholic University, Porto Alegre, Brazil

T24 150 **Optimization of Photovoltaic-Wind Hybrid System for Apartment Complexes and other Community Living Environments by Minimizing Excess Capacity**
Mohammad B. Shadmand, Robert S. Balog
Texas A&M University, College Station, TX, USA

U4 151 **Building-Applied PV Arrays: A Side-by-Side Comparison of Two Arrays with and Without Fan Cooling**
Saurabh Chatterjee, Govindasamy TamizhMani
Arizona State University, Mesa, AZ, USA

U8 152 **Performance Evaluation of a 3.8 kW BIPV System in South Africa**
Sosten Ziuku, Edson L. Meyer
Fort Hare Institute of Technology, University of Fort Hare, Alice, South Africa

U12 153 **Five-Year Verification Test Results in Hokuto Mega-Solar System**
Hiroo Konishi[1], Mitsuru Kudou[1], Hiroaki Miyata[2], Uzuru Ueda[3]
[1]NTT Facilities, Inc., Tokyo, Japan, [2]Hitachi, Ltd., Hitachi, Japan, [3]Tokyo Institute of Technology, Tokyo, Japan

U16 154 **Analysis of 100 Rooftop PV Systems in the Tucson, Arizona Area**
Vincent P. Lonij[1], Adria E. Brooks[1], Kevin Koch[2], Alexander D. Cronin[1]
[1]University of Arizona, Tucson, AZ, USA, [2]Technicians for Sustainability, Tucson, AZ, USA

U20 155 **Development of Electrical Performance Testing Standards for the Acceptance of Solar Photovoltaic Projects Based on Field Experience and Observation**
Cari D. Williamette, Lucius N. Jonett, Eric Hansen
Westwood Professional Services, Eden Prairie, MN, USA

U24 156 **Comparison of Two Grid-Connected Photovoltaic Systems (GCPVS) with Different Dimensioning Factor FD During Three Years Operation in Bogotá, Colombia**
Johann A. Hernández[1], Carlos A. Arredondo[2], William A. Vallejo[3], Gerardo Gordillo[4]
[1]Facultad de Ingeniería, Universidad Distrital Francisco José de Caldas, Bogota, Columbia, [2]Facultad de Ingeniería Electrónica y Biomédica, Universidad Antonio Nariño, Bogota, Columbia, [3]Facultad de Ingeniería, Universidad América, Bogota, Columbia, [4]Departamento de Física, Universidad Nacional de Colombia, Bogota, Columbia

V4 157 **Design and Installation of a Smart Grid with Distributed Generation: A Pilot Case in the Colombian Networks**
Johann A. Hernández[1], Ana M. Blanco[2], Luis E. Luna[2]
[1]Facultad de Ingeniería, Universidad Distrital Francisco José de Caldas, Bogota, Columbia, [2]Facultad de Ingeniería Eléctrica, Universidad Nacional, Bogota, Columbia

V8 158 **Energy Storage Sizing for Large-Scale PV Power Plants' Base-Load Operation: Comparative Study & Results**
Dimitrios Doukas, Konstantinos Papastergiou, Panagiotis Bakas, Antonis Marinopoulos, Bengt Stridh
ABB Corporate Research, Västerås, Sweden

V12 159 **PV with Battery in Smart Grid Paradigm: Price-Based Energy Management System**
Chee Lim Nge[1,2], Ole-Morten Midtgard[2], Lars Norum[1]
[1]Norwegian University of Science and Technology, Trondheim, Norway, [2]University of Agder, Grimstad, Norway

V16 160 **Controller Area Network (CAN)-Based Smart Protection Scheme for Solar PV, Fuel Cell, Ultra-Capacitor and Wind Energy System Based Microgrid**
Sushil Thale, Vivek Agarwal
Department of Electrical Engineering, Indian Institute of Technology, Bombay, Mumbai, India

V20 161 **PV Ramping in a Distributed Generation Environment: A Study Using Solar Measurements**
Manajit Sengupta, Jamie Keller
National Renewable Energy Laboratory, Golden, CO, USA

V24 162 **Peak Load Offset and the Effect of Dust Storms on 10MW Distributed Grid-Tied Photovoltaic Systems Installed at Arizona State University**
Vivek Sharma, Jaewon Oh, Stuart Bowden
Solar Power Lab, Arizona State University, Tempe, AZ, USA

W4 163 **Detailed Grid Integration Modeling and Analysis of Variably Deployed Distributed PV**
Jimmy E. Quiroz
Sandia National Laboratories, Albuquerque, NM, USA

W8 164 **Synchrophasors for Island Detection**
Michael E. Ropp[1], Scott J. Perlenfein[1], Michael Mills-Price[2], Mesa Scharf[2], Krishnanjan Gubba Ravikumar[3], Greg Zweigle[3]
[1]Northern Plains Power Technologies, Brookings, SD, USA, [2]Advanced Energy, Bend, OR, USA, [3]Schweitzer Engineering Laboratories, Pullman, WA, USA

W12 165 **Advancing the Deployment of Utility-Scale Photovoltaic Plants in the Northeast**
Robert Lofaro, Michael Villaran, Alessandra Colli
Brookhaven National Laboratory, Upton, NY, USA

W16 166 **Electrical Arc-Flash Energy Calculations for Photovoltaic Systems**
Jumie N. Yuventi
Stanford University, Stanford, CA, USA

W20 167 **Aerial Solar Thermography and Condition Monitoring of Photovoltaic Systems**
Harley E. Denio, III, Harley E. Denio
Oregon Infrared, Aloha, OR, USA

1:30 - 3:00 PM **19B**

Area 10: PV Velocity Forum: Equipment-Related PV ESH (Orals)

Chair(s): Vasilis Fthenakis, Jeanne Yturri

1:30 168 **Photovoltaic Specialty Materials Safety**
Eugene Ngai
Chemically Speaking LLC, Whitehouse Station, NJ, USA

2:00 169 **Industrial Hygiene (IH) Exposure Monitoring Results for Major Preventative Maintenance Chamber Clean Tasks**
Molly E. McKenna[1], Ken C. Jeffcoat[2]
[1]Zephyr Environmental Corp., Austin, TX, USA, [2]Heliovolt, Austin, TX, USA

2:15 170 **Economic PV Waste Recycling Solutions - Results from R&D and Practice**
Wolfram J. Palitzsch, Ulrich M. Loser
Loser Chemie GmbH, Langenweißbach, Germany

2:30 171 **Managing PV-Related EHS at the National Renewable Energy Laboratory**
Troy D. McCuskey, Brent P. Nelson
NREL, Golden, CO, USA

2:45 172 **Design for Safety: Equipment Engineering as a Risk Management Tool**
John B. Visty
Salus Engineering International, Santa Clara, CA, USA

3:00 - 3:30 PM **4th Floor Foyer**

Coffee Break

3:30 - 5:00 PM **18AB**

Area 1: Fundamentals and New Concepts: Intermediate-Band Solar Cells (Orals)

Chair(s): Seth Hubbard, Yoshitaka Okada, Ryne Raffaelle

3:30 173 **Issues in the Physical Measurement of the Intermediate Band Effect**
Nicholas J. Ekins-Saukes[1], Stephen P. Bremner[2], Christiana B. Honsberg[3], Stephen Goodnick[3]
[1]Imperial College, London, United Kingdom, [2]University of New South Wales, Sydney, Australia, [3]Arizona State University, Tempe, AZ, USA

4:00 174 **Low-Temperature Analysis of Quantum Dot Solar Cells**
Stephen J. Polly[1], Zachary S. Bittner[1], Christopher G. Bailey[2], David V. Forbes[1], Yushuai Dai[1], Seth M. Hubbard[1]
[1]NanoPower Research Laboratories, RIT, Rochester, NY, USA, [2]U.S. Naval Research Laboratory, Washington, DC, USA

4:15 175 **InAs/AlGaAs Quantum Dot Intermediate Band Solar Cells with Enlarged Sub-Bandgaps**
Iñigo Ramiro[1], Elisa Antolín[1,3], Pablo G. Linares[1], Estela Hernández[1], Irene Artacho[1], Esther López[1], Antonio Martí[1], Antonio Luque[1], Matthew J. Steer[2], Colin R. Stanley[2], José M. Ripalda[3], Fernando Briones[3], Teresa Ben[4], Sergio I. Molina[4]
[1]Instituto de Energía Solar, ETSI Telecomunicación, Universidad Politécnica de Madrid, Madrid, Spain, [2]School of Engineering, University of Glasgow, Glasgow, United Kingdom, [3]Instituto de Microelectrónica de Madrid, CNM (CSIC), Madrid, Spain, [4]Dpto. de Ciencia de los Materiales e Ingeniería Metalúrgica y Química Inorgánica, Facultad de Ciencias, Universidad de Cádiz, Cádiz, Spain

4:30 176 **InGaAs/GaAsSb Type-II Quantum Dots for Intermediate-Band Solar Cell**
Yasushi Shoji[1,2], Katsuhiro Akimoto[2], Yoshitaka Okada[1]
[1]Research Center for Advanced Science and Technology, The University of Tokyo, Meguro-ku, Japan, [2]Institute of Applied Physics, University of Tsukuba, Tsukuba, Japan

4:45 177 **Towards Intermediate-Band Formation in Solar Cells with AlGaInAs Quantum Dots**
Stefan Kremling[1], Christian Schneider[1], Tristan Braun[1], Nadezda V. Tarakina[2], Maxwell Adams[1], Matthias Lermer[1], Stephan Reitzenstein[1,3], Lukas Worschech[1], Sven Höfling[1], Alfred Forchel[1], Martin Kamp[1]
[1]Technische Physik, Universität Würzburg, Germany, [2]Experimentelle Physik III, Universität Würzburg, Germany, [3]Institute of Solid State Physics, Technische Universität Berlin, Germany

3:30 - 5:00 PM **18CD**

Area 2: Polycrystalline Thin Films: Wide Bandgap Devices (Orals)

Chair(s): William Shafarman, Rebekah Feist

3:30
178 **Control of Ga Profiles in (AgCu)(InGa)Se_2 Absorber Layers Deposited on Polyimide Substrates**
Gregory M. Hanket, Christopher P. Thompson, Erter Eser, William N. Shafarman
Institute of Energy Conversion, University of Delaware, Newark, DE, USA

4:00
179 **Cu Off-Stoichiometry of $CuInS_2$ Thin-Film Solar Cell Absorbers: Effect on the Electronic Surface Structure**
M. Bär[1,2,3], J. Klaer[1], L. Weinhardt[2,4], N. Barreau[5], C. Heske[2,4,6], H.-W. Schock[1]
[1]Solar Energy Research, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany, [2]Department of Chemistry, University of Nevada, Las Vegas, Las Vegas, NV, USA, [3]Institut für Physik und Chemie, Brandenburgische Technische Universität Cottbus, Cottbus, Germany, [4]Institute for Synchrotron Radiation, Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany, [5]Institut des Matériaux Jean Rouxel, Université de Nantes, CNRS, Nantes, France, [6]Institute for Chemical Technology and Polymer Chemistry, Karlsruhe Institute of Technology, Karlsruhe, Germany

4:15
180 **Understanding the Role of Grain Boundaries in Sulfide Thin-Film Solar Cells with Scanning Probe Microscopy**
Joel B. Li[1], Vardaan Chawla[2], Bruce M. Clemens[3]
[1]Department of Electrical Engineering, Stanford University, Stanford, CA, USA, [2]AQT Solar, Sunnyvale, CA, USA, [3]Department of Materials Science & Engineering, Stanford University, Stanford, CA, USA

4:30
181 **High-Efficiency $Cu_2ZnSnSe_4$ Solar Cells with a TiN Diffusion Barrier on the Molybdenum Bottom Contact**
Byungha Shin, Yu Zhu, Nestor A. Bojarczuk, Jay S. Chey, Supratik Guha
IBM T. J. Watson Research Center, Yorktown Heights, NY, USA

4:45
182 **Best Student Presentation Award Finalist**
Growth Kinetics During Kesterite Co-Evaporation
Wan-Ching Hsu[1], Ingrid Repins[2], Carolyn Beall[2], Glenn Teeter[2], Clay DeHart[2], Bobby To[2], Yang Yang[1], Rommel Noufi[2]
[1]Department of Materials Science and Engineering, University of California, Los Angeles, Los Angeles, CA, USA, [2]Renewable Energy Laboratory, Golden, CO, USA

3:30 - 5:00 PM **Blrm G**

Area 4: Crystalline Silicon: New Device Concepts (Orals)

Chair(s): Giso Hahn, Rubin Sidhu

3:00 183 **Large-Area Back-Contact Back-Junction Solar Cell with Efficiency Exceeding 20%**
Giuseppe Galbiati[1], Valentin D. Mihailetchi[1], Andreas Halm[1], Lejo J. Koduvelikulathu[1], Razvan Roescu[1], Radovan Kopecek[1], Kristian Peter[1], Joris Libal[2]
[1]International Solar Energy Research Center (ISC), Konstanz, Germany, [2]Silfab S.p.A., Padova, Italy

3:15 184 **Latest R&D Results of Quantum Technology Leading to Module Efficiencies of 18.5% and Moreover Consideration of Symmetrical Passivation Schemes**
Stefan Bordihn, Peter Engelhart, Christian Klenke, Karl Suva, Thomas Kaden, Sydney Dähne, Carsten Baer, Florian Stenzel, Gregor Zimmermann, Johannes Wendt, Ansgar Mette, Matthias Strobel, Sven Schmidt, Markus Fischer, Jörg W. Müller, Peter Wawer
Q-Cells SE, Saxony Anhalt, Germany

3:30 185 **Bifacial n-Type Cells with >20% Front-Side Efficiency for Low-Cost Production**
Tim S. Böscke, Daniel Kania, Anke Helbig, Thomas Roth, Claus Schöllhorn, Martin Dupke, Patrick Sadler, Matthias Braun, Daniel Stichtenoth, Tobias Wütherich, Reik Jesswein, Dennis Fiedler, Robert Carl, Jan Lossen, H.-J. Krokoszinski
Bosch Solar Energy, Arnstadt, Germany

3:45 186 **A Transformational Approach to Front-Face Metallization**
David H. Hook[1], Seyman Aygun[1], Jon-Paul Maria[1], Brian J. Laughlin[2], William J. Borland[2]
[1]North Carolina State University, Raleigh, NC, USA, [2]DuPont Microcircuit Materials, Research Triangle Park, NC, USA

4:00 187 **Antireflection and SiO_2 Surface Passivation by Liquid-Phase Chemistry for Efficient Black Silicon Solar Cells**
Hao-Chih Yuan[1], Jihun Oh[1], Yuanchang Zhang[2], Oleg A. Kuznetsov[2], Dennis J. Flood[2], Howard M. Branz[1]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Natcore Technology, Red Bank, NJ, USA

4:15 188 **19.8% Efficiency on Large Area n-Type Czochralski Silicon Solar Cells with Aluminum Rear Emitter**
Xi Xi, Wenjuan Wu, Liping Chen, Jin Xu, Feng Gao, Zhengxin Wang, Haidong Zhu, Yongfei Jiang, Cheng Huang, Jingjia Ji, Zhengrong Shi
Suntech Power Co., Ltd., Wuxi, China

3:30 - 5:00 PM **19A**

Area 5: Thin-Film Silicon: Light Trapping in Solar Cells 1 (Orals)

Chair(s): Olindo Isabella, Matthieu Despeisse

3:30 189 **Advances in Light Trapping for Hydrogenated Nanocrystalline Silicon Solar Cells**
Laura M. Sivec, Baojie Yan, Guozhen Yue, Jessica M. Owens-Mawson, Jeffrey Yang, Subhendu Guha
United Solar Ovonic LLC, Troy, MI, USA

4:00 190 **Gen5 Production Tool for Light Management Textures**
A.J.M. van Erven, M. Steltenpool, M. Bos, J. Rutten, G. van der Hofstad, J. Muller, H. de Groot, J. de Ruijter, B. Titulaer, G. Rajeswaran
OM&T B.V. / Moser Baer Technologies, Eindhoven, Netherlands

4:30 191 **Stencil-Nanopatterned Back Reflectors for Thin-Film Amorphous Silicon n-i-p Solar Cells**
Celine Pahud[1], Veronica Savu[2], Mona Klein[3], Oscar Vazquez-Mena[4], Karin Söderström[1], Franz-Joseph Haug[1], Jürgen Brugger[2], Christophe Ballif[1]
[1]EPFL, IMT, Photovoltaics and Thin Film Electronics Laboratory, Neuchatel, Switzerland, [2]EPFL, IMT, Microsystem Laboratory, Lausanne, Switzerland, [3]IBM Research, Zurich, Switzerland, [4]Berkeley University, San Francisco, CA, USA

4:45 192 **Investigation of Textured Back Reflectors with Periodic Honeycomb Patterns in Thin-Film Silicon Solar Cells for Improved Photovoltaic Performance**
Hitoshi Sai[1], Kimihiko Saito[2], Michio Kondo[1]
[1]National Institute of Advanced Industrial Science and Techonology (AIST), Tsukuba, Japan, [2]Photovoltaic Power Generation Technology Research Association (PVTEC), Tsukuba, Japan

3:30 - 5:00 PM **17A**

Area 8: PV Characterization: PV Modules: Testing and Standards (Orals)

Chair(s): Michael Kempe, Gerald Siefer

3:30 193 **Evaluating the IEC 61215 Ed.3 NMOT Procedure Against the Existing NOCT Procedure with PV Modules in a Side-by-Side Configuration**
Matthew T. Muller, Bill Marion, Jose Rodriguez
NREL, Golden, CO, USA

3:45 194 **Systematic Approaches to Ensure Correct Representation of Measured Multi-Irradiance Module Performance in PV System Energy Forecasting Models**
Kenneth J. Sauer[1], Thomas Roessler[2]
[1]Yingli Green Energy Americas, Inc., San Francisco, CA, USA, [2]Yingli Green Energy Europe GmBh, Munich, Germany

4:00 195 **Non-Destructive Determination of the Degree of Cross-Linking of EVA Solar Module Encapsulation Using DMA Shear Measurements**
Rafal A. Mickiewicz, Edward Cahill, Po-I Wu
Fraunhofer Center for Sustainable Energy Systems (CSE), Cambridge, MA, USA

4:15 196 **Analytical Techniques Used to Determine Chemical Degradation of Polymeric Materials Used in PV Modules After Sustained Exposure to Partial Discharge Voltages**
Nancy H. Phillips[1], Bradley L. Givot[1], William D. O'Brien[1], Jaylon J. Loyd[2], Gary A. Korba[1]
[1]3M Company, Saint Paul, MN, USA, [2]3M Company, Austin, TX, USA

4:30 197 **Differentiating Series and Parallel Photovoltaic Arc-Faults**
Jay Johnson[1], Scott McCalmont [2], Gil Katzir [2], Sigifredo Gonzalez[1], Jennifer Granata[1], Armando Fresquez[1], Michael Montoya [1]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]Tigo Energy, Los Gatos, CA, USA

4:45 198 **Qualification of Arcing Risks in PV Modules**
Florian Reil[1], Annett Sepanski[1], Mirco Vosen[1], Willi Vaassen[1], Werner Herrmann[1], Heribert Schmidt[2]
[1]TÜV Rheinland Energie und Umwelt GmbH, Cologne, Germany, [2]Fraunhofer Institute ISE, Freiburg, Germany

3:30 - 5:00 PM **16AB**

Area 9: Modules and Systems: Utility Scale and High Penetration (Orals)

Chair(s): Michael Coddington, Chris Barker

3:30 199 **Current Results of the US DOE High Penetration Solar Deployment Project**
Holly Thomas[1], Kevin Lynn[2], Alvin Razon[2]
[1]US DOE, Golden, CO, USA, [2]US DOE, Washington, DC, USA

3:45 200 **Economic Value of Photovoltaic Generation at High Penetration Levels**
Andrew D. Mills, Ryan H. Wiser
Lawrence Berkeley National Laboratory, Berkeley, CA, USA

4:00 201 **Initial Operating Experience of the 1.2-MW La Ola Photovoltaic System**
Jay Johnson [1], Benjamin Schenkman[1], Abraham Ellis[1], Jimmy Quiroz[1], Carl Lenox [2]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]SunPower Corporation, Richmond, CA, USA

4:15 202 **Integrating High Penetrations of PV into Southern California: Year 2 Project Update**
Barry Mather[1], Russell Neal[2]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Southern California Edison, Westminster, CA, USA

4:30 203 **Evaluation of Alternatives to the Federal Energy Regulatory Commission (FERC) Small Generator Interconnection Procedures (SGIP) Screens for PV Interconnection Studies**
Robert J. Broderick, Abraham Ellis
Sandia National Laboratories, Albuquerque, NM, USA

4:45 204 **Guidelines Document for Helping Utility Protection Engineers Determine When Additional Anti-Islanding Studies Are Prudent**
Michael E. Ropp[1], Abraham Ellis[2]
[1]Northern Plains Power Technologies, Brookings, SD, USA, [2]Sandia National Laboratories, Albuquerque, NM, USA

3:30 - 5:00 PM **19B**

Area 10: PV Velocity Forum: Sustainability and PV EHS (Orals)

Chair(s): Amy Galland, Troy McCuskey

3:30 205 **Greenhouse Gases Emissions and Energy Payback of Large Photovoltaic Power Plants in the Northeast United States**
Annick Anctil, Vasilis Fthenakis
Brookhaven National Laboratory, Upton, NY, USA

3:45 206 **Electrothermal Heating Process Applied to c-Si PV Recycling**
Angelo Doni, Fabrizio Dughiero
Department of Industrial Engineering - University of Padua, Padua, Italy

4:00 207 **Exploring Large-Scale Solar Deployment in DOE's SunShot Vision Study**
Easan Drury[1], Greg Brinkman[1], Paul Denholm[1], Robert Margolis[2]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]National Renewable Energy Laboratory, Washington DC, DC, USA

4:15 208 **Direct Te Mining: Resource Availability and Impact on CdTe PV Life Cycles**
Vasilis Fthenakis[1,2], Annick Anctil[2]
[1]Columbia University, New York, NY, USA, [2]Brookhaven National Laboratory, Upton, NY, USA

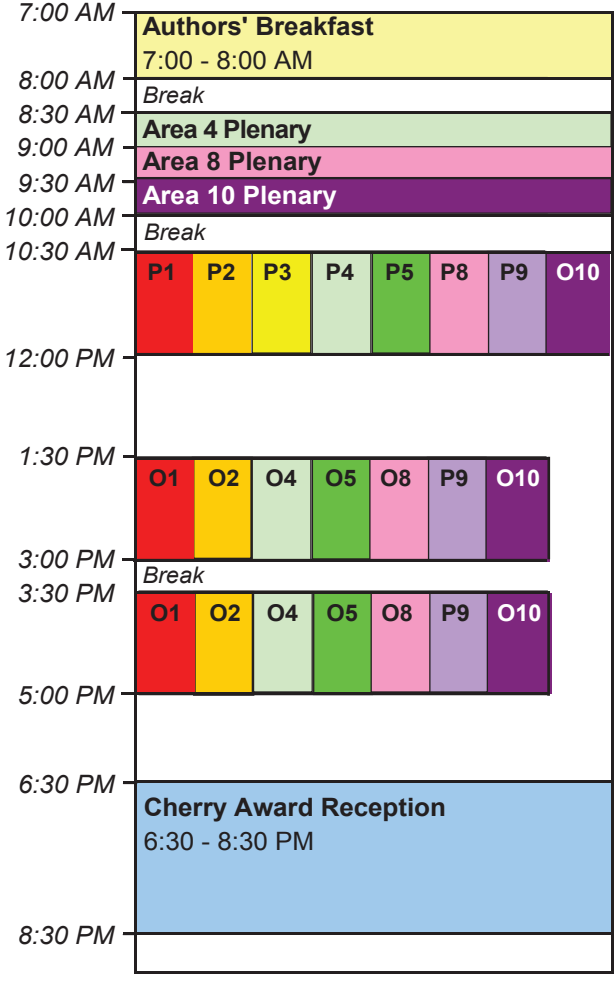
4:30 209 **Life Cycle Water Usage in CdTe Photovoltaics**
Parikhit Sinha[1], Amy Meader[2], Mariska de Wild-Scholten[3]
[1]First Solar, Tempe, AZ, USA, [2]First Solar, Perrysburg, OH, USA, [3]SmartGreenScans, Groet, Netherlands

4:45 210 **Current and Conceivable Supply-Chain Dynamics of Tellurium and Indium Within the Context of PV Module Manufacturing Costs**
Michael A. Woodhouse[1], Alan Goodrich[1], Martin Lokanc[2], Roderick Eggert[2]
[1]Strategic Energy Analysis Center, The National Renewable Energy Lab, Golden, CO, USA, [2]Department of Mineral and Energy Economics, Golden, CO, USA

5:30 - 8:00 PM **EH4-A**

Welcome Reception

TUESDAY PROGRAM SUMMARY



AREA LEGEND

- Area 1: Fundamentals and New Concepts for Future Technologies
- Area 2: Thin Film Polycrystalline Photovoltaics
- Area 3: III-V and Concentrator Technologies
- Area 4: Crystalline Silicon Photovoltaics
- Area 5: Thin Film Silicon Based PV Technologies
- Area 6: Organic Photovoltaics
- Area 7: Space Technologies
- Area 8: Characterization Methods
- Area 9: PV Modules and Terrestrial Systems
- Area 10: PV Velocity Forum

O = Oral Session P = Poster Session

8:00 - 8:30 AM **4th Floor Foyer**

Coffee Break

8:30 - 9:00 AM **Blrm D**

Area 4: Crystalline Silicon: Plenary

8:30 211 **The Future of Crystalline Silicon Photovoltaic Technology**
Eicke Weber
Fraunhofer ISE, Freiburg, Germany

9:00 - 9:30 AM **Blrm D**

Area 8: PV Characterization: Plenary

Chair(s): Gerald Siefer

9:00 212 **Calibration and Rating of Photovoltaics**
Keith A. Emery
NREL, Golden, CO, USA

9:30 - 10:00 AM **Blrm D**

Area 10: PV Velocity Forum: Plenary

Chair(s): Elaine Ulrich

213 **Area 10: Plenary The DOW POWERHOUSE™ Solar Shingle Launch – Investment & Technology Decisions**
Dave Parrillo
The Dow Chemical Company

10:00 - 10:30 AM **Exhibit Hall 4**

Coffee Break

10:30 - 12:00 PM **EH4-A**

Area 1: Fundamentals and New Concepts: Session 2 (Posters)

Chair(s): Annick Anctil, Chris Bailey, Seth Hubbard

A2
214 **Effect of Base Width Variation on the Performance of a Proposed Ultraviolet Low-Cost High-Efficiency Solar Cell Structure**
Marwa Salem Basyoni
Ain Shams University, Cairo, Egypt

A6
215 **Broadband Quantum Dots-in-a-Well Solar Cells**
C. H. Chang[1], T. E. Tzeng[1], T. S. Lay[1], H. Cho[2], David J.Y. Feng[2]
[1]National Sun Yat-Sen University, Kaohsiung, Taiwan, [2]National University of Kaohsiung, Kaohsiung, Taiwan

A10
216 **Photovoltaic Response for High Density InGaAs Coupled Quantum Dots**
Kuei-Ya Chuang[1], K. D. Tzeng[1], T. E. Tzeng[1], T. S. Lay[1], Chien-chung Lin[2], H. Cho[3], David J. Y. Feng[3]
[1]Department of Photonics, National Sun Yat-Sen University, Kaohsiung, Taiwan, [2]Institute of Photonic Systems, College of Photonics, National Chiao-Tung University, Tainan, Taiwan, [3]Department of Electrical Engineering, National University of Kaohsiung, Kaohsiung, Taiwan

A14
217 **Fabrication of Silicon Nanostructures via Self-Assembled Silver Nanoparticles Catalyzed Chemical Etching for Solar Cells**
Bingfei Dou, Rui Jia, Haofeng Li, Chen Chen, Xinyu Liu, Tianchun Ye
Institute of Microelectronics, Chinese Academy of Sciences, Beijing, China

A18
218 **Design and Simulation of a Multi-Quantum-Well AlGaAs/GaAs Single-Junction Solar Cell with Back Surface Reflector**
Hamid Fardi[1], Mohammed Jan[1], Bart Van Zeghbroeck[2]
[1]University of Colorado Denver, Denver, CO, USA, [2]University of Colorado at Boulder, Boulder, CO, USA

A22
219 **Enhanced V_{oc} in InAs Quantum-Dot-Based *p-i-n* Solar Cells Using a Non-Alternating Strain-Balancing Epitaxial Growth Method**
Jateen S. Gandhi, Choong-un Kim, Wiley P. Kirk
University of Texas at Arlington, Arlington, TX, USA

A26 220 **In-Plane Miniband Formation of Si Nanodisk and Its Application in Intermediate-Band Photovoltaics**
W. Hu[1,2], M. F. Budiman[1,2], M. Igarashi[1,2], M.-Y. Lee[3], Y. Li[3], S. Samukawa[1,2]
[1]Institute of Fluid Science, Tohoku University, Sendai, Japan, [2]Japan Science and Technology Agency, CREST, Tokyo, Japan, [3]Department of Electrical Engineering, National Chiao Tung University, Taiwan, China

B2 221 **Effect of Variation in Energy Bandgap and Intrinsic Layer Thickness on Silicon Quantum Dot Solar Cell Performance**
Paresh Kale, Chetan Solanki
Indian Institute of Technology Bombay, Mumbai, India

B6 222 **Effect of Variation in Energy Bandgap and Intrinsic Layer Thickness on Silicon Quantum Dot Solar Cell Performance**
Paresh Kale, Chetan Solanki
Indian Institute of Technology Bombay, Mumbai, India

B10 223 **SnS Quantum Dot Solar Cells with Cu_2S as Counter Electrode**
Deepa K.G., Anantha Sunil M., Nagaraju J.
Department of Instrumenation and Applied Physics, Bangalore, India

B14 224 **Application of Ge Quantum Wells Fabricated by Laser Annealing as Energy Selective Contacts for Hot-Carrier Solar Cells**
Sammy Lee, Shujuan Huang, Gavin J. Conibeer, Martin A. Green
ARC Photovoltaics Centre of Excellence, Sydney, Australia

B18 225 **Optical Bandgap Tuning of ICPCVD-Made Silicon Nanocrystals for Next Generation Photovoltaics**
Narasimha Rao Mavilla[1,2], Dharmendra Kumar R. Rai[1,3], Chetan S. Solanki[1,3], Vasi Juzer[1,2]
[1]National Centre for Photovoltaic Research and Education, IIT Bombay, Mumbai, India, [2]Department of Electrical Engineering, IIT Bombay, Mumbai, India, [3]Department of Energy Science and Engineering, IIT Bombay, Mumbai, India

B22 226 **Improvement in Short Circuit Current of *p-i-n* Solar Cell with Silicon Quantum Dot Superlattice Structure by Optimizing SiN_x Thickness**
Dharmendra kumar R. Rai[1], Narasimha Rao Mavilla[2], Ashish K. Panchal[3], Chetan S. Solanki[1]
[1]NCPRE, Department of Energy Science and Engineering, IIT Bombay, Mumbai, India, [2]NCPRE, Department of Electrical Engineering, IIT Bombay, Mumbai, India, [3]Department of Electrical Engineering, S. V. NIT, Surat, India

B26 227 **Transport Mechanism of Novel Silicon-Riched Nitride (SRN)/Silicon-Riched Oxide (SRO) Superlattice Quantum Dot**
Yeliao Tao, Yuhua Zuo, Jun Zheng, Qian Cao, Tianwei Zhou, Chunlai Xue, Buwen Cheng, Xiangbo Zeng, Qiming Wang
State Key Laboratory on Integrated Optoelectronics, Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China

C2 228 **One-Step Catalyst-Assist Formation of Silicon Nanohole Arrays with Omnidirectional Antireflection Properties**
Subramani Thiyagu, B.Parvathy Devi, Zingway Pei
National Chung Hsing University, Taichung, Taiwan

C6 229 **Transition Rate in the InGaN Quantum Dot Intermediate-Band Solar Cell**
Kuang-Chung Wang, Yuh-Renn Wu Wu
Natiional Taiwan University, Taipei, Taiwan

C10 230 **Photoelectrochemical Characterization of Si Microwire Array Solar Cells**
Emily L. Warren[1], Daniel B. Turner-Evans[2], Ron L. Grimm[1], Harry A. Atwater[2], Nathan S. Lewis[1]
[1]Division of Chemistry and Chemical Engineering, California Institute of Technology, Pasadena, CA, USA, [2]Department of Applied Physics and Materials Science, California Institute of Technology, Pasadena, CA, USA

C14 231 **(In)GaAsN Materials and Solar Cells for Super-High-Effiency Multijunction Solar Cells**
Masafumi Yamaguchi[1], Boussairi Bouzazi[1], Hidetoshi Suzuki[2], Nobuaki Kojima[1], Yoshio Ohshita[1]
[1]Toyota Technological Institute, Nagoya, Japan, [2]Miyazaki University, Miyazaki, Japan

C18 232 **Photovoltaic Performances Enhanced by Novel Indium Nanoparticles Using Surface Plasmonic in GaAs-Based 3-Junction Solar Cells**
Cheng-Ming Yu[1], Wen-Jeng Ho[1], Yi-Yu Lee[1], Jheng-Jie Liu[1], Chin-Cing Liao[1], Wei-Ting Wang[1], Shu-Chia Shiu[2], Ching-Fuh Lin[2], Hung-Pin Shiau[3]
[1]Department of Electro-Optical Engineering, National Taipei University of Technology, Taipei, Taiwan, [2]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan, [3]Win Semiconductor Corp., Taoyuan, Taiwan

10:30 - 12:00 PM **EH4-B**

Area 2: Polycrystalline Thin Films: Device Properties, Modeling, Stability, and Defect Characterization (Posters)

Chair(s): Susanne Siebentritt, Jim Sites

E7 233 **Nanopatterning and Bandgap Grading to Reduce Defects in CdTe Solar Cells**
Jose L. Cruz-Campa[1], David Zubia[2], Xiaowang Zhou[3], Donald Ward[3], Carlos A. Sanchez[1], Jose J. Chavez[2], Brandon A. Aguirre[2], Farhana Anwar[2], Damian Marrufo[2], Ping Lu[1], Michael J. Rye[1], John C. McClure[2], Gregory N. Nielson[1]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]University of Texas at El Paso, El Paso, TX, USA, [3]Sandia National Laboratories, Livermore, CA, USA

E11 234 **Cu Effects on CdS/CdTe Thin-Film Solar Cells Prepared on Flexible Substrates**
Xianjin Feng, Kartikay Singh, Sushma Bhavanam, Vasilios Palekis, Don L. Morel, Chris Ferekides
University of South Florida, Tampa, FL, USA

E15 235 **Impact of Interface Recombination on Time-Resolved Photoluminescence Decays (TRPL) in CdTe Solar Cells (Numerical Simulation Analysis)**
Ana Kanevce, Darius Kuciauskas, Timothy A. Gessert, Dean H. Levi
National Renewable Energy Laboratory, Golden, CO, USA

E19 236 **Sputtered Oxygenated CdS Window Layers for Higher Current in CdS/CdTe Thin-Film Solar Cells**
Jason M. Kephart, Russell Geisthardt, W.S. Sampath
Colorado State University, Fort Collins, CO, USA

E23 237 **Plasma Cleaning of TCO Surfaces Prior to CdS/CdTe Deposition**
Drew E. Swanson, Ryan M. Lutze, W.S. Sampath, John D. Williams
Materials Engineering Lab, NSF I/UCRC for Next Generation Photovoltaic, Colorado State University, Fort Collins, CO, USA

E27 238 **3-D Simulations for the Optimization of Antireflection Subwavelength Structures in CIGS Solar Cells**
Sehyun Hwang[1], Jae-Hyung Jang[1,2]
[1]Research Institute for Solar and Sustainable Energies (RISE), Gwangju Institute of Science and Technology (GIST), Gwangju, South Korea, [2]Department of Information and Communications, Gwangju Institute of Science and Technology (GIST), Gwangju, South Korea

F3 239 **Study of Point Defects in ns-Pulsed Laser-Annealed $CuInSe_2$ Thin Films**
Ashish Bhatia[1], Helen Meadows[2], Mitchell C. Hymas[1], Elizabeth M. Smith[1], Phillip J. Dale[2], Michael A. Scarpulla[1,3]
[1]Materials Science and Engineering, University of Utah, Salt Lake City, UT, USA, [2]Laboratory Photovoltaic, University of Luxembourg, Belvaux, Luxembourg, [3]Electrical and Computer Engineering, University of Utah, Salt Lake City, UT, USA

F7 240 **Reverse Stress Metastability of Shunt Current in CIGS Solar Cells**
Sourabh Dongaonkar[1], Erik Sheets[2], Rakesh Agrawal[2], Muhammad A. Alam[1]
[1]School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, USA, [2]School of Chemical Engineering, Purdue University, West Lafayette, IN, USA

F11 241 **J_{sc} Improvement of CdS/Cu(In,Ga)Se_2 Solar Cells After Rapid Thermal Annealing**
D.S. Chen[1,2], J. Yang[1], F. Xu[1], H.W. Du[1], J.W. Shi[1], Z.S. Yu[3], Y.H. Zhang[3], Z.Q. Ma[1]
[1]SHU-SolarE R&D Lab, Shanghai University, shanghai, China, [2]College of Mathematics and Physics, Shanghai University of Electric Power, shangha, China, [3]Shanghai Solar EnerTech Co.Ltd, shangha, China

F15 242 **Effects of Annealing in Sulfur Vapor on Electrodeposited $CuInSe_2$ Films**
Ashish Bhatia[1], Makarand A. Karmarkar[1], Helen Meadows[2], Mitchell C. Hymas[1], Elizabeth M. Smith[1], Phillip J. Dale[2], Michael A. Scarpulla[1,3]
[1]Materials Science and Engineering, University of Utah, Salt Lake City, UT, USA, [2]Laboratory Photovoltaic, University of Luxembourg, Belvaux, Luxembourg, [3]Electrical and Computer Engineering, University of Utah, Salt Lake City, UT, USA

F19 243 **Analysis of (Ag,Cu)(In,Ga)Se2 Solar Cells Deposited by a Hybrid Process**
Scott Little[1], Vikash Ranjan[2], Robert W. Collins[1], Sylvain Marsillac[2]
[1]University of Toledo, Toledo, OH, USA, [2]Old Dominion University, Norfolk, VA, USA

F23 244 **The Impact of Selenisation on Damp Heat Degradation of the CIGS Back Contact Molybdenum**
Mirjam Theelen[1,2,3], Mathieu Tomassini[4], Nicolas Barreau[4], Henk Steijvers[1], Annalisa Branca[1], Sylvie Harel[4], Zeger Vroon[1], Miro Zeman[2]
[1]TNO, Eindhoven, Netherlands, [2]Delft University of Technology, Delft, Netherlands, [3]M2i, Delft, Netherlands, [4]IMN-UMR, Nantes, France

F27 245 **Determination of Moisture Ingress Through Various Encapsulants Used in CIGS PV Module Under Continuously Varying Environment**
Namsu Kim[1], Chanwoon Han[1], Dohyun Baek[2], Jaehoon Lee[2], Dongseop Kim[2]
[1]Components and Materials Physics Research Center, Korea Electronic Research Center, Gyeongi-Do, South Korea, [2]Solar Energy Business Division, Samsung SDI Co., Ltd., Gyeongi-Do, South Korea

G3 246 **Reliability Studies of Mo Layer Deposited on Polyimide Substrate for CIGS Solar Cell Applications**
Dung-Ching Perng, Ming-Chen Hung, Kuo-Yu Wang
National Cheng Kung University, Tainan, Taiwan

G7 247 **Development of a High-Pressure CdS Sputtering Process for Improved Efficiency in CIGS-Based Photovoltaic Devices**
Melissa Mushrush, Rebekah Feist, Steve Rozeveld, Gary Mitchell, Jeffrey Fenton
The Dow Chemical Company, Midland, MI, USA

G11 248 **Impact of P2 Scribe Geometry on Monolithic Series Interconnected CIGS Modules**
Mathew N Rekow[1], Dominik Bartl[2], Christian Sandfort[3], Andreas Letsch[2]
[1]ESI-PyroPhotonics, Montreal, QC, Canada, [2]Robert Bosch GmbH, Stuttgart, Germany, [3]Bosch Solar CISTech GmbH, Brandenburg, Germany

G15 249 **Growth and Characterization of Cu_2ZnSnS_4 Single Crystal**
Akira Nagaoka[1], Kenji Yoshino[1], Hideto Miyake[2]
[1]University of Miyazaki, Miyazaki, Japan, [2]Mie University, Mie, Japan

G19 250 **Interface Modification by In-S Soaking Process on CIGS Solar Cells with CBD-ZNS Buffer Layer**
Yu-Han Chang[1], Chia-Hsiang Chen[1], Yan-huei Wu[1], Shih-Yuan Wei[1], Chih-Huang Lai[1,2]
[1]Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan, [2]Low Carbon Energy Research Center, National Tsing Hua University, Hsinchu, Taiwan

G23 251 **Batch Simulation of Solar Cells by Using Matlab and wxAMPS**
Yiming Liu[1], Yun Sun[1], Angus Rockett[2]
[1]Nankai University, Tianjin, China, [2]University of Illinois at Urbana Champaign, Urbana, IL, USA

G27 252 **Graded Band gap CIGS Solar Cells Considering the Valence Band Widening**
Nima Eshaghi Gorji[1], Ugo Reggiani[1], Leonardo Sandrolini[1]
[1]Department of Electrical Engineering, University of Bologna, Bologna, Italy, [2]Department of Electrical Engineering, University of Bologna, Bologna, Italy, [3]Department of Electrical Engineering, University of Bologna, Bologna, Italy

10:30 - 12:00 PM **EH4-C**

Area 3: III-V's and Concentrators: Cells, Modules, and Systems 1 (Posters)

Chair(s): Alexander Hass

H9
253
Ultrathin Tunnel Junction for Use in III-V Multijunction Solar Cells
Gerard J. Bauhuis, Peter Mulder, Erik J. Haverkamp, John J. Schermer
Radboud University Nijmegen, Nijmegen, Netherlands

H11
254
Towards High-Efficiency GaAs Thin-Film Solar Cells Grown via Close Space Vapor Transport from a Solid Source
Shannon W. Boettcher, Andrew J. Ritenour
Department of Chemistry and the Materials Science Institute, University of Oregon, Eugene, OR, USA

H13
255
Nonpolar Substrates for III-V-Based Solar Cells: Hydrogen Termination of Si(100) and Ge(100) Surfaces in MOVPE Process Ambient
Sebastian Brueckner[1,2], Henning Doescher[1,2], Anja Dobrich[1], Enrique Barrigón[3], Oliver Supplie[1], Claas Loebbel[1], Johannes Luczak[1], Ignacio Rey-Stolle[3], Peter Kleinschmidt[1,4], Thomas Hannappel[1,2,4]
[1]Helmholtz-Zentrum Berlin, Berlin, Germany, [2]Ilmenau University of Technology, Ilmenau, Germany, [3]Instituto de Energía Solar, Madrid, Spain, [4]CiS Research Institute, Erfurt, Germany

H15
256
GEN 2 of CPV Technology at ISOFOTON: System Market Penetration
Javier Cabrera, Vicente Díaz, Ricardo Hernández, Jorge López
Isofoton, S.A., Málaga, Spain

H17
257
Lattice-Matched GaP/SiGe Virtual Substrates for Low-Dislocation Density GaInP/GaAsP/Si Solar Cells
Andrew M. Carlin[1], Tyler J. Grassman[1], Mark R. Brenner[1], Javier Grandal[1], Chris Ratcliff[1], Limei Yang[2], Michael Mills[2], Prithu Sharma[3], Eugene A. Fitzgerald[3], Steven A. Ringel[1]
[1]Dept. of Electrical and Computer Engineering, The Ohio State University, Columbus, OH, USA, [2]Dept. of Materials Science & Engineering, The Ohio State University, Columbus, OH, USA, [3]Dept. of Materials Science & Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA

H19
258
Quantifying the Impact of Individual Atmospheric Parameters on CPV System Power and Energy Yield
Ngai L.A. Chan, Helen E. Brindley, Nicholas J. Ekins-Daukes
Department of Physics, Imperial College London, London, United Kingdom

H21 259 **High-Efficiency Screen-Printed Low-Medium Concentrator Silicon Solar Cells with Direct-Printed 50um-Wide Fingers**
Chia-Wei Chen[1], Xudong Chen[2], Kenneth Church[2], Haixin Yang[3], Keith Tate[1], Ian B. Cooper[1], Ajeet Rohatgi[4]
[1]University Center of Excellence for Photovoltaic Research and Education, School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, USA, [2]nScrypt, Inc., Orlando, FL, USA, [3]DuPont Microcircuit Materials, North Carolina, NC, USA, [4]Suniva Inc., Norcross, GA, USA

H23 260 **Fabrication of Lattice-Mismatched Multijunction Cells by 3-D Integration Concepts**
Jose L. Cruz-Campa[1], Gregory N. Nielson[1], Anlthony L. Lentine[1], Anton A. Filatov[2], Paul J. Resnick[1], Carlos A. Sanchez[1], Adam M. Rowen[1], Murat Okandan[1], Vipin P. Gupta[1], Jeffrey S. Nelson[1]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]Colorado School of Mines, Golden, CO, USA

H25 261 **Enhanced Performance of Small GaAs Solar Cells via Edge and Surface Passivation with Trioctylphosphine Sulfide**
Carissa N. Eisler, Matthew T. Sheldon, Harry A. Atwater
CalTech, Pasadena, CA, USA

H27 262 **Evaluation of the Stability Improvement in Power Generation of a Concentration Photovoltaic Module with Supercapacitors**
Yu-Pei Huang, Ko-Wei Weng, Peng-Fei Tsai
Department of Electronic Engineering, Nation Quemoy University, Kinmen County, Taiwan

I1 263 **Fabrication of Two-Terminal Metal-Interconnected Multijunction III-V Solar Cells**
Chieh-Ting Lin[1], W.E. McMahon[2], J.S. Ward[2], J.F. Geisz[2], M.W. Wanlass[2], J.J. Carapella[2], W. Olavarria[2], M. Young[2], M.A. Steiner[2], R.M. France[2], A.E. Kibbler[2], A. Duda[2], J.M. Olson[2], E.E. Perl[1], D.J. Friedman[2], J.E. Bowers[1]
[1]University of California at Santa Barbara, Santa Barbara, CA, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

I3 264 **Development of Tunnel Junctions with High Peak Tunneling Currents for InP-Based Multijunction Solar Cells**
Matthew P. Lumb[1,2], Michael Yakes[2], Maria Gonzalez[3,2], Raymond Hoheisel[1,2], Woojun Yoon[2], Robert J. Walters[2]
[1]The George Washington University, Washington, DC, USA, [2]US Naval Research Laboratory, Washington, DC, USA, [3]Sotera Defense Solutions, Crofton, MD, USA

I5 265 **Study on the Device Structure of GaInNAs(Sb)-Based Solar Cells for Use in 4-Junction Tandem Solar Cells**
Naoya Miyashita, Nazmul Ahsan, Muhammad Monirul Islam, Yoshitaka Okada
The University of Tokyo, Tokyo, Japan

I7 266 **Optimizing Wide Bandgap Subcells for Multijunction Solar Cells Using the Strain-Free AlGaAs/GaAs System**
Kyle H. Montgomery, Xin Zhao, Jerry M. Woodall
School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, USA

I9 267 **"Gondola": Trackless LCPV Module for Si Cells with Low-Aspect Ratio and High Energy Rating**
Francesco Morichetti[1], Aldo Righetti[2], Giorgio Grasso[2], Maria C. Ubaldi[2], Silvia M. Pietralunga[3]
[1]Politecnico di Milano, Dip. Elettronica e Informazione, Milano, Italy, [2]CIFE, Milano, Italy, [3]CNR-IFN, Milano, Italy

I11 268 **Influence of Temperature Distribution on 25 Series-Connected 820X CPV Module Output During Outdoor Operation**
Yasuyuki Ota[1], Tsuyoshi Sueto[1], Hirokazu Nagai[2], Kenji Araki[2], Kensuke Nishioka[1]
[1]University of Miyazaki, Miyazaki, Japan, [2]Daido Steel, Nagoya, Japan

I13 269 **Growth and Characterization of Quaternary (GaInAsP-GaAs)-Graded Heterostructures**
Monika Rathi, Pavel Dutta, S. P. Ahrenkiel
South Dakota School of Mines and Technology, Rapid City, SD, USA

I15 270 **Preliminary Development and Analysis of Tandem III-V/SiGe Devices Grown on Si**
Ken Schmieder[1], Andrew Gerger[2], Martin Diaz[1], Ziggy Pulwin[3], Chris Ebert[3], Robert Opila[1], Anthony Lochtefeld[2], Allen Barnett[4]
[1]University of Delaware, Newark, DE, USA, [2]AmberWave Inc., Salem, NH, USA, [3]Veeco MOCVD, Somerset, NJ, USA, [4]The University of New South Wales, Sydney, Australia

I17 271 **High-Efficiency Thin-Film InGaP/(In)GaAs/Ge Multijunction Solar Cells Enabled by Controlled Spalling Technology**
Davood Shahrjerdi[1], Stephan Bedell[1], Chris Ebert[2], Can Bayram[1], Bahman Hekmatshoar[1], Keith Fogel[1], Paul Lauro[1], Michael Gaynes[1], John Ott[1], Tayfun Gokmen[1], Devendra Sadana[1]
[1]IBM T J Watson Research Center, Yorktown Heights, NY, USA, [2]Veeco Corporations, Somerset, NJ, USA

I19 272 **A GaAs Single-Junction Solar Cell with a Roughened Back Scattering Surface**
Weiquan Yang[1], Charles Allen[1], Jing-jing Li[1], Shi Liu[1], Ding Ding[1], Stuart Farrell[1], Zhaoyu He[1], Hua Li[1], Hank Dettlaff[1], Yong-hang Zhang[1], Hector Cotal[2], Chritopher Fetzer[2], Nasser Karam[2]
[1]Arizona State University, tempe, AZ, USA, [2]Boeing-Spectrolab Inc., Sylmar, CA, USA

I21 273 **The Effect of Offcut Angle on Electrical Conductivity of Wafer-Bonded n-GaAs/n-GaAs Structures for Wafer-Bonded Tandem Solar Cells**
King W. Yeung, Mark S. Goorsky
Department of Materials Science and Engineering, UCLA, Los Angeles, CA, USA

I23 274 **MBE Growth of ZnTe and ZnTeSe on GaSb**
Jessica Chai, Kyoung K. Lee, Kevin Doyle, John H. Dinan, Thomas H. Myers
Texas State University - San Marcos, San Marcos, TX, USA

10:30 - 12:00 PM **EH4-D**

Area 4: Crystalline Silicon: Passivation and Advanced Devices (Posters)

Chair(s): Bart Geerligs

I25 275 **Process Optimization for High-Efficiency Heterojunction c-Si Solar Cells Fabrication Using Hot-Wire Chemical Vapor Deposition**
Yuming Ai, Hao-Chih Yuan, Matthew Page, William Nemeth, Lorenzo Roybal, Lynn Gedvilas, Qi Wang
National Renewable Energy Laboratory, Golden, CO, USA

J1 276 **Passivation of n-Type Silicon (111) Surfaces by the Attachment of Charged Molecules**
Nicholas P. Alderman[1], Lefteris Danos[1], Martin C. Grossel[2], Tom Markvart[1]
[1]Solar Energy Laboratory, Faculty of Engineering and the Environment, University of Southampton, Southampton, United Kingdom, [2]Faculty of Natural and Environmental Sciences, University of Southampton, Southampton, United Kingdom

J5 277 **Effect of Interface States (Dit) at the a-Si/c-Si Interface on the Performance of Thin-Film a-Si/c-Si/c-Si Heterojunction Solar Cells**
Aaesha Alnuaimi, Ammar Nayfeh
Masdar Institute of Science and Technology, Abu Dhabi, United Arab Emirates

J9 278 **Thin Monocrystalline Silicon Solar Cell with 100μm Thickness and 156x156mm^2**
Tae-Hyun Baek[1], Kyeom Seon Do[2], Sung Jin Choi[3], Gi Hwan Kang[4], Gwon Jong Yu[4], Jeong Chul Lee[4], Hye Mi Hwang[4], Kee-Joe Lim [1], Hee-eun Song[4]
[1]Department of Electrical Engineering, Chungbuk National University, Chongju, South Korea, [2]Department of Material Science & Engineering, Yonsei University, Seoul, South Korea, [3]Green Graduate School, Korea University, Seoul, South Korea, [4]Solar Energy Research Center, Korea Institute of Energy Research, Daejeon, South Korea

J13 279 **Improved Performance of Uncapped Al_2O_3 and Local Firing-Through Al-BSF in Bifacial Solar Cells**
I. Cesar[1], A.A. Mewe[1], E. Granneman[2], P. Vermont[2], A.W. Weeber[2]
[1]ECN, Petten, Netherlands, [2]Levitech, Almere, Netherlands

J17 280 **Novel Dual-Layered Passivation Approach for 18.8% Efficiency Laser-Doped Selective-Emitter Cells**
Tseng-Jung Chang, Te-Yu Wei, Sean H.T. Chen, Li-Wei Cheng
Topcell Solar International CO., LTD, Taoyuan County, Taiwan

J21 281 **n-Type Aluminum-Alloyed Rear-Junction Silicon Solar Cells with Implanted Front Surface Field**
Naratip Chantarat, Shao-peng Su
Topcell Solar International Co., LTD., Guanyin Township, Taoyuan Country, R.O.C., Taiwan

J25 282 **Effect of Interface Trap States in Reduced-Base-Thickness a-Si/c-Si Heterojunction Solar Cells**
Raghu Vamsi K. Chavali, John Wilcox, Jeffery L. Gray
School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, USA

K1 283 **Structure Simulation of Screen-Printed Local Back Surface Field for Rear-Passivated Silicon Solar Cell**
Daming Chen, Zongcun Liang, Hui Shen, Yang Liu
Institute for Solar Energy System, School of Physics and Engineering, State Key Laboratory of Optoelectronic Materials and Technologies, Sun Yat-Sen University, Guangzhou, Christmas Island

K5 284 **Industrial Development of Silicon Hetero-junction Back Contact Solar Cells**
Jin-Ho Choi[1], Jong-Chul Lee[1], Sang-Kyun Kim[1], Hun Park[1], Ki-Hyun Kim[2], Won-Jae Lee[1]
[1]Hyundai Electro-Mechanical Research Institute(HEMRI), Hyundai Heavy Industries Co.,Ltd, Yong-In, Korea, [2]Green Energy Business Division, Hyundai Heavy Industries Co.,Ltd, Eum-Seong, Korea

K9 285 **The Electrical Properties with Various Pre-Deposition Times During Doping Process in Monocrystalline Silicon Solar Cell**
Sung Jin Choi[1], Gwon Jong Yu[2], Gi Hwan Kang[2], Jeong Chul Lee[2], Donghwan Kim[1], Hee-eun Song[2]
[1]Green Graduate School, Korea University, Seoul, South Korea, [2]Solar Energy Research Center, Korea Institute of Energy Research, Daejeon, South Korea

K13 286 **Excellent Low-Temperature Passivation Scheme with Reduced Optical Absorption for Back Amorphous-Crystalline Silicon Heterojunction (BACH) Photovoltaic Device**
Zahidur R. Chowdhury[1], Dmitri Stepanov[2], Davit Yeghikyan[1], Nazir P. Kherani[1,2]
[1]Department of Electrical and Computer Engineering, University of Toronto, Toronto, ON, Canada, [2]Department of Material Science and Engineering, University of Toronto, Toronto, ON, Canada

K17 287 **Full-Area Laser-Doped Boron-Emitter Silicon Solar Cells**
Morris Dahlinger, Sebastian J. Eisele, Patrick C. Lill, Jürgen R. Köhler, Jürgen H. Werner
Institute of Photovoltaics, University of Stuttgart, Stuttgart, Germany

K21 288 **Optical Modeling of the Internal Back Reflectance of Various Dielectric Stacks Featuring Al_2O_3, TiO_2, and SiO_2**
Kristopher O. Davis[1,2], Matthew Weed[2], Hubert P. Seigneur[1,2], Kaiyun Jiang[3], Carsten Demberger[3], Heiko Zunft[3], Helge Haverkamp[3], Dirk Habermann[3], Winston V. Schoenfeld[1,2]
[1]Florida Solar Energy Center, University of Central Florida, Cocoa, FL, USA, [2]College of Optics and Photonics, University of Central Florida, Orlando, FL, USA, [3]Gebr. Schmid GmbH & Co., Freudenstadt, Germany

K25 289 **State-of-the-Art Surface Passivation of Boron Emitters on *n*-Type *c*-Si using In-Line PECVD AlO_x/SiN_y Stacks for Industrial High-Efficiency Solar Cells**
Shubham Duttagupta[1, 2], Fen Lin[1], Marshall Wilson[3], Fa-Jun Ma[1], Jiaji Lin[1], Armin G. Aberle[1,2], Bram Hoex[1]
[1]Solar Energy Research Institute of Singapore (SERIS), Singapore, Singapore, [2]Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Singapore, [3]Semilab SDI LLC, Tampa, FL, USA

K28 290 **Thin Macroporous Heterojunction Silicon Solar Cells**
Marco Ernst[1], Rolf Brendel[1,2], Rafel Ferré[1], Nils-Peter Harder[1,3]
[1]Institute for Solar Energy Research Hamelin (ISFH), Emmerthal, Germany, [2]Department Solar Energy, Institute of Solid-State Physics, Leibniz Universität Hannover, Hannover, Germany, [3]Institute of Electronic Materials and Devices, Leibniz Universität Hannover, Hannover, Germany

L3 291 **Experimental and Theoretical Verification of the Presence of Inversion Region in a-Si/c-Si Heterojunction Solar Cells with an Intrinsic Layer**
Kunal Ghosh, Clarence Tracy, Stuart Bowden
Arizona State University, Tempe, AZ, USA

L6 292 **Blister Formation Mechanisms in Spatial ALD Al_2O_3 for Silicon Surface Passivation**
Luuk Hennen[1,2], Ernst Granneman[1], Erwin Kessels[2]
[1]Levitech BV, Almere, Netherlands, [2]Department of Applied Physics, Eindhoven University of Technology, Eindhoven, Netherlands

L9 293 **Reassessment of Classic Recombination Mechanisms in Silicon Point Contact Concentrator Solar Cell**
Stanislau Herasimenka[1], Pietro Altermatt[2], Stuart Bowden[1], Christiana Honsberg[1]
[1]Arizona State University, Tempe, AZ, USA, [2]Leibniz University of Hannover, Hannover, Germany

L12 294 **Self-Doping Laser Transferred Contacts for c-Si Solar Cells**
Erik Hoffmann, Tobias Röder, Jürgen Köhler
Institute for Photovoltaics, Stuttgart, Germany

L15 295 **Improvement of Short Wavelength Optical Response by Applying Double SiN_x:H Layers on Monocrystalline Silicon Solar Cells**
Kihyun Kim, Hoon Oh, Jongbin Lim, Jongkyu Heo, Sumi Yang, Younghyun Oh, Myungick Hwang, Eunchel Cho
Hyundai Heavy Industries Co., Ltd, Eumseong, Chungcheongbuk-Do, Korea

L18 296 **Fabrication of Large-Area n-Type Silicon Solar Cells with Al-doped p^+ Rear Emitter and Analysis of Rear Metal Contact Properties for Rear Passivated Solar Cells**
Young Do Kim, Kyung Dong Lee, Seongtak Kim, Hyunho Kim, Soohyun Bae, Hyomin Park, Sungeun Park, Sung Ju Tark, Donghwan Kim
Korea University, Seoul, South Korea

L21 297 **Excellent Passivation and Low-Reflectivity Al_2O_3/TiO_2 Bilayer Coatings for n-Wafer Silicon Solar Cells**
Benjamin G. Lee[1], Jarmo Skarp[2], Ville Malinen[2], Shuo Li[2], Howard M. Branz[1]
[1]National Center for Photovoltaics, National Renewable Energy Lab, Golden, CO, USA, [2]Beneq Oy, Vantaa, Finland

L24 298 **Thermal Stable a-Si:H/SiN_x Stack Passivating System and the Application in Rear-Localized Contact Solar Cells on CZ p-Type Crystalline Silicon**
Hua Li, Stuart Wenham
Photovoltaics Centre of Excellence, the University of New South Wales, Sydney, Australia

L27 299 **Boron Diffused Emitter Etch Back and Passivation**
Xiaoqiang Li, Longzhong Tao, Zhengyue Xia, Zhuojian Yang, Jingbing Dong, Wentao Song, Guoqiang Xing
Hareon Solar Technology Co., Ltd., Huangtang Industrial Park, Jiangyin, China

M2 300 **Research on Ultra-Small Textured Surface of Multicrystalline Silicon Solar Cell**
Haofeng Li[1], Rui Jia[1,2], Bingfei Dou[1], Chen Chen[1], Xinyu Liu[1], Tianchun Ye[1]
[1]Institute of Microelectronics, Chinese Academy of Sciences, Beijing, China, [2]Research Center of Advanced Solar Cells, Shanghai, China

M5 301 **A Novel Low-Cost ~25µm-Thin Monocrystalline Silicon Bifacial Solar Cell Technology with Flexible and Rigid Form-Factor and Electroplated Contacts**
Leo Mathew[1], Rajesh Rao[1], Dabraj Sarkar[3], Sanjay Banerjee[2], Darmesh Jawarani[1], Jerry Fossum[3], Rico Garcia[1], Scott Smith[1], Dewei Xu[2], Moses Ainom[1], Emmanuel Oneygam[2], Rachel Stout[1], Sayan Saha[1], Aarium Gurmu[1]
[1]AstroWatt Inc., Austin, TX, USA, [2]Univ. of Texas, Austin, TX, USA, [3]Univ. of Florida, Gainesville, FL, USA

M8 302 **Electrical Characterization of Al_2O_3 Passivation Layers for p-Type CZ-Si PERC Solar Cells**
Alessandro Morato[1], Bart Vermang[2,3], Hans Goverde[4], Gaudenzio Meneghesso[1], Joachim John[2], Jef Poortmans[2,3], Robert Mertens[2,3]
[1]Department of Information Engineering, University of Padova, Padova, Italy, [2]IMEC, Leuven, Belgium, [3]Katholieke Universiteit Leuven (K.U.Leuven), Leuven, Belgium, [4]Eindhoven University of Technology (TU/e), Eindhoven, Netherlands

M11 303 **Plasma Immersion Ion Implantation for Shallow Junction of Silicon Solar Cells**
Hyomin Park, Jong-Han Lee, Doowon Lee, Soomin Kim, Sungeun Park, Young Do Kim, Sung Ju Tark, Donghwan Kim
Korea University, Seoul, South Korea

M14 304 **Impact of Surface Preparation Prior to AlO_x Deposition for i-PERC Cells**
Julien Penaud[1], Périne Jaffrennou[1], Aude Rothschild[2], Benoit Lombardet[1]
[1]TOTAL, Paris, France, [2]imec, Leuven, Belgium

M17 305 **Oxidation Enhanced Diffusion for Screen-Printed Silicon Solar Cells**
Victor Prajapati[1,2], Jorg Horzel[1], Patrick Choulat[1], Tom Janssens[1], Jef Poortmans[1,2], Robert Mertens[1,2]
[1]imec, Leuven, Belgium, [2]Katholiek Universiteit Leuven, Leuven, Belgium

M19 306 **Charge Trapping and Charge Storage in SiN_x Thin Films Deposited with Oxford PlasmaLab 100 System**
Yongling Ren[1], Klaus J. Weber[1], Fouad Karouta[2], Kaushal Vora[2], Wensheng Liang[1]
[1]Centre for Sustainable Energy Systems, College of Engineering and Computer Science, The Australian National University, Canberra, Australia, [2]Department of Electronic Materials Engineering, Research School of Physics & Engineering, The Australian National University, Canberra, Australia

M21 307 **Crystalline Silicon Solar Cells with Segmented Selective Emitter by Ultraviolet Laser Doping**
John S Renshaw[1,2], Ajay Upadhyaya[2], Vijay Upadhyaya[2], Ajeet Rohatgi[2,3]
[1]Department of Physics, Georgia Institute of Technology, Atlanta, GA, USA, [2]University Center of Excellence for Photovoltaics, Georgia Institute of Technology, Atlanta, GA, USA, [3]Suniva, Norcross, GA, USA

M23 308 **Optimization of ICP-CVD Silicon Nitride for Si Solar Cell Passivation**
Sandeep S. S.[1,2], Ketan Warikoo[1], Anil Kottantharayil[1,2]
[1]National Centre for Photovoltaic Research and Education, Mumbai, India, [2]Department of Electrical Engineering, IIT Bombay, Mumbai, India

M25 309 **Distinctive Aspects of the Centaurus Solar Cell Technology**
J. Schöne[1], K. A. Münzer[1], M. Hein[1], A. Teppe[1], M. Hanke[1], R. E. Schlosser[1], K. Varner[1], H. Mäckel[1], J. Maier[1], A. Yodyunyong[1], S. Keller[1], P. Fath[2]
[1]Centrotherm Cell & Module GmbH, Konstanz, Germany, [2]Centrotherm Photovoltaics AG, Blaubeuren, Germany

M27 310 **Characterization and Modeling of Low-Temperature Surface Passivation for Interdigitated Back-Contact Silicon Heterojunction Solar Cell**
Brent Shu[1,2], Ujjwal Das[1], Steven Hegedus[1], Robert Birkmire[1,2]
[1]Institute of Energy Conversion, University of Delaware, Newark, DE, USA, [2]Department of Physics and Astronomy, University of Delaware, Newark, DE, USA

N1 311 **Self-Aligned Hydrogenated Selective Emitter for n-Type Solar Cells**
Seth D. Shumate[1,2], Douglas A. Hutchings[2], Mohammed K. Hafeezuddin[2], Genevra Beilke[1,2], Benjamin S. Newton[1], Matthew Young[1], Husam H. Abu-Safe[3,4], Shui-Qing Yu[3], Hameed A. Naseem[3]
[1]Microelectronics-Photonics, University of Arkansas, Fayetteville, AR, USA, [2]Silicon Solar Solutions LLC, Fayetteville, AR, USA, [3]Department of Electrical Engineering, University of Arkansas, Fayetteville, AR, USA, [4]Natural Science Division, Lebanese American University, Byblos, Lebanon

N3 312 **Understanding Light-Induced Degradation of c-Si Solar Cells**
Bhushan Sopori[1], Prakash Basnyat[1,2], Sudhakar Shet[1,2], Vishal Mehta[1,2], Srinivas Devayajanam[1,2], Jeff Binns[3], Jesse Appel[3]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]New Jersey Institute of Technology, Newark, NJ, USA, [3]MEMC Electronic Materials, St Peters, MO, USA

N5 313 **Improved Uniformity for Thin Oxides when Using Wet Thermal Oxidation**
Jeffrey Spiegelman
RASIRC, San Diego, CA, USA

N7
314 **Industrially Feasible Casting: Monocrystalline Solar Cells with PECVD AlO_x/SiN_x Rear Passivation Stack Towards 19.6% Efficiency**
Baoming Sun, Jian Sheng, Shengzhao Yuan, Chun zhang, Zhiqiang Feng, Qiang Huang
State Key Laboratory of PV Science and Technology, Trina solar Limited Company, Changzhou, China

N9
315 **Halogen-Doped Al_2O_3 Thin Films with Excellent Passivation Layer for High-Efficiency Solar Cell Application**
Wen-Ching Sun, Terry Tai-Jui Wang, Sheng-Min Yu, Yi-Fan Chen, Chia-Liang Sun, Tzer-Shen Lin
Material & Chemical Research Laboratories, Industrial Technology Research Institute, Hsinchu, Taiwan

N11
316 **Fabrication of Nanoporous Black Silicon Surface for Solar Cells in One Step Via a Modified Etching Solution**
Yehua Tang[1,2], Wenjing Wang[1], Chunlan Zhou[1], Su Zhou[1,2], Yan Zhao[1,2], Jingwei Chen[1,2], Baojun Yan[1,2], Xiangxin Liu[1], Jianming Fei[3], Hongbin Cao[3]
[1]Institute of Electrical Engineering, Key Laboratory of Solar Thermal Energy and Photovoltaic System, Chinese Academy of Sciences, Beijing, China, [2]Graduate University of the Chinese Academy of Sciences, Beijing, China, [3]Eoplly New Energy Technology Co., Ltd., Nantong, Jiangsu, Nantong, China

N13
317 **Crystalline Silicon Interconnected Strips (XIS): Introduction to a New, Integrated Device and Module Concept**
John van Roosmalen, Paula Bronsveld, Arthur Weeber
ECN Solar Energy, Petten, Netherlands

N15
318 **Atomic Layer Deposition of Al_2O_3 as Rear Surface Passivation for p-type Si Passivated Emitter and Rear Cells: An Overview**
Bart Vermang[1,2], Hans Goverde[3], Emanuele Cornagliotti[2], Victor Prajapati[1,2], Eddy Simoen[2], Alessandro Morato[4], Anne Lorenz[2], Loic Tous[1,2], Angel Uruena[1,2], Patrick Choulat[2], Aude Rothschild[2], Joachim John[2], Jorg Horzel[2], Jef Poortmans[1,2], Robert Mertens[1,2]
[1]University of Leuven, Leuven, Belgium, [2]Imec, Leuven, Belgium, [3]University of Eindhoven, Eindhoven, Netherlands, [4]University of Padova, Padova, Italy

N17
319 **Characterisation of Mechanical Stress in PECVD Silicon Nitride and Implications to Silicon Surface Passivation**
Yimao WAN[1], Keith R. McIntosh[2], Andrew F. Thomson[1]
[1]Research School of Engineering, Australian National University (ANU), Canberra ACT, Australia, [2]PV Lighthouse, Coledale NSW, Australia

N19 320 **Silicon Grain Boundary Passivation for Photovoltaics: A Novel Approach with Small Polar Molecules**
Wentao Wang[1], Lei Wang[1], Fude Liu[1], Fei Yan[2], Steve Johnston[2], Mowafak Al-Jassim[2]
[1]The University of Hong Kong, Hong Kong, Hong Kong, [2]National Renewable Energy Laboratory, Golden, CO, USA

N21 321 **18.82%-Efficient Laser-Doped Semiconductor Fingers Screen-Printed Silicon Solar Cell with Light-Induced Plating**
Kee Soon Wang, Dong Lin, Ly Mai, Xin Rui An, Emily Mitchell, Stuart Ross Wenham
University of New South Wales, Sydney, NSW 2052, Australia

N23 322 **Effect of TCO Work Function on the Back Contact Carrier Transport of Heterojunction Solar Cells**
Wangping Wang, Qiang Huang
State Key Laboratory of PV Science and Technology, Trina Solar Limited Company, Changzhou, Jisuang, China

N24 323 **20.3% Efficiency Rear-Passivated Silicon Solar Cells with Local Back Contact Using Commercial P-Cz Wafers**
Zhenjiao Wang[1], Peiyu Han[1], Qinglei Meng[1], Hongqiang Qian[1], Jiaqi Wu[1], Yongfei Jiang[1], Ning Tang[1], Hongyan Lu[1], Haidong Zhu[1], Rulong Chen[1], Peter Yang[1], Jingjia Ji[1], Zhengrong Shi[1], Adeline Sugianto[1,2], Stuart Wenham[1,2]
[1]Suntech Power Holdings Co.,Ltd, Wuxi, China, [2]Centre of Excellence for Advanced Silicon Photovoltaics and Photonics University of New South Wales, Sydney, Australia

N25 324 **Development of High-Efficiency Mono-Silicon Solar Cells: Optimization of Rear Point Contacts Formation on Dielectrically Passivated Surfaces**
Kapila Wijekoon, Prabhat Kumar, Jeff Franklin, Mukul Agrawal, Hemant Mungekar, Kalyan Rapolu, Michael Stewart, Yi Zheng, Lin Zhang, David Tanner, Hari Ponnekanti
Applied Materials, Santa Clara, CA, USA

N26 325 **Comparison Between Passivation Properties of Thermal ALD Al_2O_3 Deposited with TMS+ O_3 and TMA+ H_2O**
Zhengyue Xia, Changrui Ren, Longzhong Tao, Xiaoqiang Li, Zhuojian Yang, Jingbing Dong, Wentao Song, Guoqiang Xing, Bin Zhang
Hareon Solar Technology Co., Ltd, Jiangyin, China

N27 326 **Optical Transparency and Surface Recombination Considerations for High Sheet Resistance Emitter Passivation**
Satoshi Yamanaka, Maciej Dybiec, Bradley Kopp, Nicholas Gurnon, Ethan A. Good
SolarWorld Industries America, Hillsboro, OR, USA

N28 327 **The Effect of Rear Surface Passivation Layer Thickness on High-Efficiency Solar Cells with Planar and Scattering Metal Reflectors**
Yang Yang, Hamid Mehrvarz, Supriya Pillai, Henner Kampwerth, Anita Ho-Baillie, Martin Green
Photovoltaics Centre of Excellence, University of New South Wales, Sydney, Australia

O1 328 **Low-Cost Spraying Halogen-Doped Al_2O_3 Thin Film for Passivated Emitter and Rear Cells**
S.M. Yu, W.C. Sun, Terry T.J. Wang, Y.F. Chen, C.L. Sun, T.S. Lin
Material & Chemical Research Laboratories, Industrial Technology Research Institute, Hsinchu, Taiwan

O2 329 **Impact of Back-Surface Patterning Process on FF in Interdigitated Back Contact Silicon Heterojunction (IBC-SHJ) Solar Cell**
Lulu Zhang[1,2], Brent Shu[1,2], Robert W Birkmire[1,2], Steve S Hegedus[1], Ujjwal K Das[1]
[1]Institute of Energy Conversion, University of Delaware, Newark, DE, USA, [2]Department of Physics and Astronomy, University of Delaware, Newark, DE, USA

10:30 - 12:00 PM **EH4-E**

Area 5: Thin-Film Silicon: Solar Cells, Novel Concepts, Thin Crystalline Silicon Film, Solar Cells and Modules (Posters)

Chair(s): Jimmy Melskens, Remi Biron

O4 330 **Towards Light-Trapping Free Amorphous-Si-Only Multijunction Solar Cells**
Seung Jae Baik[1], Koeng Su Lim[1], Jeong Chul Lee[2]
[1]KAIST, Daejeon, Korea, [2]KIER, Daejeon, Korea

O6 331 **Epitaxial n-ZnO on p-Si with Native SiO_x Reduced by Al Overlayer**
Chun-Fu Chang[1], Quark Y. Chen[1,2], Jin-Jie Lin[1], Guo-Sin Huang[1], Jun-Hau Wang[1], Paritosh V. Wadekar[1], Chih-Hsiung Liao[3], Hua-Hsien Liao[4], Hui-Chun Huang[5], Dharshana Wijesundera[2], Wei-Kan Chu[2], Li-Wei Tu[1], New-Jin Ho[5]
[1]Physics and Center for Nanoscience and Nanotechnology, National Sun Yat-Sen University, Kaohsiung, Taiwan, [2]Physics and Texas Center for Super Conductivity, University of Houston, Houston, TX, USA, [3]Physics, R.O.C. Military Academy, Kaohsiung, Taiwan, [4]Enli Technology Co., Ltd., Kaohsiung, Taiwan, [5]Materials and Optoelectronic Science, National Sun Yat-Sen University, Kaohsiung, Taiwan

O8
332 **High Efficiency Multijunction Solar Cells and TPV Using SiGeSn Materials**
Benjamin R. Conley[1], Hameed Naseem[2], Greg Sun[3], Paul Sharps[4], Shui-Qing Yu[2]
[1]microElectronics-Photonics, University of Arkansas, Fayetteville, AR, USA, [2]Department of Electrical Engineering, University of Arkansas, Fayetteville, AR, USA, [3]Department of Physics, University of Massachusetts, Boston, MA, USA, [4]Emcore Photovoltaics, Albuquerque, NM, USA

O10
333 **Improved Internal Quantum Efficiency in High-Quality $BaSi_2$ Films Grown by Molecular Beam Epitaxy**
Weijie Du[1], Mitsushi Suzuno[1], Khan Muhammad Ajmal[1], Katsuaki Toh[1], Masakazu Baba[1], Kotaro Nakamura[1], Kaoru Toko[1], Noritaka Usami[2,3], Takashi Suemasu[1,3]
[1]Institute of Applied Physics, University of Tsukuba, Tsukuba, Japan, [2]Institute of Materials Science, Tohoku University, Sendai, Japan, [3]JST-CREST, Tokyo, Japan

O12
334 **Determination of Intrinsic Minority-Carrier Lifetime in Barium Disilicide Epitaxial Films**
Kosuke O. Hara[1,2], Noritaka Usami[1,2], Katsuaki Toh[3], Masakazu Baba[3], Kaoru Toko[3], Takashi Suemasu[2,3]
[1]Tohoku University, Sendai, Japan, [2]JST-CREST, Tokyo, Japan, [3]University of Tsukuba, Tsukuba, Japan

O14
335 **Low-Cost High-Efficiency High-Density-Plasma Silicon-Based Thin-Film Solar Cells with High Light-Soaking Stability**
Tzu-Hsuan Hsiao[1], Jia-Min Shieh[2], Peichen Yu[1], Chang-Houng Shen[2], Ming-Hsuan Kao[1], Uio-Pu Chiou[1], Wei-Hsiang Shieh[2]
[1]National Chiao Tung University, Hsinchu, Taiwan, [2]National Nano Device Laboratories, Hsinchu, Taiwan

O16
336 **Novel Process Flow and Cell Architecture for 10µm-Thick Membrane Single-Crystalline Silicon Solar Cells**
Erik W. Janssen, Rafael N. Kleiman
McMaster University, Hamilton, ON, Canada

O18
337 **Development of Thin-Film Solar Cells Using Solar Spectrum Splitting Technique**
Sinae Kim[1], Fuminori Takahashi[1], Shunsuke Kasashima[1], Yoshiaki Hirai[1], Sichanugrist Porponth[1], Akira Yamada[1,2], Makoto Konagai[1,2]
[1]Tokyo Institute of Technology, Tokyo, Japan, [2]Photovoltaic Research Center (PVREC), Tokyo Institute of Technology, Tokyo, Japan

O20
338 **Si Thin-Film Solar Cell with Asymmetric p-n Junction**
Myung-Dong Ko[1], Chang-Ki Baek[2], Taiuk Rim[1], Sooyoung Park[1], Yoon-Ha Jeong[1,2,3]
[1]POSTECH, Department of Electrical Engineering, Pohang, Korea, [2]POSTECH, Creative IT Excellence Engineering, Pohang, Korea, [3]POSTECH, Division of IT Convergence Engineering, Pohang, Korea

O22 339 **Thin-Film ZnO/Si Heterojunction Solar Cells: Design and Implementation**
Eric Kozarsky, Juhyung Yun, Chong Tong, Xueli Hao, Jun Wang, Wayne A. Anderson
University at Buffalo, Buffalo, NY, USA

O24 340 **Fabrication of Site-Specific Amorphous/ Nanocrystalline Silicon Composite Thin Film for Solar Cells**
Benjamin S. Newton[1], Husam Abu-Safe[2,3], Mourad Benamara[4], Shui -Qing Yu[3], Hameed Naseem[3]
[1]Microelectronics Photonics Program, Fayetteville, AR, USA, [2]Natural Science Division, Beirut, Lebanon, [3]Department of Electrical Engineering, Fayetteville, AR, USA, [4]Institute of Nanoscale Material Science and Engineering, Fayetteville, AR, USA

O26 341 **Formation of Polycrystalline Silicon Films with µm-Order-Long Grains Through Liquid-Phase Explosive Crystallization by Flash Lamp Annealing**
Keisuke Ohdaira[1,2], Sergey Varlamov[3], Noritaka Usami[4], Hideki Matsumura[1]
[1]Japan Advanced Institute of Science and Technology, Nomi, Japan, [2]PRESTO, Japan Science and Technology Agency, Kawaguchi, Japan, [3]University of New South Wales, Sydney, Australia, [4]Institute for Materials Research, Tohoku University, Sendai, Japan

O28 342 **Amorphous InZnO Transparent Conductors for c-Si/a-Si Heterojunction PV**
J.D. Perkins, T. Gennett, S. Grover, D.L. Young, D.S. Ginley, C.W. Teplin
National Renewable Energy Laboratory, Golden, CO, USA

P2 343 **A Si-Rich Si_xC_{1-x}-Based p-n Junction Photovoltaic Solar Cells**
Ling-Hsuan Tsai, Chiao-Ti Lee, Yung-Hsiang Lin, Gong-Ru Lin
Graduate Institute of Photonics and Optoelectronics, and Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan

P4 344 **Improving Tunnel Junction in Micromorph Tandem Cells by Inserting p-Type Nanocrystalline Silicon Layer**
Wenjie Yao, Xiangbo Zeng, Xiaobing Xie, Ping Yang, Hao Li, Jingyan Li, Xianbo Liao, Qiming Wang
State Key Laboratory on Integrated Optoelectronics, Institute of Semiconductors, CAS, Beijing, China

P5 345 **a-Si:H/c-Si Nanocomposite Material for Solar Cells Fabricated from PECVD**
Matthew G Young[1,4], Mourad Benamara[2], Husam Abu-Safe[1,3], Shui-Qing Yu[1], Hameed A Naseem[1]
[1]Department of Electrical Engineering, University of Arkansas, Fayetteville, AR, USA, [2]Institute of Nanoscale Material Science and Engineering, University of Arkansas, Fayetteville, AR, USA, [3]Natural Science Division, Lebanese American University, Beiruit, Lebanon, [4]Microelectronics-Photonics Program, University of Arkansas, Fayetteville, AR, USA

10:30 - 12:00 PM **EH4-F**

Area 8: PV Characterization: Session 2 (Posters)

Chair(s): Yoshihiro Hishikawa, Manuel Romero, Gerald Siefer

Q21 346 **Effect of Shunt Resistance on the Performance of mc-Silicon Solar Cells: A Combined Electro-Optical and Thermal Investigation**
Marco Barbato[1], Matteo Meneghini[1], Valentina Giliberto[1], Daniele Giaffreda[2,3], Paolo Magnone[2,3], Raffaele De Rose[2,3], Claudio Fiegna[2,3], Gaudenzio Meneghesso[1,3]
[1]University of Padova, Padova, Italy, [2]University of Bologna, Bologna, Italy, [3]IUNET, Bologna, Italy

Q23 347 **European Pre-Standardization for Building-Integrated Photovoltaic Applications in Nearly-Zero-Energy Buildings**
J.J. Bloem[1], C. Lodi[2]
[1]Joint Research Centre, Institute for Energy and Transport, Renewable Energies Unit, Ispra, Italy, [2]Applied Physics Section of the Environmental Science Department, University of Lleida, Lleida, Spain

R1 348 **Irradiance-Dependent Current-Limiting Behavior of Multijunction Solar Cells**
Avi Braun[1], Eugen A. Katz[1], Klaus Schwarzburg[2], Thomas Hannappel[2], Jeffrey M. Gordon[1]
[1]Department of Solar Energy and Environmental Physics, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer Campus, Israel, [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany

R3 349 **Photovoltaic Module Performance and Degradation as Compared in Distinct Climatic Regions**
Jesse A. Campbell
Solon Corporation, Tucson, AZ, USA

R5 350 **Thermal Effusion Measurements: Probing Hydrogen in Surface Passivation Schemes**
Gijs Dingemans[1], Wolfhard Beyer[2], Erwin Kessels[1]
[1]Eindhoven University of Technology, Eindhoven, Netherlands, [2]Forschungszentrum Juelich, Juelich, Germany

R7 351 **Lifetime Measurements on III-V Solar Cell Relevant Materials in the Presence and Absence of Electrical Fields**
Anja Dobrich[1], Klaus Schwarzburg[1], Elias Martinez Moreno[1], Marinus Kunst[1], Thomas Hannappel[1,2,3]
[1]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany, [2]Ilmenau University of Technology, Ilmenau, Germany, [3]CiS Research Institute, Erfurt, Germany

R9 352 **Light-Soaking Measurements of Commercially Available CIGS PV Modules**
Lawrence Dunn, Michael Gostein
Atonometrics, Inc., Austin, TX, USA

R11 353 **A Study of Thermal, Voltage, and Photoinduced Effects on the External Quantum Efficiency of CuInGaSe$_2$ (CIGS) Photovoltaic Devices**
Rebekah K. Feist, Michael Mills, R. Kirk Thompson, Narayan Ramesh
The Dow Chemical Company, Midland, MI, USA

R13 354 **Photothermal Spectroscopy on Multicrystalline Silicon Solar Cell Materials by Dual Sampling Method in Atomic Force Microscopy**
Kenji Hara[1], Takuji Takahashi[1,2]
[1]Institute of Industrial Science, The University of Tokyo, Tokyo, Japan, [2]Institute for Nano Quantum Information Electronics, The University of Tokyo, Tokyo, Japan

R15 355 **Insolation-Dependent Solar Module Performance Evaluation from PV Monitoring Data**
Volker Herbort[1], Reinhold von Schwerin[2], Ben Compton[4], Leo Brecht[5], Henrik te Heesen[1]
[1]meteocontrol GmbH, Augsburg, Germany, [2]University of Applied Sciences, Ulm, Germany, [3]Ulm University, Ulm, Germany, [4]meteocontrol North America, Alameda, CA, USA

R17 356 **The Effect of Back-Surface Reflectance on the Interpretation of Internal Quantum Efficiency Data**
Gregory S. Horner[1], Maciej Dybiec[2], John Schmidt[3], Timothy J. Coutts[4], Ethan A. Good[2], Leonid A. Vasilyev[1], Kyle Lu[1], James E. Hudson[1]
[1]Tau Science Corporation, Beaverton, OR, USA, [2]Solarworld Industries America, Hillsboro, OR, USA, [3]Tau Science Corporation, Mountain View, CA, USA, [4]Timothy J. Coutts Consulting, Golden, CO, USA

R19 357 **Fast Characterization of Tandem Solar Cells**
Juan Jimeno[1], Carmen Ikaran[1], Joseba Ezquerra[1], Ignacio Ruiz[2]
[1]UPV/EHU, Zamudio, Spain, [2]Agilent Technologies, Getxo, Spain

R21 358 **A Cost-Effective Method for PV Module Field Test Using an Electronic Load**
Ahn Jin-Ho, Cho Eun-Chel, Hwang Myung-Ick, Shin Seung-Min, Kim Hyun-Il
Hyundai Heavy Industries, Eumseong-Kun, South Korea

R23 359 **Investigation of Defects in n⁺-CdS/p-CdTe Solar Cells**
P.R. Kharangarh[1], D. Misra[2], G.E. Georgiou[1], A.E. Delahoy[1], Z. Cheng[1], G. Liu[1], H. Opyrchal[1], T. Gessert[3], K.K. Chin[1]
[1]Dept. of Physics and Apollo CdTe Solar Energy Center, NJIT, University Heights, NJ, USA, [2]Dept. of Electrical and Computer Engineering, NJIT, University Heights, NJ, USA, [3]NREL, Golden, CO, USA

S1 360 **Algorithm for Building a Simulator Spectrum for NREL One-Sun Multi-Source Simulator**
Tom Moriarty[1], Joe Jablonski[2], Keith Emery[1]
[1]National Renewable Energy Lab, Golden, CO, USA, [2]Labsphere, Inc., North Sutton, NJ, USA

S3 361 **Comparative Study of a Directly-Cooled PV Water Heating System to a Naturally-Cooled Module in South Africa**
Busiso Mtunzi, Edson L. Meyer
University of Fort Hare, Institute of Technology, Alice, Eastern Cape, South Africa

S5 362 **Steady State Photoconductance: A new parameter to predict solar cell performance**
Bijaya B Paudyal[1], Steve Johnston[2], David House[1]
[1]MKS Instruments Inc., San Jose, CA, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

S7 363 **Method for Estimating the Power Conversion Output in Photovoltaic Systems with More than One Maximum Power Point Tracking Device**
Stephen G. Pisklak[1], Michael E. Mills[1], Conor Quinn[2]
[1]Dow Chemical, Midland, MI, USA, [2]Emerson Network Power, Eden Prarie, MN, USA

S9 364 **Indoor-Outdoor Measurement Inter-Comparison of c-Si CPV Cells at 1X to 300X: Spectral and Capacitive Effects**
Mauro Pravettoni[1], Raffaele Fucci[2], Matthew Norton[3]
[1]University of Applied Sciences and Arts of Southern Switzerland (SUPSI-ISAAC), Canobbio, Switzerland, [2]Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Portici, Italy, [3]University of Cyprus, Department of Electrical and Computer Engineering, PV Technology, Nicosia, Cyprus

S11 365 **PV Fire Safety: Examining the Conductivity of Water Jets and Nozzles at a Simulated PV Solar Array of 1kV**
Florian Reil[1], Ferdi Gülenc[1], Willi Vaassen[1], Annett Sepanski[1], Bettina van Heeckeren[1], Horst Thiem[2]
[1]TÜV Rheinland Energie und Umwelt GmbH, Cologne, Germany, [2]Fire Department, Munich, Germany

S13 366 **Characterization of Diffuse Anisotropic Illumination Effects to the Output of Bifacial and Holographic Planar Concentrating Photovoltaic Panel Configurations**
Juan M. Russo[1], Deming Zhang[1], Michael Gordon[2], Shelby Vorndran[2], Jose Castillo[3], Adria Brooks[4], Vincent Lonij[4], Alex Cronin[4], Raymond K. Kostuk[1]
[1]The University of Arizona Department of Electrical and Computer Engineering, Tucson, AZ, USA, [2]The University of Arizona College of Optical Sciences, Tucson, AZ, USA, [3]Prism Solar Technologies, Inc., Tucson, AZ, USA, [4]The University of Arizona Department of Physics, Tucson, AZ, USA

S15 367 **A Newton-Raphson Method Approach to Adjusting Multi-Source Solar Simulators**
David B. Snyder, David S. Wolford
NASA Glenn Research Center, Cleveland, OH, USA

S17 368 **Sub-Hourly Irradiance Models on the Plane of Array for Photovoltaic Energy Forecasting Applications**
Giuseppe Marco Tina[1], Sebastiano De Fiore[2], Ventura Cristina[1]
[1]University of Catania, Catania, Italy, [2]Softeco Sismat SpA, Genoa, Italy

S19 369 **Analysis of Solar Cell Quality Using Voltage Metrics**
Eric S. Toberer[1], Adele C. Tamboli[1], Myles Steiner[2], Sarah Kurtz[2]
[1]Colorado School of Mines, Golden, CO, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

S21 370 **Evaluating TCO Long-Term Performance by Electrochemical Corrosion Test and Residual Film Stress Analysis**
Mei Wen, Pierre Ricou
Arkema Inc., King of Prussia, PA, USA

S23 371 **A Multi-Purpose Wafer Scanning System for PV Inspection**
Chris Yang[1], Steven Danyluk[2]
[1]Manufacturing Research Center, Georgia Institute of Technology, Atlanta, GA, USA, [2]G.W.W School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, USA

T1 372 **Diagnosis Photovoltaic Failure by Simple Function Method to Acquire *I-V* Curve of Photovoltaic Modules String**
Hirata Youichi, Noro Shouta, Aoki Takumi, Miyazawa Satoru
Tokyo University of Science, Suwa, Nagano, Japan

T3 373 **Temperature and Reverse Voltage on Shaded PV Cell Under Hot Spot Test Condition**
Qi Zhang
Solaria, Fremont, CA, USA

10:30 - 12:00 PM **EH4-G**

Area 9: Modules and Systems: Inverters, Balance-of-System Devices, and Module Shading (Posters)

Chair(s): Mike Ropp, Rob Sorensen, Chris Deline

T9 374 **Development of a Low-Cost Induction Motor Drive System Using a PVM, Boost Converter and Three-Phase Inverter**
Nelson M. Méndez-Gómez, Orlando Bousoño, Ricardo Castañeyra, Eduardo I. Ortiz-Rivera
University of Puerto Rico - Mayagüez, Mayagüez, PR, USA

T13 375 **Decision-Making Framework for Solar Photovoltaic Power Conditioning Unit Topologies Using Six Sigma**
Harish S. Krishnamoorthy, Poornima Mazumdar, Ilaval Manickam, Robert S. Balog, Prasad N. Enjeti
Texas A&M University, College Station, TX, USA

T17 376 **Differential Power Processing for Efficiency and Performance Leaps in Utility-Scale Photovoltaics**
Pradeep Shenoy[1], Philip T. Krein[1], Patrick L. Chapman[2]
[1]University of Illinois, Urbana, IL, USA, [2]SolarBridge Technologies, Austin, TX, USA

T21 377 **Implementation of Advanced Inverter Interoperability and Functionality**
Sigifredo Gonzalez[1], Frank Hoffmann[2], Michael Mills-Price[3], Mark Ralph[1], Abraham Ellis[1]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]Princeton Power Systems, Princeton, NJ, USA, [3]Advanced Energy, Bend, OR, USA

U1 378 **Determination of Parasitic Parameters in a High Frequency Magnetic to Improve the Manufacturability, Performance, and Efficiency of a PV Inverter**
Mohammad B. Shadmand, Robert S. Balog
Texas A&M University, College Station, TX, USA

U5 379 **Optimum Core Dimension for Minimizing Proximity Effect Losses of an AC Inductor for a Galvanically Isolated PV Inverter**
Abozar Alabakhshizadeh[1,3], Ole-Morten Midtgård[1,2]
[1]University of Agder, Grimstad, Norway, [2]Norwegian University of Science and Technology, Trondheim, Norway, [3]Eltek, Kristiansand, Norway

U9 380 **PV Arc-Fault Detector Algorithm Evaluation Method Utilizing Prerecorded Arcing Signatures**
Jack Kang[1], Jay Johnson[2]
[1]Sensata Technologies, Attleboro, MA, USA, [2]Sandia National Laboratories, Albuquerque, NM, USA

U13 381 **Cross-Talk Nuisance Trip Testing of Photovoltaic DC Arc-Fault Detectors**
Jay Johnson[1], Chris Oberhauser[2], Sigifredo Gonzalez[1], Armando Fresquez[1], Michael Montoya [1], Ash Patel [2]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]Texas Instruments, Santa Clara, CA, USA

U17 382 **Module Mismatch Loss and Recoverable Power in Unshaded PV Installations**
Sara MacAlpine[1], Chris Deline[2], Michael Brandemuehl[1], Robert Erickson[1]
[1]University of Colorado, Boulder, CO, USA, [2]National Renewable Energy Laboratory (NREL), Golden, CO, USA

U21 383 **A Survey of Maximum PPT Techniques of PV Systems**
Mohamed Saied
Abu Qir Fertilizers & Chemical Industries Company (AFC), Alexandria, Egypt

V1 384 **Impact of PV Module Mismatch on the PV Array Energy Yield and Comparison of Module, String and Central MPPT**
Panagiotis Bakas, Antonis Marinopoulos, Bengt Stridh
ABB Corporate Research, Västerås, Sweden

V5 385 **In-situ measurements applied to large PV grid-connected inverters (100 kW- 1 MW)**
Vicente Salas
Universidad Carlos III de Madrid, Leganes, Spain

V9 386 **A Control Strategy to Reduce the Effect of Intermittent Solar Radiation and Wind Velocity in the Hybrid Photovoltaic/Wind SCIG System Without Losing MPPT**
Rupesh G. Wandhare, Vivek Agarwal
Indian Institute of Technology- Bombay, Mumbai, India

V13 387 **Novel Three-Phase Single Power Stage Photovoltaic Inverter Topology with MPPT**
Moumita Das, Vivek Agarwal
IIT Bombay, Mumbai, India

V17 388 **Exact Maximum Power Point Tracking for Partially-Shaded PV Strings Based on Current Equalization Concept**
Pooja Sharma[1], Pradeep K. Peter[2], Vivek Agarwal[1]
[1]Indian Institute of Technology Bombay, Mumbai, India, [2]Indian Space Research Organization, Banglore, India

V21 389 **Run-Time Partially Reconfigurable FPGA Applications in PV-Fed Systems**
Sajeesh Kumar, Vivek Agarwal
Dept. of Electrical Engineering, IIT Bombay, Mumbai, India

W1 390 **Development of a Field Programmable Gate Array (FPGA)-Based Photovoltaic Panel Emulator Based on a DC/DC Converter**
Hayrettin Can, Koray Sener Parlak, Damla Ickilli
Firat University, Elazig, Turkey

W5 391 **Switched Capacitor DC-DC Converter-Based Current Equalization Scheme for Maximum Power Extraction from Partially-Shaded PV Modules Without Bypass Diodes**
Pradeep Peter[1], Pooja Sharma[2], Vivek Agarwal[2]
[1]Indian Space Research Organization, Bangalore, India, [2]Indian Institute of Technology-Bombay, Mumbai, India

W9 392 **High-Gain, High-Efficiency DC-DC Converter with Soft Switching Feature**
Vivek Agarwal[2], Sachin Jain[1]
[1]IIT-Bombay,Mumbai, Bombay, India, [2]Schneider-Electric, Bangalore, India

W13 393 **Maximum Power Point Tracking Method Under Partial Shading Conditions**
Chee Lim Nge[1,2], Ole-Morten Midtgard[2], Lars Norum[1]
[1]Norwegian University of Science and Technology, Trondheim, Norway, [2]University of Agder, Grimstad, Norway

W17 394 **Analysis of Photovoltaic Array with Reconfigurable Modules Under Partial Shading**
Priyanka O. Singh[1], Srinivasa R. Vemuru[2], Mohammad Niamt[1]
[1]Department of EECS, The University of Toledo, Toledo, OH, USA, [2]Department of ECE, Ohio Northern University, Ada, OH, USA

W21 395 **Switch-Based Reconfigurable Photovoltaic Array for Power Maximization**
Kalpesh C. Chheladiya[1], Paresh N. Chavada[1], Hetal G. Bhatt[2], Rajesh A. Thakker[1]
[1]Electronics and Communication Department, VGEC, Gandhinagar, India, [2]Electronics and Communication Department, S.P.C.E., Visnagar, India

W24 396 **Controlled-Partial-Shading Evaluation of PV Arrays During Realistic Operation**
Abraham K. Ishihara
Carnegie Mellon University, Moffett Field, CA, USA

X3
397 **String-Level (Kw-Scale) IV Curves from Different Types Of Modules Under Partial Shade**
Patricia L. Hidalgo-Gonzalez[1,2], Adria E. Brooks[2,3], Emily S. Kopp[4], Vincent P. Lonij[2], Alexander D. Cronin[2,3,4]
[1]Pontificia Universidad Catolica de Chile, Santiago, Chile, [2]University of Arizona, Department of Physics, Tucson, AZ, USA, [3]Arizona Research Institute for Solar Energy, Tucson, AZ, USA, [4]University of Arizona, College of Optical Sciences, Tucson, AZ, USA

X6
398 **Architecture of a Smart Photovoltaic Module**
Peter Mark Jansson[1,2], Carlos Barreiro[2,3], John L. Schmalzel[2,4]
[1]Bucknell University, Lewisburg, PA, USA, [2]Center for Sustainable Design, Glassboro, NJ, USA, [3]Alencon Systems, Inc, Plymouth Meeting, PA, USA, [4]Rowan University, Glassboro, NJ, USA

X9
399 **Evaluation of Economical Benefit of Cleaning of Soiling and Snow in PV Plants at Three Selected Locations in Europe**
Bengt Stridh
ABB Corporate Research, Västerås, Sweden

X12
400 **Output Performance and Payback Analysis of a Residential Photovoltaic System in Colorado**
Steven W. Johnston
National Renewable Energy Laboratory, Golden, CO, USA

10:30 - 12:00 PM **19B**

Area 10: PV Velocity Forum: PV Executive Forum

Chair(s): Dave Parrillo

401 **PV Executive Forum**
Danielle Merfeld
GE Global Research

402 **PV Executive Forum**
Zhengrong Shi
Suntech

403 **PV Executive Forum**
Cai Steger
Energy Analyst, NRDC

404 **PV Executive Forum**
Frank Mierlo
1366 Technologies

405 **PV Executive Forum**
Yanev Suissa
New Enterprise Associates, Washington, DC, USA

1:30 - 3:00 PM **18AB**

Area 1: Fundamentals and New Concepts: Quantum Well Solar Cells (Orals)

Chair(s): Ryne P. Raffaelle, Martha Symko-Davies, Greg Wilson

1:30
406

Best Student Presentation Award Finalist

High-Aspect-Ratio Structures for Efficient Light Absorption and Carrier Transport in InGaAs/GaAsP Multiple Quantum Well Solar Cells

Hiromasa Fujii[1], Yunpeng Wang[2], Kentaroh Watanabe[2], Masakazu Sugiyama[1], Yoshiaki Nakano[2]

[1]Department of Electrical Engineering and Information Systems, the University of Tokyo, Tokyo, Japan, [2]Research Center for Advanced Science and Technology, Tokyo, Japan

2:00
407

The Optimization of High Phosphorus Content InGaAs/GaAsP Strained Layer Superlattices for Use in Multijunction Solar Cells

Conrad Z. Carlin[1], Joshua P. Samberg[2], Geoffrey K. Bradshaw[1], Nadia A. El-Masry[2], Peter C. Colter[1], Salah M. Bedair[1]

[1]Department of Electrical and Computer Engineering, North Carolina State University, Raleigh, NC, USA, [2]Department of Materials Science and Engineering, North Carolina State University, Raleigh, NC, USA

2:15
408

Best Student Presentation Award Finalist

Multijunction Solar Cell with Dilute Nitride Cascaded Quantum Wells Design

Gopi K Vijaya, Akhil Mehrotra, Andenet Alemu, Alexandre Freundlich

University of Houston, Houston, TX, USA

2:30
409

Effect of GaAs Step Layer Thickness in InGaAs/GaAsP Stepped Quantum Well Solar Cell

Yu Wen[1], Yunpeng Wang[1], Kentaroh Watanabe[1], Masakazu Sugiyama[2], Yoshiaki Nakano[1]

[1]Research Center for Advanced Science and Technology, the, University of Tokyo, Tokyo, Japan, [2]Department of Electrical Engineering and Information Systems, School of Engineering, the University of Tokyo, Tokyo, Japan

2:45
410

Optimization of MOCVD-Grown MQW Structures for Triple-Junction Solar Cells

Chris W. Ebert[1], C.L. Reynolds Jr.[2], Davood Shahrjerdi[3], T.A. Rawdanowicz[2], Ziggy Pulwin[1], Frank Lu[1], Devon Dyer[1]

[1]Veeco Instrumnets, Somerset, NJ, USA, [2]North Carolina State University, Raleigh, NC, USA, [3]IBM T.J. Watsion Research Center, Yorktown Heights, NY, USA

1:30 - 3:00 PM **18CD**

Area 2: Polycrystalline Thin Films: Absorber and Device Modeling (Orals)

Chair(s): Susanne Siebentritt, Jim Sites

1:30 411 **Characterization and Understanding of Performance Losses in a Highly-Efficient Solution-Processed CZTSSe Thin-Film Solar Cell**
Kaushik Roy Choudhury, Yanyan Cao, Jonathan V. Caspar, William E. Farneth, Qijie Guo, Alex S. Ionkin, Lynda K. Johnson, Meijun Lu, Irina Malajovich, Daniela Radu, H David Rosenfeld, Wei Wu
The DuPont Company, Central Research and Development, Experimental Station, Wilmington, DE, USA

1:45 412 **Best Student Presentation Award Finalist**
Influence of Ge Doping on the Defect Distributions of $Cu_2Zn(Sn_xGe_{1-x})(S_ySe_{1-y})$ Fabricated by Nanocrystal Ink Deposition with Selenization
James Moore[1], Charles Hages[2], Mark Lundstrom[1], Rakesh Agrawal[2]
[1]Department of Electrical and Computer Engineering, Purdue University, Lafayette, IN, USA, [2]Department of Chemical Engineering, Purdue University, Lafayette, IN, USA

2:00 413 **2-D Finite Element Model of a CIGS Module**
Gaby J.M. Janssen, Lenneke H. Slooff, Evert E. Bende
ECN Solar Energy, Petten, Netherlands

2:15 414 **Determination of Grain-Boundary Charging in $Cu(In,Ga)Se_2$ Thin Films**
Chun-Sheng Jiang, Miguel A. Contreras, Ingrid Repins, Helio R. Moutinho, Rommel Noufi, Mowafak M. Al-Jassim
National Renewable Energy Laboratory, Golden, CO, USA

2:30 415 **Modeling the Effects of Na Incorporation on CIGS Solar Cells**
Elif S. Mungan, Xufeng Wang, Muhammad A. Alam
Purdue University, West Lafayette, IN, USA

2:45 416 **Toward Ultrathin CIGS Solar Cells**
Sylvain Marsillac[1], Vikash Ranjan[1], Krishna Aryal[1], Scott Little[2], Yunus Erkaya[1], Grace Rajan[1], Patrick Boland[1], Dinesh Attygalle[2], Puruswottam Aryal[2], Puja Pradhan[2], Robert W. Collins[2]
[1]Old Dominion University, Norfolk, VA, USA, [2]The University of Toledo, Toledo, OH, USA

1:30 - 3:00 PM **Blrm G**

Area 4: Crystalline Silicon: Fundamentals (Orals)

Chair(s): Mariana Bertoni, Gianluca Coletti

3:30 417 **Diffusion Gettering of Metal Impurities in Crystalline Silicon**
Hele I. Savin
Aalto University, Espoo, Finland

4:15 418 **Quantification of Atomic-Scale Defects in Poly Si PV Devices Using Atom Probe Tomography**
Brian P. Gorman[1], Harvey L. Guthrey[1, 2], Mowafak Al-Jassim[2], David R. Diercks[1]
[1]Colorado School of Mines, Golden, CO, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

4:30 419 **Effect of Dislocation-Impurity Interaction on Dislocation Annihilation in Solar-Grade Silicon**
Hyunjoo Choi, Mariana Bertoni, Jasmin Hofstetter, David Fenning, Sergio Castellanos, Douglas Powell, Tonio Buonassisi
Massachusetts Institute of Technology, Cambridge, MA, USA

4:45 420 **Impurity-Related Limitations of Next-Generation Industrial Silicon Solar Cells**
Jan Schmidt[1,2], Bianca Lim[1], Karsten Bothe[1], Sebastian Gatz[1], Thorsten Dullweber[1], Pietro P. Altermatt[2]
[1]Institute for Solar Energy Research Hamelin (ISFH), Emmerthal, Germany, [2]Institute of Solid-State Physics, Leibniz Univerity of Hanover, Hanover, Germany

1:30 - 3:00 PM **19A**

Area 5: Thin-Film Silicon: Solar Cells and Modules (Orals)

Chair(s): Christophe Ballif, Arno Smets

1:30 421 **Towards High-Efficiency Thin n-i-p Micromorph Solar Cells on Plastic**
Rémi Biron, Grégory Bugnon, Escarré Jordi, Franz-Josef Haug, Christophe Ballif
Ecole Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering (IMT), Photovoltaics and Thin Film Electronics Laboratory, Neuchâtel, Switzerland

2:00 422 **Deposition of High-Efficiency Microcrystalline Silicon Solar Cells Using $SiF_4/H_2/Ar$ Mixtures**
Jean-Christophe Dornstetter[1,2], Samir Kasouit[1], Pere Roca i Cabarrocas[2]
[1]TOTAL S.A. Gas & Power, Paris La defense, France, [2]LPICM-CNRS, Palaiseau, France

2:15 423 **Best Student Presentation Award Finalist**
On the Interplay Between Material Quality and Interfaces in High-Efficiency Microcrystalline Silicon Solar Cells
Simon Hänni, Mathieu Boccard, Laura Ding, Corsin Battaglia, Grégory Bugnon, Peter Cuony, Jordi Escarré, Gaetano Parascandolo, Sylvain Nicolay, Matthieu Despeisse, Fanny Meillaud, Ballif Christophe
Institute of Microengineering (IMT), Ecole Polytechnique Fédérale de Lausanne (EPFL), Laboratory of Photovoltaics and Thin Film Electronics, Neuchâtel, Switzerland

2:30 424 **Progress in Research and Mass Production of Large-Scale Thin-Film Si Solar Cells**
Xinwei Niu, Minghua Wang, Xin Zhu, Cao Yu, Guijun Li, Bing Cheng, Junmei Rong, Zhen Chen, Jian Ding, Liyou Yang
Chint Solar (Zhejiang) Co. Ltd., Hangzhou, China

2:45 425 **Correlations Between Mapping Spectroscopic Ellipsometry Results and Solar Cell Performance for Evaluations of Non-Uniformity in Thin-Film Silicon Photovoltaics**
Lila Dahal[1], Zhiquan Huang[1], Dinesh Attygalle[1], Carl Salupo[1], S. Marsillac[2], N.J. Podraza[1], R.W. Collins[1]
[1]Center for Photovoltaics Innovation and Commercialization, University of Toledo, Toledo, OH, USA, [2]Department of Electrical and Computer Engineering, Old Dominion University, Norfolk, VA, USA

1:30 - 3:00 PM **17A**

Area 8: PV Characterization: Challenges in Characterization of Multijunction Devices (Orals)

Chair(s): Keith Emery, Gerald Siefer

1:30 426 **Electro- and Photoluminescence Characterization of Multijunction Solar Cells**
Helmut Nesswetter[1], Paolo Lugli[2], Claus G. Zimmermann[1]
[1]EADS Astrium GmbH, Munich, Germany, [2]Institute for Nanoelectronics, Technical University of Munich, Munich, Germany

2:00 427 **Best Student Presentation Award Finalist**
Elimination of Measurement Artifacts of External Quantum Efficiency of Multijunction Solar Cells Using a Pulse Light Bias
Jing-Jing Li, Yong-Hang Zhang
Arizona State University, Tempe, AZ, USA

2:15 428 **Spatial Characterization Techniques for Dye-Sensitized Solar Cells**
Matevz Bokalic, Ursa Opara Krasovec, Mateja Hocevar, Marko Topic
University of Ljubljana, Faculty of Electrical Engineering, Ljubljana, Slovenia

2:30 429 **A Low-Cost Weather-Balloon Borne Solar Cell Calibration Payload**
David B. Snyder, David S. Wolford
NASA Glenn Research Center, Cleveland, OH, USA

2:45 430 **Best Student Presentation Award Finalist**
Characterization of a TS-Space Quad-Source Solar Simulator
Kyle H. Montgomery[1,2], David M. Wilt[1], Alex Howard[1], Bill Williams, Sr.[3], Bill Williams, Jr.[3]
[1]Air Force Research Laboratory Space Vehicles Directorate, Kirtland AFB, NM, USA, [2]School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, USA, [3]TS-Space Systems, Marlow, United Kingdom

1:30 - 3:00 PM **16AB**

Area 9: Modules and Systems: Systems Design, Control, and Performance (Orals)

Chair(s): Greg Ball, Angele Reinders

1:30 431 **PV Output Smoothing with Energy Storage**
Abraham Ellis, David Schoenwald
Sandia National Laboratories, Albuquerque, NM, USA

1:45 432 **New Approaches for Characterizing Photovoltaic System Performance**
Owen W. Westbrook, Beth H. Copanas, Forrest D. Collins
Juwi solar, Inc., Boulder, CO, USA

2:00 433 **Photovoltaic Prognostics and Heath Management Using Learning Algorithms**
Daniel Riley, Jay Johnson
Sandia National Laboratories, Albuquerque, NM, USA

2:15 434 **Best Student Presentation Award Finalist**
A Modified Control Strategy for Centralized PV – Grid Systems for Assisting Dynamic Stability to Overcome Penetration Issues
Rupesh G. Wandhare, Vivek Agarwal
Indian Institute of Technology - Bombay, Mumbai, India

2:30 435 **Interconnection Wiring Considerations in Evaluating Large Photovoltaic System Designs**
Jumie N. Yuventi
Electrical Engineering, Stanford University, Stanford, CA, USA

2:45 436 **System Performance Analysis and Estimations of Degradation Rates Based on 500 Years of Monitoring Data**
Nils Reich, Alexander Goebel, Daniela Dirnberger, Christian Reise, Klaus Kiefer
Fraunhofer ISE, Freiburg, Germany

1:30 - 3:10 PM **19B**

Area 10: PV Velocity Forum: National Programs (Orals)

Chair(s): Elaine Ulrich

1:50 437 **Overview of Korean PV programs**
Donghwan Kim
Korea University, Seoul, Korea

2:10 438 **Importance of PV and Overview of Japanese PV Programs**
Sadao Wasaka
NEDO

2:30 439 **Overview of Chinese PV Programs**

2:50 440 **US Department of Energy SunShot Initiative**
Ramamoorthy Ramesh
US Dept of Energy

3:00 - 3:30 PM **Exhibit Hall 4**

Coffee Break

3:30 - 5:00 PM **18AB**

Area 1: Fundamentals and New Concepts: Light Concentration and Light Trapping 1 (Orals)

Chair(s): Ryne P. Raffaelle, Seth Hubbard

3:30 441 **The Opto-Electronic Physics That Broke the Efficiency Limit in Solar Cells**
Eli Yablonovitch[1,2], Owen D. Miller[1,2], Sarah R. Kurtz[3]
[1]Material Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA, [2]University of California, Berkeley, Dept. of Electrical Engineering & Computer Science, Berkeley, CA, USA, [3]National Renewable Energy Laboratory, Golden, CO, USA

4:00 442 **Two-Photon Excitation in a Dilute Nitride Intermediate-Band Solar Cell**
Nazmul Ahsan[1], Naoya Miyashita[1], Muhammad Monirul Islam[1], Kin Man Yu[2], Wladek Walukiewicz[2], Yoshitaka Okada[1]
[1]The University of Tokyo, Tokyo, Japan, [2]Lawrence Berkeley National Laboratory, Berkeley, CA, USA

4:15 443 **Mid-IR Photovoltaic Devices Based on Interband Cascade Structures**
Zhaobing Tian[1], Robert T. Hinkey[1,2], Rui Q. Yang[1], John F. Klem[3], Matthew B. Johnson[2]
[1]School of Electrical and Computer Engineering, University of Oklahoma, Norman, OK, USA, [2]Homer L. Dodge Department of Physics and Astronomy, Norman, OK, USA, [3]Sandia National Laboratories, Albuquerque, NM, USA

4:30 444 **Performance Benefits for Thin-Film Solar Cells Incorporating Semiconductor Heterostructures and Light Trapping**
Claiborne O McPheeters[1], Dongzhi Hu[2], Xiaohan Li[1], Daniel M Schaadt[2], Edward T Yu[1]
[1]Microelectronics Research Center, Department of Electrical and Computer Engineering, The University of Texas at Austin, Austin, TX, USA, [2]Institute of Energy Research and Physical Technologies/Energy Research Center of Lower Saxony, Clausthal University of Technology, Goslar, Germany

4:45 445 **Best Student Presentation Award Finalist** **Inverse Electromagnetic Design for Subwavelength Light Trapping**
Vidya Ganapati[1,2], Owen D. Miller[1,2], Eli Yablonovitch[1,2]
[1]University of California, Berkeley, Berkeley, CA, USA, [2]Lawrence Berkeley National Laboratory, Berkeley, CA, USA

3:30 - 5:00 PM **18CD**

Area 2: Polycrystalline Thin Films: Junctions and Device Stability (Orals)

Chair(s): Rommel Noufi, Marcus Bär

3:30 446 **Buffer and Transparent Conducting Oxide Layers for CIGS-Based Thin-Film Solar Cells**
Tokio Nakada
Aoyama Gakuin University, Kanagawa, Japan

4:00 447 **Buffer-Less Cu(In,Ga)Se_2 Solar Cells with New Transparent Electrode for Band Offset Control**
Takashi Minemoto, Jasmeen Julayhi
Ritsumeikan University, Kusatsu, Japan

4:15 448 **Optical Properties of Zn(O,S) Thin Films Deposited by RF Sputtering, Atomic Layer Deposition, and Chemical Bath Deposition**
Jian Li[1,2], Stephen Glynn[1], Steven Christensen[1], Jonathan Mann[1], Bobby To[1], Kannan Ramanathan[1], Rommel Noufi[1], Thomas E. Furtak[2], Dean Levi[1]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Department of Physics, Colorado School of Mines, Golden, CO, USA

4:30 449 **Accelerated Aging and Contact Degradation of CIGS Solar Cells**
Thomas Ott[1], Thomas Walter[1], Dimitrios Hariskos[2], Oliver Kiowski[2], Raymund Schäffler[3]
[1]University of Applied Sciences, Ulm, Germany, [2]Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden Württemberg, Stuttgart, Germany, [3]Manz CIGS Technology GmbH, Schwäbisch Hall, Germany

4:45 450 **The Effects of Device Geometry and TCO/Buffer Layers on Damp Heat Accelerated Lifetime Testing of Cu(In,Ga)Se_2 Solar Cells**
Christopher P. Thompson[1], Steven S. Hegedus[1], Peter F. Carcia[2], R. Scott McLean[2]
[1]Institute of Energy Conversion, University of Delaware, Newark, DE, USA, [2]DuPont Research and Development, Experimental Station, Wilmington, DE, USA

3:30 - 5:00 PM **Blrm G**

Area 4: Crystalline Silicon: Advanced Devices (Orals)

Chair(s): Dave Carlson, Tonio Buonassisi

1:30 451 **Rear-Surface Passivation Technology for Large-Scale Manufacturing of High-Efficiency Crystalline Silicon Solar Cells**
A. Metz, Y. Gassenbauer, J. D. Moschner, M. Fiedler, K. Dressler, E. Brower, B. Bethmann, M. Feldhaus, N. Lenck
SCHOTT Solar AG, Alzenau, Germany

1:45 452 **Effects of Process Conditions for the n^+-Emitter Formation in Crystalline Silicon**
Amir Dastgheib-Shirazi[1], Hannes Wagner[2], Michael Steyer[1], Giso Hahn[1]
[1]Div. Photovoltaics, Dep. of Physics, University of Konstanz, Konstanz, Germany, [2]Dep. Solar Energy, Inst. Solid-State Physics, Leibniz University of Hannover, Hannover, Germany

2:00 453 **High-Efficiency Heterojunction Solar Cells on Crystalline Silicon and Germanium Substrates Enabled by Low-Temperature Epitaxial Growth of Silicon**
Bahman Hekmatshoar, Davood Shahrjerdi, Stephen W. Bedell, Devendra K. Sadana
IBM T.J. Watson Research Center, Yorktown Heights, NY, USA

2:15 454 **Generation III High-Efficiency Lower-Cost Technology: Transition to Full-Scale Manufacturing**
David D. Smith, Peter J. Cousins, Asnat Masad, Staffan Westerberg, Michael Johnson, Xiuwen Tu, Tim Dennis, Gabriel Harley, Genevieve Solomon, Seung Rim, Michael Shepherd, Scott Herrington, Michael Defensor, Arjelene Leygo, Princess Tomada, Junbo Wu
SunPower Corp., San Jose, CA, USA

2:30 455 **Stack-Junction Approach to Overcome Silicon Single-Junction Limit**
Dongkyun Kim, Youngmoon Choi, Eun Cheol Do, Chulki Kim, Yeonil Lee, Yun Gi Kim
Energy Lab, Samsung Advanced Institute of Technology, Yongin-si, Korea

2:45 456 **SLASH Concept: A Novel Approach for Simplified Interdigitated Back Contact Solar Cells Fabrication**
Thibaut Desrues, Sylvain De Vecchi, Florent Souche, Delfina Munoz, Pierre-Jean Ribeyron
CEA-INES, Le Bourget du Lac, France

3:30 - 5:00 PM **19A**

Area 5: Thin-Film Silicon: Novel Concepts: Hybrid, Plasmonics and Diagnostic Tools (Orals)

Chair(s): Hitoshi Sai, Yasushi Sobajima

3:30
457 **Ultra Light-Trapping Filters with Broadband Reflection Volume Holograms**
Deming Zhang[1], Shelby Vorndran[2], Juan M. Russo[1], Michael Gordon[2], Raymond K. Kostuk[1]
[1]University of Arizona Electrical and Computer Engineering Department, Tucson, AZ, USA, [2]University of Arizona College of Optical Sciences, Tucson, AZ, USA

3:45
458 **Novel Hybrid Amorphous Si/Organic Solar Cell**
Vikram Dalal, Sambit Pattnaik, Teng Xiao, Ruth Shinar, Joseph Shinar
Iowa State University, Ames, IA, USA

4:00
459 **Best Student Presentation Award Finalist Nanoparticles-Based Plasmonic Back Reflector for High-Efficiency Thin-Film Silicon Solar Cells**
Hairen Tan, Rudi Santbergen, Guangtao Yang, Miro Zeman, Arno Smets
Photovoltaic Materials and Devices Laboratory, Delft University of Technology, Deflt, Netherlands

4:15
460 **Coupled Optical and Electrical Design of Plasmonic and Nanophotonic Thin-Film Amorphous Silicon Solar Cells**
Michael G. Deceglie[1], Vivian E. Ferry[2], A. Paul Alivisatos[2], Harry A. Atwater[1]
[1]Thomas J. Watson Laboratories of Applied Physics, California Institute of Technology, Pasadena, CA, USA, [2]Materials Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA

4:30
461 **Light Trapping for Thin Silicon Solar Cells by Femtosecond Laser Texturing**
Benjamin G. Lee[1], Yu-Ting Lin[2], Meng-Ju Sher[3], Eric Mazur[2,3], Howard M. Branz[1]
[1]National Center for Photovoltaics, National Renewable Energy Lab, Golden, CO, USA, [2]School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA, [3]Department of Physics, Harvard University, Cambridge, MA, USA

4:45
462 **In Situ Determination of Silane Gas Utilization and Deposition Rate for Different Deposition Regimes of µc-Si:H Using FTIR and OES In Situ**
A.J. Flikweert, J. Woerdenweber, A. Gordijn
IEK-5 Photovoltaik, Forschungszentrum Juelich GmbH, Juelich, Germany

3:30 - 5:00 PM **17A**

Area 8: PV Characterization: Defects in PV Materials and Solar Cells (Orals)

Chair(s): Manuel Romero, Martin Schubert

3:30
463
Nanoprobe-XRF and Micro-Raman Studies of Metal Impurity Decoration Around Dislocations
Mariana I. Bertoni[1], David P. Fenning[1], George Sarau[2], Markus Rinio[3], Volker Rose[4], Jorg Maser[5], Tonio Buonassisi[1]
[1]Massachusetts Institute of Technology, Cambridge, MA, USA, [2]Max Planck Institute for the Science of Light, Erlangen, Germany, [3]Fraunhofer ISE, Laboratory and Servicecenter, Gelsenkirchen, Germany, [4]Advanced Photon Source, Argonne National Laboratory, Argonne, IL, USA, [5]Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL, USA

4:00
464
Best Student Presentation Award Finalist
Non-Destructive Defect Characterization of Saw-Damage-Etched Multicrystalline Silicon Wafers Using Scanning Electron Acoustic Microscopy
Lei Meng[1,4], Satyavolu S. Papa Rao[2], Charanjit S. Bhatia[1,4], Steven E. Steen[2], Alan G. Street[3], Jacob C.H. Phang[1,3]
[1]Centre for Integrated Circuit Failure Analysis and Reliability (CICFAR), Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Singapore, [2]IBM, Thomas J. Watson Research Center, Yorktown Heights, NY, USA, [3]Inscope Labs Pte. Ltd., Singapore, Singapore, [4]Solar Energy Research Institute of Singapore (SERIS), National University of Singapore, Singapore, Singapore

4:15
465
A Model for Electron-Beam-Induced Current Analysis of mc-Si Addressing Defect Contrast Behavior in Heavily Contaminated PV Material
Harvey L. Guthrey[1,2], Brian P. Gorman[1], Gianluca Coletti[3], Mowafak M. Al-Jassim[2]
[1]Colorado School of Mines, Golden, CO, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA, [3]ECN Solar Energy, Petten, Netherlands

4:30
466
Large-Area Plan-View Transmission Electron Microscopy Sample Preparation for Multijunction Metamorphic Solar Cell Devices
M. Jackson[1], B. Jackson[1], N. Bodzin[1], A. Zakaria[2], X.-Q. Liu[2], R. King[2], M.S. Goorsky[1]
[1]UCLA Department of Materials Science and Engineering, Los Angeles, CA, USA, [2]Spectrolab, Inc., Slymar, CA, USA

4:45
467
A Comparison of Photoluminescence Imaging and Confocal Photoluminescence Microscopy in the Study of Diffusion near Isolated Extended Defects in GaAs
Timothy H. Gfroerer[1], Yong Zhang[2], Mark W. Wanlass[3]
[1]Davidson College, Davidson, NC, USA, [2]University of North Carolina at Charlotte, Charlotte, NC, USA, [3]National Renewable Energy Laboratory, Golden, CO, USA

3:30 - 5:00 PM **16AB**

Area 9: Modules and Systems: Inverters and Balance-of-System Devices (Orals)

Chair(s): Mike Fife, Sigifredo Gonzalez

3:30
468
Thermal Study of Inverter Components
N. Robert Sorensen[1], Edward V. Thomas[1], Michael A. Quintana[1], Steven Barkaszi[2], Andrew Rosenthal[3]
[1]Sandia National Labs, Albuquerque, NM, USA, [2]Florida Solar Energy Center, Cocoa, FL, USA, [3]New Mexico State University, Las Cruces, NM, USA

3:45
469
A High Power Density DC-DC Converter for Distributed PV Architectures
Mohammed Agamy, Yan Jiang, Maja Harfman Todorovic, Ahmed Elasser, Fengfeng Tao, Song Chi, Lei Wang
GE Global Research Center, Niskayuna, NY, USA

4:00
470
Partial-Shade Evaluation of Distributed Power Electronics for Photovoltaic Systems
Chris Deline[1], Jenya Meydbray[2], Matt Donovan[2]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]PV Evolution Labs, Davis, CA, USA

4:15
471
Light-Generated Effect on Power Switches Used in a Planar PV Power System with Monolithically-Embedded Power Converters
Abusaleh M. Imtiaz, Faisal H. Khan
University of Utah, Salt Lake City, UT, USA

4:30
472
A New Model-Based Method for Hot Spot Suppression in Photovoltaic Modules
Sorin Spanoche[1], David Stewart[1], Shiloh Hawley[1], Ion Opris[2]
[1]ArrayPower Inc., Sunnyvale, CA, USA, [2]Opris Consluting, San Jose, CA, USA

4:45
473
Dynamic Loss Comparison Between Fixed-State and Reconfigurable Solar Photovoltaic Array
Bhawani Patnaik, Jyotsna Mohod, Siddhartha P. Duttagupta
Indian Institute of Technology Bombay, Mumbai, India

3:30 - 5:00 PM **19B**

Area 10: PV Velocity Forum: Markets and Scalability (Orals)

Chair(s): Martha Symko-Davies

3:30 474 **PV Manufacturing Cost Analysis**
Alan Goodrich
NREL, Golden, CO, USA

3:45 475 **Best Practices in Manufacturing: Photovoltaics**
Amy Galland
As You Sow, San Francisco, CA, USA

4:00 476 **Increasing Predictability and Investor Confidence in PV Power Plants Through Latent Defect Screening**
Alex C. Mayer, Jenya Meydbray
PV Evolution Labs, Berkeley, CA, USA

4:15 477 **The History of Photovoltaic Industry Pricing and Future Direction in a Low Incentive Environment**
Paula J. Mints
Navigant, Palo Alto, CA, USA

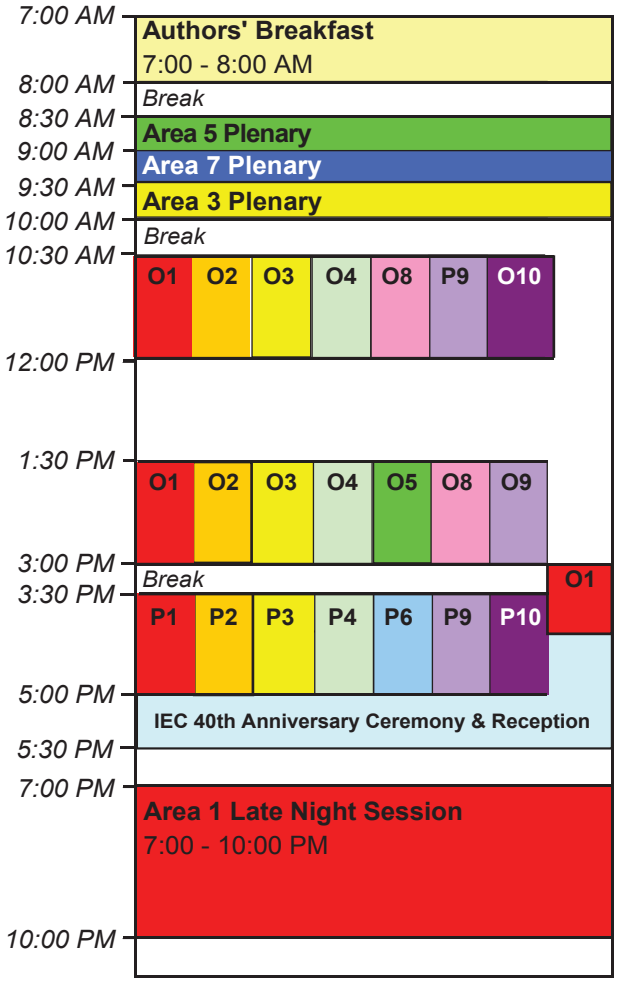
4:30 478 **The Impact of a Rapidly Changing Global PV Market on the PV Manufacturing Supply Chain**
Ray E Morgan[1], Bettina Weiss[1], Joseph Berwind[3], Stephan Raithel[2]
[1]SEMI PV Group, San Jose, CA, USA, [2]SEMI PV Group, Berlin, Germany, [3]AEI Research, Summit, NJ, USA

4:45 479 **Strategic Innovation for Accelerated Grid Penetration and Competitive Domestic Manufacturing**
Douglas M. Powell, Mark T. Winkler, Hyunjoo Choi, Christie B. Simmons, David Berney Needleman, Tonio Buonassisi
Massachusetts Institute of Technology, Cambridge, MA, USA

6:30 - 8:30 PM **Hilton Austin, Salon ABC**

Cherry Reception

WEDNESDAY PROGRAM SUMMARY



AREA LEGEND

- Area 1: Fundamentals and New Concepts for Future Technologies
- Area 2: Thin Film Polycrystalline Photovoltaics
- Area 3: III-V and Concentrator Technologies
- Area 4: Crystalline Silicon Photovoltaics
- Area 5: Thin Film Silicon Based PV Technologies
- Area 6: Organic Photovoltaics
- Area 7: Space Technologies
- Area 8: Characterization Methods
- Area 9: PV Modules and Terrestrial Systems
- Area 10: PV Velocity Forum

O = Oral Session P = Poster Session

8:00 - 8:30 AM **4th Floor Foyer**

Coffee Break

8:30 - 9:00 AM **Blrm D**

Area 5: Thin-Film Silicon: Plenary

Chair(s): Arno Smets

8:30
480 **Thin-Film Silicon Solar Cells Based on Amorphous and Microcrystalline Silicon and Silicon Alloys: New Approaches for High-Efficiency Devices and Perspectives for the Terawatt Solar Society**
Christophe Ballif
Ecole Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering (IMT), Photovoltaics and Thin-Film Electronics Laboratory (PV-Lab), Neuchâtel, Switzerland

9:00 - 9:30 AM **Blrm D**

Area 7: Space Technologies: Plenary

Chair(s): David Wilt, Steve Taylor, Mitsuru Imaizumi

9:00
481 **NASA Space Technology Program Plans for Advanced Space Power**
James Reuther
NASA Headquarters

9:30 - 10:15 AM **Blrm D**

Area 3: III-V's and Concentrators: Plenary

Chair(s): Mark Stan

9:30
482 **Low-Cost Reliable Highly-Concentrating Photovoltaics: A Reality**
Andreas Gombert
Soitec Solar GmbH, Freiburg, Germany

10:00 - 10:30 AM **Exhibit Hall 4**

Coffee Break

10:30 - 12:00 PM **18AB**

Area 1: Fundamentals and New Concepts: Simulation and Modeling of Advanced Concept Solar Cells (Orals)

Chair(s): Ryne P. Raffaelle, Seth Hubbard

10:30 483 **Simulation of Carrier Relaxation in Hot-Carrier Solar Cells**
Stephen Goodnick, Christiana Honsberg
Arizona State University, Tempe, AZ, USA

11:00 484 **The Shockley-Queisser Limit and Practical Limits of Nanostructured Photovoltaics**
Robert F. McCarthy[1], Hugh W. Hillhouse[2]
[1]Purdue University, West Lafayette, IN, USA, [2]University of Washington, Seattle, WA, USA

11:15 485 **A New Methodology for Calculating the Efficiency of Multijunction Solar Cells**
Zeev R. Abrams
University of California, Berkeley, Berkeley, CA, USA

11:30 486 **Device Simulation of Intermediate-Band Solar Cells: Dependence on Number of Intermediate-Band Layers**
Katsuhisa Yoshida[1,2], Yoshitaka Okada[1,2], Nobuyuki Sano[3]
[1]School of Engineering, The University of Tokyo, Tokyo, Japan, [2]Research Center for Advanced Science and Technology, The University of Tokyo, Tokyo, Japan, [3]Institute of Applied Physics, University of Tsukuba, Ibaraki, Japan

11:45 487 **The Effect of Photonic Bandgap Materials on the Shockley-Queisser Limit**
Jeremy N. Munday[1,2]
[1]Department of Electrical and Computer Engineering, University of Maryland, College Park, MD, USA, [2]Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, MD, USA

10:30 - 12:00 PM **18CD**

Area 2: Polycrystalline Thin Films: Window Layers and Flexible Devices (Orals)

Chair(s): Tokio Nakada, Joel Duenow

10:30 488 **Review of Progress Towards 20%-Efficiency Flexible CIGS Solar Cells and Manufacturing Issues of Solar Modules**
Adrian Chirila, Patrick Bloesch, Shiro Nishiwaki, Stephan Buecheler, Ayodhya Tiwari
EMPA, Dubendorf, Switzerland

11:00 489 **Using Amorphous Zinc-Tin Oxide Alloys in the Emitter Structure of CIGS PV Devices**
Peter A. Hersh[1], Maikel van Hest[2], Vincent Bollinger[2], Joseph J. Berry[2], David S. Ginley[2], Billy J. Stanbery[1]
[1]HelioVolt Corporation, Austin, TX, USA, [2]National Renewable Energy Labarotory, Golden, CO, USA

11:15 490 **Comparison in Cell Performance of ZnS(O,OH)/CIGS Solar Cells Using MOCVD-ZnO:B and Sputter-Deposited ZnO:Al Window Layers**
Taizo Kobayashi, Kotaro Yamauchi, Tokio Nakada
Aoyama Gakuin University, Sagamihara, Japan

11:30 491 **A Comparative Study of ZnS Buffer Layer CIGS Solar Cells Fabricated by CBD, ALD and Sputtering**
Kannan Ramanathan, Jonathan Mann, Steve Glynn, Steve Christensen, Jian Li, John Scharf, Miguel Contreras, Lorelle Mansfield, Rommel Noufi
NREL, Golden, CO, USA

11:45 492 **Cu(In,Ga)Se_2 Thin-Film Solar Cell Absorbers on Flexible Polyimide: Effect of Na on the Chemical and Electronic Surface and Interface Structure**
Regan G. Wilks[1], Xin Song[1], Raquel Caballero[1,2], Roberto Félix[1], Dominic Gerlach[1], Christian A. Kaufmann[1], Hans-Werner Schock[1], Marcus Bär[1,3]
[1]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany, [2]Universidad Autónoma de Madrid, Madrid, Spain, [3]Brandenburgische Technische Universität Cottbus, Cottbus, Germany

10:30 - 12:00 PM **17B**

Area 3: III-V's and Concentrators: Cells (Orals)

Chair(s): Mark Stan, Scott Burroughs

10:30
493
Metal Pillar Interconnection Topology for Bonded Two-Terminal Multijunction III-V Solar Cells
W.E. McMahon[1], C.-T. Lin[2], J.S. Ward[1], J.F. Geisz[1], M.W. Wanlass[1], J.J. Carapella[1], W. Olavarría[1], M. Young[1], M.A. Steiner[1], R.M. France[1], A.E. Kibbler[1], A. Duda[1], J.M. Olson[1], E.E. Perl[2], D.J. Friedman[1], J.E. Bowers[2]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]University of California at Santa Barbara, Santa Barbara, CA, USA

10:48
494
Temperature Coefficients of Concentrator Solar Cells up to Ultrahigh Irradiance
Avi Braun, Baruch Hirsch, Alexis Vossier, Eugene A. Katz, Jeffrey M. Gordon
Department of Solar Energy and Environmental Physics, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer Campus, Israel

11:06
495
Demonstration of Multiple Substrate Reuses for Inverted Metamorphic Solar Cells
Jessica G.J. Adams, Victor C. Elarde, Alexander Hains, Christopher Stender, Francis Tuminello, Christopher T. Youtsey, Andree Wibowo, Mark Osowski
MicroLink Devices, Inc., Niles, IL, USA

11:24
496
Best Student Presentation Award Finalist
Metamorphic GaAsP Solar Cells on GaP Grown by Molecular Beam Epitaxy
Stephanie Tomasulo, Kevin Nay Yaung, John Simon, Minjoo L. Lee
Yale University, New Haven, CT, USA

11:42
497
Best Student Presentation Award Finalist
Epitaxial Liftoff of GaAs Thin-Film Solar Cells Followed by Substrate Reuse
Kyusang Lee[1], Jeramy D. Zimmerman[1], Yifan Zhang[2], Stephen R. Forrest[1,2,3]
[1]Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI, USA, [2]Department of Physics, University of Michigan, Ann Arbor, MI, USA, [3]Department of Material Science and Engineering, University of Michigan, Ann Arbor, MI, USA

10:30 - 12:00 PM **Blrm G**

Area 4: Crystalline Silicon: Passivation (Orals)

Chair(s): Ron Sinton, Stefan Glunz

10:30 498 **Progress in Low-Cost n-Type Cell Technology**
L.J. Geerligs[1], I.G. Romijn[1], A.R. Burgers[1], A.W. Weeber[1], J.H. Bultman[1], Hongfang Wang[2], Fang Lang[2], Wenchao Zhao[2], Gaofei Li[2], Zhiyan Hu[2], Jingfeng Xiong[2], Ard Vlooswijk[3]
[1]ECN Solar Energy, Petten, Netherlands, [2]Yingli Solar, Baoding, China, [3]Tempress Systems BV, Vaassen, Netherlands

11:00 499 **a-Si:H/c-Si Heterojunctions: A Future Mainstream Technology for High-Efficiency Crystalline Silicon Solar Cells?**
Christophe Ballif, Loris Barraud, Antoine Descoeudres, Zachary Holman, Sophie Morel, Stefaan De Wolf
Ecole Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering (IMT), Photovoltaics and Thin-Film Electronics Laboratory, Neuchâtel, Switzerland

11:15 500 **Design Considerations for Industrial Rear-Passivated Solar Cells**
Thomas Lauermann, Benjamin Fröhlich, Giso Hahn, Barbara Terheiden
University of Konstanz, Konstanz, Germany

11:30 501 **Best Student Presentation Award Finalist**
Process Control of Reactive Sputter Deposition of AlOx and Improved Surface Passivation of Crystalline Silicon
Xinyu Zhang, Andres Cuevas, Andrew Thomson
Research School of Engineering, The Australian National University, Canberra, Australia

11:45 502 **Multifunctional Dielectrics: Dopant Source, Passivation and Optics**
Johannes Seiffe, Florian Pillath, Daniel Trogus, Andreas Brand, Christian Savio, Marc Hofmann, Jochen Rentsch, Ralf Preu
Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany

10:30 - 12:00 PM **17A**

Area 8: PV Characterization: Characterization of Thin Films (Orals)

Chair(s): Chun-Sheng Jiang, Yanfa Yan

10:30 503 **Best Student Presentation Award Finalist**
Identification and Analysis of Distinct Features in Imaging Thin-film Solar Cells
Katherine N. Zaunbrecher[1,2], Steve W. Johnston[1], James R. Sites[2]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Colorado State University, Fort Collins, CO, USA

10:45 504 **Best Student Presentation Award Finalist**
Large-Area Compositional Mapping of $Cu(In_{1-x}Ga_x)Se_2$ Materials and Devices with Spectroscopic Ellipsometry
Puruswottam Aryal[1], Dinesh Attygalle[1], Nikolas J. Podraza[1], Sylvain X. Marsillac[1], Robert W. Collins[2]
[1]Center for Photovoltaics Innovation & Commercialization and Department of Physics & Astronomy, University of Toledo, Toledo, OH, USA, [2]Department of Electrical and Computer Engineering, Old Dominion University, Norfolk, VA, USA

11:00 505 **Optical-Fiber-Based Time-Resolved Photoluminescence Spectrometer for Rapid Thin-Film Absorber Characterization and Analysis of TRPL Data for CdS/CdTe**
Darius Kuciauskas, Joel N. Duenow, Ana Kanevce, Jian V. Li, Dean H. Levi
NREL, Golden, CO, USA

11:15 506 **Analysis of $CuIn_xGa_{1-x}Se_2$ Solar Cells Using Admittance Spectroscopy Under Light Bias**
Angus A Rockett[1], D. Westley Miller[2], J. David Cohen[2]
[1]University of Illinois, Urbana, IL, USA, [2]University of Oregon, Eugene, OR, USA

11:30 507 **Optoelectronic Methods for Characterizing Uniformity in CIGS Thin-Film Solar Cells**
Thomas D. Boone, David Soltz, Anika A. Kinkhabwala, Geordie Zapalac, Mustafa Pinarbasi
SoloPower Inc., San Jose, CA, USA

11:45 508 **Photovoltage Decay Measurements on $Cu(In,Ga)Se_2$ Solar Cells by Photo-Assisted Kelvin Probe Force Microscopy**
Yu Nakajima[1], Masaki Takihara[1], Takashi Minemoto[3], Takuji Takahashi[1,2]
[1]Institute of Industrial Science, The University of Tokyo, Tokyo, Japan, [2]Institute for Nano Quantum Information Electronics, The University of Tokyo, Tokyo, Japan, [3]Department of Photonics, Ritsumeikan University, Shiga, Japan

10:30 - 12:00 PM **16AB**

Area 9: Modules and Systems: PV Reliability (Orals)

Chair(s): Mike Fife, Tassos Golnas

10:30 509 **Design for Reliability: A Low Concentration PV Case Study**
Jennifer E. Granata[1], Neil R. Sorensen[1], Zachary S. Judkins[2], Sy Olson[2]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]SunPower Corporation, San Jose, CA, USA

10:45 510 **PVLife: An Integrated Model for Predicting PV Performance Degradation over 25+ Years**
Mark Mikofski, David F.J. Kavulak, David Okawa, Yu-Chen Shen, Akira Terao, Michael Anderson, Wendell Caldwell, Doug Kim, Nicholas Boitnott, Junrhey Castro, Laurice Ann Laurio-Smith, Ryan Lacerda, Ernest F. Hasselbrink, Jr.
SunPower Corp., San Jose, CA, USA

11:00 511 **Testing and Analysis for Lifetime Prediction of Crystalline Silicon PV Modules Undergoing Degradation by System Voltage Stress**
P. Hacke, R. Smith, K. Terwilliger, S. Glick, D. Jordan, S. Johnston, M. Kempe, S. Kurtz
NREL, Golden, CO, USA

11:15 512 **Reliability of a PV Module-Integrated Inverter (PV-MII): A Usage Model Approach**
Souhib Harb, Robert S. Balog
Texas A&M University, College Station, TX, USA

11:30 513 **PV Inverter Performance and Reliability: What is the Role of the Bus Capacitor?**
Jack D. Flicker, Matthew Marinella, Robert Kaplar, Jennifer Granata
Sandia National Laboratories, Albuquerque, NM, USA

11:45 514 **PV Reliability Session: Questions for Discussion**
Jennifer E. Granata
Sandia National Laboratories, Albuquerque, NM, USA

10:30 - 12:00 PM **19B**

Area 10: PV Velocity Forum: Models and Markets (Orals)

Chair(s): Ardeth Banrhart

10:30 515 **Quantifying Non-Hardware Balance of System Costs for Photovoltaic Installations in the United States Using a Combined Annual Expenditure-Labor Hour Productivity Approach**
Kristen Ardani[1], Galen Barbose[2], David Feldman[1], Robert Margolis[1], Sean Ong[3]
[1]National Renewable Energy Laboratory, Washington, DC, USA, [2]Lawerence Berkeley National Laboratory, Berkeley, CA, USA, [3]National Renewable Energy Laboratory, Golden, CO, USA

10:45 516 **Updating Interconnection Screens for PV Integration**
Michael H. Coddington[1], Benjamin D. Kroposki[1], Barry A. Mather[1], Kevin Lynn[2], Abraham Ellis[3]
[1]NREL, Golden, CO, USA, [2]DOE, Washington, DC, USA, [3]Sandia National Laboratories, Albuquerque, NM, USA

11:00 517 **Modeling the Grid Impacts of High Penetration of Solar Photovoltaics**
Paul Denholm[1], Greg Brinkman[1], Easan Drury[1], Robert Margolis[2]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]National Renewable Energy Laboratory, Washington, DC, USA

11:15 518 **Solar Installation Labor Market Analysis and New NREL Models for PV Jobs and Economic Impacts Analysis**
Barry C. Friedman
NREL, Golden, CO, USA

11:30 519 **Do PV Systems Increase Residential Selling Prices? If So, How Can Practitioners Estimate This Increase?**
Ben Hoen[1], Ryan Wiser[1], Mark Thayer[2], Peter Cappers[1]
[1]Lawrence Berkeley National Laboratory, Berkeley, CA, USA, [2]San Diego State University, San Diego, CA, USA

11:45 520 **IEA PVPS Task8: Study on Very-Large-Scale Photovoltaic (VLS-PV) Systems**
Keiichi Komoto[1], Edwin Cunow[2], Christian Breyer[3], David Faiman[4], Karim Megherbi[5], Peter van der Vleuten[6]
[1]Mizuho Information & Research Institute, Inc., Tokyo, Japan, [2]LSPV Consulting, Groebenzell, Germany, [3]Reiner Lemoine Institut gGmbH, Berlin, Germany, [4]Ben Gurion University of the Negev, Be'er Sheva, Israel, [5]Helios Energie, Paris, France, [6]Free Energy Consulting, Eindhoven, Netherlands

1:30 - 3:00 PM **18AB**

Area 1: Fundamentals and New Concepts: Quantum Dot Solar Cells (Orals)

Chair(s): Ryne P. Raffaelle, Cory Cress, Annick Anctil

1:30 521 **Carrier Dynamics in Intermediate States of InAs/GaAs Quantum Dots Embedded in Photonic Cavity Structure**
Takashi Kita, Tsuyoshi Maeda, Yukihiro Harada
Kobe University, Kobe, Japan

2:00 522 **Growth and Characterization of $In_xGa_{1-x}As$ Quantum Dots on Metamorphic $GaAs_yP_{1-y}$ Templates by Molecular Beam Epitaxy**
J. Grandal[1], T.J. Grassman[1], A.M. Carlin[1], M.R. Brenner[1], L. Yang[2], M.J. Mills[2], S.A. Ringel[1]
[1]Dept. of Electrical & Computer Engineering, The Ohio State University, Columbus, OH, USA, [2]Dept. of Materials Science & Engineering, The Ohio State University, Columbus, OH, USA

2:15 523 **Optimization of Growth and Device Performance for InAs Quantum Dot Solar Cells**
Seth M. Hubbard, Adam Podell, Chelsea Mackos, Stephen Polly, David Forbes
Rochester Institure of Technology, Rochester, NY, USA

2:30 524 **Real Time During Growth Metrology and Assessment of Growth Kinetics of Epitaxial Quantum Dots by Rheed**
Manori V Gunasekera, Alexandre Freundlich
University of Houston, Houston, TX, USA

2:45 525 **Correlation Between Quantum Dot Morphology and Photovoltaic Performance**
David V. Forbes[1], Christopher G. Bailey[2], Stephen Polly[1], Chris Kerestes[1], Michael Slocum[1], Zachary S. Bittner[1], Seth M. Hubbard[1]
[1]Rochester Institute of Technology, Rochester, NY, USA, [2]U.S. Naval Research Laboratory, Washington, DC, USA

1:30 - 3:00 PM **18CD**

Area 2: Polycrystalline Thin Films: Thin-Film Manufacturing (Orals)

Chair(s): Harin Ullal, Bernhard Dimmler

1:30 526 **Advancing the Manufacturing of CdTe Modules**
Kevin Walters, Hiroshi Sakurai, W.S. Sampath
NSF I/UCRC for Next Generation Photovoltaics, Colorado State University, Fort Collins, CO, USA

2:00 527 **Electrical Characterization of Cu Composition Effects in CdS/CdTe Thin-Film Solar Cells with a ZnTe:Cu Back Contact**
Jian V. Li, Joel N. Duenow, Darius Kuciauskas, Ana Kanevce, Ramesh G. Dhere, Dean H. Levi
National Renewable Energy Laboratory, Golden, CO, USA

2:15 528 **Effect of Annealing Atmosphere and Temperature on the Properties of Cd_2SnO_4 Thin Films**
Tiejun Meng, Brian E. McCandless, Wayne A. Buchanan, Robert W. Birkmire
Institute of Energy Conversion, University of Delaware, Newark, DE, USA

2:30 529 **Achievement of 17.5% Efficiency with 30x30cm^2-Sized Cu(InGa)(SeS)^2 Submodules**
Motoshi Nakamura, Yoshiyuki Chiba, Kyouhei Horiguchi, Yoshihiko Yanagisawa, Yuko Sawai, Hideki Hakuma
Showa Shell Sekiyu K. K., Atsugi, Japan

2:45 530 **Development of High-Efficiency Cu_2ZnSnS_4 Submodule with Cd-Free Buffer Layer**
Homare Hiroi, Noriyuki Sakai, Satoshi Muraoka, Takuya Katou, Hiroki Sugimoto
Solar Frontier K.K., Atsugi, Japan

1:30 - 3:00 PM **17B**

Area 3: III-V's and Concentrators: Modules and Systems (Orals)

Chair(s): Carlos Algora, Kenji Araki

1:30
531 **System Performance Considerations for Low-Concentration Linear-Focus Silicon-Based Photovoltaic Modules**
Raphael V. Varieras, David L. King, Jusong Wang
Solaria Corporation, Fremont, CA, USA

1:48
532 **Advancing Efficiency and Scale in CPV Arrays**
Geoffrey S. Kinsey, Mingguo Liu, William Bagienski, Aditya Nayak, Vahan Garboushian
Amonix, Inc., Seal Beach, CA, USA

2:06
533 **Experiences After Four Years of Operation of the CPV Plants in ISFOC**
Francisca T. Rubio, Maria C. Martinez, Daniel Sanchez, Pablo J. Trujillos
ISFOS, Puertollano, Spain

2:24
534 **Design and Development of 35%-Efficient and 1000X CPV Module with Sufficient Optical Alignment Tolerance**
Kenji Araki[1], Pablo Zamora[2], Hirokazu Nagai[1], Pablo Benítez[2], Kenji Hobo[1], Juan C. Miñano[2], Masayoshi Futo[1], Gabriel Sala[2], Kazuyuki Tamura[1], Isao Kumagai[1]
[1]Daido Steel, Nagoya, Japan, [2]Universidad Politecnica de Madrid, Madrid, Spain

2:42
535 **On the Effect of Ramp Rate in Damage Accumulation of the CPV Die-Attach**
Nick S. Bosco, Timothy J. Silverman, Sarah R. Kurtz
National Renewable Energy Laboratory, Golden, CO, USA

1:30 - 3:00 PM **Blrm G**

Area 4: Crystalline Silicon: Crystallization and Wafering (Orals)

Chair(s): Jinggang Lu, Paul Von Dollen

1:30 536 **Status of Mono²™ Gen5 Casting at IdealCast Solar**
Roger Clark[1], Christian Lehnert[2]
[1]AMG IdealCast Solar Corp., Frederick, MD, USA, [2]ALD Vacuum Technologies, GmbH, Hanau, Germany

1:45 537 **Integration and Reliability of Ultrathin Silicon Solar Cells and Modules Fabricated using SOM Technology**
Dharmesh Jawarani[1], Dewei Xu[2], Scott Smith[1], Rajesh Rao[1], Leo Mathew[1], Sayan Saha[1], Dabraj Sarkar[3], Curt Vass[1], Sanjay Banerjee[2], Paul S. Ho[2]
[1]AstroWatt, Inc., Austin, TX, USA, [2]The University of Texas at Austin, Austin, TX, USA, [3]The University of Florida, Gainesville, FL, USA

2:15 538 **Laser Wafering**
Stuart Bowden, James Lebeau
Arizona State University, Tempe, AZ, USA

2:30 539 **Structural Analysis of Longitudinal Si-C-N Precipitates in Multicrystalline Silicon: Towards Intrinsic Growth of Current-Conducting and Current-Collecting Channels**
Stefan Köstner[1], Angelika Hähnel[1], Horst Blumtritt[1], Rajmund Mokso[2], Jan Bauer[1], Peter Werner[1], Otto Breitenstein[1]
[1]Max Planck Institute of Microstructure Physics, Halle, Germany, [2]Paul Scherrer Institute, Villigen, Switzerland

2:45 540 **Growth of Multicrystalline Si Ingots for Solar Cells Using Noncontact Crucible Method Without Touching the Crucible Wall**
Kazuo Nakajima[1], Ryota Murai[1], Kohei Morishita[1], Kentaro Kutsukake[2], Noritaka Usami[2]
[1]Kyoto University, Kyoto, Japan, [2]Tohoku University, Sendai, Japan

1:30 - 3:00 PM **19A**

Area 5: Thin-Film Silicon: Thin-Crystalline Silicon Technology (Orals)

Chair(s): Ivan Gordon, Vikram Dalal

1:30 541 **High-Quality Epitaxial Foils, Obtained by a Layer Transfer Process, for Integration in Back Contacted Solar Cells Processed on Glass**
Kris Van Nieuwenhuysen, Frederic Dross, Valerie Depauw, Roberto Martini, Barry O'Sullivan, Twan Bearda, Jonathan Govaerts, Riet Labie, Maarten Debucquoy, Hariharsudan Sivaramakrishnan, Ivan Gordon, Jozef Poortmans
IMEC, v.z.w., Leuven, Belgium

2:00 542 **Device Physics of Heteroepitaxial Film c-Si Heterojunction Solar Cells**
Sachit Grover[1], Charles W. Teplin[1], Jian V. Li[1], David Bobela[2], Jon Bornstein[2], Paul Schroeter[2], Steve Johnston[1], Harvey Guthrey[1], Howard M. Branz[1], David Young[1]
[1]National Renewable Energy Lab., Golden, CO, USA, [2]Ampulse Corporation, Golden, CO, USA

2:15 543 **A Low-Cost Kerfless Thin Exfoliated Si Solar Cell Technology**
Rajesh Rao[1], Leo Mathew[1], Dabraj Sarkar[2], Scott Smith[1], Sayan Saha[1], Ricardo Garcia[1], Rachel Stout[1], Ariam Gurmu[1], Moses Ainom[1], Emmanuel Onyegam[3], Dewei Xu[1], Dharmesh Jawarani[1], Ujjwal Das[4], Sanjay Banerjee[3], Jerry Fossum[2]
[1]AstroWatt, Austin, TX, USA, [2]University of Florida, Gainesville, FL, USA, [3]University of Texas, Austin, TX, USA, [4]Institute of Energy Conversion, Newark, DE, USA

2:30 544 **Best Student Presentation Award Finalist**
Remote Plasma Chemical Vapor Deposition for High-Efficiency Ultra-Thin ~25-Microns Crystalline Si Solar Cells
Dabraj Sarkar[1], Emmanuel U. Onyegam[2], Sayan Saha[3], Leo Mathew[3], Rajesh A. Rao[3], Mohamed H. Hilali[2], Ryan S. Smith[3], Dewei Xu[2], Dharmesh Jawarani[3], Ricardo Garcia[2], Rachel Stout[3], Ariam Gurmu[3], Moses Ainom[3], Jerry G. Fossum[1], Sanjay K. Banerjee[2]
[1]University of Florida, Gainesville, FL, USA, [2]University of Texas, Austin, TX, USA, [3]AstroWatt Inc., Austin, TX, USA

2:45 545 **Characterization of Epitaxial Film Silicon Solar Cells Grown on Seeded Display Glass**
David L. Young[1], Sachit Grover[1], Charles Teplin[1], Pauls Stradins[1], Vincenzo LaSalvia[2], Ta-Ko Chuang[2], J. Greg Couillard[2], Howard M. Branz[1]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Corning Incorporated, Corning, NY, USA

1:30 - 3:00 PM **17A**

Area 8: PV Characterization: Advanced Characterization Methods and Instruments (Orals)

Chair(s): Yoshihiro Hishikawa, Jan Schmidt

1:30 546 **Novel Free Carrier Pump-Probe Analysis of Carrier Recombination Lifetime in Semiconductors**
Richard K. Ahrenkiel[1], Ari Feldman[1,2], John Lehman[2]
[1]Colorado School of Mines, Golden, CO, USA, [2]National Institute of Standards and Technology, Boulder, CO, USA

1:45 547 **Multimodal System for the Characterization of Photovoltaic Structures**
Razvan Ciocan[1], Behrang Hamadani[2], Domenic Assalone[1], Zhuoyun Li[1], Tom Moriarty [3], Keith Emery[3], Mike Carroll[4], Shahram Seyedmohammadi[5], Eugenia Ciocan[6], Mantu Hudait[7], Michael Slocum[8], Aymeric Maros[8], Chris Kerestes[8], Seth Hubbard[8]
[1]Oriel Instruments, Newport Corporation, Stratford, CT, USA, [2]National Institute of Standards and Technology, Gaithersburg, MD, USA, [3]National Renewable Energy Laboratory, Golden, CO, USA, [4]RFMD, Greensboro, NC, USA, [5]Ferro Corp, Vista, CA, USA, [6]Wentworth Institute of Technology, Boston, MA, USA, [7]Virginia Tech, Blacksburg, VA, USA, [8]Rochester Institute of Technology, Rochester, NY, USA

2:00 548 **A Novel Solar Simulator Based on a Super-Continuum Laser**
Tasshi Dennis[1], John B. Schlager[1], Hao-Chih Yuan[2], Qi Wang[2], Daniel Friedman[2]
[1]National Institute of Standards and Technology, Boulder, CO, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

2:15 549 **Characterization of Three-Dimensional Structures in Silicon Solar Cells by Spatially-Resolved Illuminated Lock-in Thermography**
Tobias M. Pletzer, Markus Lenz, Horst Windgassen, Joachim Knoch
RWTH Aachen University, Aachen, Germany

2:30 550 **Spatially-Resolved Luminescence Imaging of All Essential Silicon Solar Cell Parameters**
C Shen, H Kampwerth, M.A Green
UNSW, Sydney, Australia

2:45 551 **Unified Lifetime Measurement for Silicon PV**
Marshall Wilson[1], Jacek Lagowski[1], Andrew Findlay[1], Sara Olibet[2], Valentin Mihailetchi[2]
[1]Semilab SDI, Tampa, FL, USA, [2]ISC Konstanz, Konstanz, Germany

1:30 - 3:00 PM **16AB**

Area 9: Modules and Systems: Module Materials, Durability, and Performance 1 (Orals)

Chair(s): Peter Hacke, Govindasamy Tamizhmani

1:30 552 **Damp Heat Versus Field Reliability for Crystalline Silicon**
Kent L. Whitfield[1], Asher Salomon[1], Michael D. Kempe[2], Tsuyoshi Shioda[3]
[1]Solaria, Fremont, CA, USA, [2]NREL, Golden, CO, USA, [3]Mitsui Chemicals, Nagaura, Japan

2:00 553 **A Field Evaluation of the Potential for Creep in Thermoplastic Encapsulant Materials**
Michael D. Kempe[1], David C. Miller[1], John H. Wohlgemuth[1], Sarah R. Kurtz[1], John M. Moseley[1], Qurat Shah[4], Govindasamy Tamizhmani[4], Keiichiro Sakurai[2], Masanao Inoue[3], Takuya Doi[3], Atsushi Masuda[3]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan, [3]National Institute of Advanced Industrial Science and Technology, Tosu, Japan, [4]Arizona State University Polytechnic Campus, Mesa, AZ, USA

2:15 554 **Performance of Thermoplastic Ionomer Encapsulant Material with Advanced Emitter Solar Cells**
Michael Z. Burrows[1], Andreas Meisel[1], Francesco Lemmi[1], Homer Antoniadis[1], Silvia Schreiber[2], Lucie Garreau-Iles[2], Philip Boydell[2], Alison M.A. Bennett[3], Rebecca L. Smith[4]
[1]Innovalight, Inc., Sunnyvale, CA, USA, [2]DuPont de Nemours Int. SARL, Geneva, Switzerland, [3]E. I. DuPont de Nemours & Co., Wilmington, DE, USA, [4]E. I. DuPont de Nemours & Co., Parkersburg, WV, USA

2:30 555 **Soiling Test Methods and Their Use in Predicting Performance of Photovoltaic Modules in Soiling Environments**
Kathy Brown, Tim Narum, Naiyong Jing
3M Company, St. Paul, MN, USA

2:45 556 **Best Student Presentation Award Finalist**
The Effect of Dust Deposition on Photovoltaic Modules
Reinhart H. Appels[1], Buvaneshwari Muthirayan[1], Alexander Beerten[1], Robin Paesen[1], Johan Driesen[1], Jozef Poortmans[2]
[1]ESAT/ELECTA, KU Leuven, Heverlee, Belgium, [2]IMEC vzm, Heverlee, Belgium

3:00 - 4:00 PM **19B**

SCREAM Workshop

3:00 - 3:30 PM **Exhibit Hall 4**

Coffee Break

3:30 - 5:00 PM **EH4-A**

Area 1: Fundamentals and New Concepts: Session 3 (Posters)

Chair(s): Annick Anctil, Chris Bailey, Seth Hubbard

A3
557 **Synthesis and Characterization of PECVD-Grown, Silane-Terminated Silicon Quantum Dots**
Ingrid E. Anderson[1], Rebecca A. Shircliff[1], Brian Simonds[1], Matt Bergren[1], Pauls Stradins[2], Reuben T. Collins[1]
[1]Colorado School of Mines, Golden, CO, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

A7
558 **Realization of an Intermediate-Band Solar Cell: The InAs/GaAsSb Quantum Dot System as a Candidate**
Stephen P. Bremner[1], Keun Yong Ban[2], Christiana B. Honsberg[2]
[1]University of New South Wales, Sydney, Australia, [2]Arizona State University, Tempe, AZ, USA

A11
559 **Investigation of Carrier Escape Mechanism in InAs/GaAs Quantum Dot Solar Cells**
Yushuai Dai[1], Chris Bailey[2], Chris Kerestes[1], David Forbes[1], Seth Hubbard[1]
[1]Nanopower Research Laboratory, Rochester Institute of Technology, Rochester, NY, USA, [2]Naval Research Lab, Washington, DC, USA

A15
560 **Epitaxy of High Aspect Ratio and Wetting-Layer-Free InAs Quantum Dots on (Al)GaAs**
Alex Freundlich[1], Manori Gunasekera[1], Chandani Rajapaksha[1], Irena Rusakova[2]
[1]Center for Advanced Materials and Physics Department, University of Houston, Houston, TX, USA, [2]Texas Center for Superconductivity and Physics Department, Houston, TX, USA

A19
561
Numerical Modeling of Axial Junction Compositionally Graded $In_xGa_{1-x}N$ Nanorod Solar Cells
Jian-Wei Ho[1], Andrew A. O. Tay[2], Soo-Jin Chua[3]
[1]NUS Graduate School of Integrative Sciences & Engineering, National University of Singapore, Singapore, Singapore, [2]Department of Mechanical Engineering, National University of Singapore, Singapore, Singapore, [3]Singapore-MIT Alliance, National University of Singapore, Singapore, Singapore

A23
562
Nanohole Structure as Efficient Antireflection Layer for Silicon Solar Cell Fabricated by Maskless Laser Annealing
Lei Hong[1,2], Rusli Rusli[1], Fei Wang[1], Lining He[1], Xincai Wang[2], Hongyu Zheng[2], Hao Wang[1], Hongyu Yu[3]
[1]Nanyang Technological University, Singapore, Singapore, [2]Singapore Institute of Manufacturing Technology, Singapore, Singapore, [3]South University of Science and Technology of China, Shenzhen, China

A27
563
Photoelectrochemical Study of GaAs Nanowires for Tandem III-V/Si Solar Cells
Shu Hu[1, 3], Chun-Yung Chi[2], Maoqing Yao[2], Chongwu Zhou[2], P. Daniel Dapkus[2], Nathan S. Lewis[1, 3]
[1]Division of Chemistry and Chemical Engineering, California Institute of Technology, Pasadena, CA, USA, [2]Ming Hsieh Department of Electrical Engineering, University of Southern California, Los Angeles, CA, USA, [3]Joint Center for Artificial Photosynthesis, Pasadena, CA, USA

B3
564
The Relation Between Photovoltaic Performance and Film Thickness in PbS Quantum Dot Solar Cells
Junhee Kim[1], Cholong Jung[2], Yongseok Jun[2], Donghwan Kim[1]
[1]Korea University, Seoul, South Korea, [2]UNIST, Ulsan, South Korea

B7
565
Best Student Presentation Award Finalist
InGaAs/GaAsP Asymmetric Quantum Wells for Enhancing Carrier Escape Through Resonant Tunneling
ShaoJun Ma[1], Hassanet Sodabanlu[2], YunPeng Wang[2], Kentaroh Watanabe[2], Masakazu Sugiyama[1], Yoshiaki Nakano[1,2]
[1]Department of Electrical Engineering and Information Systems, School of Engineering, The University of Tokyo, Tokyo, Japan, [2]Research Center for Advanced Science and Technology, The University of Tokyo, Tokyo, Japan

B11
566
Silicon Nanowires Development for Solar Cell Devices
Gopal G. Pethuraja[1,2], Manisha V. Rane-Fondacaro[1], Harry Efstathiadis[1], Ashok K. Sood[2], Pradeep Haldar[1]
[1]Energy and Environmental Applications Center (E2TAC), College of Nanoscale Science and Engineering, University at Albany, State University of New York, Albany, NY, USA, [2]Magnolia Solar Inc., Albany, NY, USA

B15
567 **Numerical Study of GaAs-Based Dual-Junction Intermediate-Band Solar Cells**
Ching-Yu Shih[1], Ming-hsuan Tan[1], Lung-Hsing Hsu[1], Che-Pin Tsai[1], Chien-chung Lin[1], Hao-Chung Kuo[2], K.Y. Chuang[3], T.S. Lay[3]
[1]Institute of Photonic System, National Chiao Tung University, Tainan, Taiwan, [2]Department of Photonic & Institute of Electro-Optical Engineering, National Chiao Tung University, Hsin-chu, Taiwan, [3]Department of Photonics, National SunYat-Sen University, Kaohsiung, Taiwan

B19
568 **Carrier Sweep-Out Time in InGaAs/GaAsP Multiple Quantum Well Solar Cells by Time-Resolved Photoluminescence: Effects of Well Depth and Barrier Thickness**
Hassanet Sodabanlu[1], Shaojun Ma[2], Kentaroh Watanabe[1], Masakazu Sugiyama[2,3], Yoshiaki Nakano[1,2]
[1]Research Center for Advanced Science and Technology, the University of Tokyo, Tokyo, Japan, [2]School of Engineering, the University of Tokyo, Tokyo, Japan, [3]Institute of Engineering Innovation, the University of Tokyo, Tokyo, Japan

B23
569 **Highly-Ordered Silicon Nanowire Arrays on Heterojunction Solar Cells**
Hong-Jhang Syu[1], Yung-Jr Hung[2], Shu-Chia Shiu[1], San-Liang Lee[2], Ching-Fuh Lin[1,3,4]
[1]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan, [2]Department of Electronics Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan, [3]Graduate Institute of Electronic Engineering, National Taiwan University, Taipei, Taiwan, [4]Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan

B27
570 **High-Efficiency InAs/GaAs Quantum Dot Solar Cells by MOCVD**
Katsuaki Tanabe, Denis Guimard, Damien Bordel, Ryo Morihara, Masao Nishioka, Yasuhiko Arakawa
University of Tokyo, Tokyo, Japan

C3
571 **Investigations of the Optical Properties of ZnO-Metal Oxide Core-Shell Nanowire Arrays for Use in Advanced Optoelectronics**
M. Allan Thomas, Jingbiao Cui
University of Arkansas at Little Rock, Little Rock, AR, USA

C7 572 **Growth and Characterization of III-Nitride-Based Multiple Quantum Wells for Photovoltaic Devices**
P.V Wadekar[1], C.W Chang[1], T.W. Dung[1], Y.T. Lin[1], Q.Y. Chen[1,2], M.C. Chou[3], S.W. Feng[4], H.C. Huang[3], N.J. Ho[3], L.W. Tu[1], D. Wijesundera[2], W.K. Chu[2]
[1]Department of Physics and Center for Nanoscience and Nanotechnology, National Sun Yat Sen University, Kaohsiung, Taiwan, [2]Department of Physics and Texas Center for Superconductivity, University of Houston, Houston, TX, USA, [3]Department of Materials and Opto-electronic Science, National Sun Yat Sen University, Kaohsiung, Taiwan, [4]Department of Applied Physics, National University of Kaohsiung, Kaohsiung, Taiwan

C11 573 **A Multi-Step Superlattice Solar Cell with Enhanced Sub-Band Absorption and Open Circuit Voltage**
YunPeng Wang[1], ShaoJun Ma[1], Hassanet Sodabanlu[1], Hiromasa Fujii[1], Kentaroh Watanabe[1], Masakazu Sugiyama[2], Yoshiaki Nakano[1]
[1]Research Center for Advanced Science and Technology, the University of Tokyo, Tokyo, Japan, [2]Department of Electrical Engineering and Information Systems, School of Engineering, the University of Tokyo, Tokyo, Japan

C15 574 **Macroporous Silicon Solar Cell on Upgraded Metallurgical-Grade Silicon Wafer**
Lei Zhao, Zhaochen Li, Hongwei Diao, Hailing Li, Chunlan Zhou, Wenjing Wang
Institute of Electrical Engineering, The Chinese Academy of Sciences, Beijing, China

C19 575 **Photovoltaic Measurements in Carbon Nanotube - Amorphous Silicon Core/Shell Nanowire**
Hang Zhou[1,2], Georgis Lentaris[2], Pritesh Hiralal[2], Tim Butler[2], Emrah Unalan[2], Gehan Amaratunga[2], Alan Colli[3]
[1]Peking University Shen Zhen Graduate School, Shen Zhen, China, [2]University of Cambridge, Cambridge, United Kingdom, [3]Nokia Research Center, Cambridge, United Kingdom

C22 576 **Evaluating Photovoltaic Performance Indoors**
Yasmin Afsar[1], John Sarik[2], Maria Gorlatova[2], Gil Zussman[2], Ioannis Kymissis[2]
[1]Princeton University, Princeton, NJ, USA, [2]Columbia University, New York, NY, USA

C25 577 **Simulation-Guided Design of Flexible Photovoltaic Laminates**
Siddharth Ram Athreya, Rahul Sharma, Keith Kauffmann, Leo Lopez, Jie Feng
The Dow Chemical Company, Midland, MI, USA

C28 578 **The Pathway to Achieve More than 5% PbS Quantum Dot Solar Cells**
Jianbo Gao[1], Octavi Semonin[2], Joseph Luther[1], Randy Ellingson[3], Arthur Nozik[1], Matthew Beard[1]
[1]NREL, Golden, CO, USA, [2]University of Colorado, Boulder, CO, USA, [3]University of Toledo, Toledo, CO, USA

D3 579 **Novel Modeling and Simulation of a-Si/c-$Si_{1-x}Ge_x$/c-Si Hetrostructure Thin-Film Solar Cells**
Muhammad Khizar, Md. Amimul Ehsan, Christina Keller, Dongming Mei
Department of Physics, University of South Dakota, Vermillion, SD, USA

D6 580 **Development of Zinc Phosphide as a p-Type Absorber**
Parag S. Vasekar, Siva P. Adusumilli, Daniel Vanhart, Tara Dhakal
Center for Autonomous Solar Power, The State University of New York at Binghamton, Binghamton, NY, USA

D9 581 **Crystal Phase-Controlled Synthesis of Cu_2FeSnS_4 Nanocrystals with Band Gap around 1.5 eV**
Xiaoyan Zhang[1,2], Ningzhong Bao[3], Karthik Ramasamy[1], Yu-Hsiang A. Wang[1], Yifeng Wang[3], Baoping Lin[2], Arunava Gupta[1]
[1]University of Alabama, Tuscaloosa, AL, USA, [2]Southeast University, Nanjing, China, [3]Nanjing University of Technology, Nanjing, China

3:30 - 5:00 PM **EH4-B**

Area 2: Polycrystalline Thin Films: Alternate Substrates, Back Contact Materials, Buffer Compounds, TCOs, Manufacturing, Metrology, Process Control, and Reliability (Posters)

Chair(s): Ayodhya Tiwari, Katsumi Kushiya

E8 582 **Device Degradation Studies of CIGS Solar Cells Using *In Situ* High-Temperature X-Ray Diffraction**
Rangarajan Krishnan[1], Tim Anderson[1], Ryan Kaczynski[2], Urs Schoop[2], Andrew Payzant[3], Woo Kyoung Kim[4]
[1]University of Florida, Gainesville, FL, USA, [2]Global Solar Inc, Tucson, AZ, USA, [3]Oak Ridge National Laboratory, Oak Ridge, TN, USA, [4]Yeungnam University, Dae-Dong, South Korea

E12 583 **Optical Monitoring and Control of Three-Stage Co-Evaporated $Cu(In_{1-x}Ga_x)Se_2$ by Real Time Spectroscopic Ellipsometry**
Dinesh Attygalle[1], Vikash Ranjan[2], Puruswottam Aryal[1], Puja Pradhan[1], S Marsillac[2], N. J Podraza[1], R. W. Collins[1]
[1]Center for Photovoltaics Innovation and Commercialization, University of Toledo, Toledo, OH, USA, [2]Department of Electrical and Computer Engineering, Old Dominion University, Norfolk, VA, USA

E16 584 **Metrology and Process Optimization for Large-Area Monolithically-Iintegrated $Cu(In,Ga)Se_2$ Modules**
Dingyuan Lu, Eric P. Christiansen, Colm W. Walsh, Joseph F. Chase, Roy M. Miller, Michael F. Miller, B.J. Stanbery
HelioVolt Corporation, Austin, TX, USA

E20 585 **First-Ever Full-Size CdTe Luminescent Down-Shifting Module**
David Ross[1], Diego Alonso Álvarez[1], Jochen Fritsche[2], Michael Bauer[2], Bryce S. Richards[1]
[1]Heriot-Watt University, Edinburgh, United Kingdom, [2]Calyxo GmbH, Bitterfeld-Wolfen, Germany

E24 586 **Investigation of Post-Deposition and In Situ Cl Treatments for Fully-Sputtered CdTe/CdS Thin-Film Solar Cells**
R. E. Treharne[1], K. Durose[1], L. Bowen[2], B. G. Mendis[2]
[1]University of Liverpool, Liverpool, United Kingdom, [2]University of Durham, Durham, United Kingdom

E28 587 **$In(O,OH)S/AgInS_2$ Absorbent-Layer/Buffer-Layer System for Thin-Film Solar Cells**
Carlos A. Arredondo[1], William A. Vallejo[2], Johann Hernandez[3], Gerardo Gordillo[4]
[1]Universidad Antonio Nariño, Bogota, Columbia, [2]Universidad de America, Bogota, Columbia, [3]Universidad Distrital Francisco Jose de Caldas, Bogota, Columbia, [4]Universidad Nacional de Colombia, Bogota, Columbia

F4 588 **Two-Stage Chemical-Bath Deposition for Well-Covered and Stoichiometric ZnS Thin Films**
Po-Chuan Tsai[1], Ian Pai[1], Han-Ping D. Shieh[2]
[1]Department of Photonics & Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan, [2]Department of Photonics & Display Institute, National Chiao Tung University, Hsinchu, Taiwan

F8 589 **Influence of $Cu(In,Ga)Se_2$ Grain Orientation on Solution Growth of Zn(O,S) and CdS**
Wolfram Witte[1], Daniel Abou-Ras[2], Dimitrios Hariskos[1]
[1]Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), Stuttgart, Germany, [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany

F12 590 **Mo Effect on One-Step Sputtering Chalcopyrite CIGS Thin Films**
Tzu-Ying Lin[1], Chia-Hsiang Chen[1], Chih-Huang Lai[1,2]
[1]Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan, [2]Low Carbon Energy Research Center, Tsing Hua University, Hsinchu, Taiwan

F16 591 **Metallic Grids for Low-Resistive Transparent Conductors: Modeling and Experiments**
Joop van Deelen, Henk Rendering, Hero het Mannetje, Lennaert Klerk, Arjan Hovestad
TNO, Eindhoven, Netherlands

F20 592 ***In Situ* Real Time Spectroscopic Ellipsometry Analysis of Ag Nanoparticle Layers for Back Contact Reflector Applications**
Scott Little[1], Vikash Ranjan[2], Thomas Begou[2], Robert W. Collins[1], Sylvain Marsillac[2]
[1]University of Toledo, Toledo, OH, USA, [2]Old Dominion University, Norfolk, VA, USA

F24 593 **High Quality Indium Tin Oxide (ITO) Film Growth by Controlling Deposition Pressure in RF Magnetron Sputtering**
M. Mannir Aliyu[1], M. Sharafat Hossain[1], Jamilah Husna[1], Nripen Dhar[2], M. Qamarul Huda[2], Kamaruzzaman Sopian[2], Nowshad Amin[1,2]
[1]Department of Electrical, Electronics and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia, [2]Solar Energy Research Institute (SERI), Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia

F28 594 **Atmospheric Pressure Deposition of SnO_2 and ZnO**
Joop van Deelen, Bas Kniknie, Frank Grob, Ioanna Volintiru, Fred Roozeboom, Paul Poodt, Andrea Illiberi
TNO, Eindhoven, Netherlands

G4 595 **Characterization of TCO Deposition for CIGS Solar Cells**
Krishna Aryal[1], Grace Rajan[1], Yunus Erkaya[1], Nitin Hegde[1], Patrick Boland[1], Vikash Ranjan[1], Robert W. Collins[2], Sylvain Marsillac[1]
[1]Old Dominion University, Norfolk, VA, USA, [2]The University of Toledo, Toledo, OH, USA

G8 596 **The ZnO-Reflectance Effect on the Heterojunction ITO/ZnO/CdS/CdTe**
Juan Luis Peña, Victor Rejón, Oscar Arés, Juan M. Camacho, Araceli Rios-Flores
Applied Physics Department, CINVESTAV-IPN, Mérida, Yucatán, Mexico

G12 597 **Low-Resistivity and High-Transparency ZnO Thin Films on PET Substrate Grown by Atmospheric Spray Pyrolysis**
Kenji Yoshino[1], Naomi Kamiya[1], Minoru Oshima[1], Akiko Ide[1], Yumi Yamamoto[1], Yujin Takemoto[2], Kouji Toyota[2], Koichiro Inaba[2], Ken-ichi Haga[2], Kouichi Tokudome[2]
[1]University of Miyazaki, Miyazaki, Japan, [2]Tosoh Finechem Corporation, Syunan, Japan

G16 598 **Transparent Conductors for Full Spectrum Photovoltaics**
Kin Man Yu[1], Marie M. Mayer[1,2], Derrick T. Speaks[1,2], Hongcai He[3,4], Ruying Zhao[1,2], Leon Hsu[5], Samuel S. Mao[3], Eugene E. Haller[1,2], Wladek Walukiewicz[1]
[1]Lawrence Berkeley National Laboratory, Materials Sciences Division, Berkeley, CA, USA, [2]University of California, Berkeley, Department of Materials Science and Engineering, Berkeley, CA, USA, [3]Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, Berkeley, CA, USA, [4]University of Electronic Science and Technology of China, State Key Laboratory of Electronic Thin Films and Integrated Devices, Chengdu, China, [5]University of Minnesota, Minneapolis, MN, USA

G20 599 **Reflection Optimization for Alternative Thin-Film Photovoltaics**
Jonathan R. Mann, Jian Li, Ingrid L. Repins, Kannan V. Ramanathan, Stephen C. Glynn, Clay M. DeHart, Rommel Noufi
National Renewable Energy Laboratory, Golden, CO, USA

G24 600 **Green Electrodeposition of ZnO as a TCO in Terawatt Solar Cells**
Bin Zhou[1], Xiaofei Han[1], Qing Feng[2], Meng Tao[1]
[1]School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, USA, [2]Department of Chemistry and Biochemistry, University of Texas at Arlington, Arlington, TX, USA

G28 601 **Development of a Microreactor Assisted Solution Deposition Process for Fabrication of a PV Thin Film**
Michael O'Halloran[1], Sudhir Ramprasad[2], Dan Palo[2], Clayton Hires[3], Brian K. Paul[3], Yu-Wei Su[4], Chih-hung Chang[4]
[1]CH2M HILL, Portland, OR, USA, [2]Microproducts Breakthrough Institute, Pacific Northwest National Laboratory, Corvallis, OR, USA, [3]School of Mechanical, Industrial and Manufacturing Engineering, Oregon State University, Corvallis, OR, USA, [4]School of Chemical, Biological & Environmental Engineering, Oregon State University, Corvallis, OR, USA

H3 602 **Flexible and Cd-free CIGS Solar Cell Yielding 13.37% Efficiency Produced by Non-Vacuum Process**
Wei-Tse Hsu, Chien-Chih Chiang, Tsung-Yeh Chuang, Lung-Teng Cheng, Lih-Ping Wang, Sheng-Wen Cha, Ke-Yu Lai, Wei-Chien Chen, Hsien-Te Cheng, Chou-Cheng Li, Jen-Chuan Chang, Yan-Ying Tsai, Song-Yeu Tsai
Green Energy & Environment Research Laboratories (GEL), Industrial Technology Research Institute, Hsinchu, Taiwan

3:30 - 5:00 PM **EH4-C**

Area 3: III-V's and Concentrators: Cells, Modules, and Systems 2 (Posters)

Chair(s): Daniel Derkacs

H10 603 **Absorption Performance of the Micro-Concentrating Photovoltaic with Multimode Waveguide and Slanted Micro-Hole Cell**
Md. Mosaddek Hossain Adib[1], Arshad M. Chowdhury [1,2], Gee-Kung Chang[2], Nowshad Amin[3]
[1]Department of Electrical Engineering and Computer Science, North South University, Dhaka, Bangladesh, [2]School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, USA, [3]Department of Electrical, Electronic & Systems Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia

H12 604 **Study of Wind Convection Coefficient Correlations for CPV Module Cooling**
Deborah A. Adkins, Yuying Y. Yan
University of Nottingham, Nottingham, United Kingdom

H14 605 **Improvement of CPV System Performance by NGCPV Collaboration**
Kenji Araki[1], César Domínguez[2], Hirokazu Nagai[1], Ignacio Luque-Heredia[3], Kensuke Nishioka[4], Kenji Hobo[1], Ignacio Anton[2], Masayoshi Futo[1], Gabriel Sala[2], Kazuyuki Tamura[1], Isao Kumagai[1]
[1]Daido Steel, Nagoya, Japan, [2]Universidad Politecnica de Madrid, Madrid, Spain, [3]BSQ Solar, Madrid, Spain, [4]University of Miyazaki, Miyazaki, Japan

H16 606 **Design of Semiconductor-Based Back Reflectors for High-V_{oc} Monolithic Multijunction Solar Cells**
Ivan Garcia, John Geisz, Myles Steiner, Jerry Olson, Daniel Friedman, Sarah Kurtz
National Renewable Energy Laboratory, Golden, CO, USA

H18 607 **Trackless LCPV Modules: A Competitive Solution?**
Giorgio Grasso[1], Francesco Morichetti[2], Aldo Righetti[1], Silvia M. Pietralunga[3], Maria C. Ubaldi[1]
[1]CIFE, Milano, Italy, [2]Politecnico di Milano, Dip. Elettronica e Informazione, Milano, Italy, [3]CNR-IFN, Milano, Italy

H20 608 **Numerical Modeling of $In_xGa_{1-x}N$/Silicon Multijunction Tandem Solar Cell**
Ming-Han Hsieh, Yuh-Renn Wu
National Taiwan University, Tapei, Taiwan

H22 609 **Design of Metamorphic Dual-Junction InGaP/ GaAs Solar Cell on Si with Efficiency Greater than 29% Using Finite Element Analysis**
Nikhil Jain, Mantu K Hudait
Virginia Tech, Blacksburg, VA, USA

H24 610 **High-Bandgap Solar Cells for Underwater Photovoltaic Applications**
Phillip P. Jenkins[1], Scott R. Messenger[1], Kelly M. Trautz[1], Sergey Maximenko[2], David Goldstein[1], David A. Scheiman[1], Robert J. Walters[1]
[1]Naval Research Laboratory, Washington, DC, USA, [2]Soltera, Alexandria, VA, USA

H26 611 **Analysis of Energy Production of Spectrolab Multijunction Solar Cells in Field Conditions**
R. K. Jones, R. R. King, C. M. Fetzer, J. H. Ermer, K. M. Edmondson, P. Hebert
Spectrolab, Inc., Sylmar, CA, USA

H28 612 **Device Modeling of an Optimized Monolithic All Lattice-Matched 3-Junction Solar Cell with Efficiency > 51%**
Marina S. Leite[1,2,3], Harry A. Atwater[1]
[1]Thomas Watson Laboratories in Applied Physics, CALTECH, Pasadena, CA, USA, [2]CNST, National Institute for Standards and Technology, Gaithersburg, MD, USA, [3]Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, MD, USA

I2 613 **Mirror-Augmented Photovoltaic Designs and Performances**
Wei-Chun Lin[1], Dave Hollingshead[2], Roger French[1], Kara Shell[2], Joseph Karas[1]
[1]Case Western Reserve University, Cleveland, OH, USA, [2]Replex Plastics, Mount Vernon, OH, USA

I4 614 **Efficiency Enhancement of GaAs Single-Junction Solar Cells via Improved Optical Designs**
Shi Liu, Ding Ding, Shane R. Johnson, Yong-Hang Zhang
Center for Photonics Innovation and School of Electrical, Computer, and Energy Engineering, Arizona State University, Tempe, AZ, USA

I6 615 **An Examination of 1-D Solar Cell Model Limitations Using 3-D SPICE Modeling**
William E. McMahon, Jerry M. Olson, John F. Geisz, Daniel J. Friedman
National Renewable Energy Laboratory, Golden, CO, USA

I8 616 **An Alternative Arrangement to Triple-Junction Devices for Reduced Temperature Effects and Enhanced Spectrum Exploitation**
Alaeddine Mokri, Mahieddine Emziane
Masdar Institute of Science and Technology, Masdar City, United Arab Emirates

I10 617 **Annual Energy Yield: A Comparison Between Various Monolithic and Mechanically Stacked Multijunction Solar Cells**
Yves Mols[1], Lu Zhao[1,2], Giovanni Flamand[1], Marc Meuris[1], Jef Poortmans[1]
[1]Imec, Leuven, Belgium, [2]Du Pont Apollo Ltd., Shatin, N.T., Hong Kong

I12 618 **Modeling of InAs/GaSb Tunnel Junction**
Pradyumna Muralidharan[1], Dragica Vasileska[1], Y.-H. Zhang[2]
[1]School of Electrical, Computer and Energy Engineering,Arizona State University, Tempe, AZ, USA, [2]Center for Photonics Innovation and School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, USA

I14 619 **Efficiency Simulations of Top Surface Light Management Structures for Concentrator Solar Cells Using RCWA and Detailed Balance Theory**
Efrain Eduardo Tamayo Ruiz[1,2], Kentaroh Watanabe[1], Ryosuke Watanabe[1], Masakazu Sugiyama[1,2], Yoshitaka Okada[1,2], Kenjiro Miyano[1,2]
[1]Research Center for Advanced Science and Technology (RCAST), The University of Tokyo, Meguro-ku, Japan, [2]School of Engineering, The University of Tokyo, Bunkyo-ku, Japan

I16 620 **A CPV System Design Technique to Maximize Optical Concentration and Efficiency, Based on Site-Specific Irradiance Conditions**
Shelby Vorndran[1], Juan Russo[2], Deming Zhang[2], Michael Gordon[1], Raymond Kostuk[2]
[1]The University of Arizona College of Optical Sciences, Tucson, AZ, USA, [2]The University of Arizona Department of Electrical and Computer Engineering, Tucson, AZ, USA

I18 621 **Optimizing the Design of 2-D Subwavelength ARC Gratings for Multijunction III-V Concentrator Cells**
Wei Wang, Alex Freundlich
University of Houston, Houston, TX, USA

I20 622 **Approaching the Shockley-Queisser Limit in GaAs Solar Cells**
Xufeng Wang, Mohammad Ryyan Khan, Muhammad A. Alam, Mark S. Lundstrom
Purdue University, West Lafayette, IN, USA

I22 623 **A Distributed Emitter Model for Solar Cells: Extracting a Temperature Dependent Lumped Series Resistance**
John R. Wilcox, Jeffery L. Gray
Purdue, West Lafayette, IN, USA

3:30 - 5:00 PM **EH4-D**

Area 4: Crystalline Silicon: Industrial Cell Technology (Posters)

Chair(s): Bart Geerligs

I26 624 **Inline Thermal Anneal to Improve Efficiency of c-Si Solar Cells**
Tianming Bao, Hui Tao, Frank Bottari
BTU International, Shanghai, China

J2 625 **Value of Thermal Oxide for Ion Implanted Silicon Solar Cells**
Vikram Bhosle, Chris Dube, Nick Bateman
Applied Materials, Varian Semiconductor Equipment, Gloucester, MA, USA

J6 626 **Selective- and Homo-Emitter Junction Formation Using Precise Dopant Concentration Control by Ion Implantation and Microwave, Laser or Furnace Annealing Techniques**
John O. Borland[1], Victor Moroz[2], Joanne Huang[2], John Chen[3], Yao-Jen Lee[4], Peter Oesterlin[5], Peter Venema[6], Henri Geerman[6], Peter Zhao[7], Larry Wang[7]
[1]J.O.B. Technologies, Aiea, HI, USA, [2]Synopsys, Mountain View, CA, USA, [3]Kingstone, Shanghai, China, [4]Nano Device Lab, Hsinchu, Taiwan, [5]Innovavent GmbH, Gottingen, Germany, [6]Tempress Systems, Vaassen, Netherlands, [7]Eavans Analytical Group, Sunnyvale, CA, USA

J10 627 **Metal Contact and Diffusion Optimization for Selective Emitter**
Michael Z. Burrows, Andreas Meisel, Giuseppe Scardera, Francesco Lemmi, Homer Antoniadis
Innovalight, Inc., Sunnyvale, CA, USA

J14 628 **The Investigation on the Front Surface Oxidation for Aluminum Rear Emitter n-Type Solar Cells**
Liping Chen, Xi Xi, Wenjuan Wu, Feng Gao, Jin Xu, Zhengxin Wang, Zhenqiu Yu, Qian Lu, Song Zhang, Haidong Zhu, Rulong Chen, Jian Yang, Jingjia Ji, Zhengrong Shi
Suntech Power Co., Ltd., Wuxi, China

J18 629 **Shinsung Solar Energy High-Efficiency Commercial-Crystalline Si Solar Cells**
Kyeong-Yeon Cho[1], Jisoo Kim[1], Eun-Joo Lee[1], Keun-kee Hong[1], Hyun-Woo Lee[1], Ji-Myung Shim[1], Dong-Joon Oh[1], Jeong-Eun Shin[1], Ji-Sun Kim[1], Jae-Keun Seo[1], Soo-hong Lee[2], Brett Hallam[3], Stuart Wenham[3], Hae-Seok Lee[1]
[1]R&D center, Solar cell division, Shinsung solar energy, Seongnam-Si, South Korea, [2]Department of Electronic Engineering, Sejong University, Seoul, South Korea, [3]School of Photovoltaic & Renewable Energy Engineering, University of New South Wales, Kensington NSW, Australia

J22 630 **Investigation of the Dependence of a Screen-Printed Solar Cell Open Circuit Voltage on the Al Paste Composition**
Abasifreke U. Ebong[1], Ernest Addo[2]
[1]Department of Electrical and Computer Engineering, University of North Carolina at Charlotte, Charlotte, NC, USA, [2]PVCH, LLC, Newark, DE, USA

J26 631 **Method of Fabrication of a Backside Silicon Solar Cell by Electrothermal and Electrical Means**
Boris Gilman
Coolsol R&C, Mountain View, CA, USA

K2 632 **Studies on the Effect of Gas Flow Rates in Optimizing Silicon Nitride Films for Multicrystalline Silicon Solar Cells**
A. Guru Prasad, S. Saravanan, D.S. Murty, Dinesh Kumar, Prakash Suratkar
TATA BP Solar India Ltd, Bangalore, India

K6 633 **Ion Shower Doping for Emitter Fabrication in Crystalline Si Solar Cells**
Hiroki Hashiguchi[1], Tomihisa Tachibana[1], Mari Aoki[2], Takuto Kojima[2], Yoshio Ohshita[2], Atsushi Ogura[1]
[1]Meiji University, Kawasaki, Japan, [2]Toyota Tech. Inst., Nagoya, Japan

K10 634 **Preferable Opening Area of Screen Mesh to Print Fine Finger Electrode with Uniform Surface**
Hideaki Hayashi[1], Koji Honda[1], Isao Sumita[2], Uichi Itoh[3], Manabu Yoshida[3], Hideo Tokuhisa[3]
[1]Asada Mesh Co., LTD., Osaka, Japan, [2]Sumita Consulting, Yokohama, Japan, [3]National Institute of Advanced Industrial and Scientific Technology, Tsukuba, Japan

K14 635 **Comparison of Photoluminescence Imaging on Starting Multicrystalline Silicon Wafers to Finished Cell Performance**
Steven W. Johnston[1], Fei Yan[1], David Dorn[2], Katherine Zaunbrecher[1,3], Mowafak Al-Jassim[1], Omar Sidelkheir[4], Kamel Ounadjela[4]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Specialized Imaging, Loveland, CO, USA, [3]Colorado State University, Fort Collins, CO, USA, [4]Calisolar, Sunnyvale, CA, USA

K18 636 **Screen-Printed Finger Electrode with High Aspect Ratio by Single Printing for Crystal Si Solar Cell Using Novel Screen Mask**
Uichi Itoh[1], Manabu Yoshida[1], Hideo Tokuhisa[1], Nobuyuki Ushifusa[2], Isao Sumita[3], Takashi Fukunishi[4], Mari Aoki[5], Yoshio Ohshita[5], Hidetoshi Kamata[1]
[1]AIST, Tsukuba, Japan, [2]Hitachi, Ltd., Yokohama, Japan, [3]Sumita, Yokohama, Japan, [4]Chiyoda trading, Osaka, Japan, [5]Toyota Technological Institute, Nagoya, Japan

K22 637 **Advancements in Low-Silver Metallization Paste for Si Solar Cells**
Lindsey A. Karpowich, Kristin E. Murphy, Weiming Zhang
Heraeus Precious Metals North America Conshohocken LLC, W. Conshohocken, PA, USA

K26 638 **Advanced Process Control of Chemical Concentration for Solar Cell Manufacturing**
Ismail Kashkoush, Gim Chen, Dennis Nemeth, Jennifer Rieker
Akrion Systems, Allentown, PA, USA

L1 639 **The Effect of the Doping Methods for Laser-Doped Selective-Emitter Silicon Solar Cells**
Jisoo Kim[1], Kyeong-Yeon Cho[1], Eun-Joo Lee[1], Keun-Kee Hong[1], Hyun-Woo Lee[1], Ji-Myung Shim[1], Dong-Joon Oh[1], Jeong-Eun Shin[1], Ji-Sun Kim[1], Jae-Keun Seo[1], Soo-hong Lee[2], Brett Hallam[3], Stuart Wenham[3], Hae-Seok Lee[1]
[1]R&D Center, Solar Cell Division, Shinsung Solar Energy, Seongnam-Si, South Korea, [2]Department of Electronic Engineering, Sejong University, Seoul, South Korea, [3]School of Photovoltaic & Renewable Energy Engineering, University of New South Wales, Kensington NSW, Australia

L4 640 **Evaluation of Recombination in a Bifacial Si Solar Cell with Back Surface Field Formed by Ion Implantation**
Lev Kreinin[1], Ninel Bordin[1], Naftali Eisenberg[1], Peter Grabitz [2], Gerhard Wahl[2]
[1]b-Solar Ltd., Jerusalem, Israel, [2]b-Solar GmbH, Heilbronn, Germany

L7 641 **Ultrafast Laser Direct Hard-Mask Writing for High Performance Inverted-Pyramidal Texturing of Silicon**
Kitty Kumar, Kenneth C. Lee, Jun Nogami, Peter R. Herman, Nazir P. Kherani
University of Toronto, Toronto, ON, Canada

L10 642 **Progress in Production-Worthy Point Contact Solar Cells Process**
Prabhat Kumar, Kapila Wijekoon, Mukul Agrawal, Kalyan Rapolu, Hemant Mungekar, Michael Stewart, Yi Zheng, Lin Zhang, David Tanner, Hari Ponnekanti
Applied Materials Inc., Santa Clara, CA, USA

L13 643 **Large-Area ~20%-Efficient Silicon Solar Cells Using Fine-Line Direct Printing**
Jiun-Hong Lai[1], Ian B. Cooper[1], Xudong Chen[2], Kenneth Church[2], Haixin Yang[3], Chai-Wei Chen[1], Ajeet Rohatgi[4,5]
[1]University Center of Excellence for Photovoltaics, Georgia Institute of Technology, Atlanta, GA, USA, [2]nScrypt Inc, Orlando, FL, USA, [3]DuPont Microcircuit Materials, Triangle, NC, USA, [4]Regent's Professor, Georgia Institute of Technology, Atlanta, GA, USA, [5]Founder and CTO, Suniva Inc, Norcross, GA, Georgia

L16 644 **Microstructural Characterization of Front-Side Ag Contact of Crystalline Si Solar Cells with Lightly-Doped Emitter**
Z. Li[1], K. Mikeska[1], L. Liang[1], D. Roach[1], L. Cheng[1], M. Lewittes[1], A. Carroll[2], A. Meisel[3], C. Jiang[4]
[1]DuPont Central Research and Development, Wilmington, DE, USA, [2]DuPont Electronic Technologies, Research Triangle Park, NC, USA, [3]DuPont Innovalight, Sunnyvale, CA, USA, [4]National Renewable Energy Laboratory, Golden, CO, USA

L19 645 **Improved Silver Paste Allows 19%-Efficient c-Si Solar Cell with Homogeneous High-Sheet-Resistance $POCl_3$ Emitter**
Jong-Keun LIM[1], Junmo SEO[2], Kyumin LEE[1], Myung-Ick HWANG[2], Won-jae LEE[1], Eun-Chel CHO[2]
[1]Hyundai Electro-Mechanical Research Institute (HEMRI), Hyundai Heavy Industries, Co., Ltd., Yongin, Korea, [2]Green Energy Business Division, Hyundai Heavy Industries, Co., Ltd., Eumseong, Korea

L22 646 **Aluminum Local Back-Surface Field Solar Cells with Inkjet-Opened Rear Dielectric Films**
Licheng Liu[1,2], Zheren Du[1,2], Fen Lin[1], Bram Hoex[1], Armin Gerhard Aberle[1,2]
[1]Solar Energy Research Institute of Singapore (SERIS), Singapore, Singapore, [2]Department of Electrical & Computer Engineering, Faculty of Engineering, National University of Singapore, Singapore, Singapore

L25 647 **Improved Contact Formation for Large-Area Solar Cells Using the Alternative Seed Layer (ASL) Process**
Lynne M. Michaelson, Krystal Munoz, Jonathan C. Wang, Tom Tyson, Anthony Gallegos
Technic Inc., Cranston, RI, USA

L28 648 **Enhanced Phosphorus Diffusion Gettering by Temperature Optimization**
Ashley E. Morishige, David P. Fenning, Jasmin Hofstetter, Douglas M. Powell, Tonio Buonassisi
Massachusetts Institute of Technology, Cambridge, MA, USA

M3 649 **Towards Fabrication of Low-Cost High-Efficiency c-Si Solar Cell: Progress and Optimization Using TCAD Simulation Study**
Karthick Murukesan, Narasimha Rao Mavilla, Brij Mohan Arora
NCPRE, Department of Electrical Engineering, IIT Bombay, Mumbai, India

M6 650 **Optimizing the Geometry of Local Aluminum-Alloyed Contacts to Fully Screen-Printed Silicon Solar Cells**
Jens Müller[1], Sebastian Gatz[1], Karsten Bothe[1], Rolf Brendel[1,2]
[1]Institute for Solar Energy Research Hamelin, Emmerthal, Germany, [2]Institute of Solid-state Physics, University of Hanover, Hanover, Germany

M9 651 **Efficient Crystalline Si Solar Cell with Amorphous/Crystalline Silicon Heterojunction as Back Contact**
Bill Nemeth[1], Qi Wang[1], Wei Shan[2]
[1]NREL, Golden, CO, USA, [2]JA Solar, Milpitas, CA, USA

M12 652 **Fabrication and Characterization Of Thin c-Si Solar Cells By Low-Cost Methods**
Efrain Ochoa-Martinez[1], Mercedes Gabas[1], Jose R. Ramos-Barrado[1], Candido Vazquez[2], Itziar Hoces[3], Juan C. Jimeno[3], Bouchaib Hartiti[4]
[1]Dpto. de Física Aplicada I, Lab. de Materiales y Superficies, Universidad de Málaga, Malaga, Spain, [2]Isofotón S.A, Malaga, Spain, [3]Instituto de Tecnología Microelectrónica (TiM) UPV/EHU, Bilbao, Spain, [4]Laboratoire LPMAER, FST de Mohammédia, Université Hassan II, Mohammédia, Morocco

M15 653 **Thin (<100µm) Crystalline Silicon Solar Cell Fabrication Using Low-Cost Feedstock and Diamond Wire Slice Technologies**
Yoshio Ohshita[1], Mari Aoki[1], Takuto Kojima[1], Tomohisa Tachibana[2], Atsushi Ogura[2]
[1]Toyota Technological Institute, Nagoya, Japan, [2]Meiji University, Kanagawa, Japan

M18 654 **Ion-Implanted and Screen-Printed Large-Area 19%-Efficient n-Type Bifacial Si Solar cells**
Young-Woo Ok[1], Ajay D. Upadhyaya[1], Francesco Zimbardi[1], Steven Ning[1], Ajeet Rohatgi[1,2]
[1]Georgia Institute of Technology, Atlanta, GA, USA, [2]Suniva Inc., Atlanta, GA, USA

M20 655 **Non-Contact Printed Aluminum Metallization of Si Photovoltaic Devices**
Heather A.S. Platt[1], Yunjun Li[2], James P. Novak[2], Maikel F.A.M. van Hest[1]
[1]National Renewable Energy Lab, Golden, CO, USA, [2]Applied Nanotech, Inc., Austin, TX, USA

M22 656 **Industrial Process and Materials for In-Line Boron Diffusion in n-Type Silicon**
Paul Richter, Frank Bottari, David Wong
BTU International, Inc., North Billerica, MA, USA

M24 657 **High Efficiency n-Type Solar Cells with Screen-Printed Boron Emitters and Ion Implanted Back Surface Field**
Kyungsun Ryu[1], Ajay Upadhyaya[1], Young-Woo Ok[1], Helen Xu[2], Lea Metin[2], Anil Bhanap[2], Ajeet Rohatgi[1,3]
[1]UCEP, Georgia Institute of Technology, Atlanta, GA, USA, [2]Honeywell International Inc., Sunnyvale, CA, USA, [3]Founder and CTO, Suniva Inc., Norcross, GA, USA

M26 658 **A Novel Non-Lithographic Patterning Method for Fabricating Solar Cells**
Sayan Saha[1], Rajesh A. Rao[2], Leo Mathew[2], Moses Ainom[2], Sanjay K. Banerjee[1]
[1]University of Texas, Austin, TX, USA, [2]AstroWatt, Inc., Austin, TX, USA

M28 659 **Ion-Implant Doped Large-Area n-Type Czochralski High-Efficiency Industrial Solar Cells**
Manav Sheoran, Matthew Emsley, Min Yuan, Deepak Ramappa, Paul Sullivan
Applied Materials, Varian Semiconductor Equipment, Santa Clara, CA, USA

N2 660 **Design of Antireflection Coating for Surface Textured Interdigitated Back Contact Silicon Heterojunction Solar Cell**
Brent Shu[1, 2], Ujjwal Das[1], Lei Chen[1], Lulu Zhang[1], Steven Hegedus[1], Robert Birkmire[1, 2]
[1]Institute of Energy Conversion, University of Delaware, Newark, DE, USA, [2]Department of Physics and Astronomy, University of Delaware, Newark, DE, USA

N4 661 **The Investigation on Fast and Uniform Diffusion for Silicon Solar Cell Production**
Ning Tang, Xi Xi, Zhengxin Wang, Hongqiang Qian, Feng Gao, Liping Chen, Wenjuan Wu, Cheng Huang, Yongfei Jiang, Haidong Zhu, Rulong Chen, Jian Yang, Jingjia Ji, Zhengrong Shi
Suntech Power Co., Ltd., Wuxi, China

N6 662 **Silver Ink Experiments for Silicon Solar Cell Metallization by Flexographic Process**
Sébastien Thibert[1,2], Didier Chaussy[1], Beneventi Davide[1], Reverdy-Bruas Nadège[1], Johann Jourdan[2], Bernard Bechevet[2], Simon Mialon[2]
[1]Lgp2 Grenoble INP-Pagora, Saint-Martin-d'Hères, France, [2]MPO-Energy, Averton, France

N8 663 **High-Efficiency Lead-Free Silver Pastes for Crystalline Silicon Solar Cells**
Paul D. VerNooy[1], Charlie C. Torardi[1], Zhigang Li[1], Mark E. Lewittes[1], Ross Getty[1], Kurt R. Mikeska[1], Alex S. Ionkin[1], Lapkin K. Cheng[1], Alex Wu[2], Brian J. Laughlin[3], Giovanna Laudisio[4]
[1]DuPont Central Research and Development, Wilmington, DE, USA, [2]DuPont Microcircuit Materials, Taoyuan, Taiwan, [3]DuPont Microcircuit Materials, Research Triangle Park, NC, USA, [4]DuPont Microcircuit Materials, Bristol, United Kingdom

N10 664 **The Fire-Through Processing of the Screen-Printed Ag Thick-Film Metal Contacts on Etched Porous Silicon ARC of the Si Solar Cells**
P. Narayanan Vinod
Naval Physical and Oceanographic Laboratory, Thrikkakara P.O., Kochi, India

N12 665 **Electric-Arc Micro-Texturing of Silicon Surfaces for Photovoltaic Applications**
Longteng Wang, Vikram V. Iyengar, Mool C. Gupta
Department of Electrical and Computer Engineering, University of Virginia, Charlottesville, VA, USA

N14 666 **The Investigation on the Quality of Aluminum Rear Emitter for n-Type Solar Cells**
Wenjuan Wu, Xi Xi, Liping Chen, Feng Gao, Jin Xu, Zhengxin Wang, Zhenqiu Yu, Qian Lu, Song Zhang, Haidong Zhu, Rulong Chen, Jian Yang, Jingjia Ji, Zhengtong Shi
Suntech Power Co., Ltd., Wuxi, China

N16 667 **The Investigation on the Texture Differences Between p-Type and n-Type Crystalline Silicon Wafers**
Wenjuan Wu, Jin Xu, Xi Xi, Liping Chen, Feng Gao, Zhengxin Wang, Zhenqiu Yu, Qian Lu, Song Zhang, Haidong Zhu, Rulong Chen, Jian Yang, Jingjia Ji, Zhengrong Shi
Suntech Power Co., Ltd., Wuxi, China

N18 668 **Development and Comparison of Small- and Large-Area Boron-Doped Solar Cells in Cz-Si n-Type and p-Type Substrates**
Izete Zanesco, Adriano Moehlecke, Jaqueline Ludvig Pinto, Moussa Ly
PUCRS - Catholic University, Porto Alegre, Brazil

N20 669 **0.35% Absolute Efficiency Gain of Bifacial n-Type Si Solar Cells by Industrial Metal Wrap Through Technology**
Wenchao Zhao[1], Jianming Wang[1], Yanlong Shen[1], Ziqian Wang[1], Yingle Chen[1], Zhiyan Hu[1], Gaofei Li[1], Jianhui Chen[1], Jingfeng Xiong[1], N. Guillevin[2], B.J.B. Heurtault[2], L.J. Geerligs[2], A.W. Weeber[2], J.H. Bultman[2]
[1]Yingli Green Energy Holding Co., Ltd, Baoding, China, [2]ECN Solar Energy, Alkmaar, Netherlands

N22 670 **The Effect of Emitter Profile on Laser-Doped Multicrystalline Silicon Selective-Emitter Cells**
Chunlan Zhou, Su Zhou, Wenjing Wang
The Key Laboratory of Solar Thermal Energy and Photovoltaic System, Institute of Electrical Engineering, Beijing, China

3:30 - 5:00 PM **EH4-E**

Area 6: Organic Photovoltaics: Contacts and Dye Cells (Posters)

Chair(s): Ivgenny Katz, Dana Olson

P6 671 **Surface-Modified ZnO Nanorod Arrays for Hybrid Solar Cell Applications**
Samir AbdulAlmosin, Jingbiao Cui
University of Arkansas at Little Rock, Little Rock, AR, USA

P8 672 **Improvement of Morphological and Electrical Properties in Poly (3-hexylthiophene-2, 5-diyl) Films Formed by Thermal Annealing in the Presence of Electric Field During the Solvent Drying Step**
Anirban Bagui[1,3], S. Sundar Kumar Iyer[2,3]
[1]Department of Physics, Indian Institute of Technology Kanpur, Kanpur, India, [2]Department of Electrical Engineering, Indian Institute of Technology Kanpur, Kanpur, India, [3]Samtel Centre for Display Technologies, Indian Institute of Technology Kanpur, Kanpur, India

P10 673 **Atomistic Modeling of Titania Grown Using PVD Methods**
Sabrina Blackwell[1], Roger Smith[1], Steven D. Kenny[1], John M. Walls[2]
[1]Department of Mathematical Sciences, Loughborough University, Loughborough, United Kingdom, [2]Department of Electronic and Electrical Engineering, Loughborough University, Loughborough, United Kingdom

P12 674 **Development and Demonstration of Flexible, Multi-Component Hybrid Sealing System for Encapsulating Organic Photovoltaics**
Minjae Kim[1], Mike Clingerman[2], Alex Kawczak[2], Paul R. Berger[1,3]
[1]Department of Electrical and Computer Engineering, The Ohio State University, Columbus, OH, USA, [2]StrateNexus Technologies, LLC, Columbus, OH, USA, [3]Department of Physics, The Ohio State University, Columbus, OH, USA

P14 675 **Novel Non-Aggregated Hyperbranched Phthalocyanines for Efficient Dye-Sensitized Solar Cells**
Yong Li[1,2], Peifen Lu[1], Xingzhong Yan[1], Zhonghua Peng[2]
[1]Department of Electrical Engineering and Computer Science, South Dakota State University, Brookings, SD, USA, [2]Department of Chemistry, University of Missouri-Kansas City, Kansas City, MO, USA

P16 676 **Electric and Optical Transport of MWNT/ Silicon Junctions**
Muatez Z. Mohammed, Tar-pin Chen, Zhongrui Li, Jingbiao Cui
University of Arkansas at Little Rock & Arkansas GREEN Solar Cell Research Center, Little Rock, AR, USA

P18 677 **Module Construction of Dye-Sensitized Solar Cells by Using Chemical Etching**
The-Vinh Nguyen[1], O-Bong Yang[2]
[1]Hochiminh City University of Technology, Hochiminh, Vietnam, [2]Chonbuk National University, Jeonju, South Korea

P20 678 **Enhancement of Indium-Based Organic Photovoltaics**
Badr Omrane, Yindar Chuo, Jeyd Aristizabal, Clinton K. Landrock, David Fournier, Sasan V. Grayli, Siamack V. Grayli, Bozena Kaminska
Simon Fraser University, Burnaby, BC, Canada

P22 679 **Transparent Conductive Film Fabrication by Carbon Nanotube Ink Spray Coating and Ink-Jet Printing**
Wei Zhou[1,2], Amare Benor Belay[1,2], Kris Davis[1,2], Nicoleta Sorloaica-Hic kman[1,2]
[1]Florida Solar Energy Center, University of Central Florida, Orlando, FL, USA, [2]College of Optics & Photonics, University of Central Florida, Orlando, FL, USA

P24 680 **Achieving Fill Factor Above 80% in Organic Solar Cells by Interface Engineering**
Biswajit Ray, Muhammad Alam
Purdue University, West Lafayette, IN, USA

3:30 - 5:00 PM **EH4-F**

Area 9: Modules and Systems: Module Materials, Durability, and Performance (Posters)

Chair(s): Wilfried van Sark, Max Köntopp, Peter Hacke

T10 681 **Electrical Insulation Requirements for Combinations of Polymeric Film Components in PV Modules**
Howard S. Creel, Nancy H. Phillips, William D. O'Brien, Brad L. Givot
3M, St. Paul, MN, USA

T14 682 **Improved Plastic Materials for Application in PV Modules**
Dan M.J. Doble, Andrew Kodis, Rob deJong, Karen van der Wetering
Sabic IP, Pittsfield, MA, USA

T18 683 **Improving Long-Term Performance and Durability of Photovoltaic Modules by Incorporating an Edge Sealant with Optimized Properties and Application Design Flexibility**
Samar Teli, Justin Bates, Dennis Booth, Tim O'Neil
Adco Products Inc., Michigan Center, MI, USA

T22 684 **Effect of Encapsulant Film Properties on PV Module Performance**
Shaofu Wu[1], Nick Nichole[2], Bert Weaver[1], John Naumovitz[2], Neelkanth Dhere[3]
[1]The Dow Chemical Company, Freeport, TX, USA, [2]The Dow Chemical Company, Midland, MI, USA, [3]University of Central Florida, Cocoa, FL, USA

U2 685 **The Effect of Volume Resistance of EVA Encapsulant on the Insulation Performance of the PV Modules**
Jiang Weina, Zhang Yan, Zhou Jian
ET-solar, Taizhou, China

U6 686 **Effect of Encapsulant on Cell-to-Module Power Loss in PV Modules with Ion Implant and $POCl_3$ Cells**
Biao Li[1], Jennifer A. Segui[1], Cyril J. Fountain[1], Christopher E. Dube[2], Basil Tsefrekas[2]
[1]Fraunhofer Center for Sustainable Energy Systems CSE, Cambridge, MA, USA, [2]Applied Materials, Varian Semiconductor Equipment, Gloucester, MA, USA

U10 687 **Glass-Surface Morphology Effect of Antireflection-Coated Solar Glass in Crystalline Solar Module**
Jong Dae Kim, BoJoong Kim, YongWoo Choi
Solar Biz. Division, LG Electronics, Seoul, Korea

U14 688 **Yield Strength Lowering of PV Interconnector Ribbon Using Control of Crystallographic Texture**
Byungjun Kang[1], Won Wook Oh[1], Sung Ju Tark[1], Nochang Park[1,2], Young Do Kim[1], Chang-Sik Son[3], Donghwan Kim[1]
[1]Korea University, Seoul, South Korea, [2]Korea Electronics Technology Institute, Seongnam, South Korea, [3]Silla University, Busan, South Korea

U18 689 **Conductive Adhesive Based on Carbon Nanotubes for Solar Cells Interconnection**
Yonas Zemen[1,2], Carolin Schulz[3], Helge Trommler[1,4], Samuel T. Buschhorn[4], Wolfgang Bauhofer[3], Karl Schulte[4]
[1]SOLON SE, Berlin, Germany, [2]SOLON Corporation, Tucson, AZ, USA, [3]Institute for Optical and Electronic Materials, Hamburg University of Technology (TUHH), Hamburg, Germany, [4]Institute for Polymer Composites, Hamburg University of Technology (TUHH), Hamburg, Germany

U22 690 **Temperature of Solder Contact in Back-Contact Si Solar Cells and Its Effect on Reliability of Modules Under Localized Shading Environments**
Lewis Abra, Seung B. Rim, Doug Kim
SunPower Corp., San Jose, CA, USA

V2 691 **Comparative Study of Active Solder and Conventional Solder on Photovoltaic Cells**
Christopher M. Darvell, Pritpal Singh
Villanova University, Villanova, PA, USA

V6 692 **Recycling of Materials from Silicon-Based Solar Cell Modules**
Teng-Yu Wang[1], Jui-Chung Hsiao[1], Chen-Hsun Du[2]
[1]Green Energy and Environment Research Labs, Industrial Technology Research Institute, Hsinchu, Taiwan, [2]Institute of NanoEngineering and MicroSystems, National Tsing Hua University, Hsinchu, Taiwan

V10 693 **Superior Low-Light-Level Performance of Upgraded-Metallurgical-Grade Si Modules**
Kamel Ounadjela[1], Jean-Patrice Rakotoniana[1], Omar Sidelkheir[1], Olivier Laparra[1], Martin Kaes[2], Ryan Smith[3], Steve Rummel[3], Mowafak Al-Jassim[3]
[1]Calisolar Inc., Sunnyvale, CA, USA, [2]Calisolar GmbH, Berlin, Germany, [3]NREL, Golden, CO, USA

V14 694 **PV Modules with Variable Ideality Factors**
Georgi Hristov Yordanov[1,2], Ole-Morten Midtgård[1,2], Tor Oskar Saetre[1]
[1]University of Agder (UiA), Grimstad, Norway, [2]Norwegian University of Science and Technology (NTNU), Trondheim, Norway

V18 695 **Outdoor Performance of 10-Year-Old a-Si and Poly-Si Modules in Southern Norway Conditions**
Deepak Verma[1], Muhammad Tayyib[1], Tor O. Sætre[1], Ole-Morten Midtgård[1]
[1]University of Agder, Faculty of Engineering and Science, Grimstad, Norway

V22 696 **Outdoor Performance of North-Facing Multicrystalline Modules in Southern Norway**
Deepak Verma, Muhammad Tayyib, Tor O. Sætre, Ole-Morten Midtgård
University of Agder, Faculty of Engineering and Science, Grimstad, Norway

W2 697 **Comparative Study of the Performance of Field-Aged Photovoltaic Modules Located in a Hot and Humid Environment**
Nicoleta Sorloaica-Hickman[1], Kris Davis[1], Sarah Kurtz[2], Dirk Jordan[2]
[1]Florida Solar Energy Center, University of Central Florida, Orlando, FL, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

W6 698 **Test of the European Joint Research Centre Performance Model for c-Si PV Modules**
Georgi Hristov Yordanov[1,2], Muhammad Tayyib[1], Ole-Morten Midtgård[1,2], Jan-Ove Odden[3], Tor Oskar Saetre[1]
[1]University of Agder, Grimstad, Norway, [2]Norwegian University of Science and Technology, Trondheim, Norway, [3]Elkem Solar AS, Kristiansand, Norway

W10 699 **Cell-To-Module (CTM) Power Conversion Analysis of Industrial Crystalline Silicon Solar Cells**
Indeok Chung[1], Un-il Baek[1], In-Sik Moon[1], Keyman Bae[2], Sungyong Shin[2], Eun-Chel Cho[2], Ohjune Kwon[2], Seungmin Shin[2], Won-jae Lee[1]
[1]Hyundai Electro-Mechanical Research Institute, Hyundai Heavy Industries, Co., Ltd., Yongin, Korea, [2]Green Energy Business Division, Hyundai Heavy Industries, Co., Ltd., Eumseong, Korea

W14 700 **Stability of the Performance of Thin-Film Modules During One Year of Operation**
Hans Georg Beyer, Georgi Yordanov
University of Agder, Grimstad, Norway

W18 701 **Initial Light-Induced Degradation Study of Multicrystalline Modules Made from Silicon Material Processed Through Different Manufacturing Routes**
Muhammad Tayyib[1], Y. Harshavardhana[2], M. Ramanjaneyulu[2], T.S. Surendra[3], Jan Ove Odden[4], Tor Oskar Seatre[1]
[1]University of Agder, Grimstad, Norway, [2]Titan Energy Systems Ltd, Andhra Pradesh, India, [3]Padmasri Dr. B.V. Raju Inst. Of Techn, Narsapur, India, [4]Elkem Solar, Kristiansand, Norway

W22 702 **Comparison of the Performance Degradation Between Selective Emitter Solar Cells Recently Commercialized and Standard Solar Cells Under Encapsulation and Outdoor Exposure**
Zongcun Liang, Fei Zeng, Shuquan Chen, Hui Shen
Institute for Solar Energy System, School of Physics and Engineering, State Key Laboratory of Optoelectronic Materials and Technologies, Sun Yat-Sen University, Guangzhou, China

X1 703 **Seasonal Variation of PV Module Performance in Tropical Regions**
Jiaying Ye, Thomas Reindl, Joachim Luther
Solar Energy Research Institute of Singapore, Singapore, Singapore

X4 704 **Characterization of Field-Exposed Thin-Film Modules**
John H. Wohlgemuth[1], Oruganti S. Sastry[2], Adam Stokes[1], Yogesh K. Singh[2], Mithilesh Kumar[2]
[1]NREL, Golden, CO, USA, [2]Solar Energy Centre, New Delhi, India

X7 705 **A Shade-Tolerant Panel Design for Thin-Film Photovoltaics**
Sourabh Dongaonkar, Muhammad A. Alam
School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, USA

X10 706 **Statistical Analysis of Commercial c-Si PV Module Efficiency Distribution over 11-Years Period**
Joseph M. Kuitche[1], Vivek Sharma[1], Jaewon Oh[1], Rong Pan[1], Govindasamy TamizhMani[1,2]
[1]Arizona State University, Tempe, AZ, USA, [2]TUV Rheinland PTL, Tempe, AZ, USA

X13 707 **Failure Rate Analysis of Module Design Qualification Testing - IV: 1997-2005 vs. 2005-2007 vs. 2007-2009 vs. 2009-2011**
Govindasamy TamizhMani, Bo Li, Todd Arends, William Shisler, Arseniy Voropayev, Daniel Parker, Kamerine Kroner, Jameel Armstrong
TUV Rheinland PTL, Tempe, AZ, USA

X14 708 **Online Photovoltaic Array Hot-spot Bayesian Diagnostics from Streaming String-Level Electric Data**
Stephen C Yang[2], Shahar Ben Menahem[1]
[1]1Carnegie Mellon University SV, Moffett Field, Mountain View, CA, USA, [2]Wattminder Inc., Sunnyvale, CA, USA

X15 709 **Potential Induced Degradation (PID) Study on Accelerated Stress-Tested PV Modules**
Sandhya Goranti, Govindasamy TamizhMani
Arizona State University, Mesa, AZ, USA

X16 710 **Study of Potential Induced Degradation (PID) Mechanism in Commercial PV Module**
Han-Chang Liu, Chung-Teng Huang, Wen-Kuei Lee
Industrial Technology Research Institute, Chutung Hsiuchu, Taiwan

X17 711 **High-Voltage Bias Testing of PV Modules in the Hot and Humid Climate Without Inducing Irreversible Instantaneous Degradation**
Neelkanth Dhere, Ashwani Kaul, Eric Schneller, Narendra Shiradkar
Florida Solar Energy Center, Cocoa, FL, USA

X18 712 **A Decision-Making Framework for Solar Photovoltaic Module Technologies Using Six Sigma**
Harish Krishnamoorthy, Poornima Mazumdar, Ilaval Manickam, Prasad Enjeti, Robert Balog
Texas A&M University, College Station, TX, USA

X19 713 **Analytical Thermal Stress Modeling in Design for Reliability (DfR) of Photovoltaic (PV) Assemblies**
Ephraim Suhir[1], Dongkai Shangguan[2]
[1]University of California, Santa Cruz, CA, USA, [2]Flextronics, Santa Clara, CA, USA

X20 714 **Probabilistic Design-for-Reliability (PDfR) of Photovoltaic (PV) Modules**
Ephraim Suhir[1], Dongkai Shangguan[2]
[1]University of California, Santa Cruz, CA, USA, [2]Flextronics, Santa Clara, CA, USA

3:30 - 5:00 PM **EH4-G**

Area 10: PV Velocity Forum: Session (Posters)

X21 715 **PV Programme In India: Present Status & Future Prospects**
Bharat Bhargava
New Delhi, India

X22 716 **An Overview of the Bangladeshi Photovoltaic Market, Government Policies, and Deployment Challenges**
Steven Limpert[1], Holly Battelle[2]
[1]Arizona State University, Tempe, AZ, USA, [2]Fulbright Scholar, Dhaka, Bangladesh

X23 717 **Deployment of PV Systems in Japan: The Opportunities and Challenges of New Feed-in Tariff Program**
Izumi Kaizuka, Takashi Ohigashi, Hiroshi Matsukawa, Haruki Yamaya
RTS Corporation, Tokyo, Japan

X24 718 **Grid Parity Reached for Consumers in the Netherlands**
Wilfried G. van Sark[1,2], Peter Muizebelt[3], Jadranka Cace[4], Arthur de Vries[1,5], Peer de Rijk[1,6]
[1]Stichting Monitoring Zonnestroom, Utrecht, Netherlands, [2]Utrecht University, Copernicus Institute, Utrecht, Netherlands, [3]New-Energy-Works, Utrecht, Netherlands, [4]Rencom, Ouderkerk a/d Amstel, Netherlands, [5]Holland Solar, Utrecht, Netherlands, [6]Organisatie voor Duurzame Energie, Utrecht, Netherlands

Y1 719 **Engineering Workforce Challenges for PV Market Expansion and Manufacturing in Argentina**
Julio A Bragagnolo, Sebastian Kind, Walter Legnani
UTN, Buenos Aires, Argentina

Y2 720 **Techno-Economic Analysis for the Placement of a Si-Based Low-Cost Solar Cells Factory in West Africa and Compared to China**
Ricardo Guerrero-Lemus[1], Pedro Rivero-Rodríguez[1], Bruno Díaz-Herrera[2], Benjamín González-Díaz[1], Gerardo López[3], Francisco Jarabo[1]
[1]Univ. La Laguna, La Laguna, Spain, [2]China Technology Development Group Corporation, Hong Kong, China, [3]Polígono Industrial de Granadilla, S.A., Granadilla, Spain

Y3 721 **"Teach a 1000 Teachers": A Methodology for the Rapid Ramp-up of Photovoltaics Manpower Required for India's National Solar Mission**
Chetan S. Solanki[1], B. G. Fernandes[1], B. M. Arora[1], Pratibha Sharma[1], V. Agarwal[1], M. B. Patil[1], J. Vasi[1], D. B. Phatak[2], Mukta Atrey[2], Kannan Moudgalya[3], Kamal Bijlani[4]
[1]National Centre for Photovoltaic Research and Education, Indian Institute of Technology Bombay, Mumbai, India, [2]Department of Computer Science and Engineering, Indian Institute of Technology Bombay, Mumbai, India, [3]Department of Chemical Engineering, Indian Institute of Technology Bombay, Mumbai, India, [4]Amrita University, Amritapuri, Kollam, India

Y4 722 **aSUNm Solar Decathlon House**
Athena A Christodoulou[1], Joshua J Williams[2]
[1]University of New Mexico, Albuquerque, NM, USA, [2]Arizona State University, Tempe, AZ, USA

Y5 723 **Known Knowns and Known Unknowns of U.S. Patent Reform (The America Invents Act)**
Clara Davis
Hollingsworth & Funk, Minneapolis, MN, USA

Y6 724 **Quantifying the Impacts of Long-Timescale Spatio-Temporal Solar Resource Variability at High PV Penetrations**
Marc J. Perez, Vasilis M. Fthenakis
Columbia University, New York, NY, USA

Y7 725 **Economic Value of Solar- and Wind-Generated Electricity Calculated from Locational Marginal Prices**
John H. Scofield
Oberlin College, Oberlin, OH, USA

Y8 726 **Thin-Film CIGS Report Card – Progress in CIGS Achieving Scale**
Graham C. Stevens
Navigant Consulting, Inc., Burlington, MA, USA

Y9 727 **Modeling of Photovotaic Power Plants**
Kevin P. Meagher, Brian Radibratovic, Silviu Darie
Power Analytics, San Diego, CA, USA

Y10 728 **Equipment Safety Standards for Semiconductor Tools Applicable to the Photovoltaic Industry**
Andrew C. Rudack
SEMATECH/PVMC, Albany, NY, USA

3:30 - 5:00 PM **Exhibit Hall**

PV Job Fair

4:30 - 5:30 PM **Exhibit Hall**

IEC 40th Anniversary Reception and Ceremony

Established in 1972, the Institute of Energy Conversion (IEC) is celebrating its 40th anniversary. The hallmark of IEC's success has been the establishment of multidisciplinary core competencies to address R&D issues and the integration of industrial R&D needs with academic education and training. This has fostered a long history of contributions to the science and engineering of photovoltaics and the transfer of technology to the PV industry. Many concepts conceived at IEC during its 40 year history are now providing the foundation for the expanding PV industry. There will be a reception and brief ceremony highlighting IEC's achievements on Wednesday June 6 from 4:30 to 5:30 PM in the Exhibit Hall.

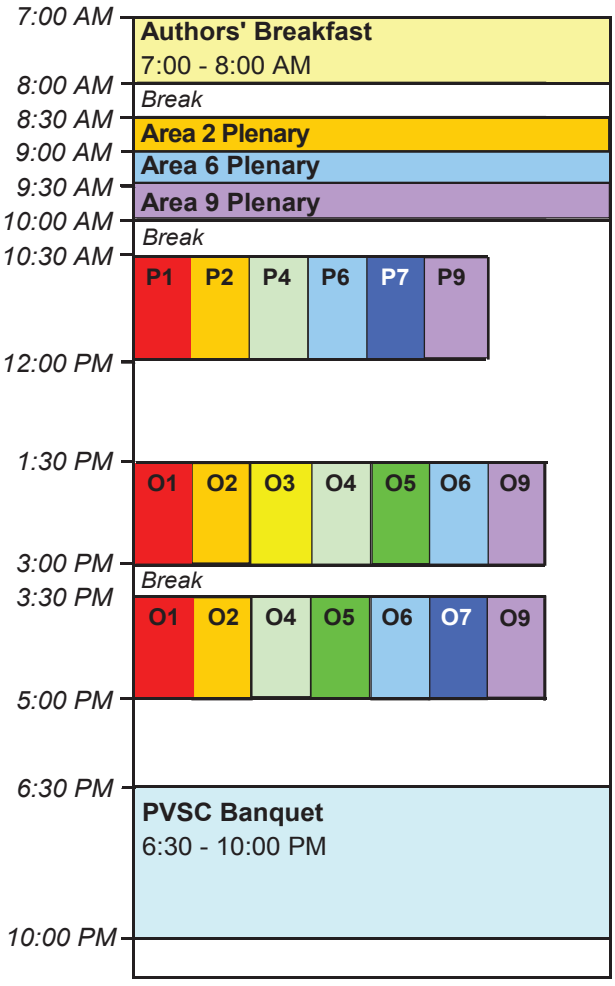
7:00 - 10:00 PM **Blrm G**

Area 1 Late Night Session

Chair(s): Ryne Raffaelle

The world premiere of "The Official Unofficial History of PV." We will debut a film of such monumental proportions import that we are sure will garner serious academy consideration (disclaimer: not by any Academy's of Science nor the Academy of Motion Picture Arts and Sciences). David Wilt of Albuquerque Times Daily proclaims "I have never witnessed anything quite like this in all my years in PV." Robert Walters of Northern Virginia Picayune writes "Congratulations David. Your review makes the most convincing argument for a sweeping overhaul of our public educational system I've read to date." B.J. Stanbery of the Austin Heckler writes "I must congratulate the filmmakers on their persistence! Most people would have given up and called someone competent long before finishing such a film." Don't miss this epic film which is guaranteed to change your life (no warrantees expressed or implied). Coming soon to a pirated DVD location near you.

THURSDAY PROGRAM SUMMARY



AREA LEGEND

- Area 1: Fundamentals and New Concepts for Future Technologies
- Area 2: Thin Film Polycrystalline Photovoltaics
- Area 3: III-V and Concentrator Technologies
- Area 4: Crystalline Silicon Photovoltaics
- Area 5: Thin Film Silicon Based PV Technologies
- Area 6: Organic Photovoltaics
- Area 7: Space Technologies
- Area 8: Characterization Methods
- Area 9: PV Modules and Terrestrial Systems
- Area 10: PV Velocity Forum

O = Oral Session P = Poster Session

8:00 - 8:30 AM **4th Floor Foyer**

Coffee Break

8:30 - 9:00 AM **Blrm D**

Area 2: Polycrystalline Thin Films: Plenary

Chair(s): Markus Beck

729 **CIGS- and CdTe-Based Thin-Film PV Modules: An Industrial Revolution**
Bernhard Dimmler
Manz AG, Schwaebisch Hall, Germany

9:00 - 9:30 AM **Blrm D**

Area 6: Organic Photovoltaics: Plenary

Chair(s): Dana Olson

730 **Efficient Organic Vacuum-Deposited Tandem Solar Cells and Modules on Glass and PET**
Martin Pfeiffer
Heliatek GmbH, Dresden, Germany

9:30 - 10:00 AM **Blrm D**

Area 9: Modules and Systems: Plenary

Chair(s): Jennifer Granata

9:30 731 **PV System Reliability: An Operator's Perspective**
Anastasios Golnas
SunEdison, Beltsville, MD, USA

10:00 - 10:30 AM **Exhibit Hall 4**

Coffee Break

10:30 - 12:00 PM **EH4-A**

Area 1: Fundamentals and New Concepts: Session 4 (Posters)

Chair(s): Annick Anctil, Chris Bailey, Seth Hubbard

A4
732 **Enhanced Photovoltaic Properties of a-C/Si Heterojunction Solar Cells**
Sudip Adhikari[1], Dilip C Ghimire[1], Sunil Adhikary[2], Hideo Uchida[1], Koichi Wakita[1], Masayoshi Umeno[1]
[1]Chubu University, Kasugai, Japan, [2]Tribhuvan University, Kathmandu, Nepal

A8
733 **Performance of Luminescence Down-Shifting Layers as a Function of the Incident Solar Spectrum**
Diego Alonso-Álvarez[1], David Ross[1], Keith R McIntosh[2], Bryce Richards[1]
[1]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, United Kingdom, [2]PV Lighthouse, Coledale, Australia

A12
734 **Dye-Sensitized Solar Cell Application of Hexagonal-Shaped ZnO Nanotubes**
Sadia Ameen, Minwu Song, Young Soon Kim, M. Shaheer Akhtar, Hyung-Shik Shin
Chonbuk National University, Jeonju, South Korea

A16
735 **Properties and Modeling of InGaN for High-Temperature Photovoltaics**
Chris Boney[1,2], Rajeev Pillai[1,2], David Starikov[1,2], Abdelhak Bensaoula[3]
[1]Integrated Micro Sensors Inc, Houston, TX, USA, [2]Dept. of Physics, Univ. of Houston, Houston, TX, USA, [3]Depts. of Physics and Electrical and Computer Engineering, Univ. of Houston, Houston, TX, USA

A20
736 **Molecular Beam Epitaxy of n-Type ZnS: A Wide-Bandgap Emitter for Heterojunction PV Devices**
Jeffrey Bosco, Faisal Tajdar, Harry Atwater
California Institute of Technology, Pasadena, CA, USA

A24
737 **Full-Spectrum Laterally-Arranged Multiple-Bandgap InGaN Solar Cells**
Derek A Caselli, Cun-Zheng Ning
Arizona State University, Tempe, AZ, USA

A28
738 **Design Criteria for Nanostructured Omni-Directional Antireflection Coatings**
Arvinder M Chadha[1], Weidong Zhou[1], Eric D Cline[2]
[1]University of Texas at Arlington, Arlington, TX, USA, [2]ZT Solar Inc., Dallas, TX, USA

B4
739 **Direct Liquid-Coated Cu_2SnS_3 as a New Absorber Material for Thin-Film Solar Cell**
Tapas K Chaudhuri, Devendra Tiwari
Dr. K. C. Patel Research and Development Centre, Changa, India

B8 740 **$ZnSnN_2$: A New Earth-Abundant Element Semiconductor for Solar Cells**
Nathaniel Feldberg[1], Benjamin Keen[1], James D. Aldous[1], David O. Scanlon[2], Patricia A. Stampe[3], Robin J. Kennedy[3], Roger J. Reeves[4], Timothy D. Veal[5], Steven M. Durbin[1,6]
[1]Dept of Physics, University at Buffalo, Buffalo, NY, USA, [2]Dept of Chemistry, University College London, London, United Kingdom, [3]Dept of Physics, Florida A&M University, Tallahassee, FL, USA, [4]Dept of Physics, University of Canterbury, Christchurch, New Zealand, [5]Stephenson Institute for Renewable Energy and Dept of Physics, University of Liverpool, Liverpool, United Kingdom, [6]Dept of Electrical Engineering, University at Buffalo, Buffalo, NY, USA

B12 741 **Si_3AlP: A New Promising Material for Solar Cell Absorber**
Xingao Gong[1], Jihui Yang[1], Yingteng Zhai[1], Hengrui Liu[1], Hongjun Xiang[1], Suhuai Wei[2]
[1]MOE Laboratory for Computational Physical Sciences, Fudan University, Shanghai, China, [2]National Renewable Energy Laboratory, Colorado, CO, USA

B16 742 **Earth-Abundant Iron Oxysulfide (FeS_xO_y) for Bandgap Optimization**
Xiaofei Han, Bin Zhou, Meng Tao
Arizona State University, Tempe, AZ, USA

B20 743 **The Effect of Tailoring Electron/Hole Blocking Layers on the Photovoltaic Performance of the Single-Junction Solar Cells**
Ming-Han Hsieh[1], Yuh-Renn Wu[1], Jasprit Singh[2]
[1]National Taiwan University, Tapei, Taiwan, [2]University of Michigan, Ann Arbor, Ann Arbor, MI, USA

B24 744 **Dependence of Substrate Temperature of Cu_2ZnSnS_4 Thin Films Deposited by Radio-Frequency Sputtering Using Quaternary Cu_2ZnSnS_4 Target**
Kuo-Min Huang[1], Meng-Chyi Wu[1,2*], I-Ping Chen[1], Yu-Ping Wang[1]
[1]Institute of Electronics Engineering, National Tsing Hua University, Hsinchu, Taiwan, [2]Institute of Photonics Technologies, National Tsing Hua University, Hsinchu, Taiwan

B28 745 **Solution-Processed Silicon Hybrid Heterojunction Photovoltaics with Silver Nanowires**
Bo-Yu Huang[1], Hsiao-Wei Liu[1], Ting-Gang Chen[1], En-Chen Chen[2], Bo-han Chen[1], Ta-Yung Liu[3], Peichen Yu[1], Hsin-Fei Meng[4]
[1]Department of Photonic & Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan, [2]Department of Electrical Engineering, National Tsing Hua University, Hsinchu, Taiwan, [3]Department of Materials engineering, Tatung university, Taipei, Taiwan, [4]Institute of Physics, National Chiao Tung University, Hsinchu, Taiwan

C4
746 **Fabrication of GaAsN Solar Cell by Chemical Beam Epitaxy with Improved Minority-Carrier Lifetime**
Kazuma Ikeda, Makoto Inagaki, Nobuaki Kojima, Yoshio Ohshita, Masafumi Yamaguchi
Toyota Technological Institute, Nagoya, Japan

C8
747 **Bias-Dependent Admittance Measurement of GaInNAsSb-Based Solar Cell Structure**
Muhammad M. Islam, Naoya Miyashita, Nazmul Ahsan, Yoshitaka Okada
Research Center for Advanced Science and Technology (RCAST), The University of Tokyo, Tokyo, Japan

C12
748 **Electrochemical Atomic Layer Deposition of a CdTe/PbTe Superlattice for the Absorber Layer of a Solar Cell**
Amal Kabalan, Pritpal Singh
Villanova University, Villanova, PA, USA

C16
749 **The Plasmonics Electrodes Applied to Thin-Film Solar Cells**
Andrzej Kołodziej, Witold Baranowski, Michał Kołodziej, Tomasz Kołodziej
AGH University of Science and Technology, Kraków, Poland

C20
750 **Fabrication of Hierarchical ZnO/TiO_2 Core-Shell Nanostructures for Advanced Photovoltaic Devices**
Keyue Wu[1,2], Jingbiao Cui[1]
[1]University of Arkansas at Little Rock, Little Rock, AR, USA, [2]Anhui Univeristy, Hefei, China

C23
751 **Growth and *p*-Type Doping of Cuprous Oxide Thin-Fims for Photovoltaic Applications**
Yun Seog Lee, Mark T. Winkler, Sin Cheng Siah, Yaron Segal, Riley Brandt, Tonio Buonassisi
Massachusetts Institute of Technology, Cambridge, MA, USA

C26
752 **Raman-Based Strategies for Improved Solar Cell Optics**
Ping Lee[1], Komal Magsi[1], Som N. Dahal[2], Yeona Kang[1], C.M. Fortmann[1,2]
[1]Materials Science and Engineering Dept., Stony Brook University, Stony Brook, NY, USA, [2]Idalia Solar Technologies LLC, New York, NY, USA

D1
753 **Ag-Assisted Electrochemical Etching of Silicon for Antireflection in Large Area Crystalline Thin-Film Photovoltaics**
Rui Li[1,2], Santhad Chuwongin[1], Shuling Wang[1], Weidong Zhou[1]
[1]University of Texas at Arlington, Arlington, TX, USA, [2]Dalian University of Technology, Dalian, China

D4 754 **Enhanced Graphene/Silicon Heterojunction Solar Cells with Work Function and Antireflection Optimization**
Yuxuan Lin[1], Dan Xie[1], Hongwei Zhu[2,3]
[1]Tsinghua National Laboratory for Information Science and Technology (TNList), Institute of Microelectronics, Tsinghua University, Beijing, China, [2]Department of Mechanical Engineering, Tsinghua University, Beijing, China, [3]Center for Nano and Micro Mechanics, Tsinghua University, Beijing, China

D7 755 **Epitaxial Growth of (100) GaAs on CeO_x-Coated Flexible Metal Substrates**
Akhil Mehrotra[1], Alex Freundlich[1], Venkat Selvamanickam[2], Renjie Wang[2], Senthil Sambandam[3]
[1]Center for Advanced Materials, University of Houston, Houston, TX, USA, [2]Department of Mechanical Engineering and Texas Center for Superconductivity, University of Houston, Houston, TX, USA, [3]SuperPower Inc., Schenectady, NY, USA

D10 756 **Equivalent Deflection Angle of Textured Surfaces**
James R. Nagel, Michael A. Scarpulla
University of Utah, Salt Lake City, UT, USA

D12 757 **Exfoliated 15-micron Thin-Crystalline Germanium Heterojunction Solar Cells**
Emmanue U. Onyegam[1], Dabraj Sarkar[2], Mohamed H. Hilali[1], Sayah Saha[2], Rajesh A. Rao[2], Leo Mathew[2], Moses Ainom[2], Ricardo Garcia[1], Dharmesh Jawarani[2], Sanjay K. Banerjee[1]
[1]University of Texas-Austin, Austin, TX, USA, [2]AstroWatt Inc., Austin, TX, USA

D14 758 **Mechanism of Electrical Passivation of Si Surfaces with Quinhydrone**
Robert L. Opila, Dan Yang, Nicole Kotulak, Luke Costello, Bhumika Chhabra
University of Delaware, Newark, DE, USA

D16 759 **Design Rules for Indoor Photovoltaic Cells**
Karola Rühle[1,2], Stefan W. Glunz[2], Martin Kasemann[1,2]
[1]University of Freiburg, Freiburg, Germany, [2]Fraunhofer Institue for Solar Energy Systems, Freiburg, Germany

D18 760 **Single-Crystalline-Like Germanium Templates on Low-Cost, Flexible Substrates for High Efficiency Photovoltaics**
Venkat Selvamanickam[1], Renjie Wang[1], Cao Jian[1], Goran Majkic[1], Eduard Galtsyan[1], Senthil Sambandam[2], Xuming Xiong[2]
[1]University of Houston, Houston, TX, USA, [2]SuperPower, Schenectady, NY, USA

D20 761 **The Effects of YAG:Ce Down-Conversion Phosphors on Solar Cells**
Guojian Shao, Chaogang Lou
Southeast University, Nanjing, China

D22 762 **Growth and Characterization of Germanium-Carbide Films for Hot-Carrier Solar Cell Absorber**
Santosh Shrestha, Neeti Gupta, Pasquale Aliberti, Gavin Conibeer
Photovoltaics Centre of Excellence, School of Photovoltaic and Renewable Energy Engineering, The University of New South Wales, Sydney, Australia

D24 763 **Low-Resistance Metal Contacts to Nitrogen-Doped Cuprous Oxide Thin Films**
Sin Cheng Siah, Yun Seog Lee, Yaron Segal, Tonio Buonassisi
Massachusetts Institute of Technology, CAMBRIDGE, MA, USA

D26 764 **Review on Up/Down Conversion Materials for Solar Cell Application**
Deepak Verma, Tor O. Sætre, Ole-Morten Midtgård
University of Agder, Grimstad, Norway

D28 765 **Application of a Graphene Buffer Layer for the Growth of High-Quality SnS Films on GaAs(100) Substrate**
Wei Wang[1], Ka Kuen Leung[1], Wai Keung Fong[1], Shifeng Wang[1], Y.Y. Hui[2], Daniel Lau[2], Charles Surya[1]
[1]The Hong Kong Polytechnic University, Department of Electronic and Information Engineering, Hong Kong, China, [2]The Hong Kong Polytechnic University, Department of Applied Physics, Hong Kong, China

E2 766 **Prospects for In-Rich InGaN-Based Photovoltaics**
Yuan Yao[1], James D. Aldous[2], Dongjin Won[3], Joan M. Redwing[3], Wojtek Linhart[4], Christopher F. McConville[4], Roger J. Reeves[5], Timothy D. Veal[6], Steven M. Durbin[1,2]
[1]Electrical Engineering, University at Buffalo, Buffalo, NY, USA, [2]Physics, University at Buffalo, Buffalo, NY, USA, [3]Materials Science and Engineering, The Pennsylvania State University, University Park, PA, USA, [4]Physics, University of Warwick, Coventry, United Kingdom, [5]Physics, University of Canterbury, Christchurch, New Zealand, [6]Physics, University of Liverpool, Liverpool, United Kingdom

E4 767 **Solution Processing of CdTe Nanocrystals for Thin-film Solar Cells**
Woojun Yoon[1], Edward E. Foos[1], Matthew P. Lumb[1,2], Joseph G. Tischler[1]
[1]U.S. Naval Research Laboratory, Washington, DC, USA, [2]School of Engineering and Applied Science, The George Washington University, Washington, DC, USA

E5 768 **Silver Nanoparticles Incorporated in Aluminum-Doped ZnO for Heterojunction Solar Cells**
Juhyung Yun[1], Eric Kozarsky[1], Joondong Kim[2], Hossein Shokri Kojori[3], Sung Jin Kim[3], Chong Tong[1], Jun Wang[1], Wayne A. Anderson[1]
[1]University at Buffalo, Buffalo, NY, USA, [2]Korea Institute of Machinery and Materials (KIMM), Daejeon, Korea, [3]University of Miami, Coral Gables, FL, USA

10:30 - 12:00 PM **EH4-B**

Area 2: Polycrystalline Thin Films: Absorber Formation and Characterization 2 (Posters)

Chair(s): Rommel Noufi, Tokio Nakada, Marcus Bär

E9 769 **Preparation of Micro-Flake Ink for Low-Cost Printing of CIS-Se absorber layers**
Armin E. Zaghi[1], Guy Brammertz[2], Kim Vanmeensel[1], Marc Meuris [2], Jef Poortmans[2], Jef Vleugels[1]
[1]Department of Metallurgy and Materials Engineering, Katholieke Universiteit Leuven, Leuven, Belgium, [2]imec, Heverlee, Belgium

E13 770 **Non-Hydrazine Solution-Processed $CuIn(Se,S)_2$ Photovoltaic Device**
Huanping Zhou, Chia-Jung Hsu, Wan-Ching Hsu, Yang Yang
Department of Materials Science and Engineering, University of California Los Angeles, Los Angeles, CA, USA

E17 771 **Selenization of CIS and CIGS Layers Deposited by Spray Pyrolysis**
B. J. Babu[1], B. Egaas[2], S. Velumani[1], R. Asomoza[1]
[1]Department of Electrical Engineering-SEES, CINVESTAV-IPN, Zacatenco, Mexico, Mexico, [2]National Renewable Energy Laboratory, Golden, CO, USA

E21 772 **Preparation and Characterization of Electrodeposited $CuInSe_2$ Thin Films on Flexible Substrates for Solar Cell Applications**
M. Estela Calixto[1], Samuel De la Luz-Merino[1], Antonio Mendez-Blas[1], Bernabe Mari-Soucase[2]
[1]Instituto de Fisica, Benemerita Universidad Autonoma de Puebla, Puebla, Mexico, [2]Departament de Fisica Aplicada-IDF, Universidad Politecnica de Valencia, Valencia, Mexico

E25
773 **Molecular Precursor Species and Their Effects on the Energy Bandgap of Hydrazine Solution Processed $CuIn(S,Se)_2$ Films**
Choong-Heui Chung[1,2], Bao Lei[1,2], Brion Bob[1,2], Hsin-Sheng Duan[1,2], Sheng-Han Li[1,2], William W. Hou[1,2], Wenbing Yang[1,2], Yang Yang[1,2]
[1]Department of Materials Science and Engineering, University of California Los Angeles, Los Angeles, CA, USA, [2]California NanoSystems Institute, University of California Los Angeles, Los Angeles, CA, USA

F1
774 **Investigation of Na Out-Diffusion and Structural Properties of IGS Thin Film During Three-Stage Growth Process of CIGS Thin Film**
Hamda A. Al-Thani, Falah S. Hasoon
National Energy & Water Research Center, Abu Dhabi, United Arab Emirates

F5
775 **Control of Na Diffusion from Soda-Lime Glass and NaF Film into $Cu(In,Ga)Se_2$ for Thin-Film Solar Cells**
Dae-Hyung Cho[1], Yong-Duck Chung[1,2], Kyu-Seok Lee[1], Ju-Hee Kim[1,2], Soo-Jeong Park[1,2], Jeha Kim[1,2]
[1]Electronics and Telecommunications Research Institute, Daejeon, Korea, [2]University of Science and Technology, Daejeon, Korea

F9
776 **Phase Separation in $Cu(In,Ga)Se_2$ Photovoltaic Absorber Film Due to Post-Deposition Na Treatment**
Chan-Wook Jeon[1], Woo-Nam Kim[1], Kyoung-Bo Kim[2], Jung-Min Cho[3], Ki-Bong Song[3], Soo-Hyun Kim[1]
[1]Yeungnam University, Gyeongsan, Korea, [2]POSCO, Incheon, Korea, [3]ETRI, Daejeon, Korea

F13
777 **Investigation of Sodium Effects on CIGS Thin Films Deposited by Sputtering from a Single Quaternary Target**
Yue-Shun Su[1], Chia-Hao Hsu[1], Chia-Hsiang Chen[1], Yan-Huei Wu[1], Wen-Chieh Shih[1], Chih-Huang Lai[1,2]
[1]Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan, [2]Low Carbon Energy Research Center, Tsing Hua University, Hsinchu, Taiwan

F17
778 **Quantitative Elemental Analysis of Photovoltaic $Cu(In,Ga)Se_2$ Thin Films Using MCs^+ Clusters**
Kai Kaufmann, Stefanie Wahl, Sylke Meyer, Christian Hagendorf
Fraunhofer Center for Silicon Photovoltaics CSP, Halle (Saale), Germany

F21 779 **Vertically Aligned $CuInSe_2$ Nanowire Arrays on Titanium Coated Glass Substrates for Photovoltaic Applications**
Bhavananda R. Nadimpally[1], Sai Guduru[1], Raghu Mangu[2], Suresh Rajaputra[1], Vijay P. Singh[1]
[1]Department of Electrical and Computer Engineering and Center for Nanoscale Science and Engineering (CeNSE), University of Kentucky, Lexington, KY, USA, [2]International Rectifier Corporation, El Segundo, CA, USA

F25 780 **Grain Growth Enhancement of Selenide CIGSe Nanoparticles to Densified CIGSe Films Using Copper Selenide Additives**
Bryce C. Walker, Steven M. McLeod, Rakesh Agrawal
Purdue University, West Lafayette, IN, USA

G1 781 **Band Alignment Limitations and Light-Soaking Effects in CZTSSe and CZTGeSSe**
Charles J. Hages[1], James Moore[2], Sourabh Dongaonkar [2], Muhammad A. Alam[2], Mark S. Lundstrom[2], Rakesh Agrawal[1]
[1]Dept. of Chemical Engineering, Purdue University, West Lafayette, IN, USA, [2]Dept. of Electrical and Computer Engineering, West Lafayette, IN, USA

G5 782 **Novel Solution Processing of High-Efficiency Earth-Abundant CZTSSe Solar Cells**
Wenbing Yang[1,2], Hsin-Sheng Duan[1,2], Brion Bob[1,2], Sheng-Han Li[1,2], Yang Yang[1,2]
[1]Department of Materials Science and Engineering,University of California Los Angeles, Los Angeles, CA, USA, [2]California NanoSystems Institute, Los Angeles, CA, USA

G9 783 **Low-Cost Cu_2ZnSnS_4 Thin Films for Large-Area High-Efficiency Heterojunction Solar Cells**
Sandip Das, Krishna C. Mandal
University of South Carolina, Columbia, SC, USA

G13 784 **Comparison of Cu_2ZnSnS_4 Thin-Film Properties Prepared by Thermal Evaporation of Elemental Metals and Binary Sulfide Sources**
Sandip Das, Krishna C. Mandal
University of South Carolina, Columbia, SC, USA

G17 785 **Preparation of 4.8%-Efficiency $Cu_2ZnSnSe_4$-Based Solar Cell by a Two-Step Process**
Andrew Fairbrother[1], Edgardo Saucedo[1], Xavier Fontané[1], Victor Izquierdo-Roca[1], Diouldé Sylla[1], Moisés Espindola-Rodriguez[1,2], Fabián A. Pulgarín[3], Osvaldo Vigil-Galán[2], Alejandro Pérez-Rodríguez[1,4]
[1]Catalonia Institute for Energy Research (IREC), Barcelona, Spain, [2]Escuela Superior de Física y Matemáticas (ESFM), IPN, México DF, Mexico, [3]Centro de Investigación en Energía-UNAM, Temixco, Morelos, Mexico, [4]IN2UB, Departament d'Electrònica, Universitat de Barcelona, Barcelona, Spain

G21 786 **Carrier Transport and Low-Temperature Device Properties of $Cu_2ZnSnSe_4$ Thin Films with Different Cu and Zn/Sn Ratio**
Ah Reum Jeong[1], William Jo[1], Jin Woo Lee[2], Jin Young Kim[3]
[1]Department of Physics, Seoul, Korea, [2]Solar Cell Business Dept./Product Development Gr., LG Innotek, Osan-City, Korea, [3]Solar Cell Center, Energy Division, Korea Institute of Science and Technology (KIST), Seoul, Korea

G25 787 **Growth of $Cu_2ZnSnSe_4$ Thin Films by Selenization of Magnetron-Sputtered Precursors for Solar Cells**
Shou-Yi Kuo[1], Jui-Fu Yang[1,2], Fang-I Lai[2], Chun-Jung Lin[3]
[1]Department of Electronic Engineering, Chang Gung University, Tao-Yuan, Taiwan, [2]Department of Photonics Engineering, Yuan-Ze University, Chung-Li, Taiwan, [3]Solar Applied Materials Technology Corp., Tainan, Taiwan

H1 788 **The Nanocomposite Synthesis and Characterization of Kesterite Cu_2ZnSnS_4 (CZTS) for Photovoltaic Applications**
Elizabeth K. Michael, Danielle Norcini, Jeffrey R.S. Brownson
The Pennsylvania State University, University Park, PA, USA

H4 789 **Optical Determination of Phase Composition and Processing Effects on $Cu_2ZnSnSe_4$ Film Quality and Device Performance**
D. L. Morel, C. S. Ferekides, S. Bendapudi, Y. Wang
University of Sout Florida, Tampa, FL, USA

H6 790 **CdS Nanowire Layers of Enhanced Transmittance for Window Layer Applications in Thin-Film Solar Cells**
Hongmei Dang, Vijay Singh, Suresh Rajaputra, Jianhao Chen, Sai Guduru, Nandu Reddy
Department of Electrical and Computer Engineering, University of Kentucky, Lexington, KY, USA

H7 791 **$Cu_2ZnSn(S,Se)_4$ Thin Film Prepared from a Single-Step Electrodeposited Cu-Zn-Sn-Se Precursor**
Wilman Septina, Shigeru Ikeda, Akio Kyoraiseki, Takashi Harada, Michio Matsumura
Research Center for Solar Energy Chemistry, Osaka University, Osaka, Japan

H8 792 **Properties of $CuInSe_2$ Thin Films Using Multi-Stage Process by Metalorganic Chemical Vapor Deposition**
Seong Man Yu[1], Gwang Soo Lim[1], Arun Khalkar[1], Ji-Beom Yoo[1,2]
[1]Sungkyunkwan Advanced Institute of Nanotechnology(SAINT), Sungkyunkwan University, Suwon, South Korea, [2]Department of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon, South Korea

10:30 - 12:00 PM **EH4-C**

Area 4: Crystalline Silicon: Feedstock, Crystallization, and Wafering (Posters)

Chair(s): Jim Rand

I27 793 **An Effective Doping Model to Prevent Earlier Breakdown of Upgraded Metallurgical-Grade Silicon Solar Cell**
Ya-Wen Chang, Jui-Chen Pu, Liang Wenglin, Yu-Chung Chen, Chih-Hsyong Wu
Motech Industries, Inc., Tainan, Taiwan

J3 794 **Quality Investigation of B-Doped CZ-Silicon Using Multiple Recharges Process**
Wen-Pin Chen, Yu-Hou Wu, Hung-Pang Chou, Yu-Chung Chen, Chih-Hsyong Wu, Wen-Tai Chung
Motech Industries, Inc, Tainan, Taiwan

J7 795 **A Bilayer Passivation Structure with Good Reflectance for Silicon Solar Cell**
Yi-Fan Chen[1], Chia-Ling Yang[1,2], Tai-Jui Wang [1], Chia-Liang Sun[1], Sheng-Min Yu[1], Wen-Ching Sun[1], Tzer-Shen Lin[1], Fu-Ron Chen [2]
[1]Material & Chemical Research Laboratories, Industrial Technology Research Institute, Hsinchu, Taiwan, [2]Department of Engineering and System Science Center for Transmission Electron Microcopy, National Tsing Hua University, Hsinchu, Taiwan

J11 796 **Enhancement of Crystal Growth Rate by a 22-Inch Hot-Zone Modification and CZ Recipe Adjustment**
Wen-Tai Chung, Yu-Hou Wu, Hung-Pang Chou, Chih Hsyong Chen, Wen-Pin Chen
Motech Industries, Inc., Tainan, Taiwan

J15 797 **Fracture Strength Analysis of Slurry Cut mc-Si Wafers**
Chris Yang[1], Shreyes Melkote[1,2], Steven Danyluk[2], Mike Seacrist[3]
[1]Manufacturing Research Center, Georgia Institute of Technology, Atlanta, GA, USA, [2]G.W.W School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, USA, [3]MEMC Electronic Materials, St. Peters, MO, USA

J19 798 **The Study of Metallurgical Refining Silicon by Using Directional Solidification for Photovoltaic System**
Eun-Su Jang[1], Dongho Park[1], Tae U Yu[1], Byung Moon Moon[2]
[1]Energy System R&D Group, Korea Institute of Industrial Technology, Hongcheon-Ri, Ipjang-Myeon, Seobuk-Gu, Cheonan-Si, Chungcheongnam-Do, Korea, [2]Production Technology R&D Division, Liquid Processing & Casting Technology R&D Department, Korea Institute of Industrial Technology, Songdo-Dong, Yeonsu-Gu, Incheon, Korea

J23 799 **Filtration of Waste Coolants from Fixed-Abrasive Wire Sawing and Recycle of Retrieved Silicon Powders for Feedstock**
Shohei Miki, Norihisa Iio, Sho-ichi Taniguchi, Hiroshi Satone, Koji Arafune
University of Hyogo, Himeji, Japan

J27 800 **Modeling and Laboratory-Scale Proof of Concept of the Horizontal Ribbon Growth Process: Application to Silicon Wafer Manufacturing**
German A. Oliveros, Ray Wang, Sridhar Seetharaman, B. Erik Ydstie
Carnegie Mellon University, Pittsburgh, PA, USA

K3 801 **Analysis of Saw Damages of Monocrystalline Slurry-Sawn Si Wafers by Raman Spectroscopy**
Marion Radet, Perine Jaffrennou, Nada Habka, Julien Penaud, Benoît Lombardet
Total Gas & Power - R&D Division, Paris, France

K7 802 **Growth of Multicrystalline Silicon Ingot from the Top of the Melt: Control of Microstructures and Reduction of Stress**
Noritaka Usami[1], Wugen Pan[1], Satoru Matsushima[1], Kazuo Nakajima[2], Haruna Watanabe[1]
[1]Tohoku University, Sendai, Japan, [2]Kyoto University, Kyoto, Japan

K11 803 **Fabrication of an Ultrathin Silicon Wafer with Honeycomb Structure by Thermal-Stress Induced Pattern Transfer (TIPT) Method**
Teng-Yu Wang[1], Chien-Hsun Chen[1], Chen-Hsun Du[1,2], Chung-Yuan Kung[3]
[1]Green Energy and Environment Research Labs, Industrial Technology Research Institute, Hsinchu, Taiwan, [2]Institute of NanoEngineering and MicroSystems, National Tsing Hua University, Hsinchu, Taiwan, [3]Department of Electrical Engineering, National Chung-Hsing University, Taichung, Taiwan

K15 804 **Dependence of Si-Faceted Dendrite Growth Orientation on Twin Spacing and Undercooling**
Xinbo Yang[1,2], Kozo Fujiwara[1], Satoshi Uda[1]
[1]Institute for Materials Research (IMR), Tohoku University, Sendai, Japan, [2]Research School of Engineering, College of Engineering and Computer Science, The Australian National University, Canberra, Australia

K19 805 **The Characteristics of Sub-Grains in the Mono-Like Silicon Crystals Grown with Directional Solidification Method**
Tao Zhang, Dongli Hu, Liang He, Dejing Zhong, Xuewen Huang, Yuepeng Wan
LDK Solar Co. Ltd., Xinyu, Jiangxi, China

K23 806 **Light-Induced Degradation in Upgraded Metallurgical-Grade Silicon Solar Cells**
Kamel Ounadjela[1], Omar Sidelkheir[1], Chun-sheng Jiang[2], Mowafak Al-Jassim[2]
[1]Calisolar Inc., Sunnyvale, CA, USA, [2]NREL, Golden, CO, USA

10:30 - 12:00 PM **EH4-D**

Area 6: Organic Photovoltaics: OPV Materials and Devices (Posters)

Chair(s): Erin Ratcliff, Barry Rand

P7
807
A Mathematical Model for the Fabrication of Thin-Film Photovoltaic Solar Cells
Morteza Eslamian
Texas A&M University-Corpus Christi, Corpus Christi, TX, USA

P9
808
Analysis of Light Intensity Dependence of Organic Photovoltaics: Towards Efficient Large-Area Solar Cells
Yulia Galagan[1], Assaf Manor[2], Ronn Andriessen[1], Eugene A. Katz[2]
[1]Holst Centre, Eindhoven, Netherlands, [2]Ben-Gurion University of the Negev, Sede Boker Campus, Israel

P11
809
The Novel Organic Photovoltaic Cell Using Interlayer for Hole-Electron Separation
You Hyun Kim[1], Sang Youn Lee[2], Nam Ho Kim[1], C.-B. Moon[1], Chul Gyu Jhun[1], Woo Young Kim[1,3]
[1]Department of Green Energy & Semiconductors, Hoseo University, Asan, Korea, [2]Semiconductor Display Engineering, Hoseo University, Asan, Korea, [3]Department of Engineering Physics, McMaster University, Hamilton, ON, Canada

P13
810
Photocurrent Transients in Polymer-Fullerene Bulk Heterojunction Organic Solar Cells
Lijun Li[1,3], Kejia Li[1,3], Petr Khlyabich[2,3], Beate Burkhart[2,3], Barry Thompson[2,3], Joe Campbell[1,3]
[1]University of Virginia, Charlottesville, VA, USA, [2]University of Southern California, Los Angeles, CA, USA, [3]Center for Energy Nanoscience, Los Angeles, CA, USA

P15
811
Morphologic Improvement of the P3HT:Indene-C60 Bis-Adduct (ICBA) Blend Film with Mixed Solvent in Inverted Polymer Solar Cells
Shang-Hong Lin[1], Ching-Fuh Lin[1,2], Shiang Lang[1], Jen-Yu Sun[1]
[1]Graduate Institute of Photonics and Optoelectronics,National Taiwan University, Taipei, Taiwan, [2]Graduate Institute of Electronics Engineering, National Taiwan University, Taipei, Taiwan

P17 812 **Fabrication and Characterization of MEH-PPV-Based Bulk-Heterojunc tion Solar Cell Using Spray-Deposited Indium Sulfide Electron Selective Layer**
M. R. Rajesh Menon [1], M. V. Maheshkumar[2], K. Sreekumar[2], C. Sudha Kartha[1], K. P. Vijayakumar[1]
[1]Department of Physics, Cochin University of Science and Technology, Cochin, India, [2]Department of Applied Chemistry, Cochin University of Science and Technology, Cochin, India

P19 813 **Study the S-Shape Behavior of Illuminated IV in Bilayer Organic Solar Cells**
Seyyed Sadegh Mottaghian, Mahdi Farrokh Baroughi
South Dakota State University EECS department, Brookings, SD, USA

P21 814 **Investigation of Electrical Characteristics of P3HT:PCBM Organic Solar Cells**
Yang Shen, Mool C. Gupta
University of Virginia, Department of Electrical and Computer Engineering, Charlottesville, VA, USA

P23 815 **Influence of Squaraine Aggregation on Short-Circuit Current and Device Efficiency**
Susan D. Spencer[1], Victor Murcia[1], Obadiah Reid[2], Garry Rumbles[2], Kevin Belfield[3], Christopher Collison[1]
[1]Rochester Institute of Technology, Rochester, NY, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA, [3]University of Central Florida, Orlando, FL, USA

P25 816 **Effect of Post-Annealing Treatment on the Contact Resistance of Small Molecule Solar Cells**
Jiaqi Wu[1,2], Wenjuan Wu[1,2], Xi Xi[2,3], Zhenjiao Wang[1,2], Hongqiang Qian[1,2], Guangyao Jin[1,2], Haidong Zhu[1,2], Hongyan Lu[1,2], Jian Yang[1,2], Jingjia Ji[1,2], Guangchun Zhang[1,2], Zhengrong Shi[1,2], Guohua Li[2,4]
[1]Suntech Power Corp., Ltd, Wuxi, China, [2]Jiangsu (Suntech) Institute for Photovoltaic Technology, Wuxi, China, [3]School of Internet of Things, Jiangnan University, Wuxi, China, [4]School of Science, Jiangnan University, Wuxi, China

P26 817 **Gold Nanoclusters Decorated Multilayer Graphene as Transparent Electrodes for Polymer Solar Cells**
Di Zhang[1], Wallace C.H. Choy[1], Hongwei Zhu[2,3]
[1]Department of Electrical and Electronic Engineering, the University of Hong Kong, Hong Kong, Hong Kong, [2]Key Laboratory for Advanced Manufacturing by Materials Processing Technology, Department of Mechanical Engineering, Tsinghua University, Beijing, China, [3]Center for Nano and Micro Mechanics, Tsinghua University, Beijing, China

P27 818 **11.3%-Efficient Planar Si-PEDOT:PSS Hybrid Solar Cell with a Thin Interfacial Oxide**
Lining He[1,2,3], Changyun Jiang[2], Hao Wang[1,3], Lei Hong[1], Donny Lai[1,3], N.A. Rusli[1,3]
*[1]School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, Singapore, [2]Institute of Materials Research and Engineering, A*STAR, Singapore, Singapore, [3]CINTRA CNRS/NTU/THALES, Singapore, Singapore*

10:30 - 12:00 PM **EH4-E**

Area 7: Space Technologies: Space PV Technologies (Posters)

Chair(s): Bao Hoang, David Wilt

P28 819 **Evolution of a 2.05 eV AlGaInP Top Subcell for 5J-IMM and 6J-IMM Applications**
Arthur B. Cornfeld, Pravin Patel, John Spann, Daniel Aiken, James McCarty
Emcore Photovoltaics, Alburquerque, NM, USA

Q1 820 **Strain Effects on Radiation Tolerance of Quantum Dot Solar Cells**
Christopher Kerestes[1], David V. Forbes[1], Zac Bittner[1], Stephen Polly[1], Yong Lin[2], Benjamin Richards[2], Paul Sharps[2], Seth M. Hubbard[1]
[1]NanoPower Research Labs, RIT, Rochester, NY, USA, [2]Emcore Photovoltaics, Albuquerque, NM, USA

Q2 821 **Bandgap Optimization of Lattice-Matched Triple-Junction Solar Cells by Incorporation of InAs Quantum Dots**
Benjamin C. Richards[1], Yong Lin[1], Pravin Patel[1], Daniel Chumney[1], Paul R. Sharps[1], Chris Kerestes[2], David Forbes[2], Kristina Driscoll[2], Seth Hubbard[2]
[1]Emcore Corporation, Albuquerque, NM, USA, [2]Nanopower Research Labs, Rochester Institute of Technology, Rochester, NY, USA

Q3 822 **Improved Electrical Properties of Direct Wafer-Bonded GaAs/InP Interfaces for III-V Multijunction Solar Cells**
Lijie Sun, Mengyan Zhang, Wei Zhang, Kaijian Chen, Xin Fang, Chuanming Xu, Yang Yang, Wencan Zhou
Center for Photovoltaic Engineering, Shanghai Institute of Space Power Sources, Shanghai, China

Q4 823 **Radiation Effect Models in Solar Cells – Comparison of Simulations with Experimental Data**
Alexander Fedoseyev[1], Timothy Bald[1], Marek Turowski[1], Ashok Raman[1], Cory Cress[2], Robert Walters[2], Seth M. Hubbard[3]
[1]CFDRC, Huntsville, AL, USA, [2]NRL, Washington, DC, USA, [3]RIT, Rochester, NY, USA

Q5 824 **Semi-Transparent Photovoltaic Devices for Smart Window Applications**
Soo Kim[1], Yu Nung Huang[1], F. Ameena[1], David Hoffman[2], Michael H.-C. Jin[1], Kulbinder K. Banger[3], David A. Scheiman[4], Lyndsey B. McMillon[5], Jeremiah S. McNatt[5]
[1]Department of Materials Science and Engineering, University of Texas, Arlington, TX, USA, [2]Department of Mechanical and Aerospace Engineering, University of Texas, Arlington, TX, USA, [3]University of Cambridge, Cambridge, United Kingdom, [4]Ohio Aerospace Institute, Cleveland, OH, USA, [5]NASA Glenn Research Center, Cleveland, OH, USA

Q6 825 **The 8-Year Effort to Address Systems-Level Space Solar Power Issues for U.S. Government Satellite Programs**
Brad Reed
Industrial Base and Critical Technologies Manager, Space and Missile Systems Center, Los Angeles Air Force Base, Los Angeles, CA, USA

Q7 826 **Optimization of the Photovoltaic-Powered Systems with Dust-Mitigation Technology for Future Lunar and Martian Missions**
Nicoleta Sorloaica-Hickman[1], Judith McFall [2], Steven Nason [1], Kris Davis[1], Ellen Arens[3]
[1]Florida Solar Energy Center, Cocoa, FL, USA, [2]ASRC Aerospace Corporation, Titusville, FL, USA, [3]Kennedy Space Center, Cape Canaveral, FL, USA

Q8 827 **Non-Solar Photovoltaics for Small Space Missions**
Geoffrey A. Landis[1], Sheila G. Bailey[1], Eric B. Clark[1], Matthew G. Myers[1], Michael F. Piszczor[1], Marcus S. Murbach[2]
[1]NASA Glenn Research Center, Cleveland, OH, USA, [2]NASA Ames Research Center, Moffett Field, CA, USA

Q9 828 **Development of a Laser Power Beaming Experiment**
Henry W. Brandhorst[1], Marcus D. Smith[2], Brian Tillotson[3], Jeffrey Oliver[4], Nicholas Tarasenko[5], Thomas Schoelzel[6]
[1]Carbon-Free Energy, LLC, Auburn, AL, USA, [2]AFRL Tyndall Air Force Base, Panama City, FL, USA, [3]Boeing Co., Seattle, WA, USA, [4]AFRL/RHDO, Brooks City Base, TX, USA, [5]AFRL/RDTA, Albuquerque, NM, USA, [6]s Diode Laser, Inc, Tucson, AZ, USA

Q10 829 **Innovative Technologies on Proton Irradiation Tests for Space Solar Cells**
Mitsuru Imaizumi[1], Yosuke Yuri[2], Shin-ichiro Sato[2], Takeshi Ohshima[2], Paul Bolton[3]
[1]JAXA, Tsukuba, Japan, [2]JAEA, Takasaki, Japan, [3]JAEA, Kizugawa, Japan

Q11 830 **Increasing the TRL Level of New PV Technologies Using Modular Solar Panels**
Theodore G. Stern[1], Nicholas Walmsley[1], David M. Wilt[2]
[1]Vanguard Space Technologies, San Diego, CA, USA, [2]Air Force Research Laboratories, Kirtland AFB, NM, USA

Q12 831 **Solar Cell Short Circuit Current Errors and Uncertainties During High Altitude Calibrations**
David B. Snyder
NASA Glenn Research Center, Cleveland, OH, USA

Q13 832 **Change in I-V Characteristics of Subcells in a Multijunction Solar Cell Due to Radiation Irradiation**
Tetsuya Nakamura[1], Mitsuru Imaizumi[1], Takeshi Ohshima[2]
[1]Japan Aerospace Exploration Agency (JAXA), Tsukuba, Japan, [2]Japan Atomic Energy Agency (JAEA), Takasaki, Japan

Q14 833 **Aquarius/SAC-D Mission: Telemetry Data Analysis for the First Year**
Elena M. Godfrin, Igor Prario, Julio C. Duran
Comision Nacional de Energia Atomica, San Martin, Argentina

Q15 834 **Degradation Behavior of Flexible a-Si/a-SiGe/a-SiGe Triple-Junction Solar Cells Irradiated with 20-350keV Protons**
Shin-ichiro Sato[1], Kevin Beernink[2], Takeshi Ohshima[1]
[1]Japan Atomic Energy Agency, Gunma, Japan, [2]United Solar Ovonic LLC, Troy, MI, USA

Q16 835 **In Situ Control Over Ge(100):As Dimer Orientation in Vapor Phase Epitaxy Ambient**
Sebastian Brueckner[1,2], Enrique Barrigón[3], Oliver Supplie[1], Peter Kleinschmidt[1,4], Johannes Luczak[1], Ignacio Rey-Stolle[3], Henning Doescher[1,2], Thomas Hannappel[1,2,4]
[1]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany, [2]Ilmenau University of Technology, Ilmenau, Germany, [3]Instituto de Energía Solar, Madrid, Spain, [4]CiS Research Institute, Erfurt, Germany

Q17 836 **Experimental Research of GaAs Photovoltaic Converter to Transform Infrared Laser Radiation for Wireless Electric Power Transmission**
Olga Zayats[1], Vjacheslav Tugaenko[1], Marlen Kagan[2], Boris Zhalnin[2]
[1]S.P. Korolev RSC «Energia», Korolev, Russia, [2]OJSC RPE «KVANT», Moscow, Russia

Q18 837 **Mirrors in Space for Low-Cost Terrestrial Solar Electric Power at Night**
Lewis M. Fraas
JX Crystals Inc., Issaquah, WA, USA

Q19 838 **Dry-Epitaxial Lift-off, Integration, Interconnect and Encapsulation of Foldable/Rollable High Efficiency Solar Cell Modules**
John Farah
OptiCOMP Networks, Attleboro, MA, USA

10:30 - 12:00 PM **EH4-F**

Area 9: Modules and Systems: Irradiance Resources, PV Modeling, and Off-Grid Applications (Posters)

Chair(s): Dan Riley, Cliff Hansen, Alma Cota

T11 839 **Experiences with Back-up PV System for Remote Rescue Application**
Kun-Lung Yen[1], Mao-Ting Huang[1], Chiou-Jye Huang[1], Ming-Sian R. Bai[2]
[1]Industrial Technology Research Institute, Hsinchu County, Taiwan, [2]National Tsing Hua University, Hsinchu City, Taiwan

T15 840 **New Jersey International & Network Distribution Center (NJNDC) Field Testing Solar Powered Location Sensors for the Yard Management System**
Dilip. A. Pandya[1], John C. Yochum[1], Ronald R. Regan[2], Robert C. Corson[2]
[1]US Postal Service-NJINDC, Jersey City, NJ, USA, [2]Triad Consulting Engineers, Inc., Morris Plains, NJ, USA

T19 841 **Water Densalination System Powered by Solar Energy**
Gayane Minasyan[2], Karen Ayvazyan[1], Artak Barseghyan[2]
[1]Engineering Academy, Yerevan, Armenia, [2]EcoAtom Co., Yerevan, Armenia

T23 842 **Intelicell, Hybrid Photovoltaic System for Energy Support**
Johann A. Hernández[1,4], Johan S. Patiño[1,2,4], Miguel A. Moreno[3]
[1]Facultad de Ingeniería, Universidad Distrital Francisco José de Caldas, Bogota, Columbia, [2]Especialización en Planeamiento Energético, Universidad Autónoma de Colombia, Bogota, Columbia, [3]ASSYCE Group, Granada, Spain, [4]Smart green Colombia, Bogota, Columbia

U3 843 **Selection of Photovoltaic Modules for Off-Grid Rural Application Based on Analytical Hierarchy Process (AHP)**
Vivek Kuthanazhi, Anand B. Rao
Centre for Technology Alternatives for Rural Areas, Indian Institute of Technology Bombay, Mumbai, India

U7 844 **Assessment of Photovoltaic Systems for Schools in Kuwait**
Ahmad H. Alotaibi, Ahmad Almulla
Kuwait Institute for Scientific Research, Shuwaikh, Kuwait

U11 845 **Optimization of Commercial Rooftop PV Systems in the Continental United States Using Angle-and-Wavelength-Resolved Solar Irradiance Data**
Bowen Zhou[1], Cheng Zheng[2], Costas P. Grigoropoulos[2]
[1]Department of Civil and Environmental Engineering, University of California, Berkeley, CA, USA, [2]Department of Mechanical Engineering, University of California, Berkeley, CA, USA

U15 846 **Comparison of Pyranometers vs. PV Reference Cells for Evaluation of PV Array Performance**
Lawrence Dunn, Michael Gostein
Atonometrics, Inc., Austin, TX, USA

U19 847 **Design and Implementation of Sun Tracker Prototype for Solar Module Positioning**
Carlos A. Arredondo, Fabian Pineda
Universidad Antonio Nariño, Facultad de Ing. Electrónica, Grupor REM, Bogotá D.C., Columbia

U23 848 **Design of a Low-Cost Irradiance Meter Using a Photovoltaic Panel**
Eduardo I. Ortiz-Rivera, Joel Cruz-Colon, Luis R. Martinez-Mitjans
University of Puerto Rico-Mayaguez, Mayaguez, PR, USA

V3 849 **Biharmonic Spline Interpolation for Solar Radiation Mapping Using Puerto Rico as a Case of Study**
Eduardo I. Ortiz-Rivera, Luisa I. Feliciano
University of Puerto Rico-Mayaguez, Mayaguez, PR, USA

V7 850 **Online Tuned Neural Networks for PV Plant Production Forecasting**
Lucio Ciabattoni[1], Gianluca Ippoliti[1], Massimo Grisostomi[1], Sauro Longhi[1], Emanuele Mainardi[2]
[1]Università Politecnica delle Marche, Ancona, Italy, [2]Energy Resources Spa, Jesi, Italy

V11 851 **Extending Performance and Evaluating Risks of PV Systems Failure Using a Fault Tree and Event Tree Approach: Analysis of the Possible Application**
Alessandra Colli
Brookhaven National Laboratory, Upton, NY, USA

V15 852 **Approximation of a Photovoltaic Module Model Using Fractional and Integral Polynomials**
Eduardo I. Ortiz-Rivera
University of Puerto Rico-Mayaguez, Mayaguez, PR, USA

V19 853 **Development and Use of a Simple Numerical Model to Quantify the Impact of Key Photovoltaics System Parameters on the Levelized Cost of Electricity**
Moon Hee Kang[1], Ajeet Rohatgi[1,2]
[1]University Center of Excellence for Photovoltaics Research and Education, School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, USA, [2]Suniva Inc., Norcross, GA, USA

V23 854 **Advanced PV Module Performance Characterization and Validation Using the Novel Loss Factors Model**
Stefan Sellner[1], Juergen Sutterlueti[1], Ludwig Schreier[1], Steve Ransome[2]
[1]Oerlikon Solar Ltd., Truebbach, Switzerland, [2]SRCL Steve Ransome Consulting Ltd., Kingston upon Thames, United Kingdom

W3 855 **Thermal Effects Due to Environmental Variables in Photovoltaic Cells**
Buvaneshwari Muthirayan[1,2], Reinhart Appels[1], Herman Oprins[2], Urmimala Chatterjee[1], Francky Catthoor[2], Johan Driesen[1], Kris Baert[2]
[1]ESAT/ELECTA, KU Leuven, Heverlee, Belgium, [2]IMEC vzw, Heverlee, Belgium

W7 856 **Multilayer Thermal Models of PV Modules for Monitoring Applications**
Giuseppe M. Tina, Giuseppe Marletta, Salvatore Sardella
University of Catania - DIEEI, Catania, Italy

W11 857 **Statistical Analysis of Back Surface vs. Cell Temperatures of c-Si Modules Using Measurement Error Models**
Joseph M. Kuitche[1], Rong Pan[1], Govindasamy Tamizhmani[1,2]
[1]Arizona State University, Tempe, AZ, USA, [2]TUV Rheinland PTL, Tempe, AZ, USA

W15 858 **Crystalline-Silicon-Based Photovoltaic (PV) Module: Analytical Thermal Stress Modeling at the Design Stage**
Ephraim Suhir
University of California, Santa Cruz, CA, USA

W19 859 **Analysing Partial Shading of PV Modules by Circuit Modeling**
Siyu Guo, Timothy M. Walsh, Armin G. Aberle, Marius Peters
Solar Energy Research Institute of Singapore, Singapore, Singapore

W23 860 **LabVIEW-Based Emulation of Photovoltaic Array to Study Maximum Power Point Tracking Algorithms**
Kapil S. Bhise, Nataraj Pragallapati, Sushil S. Thale, Vivek Agarwal
Dept of Elec Engg, IIT-Bombay, Mumbai, India

X2 861 **Modeling of Annual DC Energy Losses Due to Off Maximum Power Point Operation in PV Arrays**
Aron P. Dobos
National Renewable Energy Laboratory, Golden, CO, USA

X5 862 **VLS-PV Intermittence and Stationary Storage**
Aurélien BERTIN[1,2]
[1]Hélios Energie, Paris, France, [2]Institut de Physique du Globe de Paris, Paris, France

X8 863 **Changes in Cadmium Telluride Photovoltaic System Performance Due to Spectrum**
Lauren Nelson, Mark Frichtl
First Solar, San Francisco, CA, USA

X11 864 **A New Approach in Numerical Simulation of PV Systems for PV-Powered Boats**
Tim Gorter[1], Ernst-Jan Voerman[2], Peter Joore[2,3], Angèle Reinders[1,3], Fred Van Houten[1]
[1] University of Twente, Faculty of CTW, Department of Design, Production and Management, Enschede, Netherlands, [2]University of Applied Sciences, NHL hogeschool, Leeuwarden, Netherlands, [3]Delft University of Technology, Faculty of Industrial Design Engineering, Delft, Netherlands

1:30 - 3:00 PM **18AB**

Area 1: Fundamentals and New Concepts: Advanced Approaches for Photoconversion (Orals)

Chair(s): Ryne P. Raffaelle, Martha Symko-Davies, Loucas Tsakalakas

1:30
865
Best Student Presentation Award Finalist
Characterization of a Quantum Dot *nipi* Photovoltaic Device
Michael A. Slocum, David V. Forbes, Seth M. Hubbard
Rochester Institute of Technology, Rochester, NY, USA

2:00
866
Infrared Optical Response of Geometric Diode Rectenna Solar Cells
Saumil Joshi[1], Zixu Zhu[1], Sachit Grover[2], Garret Moddel[1]
[1]Department of Electrical, Computer, and Energy Engineering, University of Colorado, Boulder, CO, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA

2:15
867
Bandgap Engineering Achieved with Doping Superlattices
Michael K. Yakes[1], Cory D. Cress[1], Matthew P. Lumb[1,2], Jeffrey H. Warner[1], Christopher G. Bailey[1], Raymond Hoheisel[1,2], Robert J. Walters[1]
[1]Naval Research Laboratory, Washington, DC, USA, [2]The George Washington University, Washington, DC, USA

2:30
868
Modeling the Optical and Electrical Response of Nanostructured III-V Solar Cells
Kristina Driscoll, Seth M. Hubbard
Rochester Institute of Technology, Rochester, NY, USA

2:45
869
GaAs/ PBnDT-FTAZ Nanopillar Hybrid Solar Cells: Study of Effect of Passivation Agent on the Morphology and Performance
Ramesh babu Laghumavarapu[1], Michael Anthony Haddad[1], Liang Yan[2], Wei You[2], Diana L. Huffaker[1]
[1]University of California, Los Angeles, CA, USA, [2]University of North Carolina, Chapel Hill, CA, USA

1:30 - 3:00 PM **18CD**

Area 2: Polycrystalline Thin Films: Kesterites (Orals)

Chair(s): Katsumi Kushiya, Greg Hanket

1:30 870 **Kesterite Successes, Ongoing Work, and Challenges: A Perspective from Vacuum Deposition**
Ingrid L. Repins[1], Manuel J. Romero[1], Glenn Teeter[1], Jian V. Li[1], Su-Huai Wei[1], Darius Kuciauskas[1], Carolyn L. Beall[1], Clay M. DeHart[1], Jonathan R. Mann[1], Wan-Ching Hsu[2], Alan C. Goodrich[1], Rommel Noufi[1]
[1]National Renewable Energy Lab, Golden, CO, USA, [2]Department of Materials Science and Engineering, University of California, Los Angeles, CA, USA

2:00 871 **Effect of Composition on High-Efficiency CZTSSe Devices Fabricated by Co-Sputtering of Compound Targets**
Vardaan Chawla[1], Bruce Clemens[2]
[1]AQT Solar, Sunnyvale, CA, USA, [2]Stanford University, Stanford, CA, USA

2:15 872 **A Simple Solution-Based Route to High-Efficiency CZTSSe Thin-Fim Solar Cells**
Qijie Guo, Yanyan Cao, Jonathan V. Caspar, William E. Farneth, Alex S. Ionkin, Lynda K. Johnson, Meijun Lu, Irina Malajovich, Daniela Radu, Kaushik Roy Choudhury, H David Rosenfeld, Wei Wu
The DuPont Company, Central Research and Development, Experimental Station, Wilmington, DE, USA

2:30 873 **Over 8% Efficiency Cu_2ZnSnS_4 Submodules with Ultrathin Absorber**
Hiroki Sugimoto, Homare Hiroi, Noriyuki Sakai, Satoshi Muraoka, Takuya Katou
Solar Frontier K.K., Atsugi, Japan

2:45 874 **Device Characteristics of High-Performance Cu_2ZnSnS_4 Solar Cell**
Oki Gunawan, Tayfun Gokmen, Byungha Shin, Supratik Guha
IBM T J Watson Research Center, Yorktown Heights, NY, USA

1:30 - 3:00 PM **17B**

Area 3: III-V's and Concentrators: High-Efficiency Cells (Orals)

Chair(s): Dan Aiken, Damien Buie

1:30
875
Measuring IV Curves and Subcell Photocurrents in the Presence of Luminescent Coupling
Myles A. Steiner, John F. Geisz, Tom E. Moriarty, Ryan M. France, William E. McMahon, Jerry M. Olson, Sarah R. Kurtz, Daniel J. Friedman
National Renewable Energy Laboratory, Golden, CO, USA

1:48
876
Best Student Presentation Award Finalist
Temperature Accelerated Life Test (ALT) on III-V Concentrator Triple-Junction Solar Cells
Pilar Espinet-González[1], Carlos Algora[1], Jesús Bautista[1], Neftalí Núñez[1,2], Manuel Vázquez[1,2], Kenji Araki[3]
[1]Institute of Solar Energy (IES), Technical University of Madrid (UPM), Madrid, Spain, [2]EUIT de Telecomunicación, Universidad Politécnica de Madrid, Madrid, Spain, [3]Daido Steel Co., Nagoya, Japan

2:06
877
Lattice-Matched Solar Cells with 40% Average Efficiency in Pilot Production and a Roadmap to 45%
Daniel J. Aiken, Pravin Patel, Fred Newman, Edwin Dons
Emcore Corporation, Albuquerque, NM, USA

2:24
878
Pushing Inverted Metamorphic Multijunction Solar Cells Towards Higher Efficiency at Realistic Operating Conditions
Ryan M. France, John F. Geisz, Myles A. Steiner, Daniel J. Friedman, J. Scott Ward, Jerry M. Olson, Waldo Olavarria, Michelle Young, Anna Duda
National Renewable Energy Laboratory, Golden, CO, USA

2:42
879
Comparison of III-V Concentrator Multijunction Solar Cells
Mingguo Liu, Geoffrey S. Kinsey, Aditya Nayak, William Bagienski, Vahan Garboushian
Amonix Inc., Seal Beach, CA, USA

1:30 - 3:00 PM **Blrm G**

Area 4: Crystalline Silicon: Texture, Emitter, and ARC (Orals)

Chair(s): Joachim John

1:30 880 **Progress in n-Type Si Solar Cell and Module for High Efficiency and Low Cost**
Dengyuan Song, Jingfeng Xiong, Zhiyan Hu, Gaofei Li, Hongfang Wang
Yingli Green Energy Holding Co., TLD, Baoding, China

2:00 881 **Crystalline Silicon Photovoltaic Solar Power : Accelerating to Global Grid Parity**
Charlie Gay
President, Applied Solar

2:15 882 **Etching Paste for Innovative Solar Cell Applications**
Mohamamdreza Nejati[1], Wen Zhang[2], Lun Huang[2]
[1]GP Solar GmbH, Konstanz, Germany, [2]Dongfang Electric (YiXing) MAGI Solar Power Technology Co., Ltd., Yixing Jiangsu, China

2:30 883 **Analysis of Cast Monocrystalline Ingot Characteristics with Applications to Solar Cells**
Brian C. Rounsaville, Ian Cooper, John K. Tate, Malka Kadish, Arnab Das, Ajeet Rohatgi
UCEP, Georgia Tech, Atlanta, GA, USA

2:45 884 **Immeasurably Low Surface Recombination Velocity Passivated by Low Absorption Silicon Nitride on c-Si**
Yimao Wan[1], Keith R. McIntosh[2], Andrew F. Thomson[1], Andres Cuevas[1]
[1]Research school of Engineering, Australian National University (ANU), Canberra ACT, Australia, [2]PV Lighthouse, Coledale NSW, Australia

1:30 - 3:00 PM **19A**

Area 5: Thin-Film Silicon: Light Trapping in Solar Cells 2 (Orals)

Chair(s): Laura Sivec, AJM van Erven

1:30 885 **Light Harvesting Schemes for High-Efficiency Thin-Film Solar Cells**
Matthieu Despeisse, Mathieu Boccard, Corsin Battaglia, Jordi Escarré, Karin Söderström, Laura Ding, Sylvain Nicolay, Jan-Willem Schüttauf, Simon Hänni, Gregory Bugnon, Michael Stuckelberger, Maximilien Bonnet-Eymard, Gaetano Parascandolo, Fanny Meillaud, Christophe Ballif
Institute of Microengineering (IMT), Ecole Polytechnique Fédérale de Lausanne (EPFL), Laboratory of Photovoltaics and Thin Film Electronics, Neuchatel, Switzerland

2:00 886 **Development of High-Efficiency Tandem Silicon Solar Cells on W-Textured Zinc Oxide-Coated Soda-Lime Glass Substrates**
Yuki Moriya[1], Taweewat Krajangsang[3], Porponth Sichanugrist[1], Makoto Konagai[1,2]
[1]Department of Physical Electronics, Tokyo Institute of Technology, Tokyo, Japan, [2]Photovoltaic Research Center (PVREC), Tokyo Institute of Technology, Tokyo, Japan, [3]Solar Energy Technology Laboratory, National Electronics and Computer Technology Center, Pathumthani, Thailand

2:15 887 **Quantification of Optical Deflection by Laser-Structured ZnO:Al**
Marcel Berner, Marc Sämann, Ahmed Garamoun, Markus B. Schubert
Universität Stuttgart, Institut für Photovoltaik, Stuttgart, Germany

2:30 888 **Optical Modeling and Optimization of Flattened Light-Scattering Substrate for Thin-Film Silicon Solar Cells**
Olindo Isabella[1], Hitoshi Sai[2], Michio Kondo[2], Miro Zeman[1]
[1]Photovoltaic Materials and Devices Laboratory, Delft University of Technology, Delft, Netherlands, [2]Research Center for Photovoltaic Technologies, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan

2:45 889 **Lithographically-Definable Solar Cell Random Reflector Using Genetic Algorithm Optimization**
Albert S. Lin[1], Sze-Ming Fu[1], Yan-Kai Chung[2]
[1]Institute of Electronic Engineering, National Chiao-Tung University, Hsinchu, Taiwan, [2]Department of Electro-Physics, National Chiao-Tung University, Hsinchu, Taiwan

1:30 - 3:00 PM **17A**

Area 6: Organic Photovoltaics: New Organic and Interface Materials (Orals)

Chair(s): Erin Ratcliff, Ivgenny Katz

1:30 890 **Wrinkles and Folds as Photonic Structures in Polymer Photovoltaics**
Y.-L. Loo
Princeton University, Princeton, NJ, USA

2:00 891 **Best Student Presentation Award Finalist**
Efficiency Limitations in Organic Bulk Heterojunction Solar Cells
Kejia Li[1,3], Lijun Li[1,3], Petr P. Khlyabich[2,3], Beate Burkhart[2,3], Barry C. Thompson[2,3], Joe C. Campbell[1,3]
[1]University of Virginia, Charlottesville, VA, USA, [2]University of Southern California, Los Angeles, CA, USA, [3]Center for Energy Nanoscience at University of Southern California, Los Angeles, CA, USA

2:15 892 **Recombination Barrier Layers in Solid-State Quantum Dot-Sensitized Solar Cells**
Katherine E. Roelofs[1], Thomas P. Brennan[2], Juan C. Dominguez[2], Stacey F. Bent[2]
[1]Department of Materials Science and Engineering, Stanford University, Stanford, CA, USA, [2]Department of Chemical Engineering, Stanford University, Stanford, CA, USA

2:30 893 **Electrical Study on Effects of 2-D Plasmonic Grating on Organic Solar Cells**
Wei E.I. Sha[1], Wallace C.H. Choy[1], Weng Cho Chew[1,2]
[1]Department of Electrical and Electronic Engineering, the University of Hong Kong, Hong Kong, Hong Kong, [2]Department of Electrical and Computer Engineering, University of Illinois, Urbana-Champaign, Champaign, IL, USA

2:45 894 **Thermally-Induced Morphological Changes in PAT/PCBM Bulk Heterojunctions Studied by Time-Resolved Small- and Wide-Angle X-ray Scattering**
Soo Kim[1], Eun Ji Lee[2], Jong Kwan Lee[1], Kwang Hee Lee[2], Michael H.-C. Jin[1]
[1]Department of Materials Science and Engineering, University of Texas, Arlington, TX, USA, [2]Department of Polymer Science and Engineering, Inha University, Incheon, South Korea

1:30 - 3:00 PM **16AB**

Area 9: Modules and Systems: PV Performance Modeling Collaborative (Orals)

Chair(s): Dan Riley, Ben Bourne

1:30 895 **The Photovoltaic Performance Modeling Collaborative**
Joshua S. Stein
Sandia National Laboratories, Albuquerque, NM, USA

1:45 896 **What Must Project Developers and Technology Providers Do to Support Performance Estimates During Project Development?**
Evan Riley
Black & Veatch, San Francisco, CA, USA

2:00 897 **Solar Input Data for PV Performance Modeling**
Marie A. Schnitzer, Christopher C. Thuman, Peter N. Johnson, Janine M. Freeman
AWS Truepower, LLC, Albany, NY, USA

2:15 898 **PV Technology Differences and Discrepancies in Modeling Between Simulation Programs and Measurements**
Steve J. Ransome
srcl, London, United Kingdom

2:30 899 **Calibration of the Sandia Array Performance Model Using Indoor Measurements**
Clifford W. Hansen[1], Daniel M. Riley[1], Manuel Jaramillo[2]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]CFV Solar Test Laboratory, Inc., Albuquerque, NM, USA

2:45 900 **Thermal Modeling Accuracy of Hourly Averaged Data for Large Free-Field Cadmium Telluride PV Arrays**
William J. Hayes, Alex F. Panchula
First Solar, Inc., San Francisco, CA, USA

3:00 - 3:30 PM **4th Floor Foyer**

Coffee Break

3:30 - 5:00 PM **18AB**

Area 1: Fundamentals and New Concepts: Novel Materials 1 (Orals)

Chair(s): Ryne P. Raffaelle, Alex Freudnlich

3:30 901 **Intermediate-Band to Conduction-Band Optical Absorption in ZnTeO**
Elisa Antolin[1,2], Iñigo Ramiro[1], Esther Lopez[1], Estela Hernandez[1], Irene Artacho[1], Cesar Tablero[1], Antonio Marti[1], Antonio Luque[1], Chihyu Chen[3], Justin Foley[3], Jamie D. Phillips[3]
[1]Instituto de Energia Solar, Universidad Politecnica de Madrid, Madrid, Spain, [2]Instituto de Microelectronica de Madrid, Consejo Superior de Investigaciones Cientificas, Tres Cantos, Madrid, Spain, [3]Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI, USA

4:00 902 **A Highly Efficient Hybrid CdS-GaAs Solar Cell**
Hsin Chu Chen[1], Chien Chung Lin[2], Yu Lin Tsai[1], Hau Vei Han[1], PeiChen Yu[1], Hao Chung Kuo[1]
[1]Department of Photonic & Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan, [2]Institute of Photonic System, National Chiao Tung University, Tainan, Taiwan

4:15 903 **Heterogeneous Integration of InGaN and Silicon Solar Cells for Enhanced Energy Harvesting**
Naresh C Das[1], Meredith Reed[1], Mike Wraback[1], Anand Sampath[1], Paul Shen[1], Robert Farrell[2], M. Iza[2], S.C. Cruz[2], J.R. Lang[2], N.G. Young[2], Y. Terao[2], C.J. Neufeld[3], S. Keller[3], S Nakamura[2,3], U.K. Mishra[3], James Speck[2]
[1]Army Researcch Laboratory, Adelphi, MD, USA, [2]Material Science Department, Santa Barbara, CA, USA, [3]Electrical Engineering Department, Santa Barbara, CA, USA

4:30 904 **High-Perfomance Patterned Arrays of Core-Shell GaAs Nanopillar Solar Cells with** *In Situ* **InGaP Passivation Layer**
Giacomo Mariani[1], Adam Scofield[1], Diana Huffaker[1,2]
[1]University of California, Los Angeles, Los Angeles, CA, USA, [2]California Nanosystem Institute, Los Angeles, CA, USA

4:45 905 **Fabrication and Modeling of Large-Scale Silicon Nanowire Solar Cells for Thin-Film Photovoltaics**
Yu-Chih Cheng[1], Ting-Gang Chen[1], Feng-Yu Chang[1], Bo-Yu Huang[1], Huai-Te Pan[1], Peichen Yu[1], Chi-Kang Li[2], Yuh-Renn Wu[2]
[1]Department of Photonic & Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan, [2]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan

3:30 - 5:00 PM **18CD**

Area 2: Polycrystalline Thin Films: CIGS Absorber Processing (Orals)

Chair(s): Gregory Wilson, Shogo Ishizuka

3:30 906 **Hybrid Sputtering/Evaporation Deposition of Cu(In,Ga)Se_2 Thin-Film Solar Cells**
Maurizio Acciarri[1], Simona Binetti[1], Alessia Le Donne[1], Bruno Vodopivec[1], Leo Miglio[1], Stefano Marchionna[2], Maurilio Meschia[2], Raffaele Moneta[2]
[1]Dip. of Material Science and Solar Energy Research Center, University of Milan-Bicocca, Milan, Italy, [2]Voltasolar s.r.l, Turate (Co), Italy

3:45 907 **Three-Step $H_2Se/Ar/H_2S$ Reaction of Metal Precursors for Large-Area Cu(In,Ga)$(Se,S)_2$ with Uniform Ga Distribution**
Kihwan Kim, Evan L. Kimberly, Andrew Damiani, Gregory M. Hanket, William N. Shafarman
University of Delaware, Newark, DE, USA

4:00 908 **Advances in Electroplating-Based CIGS Solar Cell Fabrication**
Serdar Aksu, Sarah Lastella, Shirish Pethe, Alan Kleiman-Shwarsctein, Sambhu Kundu, Mustafa Pinarbasi
SoloPower, Inc., San Jose, CA, USA

4:15 909 **Structural and Electronic Characteristics of Cu(In,Ga)Se_2 Thin Films Sputtered from Quaternary Targets**
Jesse A. Frantz[1], Robel Y. Bekele[2], Jason D. Myers[1], Vinh Q. Nguyen[1], Jasbinder S. Sanghera[1], Sergey I. Maximenko[1], Maria Gonzalez[3], Joseph G. Tischler[1], Robert J. Walters[1], Marina S. Leite[4,5], Allan Bruce[6], Sergey V. Frolov[6], Michael Cyrus[6]
[1]U.S. Naval Research Laboratory, Washington, DC, USA, [2]University Research Foundation, Greenbelt, MD, USA, [3]Sotera Defense Solutions, Crofton, MD, USA, [4]CNST, National Institute for Standards and Technology, Gaithersburg, MD, USA, [5]Maryland Nanocenter, University of Maryland, College Park, MD, USA, [6]Sunlight Photonics Inc., South Plainfield, NJ, USA

4:30 910 **High-Efficiency CIGSe Solar Cells by Sputtered Cu(In,Ga) Followed by Selenization**
Haifan Liang, Wei Liu, Sang Lee, Jeroen van Duren, Tim Franklin, Michael Patten, Sandeep Nijhawan
Intermolecular Inc., San Jose, CA, USA

4:45 911 **Fabrication of Selenized/Sulfurized Cu(in,Ga)$(Se,S)_2$ Solar Cells Based on High-Temperature Process Using High-Strain-Point Glass Substrate**
Reo Usui, Takeshi Tomizawa, Takeshi Okato, Hidehumi Odaka
Asahi Glass Co, Ltd., Yokohama, Kanagawa, Japan

3:30 - 5:00 PM **Blrm G**

Area 4: Crystalline Silicon: Discussion and Harumph (Workshop)

Chair(s): Nathan Stoddard, Zhigang Rick Li

3:30 - 5:00 PM **19A**

Area 5: Thin-Film Silicon: Fundamentals and Defects in Solar Cells (Orals)

Chair(s): David Young, Nicolas Podraza

3:30
912 **Best Student Presentation Award Finalist**
The Relation Between Vacancies and the Dominant Defects in Hydrogenated Amorphous Silicon
Jimmy Melskens[1], Arno H.M. Smets[1], Stephan W.H. Eijt[2], Henk Schut[3], Miro Zeman[1]
[1]Photovoltaic Materials and Devices, Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology, Delft, Netherlands, [2]Fundamental Aspects of Materials and Energy, Faculty of Applied Sciences, Delft University of Technology, Delft, Netherlands, [3]Neutron and Positron Methods in Materials, Faculty of Applied Sciences, Delft University of Technology, Delft, Netherlands

4:00
913 **Best Student Presentation Award Finalist**
Valence Band Alignment of the ZnO:Al/a-Si:B Interface: Unraveling the Electronic Structure of a Poorly Performing Contact
D. Gerlach[1], D. Wippler[2], R.G. Wilks[1], M. Wimmer[1], M. Lozach[3], S. Ueda[3], H. Yoshikawa[4], M. Sumiya[3], K. Kobayashi[3], J. Hüpkes[2], M. Bär[1]
[1]Helmholtz-Zentrum Berlin, Berlin, Germany, [2]Forschungszentrum Jülich, Jülich, Germany, [3]National Institute for Materials Science, Hyogo, Japan, [4]NIMS Beamline Station, SPring-8, Tsukuba, Japan

4:15
914 **Infrared Dielectric Functions of Hydrogenated Amorphous Silicon Thin Films Determined by Spectroscopic Ellipsometry**
David B. Saint John[1], Haoting Shen[1], Hang-Beum Shin[2], Thomas N. Jackson[2], Nikolas J. Podraza[3]
[1]Department of Materials Science and Engineering, University Park, PA, USA, [2]Department of Electrical Engineering, University Park, PA, USA, [3]Department of Physics and Astronomy, Toledo, OH, USA

4:30
915 **Identification of Defects in Thin-Film Solar Cells for New-Generation Energy Devices**
Yohko Naruse, Mitsuhiro Matsumoto, Takeyuki Sekimoto, Mitsuoki Hishida, Youichirou Aya, Wataru Shinohara, Atsushi Fukushima, Shigeo Yata, Akira Terakawa, Masahiro Iseki, Makoto Tanaka
Panasonic Corporation, Gifu, Japan

4:45
916 **Hydrogenation of Dislocation-Limited Heteroepitaxial Silicon Solar Cells**
Michael L. Bolen[1], Sachit Grover[1], Charles W. Teplin[1], David Bobela[2], Howard M. Branz[1], Paul Stradins[1]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Ampulse Corporation, Golden, CO, USA

3:30 - 5:00 PM **17A**

Area 6: Organic Photovoltaics: Device Concepts (Orals)

Chair(s): Dana Olson, Barry Rand

3:30 917 **Modeling Low-Cost Hybrid Tandem Photovoltaics with Power Conversion Efficiencies Exceeding 20%**
Michael D. McGehee, Zach M. Beiley
Stanford University, Department of Materials Science and Engineering, Stanford, CA, USA

4:00 918 **OPV Technology Flow Accelerates from the Laboratory to the Customer**
James Buntaine
Konarka Technologies, Inc., Lowell, MA, USA

4:15 919 **Guided-Mode Absorption in Ultrathin Organic Photovoltaics**
Yutong Pang[1,2], Nanditha Dissanayake[2], Matthew D. Eisaman[1,2]
[1]Stony Brook University, Stony Brook, NY, USA, [2]Brookhaven National Laboratory, Upton, NY, USA

4:30 920 **Large-Area CVD Graphene as Transparent Electrode for Efficient Organic Solar Cells**
Golap Kalita[1], Masaki Tanemura[2], Koichi Wakita[1], Masayoshi Umeno[1]
[1]Department of Electronics and Information Engineering, Chubu University, Kasugai, Japan, [2]Department of Frontier Materials, Nagoya Institute of Technology, Nagoya, Japan

4:45 921 **Best Student Presentation Award Finalist**
Fabrication and Device Modeling of Micro-Textured Conductive Polymer/Silicon Heterojunction Solar Cells
Ting-Gang Chen[1], Bo-Yu Huang[1], Yang-Yue Huang[1], En-Chen Chen[2], Peichen Yu[1], Hsin-Fei Meng[2]
[1]Department of Photonics and Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan, [2]Institute of Physics, National Chiao Tung University, Hsinchu, Taiwan

3:30 - 5:00 PM **17B**

Area 7: Space Technologies: High Performance PV for Space Applications (Orals)

Chair(s): Steve Taylor, Mitsuru Imazumi

3:30
922
Initial Results of the Monolithically-Grown Six-Junction Inverted Metamorphic Multijunction Solar Cell
Pravin M. Patel, Daniel Aiken, Daniel Chumney, Arthur Cornfeld, Yong Lin, Chelsea Mackos, Jim McCarty, Nathaniel Miller, Paul Sharps, Mark Stan
EMCORE Corporation, Albuquerque, NM, USA

4:00
923
Recent Progress of Spectrolab High-Efficiency Space Solar Cells
Daniel C. Law, X.Q. Liu, J.C. Boisvert, E.M. Rehder, C.M. Fetzer, S. Mesropian, R.R King, K.E Edmondson, B. Jun, R.L. Woo, D.D. Krut, P.T. Chiu, D.M. Bhusari, S.K. Sharma, N.H. Karam
Spectrolab Inc, a wholly owned subsidary of Boeing, Sylmar, CA, USA

4:15
924
Best Student Presentation Award Finalist
Superior Radiation and Dislocation Tolerance of IMM Space Solar Cells
Akhil Mehrotra, Alex Freundlich
Center for Advanced Materials, University of Houston, Houston, TX, USA

4:30
925
The One-per-Wafer ZTJ Solar Cell from Emcore- Confidence Testing and Volume Manufacturing Performance
Benjamin Cho, MIchael Winter, Ian Aeby, Pravin Patel, Navid Fatemi, Paul Sharps
Emcore Photovoltaics, Albuquerque, NM, USA

4:45
926
Best Student Presentation Award Finalist
Characterization of InGaP Heterojunction Emitter Quantum Dot Solar Cells
Zachary S. Bittner[1], Christopher G. Bailey[2], Stephen J. Polly[1], David V. Forbes[1], Seth M. Hubbard[1]
[1]Rochester Institute of Technology, Rochester, NY, USA, [2]U.S. Naval Research Laboratory, Washington, DC, USA

3:30 - 5:00 PM **16AB**

Area 9: Modules and Systems: Module Materials, Durability, and Performance 2 (Orals)

Chair(s): Wilfried van Sark, Howard O Barikmo

3:30 927 **How Can We Make PV Modules Safer?**
John H. Wohlgemuth, Sarah Kurtz
NREL, Golden, CO, USA

3:45 928 **I-V Curves from 300 Modules Deployed over 5-Years in Tucson**
Emily S. Kopp[1], Patricia L. Hidalgo-Gonzalez [2], Adria E. Brooks[3,4], Vincent P. Lonij[3], Alexander D. Cronin[1,3]
[1]University of Arizona, College of Optical Sciences, Tucson, AZ, USA, [2]Pontificia Universidad Católica de Chile, Santiago, Chile, [3]University of Arizona, Department of Physics, Tucson, AZ, USA, [4]Arizona Research Institute for Solar Energy, Tucson, AZ, USA

4:00 929 **Stress Analysis of Silicon-Wafer-Based Photovoltaic Modules in Operation**
Yixian Lee[1,2], Andrew A.O. Tay[1,2]
[1]Solar Energy Research Institute of Singapore, National University of Singapore, Singapore, Singapore, [2]Department of Mechanical Engineering, National University of Singapore, Singapore, Singapore

4:15 930 **Optimized Module Design: A Study of Encapsulation Losses and the Influence of Design Parameters on Module Performance**
Max B. Koentopp, Robert Seguin
Q-Cells SE, Bitterfeld-Wolfen, Germany

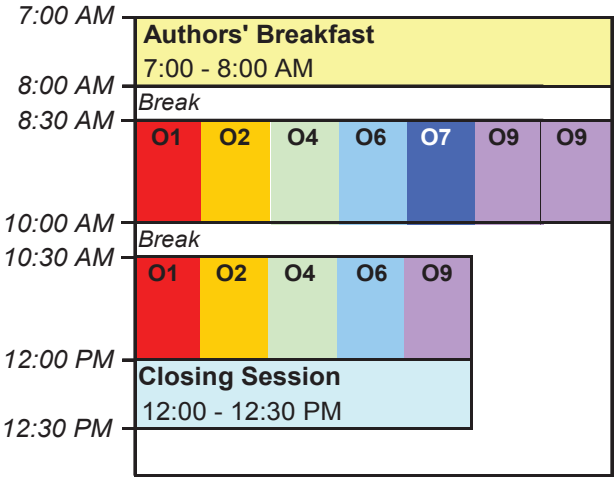
4:30 931 **NICE Modules Technology from Concept to Mass Production: A 10-Year Review**
Julien Dupuis[1], Etienne Saint-Sernin[1], Oleksiy Nichiporuk[1], Paul Lefillastre[2], Denis Bussery[3], Roland Einhaus[1]
[1]Apollon Solar, Lyon, France, [2]CEA INES, LMPV Modules, Le Bourget du Lac, France, [3]Vincent Industrie, Brignais, France

4:45 932 **New Module Efficiency Record: 23.5% Under 1-Sun Illumination Using Thin-Film Single-Junction GaAs Solar Cells**
Laila S. Mattos, Shawn R. Scully, Maria Syfu, Eric Olson, Linlin Yang, Gang He
Alta Devices, Inc., Santa Clara, CA, USA

6:30 - 10:00 PM

PVSC Banquet
Austin City Limits at Moody Theater

FRIDAY PROGRAM SUMMARY



AREA LEGEND

- Area 1: Fundamentals and New Concepts for Future Technologies
- Area 2: Thin Film Polycrystalline Photovoltaics
- Area 3: III-V and Concentrator Technologies
- Area 4: Crystalline Silicon Photovoltaics
- Area 5: Thin Film Silicon Based PV Technologies
- Area 6: Organic Photovoltaics
- Area 7: Space Technologies
- Area 8: Characterization Methods
- Area 9: PV Modules and Terrestrial Systems
- Area 10: PV Velocity Forum

O = Oral Session P = Poster Session

8:00 - 8:30 AM **4th Floor Foyer**

Coffee Break

8:30 - 10:00 AM **18AB**

Area 1: Fundamentals and New Concepts: Novel Materials 2 (Orals)

Chair(s): Ryne P. Raffaelle

8:30 933 **Analysis of Current Transport Mechanisms in GaAsN Homojunction Solar Cell Grown by Chemical Beam Epitaxy**
Boussairi Bouzazi, Nobuaki Kojima, Yoshio Ohshita, Masafumi Yamaguchi
Toyota Technological Institute, Nagoyta, Japan

9:00 934 **Thin, Free-Standing Cu_2O Substrates via Thermal Oxidation for Photovoltaic Devices**
Samantha S. Wilson, Chengxiang Xiang, Yulia Tolstova, Harry A. Atwater
California Institute of Technology, Pasadena, CA, USA

9:15 935 **High-Efficiency Quantum Dot Solar Cells Using 2-Dimensional 6.4-nm-Diameter Si Nanodisk with SiC Interlayer**
Makoto Igarashi[1,4], Mohd Fairuz Budiman[1,4], Wugen Pan[2], Yusuke Hoshi[2], Weiguo Hu[1,4], Mohd Erman Syazwan[1,4], Kentarou Sawano[3], Noritaka Usami[2], Seiji Samukawa[1,4]
[1]Institute of Fluid Science, Tohoku University, Sendai, Japan, [2]Institute for Materials Research Crystal Physics, Tohoku University, Sendai, Japan, [3]Research Center for Silicon Nano-Science, Advanced Research Laboratories, Tokyo City University, Tokyo, Japan, [4]Japan Science and Technology Agency, CREST, Tokyo, Japan

9:30 936 **Enhanced Carrier Extraction Under Strong Light Irradiation in Ge/Si Type-II Quantum Dot Solar Cells**
Takeshi Tayagaki[1,2], Noritaka Usami[3], Wugen Pan[3], Yusuke Hoshi[3], Yoshihiko Kanemitsu[1]
[1]Kyoto University, Uji, Japan, [2]PRESTO-JST, Kawaguchi, Japan, [3]Tohoku University, Sendai, Japan

9:45 937 **Bandgap Engineering of ZnSnxGe1-xN2 Alloys as Earth-Abundant Photovoltaic Absorber Materials**
Naomi C. Coronel[1], Lise Lahourcade[1], Kris T. Delaney[2], Amanda M. Shing[1], Harry A. Atwater[1,3]
[1]Thomas J Watson Laboratories of Applied Physics, Caltech, Pasadena, CA, USA, [2]Materials Research Laboratory, UCSB, Santa Barbara, CA, USA, [3]Kavli Nanoscience Institute, Caltech, Pasadena, CA, USA

8:30 - 10:00 AM **18CD**

Area 2: Polycrystalline Thin Films: CdTe Processing & Devices (Orals)

Chair(s): Markus Gloeckler, Ayodhya Tiwari

8:30 938 **Development of Substrate Structure CdTe Photovoltaic Devices with Performance Exceeding 10%**
Ramesh G. Dhere, Joel N. Duenow, Clay M. DeHart, Jian V. Li, Darius Kuciauskas, Timothy A. Gessert
National Renewable Energy Laboratory, Golden, CO, USA

8:45 939 **Response of CdS/CdTe Devices to Te Additions at Back Contact**
Timothy A. Gessert, James Burst, Jie Ma, Darius Kuciauskas, Teresa Barnes, William Rance
National Renewable Energy Laboratory, Golden, CO, USA

9:00 940 **High-Resolution Local-Current Measurement of CdTe Solar Cells**
Heayoung P. Yoon[1,3], Dmitry Ruzmetov[1,3], Paul M. Haney[1], Marina S. Leite[1,3], Behrang H. Hamadani[1], A. Alec Talin[1], Nikolai B. Zhitenev[1]
[1]Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Giathersburg, MD, USA, [2]Energy and Environment Division, Engineering Laboratory, National Institute of Science and Technology, Gaithersburg, MD, USA, [3]Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, MD, USA

9:15 941 **Improved Performance of CdTe Solar Cells Grown at High Temperatures on Specialty Glass**
Teresa M. Barnes[1], James Burst[1], Matthew O. Reese[1], Will Rance[1], Timothy A. Gessert[1], Kan Zhang[2], Kim M. Fuller[2], Charles T. Hamilton[2], Bruce Aitken[2], Carlo A. Kosik-Williams[2]
[1]National Renewable Energy Lab, Golden, CO, USA, [2]Corning, Inc, Corning, NY, USA

9:30 942 **Oxygen Incorporation During Fabrication of Substrate CdTe Photovoltaic Devices**
Joel N. Duenow, Ramesh G. Dhere, Darius Kuciauskas, Jian V. Li, Joel W. Pankow, Patricia C. Dippo, Clay M. DeHart, Timothy A. Gessert
National Renewable Energy Laboratory, Golden, CO, USA

9:45 943 **Device Characteristics of a 17.1%-Efficient Solar Cell Deposited by Non-Vacuum Printing Method on Flexible Foil**
Gregory Brown, Peter Stone, Jacob Woodruff, Ben Cardozo, David Jackrel
Nanosolar, San Jose, CA, USA

8:30 - 10:00 AM **Blrm G**

Area 4: Crystalline Silicon: Feedstock (Orals)

Chair(s): Roland Einhaus

8:30 944 **19% Efficiency Heterojunction Solar Cells on Cz Wafers from Non-Blended Upgraded Metallurgical Silicon**
J. Kraiem[1], P. Papet[2], J. Degoulange[1], O. Nichiporuk[1], Y. Andrault[2], D. Grosset-Bourbange[3], F. Cocco[3], R. Einhaus[1]
[1]Apollon Solar, Lyon, France, [2]Roth & Rau, Neuchatel, Switzerland, [3]FerroPem, Chambéry, France

9:00 945 **Fluidized Bed Silicon for Solar Cells**
Paul Ege, Alireza Abbasi
Reactech, Markham, ON, Canada

9:15 946 **The Value Proposition for High Lifetime Silicon in Solar PV Applications**
Alan C. Goodrich, Michael Woodhouse, Peter Hacke
NREL, Golden, CO, USA

9:30 947 **Best Student Presentation Award Finalist**
Incomplete Ionization and Carrier Mobility in Compensated Silicon
Maxime Forster[1, 2, 3], Andres Cuevas[2], Fiacre Emile Rougieux[2], Erwann Fourmond[3], Mustapha Lemiti[3]
[1]APOLLON SOLAR, Lyon, France, [2]The Australian National University, Canberra, Australia, [3]INSA de Lyon, Lyon, France

9:45 948 **Light-Induced Degradation in Compensated mc-Si p-Type Solar Cells**
Simone Bernardini[1], Desislava Saynova[1], Simona Binetti[2], Gianluca Coletti[1]
[1]ECN Solar Energy, Petten, Netherlands, [2]Materials Science Departement, University of Milano-Bicocca, Milano, Italy

8:30 - 10:00 AM **17A**

Area 6: Organic Photovoltaics: Lifetime Processing and Reliability (Orals)

Chair(s): Yang Yang, Neal Armstrong

8:30 949 **Advanced Design and Up-Scaling of ITO-Free Solar Cells via All-Solution Roll-to-Roll Processing**
Yulia Galagan
Holst Centre, Eindhoven, Netherlands

9:00 950 **Low-Bandgap Organic Solar Cells with Enhanced Optical Properties by Embedded PEDOT:PSS Gratings**
Xiaolong Zhu[1], Chuihui Duan[2], Wallace C.H. Choy[1], Fengxian Xie[1], Chuandao Wang[1], Fei Huang[2], Yong Cao[2]
[1]Department of Electrical and Electronic Engineering, the University of Hong Kong, Hong Kong, Hong Kong, [2]Institute of Polymer Optoelectronic Materials and Devices, State Key Laboratory of Luminescent Materials and Devices, South China University of Technology, Guangzhou, China

9:15 951 **Accelerated Stability Testing of Organic Photovoltaics Using Concentrated Sunlight**
Eugene A. Katz[1], Assaf Manor[1], Asaf Mescheloff[1], Thomas Tromholt[2], Frederik C. Kreebs[2]
[1]Dept. of Solar Energy and Environmental Physics, J. Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boker, Israel, [2]Risø National Lab., Technical University of Denmark, Roskilde, Denmark

9:30 952 **A Methodology to Characterize OPV Temperature, Humidity and Irradiation Degradation: Preliminary Results**
Elsa Kam-Lum
Total New Energies USA, Lowell, MA, USA

9:45 953 **The Effect of Anneal, Solar Irradiation and Humidity on the Adhesion/Cohesion Properties of P3HT:PCBM-Based Inverted Polymer Solar Cells**
Stephanie R. Dupont[1], Eszter Voroshazi[2,3], Paul Heremans[2,3], Reinhold H. Dauskardt[1]
[1]Stanford University, Stanford, CA, USA, [2]Imec, Leuven, Belgium, [3]Katholieke Universiteit Leuven, ESAT, Leuven, Belgium

8:30 - 10:00 AM **17B**

Area 7: Space Technologies: Testing and Design of Space PV Technologies (Orals)

Chair(s): Scott Billets, Claus Zimmerman

8:30
954 **Test Program of Multijunction GaAs/Ge Solar Array Coupons with Combined Space Environmental Exposures**
Bao Hoang[1], Frankie Wong[1], Ron Corey[1], George Gardiner[1], Victor Funderburk[1], Richard Gahart[1], Todd Schneider[2], Jason Vaungh[2], Kenneth Wright[3]
[1]Space Systems Loral, Palo Alto, CA, USA, [2]NASA Marshall Space Flight Center, Huntsville, AL, USA, [3]University of Alabama, Huntsville, Huntsville, AL, USA

8:45
955 **High-Irradiance High-Temperature Vacuum Testing of the Solar Probe Plus Array Design**
Andreea Boca, Philip Blumenfeld, Kevin Crist, Karen De Zetter, Richard Mitchell, Benjamin Richards, Charles Sarver, Paul Sharps, Mark Stan, Cory Tourino
Emcore Photovoltaics, Albuquerque, NM, USA

9:00
956 **The Influence of High Temperatures on the Radiation Behaviour of GaInP$_2$/GaInAs/Ge Triple-Junction Cells**
Christan Brandt[1], Carsten Baur[2], Antonio Caon[2], Peter Müller-Buschbaum[3], Claus Zimmermann[1], Thomas Andreev[1]
[1]EADS Astrium GmbH Satellites, Munich, Germany, [2]European Space Agency (ESA/ESTEC), Noordwijk, Netherlands, [3]TU-München, Physik-Department, Lehrstuhl für Funktionelle Materialien, Garching, Germany

9:15
957 **Selected On-Orbit Data from the FTSCE II Aboard the MISSE 7 Testbed**
Alexander D. Howard[1], David M. Wilt[1], Phillip P. Jenkins[2], Kelly M. Trautz[2], John M. Merrill[1]
[1]Air Force Research Laboratory Space Vehicles Directorate, Kirtland AFB, NM, USA, [2]US Naval Research Laboratory, Washington, DC, USA

9:30
958 **Advancements to SCREAM: Multiple Spectrum Input and ShielDDDose Options**
Scott R. Messenger, Eric A. Jackson, Jeffrey H. Warner, Phillip P. Jenkins, Robert J. Walters
US Naval Research Laboratory, Washington, DC, USA

9:45
959 **Solar Cell and Array Technology Development for NASA Solar Electric Propulsion Missions**
Michael F. Piszczor[1], Jeremiah S. McNatt[1], Carolyn R. Mercer[1], Thomas W. Kerslake[1], Richard S. Pappa[2]
[1]NASA Glenn Research Center, Cleveland, OH, USA, [2]NASA Langley Research Center, Hampton, VA, USA

8:30 - 10:00 AM **16AB**

Area 9: Modules and Systems: Irradiance Resources (Orals)

Chair(s): Steve Ransome, Joshua Stein

8:30 960 **Performance Testing Using Silicon Devices: Analysis of Accuracy**
Manajit Sengupta, Peter Gotseff, Daryl Myers, Thomas Stoffel
National Renewable Energy Laboratory, Golden, CO, USA

8:45 961 **Spectrally Selective Sensors for PV System Performance Monitoring**
Anton Driesse, Daniela Dirnberger, Nils Reich, Christian Reise
Fraunhofer ISE, Freiburg, Germany

9:00 962 **Over-Irradiance (Cloud Enhancement) Events at High Latitudes**
Georgi Hristov Yordanov[1,2], Ole-Morten Midtgård[1,2], Tor Oskar Saetre[1], Henrik Kofoed Nielsen[1], Lars Einar Norum[2]
[1]University of Agder (UiA), Grimstad, Norway, [2]Norwegian University of Science and Technology (NTNU), Trondheim, Norway

9:15 963 **Best Student Presentation Award Finalist**
PV Output Variability Modeling Using Satellite Imagery and Neural Networks
Matthew J. Reno[1,2], Joshua S. Stein[1]
[1]Sandia National Laboratories, Albuquerque, NM, USA, [2]Georgia Institute of Technology, Atlanta, GA, USA

9:30 964 **Best Student Presentation Award Finalist**
Analyzing and Simulating the Reduction in PV Powerplant Output Variability Due to Geographic Smoothing in Ota City, Japan and Alamosa, Colorado
Matthew Lave, Joshua S. Stein, Abraham Ellis
Sandia Nantional Laboratories, Albuquerque, NM, USA

9:45 965 **Improving Forecasts of PV Power Output Using Real-Time Measurements of PV Output of 100 Residential PV Systems**
Vincent P. Lonij[1], Vijai T. Jayadevan[1], Adria E. Brooks[1], Kevin Koch[2], Mike Leuthold[1], Alexander D. Cronin[1]
[1]University of Arizona, Tucson, AZ, USA, [2]Technicians for Sustainability, Tucsin, AZ, USA

8:30 - 10:00 AM **19A**

Area 9: Modules and Systems: Off-Grid Applications (Orals)

Chair(s): Robert Foster, Vaughn Nelson

8:30 966 **Afghanistan Photovoltaic Power Applications for Rural Development**
Robert Foster[1,2], Alma D. Cota[1]
[1]Winrock International, Arlington, VA, USA, [2]New Mexico State University, Las Cruces, NM, USA

9:00 967 **New Growth Markets for PV: Mini-Grids in Developing Countries – Implications for PV Technology**
Andy Skumanich, Shannon Fulton
SolarVision Co, Los Gatos, CA, USA

9:15 968 **Remote Markets for Photovoltaic Technologies, 1974 to Present and Ten-Year Forecast**
Paula J. Mints
Navigant, Palo Alto, CA, USA

9:30 969 **Mobile Solar Power**
Kelly M. Trautz[1], Phillip P. Jenkins[1], Robert J. Walters[1], David A. Scheiman[1], Raymond Hoheisel[1,2], Rao Tatavarti[3], Ray Chan[3], Haruki Miyamoto[3], Jessica Adams[3], Victor Elarde[3], James L. Grimsley[4]
[1]US Naval Research Laboratory, Washington, DC, USA, [2]George Washington University, Washington, DC, USA, [3]MicroLink Devices, Inc., Niles, IL, USA, [4]Design Intelligence Incorporated, LLC, Norman, OK, USA

9:45 970 **PV System Data Analysis of a PV-Powered Racing Boat During the Frisian Solar Challenge 2010**
Tim Gorter[1], Ernst-Jan Voerman[2], Peter Joore[2,3], Angèle Reinders[1,3], Fred Van Houten[1]
[1]University of Twente, Faculty of CTW, Department of Design, Production and Management, Enschede, Netherlands, [2]University of Applied Sciences, NHL hogeschool, Leeuwarden, Netherlands, [3]Delft University of Technology, Faculty of Industrial Design Engineering, Delft, Netherlands

10:00 - 10:30 AM **4th Floor Foyer**

Coffee Break

10:30 - 12:00 PM **18AB**

Area 1: Fundamentals and New Concepts: Light Concentration and Light Trapping 2 (Orals)

Chair(s): Ryne P. Raffaelle, Peichen Yu

10:30 971 **Antireflective Scheme for InGaP/InGaAs/Ge Triple-Junction Solar Cells based on TiO_2 Biomimetic Structures**
Kuo-Hsuan Hung[1], Ting-Gang Chen[1], Tung-Ting Yang[1], Peichen Yu[1], Chung-Yu Hong[2], Yu-Rue Wu[2], Guo-Chung Chi[1]
[1]Department of Photonics and Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu, Taiwan, [2]Arima Photovoltaic & Optical Corp, Taoyuan, Taiwan

11:00 972 **Configuration Optimization of a Nanosphere Array on Top of a Thin-Film Solar Cell**
Jonathan Grandidier, Dennis M. Callahan, Harry A. Atwater
Caltech, Pasadena, CA, USA

11:15 973 **Design and Demonstration of Light Trapping for Ge:Si Solar Cell Below Si Solar Cell in a Multijunction Solar Cell System**
Yi Wang[1], Andrew Gerger[2], Anthony Lochtefeld[2], Robert Opila[1,3], Allen Barnett[1,4]
[1]Department of Electrical Engineering, University of Delaware, Newark, DE, USA, [2]AmberWave, Inc., Salem, NH, USA, [3]Department of Materials Science, University of Delaware, Newark, DE, USA, [4]School of Photovoltaic and Renewable Energy Engineering, The University of New South Wales, Sydney, Australia

11:30 974 **Flexible Luminescent Solar Concentrators Utilizing Bio-Derived Tandem Fluorophores**
Martyn Fisher[1], Daniel Farrell[1], Kelly Trautz[2], Maria González[2], Robert Walters[2], Christian Ippen[3], Andreas Büchtemann[3], John Morseman[4], Amanda Chatten[1]
[1]Imperial College London, London, United Kingdom, [2]Naval Research Laboratory, Washington, DC, USA, [3]Fraunhofer Institute for Applied Polymer Research, Potsdam, Germany, [4]Columbia Biosciences, Washington, DC, USA

11:45 975 **Broadband Nanostructured Antireflection Coating on Glass for Photovoltaic Applications**
Roger Welser[1], Xing Yan[2], David Poxson[2], Adam Sood[1], Jaehee Cho[2], Ashok Sood[1], Jennifer Harvey[3], E. Fred Schubert[2]
[1]Magnolia Solar, Albany, NY, USA, [2]Rensselaer Polytechnic Institute, Troy, NY, USA, [3]NYSERDA, Albany, NY, USA

10:30 - 12:00 PM **18CD**

Area 2: Polycrystalline Thin Films: CIGS Processing & Devices (Orals)

Chair(s): Ingrid Repins, Chris Ferekides

10:30 976 **Roadmap for Manufacturing Cost-Competitive CIGS Modules**
Vijay Kapur, vincent Kapur, Ashish Bansal, Steve Roth
International Solar Electric Technology Inc. (ISET), Chatsworth, CA, USA

10:45 977 **Why Are Cu-Rich CIS Solar Cells Not Living Up to Their Promises?**
Valérie Depredurand[1], Daisuke Tanaka[1,2], Yasuhiro Aida[2], Nicole Fevre[1], Susanne Siebentritt[1]
[1]University of Luxembourg - LPV, Belval, Luxembourg, [2]TDK Corporation, Ichikawa, Japan

11:00 978 **Rapid Two-Step Selenization Growth of $Cu(In,Ga)Se_2$ Thin Films**
Shogo Ishizuka[1,2], Lorelle M. Mansfield[1], Clay DeHart[1], Marty Scott[1], Bobby To[1], Matthew R. Young[1], Rommel Noufi[1]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan

11:15 979 **Best Student Presentation Award Finalist**
High-Efficiency Ultrathin $Cu(In,Ga)(Se,S)_2$ Solar Cells by Three-Step $H_2Se/Ar/H_2S$ Reaction of Cu-In-Ga Metal Precursor
Kihwan Kim[1], Hyeonwook Park[2], Woo Kyoung Kim[2], Gregory M. Hanket[1], William N. Shafarman[1]
[1]University of Delaware, Newark, DE, USA, [2]Yeungnam University, Gyeongsan, South Korea

11:30 980 **A Comparative Study of the Defect Point Physics and Luminescence of the Kesterites Cu_2ZnSnS_4 and $Cu_2ZnSnSe_4$ and Their Related Chalcopyrites $Cu(In,Ga)S_2$ and $Cu(In,Ga)Se_2$**
Manuel Romero[1], Ingrid Repins[1], Glenn Teeter[1], Miguel Contreras[1], Thomas Unold[2], Jo Klaer[2], Mowafak Al-Jassim[1], Rommel Noufi[1]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]Helmontz Zentrum Berlin fur Materialien und Energie, Berlin, Germany

11:45 981 **Influence of the Ga Content on the Optical and electrical Properties of $CuIn_{1-x}Ga_xSe_2$ Thin-Film Solar Cells**
Zhenhao Zhang[1,2], Wolfram Witte[3], Oliver Kiowski[3], Uli Lemmer[1], Michael Powalla[1,3], Hendrik Hölscher[2]
[1]Light Technology Institute, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, [2]Institute of Microstructure Technology, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, [3]Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), Stuttgart, Germany

10:30 - 12:00 PM **Blrm G**

Area 4: Crystalline Silicon: Metallization (Orals)

Chair(s): Zhigang Rick Li

10:30 982 **Silver Metallization for Crystalline Silicon Cells**
Weiming Zhang
Heraeus Precious Metals North America Conshohocken LLC, Conshohocken, PA, USA

10:45 983 **Formation of Very Low Resistance Contact for Silicon Photovoltaic Cells**
Baomin Xu, Scott Limb, Alexandra Rodkin, Eric Shrader, Sean Garner
Palo Alto Research Center, Palo Alto, CA, USA

11:00 984 **Low Resistance Screen-Printed Ag Contacts to $POCl_3$ Emitters with Low Saturation Current Density for High-Efficiency Si Solar Cells**
Ian B. Cooper[1], Keith Tate[1], Alan F. Carroll[2], Kurt R. Mikeska[3], Ajeet Rohatgi[1]
[1]Georgia Institute of Technology, Atlanta, GA, USA, [2]DuPont Microcircuit Materials, Research Triangle Park, NC, USA, [3]Dupont Central Research & Development, Wilmington, DE, USA

11:15 985 **The Effect of Front-Side Ag Metallization on Underlying n^+-p Junction in Multicrystalline Si Solar Cells**
Chun-Sheng Jiang, Helio R. Moutinho, Mowafak M. Al-Jassim
National Renewable Energy Laboratory, Golden, CO, USA

11:30 986 **19.6% Cast Mono MWT Solar Cells and 268W Modules**
Weiwei Yin, Feng Zhang, Xusheng Wang, Lingjun Zhang
Canadian Solar Inc., Suzhou, China

11:45 987 **Integration of High Sheet Resistance Front Homogeneous Emitter in a Process Flow for PERI-Type Solar Cells with Cu Contacts**
Michel Ngamo[1], Loic Tous[2], Emanuele Cornagliotti[2], Jorg Horzel[2], Tom Janssens[2], Richard Russell[2], Jeff Poortmans[2], Benoit Lombardet[1]
[1]TOTAL Gas & Power, Paris la défense, France, [2]imec vzw, Leuven, Belgium

10:30 - 12:00 PM **17A**

Area 6: Organic Photovoltaics: OPV Modeling and Inorganic Hybrids (Orals)

Chair(s): Darin Laird, Barry Rand

10:30
988
Understanding Energy Level Alignment in PCDTBT:$PC_{70}BM$ Solar Cells
Erin L. Ratcliff[1], Andres Garcia[2], Sarah R. Cowan[2], Jens Meyer[3], K. Xerxes Steirer[1], Sergio A. Paniagua[4], Anthony Giorando[4], Seth Marder[4], Neal R. Armstrong[1], Antoine Kahn[3], David Ginley[2], Dana C. Olson[2]
[1]University of Arizona, Tucson, AZ, USA, [2]National Renewable Energy Laboratory, Golden, CO, USA, [3]Princeton University, Princeton, NJ, USA, [4]Georgia Institute of Technology, Atlanta, GA, USA

11:00
989
Understanding the Origin of Free-Carrier Generation in Organic Photovoltaic Devices
Garry Rumbles[1,2], Obadiah Reid[1], David Coffey[2], Nikos Kopidakis[1]
[1]National Renewable Energy Laboratory, Golden, CO, USA, [2]University of Colorado, Boulder, CO, USA

11:30
990
Plasmonic Au Nanoparticles Integration into All Polymer Layers for Improving the Efficiency of Organic Solar Cells
Wallace C.H. Choy, Charlie C.D. Wang, Dixon D.S. Fung, Wei E.I. Sha, Feng-Xian Xie
Department of Electrical and Electronic Engineering, the University of Hong Kong, Hong Kong, Hong Kong

11:45
991
Optimizing Bulk Heterojunctions of Organic Solar Cells via Multi-Scale Simulation
Fanan Wei[1], Lianqing Liu[2], Zaili Dong[2], Guangyong Li[1]
[1]University of Pittsburgh, Pittsburgh, PA, USA, [2]Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang, China

10:30 - 12:00 PM **16AB**

Area 9: Modules and Systems: Performance Modeling (Orals)

Chair(s): Bruce King, Rhonda Bailey

10:30 992 **Best Student Presentation Award Finalist**
Experimental Characterization of a Thermoelectrical Model of Photovoltaic Modules
Sharif Z. Aljoaba, Aaron M. Cramer, Bruce L. Walcott
Department of Electrical and Computer Engineering, University of Kentucky, Lexington, KY, USA

10:45 993 **Prediction of Energy Effects on Photovoltaic Systems Due to Snowfall Events**
Rob Andrews[1], Joshua M. Pearce[2]
[1]Department of Mechanical and Materials Engineering Queen's University, Kingston, ON, Canada, [2]Department of Materials Science & Engineering and Department of Electrical & Computer Engineering, Michigan Technological University, Houghton, MI, USA

11:00 994 **Beyond the Module Model and into the Array: Mismatch in Series Strings**
Sara MacAlpine, Michael Brandemuehl, Robert Erickson
University of Colorado, Boulder, CO, USA

11:15 995 **Direct Monitoring of Energy Lost Due to Soiling on First Solar Modules in California**
Riley Caron, Bodo Littmann
First Solar, San Francisco, CA, USA

11:30 996 **Soiling Correction Model for Long-Term Energy Prediction in Photovoltaic Modules**
Hassan Qasem, Tom Betts, Ralph Gottschalg
Centre for Renewable Energy Systems Technology (CREST), School of Electronic, Electrical and System Engineering, Loughborough University, Loughborough, United Kingdom

11:45 997 **Influence of Atmospheric Variations on Photovoltaic Performance and Modeling Their Effects for Days with Clear Skies**
Bill Marion
National Renewable Energy Laboratory, Golden, CO, USA

12:00 - 12:30 PM **Blrm D**

Closing Session

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