



8th WORLD CONFERENCE ON PHOTOVOLTAIC ENERGY CONVERSION

26 – 30 SEPTEMBER 2022
MILANO CONVENTION CENTRE · MILAN · ITALY

CONFERENCE PROGRAMME

EU PVSEC | PVSEC | IEEE PVSC
European Photovoltaic Solar Energy Conference and Exhibition |
International PV Science and Engineering Conference |
Photovoltaic Specialists Conference



WCPEC-8 is hosted
by EU PVSEC

CONFERENCE PROGRAMME

Please note, that this Programme may be subject to alteration and the organisers reserve the right to do so without giving prior notice. The current version of the Programme is available at www.wcpec-8.com.

(i) = invited

SUNDAY, 25 SEPTEMBER 2022

PV ACADEMY

Taking place on Sunday, 25 September, the PV Academy is an educational format consisting of tutorials presented leading experts which will give a deep insight into selected PV research & development topic and supports the global PV community with the mission:

- to educate about the fundamentals of different PV technologies
- to facilitate newcomers in the field to understand and contribute to PV research as well as follow talks at PV specialist conferences
- to summarize and contextualize the latest developments in PV research
- to give graduates and educators the opportunity to refresh and update their knowledge

For further info, and to see the detailed programme, please visit www.wcpec-8.com.

IMPORTANT NOTE: Kindly note that registration to the PV Academy is not included in the Conference ticket and a separate registration is required

MONDAY, 26 SEPTEMBER 2022

MONDAY MORNING

CONFERENCE OPENING

Plenary Presentations 3AP.1

08:30- 09:30 Reliable and High Performance PV Modules

Chairpersons:

Werner HERRMANN
TÜV Rheinland, Cologne, Germany

Robert P. KENNY
European Commission JRC, Ispra, Italy

3AP.1.1

Technology Evolution of PV Industry: Learning from Historical and Recent Progress

Yifeng Chen¹, Le Wang¹, Sam Lee¹, Daming Chen¹, Xueling Zhang¹, Pietro P. Altermatt¹, Zhiqiang Feng¹, Pierre Verlinden^{1,2,3}

¹Trina Solar, Changzhou, China; ²AMROCK, QLD, Australia; ³UNSW, NSW, Australia

3AP.1.2

Evaluation of Bifacial Modules and PV Technologies with Combined-Accelerated Stress Testing

Peter Hacke¹, Akash Kumar², Ashwini Pavgi², Sergiu V. Spataru³, Kaushik Roy-Choudhury⁴, Govindasamy Tamizhmani²

¹NREL, Golden, CO, United States; ²Arizona State University, Mesa, AZ, United States; ³DTU Fotonik, Roskilde, Denmark; ⁴DuPont, Wilmington, DE, United States

3AP.1.3

International Photovoltaic Modeling Intercomparison

Marios Theristis¹, Joshua S. Stein¹, Nicholas Riedel-Lyngskær², Leonardo Micheli³, Lelia Marie Deville¹, Mark Campanelli⁴, Rajiv Daxini⁵, Anton Driesse⁶, William B. Hobbs⁷, Heather Hodges⁷, Javier Ramirez Ledesma⁸, Ismael Lokhat⁹, Brendan McCormick¹⁰, Bin Meng¹¹, Bill Miller⁷, Silvana Ayala Pelaez¹², Megan Parker⁷, Jesús Polo¹³, Daniel Powell¹⁴, Miguel Angel del Pozo¹⁵, Matthew Prilliman¹², Steve Ransome¹⁶, Martin Schneider¹⁷, Branislav Schnierer¹⁸, Bowen Tian¹¹, Frederik Werder¹⁹, Robert Williams²⁰, Bruno Wittmer²¹, Julio Yuzo²², Changrui Zhao²³

¹Sandia National Laboratories, Albuquerque, United States; ²Technical University of Denmark, Roskilde, Denmark; ³University of Jaén, Jaén, Spain; ⁴Intelligent Measurement Systems, Bozeman, United States; ⁵University of Nottingham, Nottingham, United Kingdom; ⁶PV Performance Labs, Freiburg, Germany; ⁷Southern Power, Birmingham, United States; ⁸UPM, Madrid, Spain; ⁹Cythelia Energy, La Motte-Servolex, France; ¹⁰Solphi Engineering, Savannah, United States; ¹¹Eindhoven University of Technology, Eindhoven, Netherlands; ¹²NREL, Golden, United States; ¹³CIEMAT, Madrid, Spain; ¹⁴Intersect Power, Oakland, United States; ¹⁵Qualifying Photovoltaics, Madrid, Spain; ¹⁶Steve Ransome Consulting, Kingston upon Thames, United Kingdom; ¹⁷Terabase Energy Inc., Berkeley, United States; ¹⁸Solargis, Bratislava, Slovakia; ¹⁹Valentin Software, Berlin, Germany; ²⁰NEO Virtus Engineering, Littleton, United States; ²¹Pysyst, Satigny, Switzerland; ²²Fotovoltec Solar Engineering, Londrina, Brazil; ²³CSI Solar, Jiangsu, China

09:30- 12:35

Award/Prize Ceremony

Opening Addresses

Moderated Panel Discussion

**Detailed programme will be published soon*

Oral Presentations 2AO.1

13:30- 15:00 Advanced Modelling and Computational Methods

Chairpersons:

Iñigo RAMIRO
NOVA University of Lisbon, Lisbon, *Portugal*

Invited

2AO.1.1

Loss Analysis of Tandem Solar Cells in PV Systems Under Realistic Operating Conditions

Malte Vogt¹, Youri Blom¹, Carlos Mario Ruiz Tobon¹, Miro Zeman¹, Rudi Santbergen¹, Olindo Isabella¹

¹*Delft University of Technology, Delft, Netherlands*

2AO.1.2

RayFlare: A Powerful and Flexible Open-Source Modelling Tool for Solar Cells

Phoebe Pearce¹, Nicholas Ekins-Daukes¹

¹*UNSW, Sydney, Australia*

2AO.1.3

Machine Learning for Accelerated Analyses of Time-resolved Photoluminescence Data Via Bayesian Inference

Calvin Fai¹, Anthony J.C. Ladd¹, Charles Hages¹

¹*University of Florida, Gainesville, United States*

2AO.1.4

Machine Learning-Based Additives Optimization for Single-Crystal Perovskite Synthesis

Noor Titan Putri Hartono^{1,2}, Mansoor Ani Najeeb Nellikkal³, Zhi LI⁴, Emory Chan⁴, Joshua Schrier⁵, Alexander Norquist³, Tonio Buonassisi⁶

¹HZB, Berlin, Germany; ²HZB, Cambridge, United States; ³Haverford College, United States; ⁴Lawrence Berkeley National Laboratory, United States; ⁵Fordham University, United States; ⁶MIT, Cambridge, United States

2AO.1.5

A Machine Learning Strategy for Analysing PERC and TOPCon Solar Cells in Mass-Production

Hannes Wagner-Mohnsen¹, Bernhard Klöter¹, Bernhard Mitchell¹, Daming Chen², Yifeng Chen², Pietro P. Altermatt²

¹WAVELABS, Leipzig, Germany; ²Trina Solar, Changzhou, China

2AO.1.6

Impact of Lateral Effects on large Scale Perovskite/Silicon Tandem Solar Cell Performance

S. Kasimir Reichmuth^{1,2}, Andreas Fell¹, Gerald Siefer¹, Michael Schachtner¹, David Chojniak¹, Oliver Fischer^{1,2}, Michael Rauer¹, Jochen Hohl-Ebinger¹, Martin C. Schubert¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany; ²University of Freiburg, Freiburg im Breisgau, Germany

Oral Presentations 1AO.4

13:30- 15:00 Silicon Materials and Limiting Defects

Chairpersons:

Deren YANG (i)
Zhejiang University, Hangzhou, China

Nathan STODDARD (i)
Leading Edge Crystal Technologies, Wilmington, United States

1AO.4.1

Progress in the Development of Upgraded Metallurgical Silicon Solar Cells for Industrial Production

Carlos del Cañizo¹, David Fuertes Marrón¹, Nerea Dasilva-Villanueva¹, Manuel Funes¹, Juan José Torres¹, Bo-Kyung Hong¹, Bülent Arikan², Hasan Hüseyin Canar², Rasit Turan^{2,3}, Hasan Asav², Ahmet Emin Keçeci², Sümeyye Koçak Bütüner², Guillermo Sánchez Plaza⁴, Laura Méndez⁵, Eduardo Forniés⁵

¹UPM, Madrid, Spain; ²GÜNAM, Turkey; ³METU, Turkey; ⁴Valencia Polytechnic University, Valencia, Spain; ⁵Aurinka PV, Rivas-Vaciamadrid, Spain

- 1AO.4.2** **Epitaxially Grown p-Type Silicon Wafers Ready for Cell Efficiencies Exceeding 25 %**
 Clara Rittmann¹, Jonas Dalke¹, Bernd Steinhäuser¹, Armin Richter¹, Marion Drießen¹, Florian Schindler¹, Charlotte Weiss¹, Martin C. Schubert¹, Stefan Janz¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany
- 1AO.4.3** **Design of a Growth Process of High-Quality Quasi-Monocrystalline Silicon Ingot Integrating Experimental, Theoretical, Computational, and Data Sciences**
 Noritaka Usami¹, Xin Liu¹, Yusuke Fukuda¹, Hiroyuki Tanaka¹, Kentaro Kutsukake², Takuto Kojima³
¹Nagoya University, Nagoya, Japan; ²RIKEN, Tokyo, Japan
- 1AO.4.4** **High Lifetime Ga Doped CZ-Si for Carrier Selective Junction Solar Cells**
 Jörg Horzel¹, Sebastian Mack¹, Sattar Bashardoust¹, Dirk Wagenmann¹, Jochen Rentsch¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany
- 1AO.4.5** **Investigating the Impurity Gettering Effect in Polycrystalline-Silicon Based Passivating Contacts**
 Zhongshu Yang¹, Jan Krügener², Frank Feldmann³, J.-I. Polzin³, Bernd Steinhäuser³, Tien Le¹, Daniel Macdonald¹, Anyao Liu¹
¹ANU, Canberra, Australia; ²Leibniz University of Hannover, Germany; ³Fraunhofer ISE, Germany
- 1AO.4.6** **Study on the Dissociation of Gallium-Hydrogen Pairs in Crystalline Silicon During Illuminated Annealing**
 Jochen Simon¹, Axel Herguth¹, Fabian Geml¹, Giso Hahn¹
¹University of Konstanz, Konstanz, Germany

Oral Presentations 4AO.7

13:30- 15:00 Vehicle and Road Integrated Photovoltaics

Chairpersons:

Bonna NEWMAN

TNO Energy Transition, Petten, *The Netherlands*

Martin HEINRICH (i)

Fraunhofer ISE, Freiburg, *Germany*

4AO.7.1

Analysis for Potential of High-Efficiency and Low-cost Vehicle Integrated Photovoltaics

Masafumi Yamaguchi¹, Taizo Masuda², Kenichi Okumura³, Akinori Satou³, Takashi Nakado⁴, Kazumi Yamada⁴, Tsutomu Tanimoto⁵, Yusuke Zushi⁵, Kenji Araki⁶, Yasuyuki Ota⁶, Kensuke Nishioka⁶, Kyotaro Nakamura⁷, Ryo Ozaki⁷, Nobuaki Kojima⁸, Yoshio Ohshita⁸

¹Toyota Technological Institute, Nagoya, Japan; ²TotalEnergies, Susono, Japan; ³Toyota, Susono, Japan; ⁴Toyota, Toyota, Japan; ⁵Nissan Motor, Yokosuka, Japan; ⁶University of Miyazaki, Miyazaki, Japan

4AO.7.2

VIPV Irradiation Modelling and Verification with Measured Travel Data

Evgenii Sovetkin¹, Neel Patel¹, Andreas Gerber¹, Bart E. Pieters¹

¹Forschungszentrum Jülich, Jülich, *Germany*

4AO.7.3

Experimental Measurement and Modellint of Solar Irradiation on a PV-powered Urban Bus

Miguel Centeno Brito¹, Teresa Santos², Michał Jan Gęca³, Mirosław Wendeker³

¹University of Lisbon, Lisboa, Portugal; ²FCSH, Lisboa, Portugal; ³Lublin University of Technology, Lublin, Poland

4AO.7.4

PV Roofing for High Ranking Road Networks: Technical Feasibility and Yield Estimation

Rita Ebner¹, Christoph Mayr¹, Marcus Rennhofer¹, Karl A. Berger¹, Martin Heinrich², Felix Basler², Andreas J. Beinert², Jonas D. Huyeng², Manfred Haider³, Dominik Prammer³, Alois Vorwagner³, Markus Fehring⁴, Tobias Beck⁵

¹AIT, Vienna, Austria; ²Fraunhofer ISE, Germany; ³AIT, Wien, Austria; ⁴Forster Industrietechnik, Waidhofen an der Ybbs, Austria

4AO.7.5

High-Voltage Vehicle Integrated Photovoltaics System Concept and Demonstrator Truck

Christoph Kutter¹, Jörg Bornwasser¹, Stefan Reichert¹, Luis Eduardo Alanis¹,

¹Fraunhofer ISE, Germany

4AO.7.6

Reliability Assessment and Development of Ultra-Lightweight PV Modules Towards Vehicle-Integrated Photovoltaics

Bin Luo^{1;2}, Jonathan Govaerts², Rik Van Dyck^{1;2}, Marta Casasola Paesa^{2;4}, Tom Borgers², Arvid van der Heide², Fabiana Lisco⁵, Michaël Daenen⁴, Aart Willem Van Vuure¹, Jozef (Jef) Poortmans^{1;2;4}

¹KU Leuven, Leuven, Belgium; ²imec, Genk, Belgium; ³Hasselt University, Hasselt, Belgium; ⁴EPFL, Neuchâtel, Switzerland

Visual Presentations 2AV.1

13:30- 15:00 Perovskite Photovoltaics

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 2AO.2

15:15- 16:45 Advanced Characterization

Chairpersons:

Phoebe PEARCE
UNSW, Sydney, Australia

Claude LÉVY-CLÉMENT (i)
CNRS, Paris, France

2AO.2.1

Increasing the Scope and Precision of the Steady-State Photocurrent Grating

Leonardo Kopprio¹, Javier Schmidt², Christophe Longeaud³

¹IPVF, Palaiseau, France; ²IFIS Litoral, Santa Fe, Argentina; ³GeePs, Gif-sur-Yvette, France

2AO.2.2

Contactless Inline IV-Measurement of Solar Cells Using an Empirical Model

Philipp Kunze¹, Johannes Greulich¹, Wiebke Wirtz¹, Hannes Höffler¹, Nico Wöhrle¹, Stefan Rein¹, Stefan W. Glunz¹, Matthias Demant¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany

2AO.2.3

Spatially Resolved Transient and Spectral Analysis of Perovskites or III-V Devices

Marie Legrand¹, Maxime Giteau², Celia Aider¹, Jean-Francois Guillemoles³, Daniel Ory¹

¹EDF R&D, Palaiseau, France; ²C2N, France; ³CNRS, France

2AO.2.4

Resolution of Band Diagram on Perovskite Solar Cells by X-Ray Photoemission Spectroscopy considering X-Ray Photovoltage and Ion Migration

Pilar Lopez-Varo¹, Jean-Baptiste Puel^{1,2}, Davide Regaldo^{1,3,4}, Philip Schulz^{1,5}

¹IPVF, Palaiseau, France; ²EDF R&D, Palaiseau, France; ³IPVF, Gif-sur-Yvette, France; ⁴IPVF, Paris, France; ⁵CNRS, Palaiseau, France

2AO.2.5

Imaging Electrical Properties of Perovskite Solar Cells by Illumination Intensity and Temperature Dependent Photoluminescence

Anh Dinh Bui¹, Khoa Dang Nhat Nguyen¹, Daniel Macdonald¹, Hieu Nguyen¹

¹ANU, Australia

2AO.2.6

Investigating Metastability Behaviour of Perovskites Solar Cells with Voltage Dependent Photoluminescence Imaging

George Koutsourakis¹, Simone Meroni², Carys Worsley², Dimitrios Raptis², James Blakesley¹, Trystan Watson², Fernando Castro¹

¹National Physical Laboratory, United Kingdom; ²Swansea University, Swansea, United Kingdom

Oral Presentations 1AO.5

15:15- 16:45 Passivating Contacts - Materials

Chairpersons:

Giso HAHN

University of Konstanz, Konstanz, *Germany*

Sébastien DUBOIS

CEA INES, Le Bourget-du-Lac, *France*

1AO.5.1

Pinhole-Enabled p-Type poly-Si/SiNy/SiOx Passivating Contact Fabrication by Nano-Galvanic Corrosion Process

Caroline Lima Salles de Souza^{1,2}, Harvey Guthrey¹, William Nemeth¹, Sumit Agarwal^{1,2}, Paul Stradins¹

¹NREL, *United States*; ²Colorado School of Mines, *United States*

1AO.5.2

In Situ Monitoring of High-temperature Passivating Contact Fabrication via X-ray Scattering

Audrey Morisset¹, Theodosios Famprikis², Franz-Josef Haug¹, Andrea Ingenito³, Christophe Ballif¹, Lars Bannenberg²

¹EPFL, *Neuchatel, Switzerland*; ²Delft University of Technology, *Delft, Netherlands*; ³CSEM, *Neuchâtel, Switzerland*

1AO.5.3

ALD Al₂O₃/SiO_x Multilayers for Silicon Surface Passivation: Influence of Voltage Stress and Plasma Treatments

Armin Richter¹, Hemangi Patel^{1,2}, Christian Reichel¹, Paul Masuch¹, Jan Benick¹, Stefan W. Glunz^{1,5}

¹Fraunhofer ISE, *Freiburg, Germany*; ²DLR- German Aerospace Center, *Cologne, Germany*; ³University of Freiburg, *Freiburg, Germany*

1AO.5.4

Stress-Induced Depassivation of Poly-Si/SiNx Layer Stacks

Jan Hoß¹, Jan Lossen¹, Jonathan Linke¹, Radovan Kopecek¹, Florian Buchholz¹

¹ISC Konstanz, *Konstanz, Germany*

1AO.5.5

The Impact of Tunneling Oxide Thickness, Boron Emitter and Polysilicon Doping on the Long-Term Stability of TOPCon Structures

Chukwuka Madumelu¹, Robert Underwood¹, Jie Bao², Jia Chen², Zheren Du², Genghua Ji², Ran Chen¹, Fiacre Emile Rougieux¹, Bram Hoex¹, Brett Hallam¹, Matthew Wright³

¹UNSW, *Australia*; ²Jolywood solar, *China*; ³University of Oxford, *United Kingdom*

1AO.5.6

Surface Polarisation of n+ poly Si / SiO₂ Passivation Layers: A New Approach to Study Surface Related Degradation in TOPCon

Donghao Liu¹, Sebastian Bonilla¹, Matthew Wright¹, Peter Wilshaw¹, Phillip Hamer²

¹University of Oxford, Oxford, United Kingdom; ²UNSW, Sydney, Australia

Oral Presentations 4AO.8

15:15- 16:45 Agrivoltaics

Chairpersons:

Robby PEIBST
ISFH, Emmerthal, Germany

Carlos David RODRÍGUEZ-GALLEGOS (i)
NUS, Singapore, Singapore

4AO.8.1

Multiple-Objective Optimisation of Nature-Inclusive Solar Parks and Agrivoltaics Systems

Bas Van Aken¹, Eduardo Barros², Bernardo Maestrini³, Frank de Ruijter³, Ilkay Cesar¹

¹TNO, Petten, Netherlands; ²TNO, Utrecht, Netherlands; ³Wageningen University & Research, Wageningen, Netherlands

4AO.8.2

Biodiversity and Ecosystems in Swedish Solar Farms: Current Practice and a Planning Framework for Net Gain

Michiel van Noord¹, Ida Pettersson², Karin Morell³, Tora Råberg³, Ursula Zinko⁴, Agnes Sandström⁵

¹RISE, Stockholm, Sweden; ²Ecogain, Malmö, Sweden; ³RISE, Lund, Sweden; ⁴Ecogain, Stockholm, Sweden; ⁵Ecogain, Uppsala, Sweden

4AO.8.3

Novel Measurement Concept for AgriPVplus Systems - A Triple Use Approach

Hugo Sánchez-Ortiz¹, Sebastian Dittmann¹, Santiago Tosello¹, Carlos Meza¹, Sandra Dullau¹, Maren Helen Meyer¹, Pascal Scholz¹, Sabine Tischew¹, Ralph Gottschalg¹

¹Anhalt University of Applied Sciences, Köthen, Germany

4AO.8.4

Rainwater Management in Agrivoltaic Systems - Research & Development Potential

Johanna-Viktoria Rößner¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany

4AO.8.5

First Results from Insolagrín, a Novel Solution for Dynamic Agrivoltaics

Gaël Nardin¹, Mathilde Duchemin¹, Laetitia Anglade¹, Mathieu Ackermann¹, Delphine Petri², Jacques Levrat², Dominika Chudy², Matthieu Despeisse², Christophe Ballif², Matthias Baumann³, Bastien Christ³, André Ançay³, Christoph Carlen³

¹Insolight, Switzerland; ²CSEM, Switzerland; ³Agroscope, Switzerland

4AO.8.6

Key Parameters for the Simulation of Agrivoltaics in Greenhouses with Bifacial PV Modules

Jesus Robledo Bueno¹, Babacar Sarr¹, Ibrahim El Boujdaini¹, Roxane Bruhwyler², Jonathan Leloux¹, Christian A. Gueymard³, Frédéric Lebeau²

¹LuciSun, Villers-la-Ville, Belgium; ²University of Liege, Gembloux, Belgium; ³Solar Consulting Services, Colebrook, United States

Visual Presentations 2AV.2

15:15- 16:45 CIGS, CdTe, Organic, DSC and Novel Concept Solar Cells and Materials

Detailed information on this session is presented in the section entitled ‘Visual Presentations’.

Oral Presentations 2AO.3

17:00- 18:30 Novel Materials for Photovoltaic Devices

Chairpersons:

Jozef (Jef) POORTMANS
imec, Leuven, *Belgium*

Jean-Paul KLEIDER
CNRS, Gif-sur-Yvette, *France*

2AO.3.1 **Towards a Graphene Transparent Conducting Electrode Alternative for Tandem Solar Cells**

John O'sullivan¹, Matthew Wright¹, Peter Wilshaw¹, Sebastian Bonilla¹
¹*University of Oxford, Oxford, United Kingdom*

2AO.3.2 **Innovative Processing Method of Q1-D Sb₂Se₃ Solar Cell Absorbers Under Very High Pressures**

Ivan Caño Prades¹, Maykel Jimenez Guerra¹, Sergio Giraldo¹, Zacharie Jehl¹, Yudenia Sánchez², Lorenzo Calvo-Barrio^{3,4}, Xavier Alcobé³, Joachim Puigdollers González¹, Marcel Placidi¹, Edgardo Saucedo¹
¹*UPC, Barcelona, Spain*; ²*IREC, Barcelona, Spain*; ³*University of Barcelona, Barcelona, Spain*

2AO.3.3 **The first Operation of P-Ion-Implanted n-BaSi₂/p-Si Solar Cells**

Sho Aonuki¹, Kaoru Toko¹, Takashi Suemasu¹
¹*University of Tsukuba, Tsukuba-city, Ibaraki-prefecture, Japan*

2AO.3.4 **Synthesis and Characterization of the Ternary Nitride Semiconductor Zn₂VN₃: Combinatorial Screening and Epitaxial Stabilization**

Siarhei Zhuk¹, Andrey Kistanov², Simon Boehme^{1,3}, Noémie Ott¹, Fabio La Mattina¹, Michael Stiefel¹, Aliaksandr Khinevich⁴, Raman Palikarpau^{5,6}, Maksym Kovalenko^{1,3}, Sebastian Siol¹
¹*EMPA, Dübendorf, Switzerland*; ²*University of Oulu, Oulu, Finland*; ³*ETH Zurich, Zürich, Switzerland*; ⁴*BSUIR, Minsk, Belarus*; ⁵*Nanyang Technological University, Singapore*; ⁶*Shopee, Singapore*

2AO.3.5 **AgBi₄ Rudorffite for Photovoltaic Application**

Vasanth Babu^{1,2}, Govindaraj Rajamanickam², Ramasamy Perumalsamy²
¹*SSN Research Centre, Chennai, India*

2AO.3.6

Harvesting Solar Energy below Si Bandgap Using Metal-Silicon Junction through Hot Carrier Effect

Ching-Fuh Lin¹, Jia-Ci Jhou¹, Chung-Han Chang¹, Lin Hsin-Ting²

¹NTU, Taipei, Taiwan

Oral Presentations 1AO.6

17:00- 18:30 Passivating Contacts - Materials and Devices

Chairpersons:

Stefan W. GLUNZ

Fraunhofer ISE, Freiburg, *Germany*

Barbara TERHEIDEN

University of Konstanz, Konstanz, *Germany*

1AO.6.1

Sputtered Poly-Si and its Implementation in Passivating Contacts at the Rear of Industrial N-PERT Solar Cells

Christophe Allebé¹, Antoine Descoeudres¹, Juan José Diaz Leon¹, Andrea Ingenito¹, Simon Hübner², Torsten Dippell², Bertrand Paviet-Salomon¹, Christophe Ballif¹

¹CSEM, Neuchatel, Switzerland; ²SINGULUS TECHNOLOGIES, Kahl am Main, *Germany*

1AO.6.2

Analysis of Losses in POLO-IBC Cells in the Constraints of Module Integration

Christina Hollemann¹, Felix Haase¹, Nadine Wehmeier¹, Byungsul Min¹, Karsten Bothe¹, Jan Krügener², Rolf Brendel^{1,3,4}, Robby Peibst^{1,2}

¹ISFH, Emmerthal, *Germany*; ²Leibniz University of Hannover, Hannover, *Germany*

1AO.6.3

Status and Perspective of Industrial TOPCon Solar Cell Development at Fraunhofer ISE

Sebastian Mack¹, Bishal Kafle¹, Christopher Teßmann¹, Katrin Krieg¹, Sattar Bashardoust¹, Elmar Lohmüller¹, Udo Belledin¹, Tobias Fellmeth¹, Bernd Steinhäuser¹, Sven Kluska¹, Andreas Wolf¹

¹Fraunhofer ISE, Freiburg im Breisgau, *Germany*

1AO.6.4

Soft Deposition of Indium Tin Oxide on Ultra-Thin Poly-Silicon Passivating Contacts

Mike Ah Sen^{1,2}, Fatemeh S. Minaye Hashemi¹, Jimmy Melskens¹, Astrid Gutjahr¹, Jons Bolding¹, Arthur Weeber^{1,2}, Agnes Mewe¹

¹TNO, Netherlands; ²Delft University of Technology, Delft, Netherlands

1AO.6.5

Towards Cost-Competitive High-Efficiency POLO IBC Solar Cells with Minimal Conversion Invest for Existing PERC+ Production Lines

Thorsten Dullweber¹, Verena Mertens¹, Larissa Mettner¹, Ulrike Baumann¹, Jonathan Langlois¹, Maximilian Stöhr¹, Felix Haase¹, Rolf Brendel¹, Joris Libal², Aaron Vogt³, Norbert Ambrosius³, Thomas Pernau⁴, Helge Haverkamp⁴

¹ISFH, Emmerthal, Germany; ²ISC Konstanz, Konstanz, Germany; ³LPKF Laser & Electronics, Garbsen, Germany; ⁴centrotherm international, Blaubeuren, Germany

1AO.6.6

Wet-Chemical Ozone-Based Silicon Oxide Layers and Electron-Beam Evaporated Silicon Layers for Passivating Contacts

Nathan Nicholson¹, Johannes Frisch², Maurice Nuys³, Uwe Breuer³, Mohammed Jaber³, Jannik Kleesiek⁵, Daniel Amkreutz⁵, Lars Korte¹, Steve Albrecht¹, Bernd Rech⁶

¹HZB, Berlin, Germany; ²Forschungszentrum Jülich, Jülich, Germany

Oral Presentations 4AO.9

17:00- 18:30 Floating PV

Chairpersons:

Thomas REINDL

National University of Singapore, Singapore, Singapore

Maarten DÖRENKÄMPER

TNO, Eindhoven, The Netherlands

4AO.9.1

Floating Photovoltaics in Europe: Techno-Economic Analysis and Perspectives

Leonardo Micheli¹, Diego L. Talavera¹, Florencia Almonacid-Cruz¹, Eduardo F. Fernandez¹

¹University of Jaén, Jaén, Spain

- 4AO.9.2** **A Critical Review of Floating PV's Potential Gain, and Physics-Based Modelling to Find its Root Cause**
 Gofran Chowdhury^{1;2;3}, Mohamed Haggag^{1;2;3}, Jozef (Jef) Poortmans^{1;2;3;5}
¹KU Leuven, Leuven, Belgium; ²imec, Leuven, Belgium; ³EnergyVille, Genk, Belgium; ⁴Hasselt University, Diepenbeek, Belgium
- 4AO.9.3** **Impact of Water Waves on the Output Power of Floating PV Systems on Water Bodies**
 Manish Kumar¹, Vilde Stueland Nysted¹, Gaute Otnes¹, Torunn Kjeldstad¹, Nathan Roosloot¹, Josefine Helene Selj¹
¹Institute for Energy Technology, Kjeller, Norway
- 4AO.9.4** **Application of DNV-RP-0584 Recommended Practice for Development, Design and Operation of Floating Solar Photovoltaic Systems**
 Michele Tagliapietra¹
¹DNV, Imola, Italy
- 4AO.9.5** **The Impact of Floating Solar Power Plants on the Water Quality of Quarry Lakes**
 Konstantin Ilgen¹, Jens Lange², Dirk Schindler², Stefan Wieland¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany; ²University of Freiburg, Freiburg im Breisgau, Germany
- 4AO.9.6** **Techno-Economic Study – Our Way to the Bifacial FPV System “Gömbhal”**
 Markus Balz¹, Verena Göcke¹, Fabian Gross¹, Vanessa Lippert¹
¹sbp sonne, Germany

Visual Presentations 2AV.3

17:00- 18:30 Tandem Solar Cells / III-V and Related Compound Semiconductors

Poster Area

Detailed information on this session is presented in the section entitled ‘Visual Presentations’.

TUESDAY, 27 September 2022

Oral Presentations 1BO.1

08:30- 10:00 Surface Passivation and Stability

Chairpersons:

Jochen RENTSCH
Fraunhofer ISE, Freiburg, *Germany*

Jun ZHAO (*i*)
CSEM, Bern, *Switzerland*

1BO.1.1 Outstanding Surface Passivation and Low Contact Resistivity on c-Si Using Alumina-Titania Electron-Selective Contact

Mohamed Ismael¹, Daniel Macdonald¹, Lachlan Black¹

¹ANU, Acton, *Australia*

1BO.1.2 Interface Treatment for High-Efficient Dopant-Free MoO_x Silicon Heterojunction Solar Cells

Liqi Cao¹, Luana Mazzarella¹, Paul A. Procel Moya¹, Yifeng Zhao¹, Jin Yan¹, Can Han¹, Guangtao Yang¹, Zhirong Yao¹, Miro Zeman¹, Olindo Isabella¹

¹Delft University of Technology, Delft, *Netherlands*

1BO.1.3 Towards High Efficiency Inversion Layer Cells Based on Ion-Charged Dielectrics

Mingzhe Yu¹, Matthew Wright¹, Jingyan Chen¹, Yifu Shi¹, Brett Hallam², En-Te Hwu³, John Murphy⁴, Nicholas Grant⁴, Peter Wilshaw¹, Sebastian Bonilla¹

¹University of Oxford, Oxford, *United Kingdom*; ²UNSW, Sydney, *Australia*;
³Technical University of Denmark, Lyngby, *Denmark*; ⁴University of Warwick, *United Kingdom*

1BO.1.4 Surface Passivation with a-Si: Determining the Role of Interface Defects and Field-Effect Using Modeling of Lifetime Curves

Fiacre Rougieux¹, Chandany Sen¹, Malcolm Abbott¹

¹UNSW, Sydney, *Australia*

1BO.1.5

High Intensity Illuminated Annealing of Silicon Heterojunction Solar Cells: a Stability Study

Matthew Wright¹, Chukwuka Madumelu², Anastasia H. Soeriyadi², Bruno Vicari-Stefani³, Dmitrii Andronikov⁴, Sebastian Bonilla¹, Brett Hallam²

¹University of Oxford, Oxford, United Kingdom; ²UNSW, Kensington, Australia; ³CSIRO Energy, Newcastle, Australia; ⁴Hevel Solar, St. Petersburg, Russian Federation

1BO.1.6

Improve Thermal Stability of Metal Oxide Passivated Contacts for Si Solar Cells

Jingnan Tong¹, Tien Le¹, Wensheng Liang¹, MD. Anower Hossain², Keith McIntosh³, Parvathala Narangari¹, Stephane Armand¹, Teng Kho¹, Kean Khoo², Yahya Zakaria⁴, Amir A. Abdallah⁴, Sachin Surve¹, Marco Ernst¹, Bram Hoex², Kean Chern Fong¹

¹ANU, Australia; ²UNSW, Australia; ³PVlighthouse, Australia; ⁴HBKU, Qatar

Oral Presentations 2BO.6

08:30- 10:00 Novel Photovoltaic Solar Cell Architectures

Chairpersons:

Antonio MARTÍ VEGA
UPM, Madrid, Spain

Francesco ROCA
ENEA, Portici, Italy

2BO.6.1

Fabrication of Silicon Heterojunction Solar Cells with Light Trapping Structures Specialized for Near-Infrared Light by Nanoimprinting

Yuto Kimata¹, Kazuhiro Gotoh¹, Satoru Miyamoto¹, Shinya Kato¹, Yasuyoshi Kurokawa¹, Noritaka Usami¹

¹Nagoya University, Japan

2BO.6.2

Scalable Antireflective Huygens's Metasurface with Correlated Disorder Made from High-Index Disks

Peter Piechulla¹, Evgeniia Slivina², Derk L. Bätzner³, Ivan Fernandez-Corbaton⁴, Prerak Dhawan², Ralf B. Wehrspohn¹, Alexander N. Sprafke¹, Carsten Rockstuhl²

¹Martin Luther University, Halle (Saale), Germany; ²Karlsruhe Institute of Technology - KIT, Karlsruhe, Germany; ³Meyer Burger Research, Haurer, Switzerland; ⁴Karlsruhe Institute of Technology - KIT, Eggenstein-Leopoldshafen, Germany

2BO.6.3**State of the Art Voc and Record Quasi-Fermi Level Splitting in GaAs/InGaP Nanowire Solar Cells directly Grown on Si**

Capucine Tong^{1,2}, Amaury Delamarre², Romaric De Lépinau^{1,2}, Andrea Scaccabarozzi², Fabrice Oehler², Jean-Christophe Harmand², Stephane Collin^{1,2}, Andrea Cattoni^{1,3}

¹IPVF, Palaiseau, France; ²C2N, Palaiseau, France

2BO.6.4**Oxyde Ferroelectric Perovskite Nanoparticles Dispersed in Biopolymer-Matrix for High-Performance Solar Cell (Ferro-OPV) for Indoor Applications**

Rémi Ndioukane¹, Fanta Balde¹, Diouma Kobor¹, Laurence Motte²

¹UASZ, Ziguinchor, Senegal; ²LVTS, France

2BO.6.5**Advanced Sub-Micron Pyramidal Texturing for Silicon Bottom Cell for Perovskite-Silicon Tandem Application**

Devika Rajagopal^{1,2,3,4}, Hariharsudan Sivaramakrishnan Radhakrishnan^{1,2,4}, Mateusz Gocyla⁵, René-Chris Brachvogel⁶, Ahmed Eljaouhari⁶, Jozef (Jef) Poortmans^{1,2,3,4}

¹imec, Genk, Belgium; ²KU Leuven, Leuven, Belgium; ³Hasselt University, Genk, Belgium; ⁴imec, Leuven, Belgium; ⁵RENA Technologies, Germany

2BO.6.6**Generation of Electrical Power Through Radiative Emission from a Thermoradiative Diode**

Michael Nielsen¹, Andreas Pusch¹, Muhammad H. Sazzad¹, Phoebe Pearce^{1,2}, Peter Reece³, Nicholas Ekins-Daukes¹

¹UNSW, Sydney, Australia; ²University of Cambridge, Cambridge, United Kingdom

Oral Presentations 3BO.11

08:30- 10:00 PV Characterization and Imaging Techniques

Chairpersons:

Yoshihiro HISHIKAWA (*i*)
AIST, Tsukuba, Japan

Invited

3BO.11.1

Investigation on Linearity of Spectroradiometers

Diego Pavanello¹, Harald Müllejans¹

¹European Commission JRC, Ispra, Italy

3BO.11.2

Primary Calibration of Solar Modules with Direct Sunlight

Stefan Riechelmann¹, Dirk Friedrich¹, Michael Müller¹, Frank Schmaljohann¹,
Stefan Winter¹

¹PTB, Braunschweig, Germany

3BO.11.3

Advanced UV-Fluorescence Image Analysis for Early Detection of PV-Power Degradation

Lukas Neumaier¹, Gabriele C. Eder², Yuliya Voronko², Karl A. Berger³, Gusztáv Újvári³, Karl Knöbl⁴

¹SAL Silicon Austria Labs, Villach, Austria; ²OFI, Wien, Austria; ³AIT, Wien, Austria; ⁴UAS Technikum Wien, Wien, Austria

3BO.11.4

Photovoltaic Module Characterization Using Light-Induced Electroluminescence of Solar Modules with Parallel Cell String Interconnection

Marc Köntges¹, Michael Siebert², Stefan Bordihn³, Jan, Kolja Wagner⁴, Carsten Schinke⁴

¹ISFH, Emmerthal, Germany; ²Insolight, Hamelin, Germany; ³ISFH, Hamelin, Germany; ⁴Leibniz University of Hannover, Hannover, Germany

3BO.11.5

Polymer-Determined Degradation-status of PV-Modules in the Field

Claudia Buerhop-Lutz¹, Tobias Pickel¹, Oleksandr Stroyuk¹, Jens Hauch¹, Marius Peters¹

¹HI ERN, Erlangen, Germany

3BO.11.6

Machine Aided Estimation of Solar Cell Crack Caused Power Loss from Electroluminescence Images

Rodrigo del Prado Santamaría¹, Thøger Kari Hass¹, Gisele Alves Dos Reis Benatto¹, Peter Poulsen¹, Sergiu V. Spataru¹

¹DTU, Roskilde, Denmark

Oral Presentations 4BO.16

08:30- 10:00 Solar Resource Modelling and Monitoring

Chairpersons:

Manajit SENGUPTA
NREL, *United States*

Ana Maria GRACIA AMILLO
CENER, Sarriguren, *Spain*

4BO.16.1

Novel Spectral Irradiance Simulation Approach for PV Systems in Geometrically Complex Environments

Andres Calcabrini¹, David Gribnau¹, Ruben Cardose¹, Patrizio Manganiello¹, Miro Zeman¹, Olindo Isabella¹

¹Delft University of Technology, Delft, Netherlands

4BO.16.2

Clustering of Sun Positions for Fast Calculation of Time Resolved Insolation Using Ray Tracing

Dennis Bredemeier^{1;2}, Carsten Schinke^{1;2}, Timo Gewohn^{1;2}, Raphael Niepelt^{1;2}, Rolf Brendel^{1;2}

¹Leibniz University of Hannover, Hanover, Germany; ²ISFH, Emmerthal, Germany

4BO.16.3

ICAROS#2: Large-Scale Solar Irradiance Measurements with a Flying Monitoring Platform on a Quadcopter and its Data Evaluation

Mike Zehner¹, Andreas Boschert¹, Fabian Pauls¹, Maik Jäkel¹, Martin Heigl¹, Josef Schreder², Gerd Becker³, Fabian Flade³

¹TH Rosenheim, Rosenheim, Germany; ²CMS Ing. Dr. Schreder, Kirchbichl, Austria; ³SeV Bavaria, Munich, Germany

4BO.16.4

Effectiveness of Short Ground-Based Measurement Campaigns of Variable Duration for the Characterization of Local Surface Albedo

Vicente Lara Fanego¹, Christian A. Gueymard², Tomas Cebecauer¹, Marcel Suri¹

¹Solargis, Slovakia; ²Solar Consulting Services, United States

4BO.16.5

Optimising Effective Albedo Data for Bifacial PV Systems

James Blakesley¹, George Koutsourakis¹, Jenna Holder², Fuaad Mukadam², Daniel Ruiz²

¹National Physical Laboratory, United Kingdom; ²RINA Tech UK, Brighton, United Kingdom

4BO.16.6

Simulation of the Irradiance and Yield Calculation of Bifacial PV Systems in the USA and Germany by Combining Ray Tracing and View Factor Model

Eva-Maria Grommes¹, Ulf Blieske¹, Sebastian Nows¹, Frederik Klag¹, Felix Schemann¹

¹Cologne University of Applied Sciences, Germany

Visual Presentations 4BV.1

08:30- 10:00 PV Integrated in the Built Environment Demonstration and Performances of Different Technologies / Infrastructure-integrated PV (VIPV, Agri-PV, Floating PV)

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 1BO.2

10:30- 12:00 Heterojunction and Tandem Device Architectures

Chairpersons:

Kaining DING
Forschungszentrum Jülich GmbH, Jülich, Germany

Laurie-Lou SENAUD
CSEM, Neuchâtel, Switzerland

1BO.2.1 **Simplified Cell Cutting, Efficient Edge Passivation, Copper Metallization: Tackling the last Hurdles for Optimized SHJ Integration in Shingle Module Configuration**

Samuel Harrison¹, Vincent Barth¹, Carolyn Carrière¹, Mickael Albaric¹, Benoit Martel¹, Marco Gialazzo², Enrico Sovrnigo², Nicola Frasson²

¹CEA, Le Bourget Du Lac, France; ²Applied Materials, Olmi Di S.Biagio Di Callalta, Italy

1BO.2.2 **Short-Circuit Current Density of 40.19 mA/cm² for Silicon Heterojunction Solar Cells with Phosphorus Catalytic Doping**

Gilbert Mains¹, Weiyuan Duan¹, Andreas Lambert¹, Karsten Bittkau¹, Uwe Breuer¹, Uwe Rau¹, Kaining Ding¹

¹Forschungszentrum Jülich, Jülich, Germany

1BO.2.3 **Closing the Gap Between n & p-Type Silicon Heterojunction Solar Cells: 24 % Efficiency on Lightly Doped GA Wafers**

Adrien Danel¹, Nicolas Chaugier¹, Jordi Veirman¹, Renaud Varache¹, Mickael Albaric¹, Etienne Pihan¹

¹INES, Le Bourget-du-Lac, France

1BO.2.4 **21% Efficient SHJ Using Compensated and Intentionally Contaminated p-Type Wafer with Defect Engineering Pre-Fabrication Process**

Anastasia H. Soeriyadi¹, Matthew Wright², Bruno Vicari-Stefani³, Shude Zhang⁴, Ilya Nyapshaev⁵, Sergey Abolmasov⁵, Dmitrii Andronikov⁵, Brett Hallam¹

¹UNSW, Sydney, Australia; ²University of Oxford, Oxford, United Kingdom; ³CSIRO Energy, Mayfield West, Australia; ⁴Suzhou Talesun Solar Technologies, Suzhou, China; ⁵R&D Center TFTE, Russian Federation

1BO.2.5

Effects of (i)a-Si:H Deposition Temperature on High-Efficiency Silicon Heterojunction Solar Cells for High-Efficiency Four-Terminal Tandem Solar Cells

Yifeng Zhao¹, Paul A. Procel Moya¹, Luana Mazzearella¹, Can Han¹, Guangtao Yang¹, Liqi Cao¹, Zhirong Yao¹, Dong Zhang^{2,3}, Valerio Zardetto², Mehrdad Najafi², Adriana Creatore⁴, René Janssen³, Sjoerd Veenstra², Gianluca Coletti², Arthur W. Weeber^{1,2}, Miro Zeman¹, Olindo Isabella¹

¹Delft University of Technology, Delft, Netherlands; ²TNO, Eindhoven, Netherlands; ³Eindhoven University of Technology, Eindhoven, Netherlands

1BO.2.6

All Si Tandem Solar Cells by Low Temperature PECVD Epitaxy

Alizadeh Maryam¹, Antonio de Jesus Olivares-Vargas², Pere Roca I Cabarrocas³

¹, France; ²LPICM, CNRS, Ecole po, Palaiseau, France; ³, Palaiseau, France

Oral Presentations 2BO.7

10:30- 12:00 Materials and Processing for Perovskites Solar Devices

Chairpersons:

Sjoerd VEENSTRA
TNO, Eindhoven, *The Netherlands*

Invited

2BO.7.1

Dynamic Co-evaporation Schemes and their Impact on the Growth of Methylammonium Lead Iodide Absorbers for Inverted Solar Cells.

Robert Heidrich^{1,2}, Paul Pistor^{2,3}, Karl Heinze², Sebastian Berwig², Jie Ge², Roland Scheer²

¹Fraunhofer CSP, Halle (Saale), Germany; ²Martin Luther University, Halle (Saale), Germany; ³University Pablo de Olavide, Sevilla, Spain

2BO.7.2

Modification of Sputtered NiOx Hole Transport Layer by Blade Coated Self-Assembled Monolayers for Highly Efficient and Fully Scalable p-i-n Perovskite Solar Cells and Modules

Merve Tutundzic^{1,2,3}, Xin Zhang^{2,3,4,5}, Stijn Lammar^{2,3,4}, Tamara Merckx^{2,3}, Aranzazu Aguirre^{2,3}, Tom Aernouts^{2,3}, Yinghuan Kuang^{2,3}, Bart Vermang^{1,2,3}

¹Hasselt University, Hasselt, Belgium; ²Imec, Genk, Belgium; ³EnergyVille, Genk, Belgium; ⁴KU Leuven, Leuven, Belgium; ⁵Fudan University, Shanghai, China

2BO.7.3

Interfacial Limitations of ALD-grown Tin Oxide as an Electron Selective Layer in Perovskite-Based Solar Cells

Félix Gayot¹, Elise Bruhat¹, Matthieu Manceau¹, Eric de Vito², Denis Mariolle², Stéphane Cros¹

¹CEA, Le-Bourget-Du-Lac, France; ²CEA, Grenoble, France

2BO.7.4

Optical Characteristics of Semi-Transparent FAPb(Br₁-XCl_x)₃ Perovskite for BIPV Applications through Temperature-Dependent Photoluminescence

Minjin Kim¹, Olivier Fournier¹, Fabio Matteocci², Jean-Francois Guillemoles¹, Aldo Dicarolo², Stefania Cacovich¹, Daniel Ory³

¹CNRS, Palaiseau, France; ²University of Rome II, Roma, Italy; ³EDF R&D, Palaiseau, France

2BO.7.5

Improving the Stability of CsPbIBr₂ Through Solvent Engineering

Alexander Wyn Stewart¹, Bernabé Marí Soucase¹

¹Valencia Polytechnic University, València, Spain

2BO.7.6

High-Throughput Synthesis and Characterization of Cs₂Ag_xNa_{1-x}Bi_yIn_{1-y}Cl₆ Perovskites with Near-Unity Photoluminescence Quantum Yield

Oleksandr Stroyuk¹, Oleksandra Raievska¹, Manuel Daum^{1,2}, Jens Hauch¹, Christoph J. Brabec^{1,2}

¹Forschungszentrum Jülich, Erlangen, Germany; ²FAU, Erlangen, Germany

Oral Presentations 3BO.12

10:30- 12:00 Outdoor Performances

Chairpersons:

Carolin ULBRICH
HZB, Berlin, *Germany*

Mauro PRAVETTONI
NUS, Singapore, *Singapore*

3BO.12.1

Long-term Performance Analysis of Solar PV Modules Installed in Open-Rack and BIPV Mounting Configurations

Ebrar Özkalay^{1,2}, Gabi Friesen², Alessandro Virtuani¹, Andrew Fairbrother¹, Mauro Cacciavio², Christophe Ballif^{1,3}

¹EPFL, Neuchâtel, Switzerland; ²SUPSI, Mendrisio, Switzerland; ³CSEM, Neuchâtel, Switzerland

3BO.12.2

Monitoring of Perovskite Module Performance in Real Operating Conditions

Gianluigi Bovesecchi¹, Giulia Bontempi¹, Marco Pierro², David Moser², Antonio Agresti³, Sara Pescetelli³, Enrico Leonardi⁴, Aldo Di Carlo¹, Cristina Cornaro¹

¹University of Rome II, Rome, Italy; ²Eurac Research, Bozen, Italy; ³University of Rome II, Roma, Italy; ⁴GreatCell Solar Italia, Rome, Italy

3BO.12.3

Extrapolating CIGS Module Performance from Laboratory Cell Performance Using Outdoor Data

Timon Sebastian Vaas^{1,2}, Bart E. Pieters¹, Theresa Magorian-Friedlmeier³, Uwe Rau^{1,2}

¹IEK-5 Photovoltaics, Jülich, Germany; ²Forschungszentrum Jülich, Aachen, Germany; ³ZSW, Stuttgart, Germany

3BO.12.4

An Approach for a Shading Resistance Classification of PV Modules

Hendrik Sträter¹, Stefan Riechelmann¹, Stefan Winter¹

¹PTB, Braunschweig, Germany

3BO.12.5

Outdoor Monitoring Results of a Full-Scale Reconfigurable PV Module

Andres Calcabrini¹, Mirco Muttillio¹, Patrizio Manganiello¹, Miro Zeman¹, Olindo Isabella¹

¹Delft University of Technology, Delft, Netherlands

Oral Presentations 4BO.17

10:30- 12:00 Forecasting of Solar Radiation and PV Output

Chairpersons:

Christos PROTOGEROPOULOS
EEPS, Athens, Greece

Wilfried G.J.H.M. VAN SARK
Utrecht University, Utrecht, Netherlands

4BO.17.1

Hybrid Modeling Approach Using Cloud Dynamics and Deep Learning for Solar Nowcasting

Jun Sasaki¹, Kenji Utsunomiya¹, Maki Okada¹, Shigeyuki Yoshikawa¹, Koji Yamaguchi¹

¹Japan Weather Association, Toshima City, Japan

4BO.17.2

Evaluation of WRF-Solar Cloud Forecast Using the NSRDB

Jaemo Yang¹, Manajit Sengupta¹, Yu Xie¹, Aron Habte¹, Pedro A. Jimenez², Ju-Hye Kim²

¹NREL, United States; ²UCAR, United States

4BO.17.3

Benchmark of Eight Commercial Solutions for Deterministic Intra-Days Solar Forecast

Jonathan Lehmann¹, Christian Koessler², Stijn Scheerlinck¹, Lina Ruiz Gomez²

¹ENGIE, Linkebeek, Belgium; ²Engie Green, Lille, France

4BO.17.4

Improved Blending of PV Power Forecasts in Case of Measurements with Limited Reliability

Wiebke Herzberg¹, Nicolas Holland¹, Jefferson Bor¹, Elke Lorenz¹

¹Fraunhofer ISE, Freiburg, Germany

4BO.17.5

Single-Site Forecasts for 100 PV Systems at DSO Level, Using a Hybrid-Physical Approach, to Improve Grid-Integration and Enable Future Smart-Grid Operation

Daniel Koster¹, David Fiorelli¹, Pierrick Bruneau¹, Christian Braun¹

¹LIST, Esch-sur-Alzette, Luxembourg

4BO.17.6

Effect of Climate on Photovoltaic Yield Prediction Using Machine Learning Models

Alba Alcañiz¹, Anders Lindfors², Miro Zeman¹, Olindo Isabella¹, Hesam Ziar¹

¹Delft University of Technology, Delft, Netherlands; ²Finnish Meteorological Institute, Helsinki, Finland

Visual Presentations 2BV.2

**10:30- 12:00 Emerging and Novel Approaches for Photovoltaics /
Advanced Modelling and Characterization**

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 1BO.3

**13:30- 15:00 Processing Solutions for Transparent Contacts /
Selective Absorbers**

Chairpersons:

Pere ROCA I CABARROCAS
CNRS, Palaiseau, France

Arthur W. WEEBER
Delft University of Technology, Petten, The Netherlands

1BO.3.1

Indium Reduction by 75% Using TCO Multilayers: an Industry-Ready Approach for Indium-Lean SHJ Cell?

Martin Bivour¹, Henning Nagel¹, Philipp Schmid¹, Winfried Wolke¹, Vasileios Georgiou-Sarlikiotis¹, Leonard Tutsch¹, Sebastian Pingel¹, Baljeet Singh Goraya¹, Anamaria Steinmetz¹, Sebastian Nold¹, Martin Hermle¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany

1BO.3.2

Sources of Sputter Damage in Transparent Passivating Contacts

Alexander Eberst^{1;2}, Weiyuan Duan¹, Depeng Qiu^{1;2}, Vladimir Smirnov¹, Uwe Rau^{1;2}, Kaining Ding¹

¹Forschungszentrum Jülich, Jülich, Germany; ²RWTH Aachen University, Aachen, Germany

1BO.3.3**Substitution of ITO by a Low-cost Sprayed TiO_x Capping Layer for SHJ Solar Cells**

Ulrike Heitmann¹, Leonard Tutsch¹, Angela De Rose¹, Dominik Dreja¹, Leonie Jakob¹, Radwa Elgazzar¹, Martin Bivour¹, Jonas Bartsch¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany

1BO.3.4**Impact of Spectrally-selective Thin-Film Si PV on Photosynthetic Organisms**

Lucia V. Mercaldo¹, Marco Della Noce¹, Manuela Ferrara¹, Fabrizio Carteni², Maurizio Zotti², Stefano Mazzoleni², Paola Delli Veneri¹

¹ENEA, Portici (NA), Italy; ²University of Naples Federico II, Portici (NA), Italy

1BO.3.5**Wavelength-selective Ultrathin a-Si:H/oxide Transparent Solar Cells**

Alex J. Lopez-Garcia¹, Cristóbal Voz Sánchez², Joachim Puigdollers González², V. Izquierdo-Roca¹, Alejandro Pérez-Rodríguez³

¹IREC, Sant Adrià de Besòs, Spain; ²UPC, Barcelona, Spain; ³IREC, Barcelona, Spain

1BO.3.6**Effect of Wafer Thickness on the Performance of Silicon Heterojunction Solar Cells under 1-Sun and Indoor Illumination**

Ugochi Kaosisochukwu Chime^{1,2}, Leon Wolf¹, Viktoriia Buga¹, Daniel Weigand¹, Alaaeldin Gad¹, Julian Köhler¹, Andreas Lambert¹, Weiyuan Duan¹, Kaining Ding¹, Uwe Rau^{1,2}, Tsvetelina Merdzhanova¹, Oleksandr Astakhov¹

¹Forschungszentrum Jülich, Jülich, Germany; ²RWTH Aachen University, Aachen, Germany

Oral Presentations 2BO.8

13:30- 15:00 Advanced Characterization and Modelling of Perovskite Devices

Chairpersons:

Paul PISTOR
Martin-Luther-University Halle-Wittenberg, Halle, *Germany*

Marion PROVOST
IPVF, Palaiseau, *France*

2BO.8.1 Correlative Imaging of Optical Properties for Perovskite Materials in Single-Junction and Tandem Solar Cells

Khoa Dang Nhat Nguyen¹, Anh Dinh Bui¹, Thien Ngoc Truong¹, Daniel Macdonald¹, Hieu Nguyen¹

¹ANU, Canberra, *Australia*

2BO.8.2 Passivation and Interface Optimization in the Lead and Tin-Based Perovskite Solar Cells Revealed by Photo Hall and Surface Photovoltage Measurements

Artem Musiienko¹, Fengjiu Yang², Hussein Mahmoud Hussein Mohamed²

¹HZB, Berlin, *Germany*; ²HZB, *Germany*

2BO.8.3 Electro-thermal Model for Lock-in Infrared Imaging of Defects in Perovskite Solar Cells

Ennio Comi¹, Evelyne Knapp¹, Mattia Battaglia¹, Kirsch Christoph¹, Sandra Jenatsch², Hiestand Roman², Mathias Bonmarin¹, Beat Ruhstaller^{1,2}

¹ZHAW, Winterthur, *Switzerland*; ²Fluxim, Winterthur, *Switzerland*

2BO.8.4 Charge Transport in Mixed Metal Halide Perovskite Semiconductors

Krishanu Dey¹, Dr. Sam Stranks²

¹University of Cambridge, Cambridge, *United Kingdom*

2BO.8.5 The Role of Reabsorption in Pero/Si Tandems Assessed by Optoelectronic Simulation

Simon Zeder^{1,2}, Beat Ruhstaller^{1,3}, Urs Aeberhard^{1,4}

¹Fluxim, Winterthur, *Switzerland*; ²EPFL, Neuchâtel, *Switzerland*; ³ZHAW, Winterthur, *Switzerland*; ⁴ETH Zurich, Zürich, *Switzerland*

2BO.8.6

Developing Strategies for Reliable Performance Evaluation of Perovskite Solar Cells: State-of-the-Art at the European Solar Test Installation

Giorgio Bardizza¹, Blago Mihaylov¹, Diego Pavanello¹, Harald Müllejjans¹, Ewan Dunlop¹

¹European Commission JRC, Italy

PANEL DISCUSSION BO.13

13:30- 15:00

Visual Presentations 3BV.3

13:30- 15:00 PV Characterization, Modelling and Energy Rating

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 1BO.4

15:15- 16:45 Passivation of Surfaces, Interfaces and Contacts

Chairpersons:

Karsten BOTHE
ISFH, Emmerthal, *Germany*

André AUGUSTO (i)
Arizona State University, Tempe, *United States*

1BO.4.1

Passivation Properties of p-Type Rear Junction Passivating Contact Silicon Solar Cells with Local Hole Selective Front Contacts

Dongkyun Kang¹, Yoonmook Kang¹, Hae-Seok Lee¹, Donghwan Kim¹

¹Korea University, Seoul, Korea, *Rep. of South*

1BO.4.2**Optimization of Front PECVD SiNx:H Layer Passivating the Emitter of PERC Solar Cells**

Hasan Hüseyin Canar^{1,2}, Gence Bektas^{1,2}, Ahmet Emin Keçeci^{1,2}, Hasan Asav^{1,2}, Sümeyye Koçak Bütüner¹, Selin Seyrek^{1,2}, Bülent Arikan¹, Rasit Turan^{1,2}

¹ODTÜ- GÜNAM, Ankara, Turkey; ²METU, Ankara, Turkey

1BO.4.3**Nafion Passivation of c-Si Surface and Edge for Electron Paramagnetic Resonance**

Kejun Chen^{1,2}, Abigail R. Meyer^{1,2}, Harvey Guthrey¹, William Nemeth¹, San Theingi¹, Matthew Page¹, Sumit Agarwal², David Young¹, Paul Stradins¹

¹NREL, Golden, United States; ²Colorado School of Mines, Golden, United States

1BO.4.4**Insights into the Recombination at the Interface of poly-Si Passivating Contacts for Application in c-Si Solar Cells**

Audrey Morisset¹, Raphael Cabal², Franz-Josef Haug¹, José Alvarez³, Sébastien Dubois², Jean-Paul Kleider³

¹EPFL, Neuchatel, Switzerland; ²CEA, Le Bourget-du-Lac, France; ³University Paris Saclay, CentraleSupélec, CNRS, IPVF, Gif-sur-Yvette, France

1BO.4.5**Insights into MoOx/i-aSi:H Interface for High Efficiency Solar Cells**

Paul A. Procel Moya¹, Alba Alcañiz¹, Liqi Cao¹, Luana Mazzarella¹, Yifeng Zhao¹, Can Han¹, Guangtao Yang¹, Rudi Santbergen¹, Miro Zeman¹, Olindo Isabella¹

¹Delft University of Technology, Delft, Netherlands

1BO.4.6**Insights into Cut-edges of SHJ Solar Cells by EL and LBIC Characterization**

Matevz Bokalic¹, Miha Kikelj¹, Benjamin Lipovsek¹, Samuel Harrison², Marko Topic¹

¹University of Ljubljana, Ljubljana, Slovenia; ²CEA, Le Bourget-du-Lac, France

Oral Presentations 2BO.9

15:15- 16:45 Stability of Perovskite Solar Cells and Mini-Modules

Chairpersons:

Giorgio BARDIZZA (*i*)
European Commission, JRC, Ispra, *Italy*

Ching-Fuh LIN
National Taiwan University, Taipei, *Taiwan*

2BO.9.1

The impact of high negative bias on perovskite solar cells in PID testing

Kristijan Brecl¹, Marko Jošt¹, Matevz Bokalic¹, Jernej Ekar², Janez Kovač², Marko Topic¹

¹University of Ljubljana, Slovenia; ²JSI, Slovenia

2BO.9.2

Thermal Stability and Degradation Kinetics of Lead Halide Perovskites

Paul Pistor^{1,2}, Thomas Burwig²

¹University Pablo de Olavide, Sevilla, Spain; ²Martin Luther University, Halle (Saale), Germany

2BO.9.3

Improvement in Stability and Efficiency of Tin-Lead Perovskite Solar Cells Using Combination of Monolayers

Gaurav Kapil¹, Takeru Bessho², Qing Shen¹, Hiroshi Segawa², Shuzi Hayase¹

¹University of Electro-Communications, Chofu, Japan; ²The University of Tokyo, Tokyo, Japan

2BO.9.4

Perovskite PV Accelerator for Commercializing Technology (PACT)

Joshua S. Stein¹, Laura Schelhas², Bruce King¹, Wanyi Nie³, Ralph Romero⁴, Jim Crimmins⁵, Cara Libby⁶, Angelique Montgomery¹, Charles Robinson¹, Christa Torrence¹, Marios Theristis¹, Joseph Berry², Timothy J Silverman², Michael Owen-Bellini², Ingrid Repins², Dana Sulas-Kern², Michael G. Deceglie², Robert White², Kirsten Perry², Paul Ndione², Nikos Kopidakis², Rob Foree⁴, Daniel Zirzow⁵, James Richards⁵, Colin Sillerud⁵, Wayne Li⁶, Michael Bolen⁶

¹Sandia National Laboratories, United States; ²NREL, United States; ³Los Alamos National Laboratory, United States; ⁴Black & Veatch, United States; ⁵CFV Labs, United States; ⁶Electric Power Research Institute, United States

2BO.9.5

Understanding Perovskite Experimental Degradation Pathways Combining Experimental Measurements and Simulations

Arthur Julien¹, Jean-Baptiste Puel², Jean-Francois Guillemoles³

¹IPVF, Palaiseau, France; ²EDF R&D, Palaiseau, France; ³CNRS, Palaiseau, France

2BO.9.6

Indoor and Outdoor Ageing of Perovskite Solar Cells: Long-Term Stability vs Meta-Stability

Mark Khenkin¹, Hans Köbler², Marko Remec^{1,3}, Quiterie Emery¹, Jinzhao LI¹, Paolo Graniero¹, Eva Unger¹, Rutger Schlatmann¹, Antonio Abate², Carolin Ulbrich¹

¹HZB, Berlin, Germany; ²HZB, Germany; ³University of Ljubljana, Ljubljana, Slovenia

Oral Presentations 3BO.14

15:15- 16:45 Modelling the Performance

Chairpersons:

Steve RANSOME

Steve Ransome Consulting, Kingston upon Thames, *United Kingdom*

Anton DRIESSE

PV Performance Labs, Freiburg, *Germany*

3BO.14.1

Special Introductory Presentation: PV Module Performance Measurements – Statistical Analysis of Technological Trends

Ulli Kräling¹, Paul Gebhardt¹, Daniel Philipp¹

¹Fraunhofer ISE, Freiburg im Breisgau, *Germany*

3BO.14.2

Modeling and Measuring the Power Output of Vertical Bifacial Solar Panels in Nordic Conditions

Sami Jouttijärvi¹, Mehmet Tok¹, Hugo Huerta Medina², Samuli Ranta², Kati Miettunen¹

¹University of Turku, Turku, *Finland*; ²TUAS, Turku, *Finland*

3BO.14.3

Model to Estimate the Performance of Full-Colored Solar Panels

Lenneke H. Slooff-Hoek¹, Antonius R. (Teun) Burgers¹, Tom Minderhoud², Ger Gijzen², Thijs Sepers^{3,4}, Wouter van Strien³

¹TNO, Petten, *Netherlands*; ²UNStudio, Amsterdam, *Netherlands*; ³Solar Visuals, Oudkarspel, *Netherlands*; ⁴Trinity Solarbeteiligungen, Oudkarspel, *Netherlands*

3BO.14.4

Deep Learning Temperature Estimation Model for PV Modules

Anastasios Kladas¹, Bert Herteleer¹, Jan Cappelle¹

¹KU Leuven, Ghent, *Belgium*

3BO.14.5

Energy-yield Modelling and Real Data: a Case Study on a Rooftop PV System in Israel

Klaus Jäger^{1,2}, Peter Tillmann^{1,2}, Asher Karsenti³, Lev Kreinin³, Christiane Becker¹

¹HZB, Berlin, Germany; ²ZIB, Berlin, Germany; ³Solaround, Jerusalem, Israel

Visual Presentations 4BV.4

15:15- 16:45 Solar Resource and Forecasting

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 1BO.5

17:00- 18:30 Optical and Electrical Solar Cell Characterization

Chairpersons:

Francesca FERRAZZA
ENI, San Donato Milanese, *Italy*

Marko TOPIC
University of Ljubljana, Ljubljana, *Slovenia*

1BO.5.1

Accurate IV-Measurements of Silicon Heterojunction Solar Cells without Front Metallization Using FEM Simulations

Malte Brinkmann¹, Felix Haase¹, Karsten Bothe¹, Karsten Bittkau², Andreas Lambert², Weiyuan Duan², Kaining Ding², Hans-Peter Sperlich³, Andreas Waltinger³, Henning Schulte-Huxel¹

¹ISFH, Emmerthal, Germany; ²Forschungszentrum Jülich, Jülich, Germany; ³Meyer Burger, Hohenstein-Ernstthal, Germany

1BO.5.2

Accurate Linearity Measurements of the Short-Circuit Current Using a Spectral Shaping Setup

Matthias Mühleis¹, S. Kasimir Reichmuth¹, Jochen Hohl-Ebinger¹

¹Fraunhofer ISE, Freiburg, Germany

1BO.5.3 Photoluminescence Imaging Using Non-Uniform Excitation: Recent Progress

Shuai Nie¹, Yan Zhu¹, Oliver Kunz¹, Thorsten Trupke¹, Ziv Hameiri¹

¹UNSW, Australia

1BO.5.4 Accurate High Throughput Current-Voltage Classification of High Efficiency Silicon Solar Cells With RapidWave®

Bernhard Mitchell¹, Don Clugston¹, Bernhard Klöter¹, Britta Mette¹, Hannes Wagner-Mohnsen¹, Sascha Esefelder¹

¹WAVELABS, Leipzig, Germany

1BO.5.5 Role of the Electron Dark Current and Early Behaviour in the Degradation of the Open Circuit Voltage and S-shape Distortion in a-Si:H(p)/c-Si SHJ Solar Cells with Schottky Contact

Moustafa Ghannam¹, Yaser Abdulraheem¹, Ivan Gordon², Jozef (Jef) Poortmans²

¹Kuwait University, Kuwait; ²imec, Leuven, Belgium

1BO.5.6 Characterizing the Capacitance of Various Industrial c-Si Cell Technologies

David van Nijen¹, Patrizio Manganiello¹, Mirco Muttillio¹, Miro Zeman¹, Olindo Isabella¹

¹Delft University of Technology, Netherlands

Oral Presentations 2BO.10

17:00- 18:30 Scaling Up Manufacturing Processes for Perovskite Devices and First Applications

Chairpersons:

Wolfgang TRESS
ZHAW, Winterthur, Switzerland

Mark KHENKIN
HZB, Berlin, Germany

2BO.10.1 Process Engineering and 2D Interfacial Defects Passivation of Large Area Perovskite Solar Modules

Luigi Vesce¹, Maurizio Stefanelli¹, Stefano Razza¹, Luigi Angelo Castriotta¹, Francesco DI Giacomo¹, Aldo DI Carlo^{1,2}

¹University of Rome II, Rome, Italy; ²CNR, Rome, Italy

2BO.10.2**Efficient Upscaling of Perovskite Photovoltaics: Investigation of Slot-Die Coated Perovskite Solar Cells Dried via Gas-Quenching**

Kristina Geistert^{1,2}, Ulrich Wilhelm Paetzold^{1,2}, Simon Ternes^{1,2,3}, Felix Laufer², Benjamin Hacene²

¹Karlsruhe Institute of Technology - KIT, Eggenstein-Leopoldshafen, Germany;

²Karlsruhe Institute of Technology - KIT, Karlsruhe, Germany

2BO.10.3**Scalable Manufacturing and Characterization of Large-Scale Perovskite Solar Device**

Aider Celia¹, Iwan Zimmermann², Sophie Bernard², Frédéric Sauvage³, Daniel Ory¹, Jean Rousset¹

¹EDF R&D, Palaiseau, France; ²IPVF, Palaiseau, France; ³LRCS, France

2BO.10.4**Flash Annealed Nickel Oxide for the Fast Production of Large Area Perovskite Solar Cells**

Efrain Ochoa Martinez¹, Shanti Bijani², Ullrich Steiner¹, Jovana Milic¹

¹Adolphe Merkle Institute, Fribourg, Switzerland; ²UMA, Malaga, Spain

2BO.10.5**In-Situ & Ex-Situ Study of Protons Irradiations of Perovskites Solar Cells for Space Applications**

Carla Costa^{1,2}, Matthieu Manceau², Thierry Nuns¹, Sophie Duzellier¹, Romain Cariou²

¹ONERA, Toulouse, France; ²CEA, Le Bourget-du-Lac, France

2BO.10.6**Envisaging Building-Integrated Translucent Tandem Photovoltaics: Process Optimization and Transfer to Perovskite Tandem Cells**

David Benedikt Ritzer¹, Marco A. Ruiz-Preciado², Bahram Abdollahi Nejand², Tobias Abzieher², Ulrich Wilhelm Paetzold^{1,2}

¹Karlsruhe Institute of Technology - KIT, Eggenstein-Leopoldshafen, Germany;

²Karlsruhe Institute of Technology - KIT, Karlsruhe, Germany

Oral Presentations 3BO.15

17:00- 18:30 Energy Yield and Energy Rating

Chairpersons:

Tom BETTS (i)
Loughborough University, Loughborough, *United Kingdom*

Jatin ROY (i)
IIT Kharagpur, Kharagpur, *India*

3BO.15.1 Energy Performance of Commercial c-Si PV-Modules in Accordance with IEC 61853-1,-2 and Impact on the Annual Specific Yield

Christos Monokroussos¹, Eleanor W. L. Lee², Frank Xu¹, Allen Zhou¹, Yichi Zhang¹, Werner Herrmann³

¹TÜV Rheinland, Shanghai, China; ²TÜV Rheinland, Taipei, Taiwan; ³TÜV Rheinland, Cologne, Germany

3BO.15.2 Virtual Energy Rating: a Method for Optimizing Module Performance Through Cell-To-Module Analysis

Alexander Aguilar Protti¹, Jibran Shahid¹, Max Mittag¹, Holger Neuhaus¹, Ulli Kräling¹, Martin Kaiser¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany

3BO.15.3 Impact of Various Photovoltaic Module Characteristics across Geographic Regions

Madhuri Kumari¹, Marios Theristis¹, Joshua S. Stein¹

¹Sandia National Laboratories, Albuquerque, United States

3BO.15.4 Differentiation of PV Devices According to Energy Rating Standard IEC 61853

Ana Maria Gracia Amillo¹, Robert P. Kenny¹, Diego Pavanello¹

¹European Commission JRC, Ispra, Italy

3BO.15.5 Developing an Energy Rating for Bifacial PV Modules

Malte Vogt¹, Giorgos Pilis¹, Miro Zeman¹, Rudi Santbergen¹, Olindo Isabella¹

¹Delft University of Technology, Delft, Netherlands

3BO.15.6 Comparison of Energy Performance of Vertical and Tilted Bifacial PV Modules in Arid Environments

Maulid M. Kivambe¹, Giovanni Scabbia¹, Amir A. Abdallah¹, Benjamin Figgis¹, Juan Lopez Garcia¹

¹QEERI, Doha, Qatar

Visual Presentations 4BV.5

17:00- 18:30 Performance and Monitorisation of PV Systems

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Plenary Presentations 4CP.1

08:30- 10:00 PV Works Everywhere

Chairpersons:

Minne M. DE JONG
TNO, Eindhoven, *The Netherlands*

Victor KHORENKO (i)
Azur Space, Heilbronn, *Germany*

4CP.1.1

Keynote presentation: The Photovoltaic Potential of a Fleet of Urban Vehicles

Dora de Jong¹, Vasiliki Sionti¹, Hesam Ziar¹

¹*Delft University of Technology, Netherlands*

4CP.1.2

Impact of the 2019-2020 Australian Black Summer Wildfires on Photovoltaic Energy Production

Ethan Ford¹, Bram Hoex¹, Marius Peters²

¹*UNSW, Kensington, Australia;* ²*Forschungszentrum Jülich, Erlangen, Germany*

4CP.1.3

"Little Maintenance Over 25 Years?" – A Comprehensive Statistical Assessment of 35,000 O&M Tickets Across 5 Countries and their Techno-Economic Impacts

Sascha Lindig¹, Magnus Herz², David Moser¹, Guillermo Oviedo-Hernandez³, Sarah Southern⁴, Leonardo Moretti⁵

¹*Eurac Research, Bolzano, Italy;* ²*TÜV Rheinland, Cologne, Germany;* ³*BayWa, Roma, Italy;* ⁴*Statkraft UK, United Kingdom;* ⁵*ENEL Green Power, Roma, Italy*

4CP.1.4

Agrovoltaic Plant Management: How to Optimize Energy Production and Agricultural Output

Antonio Lancellotta¹

¹*SET Energy, Rome, Italy*

Plenary Presentations 1CP.2

10:30- 11:30 Advances in Efficiency and Production of Crystalline Silicon

Chairpersons:

Delfina MUÑOZ
CEA-INES, Le Bourget-du-Lac, France

Invited

1CP.2.1

Lessons Learned from 25 Years Production Technology Research & Development

Ralf Preu¹, Jochen Rentsch¹, Stefan Rein¹, Florian Clement¹, Jan-Frederik Nekarda¹, Andreas W. Bett¹

¹Fraunhofer ISE, Freiburg, Germany

1CP.2.2

Over 26% Efficiency SHJ Solar Cell Using Nanocrystalline Silicon Oxide Window Layer

Xiaoning Ru¹, Miao Yang¹, Chengjian Hong¹, Shi Yin¹, Fuguo Peng¹, Minghao Qu¹, Xixiang Xu¹

¹LONGi Solar Technology, Xi'an, China

1CP.2.3

24% Efficient Interdigitated Back Contact Solar Cells in Mass Production without Passivating Contacts

Radovan Kopecek¹, Joris Libal¹, Florian Buchholz¹, Jan Lossen¹, Valentin Dan Mihailetchi¹, Dominik Rudolph¹, Haifeng Chu¹, Ning Chen¹, Christoph Peter¹, Tudor Timofte¹, Andreas Halm¹, Jianda Liu², Y. Guo², Xiaoyong Qu², Xiang Wu², Jianqing Gao², P. Dong²

¹ISC Konstanz, Germany; ²SPIC Solar Power, China

Plenary Presentations 2CP.3

11:30- 12:30 Thin Film Progress for Photovoltaic Devices

Chairpersons:

Charles HAGES
University of Florida, Berlin, *Germany*

Ayodhya Nath TIWARI
EMPA, Dübendorf, *Switzerland*

2CP.3.1

Perovskite/Silicon Tandem Solar Cells with Sinusoidal Nanotextures Achieving 29.80% Certified Efficiency

Philipp Tockhorn¹, Johannes Sutter², Alexandros Cruz³, Klaus Jäger², Felix Lang⁴, Max Grischek¹, Philipp Wagner¹, Danbi Yoo², Dr. Martin Stollerfoht⁴, Bernd Stannowski³, Steve Albrecht¹, Christiane Becker²

¹HZB, Berlin, Germany; ²University of Potsdam, Potsdam, Germany

2CP.3.2

Novel Semitransparent Solar Cell Based on Ultrathin Multiple Si/Ge Quantum Wells

Hosni Meddeb¹, Maximilian Götz¹, Kai Gehrke¹, Martin Vehse¹

¹DLR- German Aerospace Center, Oldenburg, Germany

2CP.3.3

Where do the Electrons Go? A Look Inside Characterization Techniques for Thin-Film Solar Cells

Ana Kanevce¹

¹ZSW, Stuttgart, Germany

Oral Presentations 2CO.1

13:30- 15:00 Targeting High Efficiencies with Perovskite Silicon Tandem Solar Cells

Chairpersons:

Erkan AYDIN
KAUST, Jeddah, *Saudi Arabia*

Ivan GORDON
imec, Leuven, *Belgium*

2CO.1.1

Special Introductory Presentation: Pathways to High-Efficiency and Outdoor-Stable Perovskite/Silicon Tandem Solar Cells

Stefaan De Wolf¹

¹KAUST, Thuwal, *Saudi Arabia*

2CO.1.2

Interface between Poly-Si on Oxide Passivated Si Bottom and Perovskite Top Cells – Search for the Leanest and best Working Layer Stack

Christian Schwarz¹, Yevgeniya Larionova¹, Sascha Wolter¹, Michael Rienäcker¹, Tobias Wietler¹, Marvin Diederich¹, Rolf Brendel¹, Robby Peibst¹

¹ISFH, Emmerthal, *Germany*

2CO.1.3

Alkali Salt Interfacial Passivation Strategy for Hysteresis-Free Monolithic Perovskite/silicon Tandem Solar Cells

Yongcai He¹, Xiaobing Gu², Lei Ding³, Xin Dong³, Xiaoning Ru³, Miao Yang³, Minghao Qu³, Bo He¹, Xixiang Xu²

¹LONGi Clean Energy, Xi'an, *China*

2CO.1.4

Two-Terminal Perovskite/Silicon Tandem Based on Double Cation Formulation

Elisa Nonni¹, Fabio Matteocci¹, Luca Serenelli², Erica Magliano¹, Mario Tucci², Luca Martini², Francesca Menchini², Aldo Di Carlo^{1;3}

¹University of Rome II, Rome, *Italy*; ²ENEA, Roma, *Italy*; ³CNR, Roma, *Italy*

2CO.1.5

Potential of NiOx/Nickel Silicide/n+Poly-Si Contact for Perovskite/TOPCon Tandem Solar Cells

Dowon Pyun¹, Jiryang Kim², Dongjin Choi¹, Jeong Seokhyun¹, Changhyun Lee¹, Ji Yeon Hyun¹, Ha Eun Lee¹, Sang-Won Lee¹, Hoyoung Song¹, Solhee Lee¹, Donghwan Kim¹, Yoonmook Kang², Hae-Seok Lee²

¹Korea University, Seoul, *Korea, Rep. of South*

Oral Presentations 3CO.4

13:30- 15:00 Cell Interconnection

Chairpersons:

Antonin FAES
CSEM, Neuchâtel, *Switzerland*

Jonathan GOVAERTS
imec, Genk, *Belgium*

3CO.4.1

Interconnection Heterojunction Industrial and Sustainable Strategy

Vincent Barth¹, Remi Monna¹, Romain Soulas¹, Florent Pernoud¹, Armand Bettinelli¹, Carolyn Carrière¹, Bertrand Hladys¹, Corentin Lucas¹, Samuel Harrison¹, Nouha Gazbour¹

¹CEA, Le Bourget-du-Lac, *France*

3CO.4.2

Improvement of Silicon Heterojunction Module Efficiency Using fast Illumination Post-treatments

Tristan Gageot¹, Jordi Veirman¹, Jean-Sébastien Caron¹, Pedro Jeronimo¹, Romain Soulas¹, Sylvain De Vecchi¹, Wilfried Favre¹, Lorenzo Carbone², Gaetano Izzo², Antonino Ragonesi², Francesco Rametta², Alessandro Fucile², Cosimo Gerardi²

¹CEA, Le Bourget-du-Lac, *France*; ²Enel Green Power, Catania, *Italy*

3CO.4.3

Influence of IR Soldering Profile on Industrial Silicon Heterojunction Solar Cells

Angela De Rose¹, Cristina Rosado Alberdi¹, Achim Kraft¹

¹Fraunhofer ISE, Freiburg, *Germany*

3CO.4.4

Development of Shingle Matrix Technology for Integrated PV Applications

Daniel von Kutzleben¹, Torsten Roessler¹, Julian Weber¹, Sanjeev Sigdel¹, Nils Klasen¹, Philipp Zahn², Achim Kraft¹, Holger Neuhaus¹

¹Fraunhofer ISE, Freiburg, *Germany*; ²M10 Industries, Freiburg, *Germany*

3CO.4.5

Feasibility Study of Synergistic Back-Contact Silicon Solar Cells Metallization and Electrically Conductive Adhesive Interconnection Approach

Tudor Timofte¹, Robert Wade², Tobias Messmer¹, Ignacia Devoto^{1,3}, Karl Wienands¹, Daniel Tune¹, Frank Köhler², Thomas Fischer², Stephan Großer⁴, Christof Erban⁵, Joris Libal¹, Andreas Halm¹

¹ISC Konstanz, Konstanz, Germany; ²teamtechnik Maschinen und Anlagen, Freiberg am Neckar, Germany; ³Anhalt University of Applied Sciences, Köthen (Anhalt), Germany; ⁴Fraunhofer CSP, Halle (Saale), Germany; ⁵SUNOVATION, Elsenfeld, Germany

3CO.4.6

Pushing the Limits of Heterojunction Shingle Modules Performance, Cost and Sustainability

Carolyn Carrière¹, Samuel Harrison¹, Vincent Barth¹, Armand Bettinelli¹, Eszter (Esther) Voroshazi¹, Marco Gialazzo², Enrico Sovernigo²

¹CEA, Le Bourget-du-Lac, France; ²Applied Materials, SAN BIAGIO DI CALLALTA, Italy

PANEL DISCUSSION CO.7

13:30- 15:00

Visual Presentations 4CV.1

**13:30- 15:00 Engineering Design and Installation of PV Systems /
Power Electronics and Electrical Grid Interface**

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 2CO.2

15:15- 16:45 Innovative Material and Tandem Concepts

Chairpersons:

Stefaan DE WOLF

King Abdullah University of Science and Technology, Thuwal, Saudi Arabia

Muriel MATHERON

CEA-INES, Le Bourget du Lac, France

2CO.2.1

Sustainability Evaluations on Material Consumption for Terawatt Scale Manufacturing of Silicon based Tandem Solar Cells

LI Wang¹, Yuchao Zhang², Moonyong Kim², Robert Underwood¹, Storm Drury¹, Brett Hallam¹

¹UNSW, Sydney, Australia

2CO.2.2

Flexible GaAs//Cu(In_{1-x}Ga_x)(S_ySe_{1-y})₂-based Three-Junction Solar Cells Using Modified Smart Stack Technology

Kikuo Makita¹, Hiroshi Tomita², Hidenori Mizuno¹, Ryuji Oshima¹, Yasushi Shoji¹, Ralph Müller³, David Lackner³, Frank Dimroth³, Takeyoshi Sugaya¹

¹AIST, Tsukuba, Japan; ²Idemitsu, Atsugi, Japan; ³Fraunhofer ISE, Freiburg, Germany

2CO.2.3

25+% Large Area Efficient Semi-Transparent Stable Perovskite Solar Modules in 4T Hybrid Tandem Configurations

Valerio Zardetto¹, Lukas Simurka¹, Dong Zhang¹, Wiljan Verhees¹, Giulia Lucarelli¹, Henri Fledderus¹, Mehrdad Najafi¹, Ilker Dogan¹, Dorrit Roosen-Melsen¹, Petra Manshanden², Gianluca Coletti², Veronique Gevaerts¹, Sjoerd Veenstra¹

¹TNO, Eindhoven, Netherlands; ²TNO, Petten, Netherlands

2CO.2.4

Highly Efficient Monolithic Perovskite/CuIn(Ga)Se₂ Tandem Solar Cells

Marco A. Ruiz-Preciado^{1,2}, Fabrizio Gota^{1,2}, Ihtezaz Muhaimin Hossain^{1,2}, Paul Fassl^{1,2}, Felix Laufer^{1,2}, Fabian Schackmar^{1,2}, Thomas J. Feeney^{1,2}, Ahmed Farag^{1,2}, Isabel Allegro¹, Hang Hu^{1,2}, Saba Gharibzadeh^{1,2}, Bahram Abdollahi Nejad^{1,2}, Veronique Gevaerts³, Marcel Simor³, Pieter Jan Bolt³, Ulrich Wilhelm Paetzold^{1,2}

¹Karlsruhe Institute of Technology - KIT, Karlsruhe, Germany; ²Karlsruhe Institute of Technology - KIT, Eggenstein-Leopoldshafen, Germany; ³TNO, Eindhoven, Netherlands

2CO.2.5

In-Depth Characterization and Optimization of Hole-Transport Layers for Efficient Shunt Quenching and Charge-Carrier Collection in CIGS-Perovskite Tandem Solar Cells

Ivona Kafedjiska¹, Igal Levine², Artem Musiienko², Natalia Maticiuc³, Hannes Hempel³, Tobias Bertram¹, Guillermo Antonio Farias Basulto¹, Pablo Itzam Reyes-Figueroa¹, Amran Al-Ashouri², Christian Kaufmann¹, Steve Albrecht^{2,4}, Rutger Schlatmann^{1,5}, Iver Lauermann¹

¹HZB, Berlin, Germany; ²HZB, Germany; ³Berlin University of Technology, Berlin, Germany; ⁴Berlin University of Applied Sciences, Berlin, Germany

2CO.2.6

Laser-based Monolithic Series Interconnection of CIGSE-Perovskite Tandem Solar Cells – Determination of Optimum Scribe Line Properties

Christof Schultz¹, Guillermo Antonio Farias Basulto², Nico Hansen¹, Janardan Dagar³, Rutger Schlatmann¹, Eva Unger³, Bert Stegemann¹

¹Berlin University of Applied Sciences, Berlin, Germany; ²HZB, Berlin, Germany

Oral Presentations 3CO.5

15:15- 16:45 Thermomechanical Design, Integration and Materials for Modules

Chairpersons:

Daniel KRAY

University of Applied Sciences Offenburg, Offenburg, Germany

Silvia Maria PIETRALUNGA

CNR-IFN, Milano, Italy

3CO.5.1

Thermomechanical Design Rules for PV Modules

Andreas J. Beinert^{1,2}, Pascal Romer¹, Martin Heinrich¹, Jarir Aktaa², Holger Neuhaus¹

¹Fraunhofer ISE, Freiburg, Germany; ²Karlsruhe Institute of Technology - KIT, Eggenstein-Leopoldshafen, Germany

3CO.5.2

PV Integration in Curved Parts: Mechanical Limits and Key Parameters from a Theoretical Point of View

Jean-Baptiste Charpentier¹, Tatiana Duigou¹, Bertrand Chambion¹, Philippe Voarino¹, Fabien Chabuel¹

¹CEA, Le Bourget du Lac, France

3CO.5.3**The Beauty as well as the Beast: Towards Appealing Aesthetics and Reliable Photovoltaics for Vehicle Integration and Beyond**

Jonathan Govaerts^{1;2;3}, Tom Borgers^{1;2;3}, Bin Luo^{1;2;3;4}, Rik Van Dyck^{1;2;3;4}, Arvid van der Heide^{1;2;3}, Bart Reekmans^{1;2;3}, Luc Vastmans^{1;2;3}, Reinoud Moors^{1;2;3}, Geert Doumen^{1;2;3}, Loïc Tous^{1;2;3}, Jozef (Jef) Poortmans^{1;2;3;4}

¹imec, Genk, Belgium; ²EnergyVille, Genk, Belgium; ³Hasselt University, Hasselt, Belgium; ⁴KU Leuven, Leuven, Belgium

3CO.5.4**Impact of Modern Cell Concepts and Module Layouts on Hot-spot Temperatures in Solar Modules**

Klaus Ramspeck¹, Christian Müller¹, Michael Meixner¹

¹halm, Frankfurt, Germany

3CO.5.5**Effect of Cooling Press on Residual Stresses, Optical Properties and Lifetime of Photovoltaic Modules**

Bertrand Chambion¹, Vincent Meslier¹, Amandine Boulanger¹, Ichrak Rahmoun¹, Fabien Chabuel¹

¹CEA, Le Bourget-du-Lac, France

3CO.5.6**Comparative Optical Performance Analysis of Micro- and Nanotextures on PV Glasses**

Danbi Yoo¹, Tobias Kraus², Hubert Hauser², Christiane Becker¹

¹HZB, Berlin, Germany; ²temicon, Freiburg, Germany

Oral Presentations 4CO.8

15:15- 16:45 Experimental Studies of Building Integrated PV Solutions

Chairpersons:

Rebecca YANG
RMIT University, Melbourne, *Australia*

Natasha HJERRILD (i)
GAF, San Jose, *United States*

4CO.8.1

1-Year Outdoor Performance Test Results of Luminescent Solar Concentrators with Embedded Nanocrystals

Thomas de Bruin¹, Natalia Zawacka², Anne de Waal¹, Stijn Verkuilen³, Tim Prins⁴, Paul Leblans⁵, Daniel Vanmaekelbergh⁴, Zeger Hens², Celso de Mello Donegá⁴, Wilfried G.J.H.M. van Sark¹

¹*Utrecht University, Utrecht, Netherlands*; ²*Ghent University, Gent, Belgium*; ³*Heijmans, Rosmalen, Netherlands*; ⁴*Agfa, Mortsel, Belgium*

4CO.8.2

Experimental Study of Cool Roof Paint for Albedo Increase in Bifacial PV Systems

Daniel Valencia-Caballero¹, Salim Bouchakour², Alvaro Luna³, Borja Garcia-Marco³, Ana Huidobro¹, Asier Sanz Martinez¹, Eduardo Román Medina¹

¹*TECNALIA, Donostia - San Sebastián, Spain*; ²*CDER, Algiers, Algeria*; ³*UPC, Terrassa, Spain*

4CO.8.3

Impact Resistance of BIPV Systems: Proposal of a Test Procedure to Harmonize Building and Electrical Performance Assessment

Pierluigi Bonomo¹, Fabio Parolini¹, Francesco Frontini¹, Mauro Caccivio¹, Giovanni Bellenda¹

¹*SUPSI, Mendrisio, Switzerland*

4CO.8.4

Design of "hotspot-free" BIPV Modules - Peranakan PV

Min Hsian Saw¹, Srinath Nalluri¹, Mauro Pravettoni¹

¹*NUS, Singapore*

4CO.8.5

Bifacial PV Balcony and Terrace Fences

Roland M. E. Valckenborg¹, Bas Van Aken¹, Simona Villa¹, Teun Burgers¹

¹*TNO, Eindhoven, Netherlands*

4CO.8.6

Most Demanding Standard Combination to Support BIPV Development and Sustainability – Fire Safety

Simon Boddaert¹, Fabio Parolini², Pierluigi Bonomo², Muhammad Awais³, Claudio Pirota³, José Jimenez⁴, Jose M. Vega de Seoane⁵, Daniel Valencia-Caballero⁵

¹CSTB, Sophia Antipolis, France; ²SUPSI, Canobbio, Switzerland; ³PIZ, Cosio Valtellino, Italy; ⁴ONYX SOLAR, Avila, Spain; ⁵TECNALIA, Donostia - San Sebastian, Spain

Oral Presentations 5CO.10

15:15- 16:45 System Integration, Conversion and Storage

Chairpersons:

Kai-Philipp KAIRIES (i)
ACCURE Battery Intelligence, Aachen, Germany

Ingrid WEISS
WIP Renewable Energies, München, Germany

5CO.10.1

Rapid, Deep and Cheap Emissions Reductions

Andrew Blakers¹

¹ANU, Canberra, Australia

5CO.10.2

A Simple Guide for Designing a Photovoltaic and Battery System Coupled with a Heat Pump across Europe

Mattia Dallapiccola¹, Jennifer Adami¹, David Moser¹

¹Eurac Research, Bozen, Italy

5CO.10.3

Second-Life Batteries for Collective PV Self-Consumption

Guilherme Gaspar¹, André Pereira¹, Miguel Centeno Brito¹

¹University of Lisbon, Lisboa, Portugal

5CO.10.4

Upcycling Lithium-Ion Batteries: a Use Case

Ana Catarina Neves Foles¹, Luis Fialho¹, Joscha Winzer², Nuria Gonzalez³, Pedro André Dos Santos Ribeiro Horta¹, Manuel Pedro Ivens Collares-Pereira¹

¹University of Évora, Évora, Portugal; ²betteries AMPS, Berlin, Germany

5CO.10.5**Optimal PV Configuration for Stand-Alone Hydrogen Generation**

Victor Arturo Martinez Lopez¹, Hesam Ziar¹, Miro Zeman¹, Olindo Isabella¹

¹*Delft University of Technology, Delft, Netherlands*

5CO.10.6**CEOTRES: a Project for the Photovoltaic Generation OF Solar Fuels**

Antonio Martí Vega¹, Alfonso González del Valle¹, Pablo Garcia-Linares¹, Elisa Antolín¹, Inés Durán¹, Simon A. Svatek¹, Antonio L De Lacey², Marcos Pita², Maria V. Martínez-Huerta², José Carlos Conesa²

¹*UPM, Madrid, Spain;* ²*ICP, Madrid, Spain*

Visual Presentations 1CV.2

15:15- 16:45 High Temperature Route for Si Solar Cells

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 2CO.3

17:00- 18:30 Upscaling and Processing of Perovskite-based Tandem Solar Cells

Chairpersons:

Luana MAZZARELLA
Delft University of Technology, Delft, *The Netherlands*

Jan Christoph GOLDSCHMIDT
Philipps University of Marburg, Marburg, *Germany*

2CO.3.1

From Single Junction Perovskite Solar Cells to Large-area Silicon/Perovskite Tandems: Implications of Changing Substrate and Increasing Device Surface

Muriel Matheron¹, Andrii Voznyi², Lisa Champault², Jean-Patrice Rakotoniana², Carine Roux², Séverine Bailly², Noella Lemaitre², Matthieu Manceau², Olivier Dupré²

¹CEA, Le Bourget-du-Lac, France; ²CEA, Le Bourget du Lac, France

2CO.3.2

Scaling of Monolithic Perovskite/Silicon Tandem Solar Cells: Targeting for Industrial Process by Dry and Wet Approaches

Bernd Stannowski¹, Zih-Wei Peng¹, Ke Xu¹, Angelika Harter¹, Silvia Mariotti^{1,3}, Alexandros Cruz¹, Jona Kurpiers¹, Marcel Roß¹, Eike Köhnen¹, Lars Korte¹, Eva Unger¹, Steve Albrecht¹, Rutger Schlatmann¹

¹HZB, Germany; ²Okinawa Institute of Science and Technology, Japan

2CO.3.3

Hybrid PVD/VTD Vapor Deposition Processing for Perovskite Tandem Solar Cell Upscaling

Quentin Guesnay¹, Florent Sahli², Quentin Jeangros², Christophe Ballif^{1,2}, Christian Wolff¹

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

2CO.3.4

Solution-Processed Perovskites on Textured Interfaces: a Successful Platform for Efficient Perovskite/Silicon Tandem Solar Cells

Erkan Aydin¹, Jiang Liu¹, Esma Ugur¹, Randi Azmi¹, Furkan Halis Isikgor¹, Shynggys Zhumagali¹, George T. Harrison¹, Anand Selvin Subbiah¹, Ahmed Ali Said², Maxime Babics¹, Michele De Bastiani¹, Thomas Allen¹, Frédéric Laquai¹, Stefaan De Wolf¹

¹KAUST, Thuwal, Saudi Arabia; ²KAUST Solar Center, Thuwal, Saudi Arabia

2CO.3.5

Shunt Mitigation in Large Area Si-PK Tandem Devices

Olivier Dupré¹, Nathalie Nguyen¹, Caroline Bal¹, Perrine Carroy¹, Elise Bruhat¹, Noella Lemaitre¹, Muriel Matheron¹, Matthieu Manceau¹

¹CEA, Le Bourget-du-Lac, France

Oral Presentations 3CO.6

17:00- 18:30 New Module Concepts and Markets

Chairpersons:

Yifeng CHEN

Trina Solar, Changzhou, China

Klaus RAMSPECK

h.a.l.m. elektronik, Frankfurt am Main, Germany

3CO.6.1

A Low Concentration Approach to Spectral Splitting Optics for Bifacial 4-T Modules

Andrea Farina¹, Alice Carlotto², Stefano Varas², Alessandro Chiasera², Silvia Maria Pietralunga¹

¹CNR, MILANO, Italy; ²CNR, Povo-TN, Italy

3CO.6.2

Three Terminal Tandem Solar Cells – a Module Perspective

Henning Schulte-Huxel¹, Robert Witteck¹, Susanne Blankemeyer¹, Marc Köntges¹

¹ISFH, Emmerthal, Germany

3CO.6.3

Overview of Key Results Achieved in H2020 HighLite Project Helping to Raise the EU PV Industries' Competitiveness

Loïc Tous^{1,2,3}, Jonathan Govaerts^{1,2}, Samuel Harrison⁴, Carolyn Carrière⁴, Florian Buchholz⁵, Andreas Halm⁵, Antonin Faes⁶, Gizem Nogay⁶, Andrew Fairbrother⁷, Franz-Josef Haug⁷, Torsten Roessler⁸, Tobias Fellmeth⁸, Dirk Reinwand⁸, Felix Haase⁹, Christina Hollemann⁹, Arnaud Morlier⁹, Matevz Bokalic¹⁰, Kristijan Brecl¹⁰, Marko Topic¹⁰, Josco Kester¹¹, Stefan Wendlandt¹², Marco Galiazzo¹³, Alessandro Voltan¹³, Giuseppe Galbiati¹⁴, Marc Estruga Ortega¹⁴, Frank Torregrosa¹⁵, Michael Grimm¹⁶, Julius Denafas¹⁷, Tadas Radavicius¹⁷, Povilas Lukinskas¹⁸, Tuukka Savisalo¹⁹, Thomas Regrettier²⁰, Ivan Gordon¹

¹imec, Genk, Belgium; ²Hasselt University, Hasselt, Belgium; ³EnergyVille, Genk, Belgium; ⁴CEA, Le Bourget-du-Lac, France; ⁵ISC Konstanz, Konstanz, Germany; ⁶CSEM, Neuchâtel, Switzerland; ⁷EPFL, Lausanne, Switzerland; ⁸Fraunhofer ISE, Freiburg im Breisgau, Germany; ⁹ISFH, Emmerthal, Germany; ¹⁰University of Ljubljana, Ljubljana, Slovenia; ¹¹TNO, Petten, Netherlands; ¹²PI Berlin, Berlin, Germany; ¹³Applied Materials, Olmi TV, Italy; ¹⁴Henkel, Westerlo, Belgium; ¹⁵Ion

Beam Services IBS, Peynier, France; ¹⁶3D-Micromac, Chemnitz, Germany;
¹⁷SoliTek, Vilnius, Lithuania; ¹⁸Valoe, Vilnius, Lithuania; ¹⁹Valoe, Mikkeli, Finland;
²⁰Voltec Solar, Dinsheim-sur-Bruche, France

3CO.6.4

Design and Fabrication of Ultra-High Efficiency Hybrid Solar Modules based on CPV Micro-Tracking System

Jacques Levrat¹, Delphine Petri¹, Matthieu Despeisse¹, Dominika Chudy¹, Christophe Ballif^{1,2}, X. Niquille², Gaël Nardin³, Mathieu Ackermann⁴, Florian Gerlich³, Mathilde Duchemin³, José María Sanchis Ronda³, Stephen Askins⁵, César Domínguez⁵, Guido Vallerotto⁵, Ignacio Antón Hernández⁵, Gerald Siefer⁶, Marc Steiner⁶, Juan Francisco Martinez Sanchez⁶, Antonio Valor⁷, Susana Soto⁷, Aitor Apraiz⁷

¹CSEM, Neuchâtel, Switzerland; ²EPFL, Neuchâtel, Switzerland; ³Insolight, Renens, Switzerland; ⁴INL, Renens, Switzerland; ⁵UPM, Madrid, Spain; ⁶Fraunhofer ISE, Freiburg, Germany; ⁷Mondragon Assembly, Aretxabaleta, Spain

3CO.6.5

Reliable Lego®-style Assembled Stretchable Photovoltaic Module for 3-Dimensional Arbitrary Surface Application

Min Ju Yun¹, Yeon Hyang Sim¹, Dong Yoon Lee¹, Seung I. Cha¹

¹KERI, 창원시, Korea, Rep. of South

3CO.6.6

Extensive Module Interconnection Optimization by Simulation Balancing High Performance, Low Cost and Ag Consumption

Corentin Lucas¹, Yannick Veschetti¹, Remi Monna¹, Vincent Barth¹, Eszter (Esther) Voroshazi¹

¹CEA, Le Bourget-du-Lac, France

Oral Presentations 4CO.9

17:00- 18:30 Multi-Scale Design and Analysis Tools for the Integration of Photovoltaics in the Built Environment

Chairpersons:

Francesco FRONTINI
SUPSI, Canobbio, Switzerland

Veronika SHABUNKO (i)
National University of Singapore, Singapore, Singapore

4CO.9.1 **The Art and Science of Integrating Photovoltaics in the Built Environment**

Isadora Pauli Custódio¹, Ísis Portolan Dos Santos², Ricardo Rüther¹

¹UFSC, Florianópolis, Brazil; ²UFSM, Brazil

4CO.9.2 **A GIS-based Large-Scale Visibility Assessment Tool for PV Planning on Building Roofs**

Yilong Zhou¹, Dennis Wilmerk¹, Miro Zeman¹, Hesam Ziar¹, Olindo Isabella¹

¹Delft University of Technology, Delft, Netherlands

4CO.9.3 **Light Reflection Analysis of PV Modules: Comparison to Building Façades and Assessing the Possibility of Glare**

Janina Moereke¹, Peter Borowski¹, Stefan Grünsteidl¹, Jörg Palm¹, Subarna Sapkota², Thomas Dalibor¹

¹Avancis, München, Germany; ²Avancis, Torgau, Germany

4CO.9.4 **Optical and Colorimetric Study of a Digital Printer on Glass for Optimization of Aesthetics and Performance of BIPV**

Benjamin Riedel¹, Philippe Thony¹, Christophe Ménézo², Ioannis (John) Tsanakas¹

¹CEA, Le Bourget-du-Lac, France; ²Savoy Mont Blanc University, Le Bourget-du-Lac, France

4CO.9.5 **Lightweight PV Modules and Strategies for Steady Power Production: Making Industrial-Commercial Buildings Suitable for PV**

Simona Villa¹, Maarten Dörenkämper¹, Menno van den Donker², Minne M. de Jong¹

¹TNO, Eindhoven, Netherlands; ²Solarge, Eindhoven, Netherlands

4CO.9.6

LED Module with a Minimum Shading Loss for Media Façade on a Building Integrated Photovoltaic Module

Dong-Youn Shin¹, Woo Gyun Shin², Gi-Hwan Kang²

¹*Pukyong National University, Busan, Korea, Rep. of South*; ²*KIER, Daejeon, Korea, Rep. of South*

Oral Presentations 5CO.11

17:00- 18:30 Flexibility Options for the Future Energy System

Chairpersons:

Rui PESTANA
R&D NESTER, Sacavém, Portugal

Eva SCHÜPBACH (i)
BUAS, Bern, Switzerland

5CO.11.1

Flexible PV and 'Implicit' Storage Ancillary Services to balance Demand and Supply

Marco Pierro¹, Mario Barba², David Moser¹, Richard Perez³, Cristina Cornaro²

¹*Eurac Research, Bozen, Italy*; ²*University of Rome II, Italy*; ³*SUNY, Albany, United States*

5CO.11.2

Energy Sharing Control Strategies: a Benchmark Analysis in a Configurable Italian Demonstrator

Mattia Secchi¹, Grazia Barchi¹, David Moser¹, Stefano Nassuato², Daniele Pellizzari³, Alessandro Costa³

¹*Eurac Research, Bozen, Italy*; ²*Regalgrid, Mignagola, Italy*; ³*Alperia, Bolzano, Italy*

5CO.11.3

24/365 Firm Solar Power Generation in Switzerland

Jan Remund¹, Richard Perez², Marc Perez³

¹*Meteotest, Bern, Switzerland*; ²*SUNY, Albany, NY, United States*; ³*Clean Power Research, Kirkland, United States*

5CO.11.4

User Behavior Optimization In Energy Communities with High PV Penetration

Lukas Gaisberger¹

¹*FH OOE, Wels, Austria*

5CO.11.5

Hydro-Floating PV Hybrid Operational Analysis – Dispatchability Expectations Under Different Operational Modes

Imke Meyer¹, Konstantinos Priftis¹, Christian Kaufmann¹, Shilpee Sinha¹

¹Mott MacDonald, Brighton, United Kingdom

5CO.11.6

Technoeconomics Optimization Model for Utility-Scale FPV/Hydro Power Plants

Øyvind Sommer Klyve^{1,2}, Jonathan Fagerström¹, Marianne Zeyringer², Erik Stensrud Marstein^{1,2}

¹Institute for Energy Technology, Kjeller, Norway; ²University of Oslo, Kjeller, Norway

Visual Presentations 1CV.3

17:00- 18:30 Feedstock, Crystallisation, Wafering and Defects in Silicon

Poster Area

Detailed information on this session is presented in the section entitled ‘Visual Presentations’.

Oral Presentations 4DO.1

08:30- 10:00 Statistical Methodologies and Artificial Intelligence in O&M

Chairpersons:

Peter HACKE
NREL, Golden, *United States*

David MOSER
Eurac Research, Bolzano, *Italy*

4DO.1.1 Improving Operations and Maintenance at Large-Scale PV Plants Through Statistical Bootstrapping

Michael Bolen¹, Daniel Fregosi¹

¹*Electric Power Research Institute, Charlotte, United States*

4DO.1.2 Photovoltaics in Brussels: an Overview of the PV Installed Park after 15 years and 11,000 Installations

Ibrahim El Boujdaini¹, Babacar Sarr¹, Jonathan Leloux^{1,2}, Philippe Macé³, Xavier Simons³, Guillaume Declève⁴, Renaud Tieterickx⁵, Jonathan de Lathouwer⁵, Régis Lambert⁵

¹*LuciSun, Villers-la-Ville, Belgium*; ²*ULB, Bruxelles, Belgium*; ³*Becquerel Institute, Bruxelles, Belgium*; ⁴*Sun7, Woluwe-Saint-Pierre, Belgium*; ⁵*Brugel, Bruxelles, Belgium*

4DO.1.3 New Artificial Intelligence Method for PV Annual Degradation Rate Estimation

Benoit Braisaz¹, Ibrahima Tounkara², Axel Becker²

¹*EDF R&D, Écuellles, France*; ²*EDF Renewables, Paris La Défense, France*

4DO.1.4 Precise On-Site Power Analysis of Photovoltaic Arrays by Self-Reference Algorithm

Martin Scheler¹, Darwin Daume¹, Dharmik Sojitra², Tina Neumeyer², Simon Steinbach², Tamara Beck², Achim Schulze³, Bernd Hüttl²

¹*University of Applied Sciences Coburg, Coburg, Germany*; ²*Coburg, Germany*; ³*Rosenheim, Germany*

4DO.1.5

Effect of Availability and Quality of Data on the Detection of Defects Utilizing Artificial Neural Networks in PV System's Monitoring Data

David Daßler¹, Stephanie Malik¹, Matthias Ebert¹

¹Fraunhofer CSP, Halle (Saale), Germany

4DO.1.6

Intelligent Fault Diagnosis of Photovoltaic Arrays based on Deep Belief Network and Extreme Learning Machine

Kun Ding¹, Zenan Yang¹, Jingwei Zhang¹, Li Feng², Shuai Weng¹

¹Hohai University, Changzhou, China; ²University of Applied Sciences Bielefeld, Minden, Germany

Oral Presentations 2DO.6

08:30- 10:00 Processes for CIGS, CdTe and Organic Solar Cells

Chairpersons:

Alexandre CROSSAY (*i*)
IPVF, Palaiseau, France

Veronica BERMUDEZ BENITO (*i*)
QEERI, Doha, Qatar

2DO.6.1

Back Surface Passivation of Chalcopyrite Solar Cells with Metal Oxide Interlayers

Taowen Wang¹, Farooq Muhammad Uzair², Michele Melchiorre¹, Alex Redinger², Susanne Siebentritt¹

¹University of Luxembourg, Esch-sur-Alzette, Luxembourg; ²University of Luxembourg, Luxembourg, Luxembourg

2DO.6.2

Alkali Post-Deposition Treatment Strategies for Cu(In,Ga)(S,Se)₂ Solar Cell Absorbers

Pablo Itzam Reyes-Figueroa¹, Tobias Bertram¹, Shevan Alhasan¹, Erik Waack¹, Ralf Haberecht¹, Thomas P. Niesen³, Jakob Bombsch¹, Thomas Dalibor³, Regan G. Wilks¹, Marcus Bär^{1;5;6}, Christian Kaufmann¹, Reiner Klenk¹, Rutger Schlatmann^{1;7}

¹HZB, Berlin, Germany; ²AVANCIS, München, Germany; ³HI ERN, Berlin, Germany; ⁴FAU, Nürnberg, Germany; ⁵Berlin University of Applied Sciences, Berlin, Germany

- 2DO.6.3** **In+Se Capping on Cu(In,Ga)Se₂ Thin Film Solar Cells for Improved Voc**
 Rico Gutzler¹, Stefan Paetel¹, Wolfram Hempel¹, Theresa Magorian-Friedlmeier¹, Michael Powalla¹
¹ZSW, Stuttgart, Germany
- 2DO.6.4** **Selenium-Free Annealing of Cesium Fluoride on CIGS Thin Film Solar Cells**
 Ishwor Khatri¹, Pedro Santos¹, Pedro Anacleto¹, Deepanjan Sharma¹, Mohamed Belmoubarik¹, Nicoleta Nicoara¹, Mutsumi Sugiyama², Sascha Sadewasser¹
¹INL, Braga, Portugal; ²TUAS, Chiba, Japan
- 2DO.6.5** **A Comprehensive Study of CdSeTe/CdTe Devices Fabricated by Thermal Evaporation**
 Elisa Artegiani¹, Prabeesh Punathil¹, Solidea Zanetti¹, Narges Torabi¹, Alessandro Romeo¹
¹University of Verona, Verona, Italy
- 2DO.6.6** **Mixing of Non Fullerene Acceptors Ionization Energies: an Additional Tool to Increase the Quantum Efficiency of Ternary Organic Solar Cells**
 Safakath Karuthedath¹, Sri Harish Kumar Paleti¹, Anirudh Sharma¹, Nicolas Ramos², Hang Yin³, Catherine Suenne De Castro¹, Nisreen Alshehri¹, Jafar Khan¹, Jaim Martin², Gang Li³, Frédéric Laquai¹, Derya Baran¹, Julien Gorenflot¹
¹KAUST Solar Center, Thuwal, Saudi Arabia; ²UPV/EHU, Lejona, Spain; ³The Hong Kong Polytechnic University, Hong Kong

Oral Presentations 1DO.11

08:30- 10:00 Advanced Silicon Cell Processing

Chairpersons:

Peter FATH
 RCT Solutions GmbH, Konstanz, Germany

Adrien DANIEL
 CEA, Le Bourget-du-Lac, France

- 1DO.11.1** **Review, Present and Outlook for Edge Isolation Processes for Manufacturing of high Efficient Silicon Solar Cells**
 Tobias Dannenberg¹, Damian Brunner¹, Katrin Krieg², Holger Kühnlein¹, Michael Passig¹, Caroline Scheiwe¹, Jan Temmler¹, Christopher Teßmann², Iron Wang¹, Weiwei Xie¹, Sufan Xu¹, Martin Zimmer²
¹Rena Technologies, Freiburg im Breisgau, Germany; ²Fraunhofer ISE, Freiburg im Breisgau, Germany

1DO.11.2**Novel Maskless Fabrication Process for HJT IBC Solar Cells**

Erik V. Johnson¹, Junkang Wang¹, Monalisa Ghosh¹, Pere Roca I Cabarrocas¹, Pavel Bulkin¹, Dmitri Daineka¹, Sergej Filonovich², Josè Alvarez³

¹LPICM, CNRS, Ecole Polytechnique, Palaiseau, France; ²TotalEnergies, France; ³GeePs, France

1DO.11.3**Towards Totally Screen-Printed IBC Cells with Diffused Junctions**

Emine Hande Ciftçinar^{1,2}, Ateşcan Aliefendioğlu^{1,2}, Mona Mona Zolfaghari Borra¹, Rasit Turan^{1,2,3}

¹ODTÜ - GÜNAM, Turkey; ²METU, Turkey

1DO.11.4**R&D Project NextTec – Next Generation High Throughput Production Processes & Inline Characterization for Si Solar Cells**

Florian Clement¹, Marius Meßmer¹, Hannes Höffler¹, Daniel Ourinson¹, Baljeet Singh Goraya¹, Gernot Emanuel¹, Fabian Meyer¹, Andreas Lorenz¹, Jonas Bartsch¹, Matthias Demant¹, Sebastian Nold¹, Andreas Wolf¹, Martin Zimmer¹, Ralf Preu¹, Klaus Ramspeck², Marc Hemsendorf³, Bendikt Straub⁴, Christian Ebert⁵, Matthias Drews⁶, Wolfgang Jooss⁷, Elina Schmid⁸, Stephan Schoenfelder⁹, Ringo Koepge¹⁰

¹Fraunhofer ISE, Freiburg im Breisgau, Germany; ²halm, Frankfurt am Main, Germany; ³GP Inspect, Neuried, Germany; ⁴RENA Technologies, Gütenbach, Germany; ⁵SCHMID Group, Freudenstadt, Germany; ⁶ASYS, Dornstadt, Germany; ⁷RCT Solutions, Konstanz, Germany; ⁸ISC Konstanz, Konstanz, Germany; ⁹Leipzig University of Applied Science, Leipzig, Germany; ¹⁰Fraunhofer CSP, Halle (Saale), Germany

1DO.11.5**Screen-Printing of Fire-Through Ag Paste on APCVD (n) Poly-Si Passivating Contacts**

Raphael Glatthaar¹, Tobias Okker¹, Frank Huster¹, Sven Seren², Giso Hahn¹, Barbara Terheiden¹

¹University of Konstanz, Konstanz, Germany; ²SCHMID Group, Freudenstadt, Germany

1DO.11.6**Efficiency Increase and Rear Contact Formation of TOPCon Cells via LECO**

Hannes Höffler¹, Tobias Fellmeth², Alexander Haack², Katrin Krieg², Sebastian Mack², Eve Krassowski⁴, Bishal Kafle², Johannes Greulich²

¹Fraunhofer ISE, Freiburg im Breisgau, Germany; ²CE Cell Engineering, Kabelsketal, Germany

Oral Presentations 4DO.16

08:30- 10:00 Concentrators and Space PV

Chairpersons:

Ignacio ANTÓN HERNÁNDEZ
UPM, Madrid, *Spain*

Jose Ramon GONZALEZ
ESA, Noordwijk, *The Netherlands*

4DO.16.1

Avoiding Shading Losses in Concentrator Photovoltaics Using a Soft-imprinted Cloaking Geometry

Stefan Wil Tabernig^{1,2}, Anastasia H. Soeriyadi², Udo Römer², Andreas Pusch², Dimitry Lamers¹, Michael Nielsen², Albert Polman¹, Nicholas Ekins-Daukes²

¹AMOLF, Amsterdam, Netherlands; ²UNSW, Kensington, Australia

4DO.16.2

A New Method to Analyse the Soiling in Multi-Junction, III-V Based CPV Modules

Gianluca Timò¹, Nicola Castagnetti¹, Alessandro Minuto¹, Edoardo Celi¹, Stefano Rizzi¹

¹RSE, Piacenza, Italy

4DO.16.3

Optical Design and Optics Manufacturing of a Highly Integrated Micro-CPV for Space Applications

Anderson Bermudez-Garcia¹, Philippe Voarino¹, Olivier Raccurt¹

¹CEA, Le Bourget Du Lac, France

4DO.16.4

Particle-induced Degradation of III-V Multi-Junction Solar Cells under Different Configurations of Displacement Damage Dose

Sophie Duzellier¹, Thierry Nuns¹, Romain Rey¹, Claude Pons¹, Soufian Yjjou², Athina Varotsou², Carsten Baur³, Christel Noemayr⁴, Ainhua Martinez de Olcoz⁵, Ana Gras⁵

¹ONERA, Toulouse, France; ²TRAD, Labège, France; ³ESA, Noordwijk, Netherlands; ⁴Airbus Defence and Space, Munich, Germany; ⁵Spasolab INTA, Torrejón de Ardoz, Spain

4DO.16.5

Ultra-Lightweight Inverse Metamorphic grown Multijunction Solar Cells for Space Applications

Malte Klitzke¹, Jonas Schön¹, Rosalinda H. van Leest², Gunther M. M. W. Bissels², Elias Vlieg², Michael Schachtner¹, Gerald Siefer¹, Frank Dimroth¹, David Lackner¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany; ²tf2 devices, Nijmegen, Netherlands

Visual Presentations 3DV.1

08:30- 10:00 Module Design and Manufacturing Posters

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 4DO.2

10:30- 12:00 Performance, Degradation and Faults of PV Systems

Chairpersons:

Dirk STELLBOGEN
ZSW, Stuttgart, Germany

Joshua S. STEIN
Sandia National Labs, Albuquerque, United States

4DO.2.1

Assessment of String Performance Using Self-referencing Method in Comparison to Performance Ratio

Claudia Buerhop-Lutz¹, Tobias Pickel¹, Jens Hauch¹, Marius Peters¹

¹HI ERN, Erlangen, Germany

4DO.2.2

Global Quantitative Study of PV Condensation and Soiling

Benjamin Figgis¹, Marília Braga², Muhammad Zahid Khan³, Carlos David Rodríguez-Gallegos⁴, Aaron Sahm⁵, William Snyder⁶, Laurie Burnham⁶, Fabian Wolfertstetter⁷, Fernanda Norde Santos⁷, Sebastian Dittmann⁸, Veronica Bermudez Benito¹, Brahim Aissa¹, Giovanni Scabbia¹

¹QEERI, Qatar; ²Fotovoltaica-UFSC, Brazil; ³Fraunhofer CSP, Germany; ⁴SERIS, Singapore; ⁵University of Nevada, United States; ⁶Sandia National Laboratories, United States; ⁷DLR- German Aerospace Center, Spain; ⁸Anhalt University of Applied Sciences, Germany

4DO.2.3

Combined Soiling and Degradation (CODS) with Validation against Independent Soiling Station Measurements

Magnus Moe Nygård¹, Åsmund Skomedal¹, Marie Syre Wiig¹, Erik Stensrud Marstein¹

¹Institute for Energy Technology, Kjeller, Norway

4DO.2.4

Development and Evaluation of an Automatic Failure Detection System for O&M of PV Portfolios

Eduardo Abdon Sarquis Filho^{1,2}, Bernd Kollosch³, Björn Müller¹, Nicolas Holland⁴, Klaus Kiefer⁴, Christian Reise⁴, Paulo J. Costa Branco²

¹ENMOVA, Freiburg, Germany; ²IDMEC, Lisboa, Portugal; ³Pohlen - Bedachungen, Geilenkirchen, Germany; ⁴Fraunhofer ISE, Freiburg im Breisgau, Germany

4DO.2.5

RoboPV: an Aerial Robots' Embedded Code for Intelligent Monitoring and Fault Detection of Large-Scale PV Plants Using Deep Neural Network Models

Amir Mohammad Moradi Sizkouhi¹, Seyyed Majid Esmailifar², Mahdi Karimkhani², Mohammadreza Aghaei³

¹Concordia University, Montréal, Canada; ²Amirkabir University of Technology, Tehran, Iran; ³NTNU, Ålesund, Norway

Oral Presentations 2DO.7

10:30- 12:00 CIGS and CIGS_{Se}, Module Efficiency and Stability

Chairpersons:

Alessandro ROMEO
University of Verona, Verona, Italy

Ana KANEVCE
ZSW, Stuttgart, Germany

2DO.7.1

Improved World Record Efficiency of CIGS_{Se} 30x30cm² Laminated Module with Cd-free Sputtered ZnOS Buffer Layer

Patrick Eraerds¹, Hossam Elanzeery¹, Matej Hala¹, Julian Röder¹, Stefan Grünsteidl¹, Christian Schubbert¹, Michael Algasinger¹, Thomas P. Niesen¹, Anastasia Zelenina¹, Marko Stölzel¹, Peter Borowski¹, Thomas Dalibor¹

¹AVANCIS, München, Germany

2DO.7.2

High-Performance CIGS Solar Cells on Low-Cost Low Carbon Steel

Maarten van der Vleuten¹, Ganesan Palaniswamy², Jacques Wijenberg², Marcel Simor³, Remi Aninat³

¹TNO, Eindhoven, Netherlands; ²TATA Steel, IJmuiden, Netherlands

2DO.7.3

Micro-Structured Semi-Transparent Cu(In,Ga)Se₂ Solar Cells

Pedro Santos¹, Pedro Anacleto¹, Shilpi Shital², Alice Debot², Phillip Dale², Sascha Sadewasser¹

¹INL, Portugal; ²University of Luxembourg, Luxembourg

- 2DO.7.4** **Insights into the Water-Induced Degradation Mechanisms on Field-deployed CIGS Modules**
 Simona Villa¹, Remi Aninat¹, Pelin Yilmaz^{1,2}, Aldo Kingma¹, Mikolaj Dziechciarz¹, Joran van den Berg¹, Klaas Bakker¹, Mirjam Theelen¹
¹TNO, Eindhoven, Netherlands; ²University of Twente, Enschede, Netherlands
- 2DO.7.5** **The Impact of Atmospheric Aerosol Pollutants on the Degradation of CIGS-Based Solar Cells**
 Adèle Debono^{1,2}, Shan-Ting Zhang², Noor Fikree^{1,2}, Inger Odnevall³, Nathanaelle Schneider², Jean-Francois Guillemoles², Polina Volovitch¹
¹Chimie ParisTech-CNRS, PSL Research University, Paris, France; ²IPVF, Palaiseau, France; ³KTH Royal Institute of Technology, Stockholm, Sweden
- 2DO.7.6** **Validation and Benchmarking of Physics-Based Thin-Film CIGS Electrical Model with Field Data**
 Santhosh Ramesh^{1,2,3,4}, Arttu Tuomiranta^{1,2,3}, Georgi H. Yordanov⁴, Jozef (Jef) Poortmans^{2,3,4}, Bart Vermang^{1,2,3}
¹Hasselt University, Hasselt, Belgium; ²Imec, Genk, Belgium; ³EnergyVille, Genk, Belgium; ⁴KU Leuven, Leuven, Belgium

Oral Presentations 1DO.12

10:30- 12:00 Silicon Manufacturing and Material Issues

Chairpersons:

Derk L. BÄTZNER (i)
 Meyer Burger Research, Hauterive, Switzerland

Pierre VERLINDEN
 AMROCK Pty Ltd., Sydney, Australia

- 1DO.12.1** **Vertical and Horizontal Integration of GW Scale Factories: the Future of Local Manufacturing for Global Markets Towards TW Scale PV?**
 Peter Fath¹, Wolfgang Jooss¹, Wolfgang Herbst², Sukumar Madugula¹, Mehul C. Raval¹
¹RCT Solutions, Konstanz, Germany; ²viridis.iq, Konstanz, Germany
- 1DO.12.2** **The Role of Silver Usage in Manufacturing Costs of Silicon Solar Cells**
 Yuchao Zhang¹, Nathan Chang¹, Moonyong Kim¹, Li Wang¹, Storm Drury¹, Robert Underwood¹, Michael Woodhouse², Brett Hallam¹
¹UNSW, Sydney, Australia; ²NREL, United States

1DO.12.3**Large Area Bifacial Inline Ni/Cu/Ag Plated iTOPCon Solar Cells Surpassing 24%**

Mathias Kamp¹, Damian Brunner¹, Markus Sieber¹, Benjamin Gröbel², Sven Kluska², Michael Passig¹, Benjamin Brix¹, Gisela Cimiotti², Christian Schmiga², René Haberstroh², Andreas Nägele², Andreas Brand², Sufan Xu³, Jim Wu³, Holger Kühnlein¹, Ulrich Jäger⁴, Stephen Fox²

¹RENA Technologies, Freiburg im Breisgau, Germany; ²Fraunhofer ISE, Freiburg im Breisgau, Germany; ³RENA Shanghai Trading, Shanghai, China; ⁴RENA Technologies, Gütenbach, Germany

1DO.12.4**Self-aligned Copper Electrodeposition Process for Silicon Heterojunction Solar Cells**

Agata Lachowicz¹, Nicolas Badel¹, Julien Gay¹, Gaëlle Andreatta¹, Nicolas Blondiaux¹, Antonin Faes¹, Juan J. Diaz Leon¹, Jun Zhao¹, Antoine Descoeudres¹, Bertrand Paviet-Salomon¹, Christophe Ballif¹

¹CSEM, Switzerland

1DO.12.5**Potential of Sputtered AZO Layers for the Industrial Manufacturing of Hetero Junction Solar Cells**

Eric Schneiderlöchner¹, Martin Dimer¹, Uwe Graupner¹, Alexandros Cruz², Bernd Stannowski³, Stefan Janke⁴, Stefan Wendlandt², Martin Bivour⁵, Winfried Wolke⁵

¹, Dresden, Germany; ², Berlin, Germany; ³, Freiburg im Breisgau, Germany

1DO.12.6**Reduction of Indium Deposition for Silicon Heterojunction Solar Cells with Short Term Industrial Perspective**

Frédéric Jay¹, Tristan Gageot¹, Raphael Cabal¹, Sylvain De Vecchi¹, Jordi Veirman¹, Benjamin Thiriot¹, Wilfried Favre¹

¹CEA, Le Bourget du Lac, France

Oral Presentations 3DO.17

10:30- 12:00 Backsheets and Encapsulations

Chairpersons:

Christian CAMUS
LayTec, Berlin, Germany

Guy BEAUCARNE
Dow Silicones, Seneffe, Belgium

3DO.17.1

Special Introductory Presentation: Crack Propensity of PV Backsheets – Comparison of Laminated and Co-extruded Backsheets

Gernot Oreski¹, Chiara Barretta¹, Astrid Macher¹, Gabriele C. Eder², Lukas Neumaier³, Markus Feichtner⁴, Minna Aarnio-Winterhof⁵

¹PCCL, Leoben, Austria; ²OFI, Wien, Austria; ³SAL Silicon Austria Labs, Villach, Austria; ⁴KIOTO SOLAR, Sankt Veit an der Glan, Austria; ⁵Borealis Polyolefine, Linz, Austria

3DO.17.2

Quantification of Additives within Polymer Films in Photovoltaic Modules

Robert Heidrich¹, Anton Mordvinkin¹, Ralph Gottschalg¹

¹Fraunhofer CSP, Halle (Saale), Germany

3DO.17.3

Extensive Module Backsheet Qualification Protocol Correlated to SHJ Module Reliability

Timea Bejat¹, Marion Sérasset¹, Eszter (Esther) Voroshazi¹, Romain Soulas¹, Lorenzo Carbone², Lionel Sicot¹, Vincent Barth¹, Marion Vite¹, Gaetano Izzo², Antonino Ragonesi², Francesco Rametta², Alessandro Fucile², Cosimo Gerardi²

¹CEA, Le Bourget du Lac, France; ²ENEL Green Power, Catania, Italy

3DO.17.4

The Lamination Process Quantified Through In-Situ Optical Thermo-Mechanical Sensing

Philippe Nivelles^{1;2;3}, Tine Engelen^{1;3}, Tatjana Vavilkin⁴, Stefan Dewallef⁴, Jozef (Jef) Poortmans^{1;2;3;5}, Michaël Daenen^{1;3}

¹Hasselt university, Hasselt, Belgium; ²imec, Genk, Belgium; ³Energyville, Genk, Belgium; ⁴Soltech, Tienen, Belgium; ⁵KU Leuven, Leuven, Belgium

3DO.17.5

Are PV-Module Backsheets with an Outer Fluoropolymer Layer the Better Solution?

Jonathan Kriening¹, Peter Lechner¹, Maximilian Engel¹, Heiko Wirth¹, Dieter Geyer¹

¹ZSW, Stuttgart, Germany

Visual Presentations 5DV.2

10:30- 12:00 Sustainability Aspects, Life Cycle Analysis and Recycling of PV/ Experiences from Solar Energy Adoption

Poster Area

Chairpersons:

Ingrid WEISS (*i*)
WIP Renewable Energies, München, *Germany*

Annick ANCTIL (*i*)
Michigan State University, *United States*

Nigel TAYLOR
European Commission JCR, Ispra, *Italy*

Eero VARTIAINEN
Fortum Growth Oy, Fortum, *Finland*

Simona DE IULIIS
ENEA, Portici, *Italy*

Nives DELLA-VALLE
European Commission JRC, Ispra, *Italy*

5DV.2.1

Solenco Power: Hydrogen Storage for AC and DC Networks

Francisco López¹, Dr. Hugo Vandenborre¹

¹*Solenco Power, Turnhout, Belgium*

5DV.2.2

Batteries in Solar-driven Water Splitting System – Synergistic Efficiency Gain

Oleksandr Astakhov¹, LI-Chung Kin¹, Minoh Lee², Stefan Haas¹, Uwe Rau^{1,3},
Tsvetelina Merdzhanova¹

¹*Forschungszentrum Jülich, Jülich, Germany*; ²*University of Toronto, Toronto, Ontario, Canada*; ³*RWTH Aachen University, Aachen, Germany*

5DV.2.3

KALYON EV-ON Charge

Merve Tunçez¹, Ali Eren Kok¹, Duygu Kuzyaka¹, Fırat Es¹

¹*Kalyon PV, Ankara, Turkey*

5DV.2.4

Transient Response and Non-Linear Capacity Variation Aware Unified Equivalent Circuit Battery Model

Dafang Zhao¹, Ittetsu Taniguchi¹, Francky Catthoor², Takao Onoye¹

¹*University of Osaka, Suita, Japan*; ²*KU Leuven, Leuven, Belgium*

- 5DV.2.5** **Integrating Perovskite Photovoltaics and Nickel Cobalt Sulfide Catalysts for Efficient Hydrogen Evolution Reaction**
Hongjae Shim¹, Jaesung Yun¹
¹UNSW, Sydney, Australia
- 5DV.2.6** **Hydrogen Concept in the Commercial Sector with a H₂ Bus for the Use of PV Yield**
Hannah Prinz¹, Henrik Te Heesen¹
¹Environmental Campus Birkenfeld, Hoppstädten-Weiersbach, Germany
- 5DV.2.7** **Evaluating PV Integration Strategies Considering High Resolution Embedded CO₂ Emissions of Grid Electricity**
Natasa Vulic¹, Martin Ruedisueli¹
¹EMPA, Dübendorf, Switzerland
- 5DV.2.8** **Solar Photovoltaic Floating Systems Assessment Through GIS-Multicriteria Analysis: a Case Study of the Marrakech-Safi Region' Dams in Morocco**
Fatima-Zahra Ouchani^{1,2}, Ouafae Jbahi^{1,2}, Ahmed Alami Merrouni³, Samir Idrissi Kaitouni¹, Abdellatif Ghennioui¹, Zakaria Naimi¹, Mohamed Maaroufi²
¹Green Energy Park, Ben Guerir, Morocco; ²Mohammadia School of Engineers, Rabat, Morocco; ³Mohammed First University, Oujda, Morocco
- 5DV.2.9** **Reactive Power Control in PV Systems through (explainable) Artificial Intelligence**
Christian Utama¹, Christian Meske², Johannes Schneider³, Rutger Schlatmann⁴, Carolin Ulbrich⁴
¹Free University of Berlin, Berlin, Germany; ²Ruhr University Bochum, Bochum, Germany; ³University of Liechtenstein, Vaduz, Liechtenstein; ⁴HZB, Berlin, Germany
- 5DV.2.10** **Technical, Business and Regulatory Approaches to Enhance Renewable Energy Capabilities to Take Part Actively in the Electricity and Ancillary Services Markets**
Hanna Bartoszewicz-Burczy¹
¹Institute of Power Engineering, Warszawa, Poland
- 5DV.2.11** **Six Years of Development and Field Experice in Residential PV Buildings with Maximum Power Self-Consumption and Grid Friendly Operatione**
Thomas Nordmann¹, Ralph Lingel¹
¹TNC Consulting, Meilen, Switzerland

- 5DV.2.12** **Matching Photovoltaics and Heat Pumps - Against the Peak**
 Paul Grunow¹
¹Trier University of Applied Sciences, Berlin, Germany
- 5DV.2.13** **Highly efficient Indoor Charging of Sodium Ion Battery with Lead Halide Perovskite under LED Lighting**
 Li-Chung Kin¹, Tsvetelina Merdzhanova¹, Zhifa Liu¹, Hans Kungl¹, Sergey Shcherbachenko¹, Thomas Kirchartz¹, Rüdiger-A. Eichel¹, Uwe Rau^{1,3}, Oleksandr Astakhov¹
¹Forschungszentrum Jülich, Jülich, Germany; ²RWTH Aachen University, Aachen, Germany
- 5DV.2.14** **Assessment of Non-Isolated Microgrid Potential for Increased Reliability in Medium Voltage Feeders**
 Pedro Torres¹, João Tavares Pinho¹, Roberto Zilles¹
¹University of São Paulo, Sao Paulo, Brazil
- 5DV.2.15** **Impedance, Inertia and Delays of Serbian Energy Transition**
 Ilija Batas Bjelic¹
¹Institute of Technical Sciences of SASA, Beograd, Serbia
- 5DV.2.16** **Leveraging Industry Energy Flexibility to Enable Higher Shares of Renewable Energy in the Power System – an Experimental Case Study**
 Yahya Kenoussi¹, Jesus S. Da Costa Fernandes¹, Edgar Schmitt¹, Rainer Gasper¹, Niklas Hartmann¹, Michael Schmidt¹
¹University of Applied Sciences Offenburg, Offenburg, Germany
- 5DV.2.17** **Analysis of the Spatial and Temporal Variability of Solar Radiation and its Use in the Design of Energy Systems**
 Jannik Langenecker¹, Edgar Schmitt¹, Michael Schmidt¹
¹University of Applied Sciences Offenburg, Offenburg, Germany
- 5DV.2.18** **Improving the Modelling of PV Systems in Grid Optimisation Studies by Using Earth Observation and Remote Sensing Data**
 Jethro Betcke¹, Susanne Weyand¹, Alaa Alhamwi¹, Annekatrin Metz-Marconcini², Thomas Krauß², Seyedmajid Azimi², Marion Schroedter-Homscheidt¹
¹DLR- German Aerospace Center, Oldenburg, Germany; ²DLR- German Aerospace Center, Wessling, Germany

- 5DV.2.19** **The Impact of Low-Temperature Thermal Energy Storage on the Performance of Compressed Air Energy Storage Integrated with PV for Building Application**
 Elaheh Bazdar¹, Fuzhan Nasiri¹, Fariborz Haghighat¹
¹*Concordia University, Montréal, Canada*
- 5DV.2.34** **CO2 Emissions of Silicon Photovoltaic Modules – Impact of Module Design and Production Location**
 Christian Reichel¹, Amelie Müller¹, Lorenz Friedrich¹, Sina Herceg¹, Max Mittag¹, Holger Neuhaus¹
¹*Fraunhofer ISE, Freiburg, Germany*
- 5DV.2.35** **About the Recycling of Various Silicon Waste from Photovoltaics**
 Wolfram Palitzsch¹, Ingo Röver²
¹*LuxChemtech, Freiberg, Germany*
- 5DV.2.36** **Photovoltaic Waste Management – Review within the Circular Economy**
 Asmin Aşkın¹, Şiir Kılış², Bulent Gultekin Akinoglu¹
¹*ODTÜ - GÜNAM, ANKARA, Turkey;* ²*Ilmenau University of Technology, ANKARA, Turkey*
- 5DV.2.37** **Innovation, Repowering and Sustainability**
 Ian Marius Peters¹, Jens Hauch¹, Christoph Brabec¹
¹*Forschungszentrum Jülich, Erlange, Germany*
- 5DV.2.38** **Estimating the Lifetime of Solar Photovoltaic Modules in Australia**
 Verity Tan¹, Pablo Dias¹, Rong Deng¹, Nathan Chang¹
¹*UNSW, Sydney, Australia*
- 5DV.2.39** **Potential and Risk of PV Waste Management in Europe – PHOTORAMA Circular Model**
 Claire Agrafeil¹, David Pelletier¹, Karsten Wambach², Wolfram Palitzsch³
¹*CEA, Le Bourget du Lac, France;* ²*bifa Environmental Institute, Augsburg, Germany;* ³*LuxChemtech, Freiberg, Germany*
- 5DV.2.40** **Characterising the Composition of End-of-Life Solar Panel Materials in Australia**
 Rong Deng¹, Olivia Bowen¹, Pablo Dias¹, Renate Egan¹
¹*UNSW, Sydney, Australia*

- 5DV.2.41** **A Comparative Life-Cycle Assessment of Renewable Energy from High Efficiency Solar Photovoltaic Technologies**
Andrea Danelli¹, Elisabetta Brivio¹
¹RSE, Milano, Italy
- 5DV.2.42** **Life Cycle Assessment Analysis of Thin-film, Flexible Solar Panels Produced in the Netherlands**
Gianluca Limodio¹, Edward Hamers², Arno Smets¹
¹Delft University of Technology, Netherlands; ²HyET Solar Netherlands, Netherlands
- 5DV.2.43** **A Literature Overview: Environmental Assessments of CIGS Thin Film Including its End of Life (EoL) Options**
Natasha Witto¹, Mirjam Theelen², Ando Kuypers², Mitchell van der Hulst^{3,4}, Arjan Kirkels¹, Mara Hauck^{1,3}
¹Eindhoven University of Technology, Eindhoven, Netherlands; ²TNO, Eindhoven, Netherlands; ³TNO, Utrecht, Netherlands; ⁴Radboud University, Nijmegen, Netherlands
- 5DV.2.44** **Energy Transition, Solar PV and Circular Economy: Triple Helix Approach to a Second Life for PV Modules in Chile**
Maria José Riquelme¹, Nouha Gazbour², Denet Soler¹, Edward Fuentealba¹, Delfina Muñoz²
¹University of Antofagasta, Antofagasta, Chile; ²CEA, Le Bourget-du-Lac, France
- 5DV.2.45** **Carbon Payback Time for Mainstream PV is too Long for an Increasing Number of Countries, already 8 Years for the Netherlands**
Michiel Mensink¹
¹Energist, 's-Gravenhage, Netherlands
- 5DV.2.46** **Life-Cycle Global Warming Impact of Photovoltaic Powered Electrolysis and Hydrogen Import from Africa**
Olga Kanz¹, Franka Brüggemann¹, Uwe Rau¹, Kaining Ding¹, Karsten Bittkau¹, Angèle Reinders^{2,3}
¹Forschungszentrum Jülich, Jülich, Germany; ²Technical University of Darmstadt, Eindhoven, Netherlands; ³University of Twente, Enschede, Netherlands
- 5DV.2.47** **Science Dissemination in Photovoltaics? ... a “Game” for Youngsters**
Marica Mariaconcetta Canino¹, Mirko Seri¹, Armida Torreggiani¹, Simona Binetti², Alessia Le Donne²
¹CNR, Bologna, Italy; ²University of Milano-Bicocca, Milan, Italy

- 5DV.2.48** **Influence of Factory Locations and Supply Chain on the Environmental Impact of Metallurgical Silicon Production for Solar Cells**
 Jan-Philipp Mai¹, Steffen Blömeke², Jianpeng Yang¹, Robar Arafat², Juan Felipe Cerdas², Christoph Herrmann²
¹JPM Silicon, Braunschweig, Germany; ²TU Braunschweig, Germany
- 5DV.2.49** **Combining Circularity and Environmental Metrics to Guide Technology Development in PV**
 Aistis Rapolas Zubas¹, Estelle Gervais¹, Sina Herceg¹, Sebastian Nold¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany
- 5DV.2.50** **New Approaches for Recovering and Recycling EVA and Back Sheet from c-Si EOL PV Modules from India**
 Divya Jain¹, Douglas Halliday¹, Marek Szablewski¹, Namrata Sengar²
¹Durham University, Durham, United Kingdom; ²University of Kota, Kota, India
- 5DV.2.51** **Bright Prospects for Circularity in PV in India**
 Jaideep Malaviya¹
¹Malaviya Solar Energy Consultancy, India
- 5DV.2.52** **Inventory of Waste Materials from Silicon Ingot and Wafer Manufacturing for a Circular PV Value Chain**
 Yijiang Xu¹, Gaute Stokkan¹, Anne-Karin Sjøiland², Mina Elise Holter¹, Birgit Rynningen¹, Irene Bragstad¹, Martin P. Bellmann¹
¹SINTEF Industry, Norway; ²ReSiTec AS, Norway
- 5DV.2.65** **Simulation of the Officially Announced Renewable Expansion Plan for Germany - Potential Problems and Opportunities Illustrated in Exemplary Scenario Weeks**
 Simon Forster¹
¹Rosenheim University of Applied Sciences, Rosenheim, Germany
- 5DV.2.66** **Proposal of an Alternative for Developing a Global Grid Able to Provide 100% Renewable Power to the World**
 Ralf Leutz¹, Ana Rosa Lagunas²
¹TOMATO-GSL, Munich, Germany; ²Tokyo University of Science, Munich, Germany
- 5DV.2.67** **Economic Optimisation of Supportive and Protective Policy Mechanisms for Promoting Local PV Manufacturing in the Global Market**
 Mohammad Dehghanimadvar¹, Nathan Chang¹, Renate Egan¹
¹UNSW, Sydney, Australia

5DV.2.68

Updates from the AgroFossilFree Project - Strategies and Technologies to Achieve a European Fossil-Energy-Free Agriculture

Chuan MA¹, Dominik Rutz¹, Veronika Hofmeier¹, Rainer Janssen¹, Athanasios T. Balafoutis², Konstantinos Vaiopoulos², Claus Aage Grøn Sørensen³, Dimitris Manolakos⁴, Alex Koutsouris⁴, George Papadakis⁴, Magdalena Borzecka⁵, Daan Creupelandt⁶, Julio Román⁷, Vanja Bisevac⁸, Frank Oudshoorn⁹, Daniele Rossi¹⁰, Martyna Próchniak¹¹, Michail D. Kaminariaris¹², Zisis Tsiropoulos¹², Harm Brinks¹³, Barry Caslin¹⁴, Jorge Sneij¹⁵, Mirentxu Asín¹⁶

¹WIP Renewable Energies, Germany; ²CERTH, Greece; ³Aarhus University, Denmark; ⁴Agricultural University of Athens, Greece; ⁵IUNG, Poland; ⁶REScoop, Belgium; ⁷ECAF, Belgium; ⁸CEMA - European Agricultural Machinery Industry Association, Belgium; ⁹Landbrug & Fodevarer, Denmark; ¹⁰Confagricoltura, Italy; ¹¹Lublin Agricultural Advisory Center in Konskowola, Poland; ¹²AGENSO, Greece; ¹³DELPHY, Netherlands; ¹⁴TEAGASC, Ireland; ¹⁵Trama TecnoAmbiental, Spain; ¹⁶Iniciativas Innovadoras, Spain

5DV.2.69

PV Will Shine in the New Clean Energy Transition Partnership

Stefan Nowak¹, Marcel Gutschner¹, Michael Hübner², Marko Topic³

¹NET Nowak Energy & Technology, Sankt Ursen, Switzerland; ²Technikum Wien, Vienna, Austria; ³University of Ljubljana, Ljubljana, Slovenia

5DV.2.70

Mobilisation of Financing Resources for Renewable Investments in Africa, India and South America to Reach the 1.5°C Goal

Winfried Hoffmann¹, Heinz-Werner Binzel²

¹ASE, Hanau, Germany; ²Private, Langenselbold, Germany

5DV.2.71

Multilateral Industrial Research on Solar Energy – the Success Story of INES.2S

Jens Merten¹, Anis Jouini², Frédéric Storck³, Philippe Raffin⁴, Caroline Deforeit⁵, Stephane Grazi⁶, Gilles Duissard⁷, Hervé Druon², Philippe Galez⁸

¹INES.2S, France; ²INES, France; ³CNR, France; ⁴Colas, France; ⁵SteadySun, France; ⁶Renault, France; ⁷2CA, France; ⁸USMB, France

5DV.2.72

Analysis of Future Solar Power Generation Feasibility in Australia Using High-Resolution Regional Climate Model Projections

Shukla Poddar^{1,2}, Merlinde Kay³, Jason Evans², Stephen Bremner², Abhnil Prasad²

¹UNSW, Kensington, Australia; ²UNSW, Sydney, Australia

5DV.2.87

Savings by Net-Metering PV in a Spanish Household

Hugo-José Rodríguez San Segundo¹, Nair López²

¹Edhuna Consulting, Madrid, Spain; ²UAM, Madrid, Spain

- 5DV.2.88** **The Optimal Azimuth and Tilt Angle of BIPV Panels Considering the Prices at Electricity Spot Market**
Iva Batic¹
¹University of Belgrade, Belgrade, Serbia
- 5DV.2.89** **The Economics of Photovoltaic Performance and Loss Mitigation in Electricity Spot Markets**
Leonardo Micheli¹, Marios Theristis², Diego L. Talavera¹, Gustavo Nofuentes¹, Joshua S. Stein², Florencia Almonacid-Cruz¹, Eduardo F. Fernandez¹
¹University of Jaén, Jaén, Spain; ²Sandia National Laboratories, United States
- 5DV.2.90** **Economic Feasibility Study of Different Configurations of a High-Power Photovoltaic Irrigation System**
Rita Hogan Almeida¹, Celena Lorenzo¹, Luis Narvarte¹,
¹UPM, Madrid, Spain
- 5DV.2.91** **Evaluating the Economic Performance of an Off-Grid Storage-Less Hybrid Energy System Under the Guidance of Different Solar Forecasts**
Fuqiang Zhuang^{1,2}, Rodrigo Amaro e Silva¹, Thomas Carriere³, Benoit Gschwind¹, Yves-Marie Saint-Drenan¹, Philippe Blanc¹
¹MINES ParisTech, Sophia Antipolis, France; ²SPIE Industrie & Tertiaire, Serres-Castet, France; ³SOLAIS, Sophia Antipolis, France
- 5DV.2.92** **Economic Assessment of Small Scale Electrolysis Powered by Decentralized Rooftop PV in Europe**
Joeri De Pauw¹, Michael Kleemann¹, Frank Buysschaert²
¹KU Leuven, Gent, Belgium; ²KU Leuven, Sint-Michiels, Belgium
- 5DV.2.93** **Competitiveness Perspectives for Vertically Integrated Local PV Manufacturing Until 2025**
Philippe Macé¹, Elina Bosch¹, Gaëtan Masson¹, Monica Aleman¹, Adrien van Rechem¹, André Penas¹
¹Becquerel Institute, Belgium
- 5DV.2.109** **Quality Infrastructure for Solar Photovoltaic in India**
Saurabh Kumar¹
¹PTB, Braunschweig, Germany

5DV.2.125

In my Backyard Please! Testing a Co-Design Approach to Increase Local Support for a Multifunctional Solar Park

Merel Enserink¹, Rudi Van Etteger¹, Lianne Polinder², Floor Govers², Marieke Rietbergen², Thijs Sepers³, Ruben Peuchen⁴, Koen Straver⁴, Leo Van der Knaap⁴, Jan De Jong⁴, Ilkay Cesar⁴

¹Wageningen University & Research, Wageningen, Netherlands; ²Design Innovation Group, Netherlands; ³TS Visuals, Netherlands; ⁴TNO, Netherlands

5DV.2.126

Smart Strategies for the Transition in Coal Intensive Regions

Rita Mergner¹, Rainer Janssen¹, Dominik Rutz¹, Charalampos Malamatenios², Georgia Veziryianni², Dirk Knoche³, Anne Rademacher³, Rainer Schleppehorst³, Liliana Fonseca⁴, Rona Michie⁴, Angel Nikolaev⁵, Christian Doczekal⁶, Gregory (Greg) Arrowsmith⁷, Nicholas de la Vega⁷, Gloria Popescu⁸, Jasmina Mandic Lukic⁹, Igor Volchyn¹⁰, Dmytro Bondzyk¹⁰, Marcin Pietrzykowski¹¹, Marcin Chodak¹², Lee Guilfoyle¹³, Kenn Palmer¹³, Jan Frouz¹⁴, Marketa Hendrychova¹⁵, Sabina Irimie¹⁶

¹WIP Renewable Energies, München, Germany; ²CRES, Athens, Greece; ³FIB, Germany; ⁴University of Strathclyde, United Kingdom; ⁵BSERC, Bulgaria; ⁶GET, Austria; ⁷EUREC, United Kingdom; ⁸ISPE, Romania; ⁹ENTEL, Serbia; ¹⁰CETI, Ukraine; ¹¹UAK, Poland; ¹²University of Milano-Bicocca, Poland; ¹³Welsh Government, United Kingdom; ¹⁴Charles University in Prague, Czech Republic; ¹⁵Czech University of Life Sciences, Czech Republic; ¹⁶Jiu Valley Social Institute, Romania

5DV.2.127

Simple and Smart Communities for All

Rita Mergner¹, Dominik Rutz¹, Rainer Janssen¹, Angela Holzmann², Kerstin Schilcher³, Altan Sahin³, Natascha Fenz⁴, Ulfert Höhne⁴, Angel Nikolaev⁵, Mariya Trifonova⁵, Thekla Heinel⁶, Avigdor Burmeister⁶, Benjamin Dannemann⁷, Nikoloz Sumbadze⁸, Eszter Süle⁹, Slavica Robić¹⁰, Tijana Šimek¹⁰, Bence Kovacs¹¹, Krisztina Szabó¹²

¹WIP Renewable Energies, Germany; ²AEA, Austria; ³AEA, Austria; ⁴OurPower, Austria; ⁵BSERC, Bulgaria; ⁶BSU, Germany; ⁷DGRV, Germany; ⁸AYPEG, Georgia; ⁹REGEA, Croatia; ¹⁰MTVSZ, Hungary; ¹¹REXLEF, Hungary

5DV.2.128

Energy Communities-Challenge and an Opportunities for Energy Decentralization and Efficiency. A Comparison of PV Based Case-Studies with Different Control Strategies

Domenico Vito¹

¹Saint Petersburg Electrotechnical University, United States

5DV.2.129

Spatially Differentiated Assessment of Solar Park Potential in Germany Respecting Environmental, Socio-Technical and Socioeconomic Restrictions

Elham Fakharizadehshirazi¹, Christine Rösch¹

¹Karlsruhe Institute of Technology - KIT, Karlsruhe, Germany

5DV.2.130

Net-Metering Regulations and Sustainable Transition to Solar PV Technology – The Missing Behavioral Change in Pakistan

Iftikhar Shahid¹, Kafait Ullah², Clark Miller³, Muhammad Dawood⁴

¹NUST, Islamabad, Pakistan; ²NUST, Pakistan; ³Arizona State University, United States; ⁴New Mexico State University, United States

5DV.2.131

Italy 2050: a Pathway Towards 100% Renewables

Alessandro Virtuani¹

¹EPFL, Milan, Italy

5DV.2.132

How to Make a Solar PV-Based Energy Community Economically Attractive in Belgium?

Philippe Macé¹, Elina Bosch¹, Monica Aleman¹

¹Becquerel Institute, Belgium

Oral Presentations 4DO.3

13:30- 15:00 Performance and Monitoring of PV Systems

Chairpersons:

Gerhard MÜTTER
Energy Development, Vienna, Austria

Invited

4DO.3.1

Photovoltaic System Monitoring Using Peer Systems

Alba Alcañiz¹, Maitheli M. Nikam^{1,2}, Yitzi Snow², Miro Zeman¹, Olindo Isabella¹, Hesam Ziar¹

¹Delft University of Technology, Delft, Netherlands; ²Solar Monkey, Den Haag, Netherlands

4DO.3.2

A New Approach for Filtering PV Performance Data Based on Acceptance Bands Around the Ideal PV System Power Curve

Julián Ascencio-Vásquez¹, Zoe Defreitas¹

¹Envision Digital, Redwood City, United States

4DO.3.3

Evaluation of Bifacial PV Gain Projection by Use of Novel Side-By-Side Monofacial Reference and Application to a 150 MW PV Project

Dirk Stellbogen¹, Alexander Eckert², Peter Lechner¹, Olaf Schanz¹

¹ZSW, Stuttgart, Germany; ²EnBW Energie Baden-Württemberg, Stuttgart, Germany

4DO.3.4

Performance of Heterojunction PV Technologies at the Atacama Desert

Elias Urrejola¹

¹Atamostec, Antofagasta, Chile

4DO.3.5

Photovoltaics Modules and Systems Monitoring within HighLite H2020 Project

Antonin Faes¹, Nicolas Wyrsh², Gizem Nogay¹, Andreas Halm³, Jonathan Govaerts⁴, Loïc Tous⁴, Julius Denafas⁵, Thomas Regrettier⁶, Janez Krc⁷, Matevz Bokalic⁷, Alessandro Virtuani², Martin Heinrich⁸, Dirk Reinwand⁸, Hervé Colin⁹, Tadas Radavicius⁵, Renaud Langou¹, Tuukka Savisalo¹⁰, Andrew Fairbrother², Stefan Wendlandt¹¹, Ismail Kaaya⁴, Constantin Klyk³, Matthieu Despeisse¹, Kristijan Brecl⁷, Samuel Harrison⁹, Marko Topic⁷, Christophe Ballif¹

¹CSEM, Switzerland; ²EPFL, Switzerland; ³ISC Konstanz, Germany; ⁴imec, Belgium; ⁵Solitek, Lithuania; ⁶Voltec Solar, France; ⁷University of Ljubljana, Slovenia; ⁸Fraunhofer ISE, Germany; ⁹CEA, France; ¹⁰Valoe, Finland; ¹¹PI Berlin, Germany

4DO.3.6

Imagery and Monitoring Data Coupling Towards Complete PV Plant Diagnostics

Dhiaeddine Melliti¹, Duy Long Ha¹, Ioannis (John) Tsanakas¹, Laurent Sauvage², Pascal Raux², Philippe Bellon²,

¹INES, Le Bourget-du-Lac, France; ²Ener-Pacte, Lyon, France

Oral Presentations 2DO.8

13:30- 15:00 Ag Alloying in CIGS and Other Chalcogenide Solar Cells

Chairpersons:

Sascha SADEWASSER
INL, Braga, Portugal

Alex REDINGER (i)
University of Luxembourg, Luxembourg, Luxembourg

2DO.8.1

Impact of Ag on Device Properties of Cu(In,Ga)Se₂ Solar Cells

Ana Kanevce¹, Stephanie Essig², Stefan Paetel¹, Dimitrios Hariskos¹, Wolfram Hempel¹, Theresa Magorian-Friedlmeier¹

¹ZSW, Stuttgart, Germany; ²Institute for Photovoltaics, Stuttgart, Germany

2DO.8.2

High Efficiency Bifacial (Ag,Cu)(In,Ga)Se₂ Thin Film Solar Cells Grown at Low Temperature

Shih-Chi Yang¹, Tzu-Ying Lin², Mario Ochoa¹, Huagui Lai¹, Ayodhya Nath Tiwari¹, Romain Carron¹

¹EMPA, Switzerland; ²National Tsing Hua University, Taiwan

2DO.8.3

Absorber and Interface Properties of (Ag,Cu)(In,Ga)Se₂ Solar Cells: Results of the EFFCIS-II Project

Wolfram Witte¹, Dimitrios Hariskos¹, Rico Gutzler¹, Stefan Paetel¹, Matthias Maiberg², Semih Agca², Heiko Kempa², Roland Scheer², Dirk Hauschild^{3;4;5}, Elizaveta Pyatenko^{3;4}, Mary Blankenship⁵, Lothar Weinhardt^{3;4;5}, Clemens Heske^{3;4;5}, Azam Karami⁶, Oana Cojocaru-Mirédin⁶, Markus Mock⁷, Elaheh Ghorbani⁷, Karsten Albe⁸, Xiaowei Jin³, Reinhard Schneider³, Dagmar Gerthsen³, Sinju Thomas¹⁰, Jose Antonio Marquez-Prieto¹⁰, Daniel Abou-Ras¹⁰, Thomas Unold¹⁰, Roland Mainz¹⁰, Michael Dao³, Michael Hetterich³, Michael Powalla¹³

¹ZSW, Stuttgart, Germany; ²Martin Luther University, Halle, Germany; ³Karlsruhe Institute of Technology - KIT, Karlsruhe, Germany; ⁴Karlsruhe Institute of Technology - KIT, Eggenstein-Leopoldshafen, Germany; ⁵UNLV, Las Vegas, United States; ⁶RWTH Aachen University, Aachen, Germany; ⁷Technical University of Darmstadt, Darmstadt, Germany; ⁸TSEC, Darmstadt, Germany; ⁹HZB, Berlin, Germany

2DO.8.4

AG-Alloyed Wide Gap Cu(In,Ga)S₂ for Tandem Application: Optimization of Metallic Precursor and Sulfurization

Alexandre Crossay¹, Jackson Lontchi², Amelle Rebai¹, Baptiste Bérenguier¹, Eugène Bertin^{3,4}, Olivier Durand³, Nicolas Barreau⁴, Jean-Francois Guillemoles¹, Negar Naghavi¹, Daniel Lincot¹

¹CNRS, Palaiseau, France; ²IPVF, Palaiseau, France; ³University of Rennes, CNRS, Rennes, France; ⁴University of Nantes, CNRS, Nantes, France

2DO.8.5

Investigations on the Impact of RbF Post-deposition Treatment in ACIGS Solar Cells

Tim Helder¹, Ana Kanevce¹, Mario Zinßer¹, Rico Gutzler¹, Stefan Paetel¹, Theresa Magorian-Friedlmeier¹, Michael Powalla¹

¹ZSW, Stuttgart, Germany

2DO.8.6

Silver Incorporated Sb₂Se₃ Bi-layer Thin-Film Solar Cells: Mechanism for the Improved Schottky Barrier

Sanghyun (Philip) Lee¹, Michael McInerney²

¹Indiana State University, United States; ²Rose-Hulman Institute of Technology, United States

PANEL DISCUSSION DO.13

13:30- 15:00

Visual Presentations 3DV.3

13:30- 15:00 PV Module Reliability

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

Oral Presentations 4DO.4

15:15- 16:45 Inspecting Modules and Systems

Chairpersons:

João M. SERRA
University of Lisbon, Lisbon, *Portugal*

Dieter GEYER
ZSW, Stuttgart, *Germany*

4DO.4.1

Review of On-Site Inspection Techniques for the Qualification of PV Power Plants

Werner Herrmann¹, Gabriele C. Eder², Boris Farnung³, Gabi Friesen⁴, Marc Koentges⁵, Bernhard Kubicek⁶, Oliver Kunz⁷, Haitao Liu⁸, David Parlevliet⁹, Ioannis (John) Tsanakas¹⁰, Jan Vedde¹¹

¹TÜV Rheinland, Cologne, Germany; ²OFI, Vienna, Austria; ³VDE Renewables, Alzenau, Germany; ⁴SUPSI, Mendrisio, Switzerland; ⁵ISFH, Hamelin, Germany; ⁶AIT, Vienna, Austria; ⁷UNSW, Sydney, Australia; ⁸CAS, Beijing, China; ⁹Murdoch University, Perth, Australia; ¹⁰CEA, Le Bourget-du-Lac, France; ¹¹European Energy, Birkerød, Denmark

4DO.4.2

Evolution of Inverter Ground Impedances for PV-Modules with Various Backsheet Types

Claudia Buerhop-Lutz¹, Tobias Pickel¹, Oleksandr Stroyuk¹, Jens Hauch¹, Marius Peters¹

¹HI ERN, Erlangen, Germany

4DO.4.3

Identify, Analyse, Mitigate – Quantification of Technical Risks in PV Power Systems

Magnus Herz¹, Gabi Friesen², Ulrike Jahn³, Marc Koentges⁴, Sascha Lindig⁵, David Moser⁵

¹TÜV Rheinland, Cologne, Germany; ²SUPSI, Switzerland; ³VDE Renewables, Germany; ⁴ISFH, Germany; ⁵Eurac Research, Italy

4DO.4.4

Technical Considerations Resulting from Photovoltaic Module Heating During Electroluminescence Inspection

Lukas Koester¹, Emanuel Vallarella², David Moser¹

¹Eurac Research, Bozen, Italy; ²Huawei Nuremberg Research Center, Nürnberg, Germany

4DO.4.5

Outdoor Photoluminescence Imaging of PV Modules Based on String Inverter's IV Curve Sweeps

Marija Vukovic¹, Marko Jakovljevic¹, Andreas Svarstad Flø¹, Espen Olsen¹, Ingunn Burud¹

¹Norwegian University of Life Sciences, Ås, Norway

4DO.4.6

Evaluation of Snow Removal Methods for Rooftop Photovoltaics

Alexander Granlund¹, Mattias Lindh¹, Anna Malou Petersson¹, Tommy Vikberg²

¹RISE, Piteå, Sweden; ²RISE, Skellefteå, Sweden

Oral Presentations 2DO.9

15:15- 16:45 III-V and Related Compound Semiconductors

Chairpersons:

Gianluca TIMÒ
RSE, Piacenza, Italy

Roberta CAMPESATO
CESI, Milan, Italy

2DO.9.1

Special Introductory Presentation: How to Nicely Break Up? Engineering the Lift-Off of Tunable Epitaxial Germanium Foils for Multijunction Solar Cells

Valérie Depauw^{1;2;3}, Clément Porret², Roger Loo², Jinyoun Cho⁴, Guillaume Courtois⁴, Rufi Kurstjens⁴, Kristof Dessein⁴, Víctor Orejuela⁵, Ignacio Rey-Stolle⁵, Iván García⁵

¹Hasselt University, Belgium; ²imec, Belgium; ³EnergyVille, Belgium; ⁴Umicore, Belgium; ⁵UPM, Spain

2DO.9.2

Graphene/GaAs Templates for the Epitaxy of Releasable GaAs Thin Films: Towards Substrate Recycling in III-V Photovoltaics

Carlos Macias^{1;2}, Jean-Christophe Harmand², Antonella Cavanna², Ali Madouri², Stephane Collin^{1;2}, Solène Béchu³, Andrea Cattoni^{1;2}, Amaury Delamarre^{1;2}

¹IPVF, Palaiseau, France; ²C2N, Palaiseau, France; ³ILV, Versailles, France

2DO.9.3

Electron Channeling Contrast Imaging of Defects after an Improved III-V Nucleation on Si(100) Including Al

Manali Nandy¹, Agnieszka Paszuk¹, Markus Feifel², Christian Koppka¹, Peter Kleinschmidt¹, Frank Dimroth², Thomas Hannappel¹

¹Ilmenau University of Technology, Germany; ²Fraunhofer ISE, Germany

2DO.9.4

Insights in Light Trapping Mechanisms in 100-NM-Thin GaAs Solar Cell with Subwavelength Nanopatterning

Daniel Micha^{1;2}, Maxime Giteau^{2;3}, Andrea Cattoni², Jean-Francois Guillemoles^{1;4}, Stephane Collin^{1;2}

¹IPVF, Palaiseau, France; ²C2N, Palaiseau, France; ³University of Tokyo, Meguro City, Tokyo, Japan; ⁴CNRS, Palaiseau, France

2DO.9.5

Overview and Loss Analysis of III-V Single-Junction and Multi-Junction Solar Cells

Masafumi Yamaguchi^{1,2}, Frank Dimroth³, John Geisz⁴, Nicholas Ekins-Daukes⁵, Nobuaki Kojima², Yoshio Ohshita²

¹Toyota Technological Institute, Nagoya, Japan; ²Fraunhofer ISE, Freiburg, Germany; ³NREL, Golden, United States; ⁴UNSW, Sydney, Australia

Oral Presentations 5DO.14

15:15- 16:45 Sustainability Aspects, Life Cycle Analysis and Recycling of PV

Chairpersons:

Karsten WAMBACH
Wambach-Consulting, Petersdorf, Germany

Martin P. BELLMANN
SINTEF, Trondheim, Norway

5DO.14.1

Insights into Current and Potentially Circular Material and Waste Flows from c-Si PV Industry

Peter Brailovsky¹, Kerstin Baumann², Boris Mertvoy², Estelle Gervais¹, Karsten Wambach², Ann-Kathrin Briem³, Sina Herceg¹, Michael Held³, Sebastian Nold¹, Jochen Rentsch¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany; ²bifa Environmental Institute, Augsburg, Germany; ³Fraunhofer IBP, Stuttgart, Germany

5DO.14.2

Sustainability of Photovoltaic System's Manufacture, Operation and Decommissioning in Future Net-Zero Emissions Scenarios

Antonio Urbina¹

¹Public University of Navarra, Pamplona, Spain

5DO.14.3

Toward a Sustainability-Driven Technological Roadmap for PV: Case Study with the Silicon Heterojunction Technology

Alexis Barrou¹, Laurie-Lou Senaud¹, Christophe Ballif¹, Bertrand Paviet-Salomon¹

¹CSEM, Neuchâtel, Switzerland

5DO.14.4

The Strategic Research and Innovation Agenda for Reliable, Bankable, Sustainable and Circular Solar PV

David Moser¹, Delfina Muñoz², Ulrike Jahn³

¹Eurac Research, Bolzano, Italy; ²CEA, Le Bourget-du-Lac, France; ³VDE Renewables, Alzenau, Germany

5DO.14.5**Identifying Methods to Reduce Emission Intensity of Centralised PV Deployment: Life Cycle Assessment Case Study of a 30MW PV Plant**

Storm Drury¹, Moonyong Kim¹, Pablo Dias¹, Yuchao Zhang¹, Robert Underwood¹, LI Wang¹, Pietro P. Altermatt², Brett Hallam¹

¹UNSW, Sydney, Australia; ²Trina Solar, Changzhou, China

5DO.14.6**End-of-Life Management of Solar Photovoltaic in the Energy Transition**

Jinlei Feng¹, Ute Collier¹, Emanuele Bianco¹, Anindya Bhagirath¹, Karsten Wambach², Garvin Heath³, Taylor Curtis³, Phoebe O'Connor³

¹IRENA, Abu Dhabi, United Arab Emirates; ²Wambach-Consulting, Germany; ³NREL, United States

Oral Presentations 3DO.18**15:15- 16:45 Module Ageing, Degradation and Simulation****Chairpersons:**

Ulrike JAHN
VDE Renewables, Alzenau, Germany

Eszter (Esther) VOROSHAZI
CEA, Le Bourget-du-Lac, France

3DO.18.1**Detailed Performance & Degradation Assessment of Different PV Technologies with more than 10 Years Lifetime**

Sascha Lindig¹, Atse Louwen¹, Lukas Koester¹, Alexander Astigarraga¹, David Moser¹

¹Eurac Research, Bolzano, Italy

3DO.18.2**Lifetime Prediction of Photovoltaic Modules: Towards a Generalized Physics-Based Approach**

Ismail Kaaya^{1;3}, Santhosh Ramesh^{1;3}, Arttu Tuomiranta^{1;3}, Arvid van der Heide^{1;3}, Julián Ascencio-Vásquez⁴, Ivan Gordon^{1;3}

¹imec, Genk, Belgium; ²Hasselt University, Hasselt, Belgium; ³Envision Digital, United States

3DO.18.3**A Study of Module Degradation From a 10-Year Installation in the Urban Tropical Environment**

Mauro Pravettoni¹, Amit Singh Rajput¹, Wan LI², Selvam Valliappan³

¹SERIS, Singapore, Singapore; ²VISTEC, Rayong, Thailand; ³BCA Academy, Singapore, Singapore

3DO.18.4

Silicon Heterojunction Solar Technology at the Gate of the Giga-Watt-Age: Reliability and Long-Term Performance

Olatz Arriaga Arruti¹, Alessandro Virtuani¹, Christophe Ballif^{1,2}

¹EPFL, Switzerland; ²CSEM, Switzerland

3DO.18.5

Extended Durability Tests of PV Modules Fabricated from Treated Solar Cells by Laser Enhanced Contact Optimization (LECO) And Energy Yield Comparison After 1 Year of Outdoor Exposure

Eve Krassowski^{1,2,3}, Bengt Jäckel², Matthias Pander², David Daßler², Stephanie Malik²

¹CE Cell Engineering, Kabelsketal, Germany; ²Fraunhofer CSP, Halle (Saale), Germany; ³Martin Luther University, Halle (Saale), Germany

3DO.18.6

Glass-Glass PV Modules: Characterization of Chemical and Mechanical Degradation

Laura Schelhas¹, Laura Spinella¹, Sonna Ulicna², Archana Sinha², Dana Sulas-Kern¹, Michael Owen-Bellini¹, Steve Johnston¹

¹NREL, Golden, United States; ²SLAC National Accelerator Laboratory, Menlo Park, United States

Visual Presentations 1DV.4

15:15- 16:45 Characterisation & Simulation of solar cells

Poster Area

Detailed information on this session is presented in the section entitled 'Visual Presentations'.

17:00- 18:30 Poster Award Winners Sessions

Oral Presentations 4DO.5

17:00- 18:30 PV System Optimization

Chairpersons:

Franz P. BAUMGARTNER
ZHAW, Winterthur, Switzerland

Urs MUNTWYLER
Dr. Schüpbach&Muntwyler, Bern, Switzerland

4DO.5.1

State-of-Play and Emerging Challenges in PV Energy Yield Simulations: a Multi-case Multi-model Benchmarking Study

Ioannis (John) Tsanakas¹, Ismael Lokhat², Arnaud Jay¹, Clément Gregoire¹, Branislav Schnierer³, Jozef Rusnak³, Lukas Dvornak³, Josephine Berthelot⁴, Chloé Monet⁵, Kevin Garcia⁵, Ivan Lombardero⁶, Jonathan Leloux⁷, Babacar Sarr⁷, Alfons Armbruster⁸, Jefferson Bor⁸

¹CEA, Le Bourget-du-Lac, France; ²Cythelia Energy, La Motte-Servolex, France;
³Solargis, Bratislava, Slovakia; ⁴Akuo, Paris, France; ⁵CNR, Lyon, France;
⁶Qualifying Photovoltaics, Madrid, Spain; ⁷LuciSun, Villers-la-Ville, Belgium;
⁸Fraunhofer ISE, Freiburg im Breisgau, Germany

4DO.5.2

End-User Financial Optimization of Commercial Rooftop Fixed-Tilt PV Systems

Jennifer Braid¹, Joshua S. Stein¹, Pierre Lacerte², Francois Gilles-Gagnon²

¹Sandia National Laboratories, Albuquerque, United States; ²Opsun Systems, Quebec, Canada

4DO.5.3

Wind Effects on PV-Structures: When and How to Design for Wind

Francesco Dorigatti¹, Matthew Browne², Chiara Pozzuoli¹, Zachary J. Taylor²

¹RWDI, Milano, Italy; ²RWDI, Guelph, Canada

4DO.5.4

Technical due Diligence of PV Trackers – a Key Ingredient for Success

Gerhard Weinrebe¹, Benjamin Sauer¹, Vinh Hiep Nguyen¹, Jack Lehrecke², Verena Göcke¹, Yue Pan¹, Thomas Keck¹, Minxiang Gao²

¹sbp sonne, Stuttgart, Germany; ²sbp, Berlin, Germany

4DO.5.5

Impact of Structural Elements on the Bifacial Energy Gain of Photovoltaic Arrays

Jesus Robledo Bueno¹, Babacar Sarr¹, Ibrahim El Boujdaini¹, Roxane Bruhwylter², Jonathan Leloux¹, Christian A. Gueymard³, Anton Driesse⁴, Frédéric Lebeau⁵

¹LuciSun, Villers-la-Ville, Belgium; ²University of Liege, Gembloux, Belgium;
³Solar Consulting Services, Colebrook, United States; ⁴PV Performance Labs, Freiburg, Germany

4DO.5.6

Bifacial PV Canopy System in High Latitude, Model Development and Validation with First Months of Monitoring Data

Samuli Ranta¹, Hugo Huerta Medina¹, Sami Jouttijärvi², Aleksi Heinonen³, Kati Miettunen²

¹TUAS, Turku, Finland; ²University of Turku, Turku, Finland; ³TUBITAK-NMI, Turku, Finland

Oral Presentations 5DO.10

17:00- 18:30 Regional Prospects / Societal Aspects in the Deployment of PV

Chairpersons:

Simona DE IULIIS
ENEA, Rome, *Italy*

Juzer VASI
IIT Bombay, Mumbai, *India*

5DO.10.1

Towards a Prosperous and Sustainable Africa

Roberto Vigotti

RES4Africa Foundation, Rome, Italy

5DO.10.2

Photovoltaic Solar Mapping of Vulnerable Areas as a Tool for the Development of Solar Energy Cooperatives in Slums

Diego Souza Caetano^{1,2}, Louise Land Bittencourt Lomardo², Barbara Simões de Breyer¹, Luciane Martins Do Pilar¹, Jhennyfer Rodrigues Parente¹

¹La Salle University Center of Rio de Janeiro, Brazil; ²UFF, Brazil

5DO.10.3

Cities as Pioneers of the Energy Transition: Evidence and Challenges from the Covenant of Mayors and the EU Cities Mission

Giulia Ulpiani¹, Valentina Palermo¹, Giulia Melica¹, Nadja Vettters¹, Paolo Bertoldi¹

¹European Commission JRC, Ispra, Italy

5DO.10.4

Consumers' Willingness to Pay for Residential Rooftop Photovoltaics in Pakistan

Inayatullah Jan¹, Riaz Shahid²

¹University of Agriculture Peshawar, Peshawar, Pakistan; ²University of Agriculture, Peshawar, Pakistan

5DO.10.5**Socio-economic Factors and Demographic Statistics behind the Deployment of Distributed Photovoltaic and Solar Thermal Systems in Sweden**

Sofia Ekbring¹, David Lingfors¹, Robert Johansson², Johan Lindahl³

¹Uppsala University, Sweden; ²Becquerel Sweden, Sweden; ³Chalmers University of Technology, Göteborg, Sweden

5DO.10.6**Assessment of Consumers' Willingness to Pay for Solar-Powered Bus Rides**

Si Ying Lee¹, Mavian Tay¹, Stephen Tay^{1,2}

¹NUS, Singapore, Singapore; ²SERIS, Singapore, Singapore

Oral Presentations 5DO.15

17:00- 18:30 Costs, Economics, Finance, Markets

Chairpersons:

Izumi KAIZUKA
RTS, Chuo-ku, Japan

Christian BREYER (i)
LUT University, Lappeenranta, Finland

5DO.15.1**A Snapshot of Global PV Markets - the Latest Survey Results on PV Markets and Policies from the IEA PVPS Programme in 2021**

Gaëtan Masson¹, Arnulf Jäger-Waldau², Izumi Kaizuka³, Johan Lindahl⁴, Jose Donoso Alonso⁵

¹IEA PVPS, France; ²European Commission JRC, Italy; ³RTS Corporation, Japan; ⁴Becquerel Sweden, Sweden; ⁵UNEF, Spain

5DO.15.2**Impact of Disruptive Technologies on PV Decarbonization Cost**

Billy Stanbery¹, Jao Van de Lagemaat²

¹Hamburg University of Applied Sciences, Tucson, United States; ²NREL, Golden, United States

5DO.15.3**Impact of Performance Degradation Curves on the Profitability of Solar Photovoltaic Projects**

Alessandro Virtuani¹, Luca Morganti¹, Mauro Pravettoni²

¹Officina del Sole, Milan, Italy; ²SERIS, Singapore, Singapore

5DO.15.4

Levelized Profits for Residential PV-Battery Systems in Germany: an Approach for a Comprehensive Investment Appraisal

Christopher Ball¹, Wilhelm Kuckshinrichs¹, Gianmarco Aniello¹

¹*Forschungszentrum Jülich, Jülich, Germany*

5DO.15.5

A Solar PV Profitability Study as a Function of Wholesale Market Price Variation Patterns

Philippe Macé¹, Elina Bosch¹, Monica Aleman¹, André Penas¹, Adrien van Rechem¹

¹*Becquerel Institute, Belgium*

5DO.15.6

The Influence of Falling Costs for Electrolysers on the Location Factors for Green Hydrogen Production

Raphael Niepelt^{1:2}, Marlon Schlemminger^{1:2}, Dennis Bredemeier^{1:2}, Florian Peterssen¹, Clemens Lohr³, Astrid Bensmann³, Richard Hanke-Rauschenbach³, Rolf Brendel^{1:2}

¹*ISFH, Emmerthal, Germany*; ²*Leibniz University of Hannover, Hanover, Germany*

Oral Presentations 3DO.19

17:00- 18:30 Stability Testing and Qualification of PV Modules

Chairpersons:

Teresa M. BARNES
NREL, Golden, *United States*

Christian THIEL
European Commission JRC, Ispra, *Italy*

3DO.19.1 Investigating Long-term UV-Durability of Glass/Transparent Backsheet Laminates for Bifacial Photovoltaics

Xiaohong Gu¹, Soshana Smith¹, Stephanie Moffitt¹, Stefan Mitterhofer¹,
Songsyun Jhang¹, Stephanie Watson¹, Li-Piin Sung¹

¹NIST, Gaithersburg, *United States*

3DO.19.2 Highly Accelerated Durability Testing of Encapsulant/PV Module Interfaces by Superposition of Cyclic Mechanical Stresses and Environmental Influences

Gabriel Riedl¹, Gernot M. Wallner¹, Robert Pugstaller¹

¹Johannes Kepler University, Linz, *Austria*

3DO.19.3 Damp Heat induced Degradation of SHJ Glass/Glass Modules with EVA: Insights into Root-causes and Mitigation Strategies

Luca Gnocchi¹, Olatz Arriaga Arruti¹, Alessandro Virtuani¹, Christophe Ballif¹

¹EPFL, Lausanne, *Switzerland*

3DO.19.4 Mitigating the Influence of LID and LETID on Damp Heat and Thermal Cycling Test Results

Esther Fokuhl¹, Georg Mülhöfer¹, Daniel Philipp¹, Viktor Wesselak², Thomas Mikolajick³, Paul Gebhardt¹

¹Fraunhofer ISE, Freiburg, *Germany*; ²University of Applied Sciences Nordhausen, Nordhausen, *Germany*; ³TU Dresden, Dresden, *Germany*

3DO.19.5 Influence of Production Processes on PID-s Sensitivity of c-Si Modules and Novel Mitigation Strategies

Alexander Stauffenberg^{1;2;3}, Bengt Jäckel^{1;2}, Matthias Pander^{1;2}, Jens Fröbel^{1;2},
Christof Erban⁴

¹Fraunhofer CSP, Halle (Saale), *Germany*; ²Fraunhofer IMWS, Halle (Saale), *Germany*; ³Martin Luther University, Halle (Saale), *Germany*; ⁴SUNOVATION, Elsenfeld, *Germany*

3DO.19.6

Hail Impact Test on PV Modules: Improving the Test Setup to 100mm Hail Class

Mauro Caccivio¹, Moreno Ronchi¹, Mattia Ceretti¹, Falvio Valoti¹, Giovanni Bellenda¹

¹*SUPSI, Mendrisio, Switzerland*

Oral Presentations 3EO.1

08:30- 10:00 Lifetime and Degradation/ System Components and Performance

Chairpersons:

Jens MOSCHNER
KU Leuven, Leuven, *Belgium*

Paul GEBHARDT (i)
Fraunhofer ISE, Freiburg, *Germany*

3EO.1.1

LeTID in Real Life: Incoming Cell Qualification for Module Manufacturers

Alison Ciesla¹, Arastoo Teymouri¹, LI Wang¹, Moonyong Kim¹, Catherine Chan¹, Ran Chen¹, Petra Manshanden², Bas Van Aken², Jakob Jan Dijksterhuis³, Brett Hallam¹, Gianluca Coletti^{1,2}

¹UNSW, Australia; ²TNO, Netherlands; ³Elsun, Netherlands

3EO.1.2

Towards Standardization of Accelerated Stress Testing Protocols for Metal-Halide Perovskite Photovoltaic Modules

Michael Owen-Bellini¹, Timothy J Silverman¹, Michael G. Deceglie¹, Paul Ndione¹, Nikos Kopidakis¹, Ingrid Repins¹, Mickey Wilson¹, Dana Sulas-Kern¹, Kirsten Perry¹, Robert White¹, Colin Sillerud², Prem Rana³, Jinsong Huang³, Zhaoning Song⁴, Michael Heben⁴, Yanfa Yan⁴, Tanka Rana⁵, Devin Mackenzie⁵, Bruce King⁶, Joshua S. Stein⁶, Joseph Berry¹, Laura Schelhas¹

¹NREL, Denver, United States; ²CFV Labs, Albuquerque, United States; ³University of North Carolina, United States; ⁴University of Toledo, Toledo, United States; ⁵University of Washington, Seattle, United States; ⁶Sandia National Laboratories, Albuquerque, United States

3EO.1.3

Worldwide Moisture Ingress Evaluation Using Finite Element Simulations and Machine Learning

Stefan Mitterhofer¹, Julián Ascencio-Vásquez^{2,3}, Xiaohong Gu¹

¹NIST, Gaithersburg, MD, United States; ²Envision Digital, Redwood City, CA, United States; ³ASVA Consulting, Santa Cruz de Tenerife, Spain

3EO.1.4

Quantifying the Energy Impact of Soiling thanks to the Tool SoilRatio

Eric Pilat¹, Hervé Colin¹, Remi Monna¹, Mohamed Amhal¹

¹CEA, Bourget du lac, France

3EO.1.5

Interaction of PV-Modules and Tracker Structure

Benjamin Sauer¹, Fabian Gross¹, Thomas Moschner², Markus Balz¹

¹sbp sonne, Stuttgart, Germany; ²sbp, Stuttgart, Germany

3EO.1.6

High Coupling Efficiency in directly coupled PV-battery Systems under Variable Irradiance, Temperature and Load

Sergey Shcherbachenko¹, Oleksandr Astakhov¹, Ugochi Kaosisochukwu Chime¹, LI-Chung Kin¹, Egbert Figgemeier^{1;4}, Kaining Ding¹, Bart E. Pieters¹, Uwe Rau^{1;4}, Tsvetelina Merdzhanova¹

¹Forschungszentrum Jülich, Jülich, Germany; ²RWTH Aachen University, Aachen, Germany

Oral Presentations 4EO.2

08:30- 10:00 PV System Design / Power Electronics

Chairpersons:

Giovanna ADINOLFI
ENEA, Portici, Italy

Marios THERISTIS
Sandia National Labs, Albuquerque, United States

4EO.2.1

The Hybridisation of Wave and Solar Energy to Provide Consistent Power to Islanded Loads

Macauley Versey¹

¹University of Edinburgh, Edinburgh, United Kingdom

4EO.2.2

A Model Correcting the Effect of Sub-Hourly Irradiance Fluctuations on Overload Clipping Losses in Hourly Simulations

Adrien Villos¹, Bruno Wittmer¹, André Mermoud¹, Michele Oliosi¹

¹Pysyst, Satigny, Switzerland

4EO.2.3

A General PV Plant Digital Twin Concept to Support the Complete Project Lifecycle

Imre T. Horvath¹, Joris Lemmens², Brett Birnie³, Thomas M. Hall³, Guillermo Oviedo-Hernandez⁴, Olivier Dupon², Arttu Tuomiranta², Virginijus Vasylius¹, Will Hitchcock³, Ivan Gordon²

¹PVcase, Vilnius, Lithuania; ²imec, Genk, Belgium; ³Above Surveying, Colchester, United Kingdom; ⁴BayWa, Rome, Italy

4EO.2.4

GaN based Panel-Integrated, High-Efficiency DC/DC Optimizer for Maximizing the Yield of the Large Photovoltaic Power Plant

Stephane Catellani¹, Van-Sang Nguyen¹, Anthony Bier¹, Tony Delaplagne¹, Patrick Merhej², Carlotta Greco², Fabrizio Bizzarri²

¹CEA, Le Bourget-du-Lac, France; ²ENEL Green Power, Milano, Italy

4EO.2.5

Data-Driven PV System Engineering: Comprehensive Modelling and Simulation of a Grid-Connected Three-Phase Inverter

Valeriya Titova¹, Leon Lahrmann¹, Frerk Haase¹, Zouhair Khadiri-Yazami², Martin Lapke¹

¹Hamburg University of Applied Sciences, Hamburg, Germany; ²SMA Solar Technology, Niestetal, Germany

4EO.2.6

Microinverter PV Systems: Formula for Energy Yield Assessment for any PV Panel Size at Different Microinverter Types

Stefan Krauter¹, Jörg Bendfeld¹

¹University of Paderborn, Paderborn, Germany

Oral Presentations 5EO.3

08:30- 10:00 Global, Regional and National Scenarios

Chairpersons:

Maria GETSIOU

European Commission, Brussels, *Belgium*

Philippe MALBRANCHE

International Solar Alliance, Chambéry, *France*

5EO.3.1

Estimates of Material Consumption for PV Towards Net-Zero Emissions by 2050

Robert Underwood¹, Moonyong Kim¹, Yuchao Zhang¹, LI Wang¹, Storm Drury¹, Pablo Dias¹, Pietro P. Altermatt², Brett Hallam¹

¹UNSW, Kensington, Australia; ²Trina Solar, ChangZhou, China

5EO.3.2

Sector-Coupled Energy Model for the European Electricity, Heat, and Transport Sectors - Results

Alexander Blinn¹, Henrik Te Heesen²

¹Toyota, Hoppstädten-Weiersbach, Germany; ²Trier University of Applied Sciences, Hoppstädten-Weiersbach, Germany

5EO.3.3

Australian Photovoltaic Potential in Different Climate Change Scenarios: Future Projections and Associated Costs

Alejandra Isaza¹, Merlinde Kay¹, Jason Evans¹, Stephen Bremner¹, Abhnil Prasad¹

¹UNSW, Sydney, Australia

5EO.3.4

Rapid Solar Photovoltaic Adoption by the United Nations with Evolving Smart Contracts and Demand Response

Manojit Ray¹

¹IIT Kharagpur, India

5EO.3.5

The Status of Photovoltaics in Italy and the Prospects for Contributing to the Goal of Energy Decarbonisation

Salvatore Guastella¹, Ezio Terzini²

¹RSE, Milano, Italy; ²ENEA, Portici, Italy

5EO.3.6

Screening of Potential Sites Adapted for hybrid PV+CSP Systems in Marrakesh-Safi-Morocco Using a GIS-AHP Analysis

Ouafae Jbahi^{1,2}, Fatima-Zahra Ouchani^{1,2}, Ahmed Alami Merrouni³, Mohamed Maaroufi¹, Abdellatif Ghennioui², Zakaria Naimi², Mohamed Cherkaoui¹

¹Mohammadia School of Engineers, Rabat, Morocco; ²Green Energy Park, Ben Guerir, Morocco; ³Mohammed First University, Oujda, Morocco

Plenary Presentations 5EP.1

10:30- 12:00 PV in the TW Era – Scenarios for Sustainable Energy Future

Chairpersons:

Stefan NOWAK

NET Nowak Energy & Technology, St. Ursen, Switzerland

Keiichi KOMOTO

Mizuho Research & Technologies, Tokyo, Japan

Annick ANCTIL (i)

Michigan State University, Michigan, United States

5EP.1.1

A Critical Review of Circular Economy for Photovoltaic Modules – Status, Challenges, and Opportunities

Garvin Heath^{1,2}, Dwarakanath Ravikumar¹, Brianna Hansen^{1,2}, Elaine Kupets¹

¹NREL, golden, United States

5EP.1.2

Renewable Energy Scenario - Where should all the Solar Panels go?

Thomas Reindl

National University of Singapore, Singapore, Singapore

5EP.1.3

Reflecting the Energy Transition from a European Perspective and in the Global Context – Relevance of Solar Photovoltaics Benchmarking Two Ambitious Scenarios

Christian Breyer¹, Dmitrii Bogdanov¹, Manish Ram¹, Siavash Khalili¹, Eero Vartiainen², David Moser³, Eduardo Román Medina⁴, Gaëtan Masson⁵, Arman Aghahosseini¹, Theophilus Mensah¹, Michael Schmela⁶, Raffaele Rossi⁶, Walburga Hemetsberger⁶, Arnulf Jäger-Waldau⁷

¹*LUT University, Finland*; ²*Fortum Growth, Finland*; ³*Eurac Research, Italy*;
⁴*Tecnalia, Spain*; ⁵*Becquerel Institute, Belgium*; ⁶*SolarPower Europe, Belgium*;
⁷*European Commission JRC, Italy*

5EP.1.4

Social Innovations as the Pathway Towards Energy Democracy and as Sustainable Solution for the Mitigation of the Global Warming: SocialRES

Silvia Caneva¹, Sonja Wilhelm¹, Iban Lizarralde², Mikhail Hamwi², Audrey Abi Akle², Basma Samir², Volker Kromrey³, Dimitri Vedel³, Jung Lin³, Andreas Schneller⁴, Jakob Hoffmann⁴, Kathrin Kohl⁴, Lisa Richter⁴, Elisabeth Schmid⁵, Alice De Ferrari⁵, Claudia Crippa⁵, Eleanor Denny⁶, Ivan Petrov⁶, Sofia Mulero⁷, Alejandro Hernández Serrano⁷, Patxi Bergara⁸, Iban Lacoste⁸, Maria Regidor⁹, Rodrigo Ruiz⁹, Santiago Campos⁹, Eva Otero⁹, Nuno Brito Jorge¹⁰, Inês Branco¹⁰, Karl Harder¹¹, Velimir Segon¹², Tijana Šimek¹², Alexandru Costeniuc¹³

¹*WIP Renewable Energies, München, Germany*; ²*ESTIA, Bidart, France*;
³*Bodensee-Stiftung, Radolfzell am Bodensee, Germany*; ⁴*adelphi, Berlin, Germany*; ⁵*ICONS, Lodi, Italy*; ⁶*Trinity College Dublin, Ireland*; ⁷*CARTIF Technology Center, Boecillo, Spain*; ⁸*I-ENER, Saint-Jean-le-Vieux, France*;
⁹*Energética, Valladolid, Spain*; ¹⁰*GoParity - Impact Investing, Lisboa, Portugal*;
¹¹*Abundance, United Kingdom*; ¹²*Regea, Zagreb, Croatia*; ¹³*Tractebel Engineering, Germany*

5EP.1.5

Invited

12:10- 13:45 Closing Session

Keynote, Highlights of the Conference, Poster Awards, Student Awards, Farewell

VISUAL PRESENTATIONS

MONDAY, 26 SEPTEMBER 2022

Visual Presentations 2AV.1

13:30- 15:00 Perovskite Photovoltaics

Poster Area

Chairpersons:

Sjoerd VEENSTRA
TNO, Eindhoven, *The Netherlands*

Udo BACH (*i*)
Monash University, Melbourne, *Australia*

2AV.1.1

Light-Soaking, Photo-Damage and Self-Healing in Halide Perovskites

Davide Raffaele Ceratti¹, David Cahen², Gary Hodes², Philip Schulz¹, Jean-Francois Guillemoles¹

¹IPVF, Palaiseau, France; ²Weizmann Institute of Science, Rehovot, Israel

2AV.1.2

Chemical Bath Deposition: Developing Large-Scale Fabrication of SnO₂ as Electron Transport Layer for NIP Perovskite-Based Solar Cells

Marion Provost¹, Iwan Zimmermann¹, Stephanie Gbegnon¹, Alexandre Blaizot¹, Aurelien Duchatelet², Jean Rousset²

¹IPVF, Palaiseau, France; ²EDF R&D, Palaiseau, France

2AV.1.3

Quantifying Energy Losses Due to Light Soaking Effect in Perovskite Solar Cells under Outdoor Conditions

Marko Remec^{1,2}, Spela Tomsic², Mark Khenkin¹, Quiterie Emery¹, Jinzhao Li¹, Eva Unger¹, Rutger Schlatmann¹, Marko Topic², Carolin Ulbrich¹

¹HZB, Berlin, Germany; ²University of Ljubljana, Ljubljana, Slovenia

2AV.1.4

Evaluation of Performance Measurements of Different Type Perovskite Devices at Different Measurement Conditions

Vasiliki Paraskeva¹, Maria Hadjipanayi¹, Matthew S.H. Norton¹, Aranzazu Aguirre², Afshin Hadipour², George Elias Georgiou¹

¹University of Cyprus, Nicosia, Cyprus; ²IMEC, Leuven, Belgium

- 2AV.1.5** **Enhanced Electronic Properties and Stability in Tin-Lead Mixed Halides Perovskite Solar Cells via Additive Engineering**
 Shahrir Razey Sahamir¹, Muhammad Akmal Kamarudin¹, Gaurav Kapil¹, Qing Shen¹, Shuzi Hayase¹
¹The University of Electro-Communications, Japan
- 2AV.1.6** **Using the Addition of Ethyl Acetate Anti-solvent to Enhance the Efficiency of Blade-coated Perovskite Solar Cells**
 Rui Yun Hsu¹, Tsung Chieh Cheng², Yu Chen Lin², Han Ting Sun², Yung-Liang Tung¹
¹ITRI, Tainan, Taiwan; ²NKUST, Kaohsiung, Taiwan
- 2AV.1.7** **Quantification of Spatially Resolved Electrical Properties of Laser Patterned, Interconnected Perovskite Solar Cells based on Hyperspectral Imaging**
 Christof Schultz¹, Markus Fenske¹, Guillaume Gélinas², Stéphane Marcet², Laura-Isabelle Dion-Bertrand², Janardan Dagar³, Andreas Bartelt¹, Rutger Schlatmann⁴, Eva Unger³, Bert Stegemann⁵
¹Berlin University of Applied Sciences, Berlin, Germany; ²Photon etc, Montréal, QC, Canada; ³HZB, Berlin, Germany
- 2AV.1.8** **Universal Homologous Bromides Passivation for High Performance Perovskite Solar Cells**
 Yong Li^{1,2}
¹CSIRO Energy, Newcastle, Australia; ²UNSW, Australia
- 2AV.1.9** **Influence of the Anion Choice on the Passivation with Ionic Liquids in Wide-Bandgap Inverted Perovskite Solar Cells**
 Florian Scheler¹, Silvia Mariotti^{1,2}, Daniele Pane Mantione³, Artem Musiienko⁴, Kari Sveinbjornsson¹, David Mecerreyes³, Steve Albrecht¹
¹HZB, Berlin, Germany; ²OIST, Okinawa, Japan; ³UPV/EHU, Donostia-San Sebastián, Spain
- 2AV.1.10** **Exploration of Sub-Bandgap States in 2D Halide 1 Perovskite Single-Crystal Photodetector**
 Eunyoung Choi¹, Yurou Zhang², Arman Mahboubi Soufiani¹, Minwoo Lee¹, Richard Webster^{1,4}, Michael E. Pollard¹, Peter Reece¹, Jongchul Lim⁶, Wonjong Lee⁶, Jan Seidel^{1,4}, Jung-Ho Yun², Jaesung Yun^{1,8}
¹UNSW, Sydney, Australia; ²University of Queensland, Queensland, Australia;
³Chungnam National University, Daejeon, Korea, Dem. People's Rep. of;
⁴University of Surrey, Guildford, United Kingdom

- 2AV.1.11** **First-Principles Prediction of the Current-Voltage Curve in Perovskite Solar Cells**
 Juan A. Anta¹, Gerko Oskam¹, Antonio J Riquelme¹, Karen L. Valadez-Villalobos¹, Renan Escalante-Quijano¹, Paul Pistor¹
¹*University Pablo de Olavide, Sevilla, Spain*
- 2AV.1.12** **Perovskite Based Solar Ink for Different Fabrication Processes**
 Anjusree Shyla¹, Deepak Thrithamarassery Gangadharan², Erin Moloney², Sahar Sam¹, Sonal Prajapati¹, Makhsud Saidaminov²
¹*Solaires Entreprises, Victoria, Canada; ²University of Victoria, Victoria, Canada*
- 2AV.1.13** **Analysis on Long-term Stability of Perovskite Solar Cells Using SCAPS-1D Simulation**
 Seongtak Kim¹, Younghun Jeong¹, Dong-Woon Han¹, Chan Bin Mo¹
¹*KITECH, Wonju, Korea, Rep. of South*
- 2AV.1.14** **New Photoactive Lead-free Perovskite Absorber: Process and Preliminary Characterization**
 Alexandre Py¹, Yifeng Zhong¹, Pallavi Singh², David Cahen², Géraud Delport¹, Davide Raffaele Ceratti¹, Javid Hajhemati¹, Claire Darin Bapaume¹, Paul-Alexis Pavard¹, Nathanaelle Schneider¹, Jean-Francois Guillemoles¹, Philip Schulz¹
¹*IPVF, Palaiseau, France; ²Weizmann Institute of Science, Rehovot, Israel*
- 2AV.1.15** **Size/Location-Dependent Effects of the Plasmonic AU Nanoparticles on the Performance of Perovskite Solar Cells**
 Oleksii Omelianovych¹, Nikolai Tsvetkov², Liudmila Larina¹, Kwanghyeon Jo³, BA Thong Trinh³, Ilsun Yoon³, Ho-Suk Choi¹
¹*Chungnam National University, Daejeon, Korea, Rep. of South; ²KAIST, Daejeon, Korea, Rep. of South*
- 2AV.1.16** **Testing EVA, PMMA and PVDF Encapsulated Perovskite Solar Cells in a Climatic Chamber by Following the International Summit on Organic Photovoltaic Stability (ISOS-T) Protocols.**
 Luis Ocaña^{1,2}, Carlos Montes^{1,2}, Sara González-Pérez³, Benjamin González-Díaz², Elena Llarena¹
¹*ITER, Granadilla, Spain; ²ULL, San Cristóbal de La Laguna, Spain*
- 2AV.1.17** **Effect of Passivation of the Nanostructured Electron Transport Layer on the Overall Solar Cell Efficiency**
 Ivana Panzic¹, Arijeta Bafti¹, Floren Radovanovic-Peric¹, Thomas Rath², Vilko Mandić¹
¹*University of Zagreb, Zagreb, Croatia; ²Graz University of Technology, Graz, Austria*

- 2AV.1.18** **Influence of the Electron Transport Layer Pre-treatment on the Efficiency of Perovskite Solar Cells**
Arijeta Bafti¹, Ivana Panžić¹, Luka Pavić², Maja Mičetić³, Vilko Mandić¹
¹University of Zagreb, Zagreb, Croatia; ²Ruđer Bošković Institute, Zagreb, Croatia
- 2AV.1.19** **The Effect of Different PH Level Towards Control of the Size, Composition and Surface Area of NIO as HTL for Inverted Perovskite Solar Cells**
Zul Atfyi Fauzan Mohammed Napiah¹, Subathra Muniandy¹, Muhammad Idzdihar Idris¹, Nurbahirah Norddin², Marzaini Rashid³, Luke Bradley⁴
¹UTeM, Malacca, Malaysia; ²USM, Penang, Malaysia; ³Newcastle University, Newcastle, United Kingdom
- 2AV.1.20** **Optimization of Coating Parameters for Enabling High-Performance Triple Cation Perovskite Solar Cell via Upscalable Hybrid Dry-Wet Deposition Route**
Van-Son Nguyen¹, Elisa Grépin¹, Iwan Zimmermann¹, Elise Bruhat², Olivier Dupré², Solenn Berson², Matthieu Manceau², Jean Rousset³
¹IPVF, France; ²CEA, France; ³EDF R&D, France
- 2AV.1.21** **Optimization of Physical Treatments of HTL for Perovskite Solar Cells**
Eleonora Quadrivi¹, Gianluigi Marra², Rosamaria Marrazzo², Alberto Savoini², Paolo Biagini¹, Gianni Corso¹, Sergio Fanutti², Camilla Marchini¹, Riccardo Po², Mario Salvalaggio², Fiorenza Simone¹
¹eni, Novara, Italy
- 2AV.1.22** **Interface Design of Perovskite Solar Cells: Application of Molecular Additives to Improve the Stability and the Performance**
Claire Darin Bapaume¹, Mathieu Frégnaux², Baptiste Béranguier¹, Muriel Bouttemy², Philip Schulz¹
¹IPVF, Palaiseau, France; ²ILV, Versailles, France
- 2AV.1.23** **Large Scale Characterization of Perovskite Mini-Modules (25 cm²) by Wide-Field Hyperspectral Luminescence Imaging**
Alexandra Levtchenko¹, Emilie Raoult², Sebastien Jutteau², Jean Rousset², Daniel Ory²
¹IPVF, Palaiseau, France; ²EDF R&D, Palaiseau, France
- 2AV.1.24** **Effect of ETL, and MAPbBr₃ Quantum Dots at HTL/Absorber Interface on the Performance of (SN,GE) Based Perovskite Solar Cells**
Vivek Garg¹, Ravula V. N. Sai¹, Swarna S. R. Reddy¹, Anjali Mantri¹, Gaurav Siddharth¹
¹SVNIT, Surat, India

- 2AV.1.25** **Numerical Modeling and Performance Enhancement of Carbon-Based Monolithic Perovskite Solar Cell Using Cesium Based Triple Cation Composition**
Zubair Ahmad¹, Ehsan Raza¹
¹*Qatar University, Doha, Qatar*
- 2AV.1.26** **Simulation of Ecofriendly Photovoltaic Device for Indoor Application by Using SCAPS 1-D**
Km Neeraj¹, Brajendra Sengar², Saurabh Mishra¹
¹*Centre for Advanced Studies, Lucknow, India;* ²*National Institute of Technology, Sri Nagar, India*
- 2AV.1.27** **H2020 Viperlab Knowledge Exchange Platform**
Francesco Roca¹, David Casaburi¹
¹*ENEA, Portici, Italy*
- 2AV.1.28** **Insight to Perovskite p-n Homojunction**
Meicheng Li¹, Peng Cui¹, Jun Ji¹, Hao Huang¹, Luyao Yan¹, Xinxin Wang¹, Shuxian Du¹, Benyu Liu¹, Shujie Qu¹, Qiang Zhang¹, Zhineng Lan¹, Yingying Yang¹
¹*North China Electric Power University, Beijing, China*
- 2AV.1.29** **Surface Passivation Layer Using S-Based Aprotic Organic Cation for Efficient and Stable PSCs**
Sanjay Sandhu¹, Bommaramoni Yadagiri¹, Senthilkumar Muthu¹, Ashok Kumar¹, Jae-Joon Lee¹
¹*Dongguk University, Seoul, Korea, Rep. of South*
- 2AV.1.30** **Performance Improvement of Carbon-Based Perovskite Solar Cells by Modification of the Cell Architecture**
Dena Pourjafari¹, Wendy Padron¹, Diecenia Peralta¹, Nidia García¹, Simone Meroni², Carys Worsley³, Becky Bolton², Trystan Watson², Geonel Rodríguez⁴, Gerko Oskam^{4;5}
¹*CINVESTAV, MERIDA, Mexico;* ²*Swansea University, Swansea, United Kingdom;* ³*UPO, Sevilla, Spain*
- 2AV.1.31** **Efficient Low Bandgap Perovskite Mid-cells Via Hybrid Evaporation-Solution Method for Triple Junction Solar Cells**
Mohammad Reza Golobostanfard¹, Xin Yu Chin¹, Kerem Artuk¹, Daniel Anthony Jacobs¹, Quentin Jeangros², Christian Wolff¹, Christophe Ballif^{1;2}
¹*EPFL, Neuchatel, Switzerland;* ²*CSEM, Neuchatel, Switzerland*

2AV.1.32

Modeling the Optical Properties of a Perovskite Solar Cell Film Stack

Maria Fernanda Villa Bracamonte¹, Jose Raul Montes Bojorquez¹, Arturo Ayon¹

¹The University of Texas at San Antonio, San Antonio, United States

2AV.1.33

Iodine-Induced Phase Segregation in Mixed-Halide Perovskites

Jakub Holovsky^{1,2}, Katarína Ridzoňová², Amalraj Peter Amalathas^{1,3}, Branislav Dzurňák¹, Lucie Landová^{1,2}, Petr Jiříček², Oleksandr Romanyuk²

¹ASCR, Prague, Czech Republic; ²University of Jaffna, Jaffna, Sri Lanka

2AV.1.34

Characterization and Degradation of Perovskite Mini-Modules

Rita Ebner¹, Gusztáv Újvári¹, Ankit Mittal¹, Maria Hadjipanayi², Vasiliki Paraskeva², George Elias Georgiou², Aranzazu Aguirre³, Afshin Hadipour³

¹AIT, Vienna, Austria; ²University of Cyprus, Nicosia, Cyprus; ³imec, Genk, Belgium

2AV.1.35

Perovskite Solar Cells Prepared in a Hybrid Process that Makes Use of Ambient and Moisture-Free Conditions to Produce HTM-free Architectures with Back Contact Based on Carbon and MAI in PVDF Compounds

Carlos Montes^{1,2}, Luis Ocaña^{1,2}, Sara González-Pérez³, Benjamin González-Díaz², Elena Llarena¹

¹ITER, Granadilla de Abona, Spain; ²ULL, San Cristóbal de La Laguna, Spain

2AV.1.36

Optimization of Pb(SCN)₂ Composition for Enhancing PSCs Long-Terms Stability

Karim Medjoubi¹, Jean Castillon¹, Thomas Guillemot¹, Dounya Barrit^{1,2}, Camille Bainier^{1,2}, Jean Rousset^{1,3}, Jorge Posada^{1,3}

¹IPVF, Palaiseau, France; ²TotalEnergies, Paris La Défense, France; ³EDF R&D, Palaiseau, France

2AV.1.37

Ageing of Perovskite Solar Cells: Indoor Stress Tests and Their Relevance for Outdoor Stability

Ulas Erdil¹, Mark Khenkin¹, Quiterie Emery¹, Hans Köbler¹, Antonio Abate¹, Eugene Katz³, Rutger Schlatmann¹, Carolin Ulbrich¹

¹HZB, Berlin, Germany; ²BGU, Midreshet Ben-Gurion, Israel

2AV.1.38

Environmental and Health Safety Risk Assessment for Perovskite Solar Cells and Modules

Christa Torrence¹, Cara Libby², Joshua S. Stein¹

¹Sandia National Laboratories, United States; ²Electric Power Research Institute, United States

- 2AV.1.39**
Sputtering of NiOx for HTL in Perovskite Tandem or Single Junction Applications
 René Köhler¹, Martin Fischer¹, Sebastian Gatz¹
¹VON ARDENNE, Dresden, Germany
- 2AV.1.40**
Safe and Scalable Solar Inks: Inkjet Printable Perovskite Absorber Layer Solutions for Solar Cells
 Josh Turner¹, Amanda Hughes¹, Laurie Phillips², Abhinav Singh¹
¹University of Liverpool, Liverpool, United Kingdom; ²Stephenson Institute for Renewable Energy, Liverpool, United Kingdom
- 2AV.1.41**
Light and Heat Induced Degradation of Encapsulated Carbon-Based Perovskite Solar Cells
 Nikoleta Kyranaki¹, Cynthia Farha², Lara Perrin², Lionel Flandin², Emilie Planès², Lukas Wagner³, Karima Sadeddine³, David Martineau⁴, Stéphane Cros¹
¹CEA, Le Bourget-du-Lac, France; ²Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, LEPMI, Grenoble, France; ³Fraunhofer ISE, Freiburg, Germany; ⁴Solaronix, Aubonne, Switzerland
- 2AV.1.42**
Revealing the Dynamics of Thermal Reaction Between Cu and Mixed Halide Perovskite Solar Cells
 Jihoo Lim¹, Eunyoung Choi¹, Moonyong Kim¹, Minwoo Lee¹, Daniel Chen^{1,2}, Martin A. Green¹, Jan Seidel¹, Jongsung Park⁴, Xiaojing Hao¹, Jae Sung Yun^{1,5}
¹UNSW, Sydney, Australia; ²Sundrive Solar, Kirrawee, Australia; ³Gyeongsang National University, Jinju, Korea, Rep. of South; ⁴University Of Surrey, United Kingdom
- 2AV.1.43**
Surface Engineering of ZnO Thin Film for the Growth of MAPbI3 Perovskite Layer
 Muhammad Idzdihar Idris¹, Subathra Muniandy¹, Zul Atfyi Fauzan Mohammed Napiiah¹, Zarina Baharudin Zamani¹, Marzaini Rashid², Luke Bradley³
¹UTeM, Durian Tunggal, Malaysia; ²USM, Gelugor, Malaysia; ³Newcastle University, United Kingdom
- 2AV.1.44**
Investigation of Perovskite Solar Cells Stability through Impedance Spectroscopy and Dark Current-voltage Characterizations
 Ilaria Matacena¹, Laura Lancellotti², Pierluigi Guerriero¹, Brigida Alfano², Eugenia Bobeico², Antonella De Maria², Vera La Ferrara², Lucia V. Mercaldo², Mara Miglietta², Tiziana Polichetti², Gabriella Rametta², Gennaro V. Sannino², Paola Delli Veneri², Santolo Daliento¹
¹University of Naples Federico II, Naples, Italy; ²ENEA, Portici, Italy

2AV.1.45

Slow Shallow Energy States as the Origin of Hysteresis in Perovskite Solar Cells

Paul A. Procel Moya¹, Rik van Heerden¹, Luana Mazzarella¹, Rudi Santbergen¹, Olindo Isabella¹

¹*Delft University of Technology, Delft, Netherlands*

2AV.1.46

Relevance of EQE for Perovskite Solar Cells Characterization

Lucia V. Mercaldo¹, Eugenia Bobeico¹, Antonella De Maria¹, Marco Della Noce¹, Manuela Ferrara¹, Vera La Ferrara¹, Laura Lancellotti¹, Gabriella Rametta¹, Gennaro V. Sannino¹, Iurie Usatii¹, Paola Delli Veneri¹

¹*ENEA, Portici (NA), Italy*

2AV.1.47

Energy Harvesting from a Single Lab-Scale Perovskite Solar Cells for Self-Powered Indoor IoT Applications

Darjo Ursic¹, Matija Pirc¹, Marko Jošt¹, Marko Topic¹, Marko Jankovec¹

¹*University of Ljubljana, Ljubljana, Slovenia*

2AV.1.48

Interface engineering of NiOx-based perovskite solar cells using phosphinic acid derivative self-assembled monolayers

Javid Hajhemati^{1;2;3}, Nitin Mallik^{1;2}, Van-Son Nguyen², Davide Regaldo², Shan-Ting Zhang², Damien Coutancier^{1;2}, Nathanaelle Schneider¹, Frederique Donsanti^{2;4}, Jean Rousset^{2;4}, Mathieu Frégnaux³, Damien Aureau³, Philip Schulz^{1;2}

¹*CNRS, Palaiseau, France*; ²*IPVF, Palaiseau, France*; ³*University of Paris-Saclay, Versailles, France*; ⁴*EDF R&D, Palaiseau, France*

2AV.1.49

Evaluating Heterogeneity in Metal Halide Perovskites at the Nanoscale

Julien Barrier¹, Rachel Beal², Aryeh Gold-Parker², Julian Vigil², Eli Wolf², Louis Waquier³, Nicholas Weadock⁴, Zihan Zhang⁴, Laura Schelhas⁵, Ana Flavia Nogueira⁶, Michael McGehee⁴, Michael Toney⁴

¹*The University of Manchester, United Kingdom*; ²*Stanford University, Stanford, United States*; ³*ESPCI, Paris, France*; ⁴*University of Colorado Boulder, Boulder, United States*; ⁵*NREL, United States*; ⁶*University of Campinas, Brazil*

2AV.1.50

Stability Assessment of Perovskite Cells with H3pp Molecule Additives at Different Loading Conditions

Vasiliki Paraskeva¹, Maria Hadjipanayi¹, Matthew S.H. Norton¹, George Elias Georgiou¹, Sophia Hayes¹, Nicolas Charalambous¹, Mónica Lira-Cantú³, Carlos Pereyra³

¹*University of Cyprus, Nikosia, Cyprus*; ²*ICN2, Barcelona, Spain*

2AV.1.51

Role of Ion Migration on the S-type J-V characteristics of Perovskite Solar Cells

Dhyana Sivadas¹, Pradeep R. Nair¹

¹Indian Institute of Technology Bombay, Mumbai, India

2AV.1.52

Advanced laser structuring for perovskite solar modules with geometrical fill factor over 99.5% and efficiency of 20.7%

Francesco DI Giacomo¹, Luigi Angelo Castriotta¹, Fabio Matteocci¹, Aldo DI Carlo¹

¹CHOSE – Centre for Hybrid and Organic Solar Energy, Rome, Italy

2AV.1.53

Surface Passivation of FAPbI₃ Film for Efficient and Stable Solar Cells

Lahoucine Atourki^{1,2}, Juanita Hidalgo¹, Carlo A. R. Perini¹, Jake. Vagott¹, Andrés-Felipe Castro Mendez¹, Mohammed Abd-Lefdil¹, Juan-Pablo Correa-Baena¹

¹Georgia Institute of Technology, Atlanta, United States; ²Mohammed V University in Rabat, Morocco

2AV.1.54

Compositional Control of Solution-Processable Direct Bandgap Bismuth-Based Perovskite-Inspired Materials for Photovoltaics

Narendra Pai¹, Manjunath Chatti¹, Andrew D. Scully⁵, Sonia R. Raga⁶, Anthony S. R. Chesman⁵, Zhou Xu¹, Mónica Lira-Cantú⁶, Udo Bach¹, Alexandr N. Simonov¹

¹Monash University, Australia; ²CSIRO Manufacturing, Australia; ³Autonomous University of Barcelona, Spain

Visual Presentations 2AV.2

15:15- 16:45 CIGS, CdTe, Organic, DSC and Novel Concept Solar Cells and Materials

Poster Area

Chairpersons:

Ayodhya Nath TIWARI
EMPA, Dübendorf, Switzerland

Marika EDOFF (i)
Uppsala University, Uppsala, Sweden

2AV.2.1

The Effect of Defect Type, Density, and Position in Ultra-Thin CIGSe Solar Cell Simulations with COMSOL Multiphysics

Jan Lucaßen¹, Setareh Sedaghat¹, Martina Schmid¹

¹University of Duisburg-Essen, Duisburg, Germany

- 2AV.2.2** **Growth of ZnO Films by Plasma Assisted Reactive Evaporation with Improved Thickness Homogeneity**
 Julian C Peña¹, Juan Piña¹, Gerardo Gordillo¹
¹National University of Colombia, Bogotá, Colombia
- 2AV.2.3** **Alkali PDT on Sb₂Se₃ Thin Film Solar Cells**
 Pedro Vidal-Fuentes¹, Ivan Caño Prades², Claudia Malerba³, Matteo Valentini³, Xavier Alcobe⁴, Alejandro Pérez-Rodríguez¹, Edgardo Saucedo², V. Izquierdo-Roca¹
¹IREC, Barcelona, Spain; ²UPC, Barcelona, Spain; ³ENEA, Rome, Italy; ⁴UAK, Barcelona, Spain
- 2AV.2.4** **A Walkthrough of Fabricating CuIn(Ga)Se₂ Absorbers Using Solid Selenium in the Sequential Technique**
 Sarallah Hamtaei^{1,2,3}, Guy Brammertz^{1,3,4}, Jozef (Jef) Poortmans^{1,2,3,5}, Tom Aernouts^{1,3}, Bart Vermang^{1,2,3},
¹imec, Genk, Belgium; ²Hasselt University, Diepenbeek, Belgium; ³EnergyVille, Genk, Belgium; ⁴Federal University of Alagoas, Diepenbeek, Belgium; ⁵KU Leuven, Leuven, Belgium
- 2AV.2.5** **Interface and Window Optimization Studies for Wide Band Gap CIGSe Solar Cells in the Tandem Perspective**
 Jackson Lontchi¹, Alexandre Crossay², Amelle Rebai², Damien Coutancier², Nathanaelle Schneider³, Baptiste Béranguier², Polyxeni Tsoulka⁴, Nicolas Barreau⁴, Jean-Francois Guillemoles³, Negar Naghavi², Daniel Lincot²
¹IPVF, Palaiseau, France; ²CNRS, Palaiseau, France; ³University of Nantes, Nantes, France
- 2AV.2.6** **Elaboration of Highly Transparent Luminescent Solar Concentrators for Agrivoltaics: Opportunities for Agriculture and Energy Transition**
 Othmane Essahili¹, Mouad Ouafi¹, Omar Moudam¹
¹Mohammed VI Polytechnic University, Benguerir, Morocco
- 2AV.2.7** **Effect of the Sb/Se Ratio on the Structural, Morphological and Electrical Properties of Sb_xSe_y Films**
 Bobur Ergashev¹, Takhir Razykov², Kudrat Kuchkarov², Stefano Pasini³, Alessio Bosio³, Ramozan Khurramov², Diyorbek Isakov², Alessandro Romeo⁴, Nicola Romeo⁵, Mirzavqiy Makhmudov², Abdurashid Mavlonov⁶
¹Uzbekistan Academy of Sciences, Tashkent, Uzbekistan; ²University of Parma, Parma, Italy; ³University of Verona, Verona, Italy; ⁴Ritsumeikan University, Kusatsu, Japan

- 2AV.2.8** **CPEPh-Na/MoO₃ Bi-stack Hole Interfacial Layers for Enhancing the Performance of Nonfullerene Organic Photovoltaics**
Enas Moustafa¹, Josep Pallarès Marzal¹, Lluís F. Marsal Garví¹
¹University of Rovira i Virgili, Tarragona, Spain
- 2AV.2.9** **Impact of Charge Separation on Solar Cell Performance in PBDB-T-SF and PBDB-T-2Cl:NFA Photoactive Blends**
Jafar Khan¹, Neha Chaturvedi¹, George T. Harrison¹, Yuliar Firdaus¹, Dalaver Anjum², Thomas Anthopoulos¹, Stefaan De Wolf¹, Frédéric Laquai²
¹KAUST Solar Center, Saudi Arabia; ²KAUST, Saudi Arabia
- 2AV.2.10** **Metastabilities in Devices Suffering From Potential Induced Degradation Extracted From a Commercial CIGS Module**
Remi Aninat¹, Pelin Yilmaz¹, Thomas Weber², Mirjam Theelen¹
¹TNO, Eindhoven, Netherlands; ²PI Berlin, Berlin, Germany
- 2AV.2.11** **Rare-Earth-Based Luminescent Solar Concentrators for Agri-Photovoltaics Technology: Synthesis, Processing and Photophysical Properties**
Mouad Ouafi¹, Othmane Essahili², Omar Moudam³
¹Mohammed VI Polytechnic University, BENGUERIR, Morocco
- 2AV.2.12** **Evolution of Structural and Optoelectronic Properties in Fluorine-Metallic Atoms Co-Doped Zinc Oxide Thin Films and their Application in Cu₂ZnSn(S,Se)₄ Thin Film Solar Cells**
Jang Suyoung¹, Jin Hyeok Kim¹, Eunae Jo¹
¹Chonnam National University, Gwangju, Korea, Rep. of South
- 2AV.2.13** **Tunable Bandgap in Kesterite Thin-Films Absorbers Deposited by Sol-Gel Techniques and their Photovoltaic Applications**
Giorgio Tseberlidis¹, Vanira Trifiletti¹, Amin Hasan Husien¹, Maurizio Acciarri¹, Simona Binetti¹
¹University of Milano-Bicocca, Milano, Italy
- 2AV.2.14** **The Role of Solvent Selection and Post Processing Treatment in Controlling Morphology of Bulk Heterojunction Squaraine Organic Solar Cells**
Floren Radovanović-Perić¹, Ivana Panzic¹, Arijeta Baftić¹, Vilko Mandić¹, Dragana Vuk¹, Thomas Rath³
¹University of Zagreb, Zagreb, Croatia; ²Graz University of Technology, Graz, Austria

2AV.2.15

Fabrication of Dye-Sensitized Solar Cell with Improved Electron Transport Properties by Titania Nanostructures

Govindaraj Rajamanickam¹, Vasanth Babu¹, Ramasamy Perumalsamy¹

¹SSN Research Centre, Chennai, India

2AV.2.16

Back Contact Engineering in Ultralight Kesterite Solar Cells Made by a Photonic Lift-off Process

Michael Jones¹, Stephen Campbell¹, Udari Wijesinghe¹, Oliver S. Hutter¹, Ahmed Javed², Giulia Longo¹, Matthew C. Naylor¹, Guillaume Zoppi¹, Husnu Emrah Unalan², Rasit Turan², Selçuk Yerci², Vincent Barrioz¹, Linzi Dodd¹, Neil S. Beattie¹, Yongtao Qu¹

¹Northumbria University, United Kingdom; ²METU, Turkey

2AV.2.17

Analysis of Selenization Temperature for the Performance Improvement of Spin Coated CZTSSe Solar Cells

Prabeesh Punathil¹, Solidea Zanetti¹, Elisa Artegiani¹, Narges Torabi¹, Alessandro Romeo¹

¹University of Verona, Verona, Italy

2AV.2.18

Synthesis of Earth Abundant Chalcogenide Cu₂MnSnS₄ (CMTS) and its Application in Solar Devices

Luigi Frioni¹, Vanira Trifiletti¹, Giorgio Tseberlidis¹, Riccardo Sorrill¹, Stefano Marchionna², Simona Binetti³

¹University of Milano-Bicocca, Milano, Italy; ²RSE, Milano, Italy; ³TÜV Rheinland, Milano, Italy

2AV.2.19

Modelling of Thin Film Solar Cell Using Sb₂Se₃ and Sb₂S₃: a Novel Approach Towards the Sustainable Energy Conversion

Divyanshi Daksh¹, Brajendra Sengar², Saurabh Mishra³

¹Centre for Advanced Studies, Lucknow, India; ²National Institute of Technology, Sri Nagar, India

2AV.2.20

Development of Large Area Bifacial Dye-Sensitized Solar Cells with Transparency of Above 45 %

Senthilkumar Muthu¹, Kicheon Yoo¹, Heyong Cheol Kang¹, Jae Joon Lee¹

¹Dongguk University, Seoul, Korea, Rep. of South

2AV.2.21

Back Contact Engineering in CZTSSe Thin-Film Solar Cells: Strategies to Reduce the Open-circuit Voltage Loss

Baek Myeongcheol¹, Jin Hyeok Kim¹

¹, Korea, Rep. of South

2AV.2.22

Inkjet-printed Indium Sulfide Buffer Layer for Cu(In,Ga)(S,Se)₂: Is it Necessary to Pre-Form the In-S Bond in Solution?

Alice Debot¹, Jérôme Guillot², Damilola Adeleye¹, Phillip Dale¹

¹University of Luxembourg, Belvaux, Luxembourg; ²LIST, Belvaux, Luxembourg

2AV.2.23

Performance Enhancement of Dye-Sensitized Solar Cells via Co-Sensitization of Ruthenium (II) based N749 Dye and Organic Sensitizer RK1

Muhammad Younas¹, K. Harrabi¹

¹King Fahd University of Petroleum & Minerals (KFUPM), Dhahran, Saudi Arabia

2AV.2.24

Impact of Cu Content on p-n Junction in CZTS_{Se} Thin-Film Solar Cell

Jin-Soo Kim¹, Kyung-Pil Kim¹, Woo-Lim Jeonga¹, Dong-Seon Lee¹

¹GIST, Gwangju, Korea, Rep. of South

Visual Presentations 2AV.3

17:00- 18:30 Tandem Solar Cells / III-V and Related Compound Semiconductors

Poster Area

Chairpersons:

Gerald SIEFER
Fraunhofer ISE, Freiburg, Germany

Jan Christoph GOLDSCHMIDT
Philipps University of Marburg, Marburg, Germany

2AV.3.1 Investigation of the Perovskite-silicon Tandems based on Industrially Relevant PERC

Yong LI¹, Bruno Vicari-Stefani¹, Christopher Fell¹, Gregory Wilson¹

¹CSIRO Energy, Newcastle, Australia

2AV.3.2 Investigation of Zr-doped Indium Oxide Film with High Transmittance in a Wide Wavelength Region for Tandem Solar Cells

Tappei Nishihara¹, Hyunju Lee^{1,2}, Yoshio Ohshita³, Atsushi Ogura^{1,2}

¹Meiji University, Kawasaki, Japan; ²Toyota Technological Institute, Nagoya, Japan

2AV.3.3 High Near-Infrared Transmittance IWO Layer for a Rear Side of Bottom Cell in Tandem Solar Cells

Shiyu Zhang¹, Tappei Nishihara¹, Hyunju Lee^{2,3}, Yoshio Ohshita², Atsushi Ogura^{1,3}

¹Meiji University, Kawasaki, Japan; ²Toyota Technological Institute, Nagoya, Japan

2AV.3.4 Pressure-aided Growth Approach of Highly Efficient Tandem Perovskite Solar Cell via Sandwich Evaporation Technique

Ching-Fuh Lin¹, Jia-Ci Jhou¹, Chung-Han Chang¹, Ashish Gaurav¹

¹NTU, Taipei, Taiwan

2AV.3.5 Upscaling of Perovskite-Silicon Tandem Solar Cells

Oliver Schultz-Wittmann¹, Patricia Schulze¹, Oussama Er-Raji^{1,2}, Minasadat Heydarian^{1,2}, Özde S. Kabakli¹, Raphael Efinger¹, Martin C. Schubert¹, Alexander Bett¹, Oliver Fischer^{1,2}, Denis Erath¹, Sebastian Pingel¹, Ulrike Heitmann¹, Zohreh Kiaee¹, Markus Kohlstädt¹, Martin Bivour¹, Jan Christoph Goldschmidt³, Martin Hermle¹, Stefan W. Glunz^{1,2}

¹Fraunhofer ISE, Freiburg, Germany; ²University of Freiburg, Freiburg, Germany; ³University of Marburg, Germany

2AV.3.6

n++ Gas Immersion Laser Doping of p++ Emitters in POCl₃ Atmosphere: Tuning Semiconductor Dopant Concentration and Formation of Crystalline Silicon Tunnel Junction

Filipe Serra¹, Guilherme Gaspar¹, Ana Viana², Ivo Costa¹, David M. Pera¹, José Almeida Silva¹, Giso Hahn³, L. Vines⁴, João M. Serra¹, Killian Lobato¹

¹University of Lisbon, Lisboa, Portugal; ²CQE, Lisboa, Portugal; ³University of Konstanz, Konstanz, Germany; ⁴University of Oslo, Oslo, Norway

2AV.3.7

Plasma Enhanced Physical Vapor Deposition of Epitaxial III V Materials (GaN)

Lakshman Srinivasan^{1,2}, Karim Ouaras², Pere Roca I Cabarrocas^{1,2}

¹IPVF, Palaiseau, France; ²LPICM-CNRS, Palaiseau, France

2AV.3.8

III-V on Si Tandem Solar Cells Glued by Hybrid Conductive Layers

Phuong-Linh Nguyen^{1,2,3}, Jerónimo Buencuerpo^{2,3}, Philippe Baranek^{1,2}, Oliver Höhn⁴, David Lackner⁴, Frank Dimroth⁴, Marco Faustini⁵, Stephane Collin^{2,3}, Andrea Cattoni^{2,3}

¹EDF R&D, Palaiseau, France; ²IPVF, Palaiseau, France; ³C2N, Palaiseau, France; ⁴Fraunhofer ISE, Freiburg, Germany; ⁵CNRS, Paris, France

2AV.3.9

Bifacial ZEBRA IBC Silicon Solar Cells for Three and Four Terminal Perovskite Tandem Devices

Valentin Dan Mihailetchi¹, Razvan Roescu¹, Haifeng Chu¹, Radovan Kopecek¹

¹ISC Konstanz, Konstanz, Germany

2AV.3.10

Towards Indium Free TCO-Based Recombination Layers in Perovskite on Silicon Tandem Solar Cells

Elise Bruhat¹, Perrine Carroy¹, Saad Makhladi¹, Caroline Bal¹, Olivier Dupré¹, Elsa Parrat², Florian Dupont²

¹CEA, Le Bourget du Lac, France; ²CEA, Grenoble, France

2AV.3.11

Optical Effects of Laser-Reduced Graphene Oxide Layers in Tandem Perovskite/CIGS Solar Cells studied by Numerical Simulations

Milan Kovacic¹, Janez Krc¹, Stella Maragkaki², Emmanuel Stratakis², Mudasar Rashid^{3,4,5}, Merve Tutundzic^{3,4,5}, Yinghuan Kuang^{3,4,5}, Jessica de Wild^{3,4,5}, Tom Aernouts^{3,4,5}, Bart Vermang^{3,4,5}, Marko Topic¹

¹University of Ljubljana, Ljubljana, Slovenia; ²IESL-FORTH, Heraklion Crete, Greece; ³Imec, Genk, Belgium; ⁴Hasselt University, Martelarenlaan 42, Belgium; ⁵EnergyVille, Genk, Belgium

2AV.3.12

Modelling and Optimization of Perovskite-Silicon Tandem Devices for Enhanced Field Energy Production

Spela Tomsic¹, Marko Jošt¹, Kristijan Brecl¹, Benjamin Lipovsek¹, Marko Topic¹

¹University of Ljubljana, Ljubljana, Slovenia

2AV.3.13

Development of Electron Selective Tin Oxide Via Vacuum Based Deposition for Manufacturable Perovskite on Silicon Tandem Solar Cells

Elise Bruhat¹, Perrine Carroy¹, Félix Gayot¹, Caroline Bal¹, Nathalie Nguyen¹

¹CEA, Le Bourget du Lac, France

2AV.3.14

Application of Advanced Hydrogenation Process on SiGe/Si Solar Cells

Zhenyu Sun¹, Fukun Lei¹, Brett Hallam¹, Xiaodan Zhang², Li Wang¹

¹UNSW, Sydney/Kensington, Australia; ²INL, Tianjin, China

2AV.3.15

High Efficiency 3-Terminal Perovskite/Silicon Tandems Based on Tunnel Junction IBC

Laurie-Lou Senaud¹, Brett Kamino¹, Jonas Geissbühler¹, Gabriel Christmann¹, Gizem Nogay¹, Jun Zhao¹, Florent Sahli¹, Patrick Wyss¹, Derk L. Bätzner², Damien Lachenal², Quentin Jeangros¹, Christophe Ballif¹, Bertrand Paviet-Salomon¹

¹CSEM, Neuchatel, Switzerland; ²Meyer Burger Research, Haurer, Switzerland

2AV.3.16

Optimization and Characterization of Indium Zinc Oxide TCOs for Perovskite-Silicon Tandem Solar Cell Applications

Volker Sittering¹, Hunter King¹, Özde S. Kabakli², Patricia Schulze², Jan Christoph Goldschmidt³

¹Fraunhofer IST, Braunschweig, Germany; ²Fraunhofer ISE, Freiburg, Germany; ³University of Marburg, Marburg, Germany

2AV.3.17

Monolithic Perovskite-Carrier Selective Contact Silicon Tandem Solar Cells Using MoO_x as a Hole Selective Layer

Hoyoung Song¹, Changhyun Lee¹, Ji Yeon Hyun¹, Sang-Won Lee¹, Dongjin Choi², Dowon Pyun¹, Nam Jiyeon¹, Jeong Seokhyun¹, Jiryang Kim¹, Soohyun Hyun Bae², Hyunju Lee³, Yoonmook Kang⁴, Donghwan Kim¹, Hae-Seok Lee⁴

¹Korea university, Seoul, Korea, Rep. of South; ²Korea University, Korea, Rep. of South; ³Meiji University, Japan; ⁴Korea university, Korea, Rep. of South

2AV.3.18

Si-based Tunnel Recombination Junction for Perovskite / Silicon Tandem Solar Cells

Baptiste Marteau¹, Thibaut Desrues¹, Quentin Rafhay², Anne Kaminski², Sébastien Dubois¹

¹CEA, Le Bourget-du-Lac, France; ²Grenoble INP, Grenoble, France

2AV.3.19

Opto-Electrical Simulations and Optimization of Two Terminal Perovskite / CIGS Tandem Solar Cells

Paul A. Procel Moya¹, Jelle Knobbe¹, Nasim Rezaei², Valerio Zardetto³, Nga Phung⁴, Mike MA⁵, Marcel Simor³, Adriana Creatore⁴, Sjoerd Veenstra³, Rudi Santbergen¹, Olindo Isabella¹

¹Delft University of Technology, Delft, Netherlands; ²University of Twente, Enschede, Netherlands; ³TNO, Eindhoven, Netherlands; ⁴Eindhoven University of Technology, Eindhoven, Netherlands; ⁵MiaSole Hi-Tech, Santa Clara, United States

2AV.3.20

How to Design Silicon Surfaces for Efficient Si/Perovskite Tandem?

Gurleen Kaur¹, Marion Provost¹, Alexandre Blaizot¹, Antonio de Jesus Olivares-Vargas², Dmitri Daineka², Jean Rousset³, Pere Roca I Cabarrocas^{1,2}

¹IPVF, Palaiseau, France; ²LPICM-CNRS, Palaiseau, France; ³EDF R&D, Palaiseau,

2AV.3.21

Impact of Post-annealing on the Performance of Low-Bandgap CIGS Bottom-Cell for 2-Terminal Perovskite/CIGS Tandem Solar Cells

Mudasar Rashid^{1,2,3}, Jessica de Wild^{1,2,3}, Guy Brammertz^{1,2,3}, Sarallah Hamtaei^{1,2,3}, Yinghuan Kuang^{1,2,3}, Tom Aernouts^{1,2,3}, Bart Vermang^{1,2,3}

¹Hasselt University, Hasselt, Belgium; ²imec, Genk, Belgium; ³EnergyVille, Genk, Belgium

2AV.3.22

Design and Realization of Low-Temperature Perovskite Solar Cell for 2T Tandem Application with Bifacial Silicon Bottom Cells

Antonio Agresti¹, Sara Pescetelli¹, Erica Magliano¹, Paolo Mariani¹, Giuseppe Bengasi², Marcello Sciuto², Adriana Isabel Yanez Ladino², Carmelo Connelli², Cosimo Gerardi², Fabrizio Bizzarri², Marina Foti², Aldo DI Carlo³

¹University of Rome II, Rome, Italy; ²3Sun, Catania, Italy; ³CNR, Rome, Italy

2AV.3.23

Bandgap and Temperature Dependent Modelling of Perovskite/Silicon Tandem Solar Cells

Thomas Allen¹, Waseem Raja¹, Erkan Aydin¹, Ahmed Ali Said¹, Michele De Bastiani¹, Stefaan De Wolf¹

¹KAUST Solar Center, Thuwal, Saudi Arabia

2AV.3.24

Semi-Transparent Perovskite Solar Cells with Ultrathin Protective Buffer Layers for Tandem Applications

Erica Magliano¹, Antonio Agresti¹, Sara Pescetelli¹, Paolo Mariani¹, Fabio Matteocci¹, Antonio Cricenti², Marco Luce², Aldo DI Carlo^{1,2}

¹University of Rome II, Rome, Italy; ²CNR, Roma, Italy

2AV.3.25

Low-Cost III-V//Si Tandem Solar Cells Using Smart Stack Technology

Yasushi Shoji¹, Hitoshi Sai¹, Ryuji Oshima¹, Kikuo Makita¹, Takuya Matsui¹, Akinori Ubukata², Takeyoshi Sugaya¹

¹AIST, Japan; ²TNSC, Minato City, Japan

2AV.3.40

AlGaAs/InGaP Heterojunction Solar Cell Based on Temperature-graded Growth

Gan LI¹, Hassanet Sodabanlu², Kentaroh Watanabe², Masakazu Sugiyama^{1,2}, Yoshiaki Nakano¹

¹The University of Tokyo, Bunkyo City, Japan; ²University of Tokyo, Meguro City, Japan

2AV.3.41

Miniaturization of High Efficiency InGaP/InGaAs/Ge Solar Cells and Pathways for Further Improvements

Thomas Bidaud^{1,2}, Corentin Jouanneau^{1,2}, Pierre Albert^{1,2,3}, Mathieu De Lafontaine^{1,2}, Abdelatif Jaouad^{1,2}, Artur Turala^{1,2}, Gwenaëlle Hamon^{1,2}, Maxime Darnon^{1,2}

¹LN2, Sherbrooke, Canada; ²University of Sherbrooke, Sherbrooke, Canada; ³CNRS, Talence, France

2AV.3.42

Applying Ultra-High Phosphorous Composition GaAsP to InGaAs/GaAsP Strain-Balanced Quantum Structure Solar Cells Aiming for High Efficiency Multi-junction Solar Cells

Meita Asami¹, Kentaroh Watanabe², Yoshiaki Nakano¹, Masakazu Sugiyama^{1,2}

¹The University of Tokyo, Bunkyo City, Japan; ²The University of Tokyo, Meguro City, Japan

2AV.3.43

Epitaxy and Characterization of InP/InGaAs Tandem Solar Cells grown by MOVPE on InP and Si Substrate

Stefano Soresi¹, Mattia Da Lisca², Claire Besancon¹, Nicolas Vaissiere¹, Alexandre Larrue¹, Cosimo Calo¹, Josè Alvarez³, Christophe Longeaud³, Ludovic Largeau⁴, Pablo Garcia-Linares⁵, Eric Tournie⁶, Jean-Paul Kleider³, Jean Decobert¹

¹III-V Lab, Palaiseau, France; ²IPVF, Palaiseau, France; ³GeePs, Gif-sur-Yvette, France; ⁴C2N, Palaiseau, France; ⁵UPM, Madrid, Spain; ⁶IES, Montpellier, France

2AV.3.44

Improvement of InGaP Solar Cells Grown with TBP in Planetary MOVPE Reactor

Hassanet Sodabanlu¹, Gan LI², Kentaroh Watanabe¹, Yoshiaki Nakano², Masakazu Sugiyama^{1,2}

¹University of Tokyo, Meguro City, Japan; ²The University of Tokyo, Bunkyo City, Japan

2AV.3.45

Flexible Solar Cell Assemblies- Testing in Harsh Conditions

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

¹CESI, Milan, Italy; ²ESA, Noordwijk, Netherlands

2AV.3.46

Study of Sputtered GaN, Nb₂O₅ and Ta₂O₅ Anti-Reflection Coating for III/V-based Multi-junction Solar Cells

Filippo Annoni¹, Marina Cornelli¹, Elisabetta Achilli¹, Nicola Armani¹, Nicola Castagnetti¹, Emanuele Malvisi¹, Franco Trespidi¹, Maddalena Patrini², Lucio Claudio Andreani², Gianluca Timò¹

¹RSE, Piacenza, Italy; ²University of Pavia, Pavia, Italy

2AV.3.47

Fast External Quantum Efficiency Measurements Using a Fourier Transform-Based Spectroscopy Approach for the Investigation of InGaP/InGaAs/Ge Microcells

Herinirina Fanevamampandra^{1,2,3}, Christophe Longeaud³, José Alvarez³, Alexandre Jaffre³, Mattia Da Lisca³, Corentin Jouanneau¹, Thomas Bidaud^{1,4}, Jean-Paul Kleider³, Abdelatif Jaouad⁴, Marie-Estelle Gueunier-Farret³, Vincent Aimez^{1,4}, Gwenaëlle Hamon^{1,4}, Maxime Darnon^{1,4}

¹University of Sherbrooke, Sherbrooke, Canada; ²LN2, Sherbrooke, Canada; ³CNRS, Gif Sur Yvettes, France

2AV.3.48

Epitaxial Growth and Characterization of 1.0 eV Bandgap GaAsBi - InGaAs Heterojunction Solar Cells

Tadas Paulauskas¹, Jan Devenson¹, Vaidas Pačebutas¹, Arūnas Krotkus¹

¹Center for Physical Sciences and Technology, Vilnius, Lithuania

2AV.3.49

Determination of Soldering Parameters for Triple Junction GaAs Solar Cells

Sebastian Neven-du Mont¹, Torsten Roessler¹, Martin Heinrich¹, Holger Neuhaus¹, Tim Kubera²

¹Fraunhofer ISE, Freiburg, Germany; ²Azur Space, Heilbronn, Germany

2AV.3.50

Optical Characterization of the InGaAsP Solar Cells with Absolute Electroluminescence Observation

Kentaroh Watanabe¹, Riko Yokota², Hassanet Sodabanlu¹, Yoshiaki Nakano², Masakazu Sugiyama^{1,2}

¹The University of Tokyo, Meguro City, Japan; ²The University of Tokyo, Bunkyo City, Japan

2AV.3.51**High-Current Output Bifacial Perovskite/Silicon Tandem Solar Cells**

Esma Ugur¹, Erkan Aydin¹, Michele De Bastiani¹, George T. Harrison¹, Bumin Yildirim¹, Thomas Allen¹, Sam Teale², Bin Chen², Philip Schulz³, Maxime Babics¹, Randi Azmi¹, Akmaral Seitkhan¹, Mingcong Wang¹, Jiang Liu¹, Anand Selvin Subbiah¹, Atteq Ur Rehman¹, Edward H. Sargent², Frédéric Laquai¹, Stefaan De Wolf¹

¹KAUST Solar Center, Saudi Arabia; ²University of Toronto, Canada; ³CNRS, France

2AV.3.52**Analysis of Crystal Defects in GaAs Solar Cells grown at High Rates by Hydride Vapor Phase Epitaxy**

Ryuji Oshima¹, Akio Ogura², Yasushi Shoji¹, Kikuo Makita¹, Akinori Ubukata³, Mitsuru Imaizumi², Takeyoshi Sugaya¹

¹AIST, Japan; ²JAXA, Japan; ³TNSC, Japan

Visual Presentations 4BV.1

08:30- 10:00 PV Integrated in the Built Environment Demonstration and Performances of Different Technologies / Infrastructure-integrated PV (VIPV, Agri-PV, Floating PV)

Poster Area

Chairpersons:

Eszter (Esther) VOROSHAZI
CEA, Le Bourget-du-Lac, *France*

Pierluigi BONOMO
SUPSI, Mendrisio, *Switzerland*

4BV.1.1

Influence of Rear Side Ventilation and Insulation on the Module Performance of PV Facades as Ventilated Curtain Wall

Niklas Albinus¹, Björn Rau¹, Maximilian Riedel¹, Carolin Ulbrich¹, Rutger Schlatmann¹

¹HZB, Berlin, *Germany*

4BV.1.2

Optimising Free-Space Luminescent Solar Concentrator Facades for Solar Roads and Solar Car Parking Sheds

Shweta Pal¹, Rebecca Saive¹

¹University of Twente, *Netherlands*

4BV.1.3

Development from a Small to Large Scale Luminescent Downshift Layer Fabrication on Silicon Solar Cells

Bill Cass¹, Sarah McCormack¹, Subhash Chandra¹, Anita Ortega¹

¹Trinity College Dublin, *Ireland*

4BV.1.4

Performance Assessment of an Hybrid Photovoltaic/Thermal Installation: the IDEAS Project Experience

Paolo Bernardoni¹, Giulio Mangherini², Alfredo Andreoli², Valentina Diolaiti², Mohamed Amine Ouelhazi², Donato Vincenzi², Eleonora Baccega³, Silvia Cesari³, Giuseppe Emmi³, Michele Bottarelli³, Anita Ortega⁴, Bill Cass⁴, Sarah MC Cormack⁴

¹University of Ferrara, Ferrara, *Italy*; ²Trinity College Dublin, Dublin, *Ireland*

- 4BV.1.5** **Critical Issues and Novel Concepts of Cooling BIPVT and its Integration with Low-Temperature Heating**
George Aspetakis¹, Cong Wang¹, Stefan Larsson-Mastonstråle², Annika Gram¹, Qian Wang¹
¹KTH Royal Institute of Technology, Stockholm, Sweden; ²Maston Group, Sweden
- 4BV.1.6** **Thermal Influences of Rooftop Photovoltaic Panels on Building Performance: a Meta-Analysis**
Delia Dagostino¹, Danny Parker²
¹European Commission JRC, Ispra, Italy; ²Florida Solar Energy Center, United States
- 4BV.1.7** **Glass BIPVs for Commercial Building Integration in Cyprus**
Maria Hadjipanayi¹, Yerasimos Yerasimou¹, Matthew S.H. Norton¹, George Elias Georghiou¹, Valia Miltiadous², Annita Karantoni², Fanos Karantonis², Rafaela Nikolaidou³, Eliza Loucaidou³
¹University of Cyprus, Nicosia, Cyprus; ²K Energy By Karantonis, Palaioimetocho, Cyprus; ³Deloitte, Limassol, Cyprus
- 4BV.1.8** **Demonstration of Colored BIPV Façades: Installation and First Results**
Ya-Brigitte Assoa¹, Ioannis (John) Tsanakas¹, Rémi Sanson¹, Romain Joubert¹, Philippe Thony¹, Paul Messaoudi¹, Fabien Chabuel¹, Sean Erik Foss², Tine Uberg Nærland², Gaute Otnes², Nathan Rooslot², Christoph Seiffert², Laure-Emmanuelle Perret³, Andy Hoque⁴, Sebastien La Fontaine⁵, Grégory Bugnon⁶, Rayan Hammoud⁷
¹CEA, France; ²Institute for Energy Technology, Norway; ³EPFL, Switzerland; ⁴L-UP, France; ⁵ISSOL, Belgium; ⁶SOLAXESS, Switzerland; ⁷Saint-Gobain, France
- 4BV.1.9** **Demonstration of a Passively Tracked Rooftop Compatible Hybrid Thermal CPV Module**
Stephen Askins¹, Guido Vallerotto¹, David Marti², Javier Van Herpt², Jaime Caselles², Ignacio Anton¹
¹UPM, Madrid, Spain; ²Solarays Energy, Pedreguer, Spain
- 4BV.1.10** **A Solar Hybrid PVT Driven Heat Pump System Real Performance Techno-Economic Analysis**
Asier Sanz Martinez¹, Raquel Fuente Dacal², Antonio Jesús Martín Miranda³
¹TECNALIA, Derio, Spain; ²UPV/EHU, Bilbo, Spain; ³Energy Panel, Lucena, Spain

4BV.1.11

Smart Windows: Device Efficiency Characterization

Rosamaria Marrazzo¹, Stefano Zanardi¹, Fabio Melchiorre², Luciano Caccianotti¹, Mario Salvalaggio¹

¹*eni, Novara, Italy*

4BV.1.12

Inspiring BIPV in UAE, a Jury Experience in Solar Decathlon Middle East (SDME21) Contest

Cristina S. Polo López¹, Francesco Frontini², Edwin Rodriguez-Ubinas³

¹*SUPSI, Mendrisio, Switzerland;* ²*DEWA R&D Center, Dubai, United Arab Emirates*

4BV.1.13

Maximum Temperature of BIPV Components: Proposal of a New Testing Procedure to Evaluate the Thermal Behaviour of BIPV Products in Non-Conventional Shading Scenarios

Giovanni Bellenda¹, Mauro Caccivio¹, Fabio Parolini¹, Pierluigi Bonomo¹, Francesco Frontini¹

¹*SUPSI, Mendrisio, Switzerland*

4BV.1.14

Experience and Results from the SOLARISE Living Labs

Bert Herteleer¹, Cas Lavaert¹, Bert Uytterhaegen¹, Anastasios Kladas¹, Jan Cappelle¹, Victor Becerra², Ahmed Rachid³

¹*KU Leuven, Gent, Belgium;* ²*University of Portsmouth, Portsmouth, United Kingdom;* ³*University of Picardie Jules Verne, Amiens, France*

4BV.1.15

Structural-Colored PV Modules with Reduced Angle Dependence for Building-Integrated Photovoltaics Applications

Zhihao Xu¹, Takuya Matsui¹, Hitoshi Sai¹

¹*AIST, Tsukuba, Japan*

4BV.1.16

BIPV Envelope Design Optimization at Conceptual Design Stage

Samarasinghalage Tharushi Imalka¹, Pabasara Wijeratne¹, Rebecca Yang¹, Ron Wakefield¹

¹*RMIT University, Melbourne, Australia*

4BV.1.17

Experimental Performance Analysis of Coloured BIPV system

Jonggwon Ahn¹, Jin-Hee Kim¹, Jun-Tae Kim¹

¹*Kongju National University, Gongju, Korea, Rep. of South*

4BV.1.30

Technical Aspects for Road Integrated Photovoltaics Towards A More Sustainable Mobility Sector

Jonas D. Huyeng¹, Jacob Forster¹, Felix Basler¹, Pascal Romer¹, Andreas J. Beinert¹, Christian Schill¹, Martin Heinrich¹, Holger Neuhaus¹, Harry Wirth¹

¹Fraunhofer ISE, Freiburg, Germany

4BV.1.31

On-Board Photovoltaic Kit for Existing Vehicles

Benjamin Commault¹, Bertrand Chambion¹, Lionel Serra¹, Fathia Karoui¹, Shehrazade Nassibi¹

¹CEA, Le Bourget-du-Lac, France

4BV.1.32

Development of Shade Tolerant PV Road Elements for a PV-Walkway Demonstrator

Bart E. Pieters¹, Baris Dai², Aldo Kingma², Dorrit Roosen-Melsen², Andreas Gerber¹

¹Forschungszentrum Jülich, Juelich, Germany; ²TNO, Eindhoven, Netherlands

4BV.1.33

Design and Characterization of Semitransparent Patterned PV Modules for Greenhouse Applications

Carlos Alberto Toledo Arias¹, Alessandra Scognamiglio¹, Francesco Frontini²

¹ENEA, Portici (NA), Italy; ²SUPSI, Switzerland

4BV.1.34

Energy Yield Gain of Various Electrical Layouts for a Curved VIPV Module

Apostolos Bakovasilis^{1;2;3}, Arttu Tuomiranta^{1;2;3}, Loïc Tous^{1;2;3}, Ivan Gordon^{1;2;3}, Jozef (Jef) Poortmans^{1;2;3}

¹IMEC, Genk, Belgium; ²Hasselt university, Genk, Belgium; ³EnergyVille, Genk, Belgium

4BV.1.35

Validation of a Bifacial Simulation Software against Measured Energy Yield from a Utility-Scale Vertical Fixed-Tilt Agrophotovoltaic Plant

Oliver Pfeiffer¹, Jorit Hanneforth¹, Christopher Marks¹, Eva-Maria Grommes¹, Ulf Blieske¹

¹Cologne University of Applied Sciences, Germany

4BV.1.36

Impact of Additional VIPV System Weight on the Energy Balance of Passenger Electric Vehicles

Neel Patel¹, Karsten Bittkau¹, Evgenii Sovetkin¹, Bart E. Pieters¹, Angèle Reinders², Kaining Ding¹

¹Forschungszentrum Jülich, Jülich, Germany; ²Eindhoven University of Technology, Eindhoven, Netherlands

- 4BV.1.37**
Implementing Smart Panels to Mitigate Mismatch Conditions for a Dynamic Off-Shore Floating PV System
 Sara Mirbagheri Golroodbari¹, Wilfried G.J.H.M. van Sark¹
¹*Utrecht University, Utrecht, Netherlands*
- 4BV.1.38**
Design Rules Based on Ground Solar Irradiation to Maintain Soil Quality in Solar Parks
 Ilkay Cesar¹, Bas Van Aken¹, Luuk Scholten², Ron de Goede², Alex Schotman²
¹*TNO, Petten, Netherlands*; ²*Wageningen University & Research, Wageningen, Netherlands*
- 4BV.1.39**
A Novel Combined Model for Solar Garden Roof with Bifacial Technology
 Antonino Rollo¹, Piero Bevilacqua², Roberto Bruno², Vittorio Ferraro²
¹*University of Calabria, Arcavacata di Rende (Cs), Italy*; ²*University of Calabria, Rende, Italy*
- 4BV.1.40**
Evaluation of Edge Sealants for Floating PV Applications
 Nathan Roosloot^{1,2}, Dag Lindholm¹, Mike Dallaway⁴, Guillaume Kegelart⁵, Bjørn Hervold Riise⁵, Josefine Helene Selj^{1,2}, Gaute Otnes¹
¹*Institute for Energy Technology, Kjeller, Norway*; ²*University of Oslo, Oslo, Norway*; ³*Asher Group, Nantwich, United Kingdom*; ⁴*Sunlit Sea, Trondheim, Norway*
- 4BV.1.41**
Agrivoltaics as a Technological Option for Ecosystem Recovery: a Case Study for the Mar Menor Coastal Lagoon in South East Spain
 Carlos Alberto Toledo Arias¹, Adela Ramos², Lucía Serrano³, Antonio Urbina⁴
¹*ENEA, Portici, Italy*; ²*UPCT, Cartagena, Spain*; ³*URJC, Móstoles (Madrid), Spain*; ⁴*Public University of Navarra, Pamplona, Spain*
- 4BV.1.42**
Prediction of PPFD (Photosynthetic Photon Flux Density) under Transparent CPV Modules
 Teruya Toyoda¹, Daisuke Yajima², Masaaki Kirimura², Kensuke Nishioka², Kenji Araki², Yasuyuki Ota²
¹*Miyazaki, Japan*; ²*Japan*
- 4BV.1.43**
Agrivoltaics in a Blackberry Production Test Case
 Lisa Bunge¹, Luis Fialho^{1,2}, Pedro André Dos Santos Ribeiro Horta^{1,2}
¹*University of Évora, Nossa Senhora da Tourega, Portugal*; ²*University of Évora, Évora, Portugal*

4BV.1.44

Multi-scale Analysis of different PV Technologies for Greenhouses

Alessandra Scognamiglio¹, Carlos Alberto Toledo Arias¹, Lucia V. Mercaldo¹, Marco Della Noce¹, Manuela Ferrara¹, Fabrizio Carteni², Maurizio Zotti², Stefano Mazzoleni², Paola Delli Veneri¹

¹ENEA, Portici (NA), Italy; ²University of Naples Federico II, Portici (NA), Italy

4BV.1.45

A Sustainable Agrivoltaic Experience in a dry Mediterranean Area: Co-Existence of Agricultural Activities in Utility-scale Plants of EGP for Multiple Land Use

Miriam DI Blasi¹, Maria Genovese¹, Gian Maria Baldi², Michele Falce²

¹Enel Green Power, Pisa, Italy; ²Novamont, Novara, Italy

4BV.1.46

Sharing Global Expertise on Agrivoltaics with AiDO: Agrivoltaics International Discussion Group

Mike Van Iseghem^{1,2}, Özal Emre Özdemir³, Frank de Ruijter⁴, Christoph Mayr^{5,6}, Alessandra Scognamiglio⁷, Damien Fumey¹, Matthew Berwind³, Josephine Schwenke³

¹, France; ²EDF R&D, Moret-Loing-et-Orvanne, France; ³, Germany; ⁴, Netherlands; ⁵, Austria; ⁶AIT, Austria; ⁷, Italy

4BV.1.47

Dual Use of Land: Integrating PV Systems with Dykes

Maarten Dörenkämper¹, Jan Rinze Van Der Schoot², Simone Loohuizen³, Corry de Keizer¹

¹TNO, Eindhoven, Netherlands; ²Wageningen University & Research, Lelystad, Netherlands; ³Arcadis, 's-Hertogenbosch, Netherlands

4BV.1.48

How Agrivoltaics and Floating Photovoltaics Influence Evapo-Transpiration?

Baptiste Amiot^{1,2}, Sylvain Edouard^{1,3}, Rémi Le Berre¹, Mike Van Iseghem¹, Martin Ferrand^{4,5}, Javier Vidal-Hurtado⁴, Stéphanie Giroux-Julien², Didier Combes³

¹EDF R&D, Moret sur Loing - Orvanne, France; ²University of Lyon, Villeurbanne, France; ³INL, Lusignan, France; ⁴EDF R&D, Chatou, France; ⁵CEREA, Chatou, France

4BV.1.49

Solar Resource Evaluation in Dynamic and Static through Solar Tracking System at 1 Hz for VIPV Applications

Shehrazade Nassibi¹, Bertrand Chambion¹, Loic Lonardoni¹, Lionel Serra¹, Benjamin Commault¹, Fabien Chabuel¹, Jérémie Aimé¹

¹CEA, Le Bourget-du-Lac, France

4BV.1.50

Survey of the Floating Photovoltaic Potential of Portugal

Dorivaldo Duarte^{1,2}, Luis Fialho^{1,2}, Pedro André Dos Santos Ribeiro Horta^{2,3}, Manuel Pedro Ivens Collares-Pereira^{2,3}

¹University of Évora, Nossa Senhora da Tourega, Portugal, Portugal; ²University of Évora, Evora, Portugal

4BV.1.51

On the Performance of Photovoltaics on Car Roofs: Case Study Under Different Static Scenarios

Javier Macías Rodríguez¹, Rebeca Herrero¹, Rubén Núñez¹, Ignacio Antón¹

¹UPM, Madrid, Spain

4BV.1.52

Development of a Modeling Tool for the Design and Optimization of Vehicle-Integrated Photovoltaic Systems

Patricia Seoane Da Silva¹, Simone Regondi¹, Emanuele Cornagliotti¹, Maikel van Hest¹, Arjo van der Ham¹

¹Lightyear, Helmond, Netherlands

4BV.1.53

Agrivoltaic Perovskite Tandem LCA LCOE

Amaury Martin^{1,2}, Lars Oberbeck³, Pierre Philippe Grand⁴, Jean-Baptiste Puel⁴, Jean Rousset⁵

¹IPVF, Orsay, France; ²TotalEnergies, Orsay, France; ³EDF R&D, Palaiseau, France; ⁴EDF R&D, MONTREUIL, France

4BV.1.54

Floating Photovoltaics for Covering Rainwater Basins of Greenhouses: Evaluation of Energy Yield Models

Arttu Tuomiranta¹, Hariharsudan Sivaramakrishnan Radhakrishnan¹, Georgi H. Yordanov², Jens Dirk Moschner², Marco Morelli³, Michiel Voglar³, Jean Reusens⁴, Joris Lemmens¹, Loïc Tous¹, Michaël Daenen³, Hedwig Van Roy⁴, Ivan Gordon¹

¹imec, Genk, Belgium; ²KU Leuven, Leuven, Belgium; ³Hasselt University, Hasselt, Belgium; ⁴Connectum, Wuustwezel, Belgium

4BV.1.55

A Concrete Based Floating Solar Solution with Integrated Photovoltaics for Marine Applications

Asier Sanz Martinez¹, Esteban Camacho², Francesco Boscolo¹, Eneko Setien¹

¹TECNALIA, Derio, Spain; ²Research and Development Concretes, València, Spain

4BV.1.56

Design of a Flexible Agrivoltaic Research Facility Based on a Parameter Analysis

Brecht Willockx¹, Bert Herteleer¹, Jan Cappelle¹

¹KU Leuven, Gent, Belgium

4BV.1.57

3D-Printed Walkable Solar Tiles

Marica Mariaconcetta Canino¹, Shima Fasahat^{1,2}, Virginia Boldrini¹, Emanuele Centurioni¹, Laura Ferlauto², Rita Rizzoli¹, Cesare Sangiorgi², Daniela Cavalcoli²

¹CNR, Bologna, Italy; ²University of Bologna, Bologna, Italy

4BV.1.58

Design and Evaluation of an Automated Monitoring and Sensor Network System for Photovoltaic Greenhouses

Houria Assem¹

¹CDER, Alger, Algeria

4BV.1.59

Designing the Most Optimal Floating Single-Axis Azimuthal Tracking System

Maarten Dörenkämper¹, Minne M. de Jong¹, Jan M. Kroon¹

¹TNO, Netherlands

4BV.1.60

Mechanical Stress in PV Panels on Floating PV Systems

Christoph Seiffert¹, Josefine Helene Selj^{1,2}, Dag Lindholm³, Hallvard Fjær³, Sigurd Brattheim¹, Gaute Otnes¹, Nathan Roosloot^{1,2}

¹Institute for Energy Technology, Kjeller, Norway; ²University of Oslo, Kjeller, Norway

4BV.1.61

Theoretical Study of Enhanced Convective Heat Transfer in Solar Panels at Elevated Ambient Temperatures

Maciej Iwaniuk¹, Aikaterini Fragaki¹, Imran Khan¹

¹University of Central Lancashire, United Kingdom

4BV.1.64

Hotspot Endurance Test for VIPV

Bhavya Kasagani¹, Ruchita Korgaonkar¹, Narendra Shiradhkar¹

¹IIT Bombay, Mumbai, India

Visual Presentations 2BV.2

**10:30- 12:00 Emerging and Novel Approaches for Photovoltaics /
Advanced Modelling and Characterization**

Poster Area

Chairpersons:

Antonio MARTÍ VEGA
UPM, Madrid, *Spain*

Iñigo RAMIRO
NOVA University of Lisbon, Lisbon, *Portugal*

2BV.2.1

Kesterite-Based Mongrain Photovoltaics: the Ideal Solution for Sustainable Power Supply

Dieter Meissner¹, Kaia Ernits², Stefan Gahr¹, Martin Vetter¹, Christoph Glatz¹, Rumman Syed¹

¹*crystalsol, Austria*; ²*crystalsol, Tallinn, Estonia*

2BV.2.2

Opto-electrical Properties of Group IV Alloys: the Inherent Challenges of Processing Ge:H

Thierry de Vrijer¹, Bilal Bouazzata¹, Ashwath Ravichandran¹, Julian van Dingen¹, Paul Roelandschap¹, Koos Roodenburg¹, Steven Roerink¹, Federica Saitta¹, Thijs Blackstone¹, Arno Smets¹

¹*Delft University of Technology, Netherlands*

2BV.2.3

High Absorptivity of Intraband Transition Occurring at Heterointerface in Two-Step Photon Up-Conversion Solar Cells

Shigeo Asahi¹, Hambalee Mahamu¹, Takashi Kita¹

¹*Kobe University, Kobe, Japan*

2BV.2.4

Simulation and Experimental Study for a Micro-Striped Colour Neutral Semi-transparent Mini-Module

Shilpi Shital¹, Pedro Santos², Ricardo Poeira¹, Himanshu Phirke¹, Pedro Anacleto², Sascha Sadewasser², Phillip Dale¹

¹*University of Luxembourg, Belvaux, Luxembourg*; ²*INL, Braga, Portugal*

2BV.2.5

Electronic Properties of Doped Anatase TiO₂: a First-Principles Modelling and Experimental Demonstration

MD. Anower Hossain¹, Borong Sang¹, Bram Hoex¹

¹*UNSW, Kensington, NSW, Australia*

- 2BV.2.6** **Improvement of Passivation Performance of Silicon Nano-crystal/Silicon Oxide Compound Layer by Hydrogen Plasma Treatment**
 Masashi Matsumi¹, Kazuhiro Gotoh¹, Markus Wilde², Yasuyoshi Kurokawa¹, Katsuyuki Fukutani², Noritaka Usami¹
¹Nagoya University, Japan; ²University of Tokyo, Japan
- 2BV.2.7** **Zr-doped Indium Oxide as Transparent Electrodes for Photovoltaics**
 Melanie Micali^{1,2}, Marco Leonardi^{1,3}, S. Lombardo³, Giuseppe Bengasi⁴, Claudio Colletti⁴, Virginia Boldrini⁵, Esther Alarcon-Llado⁶, Antonio Terrasi^{1,2}
¹University of Catania, Catania, Italy; ²CNR, Catania, Italy; ³ENEL Green Power, Catania, Italy; ⁴CNR, Bologna, Italy; ⁵AMOLF, Amsterdam, Netherlands
- 2BV.2.8** **How Different Window Layers Influence the Performance of Sb₂Se₃-based Solar Cells**
 Alessio Bosio¹, Stefano Marchionna², Stefano Pasini¹
¹University of Parma, Parma, Italy; ²RSE, Milan, Italy
- 2BV.2.9** **Enhanced Photodetection Effect in Nanoscale MoS₂ Van der Waals Heterostructure**
 Ayman Rizk¹, Ammar Nayfeh¹
¹, United Arab Emirates
- 2BV.2.10** **Fabrication and Evaluation of Polycrystalline BaSi₂ Films on Si Substrates by Co-Sputtering of BaSi₂ and Ba Targets**
 Kazuki Kido¹, Ryota Koitabashi¹, Hayato Hasebe¹, Sho Aonuki¹, Masami Mesuda², Kaoru Toko¹, Takashi Suemasu¹
¹University of Tsukuba, Tsukuba-shi, Ibaraki-pref., Japan; ²TOMATO-GSL, Ayase-shi, Kanagawa-pref, Japan
- 2BV.2.11** **Thermodynamic Interfaces Instabilities in Sb₂Se₃ Based Solar Cells in Substrate Configuration**
 Maykel Jimenez Guerra¹, Yudenía Sánchez², Lorenzo Calvo-Barrio^{3,4}, Alejandro Navarro Güell¹, Ivan Caño Prades¹, Axel Gon Medaille², Zacharie Jehl¹, Edgardo Saucedo¹
¹UPC, Barcelona, Spain; ²IREC, Barcelona, Spain; ³University of Barcelona, Barcelona, Spain
- 2BV.2.12** **Interfacing Nanostructured Layers in Solar Cells by Ferroelectric Thin-Films for Better Electron Transport**
 Vilko Mandić¹, Ivana Panzic¹, Arijeta Baftić¹, Luka Pavić²
¹University of Zagreb, Zagreb, Croatia; ²Ruđer Bošković Institute, Zagreb, Croatia

2BV.2.13

Highly Crystalline In₂S₃ Thin Films Epitaxially Grown on Sapphire Substrates: A Potential Candidate for Intermediate Band Solar Cell Application

Tanja Jawinski¹, Roland Clausen², Heiko Kempa², Roland Scheer², Marius Grundmann¹, Holger von Wenckstern¹

¹University of Leipzig, Leipzig, Germany; ²Martin Luther University, Halle (Saale), Germany

2BV.2.14

Comparison of CdS and TiO₂ Buffer Layers for Antimony Selenide (Sb₂Se₃) Solar Cells by Vacuum Evaporation

Narges Torabi¹, Solidea Zanetti¹, Elisa Artegiani¹, Prabeesh Punathil¹, Alessandro Romeo¹

¹University of Verona, Verona, Italy

2BV.2.15

Evaluation of HNO₃ Doping in Graphene/Silicon Solar Cells by Means of Capacitance - Voltage Curves and Impedance Spectroscopy

Ilaria Maticena¹, Laura Lancellotti¹, Eugenia Bobeico¹, Nicola Lisi², Paola Delli Veneri¹

¹ENEA, Portici, Italy; ²ENEA, Roma, Italy

2BV.2.16

Light Separation for the Lateral System of Luminescent Solar Concentrators

Mykola R. Kulish¹, Anatoly Sachenko¹, Vitaliy P. Kostylyov¹, Igor O. Sokolovskyi¹, Anatoli Shkrebtii²

¹ISP NASU, Kyiv, Ukraine; ²Ontario Tech University, Oshawa,

2BV.2.17

Solder Paste Printing Optimization for Interconnecting Back Contact Cells

Narahari Pujari¹

¹MacdermidAlpha Electronics Solutions, Bengaluru, India

2BV.2.18

Pre-thermalizational Impact of Hot Carriers on Photovoltage Formation in a Single Junction Solar Cell

Jonas Gradauskas^{1,2}, Steponas Ašmontas¹, Oleksandr Masalskyi², Algirdas Sužiedelis¹, Aldis Šilenas¹, Aurimas Cerškus^{1,2}, Aleksej Rodin¹, Ihor Zharchenko¹

¹Center for Physical Sciences and Technology, Lithuania; ²VGTU, Lithuania

2BV.2.19

Overview of Materials' Hot Carrier Temperature Under Concentrated Natural Sunlight

Igor Konovalov¹

¹University of Applied Sciences Jena, Jena, Germany

- 2BV.2.20** **Defect Passivation through Spiro[Fluorene-9,9'-Xanthene] Based Additives for an Efficient Perovskite Solar Cells**
Bommaramoni Yadagiri¹, Sanjay Sandhu¹, Senthilkumar Muthu¹, Jae-Joon Lee¹
¹*Dongguk University, Seoul, Korea, Rep. of South*
- 2BV.2.21** **Enabling Transparent Conductive Oxide and Doped Amorphous Silicon Free Efficient Silicon Heterojunction Solar Cells by Flexibly Using Dopant-free Contact**
Jian He¹, Pingqi Gao¹
¹*Sun Yat-sen University, Guangzhou, China*
- 2BV.2.22** **Plasmonic Luminescent Solar Devices**
Subhash Chandra¹, Aaron Glenn¹, Bill Cass¹, Mojtaba Nasiri¹, Anita Ortega¹, Sarah McCormack¹
¹*Trinity College Dublin, Dublin , Ireland*
- 2BV.2.23** **Efficient Light-Harvesting Employing Size-Gradient Quantum Dot Films**
Jose Raul Montes Bojorquez¹, Maria Fernanda Villa Bracamonte¹, Arturo Ayon¹
¹*University of Texas at San Antonio, San Antonio, United States*
- 2BV.2.24** **Characterization of Highly Efficient Silicon-Based Solar Cells with Flat and Textured Surfaces**
Anatoly Sachenko¹, Vitaliy P. Kostilyov¹, Viktor M. Vlasiuk¹, Gowsikan Perinparajah², Igor O. Sokolovskiy¹, Mykhaylo Evstigneev³, Anatoli Shkrebtii²
¹*ISP NASU, Kyiv, Ukraine; ²Ontario Tech University, Oshawa, Canada; ³Memorial University of Newfoundland, St. John's, Canada*
- 2BV.2.25** **Optimizing the Positions of Quantum Dot Layers for Light Absorption Enhancement in Quantum Dot Solar Cells with Light Trapping**
Yusuke Oteki^{1,2}, Naoya Miyashita², Maxime Giteau¹, Kento Kitahara^{1,2}, Yoshitaka Okada^{1,2}
¹*The University of Tokyo, Japan; ²The University of Tokyo, Tokyo, Japan*
- 2BV.2.26** **Scanning Tunneling Spectroscopy Study of Quantum Dot sized SiGe Alloy Nanocrystals prepared in a Nonthermal Capacitively-Coupled Plasma**
MD Seraj Uddin Ansari¹, Salma Khatun², C. Vijayana¹, Jatindra K. Rath¹
¹*Indian Institute of Technology Madras, Madras, India; ²Indian Association for the Cultivation of Science, Kolkata, India*

2BV.2.27

Separate Measurement of Electron and Holes Photo-Induced Seebeck Effect from Photoluminescence of Hot Carrier Solar Cells

Thomas Vezin¹, Hamidreza Esmailpour², Daniel Suchet¹, Jean-Francois Guillemoles¹

¹IPVF, Palaiseau, France; ²Technical University of Munich, München, Germany

2BV.2.28

Application of Photoluminescent Pigments for Wavelength Shift of Ultraviolet Light in Solar Cells

Otávio Oliveira¹, Natália Coutinho¹, Thais Crestani¹, Gabriel Thomas Dias de Freitas¹, Marcelo Gradella Villalva¹, Francisco Marques¹

¹UNICAMP, Campinas, Brazil

2BV.2.29

Potential Opportunity of Luminescent Solar Concentrators for Hydrogen Generation

Omar Lakbita¹, Othmane Essahili², Mouad Ouafi², Omar Moudam²

¹Mohammed VI Polytechnic University, Benguerir,, Morocco; ²Mohammed VI Polytechnic University, Benguerir, Morocco

2BV.2.30

Bandgap Engineering of Halide Perovskite Quantum Dot for Solar Cell Performance

Long Hu¹, Shujuan Huang¹

¹Macquarie University, Australia

2BV.2.39

A Self-consistent Hybrid Model Connects Empirical and Optical Models for fast, Non-destructive Inline Characterization of Thin, Porous Silicon Layers

Alexandra Wörnhör¹, Matthias Demant¹, Henri Vahlman¹, Stefan Rein¹

¹Fraunhofer ISE, Freiburg im Breisgau, Germany

2BV.2.40

Assessing the Effectiveness of Encapsulation Schemes for Perovskite Devices Using Photoluminescence Imaging

George Koutsourakis¹, Simone Meroni², James Blakesley¹, Ross DIX Peek³, Richard Dixon⁴, Ernest van Dyk³, Pufinji Obene⁵, Ian Arnold⁵, Tateos Tvapanyan⁵, Jacqueline Crozier McClelland³, Roelof Roodt³, Freddie (Frederik) Vorster³, Alexander Howe⁴, Trystan Watson², Fernando Castro¹

¹National Physical Laboratory, Teddington, United Kingdom; ²Swansea University, Swansea, United Kingdom; ³Nelson Mandela University, Gqeberha, South Africa; ⁴Dycotec Materials, United Kingdom; ⁵Precision Varionic International, United Kingdom

- 2BV.2.41** **Efficient Charge Carrier Extraction in Perovskite-Silicon Tandem Solar Cells Investigated by a Full Opto-Electrical Simulation Model in Sentaurus TCAD**
 Christoph Messmer^{1,2}, Jonas Schön^{1,2}, Uli Würfel^{2,3}, Patricia Schulze², Martin C. Schubert², Martin Bivour², Stefan W. Glunz^{1,2}, Martin Hermle²
¹University of Freiburg, Freiburg im Breisgau, Germany; ²Fraunhofer ISE, Freiburg im Breisgau, Germany; ³FMF, Freiburg im Breisgau, Germany
- 2BV.2.42** **The Direct Measurement of Positive Feedback Loop-Gain During Hot-Spot Formation in Thin-Film Solar Cells**
 Suheir Nofal^{1,2}, Bart E. Pieters¹
¹Forschungszentrum Jülich , Jülich, Germany; ²RWTH Aachen University, Aachen, Germany
- 2BV.2.43** **Optoelectronic Parameters Prediction Using Combinatorial Spectroscopic Techniques and Machine Learning**
 Enric Grau-Luque¹, Andreas Zimmermann², Stefan Paetel³, Sergio Giraldo¹, Fabien Atlan¹, Robert Fonoll-Rubio¹, Ignacio Becerril-Romero¹, Alejandro Pérez-Rodríguez^{1,4}, Maxim Guc¹, V. Izquierdo-Roca¹
¹IREC, Sant Adrià de Besòs, Spain; ²Sunplugged, Wildermieming, Austria; ³ZSW, Stuttgart, Germany; ⁴University of Barcelona, Barcelona, Spain
- 2BV.2.44** **Identifying Defects on Solar Cells Using Magnetic Field Measurements and Artificial Intelligence Trained by a Finite-Element-Model**
 Kjell Buehler¹, Kai Kaufmann^{2,3}, Markus Patzold², Mawe Sprenger², Stephan Schoenfelder¹
¹Leipzig University of Applied Science, Leipzig, Germany; ²DENKweit, Halle, Germany; ³Anhalt University of Applied Sciences, Köthen, Germany
- 2BV.2.45** **Finite Element Method Simulation of Tunneling in Perovskite Based Solar Cells**
 Habtamu Tsegaye Gebrewold^{1,2}, Karsten Bittkau¹, Thomas Kirchartz^{1,3}, Uwe Rau^{1,2}, Kaining Ding¹
¹Forschungszentrum Jülich, Jülich, Germany; ²RWTH Aachen University , Aachen, Germany; ³University of Duisburg-Essen, Duisburg, Germany
- 2BV.2.46** **Evaluation Indoor Lighting Simulator for Emerging PV**
 Yean-San Long¹, Min-An Tsai¹, Teng-Chun Wu¹
¹ITRI, Hsinchu, Taiwan
- 2BV.2.47** **Enabling Tandem Solar Cell Measurements Using Common LED Based Solar Simulators – A Robust Spectral Adjustment Method**
 David Chojniak¹, Jochen Hohl-Ebinger¹, S. Kasimir Reichmuth¹, Michael Schachtner¹, Alexandra Schmid¹, Gerald Siefer¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany

2BV.2.48

Electroluminescence Radiance Maps based on Multiple Exposure Images from InGaAs Cameras

Claire Mantel¹, Sergiu V. Spataru², Rodrigo Del Prado Santamaria², Peter Behrendsdorff Poulsen², Søren Forchhammer¹

¹DTU Fotonik, Kgs. Lyngby, Denmark; ²DTU Fotonik, Roskilde, Denmark

2BV.2.49

A New Explicit Five-Parameter Solar Cell Model

Andreea Sabadus¹, Marius Paulescu²

¹UVT, Timișoara, Romania; ²West University of Timisoara, Timisoara, Romania

2BV.2.50

In-Depth Chemical and Optoelectronic Analysis of Triple-cation Perovskite Thin Films by Combining XPS Profiling and PL Imaging

Mirella Al Katrib¹, Stefania Cacovich², Guillaume Vidon¹, Marie Legrand³, Jean-Baptiste Puel³, Jean-Francois Guillemoles², Philip Schulz², Muriel Bouttemy⁴, A. Etcheberry⁴

¹IPVF, France; ²CNRS, France; ³EDF R&D, France; ⁴UVSQ, France

2BV.2.51

A Lateral Heterojunction Device as a Tool to Study and Optimize Perovskite-Based Solar Cells

Davide Regaldo^{1;2;3}, Pilar Lopez-Varo¹, Jean-Baptiste Puel^{1;4}, Josè Alvarez^{1;2;5}, Philip Schulz^{1;6}, Jean-Paul Kleider^{1;2;5}

¹IPVF, Palaiseau, France; ²University of Paris-Saclay, Gif-sur-Yvette, France; ³IPVF, Paris, France; ⁴EDF R&D, Palaiseau, France; ⁵GeePs, Paris, France; ⁶CNRS, Palaiseau, France

2BV.2.52

Online Implementation of a Multiple Linear Regression Model for CIGS Photovoltaic Module Performance

Paolo Graniero^{1;2}, Guillermo Antonio Farias Basulto², Rutger Schlatmann², Reiner Klenk², Carolin Ulbrich²

¹Free University of Berlin, Berlin, Germany; ²HZB, Berlin, Germany

2BV.2.53

Dolphin's Method for Fast In-Situ/Line Modulated Photoluminescence

Mateusz Poplawski^{1;2}, François Silva², Jean-Charles Vanel², Pere Roca I Cabarrocas^{1;2}

¹IPVF, Palaiseau, France; ²École Polytechnique, Palaiseau, France

2BV.2.54

Validation of Plasmonic Luminescent Solar Concentrator Modelling Software

Aaron Glenn¹, Sarah McCormack¹, Subhash Chandra¹, Mojtaba Nasiri¹, Anita Ortega¹

¹Trinity College Dublin, Dublin, Ireland

2BV.2.55

Characterizing the Absorption of Perovskites at the Microscale through Photoluminescence Multidimensional Imaging

Marie Legrand¹, Baptiste Béranguier², Guillaume Vidon³, Jean-Francois Guillemoles², Daniel Ory¹

¹EDF R&D, Palaiseau, France; ²CNRS, Palaiseau, France; ³IPVF, Palaiseau, France

2BV.2.56

Optical Process Control for the Synthesis of Cu(In,Ga)Se₂ Based micro-Solar Cells

Ricardo Poeira¹, Daniel Siopa¹, Pedro Anacleto², Sascha Sadewasser², Phillip Dale¹

¹University of Luxembourg, Belvaux, Luxembourg; ²INL, Braga, Portugal

2BV.2.57

TLM Method Applied on Wires for CIGS

Busra Sesli^{1,2}, Marc Meuris^{1,2}, Michaël Daenen^{1,2}, Bart Vermang^{1,2}

¹Hasselt University, Hasselt, Belgium; ²imec, Genk, Belgium

2BV.2.58

Inorganic Perovskite Solar Cells Based on Double Perovskite Oxides La₂NiMnO₆ and La₂Ni_{0.8}Fe_{0.2}MnO₆

Anna B. Nikolskaia¹, Olga Alexeeva¹, Oksana Almjasheva², Liudmila Larina¹, Sergey Kozlov¹, Oleg Shevaleevskiy¹

¹RAS, Russian Federation; ²Saint Petersburg Electrotechnical University, Russian Federation

2BV.2.59

Effect of Thermal Radiation Entropy on the Outdoor Efficiency Limit of Single Junction Solar Cells

Hesan Ziar¹

¹Delft University of Technology, Netherlands

2BV.2.60

Characterization of the Electrical Behavior of a Bifacial Photovoltaic Solar Module Obtained through Static and Transient Analyses

Patricio Valdivia¹

¹Federico Santa Maria Technical University, Chile

Visual Presentations 3BV.3

13:30- 15:00 PV Characterization, Modelling and Energy Rating

Poster Area

Chairpersons:

Christos MONOKROUSSOS
TÜV Rheinland Group, Shanghai, *China*

Juan Lopez GARCIA
QEERI, Doha, *Qatar*

3BV.3.1

Improving Spectral Responsivity Measurements by Correcting for Filter Bandwidth

Clara Edmonds¹, Harald Mülleijans¹

¹*European Commission JRC, Ispra (VA), Italy*

3BV.3.2

Analysis of Encapsulant Discoloration Effect on the Temperature of Photovoltaic Module

Arti Pareek¹, Roopmati Meena¹, Rajesh Gupta¹

¹*IIT Bombay, India*

3BV.3.3

Optimal Methodology for Forecasting Performance Loss Rate of Fielded Photovoltaic Systems Using Robust Principal Component Analysis and Auto Regressive Integrated Moving Average

Anna Michail¹, Andreas Livera¹, Andreas Kyprianou¹, George Elias Georghiou¹

¹*University of Cyprus, Nicosia, Cyprus*

3BV.3.4

Estimating Solar Cell Operating Temperature via Deep Neural Networks

Theodoros Katsaounis^{1,2}, Georgios Papadomichelakis², Konstantinos Kotsovos³, Issam Gereige³, Marwan Abdullah³, Athanasios Tzavaras⁴, Yiannis Kamarianakis¹

¹*FORTH, Heraklion, Greece;* ²*University of Crete, Heraklion, Greece;* ³*SAUDI ARAMCO, Thuwal, Saudi Arabia;* ⁴*KAUST, Thuwal, Saudi Arabia*

3BV.3.5

Characterisation of Soiling on PV Module by Microscopic Image Processing With New Parametrics

Sébastien Arbaretaz¹, Christophe Ménézo², Emilie Planès³, Eric Pilat¹

¹*INES, Le Bourget-du-Lac, France;* ²*Savoy Mont Blanc University, Le Bourget-du-Lac, France;* ³*Grenoble INP, Le Bourget-du-Lac, France*

- 3BV.3.6** **Decoupling Performance Gains of Silicon Hetero-Junction Bifacial Modules**
Hugo Quest^{1,2}, Alessandro Virtuani¹, Luca Gnocchi¹, Alejandro Borja Block¹,
Nicolas Wyrsh¹, Christophe Ballif^{1,3}
¹EPFL, Neuchâtel, Switzerland; ²3S Solar Plus, Thun, Switzerland; ³CSEM,
Neuchâtel, Switzerland
- 3BV.3.7** **Advantages of n-Type Bi-Facial TOPCon Solar Modules in Low Irradiance Performance and Energy Yield**
Kuang-Chieh (Jay) Lai¹, Chi-Chun Li¹, Chien-Chun Hsieh², Ming-Tsun Kuo²,
Liang-Tang Wang¹, Hsing-Wang Tsai¹, An-Heng Cheng¹, H. S. Lin¹
¹Motech Industries, Tainan City, Taiwan; ²ITRI, Tainan City, Taiwan
- 3BV.3.8** **Tools and Techniques for Spectral Irradiance Processing and Mismatch Estimation**
Anton Driesse¹, Marios Theristis², Josh Gallon³, Joshua S. Stein²
¹PV Performance Labs, Freiburg, Germany; ²Sandia National Laboratories,
Albuquerque, United States; ³NREL, Golden, United States
- 3BV.3.9** **Simplified Angular Responsivity Measurements of c-Si Modules**
Blago Mihaylov¹, Harald Müllejjans¹, Tony Sample¹, Ewan Dunlop¹
¹European Commission JRC, Italy
- 3BV.3.10** **Study of Optical Transmission Losses of Satinated PV Glass**
Markus Babin¹, Sune Thorsteinsson¹, Michael Jakobsen¹, Sergiu V. Spataru¹
¹Technical University of Denmark, Roskilde, Denmark
- 3BV.3.11** **Application of Electroluminescence Current-Intensity Relation for Estimation of PID Impact in Crystalline Silicon Photovoltaic Module**
Ravi Kumar¹, Vishal Eknath Puranik¹, Rajesh Gupta¹
¹IIT Bombay, India
- 3BV.3.12** **Proposal for an Indoor Test Procedure to Determine the Operational Temperature of PV Modules**
Paul Gebhardt¹, Kumara Vamsi Krishna Vandanapu¹, Jochen Markert¹, Georg Mülhöfer¹, Daniel Philipp¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany

3BV.3.13

Performance Calculation of n-PERT Solar Cell and 1-Cell Mini Module in the Atacama Desert

Pablo Ferrada¹, Sebastián Rodríguez², Aitor Marzo¹, Edward Fuentealba², Valeria del Campo³, Miriam R. Ferrández^{4,5}, Benjamin Ivorra⁴, Emilio Ruiz Reina⁷

¹University of Antofagasta, Antofagasta, Chile; ², Valparaíso, Chile; ³UPM, Madrid, Spain; ⁴University of Almería, La Cañada, Spain; ⁵University of Malaga, Málaga, Spain

3BV.3.14

Adding the MLFM to PVPMC/PVLIB

Steve Ransome^{1,2}, Juergen Sutterlueti³

¹Steve Ransome Consulting, Kingston Upon Thames, United Kingdom; ²Gantner Instruments, Schruns, Austria

3BV.3.15

Outdoor Energy Performances for Standard and Bi-Facial Modules as well on the Failure Modes Observed in Outdoor Conditions

Alessandra Ottanà^{1,2}, Francesco Rametta¹, Walter Gangemi¹, Claudio Colletti¹, Agnese DI Stefano¹, Andrea Canino¹, Marina Foti¹, Cosimo Gerardi¹, Fabrizio Bizzarri²

¹ENEL Green Power, Italy

3BV.3.16

Dynamic Simulation Model of an Air-Based BIPVT Roof Tile System

Lionel Clasing¹, Pak Hin Yam¹, Claudia Ziller¹, Ulf Blieske¹

¹Cologne University of Applied Sciences, Cologne, Germany

3BV.3.17

Photovoltaic Performance Metrics and Data Processing in Nordic Climate Conditions

Aapo Poskela^{1,2}, Lauri Karttunen¹, Heikki Palonen¹, Hugo Huerta Medina³, Samuli Ranta³, Kati Miettunen¹

¹University of Turku, Turku, Finland; ²Solar Finland, Salo, Finland; ³TUAS, Turku, Finland

3BV.3.18

Uniform and Non-Uniform Soiling of PV Modules: a Comprehensive Study of Performance and Temperature Effects

Daniel Braga¹, Antonia Sonia A.C. Diniz², Suellen Caroline Silva Costa¹, Vinícius Augusto Camatta Santana², Lawrence Kazmerski³

¹PUC Minas, Belo Horizonte, Brazil; ²Pontifical Catholic University of Minas Gerais, Belo Horizonte, Brazil; ³University of Colorado Boulder, Boulder, United States

3BV.3.19

Very Accurate Outdoor Estimation of Voc's Temperature Coefficient from Equivalent Cell Temperature Sensitivity Analysis

Georgi H. Yordanov¹, Stan Herthogs¹

¹Catholic University of Leuven, Leuven-Heverlee, Belgium

- 3BV.3.20** **A Study on Using Micro-Computed Tomography for PV Interconnection Technology Development**
 Rik Van Dyck^{1,2,3,4}, Alexandros Prapavesis¹, Tom Borgers^{2,3,4}, Jonathan Govaerts^{2,3,4}, Loïc Tous^{2,3,4}, Jozef (Jef) Poortmans^{2,3,4,5}, Aart Willem Van Vuure¹
¹KU Leuven, Leuven, Belgium; ²Hasselt University, Hasselt, Belgium; ³imec, Genk, Belgium
- 3BV.3.21** **Experimental Validation of the Simulation of the Impact of Moving Objects, Partial Shading or Penumbra on Shading Losses Affecting Photovoltaic Modules**
 João M. Serra¹, Rita Coelho¹, Dmitri Boutov¹, Jesus Robledo Bueno², Jonathan Leloux²
¹University of Lisbon, Portugal; ²Lucisun, Belgium
- 3BV.3.22** **Field Monitoring of Water in PV Modules by Near-Infrared Spectroscopy**
 Oleksandr Stroyuk¹, Claudia Buerhop-Lutz¹, Lewin Leihkamm¹, Jens Hauch¹, Marius Peters¹
¹Forschungszentrum Jülich, Erlangen, Germany
- 3BV.3.23** **Outdoor NMOT Test Stand with Adjustable Wind Field**
 Michael Schrempf¹, Stefan Riechelmann¹, Laura Stenzig¹, Stefan Winter¹
¹PTB, Germany
- 3BV.3.24** **Bifacial IV Tracer. Bifacial Performance Assessment on Outdoor Sunlight Conditions**
 Sergio Suarez¹, Eneko Ortega², Sofia Rodríguez-Conde¹, Ignacio Fernandez¹, Juan Carlos Jimeno², Jose Ruben Gutierrez², Vanesa Fano²
¹Enertis Applus, Spain; ²UPV/EHU, Gasteiz, Spain
- 3BV.3.25** **Experimental Study of Shading Effect on PV Cells by Reverse Electrical Polarization**
 Imed Derbali¹, Aurélien Raddenzati¹, Bertrand Chambion¹, Lionel Serra¹, Loic Lonardonì¹, Fabien Chabuel¹
¹INES, Le Bourget-du-Lac, France
- 3BV.3.26** **Thermal Modelling of PV Systems Based on Indoor and Outdoor PV Modules Testing**
 Oume Lgheit Rhazi¹, Julien Dupuis¹, Emmanuel Boyère¹, Geoffrey Rachinel², Daline Nap², Floriane Gay³
¹EDF R&D, Écuellles, France; ²EDF Renewables, Colombiers, France; ³EDF Renewables, Paris La Défense, France

3BV.3.27

Module Quality Control Using very Low-Cost Mobile Near-Infrared Spectroscopy Device: Application to Backsheet Type Identification

Julien Dupuis¹, Christine Abdel Nour¹, Romain Bodeux², Paul Lefillastre³, Axel Becker³

¹EDF R&D, MORET LOING ET ORVANNE, France; ²IPVF, PALAISEAU, France; ³EDF Renewables, PARIS LA DEFENSE, France

3BV.3.28

Performance Evaluation and Comparison of Solar Cell Technologies Based on Historical Data

Yiannis Pantazis¹, Evangelia Kalligiannaki¹, Yiannis Kamarianakis¹, Konstantinos Kotsovos², Issam Gereige², Marwan Abdullah², Athanasios Tzavaras³, Theodoros Katsaounis^{1,4}

¹FORTH, Heraklion, Greece; ²ARAMCO, Thuwal, Saudi Arabia; ³KAUST, Thuwal, Saudi Arabia; ⁴University of Crete, Heraklion, Greece

3BV.3.29

Linearity Measurements of Photovoltaic Modules with Attenuance of Photovoltaic Modules with Attenuating Irradiance Filter Technique

Özcan Bazkir¹, Seval Meric¹

¹TUBITAK-NMI, KOACELI, Turkey

3BV.3.30

Effect of Weather Environment and Partial Shading on Power Generation Performance of Flexible CIGS-PV Modules

Hyun Jin Cha¹, Seokhee Lee¹, Juna Kim¹, Jung Hwan Park¹, Donghyun Hwang², Chang Sik Son³

¹Pusan National University, Busan, Korea, Rep. of South; ²SHU-SOEN's R&D Lab, Busan, Korea, Rep. of South; ³Silla University, Busan, Korea, Rep. of South

3BV.3.31

Effects of Different Shading Scenarios on the Performance of PV Modules

Seval Meriç¹, Özcan Bazkir²

¹TUBITAK-NMI, KOCAELI, Turkey; ²TUBITAK-NMI, Kocaeli, Turkey

3BV.3.32

Computation of Faulty IV Curves Based on a Distributed Solar Cell Algorithm

Carlos Cárdenas-Bravo^{1,2}, Denys Dutykh¹, Duy Long Ha²

¹Savoy Mont Blanc University, Chambéry, France; ²CEA, Chambéry, France

3BV.3.33

Step by Step Current-Voltage Curve Division Method for the Estimation of Degraded Photovoltaic Cell Parameters

Vishal Eknath Puranik¹, Ravi Kumar¹, Rajesh Gupta¹

¹IIT Bombay, India

- 3BV.3.34** **Evaluation of Anti-Soiling Coating Solution for Monocrystalline Half-Cut Cells PV Modules [T1] in the Outdoor Conditions of Benguerir, Morocco**
Tijani Khalil¹, Benazzouz Aboubakr¹, Said Elhamaoui¹, Naimi Zakaria¹, Ikken Badr¹, Ghennioui Abdellatif¹
¹Green Energy Park, Ben Guerir, Morocco
- 3BV.3.35** **A Fuzzy Logic Approach for a Quantitative Evaluation of PV Modules EL Images**
Miguel Guada¹, David Pérez¹, César Hidalgo¹
¹DNV, Madrid, Spain
- 3BV.3.36** **Accurate Measurement of the Angular Dependence of PV Module Performance Using a Dual Axis Solar Tracker**
Arvid van der Heide¹, Arttu Tuomiranta¹, Michiel Daniels², Niels Capiot², Michaël Daenen³, Stefan Wendlandt⁴, Loïc Tous¹
¹imec, Genk, Belgium; ²Hasselt University, Hasselt, Belgium; ³Hasselt University, Belgium; ⁴PI Berlin, Berlin, Germany
- 3BV.3.37** **Impact of Technological Trends in Crystalline Silicon PV Modules on the Energy Yield Performance: Preliminary Result of the 14th SUPSI Outdoor Measurement Campaign**
Gabi Friesen¹, Mauro Caccivio¹, Ebrar Özkalay¹, Falvio Valoti¹
¹SUPSI, Mendrisio, Switzerland
- 3BV.3.38** **Development and Validation of a Performance Simulation Model of an Air-Based BIPVT Roof Tile Using Open-Source Libraries**
Marius Bartkowski¹, Lionel Clasing¹, Hamza Rehman Saleemi¹, Christian Brosig¹, Eberhard Waffenschmidt¹, Ulf Blieske¹
¹Cologne University of Applied Sciences, Cologne, Germany
- 3BV.3.39** **Calibrated Model for the Yield Assessment of PV Modules with Coloured Front Glass**
Martina Pelle^{1,2}, Francesco Causone¹, David Moser²
¹Polytechnic University of Milano, Milano, Italy; ²Eurac Research, Bozen, Italy
- 3BV.3.40** **Experimental Assessment of Nanoimprinted Micro-Textured Frontsheets for PV Modules**
Lionel Clasing¹, Daniel Werner-Meier¹, Leon Willem Veldhuizen², Ulf Blieske¹
¹Cologne University of Applied Sciences, Cologne, Germany; ²Morphotonics, Veldhoven, Netherlands

3BV.3.41

Proposal for the Extension of the Energy Rating Standard Series IEC 61853 to Bifacial Modules

Robert P. Kenny¹, Ana Maria Gracia Amillo¹, Teodora Lyubenova¹, Diego Pavanello¹

¹European Commission JRC, Ispra, Italy

3BV.3.42

Improvement of A LED Bias Light System for the Double Sided Characterization of Bifacial Devices

Teodora Lyubenova¹, Robert P. Kenny¹, David Shaw¹, Diego Pavanello¹

¹European Commission JRC, Ispra, Italy

3BV.3.43

Applicability of the Analytical Five-Point Method for the Degraded Silicon PV Modules Under Hot and Humid Conditions

Firoz Khan¹, Jae Hyun Kim²

¹KFUPM, Dhahran, Saudi Arabia; ²DGIST, Korea, Rep. of South

3BV.3.44

Outdoor Performances of Opaque and Semi-Transparent Perovskite Solar Modules

Karim Medjoubi¹, Anne Migan-Dubois², Thomas Guillemot¹, Johan Parra³, Jean Rousset^{1,4}, Camille Bainier^{1,5}, Dounya Barrit^{1,5}, Jordi Badosa³, Jorge Posada^{1,4}

¹IPVF, Palaiseau, France; ²GeePs, Gif-sur-Yvette, France; ³LMD, IPSL, École Polytechnique, Université Paris-Saclay, ENS, CNRS, Palaiseau, France; ⁴EDF R&D, Palaiseau, France; ⁵TotalEnergies, Paris La Défense, France

3BV.3.45

PV DC Yield Determined by Deep Neural Networks: the Case of Building Integrated PV

Eli Shirazi¹, Ebrar Özkalay², Angèle Reinders^{1,3}

¹University of Twente, Enschede, Netherlands; ²SUPSI, Manno, Switzerland; ³Eindhoven University of Technology, Eindhoven, Netherlands

3BV.3.46

The Performances of Solar Panels Produced with Different Intermediate Materials

Ayşe Çiğdem Besen¹, Ertan Arikan¹, Murat Aldemir¹, Mikat Aktas¹, Ismail Makas¹

¹GTC Gunes, Turkey

3BV.3.47

Artificially Induced Series and Parallel Resistance for Precise Determination of IV Curves from Luminescence Images of PV Modules

Bernd Doll^{1,2,3}, Karen Forberich¹, Lan-Tien Hsu², Stefanie Vorstoffel^{1,2}, Larry Lüer², Jens Hauch^{1,2}, Marius Peters¹, Christoph J. Brabec²

¹Forschungszentrum Jülich, Erlangen, Germany; ²University of Erlangen-Nuremberg, Germany; ³Graduate School in Advanced Optical Technologies, Germany

- 3BV.3.48** **Uncertainty of PV Module Characterization under Real Sun**
 Ivan Lombardero¹, J. Solorzano¹, R. Moreton¹
¹Qualifying Photovoltaics , Madrid, Spain
- 3BV.3.49** **Effects of Clearness Index on The Performance of PV Modules Power Output**
 Sudipta Basu Pal¹, Konika Das Bhattacharya², Moumita Pramanik²
¹University of Engineering & Management Kolkata, India; ²Indian Institute of Engineering Science and Technology, India
- 3BV.3.50** **Improvement of the Average Photon Energy Spectral Correction Function Using the Depth of a Water Absorption Band**
 Rajiv Daxini¹, Yupeng Wu¹, Robin Wilson¹
¹University of Nottingham, Nottingham, United Kingdom
- 3BV.3.51** **Severity Analysis of Non-Uniform Encapsulant Discolouration in Crystalline Silicon Photovoltaic Modules Using Differential Current-Voltage Analysis Approach**
 Roopmati Meena¹, Manish Kumar², Rajesh Gupta¹
¹Indian Institute of Technology Bombay, India; ²Institute for Energy Technology, Kjeller, Norway
- 3BV.3.52** **Monte Carlo approach to Consider Power Production Uncertainty due to Randomness of Module Manufacturing Process**
 Ali Sohani¹, Cristina Cornaro¹, David Moser²
¹University of Rome Tor Vergata, Rome, Italy; ²EURAC Research, Bolzano, Italy
- 3BV.3.53** **Energy-Based Soiling Loss Monitoring for Solar PV Systems**
 Pavan Fuke¹, Shoubhik De¹, Narendra Shiradhkar¹, Anil Kottantharayil¹
¹Indian Institute of Technology Bombay, Mumbai, India
- 3BV.3.54** **Influence of Environmental Parameters on Soiling Deposition for Silicon-PV Modules**
 Suellen Caroline Silva Costa¹, Denio Cassini¹, Vinícius Augusto Camatta Santana¹, Lawrence Kazmerski², Antônia Sônia Alves Cardoso Diniz¹
¹Pontifical Catholic University of Minas Gerais, Belo Horizonte, Brazil; ²University of Colorado Boulder, Boulder, United States

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Ignacio ANTÓN HERNÁNDEZ
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Roberta CAMPESATO (i)
CESI, Milan, *Italy*

4BV.4.1

Day-ahead Forecasting of Solar Power Outputs: KNN-based Ensembles

Yiannis Kamarianakis¹, Evangelia Kalligiannaki¹, Yiannis Pantazis¹, Konstantinos Kotsovos², Issam Gereige², Marwan Abdullah², Athanasios Tzavaras³, Theodoros Katsaounis^{1,4}

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4BV.4.2

Improved Adaptive Neuro-Fuzzy Inference Model for Photovoltaic Power Forecast

Mustapha Habib¹, Annika Gram¹, Qian Wang¹

¹KTH Royal Institute of Technology, Stockholm,, Sweden

4BV.4.3

A Robust Data-Driven Model for the Reconstruction of Irradiance Measurements

Gerardo Guerra¹, Pau Mercade Ruiz², Gaetana Anamiati², Lars Landberg³

¹DNV, Bristol, United Kingdom; ²GreenPowerMonitor, Barcelona, Spain; ³DNV, Hellerup, Denmark

4BV.4.4

Evaluation of Solar Radiation Potential at the Shooting Point by Identifying the Sky Area of Sky Image Using U-Net

Akito Sago¹, Yuzuru Ueda²

¹Tokyo University of Science , Katsushika City, Japan

4BV.4.5

Solar Irradiance Classification for Improved PV Performance Assessments

Hugo Quest^{1,2}, Andrew Fairbrother¹, Christophe Ballif^{1,3}, Alessandro Virtuani¹

¹EPFL, Neuchâtel, Switzerland; ²3S Solar Plus, Thun, Switzerland; ³CSEM, Neuchâtel, Switzerland

- 4BV.4.6** **Photovoltaic Yield Forecasting Using Extreme Gradient Boosting**
 Daniel Grzebyk^{1,2}, Alba Alcañiz¹, Jaap Donker², Miro Zeman¹, Olindo Isabella¹, Hesam Ziar¹
¹Delft University of Technology, Delft, Netherlands; ²Solar Monkey, Den Haag, Netherlands
- 4BV.4.7** **A Transferable Turbidity Estimation Method for High Fidelity Clear-sky Solar Irradiance Computation**
 Shanlin Chen¹, Mengying LI¹
¹The Hong Kong Polytechnic University, Kowloon, Hong Kong
- 4BV.4.8** **The Simple Sky-Dome Projector**
 Bart E. Pieters¹, Evgenii Sovetkin¹, Andreas Gerber¹
¹Forschungszentrum Jülich, Juelich, Germany
- 4BV.4.9** **Deep Learning Methods for Solar Power Plants nowcasting Systems for Grid-stability and Energy Market Operations**
 Fabrizio Ruffini¹, Antonio Piazzzi¹, Ciro Lanzetta¹
¹i-EM, Livorno, Italy
- 4BV.4.10** **Improved Models for Nowcasting Sunshine Number**
 Marius Paulescu¹, Nicoleta Stefu¹, Ciprian Dughir², Andreea Sabadus³
¹West University of Timisoara, Timisoara, Romania; ²Politehnica University of Timisoara, Timisoara, Romania; ³UVT, Timisoara, Romania
- 4BV.4.11** **A Computationally Light Data-driven Alternative to Cloud-Motion Prediction for PV Forecasting**
 Rafael Eduardo Carrillo Rangel¹, Pierre-Jean Alet¹, Stefan C. Müller², Jan Remund²
¹CSEM, Neuchâtel, Switzerland; ²Meteotest, Switzerland
- 4BV.4.12** **PV very Short-Term Power Forecasting Method based on Cloud Monitoring Data**
 Joao Esteves¹, Rui Pestana², Yang Cao¹, Nuno Pinho Da Silva¹, Zheng Wang³
¹R&D Nester, Sacavém, Portugal; ²Rede Elétrica Nacional, Lisbon, Portugal; ³EPRI, Beijing, China
- 4BV.4.13** **A Study of the Impact of Multiple Irradiance Measurements on the Performance of Data-Driven Models**
 Gerardo Guerra¹, Pau Mercade Ruiz², Gaetana Anamiati², Lars Landberg³
¹DNV, Bristol, United Kingdom; ²GreenPowerMonitor, Barcelona, Spain; ³DNV, Hellerup, Denmark

- 4BV.4.14** **3D Cloud Information and Detection for Solar Nowcasting Based on All-Sky Imagers**
 Khadija Barhmi¹, Sara Mirbagheri Golroodbari¹, Wilfried G.J.H.M. van Sark¹
¹*Utrecht University, Utrecht, Netherlands*
- 4BV.4.15** **A Physics-Based DNI Model for Advancing Solar Resource Assessment and Forecasting**
 Yu Xie¹, Jaemo Yang¹, Manajit Sengupta¹, Yangang Liu²
¹*NREL, United States; ²Brookhaven National Laboratory, United States*
- 4BV.4.16** **The SMART-G Code to Compute the Solar Resource Parameters. Validation in Clear-Sky Conditions in North of France**
 Thierry Elias¹, Nicolas Ferlay², Gabriel Chesnoiu², Isabelle Chiapello², Mustapha Moulana¹
¹*HYGEOS, Lille, France; ²University of Lille, Villeneuve d'Ascq, France*
- 4BV.4.17** **Helping Prosumers with Location-Specific Solar Radiation and PV Performance Data**
 Nigel Taylor¹, Ana Martinez Fernandez¹, Nikos Alexandris¹, Gianpiero Arcaro², Anatoli Chatzipanagi¹, Fernando Fahl³
¹*European Commission JRC, Ispra, Italy; ²Piksel, Milano, Italy; ³GFT Italia, Italy*
- 4BV.4.18** **A Hybrid Numerical Method and Comparative Study for Solar Irradiance Forecasting**
 Jayesh Thaker¹, Robert Höller²
¹*University of Oldenburg, Oldenburg, Germany; ²FH OOE, Wels, Austria*
- 4BV.4.19** **How Does the Use of Satellite-Derived Insolation Data Impact the Accuracy of Performance Ratio Estimates?**
 Ebrar Özkalay^{1,2}, Alessandro Virtuani², Andrew Fairbrother², Artur Skoczek³, Gabi Friesen¹, Christophe Ballif^{2,4}
¹*SUPSI, Mendrisio, Switzerland; ²EPFL, Neuchâtel, Switzerland; ³Solargis, Bratislava, Slovakia; ⁴CSEM, Neuchâtel, Switzerland*
- 4BV.4.20** **Day-ahead Photovoltaic Production Forecasting Using XGBoost and Post-Calibration Modeling**
 Spyros Theocharides¹, Javier Lopez Lorente¹, George Makrides¹, George Elias Georghiou¹
¹*University of Cyprus, Nicosia, Cyprus*

- 4BV.4.21** **Development of a Sky Image Based Model for Prediction of Irradiance in a Minute-Range Horizon**
 Victor Arturo Martinez Lopez¹, Pim Doodkorte¹, Hesam Ziar¹, Miro Zeman¹, Olindo Isabella¹
¹*Delft University of Technology, Delft, Netherlands*
- 4BV.4.22** **Evaluation of Irradiance Decomposition and Transposition Models for a Nordic Climate**
 Dina Martinsen¹, Heine Nygard Riise², Magnus Moe Nygård², Marie Syre Wiig², Erik Stensrud Marstein²
¹*NTNU, Trondheim, Norway; ²Institute for Energy Technology, Kjeller, Norway*
- 4BV.4.23** **Improving Site Shading Assessment from Digital Surface Models with Onsite LiDAR Measurements**
 Daniel Alvarez Mira¹, Sebastian Poessl¹, Martin Bartholomäus¹, Thøger Kari Hass¹, Peter Behrendorff Poulsen¹, Sergiu V. Spataru¹
¹*Technical University of Denmark, Lyngby, Denmark*
- 4BV.4.24** **Impact of Data Quality on the Performance Evaluation of Large-Scale PV Plants**
 Giuliano Luchetta Martins^{1,2}, Elena Koumpli¹, Sarah Southern¹, Anastasia Panoui¹, Jan Muller¹
¹*Statkraft UK, London, United Kingdom; ²Anhalt University of Applied Sciences, Köthen, Germany*
- 4BV.4.25** **Recovering Missing Data Using Low Quality Sensors and Machine Learning**
 Atse Louwen¹, Sascha Lindig¹, Alexander Astigarraga¹, David Moser¹
¹*Eurac Research, Bolzano, Italy*
- 4BV.4.26** **Cloud Dynamics Probed by Narrow and Broadband Solar Irradiance Probability Densities**
 Nick Anderson¹, Viktor Tatsiankou², Karin Hinzer¹, Richard Beal², Henry Schriemer¹
¹*University of Ottawa, Ottawa, Canada; ²Spectrafy, Ottawa, Canada*
- 4BV.4.27** **Estimating Global Horizontal Irradiance at the Urban Level: a Sensitivity Analysis Using Different Digital Surface Models**
 Rodrigo Amaro e Silva¹, Philippe Blanc¹
¹*MINES ParisTech, Sophia Antipolis, France*

4BV.4.28

Evaluation of the Duration of Albedo Measurement Campaigns

Stefan Mau¹, Christian Gertig², Adam Sharpe³, Christophe Campistron², Nicolas Chouleur²

¹Everoze, Spain; ²Everoze, France; ³Everoze, United Kingdom

4BV.4.29

Time Series Forecasting of Solar Irradiance Based on Numerical Data

Bireswar Paul¹, Palash Chhabra¹, Hrituparna Paul¹

¹, India

4BV.4.30

A Novel Approach Based on the Integration of Numeric Weather Prediction and Deep Learning for Short-term Solar Irradiance Forecasting

Navid Shirzadi¹, Fuzhan Nasiri¹, Ramanuniparakkal Manon¹, Ursula Eicker¹

¹Concordia University, Montréal, Canada

4BV.4.31

Cloud Flow Centring in Sky and Satellite Images for Deep Solar Forecasting

Quentin Paletta^{1,2}, Guillaume Arbod², Joan Lasenby¹

¹University of Cambridge, United Kingdom; ²ENGIE, Stains, France

4BV.4.32

Future Weather Data Analysis for Solar Heating and Cooling

Jeremias Schmidli¹, Daniel Carbonell¹, Christof Biba¹

¹University of Applied Sciences of Eastern Switzerland, Rapperswil, Switzerland

4BV.4.46

Outdoor Characterisation for Small Scale Compound Parabolic Concentration for Two Locations: Ferrara-Italy and Mayo-Ireland

Anita Ortega¹, Subhash Chandra¹, Sarah McCormack¹

¹Trinity College Dublin, Dublin, Ireland

4BV.4.47

Effects of Temperature Variation on Concentrated Photovoltaic (CPV) Cells with Different Sizes

Elsen Aydin^{1,2}, Gence Bektaş^{1,2}, Ahmet Emin Keçeci^{1,2}, Hasan Hüseyin Canar^{1,2}, Hasan Asav^{1,2}, Sümeyye Koçak¹, Rasit Turan^{1,2,4}, Bulent Gultekin Akinoglu^{1,2,4}

¹ODTÜ - GÜNAM, ANKARA, Turkey; ²METU, ANKARA, Turkey

4BV.4.48

Operation Analysis of Concentrated Photovoltaic/Thermal for Heating Crude Oil

Dulong Gao^{1,2}, Jing Guo^{1,2}, Xiaohu Chang^{1,2}, Mengyao Xu^{1,2}, Junhua Li¹, Bai Qiaoqiao³, He Wang³, Ning Chen⁴, Hong Yang³

¹SINOPEC, China; ²Key Laboratory of Enhanced Oil Recovery in Carbonate Fractured-vuggy Reservoirs, China; ³Xi'an Jiaotong University, China; ⁴ISC Konstanz, Germany

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Gerhard MÜTTER
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4BV.5.1 Energy Management System for Hybrid DC-AC Microgrid Including PV Installations and Storage

Mohamed Amhal¹, Grégory Pais², Anthony Bier¹
¹CEA, Le Bourget-du-Lac, France; ²CEA, France

4BV.5.2 PV Module Thermography: Long-term Study of Defect Visibility under Varying Environmental Conditions

Victoria Lofstad-Lie¹, Erik Stensrud Marstein^{1,2}, Aleksander Simonsen³, Torbjørn Skauli^{1,3}
¹University of Oslo, Kjeller, Norway; ²Institute for Energy Technology, Kjeller, Norway; ³Norwegian Defence Research Establishment, Kjeller, Norway

4BV.5.3 Cloud-based Decision Support System for Operation and Maintenance in Photovoltaic Systems

Andreas Livera¹, Panagiotis Goumenos¹, Jose G. Franquelo², Ruben Gonzalez Bernal², George Elias Georgiou¹
¹University of Cyprus, NICOSIA, Cyprus; ²Isotrol, Sevilla, Spain

4BV.5.4 Soiling Detection on Photovoltaic Modules Using Hyperspectral Imaging and Machine Learning Algorithms

Marko Turek¹
¹Fraunhofer CSP, Halle (Saale), Germany

4BV.5.5 Deep-Learning based Photovoltaic Panel Performance Monitoring Applied to Real Data

Peigen Xie¹, Sebastien Gourvenec¹, Gilles Poulain¹, Sara Aid², Daniel-Paul Dondera¹
¹TotalEnergies, Courbevoie, France; ²Tosoh, Courbevoie, France

The Influence of System Layout and Operating Conditions on PV System Degradation

¹UFSC, Florianópolis, Brazil; ²HI ERN, Erlangen, Germany

Design and Operation of the First Large Linear Vertical Bifacial PV Plant in France

¹CEA, Le bourget-du-lac, France; ²CNR, lyon, France

Experimental Observations about the Cloud Enhancement Phenomenon on PV Strings

¹Tampere University, Tampere, Finland

One year performance assessment of HTJ modules on Horizontal Single Axis Tracker (HSAT)

¹RSE, Milano, Italy; ²TECNALIA, Donostia, Spain; ³Enel Green Power, Catania, Italy; ⁴CEA, Saint-Paul-lez-Durance, France; ⁵Convert Italia, Roma, Italy; ⁶EPFL, Lausanne, Switzerland

A Facility Test to Generate Data from Real PV Systems Affected by Faults

¹*RSE, Milano, Italy*

Performance Evaluation and Operational Faults Analysis for PV System Protection and Safety Standard Improvement

¹NTNU, Norway; ²Private, Germany

A fast Software Check for PV Systems

¹Karlstad University, Karlstad, Sweden; ²Sandia National Laboratories, Albuquerque, United States

- 4BV.5.13** **Impact of Large Format Solar Panels on the Balance of System Costs of Photovoltaic Power Plants**
Djaber Berrian¹,
¹BELECTRIC Solar & Battery, Kolitzheim, Germany
- 4BV.5.14** **Thermal PV Defects Degradation Monitoring Using a Mounted Thermal Camera**
Dhiaeddine Melliti¹, Duy Long Ha¹, Mohamed Amhal²,
¹INES, Le Bourget-du-Lac, France; ²CEA, Le Bourget-du-Lac, France
- 4BV.5.15** **Outdoor Performance Analysis of Five Different Technologies in Palaiseau, France**
Moira Itzel Torres Aguilar¹, Jordi Badosa¹, Vincent Bourdin², Anne Migan-Dubois³
¹École Polytechnique, Palaiseau, France; ²LIMSI, Orsay, France; ³University of Paris-Saclay, Gif-sur-Yvette, France
- 4BV.5.16** **Comparison of Soiling Measurement Approaches in Solar PV Plants**
Paula Rodriguez¹, Jose Antonio Bolivar Munoz², Shilpee Sinha³, Imke Meyer³
¹, Colombia; ², Spain; ³, United Kingdom
- 4BV.5.17** **Analysis of Performance Enhancement of PV Systems after the Cleaning Event**
Latifa El Boujdaini¹, Christof Bucher¹, Ahmed Mezrhab², Matthias Burri¹
¹BUAS, Burgdorf, Switzerland; ²Mohammed First University, Oujda, Morocco
- 4BV.5.18** **Monitoring of Photovoltaic Soiling and Assessment of Soiling Losses Characterization Strategies**
Ruben Vardanyan¹, Narek K. Badalyan¹
¹, Armenia
- 4BV.5.19** **Modelling Soiling Losses in Different Sites in the Mediterranean Region**
João Gabriel Bessa¹, Leonardo Micheli¹, Eduardo F. Fernández¹, Florencia Almonacid-Cruz¹
¹University of Jaén, Jaén, Spain
- 4BV.5.20** **1 MW PV System at Munich Trade Fair Centre - 25 Years of Successful Operation**
Gerd Becker¹
¹Bavarian Association for the Promotion of Solar Energy, Munich, Germany

4BV.5.21

Analysis of Non-linear Long-term Degradation of PV Systems

Latifa El Boujdaini¹, Christof Bucher¹, Ahmed Mezrhab², Matthias Burri¹, Ebrar Özkalay³, Mauro Cacciavio³, Gabi Friesen³

¹BUAS, Burgdorf, Switzerland; ²Mohammed First University, Oujda, Morocco; ³SUPSI, Lugano, Switzerland

4BV.5.22

Digital Twin Modelling of PV Modules Using IoT Enabled Module Monitoring

Pranav Maheshwari¹, Shubham Sharma¹, Utkarsh Kushwah¹

¹PV Diagnostics, Indore, India

4BV.5.23

Mitigating the Influence of Clipping Variability on Performance Ratio Calculations of PV Systems

Elena Koumpli¹, George Koutsourakis², James Blakesley², Christopher West¹, Jan Muller¹

¹Statkraft UK, London, United Kingdom; ²National Physical Laboratory, United Kingdom

4BV.5.24

Fault Diagnosis of Grid-Connected Photovoltaic Systems Based on Unsupervised Sample Clustering and Multilayer Perceptron Model

Mohsen Zargarani¹, Sara Zermani¹, Chabakata Mahamat¹, Laurent Linguet¹

¹University of French Guiana, French Guiana

4BV.5.25

Cleaning Operations Planning Induced by Monitoring and Modelling of Soiling on Photovoltaic Modules

Jean Catry^{1,2}, Thomas Carriere¹, Marianne Marot¹, Alexandre Boilley¹

¹Solaïs, Valbonne, France; ²Mines ParisTech, Paris, France

4BV.5.26

Soiling Persistence Model as Benchmark for Soiling Forecasts of Solar Collectors

Fernanda Norde Santos¹, Natalie Hanrieder¹, Stefan Wilbert¹, Jesús Polo², Carmen Alonso-García², Luis F. Zarzalejo², Mounir Abraim^{4,5}, Abdellatif Ghennioui⁴, Robert Pitz-Paal⁶

¹DLR- German Aerospace Center, Almería, Spain; ²CIEMAT, Madrid, Spain; ³Green Energy Park, Ben Guérir, Morocco; ⁴USMBA, Fez, Morocco; ⁵DLR- German Aerospace Center, Cologne, Germany

4BV.5.27

Data Analytics and the Performance Ratio of PV Plant with Bifacial Solar Monocrystalline Modules

Rodrigues Luis¹

¹Lightsources bp, London, United Kingdom

- 4BV.5.28** **Distributed Detection Algorithm for Photo-Voltaic Solar Arrays Based on Least Significant Difference Test**
Luis Diego Murillo-Soto¹, Carlos Meza²
¹Costa Rica Institute of Technology, Costa Rica; ²Anhalt University of Applied Sciences, Germany
- 4BV.5.29** **An Automated Flexible Data-Driven Ensemble Approach for Estimating PV Module Degradation and Comparing against Warranty Levels**
Julián Ascencio-Vásquez¹, Haohui Lui², Zoe Defreitas¹
¹Envision Digital, Redwood City, United States; ²Envision Digital International, Singapore
- 4BV.5.30** **PV Performance Loss and Snow Shedding at Low Tilt Angle: a Utility-Scale Case Study**
Jennifer Braid¹, Laurie Burnham¹
¹Sandia National Laboratories, Albuquerque, United States
- 4BV.5.31** **Choosing the Optimal Initial Position of a UAV for Infrared Inspection of Photovoltaic Power Plants**
Tor Solend¹, Hans Jonas Fossum Moen¹, Anders Rødningsby¹
¹University of Oslo, Kjeller, Norway
- 4BV.5.32** **Effects of the Soil and Washing Cycle on the Performance of a PV-Array**
Yasuhiro Matsumoto¹, Mario Gerardo Moheyer¹, Marco Antonio Ramos¹, Edgar Roberto Sandoval², Nun Pitalúa³, Jose Antonio Urbano¹, René Asomoza¹
¹CINVESTAV, GUSTAVO A MADERO, Mexico; ²TecNM, Cuautitlán Izcalli,, Mexico; ³University of Sonora, Hermosillo, Sonora, México, Mexico
- 4BV.5.33** **Detailed Performance Metric Estimation of Solar Modules From Time-Series Monitoring of Solar Power Systems**
Yang LI¹, Haohui Lui¹, Kang Jian¹, Haoran Chang¹, Biyun Liu¹, Lu Zhao¹
¹Envision Digital International, Singapore
- 4BV.5.35** **Evaluation of the Self-cleaning Effect on the Performance of PV Plants**
Latifa El Boujdaini¹, Christof Bucher¹, Ahmed Mezrhab², Matthias Burri¹, Ebrar Özkalay³, Mauro Caccivio³, Gabi Friesen³
¹BUAS, Burgdorf, Switzerland; ²Mohammed First University, Oujda, Morocco; ³SUPSI, Lugano, Switzerland

4BV.5.36

Outdoor Performance Evaluation of CIS PV Plant under the Semi-Aride Climate of Benguerir Morocco

Said Elhamaoui¹

¹*Green Energy Park, Ben Guerir, Morocco*

4BV.5.37

Utilizing System Efficiency Evaluations to Determine DC Output of PV Systems

Bengt Jäckel¹, Matthias Pander¹, David Daßler¹, Stephanie Malik¹, Jens Fröbel¹

¹*Fraunhofer IMWS, Halle, Germany*

4BV.5.38

Autonomous Measurement System for PV and Radiometer Soiling Losses

Stefan Wilbert¹, Laura Campos¹, José Carballo², Fabian Wolfertstetter¹, José La Casa¹, Erik Borg³, Karsten Schmidt³, Luis F. Zarzalejo², Aranzazu Fernandez², Fernanda Norde Santos¹, Ginés García²

¹*DLR- German Aerospace Center, Almeria, Spain;* ²*CIEMAT, Spain;* ³*DLR- German Aerospace Center, Germany*

4BV.5.39

PV Hybrid System Data Visualization

Michael Mueller¹

¹*OFRES - Office for renewable energy systems, Ulm, Germany*

Visual Presentations 4CV.1

**13:30- 15:00 Engineering Design and Installation of PV Systems /
Power Electronics and Electrical Grid Interface**

Poster Area

Chairpersons:

Franz P. BAUMGARTNER
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Giovanna ADINOLFI (i)
ENEA, Portici, *Italy*

4CV.1.1 Effective Irradiation Estimation of PV Installations: a Performance Analysis of PV Prod Tool

Katherine Alvino^{1,2}, Boutros Ghannam², Maroun Nemer²

¹BBS Slama, Clermont-Ferrand, France; ²Mines Paris, Palaiseau, France

4CV.1.2 Evaluation of Local Conditions and Their Impact on Bifacial PV Performance at High Latitude

Alexander Granlund¹, Mattias Lindh², Josefin Sundström¹, Jimmy Narvesjö¹, Anna Malou Petersson¹

¹RISE, Piteå, Sweden; ²RISE, Umeå, Sweden

4CV.1.3 Optimal Design and Installation of Solar Home Systems for Bottom-up grids: a Comparative Case Study of Kenya and Norway

Ida Fuchs¹, Anja Myhre Waitz¹, Kari Thorset Lervik¹, Steve Völler¹, Ole-Morten Midtgård¹, Jayaprakash Rajasekharan¹

¹NTNU, Trondheim, Norway

4CV.1.4 Digital Platform for PV Tracker Technical Information and Benchmarking Tool

Cesar Hidalgo¹

¹GL-GH Solar, Barcelona, Spain

4CV.1.5 Opportunities and Limitation for PV-Systems with a Delta East/west Configuration at Higher Latitudes and Sites with low Clearness Index

Hans Georg Beyer¹

¹University of the Faroe Islands, Tórshavn, Faroe Islands

- 4CV.1.6** **Experimental and Theoretical Investigation of Fixed and Tracking PV Panel Performance in Tehran through Techno-economic Aspects**
 Shahab Eslami^{1,2}, Aryan Tadjik², Ramin Pouladian Kari³, Arman Pouladian Kari⁴, Lars Lichner²
¹University of Tehran, Iran; ²Kirchner Solar Group, Germany; ³Kirchner Solar Group, United Kingdom; ⁴University of Warwick, United Kingdom
- 4CV.1.7** **High Latitude Bifacial Orientation, a Non-Tracking Opportunity to Flatten the Production Curve**
 Christopher Pike¹, Erin Whitney¹, Michelle Wilber¹
¹UAF, Fairbanks, United States
- 4CV.1.8** **Optimal Design of a Semi Grid-Connected PV System for a Site in Lwak, Kenya Using HOMER**
 Josephine Nakato Kakande¹, Godiana Hagile Philipo¹, Stefan Krauter¹
¹University of Paderborn, Paderborn, Germany
- 4CV.1.9** **An Incorporated Geographic Information System and Multi-Criteria Decision-Making Approach for Potential Assessment of Large Photovoltaic Power Plant Sites in Iran**
 Shahab Eslami¹, Amin Golshanfard¹, Ramin Pouladian Kari¹, Lars Kirchner¹
¹Kirchner Solar Group, Germany
- 4CV.1.10** **Solar Photovoltaic Systems for High Power Pumping: a Use Case**
 Márcia Horta¹, Luis Fialho¹, Pedro André Dos Santos Ribeiro Horta¹, Carlos Marques²
¹University of Évora, Evora, Portugal; ²ABROXO, Aljustrel, Portugal
- 4CV.1.11** **Comparison of LCOE for Various PV System Configurations and Module Technologies in the South African Climatic Condition**
 Jacqui Crozier Mcclelland¹, Tshepo Serameng², Ernest van Dyk¹, Monphas Vumbugwa¹, Freddie (Frederik) Vorster¹, Ross DIX Peek¹, Roelof Roodt¹
¹Nelson Mandela University, Gqeberha, South Africa; ²ESKOM, Johannesburg, South Africa
- 4CV.1.12** **Optimization of PV Array Tilt Angles and Row Spacing to Maximize Energy Yield**
 Bader Aldalali¹, Raed Bourisli², Arttu Tuomiranta³, Jozef (Jef) Poortmans³
¹Kuwait University, Kuwait, Kuwait; ²Kuwait University, Kuwait; ³imec, Leuven, Belgium

4CV.1.13

Bifacial Energy Gain of Photovoltaic Arrays Installed on Highly Reflective Rooftops

Jesus Robledo Bueno¹, Babacar Sarr¹, Ibrahim El Boujdaini¹, Roxane Bruhwylér², Jonathan Leloux¹, Christian A. Gueymard³, Frédéric Lebeau²

¹LuciSun, Villers-la-Ville, Belgium; ²University of Liege, Gembloux, Belgium;

³Solar Consulting Services, Colebrook, United States

4CV.1.14

Disruptive Innovation for Automated PV Plant Construction Delivers Faster Time-To-Market and Lower Overall Costs for Mid-Size to Multi-MW Solar Farms

Giovanni DI Stefano¹, Francesco Beccarisi¹

¹Comau, Grugliasco, Italy

4CV.1.15

Experimental Performance of a PV-powered Center-Pivot Irrigation System

Juan Ignacio Herraiz¹, Rita Hogan Almeida¹, Manuel Castillo-Cagigal², Luis Narvarte¹

¹UPM, Madrid, Spain; ²Qualifying Photovoltaics, Madrid, Spain

4CV.1.31

Modelling Efficiency of Multi-input Inverters

Clifford Hansen¹, Jay Johnson¹, Rachid Darbali¹, Nicholas Gurule¹

¹Sandia National Laboratories, Albuquerque, United States

4CV.1.32

Analysis of Power Grids with High-Penetration of Photovoltaics: the Case of Honduras

Gustavo A. Gómez-Ramírez¹, Carlos Meza², Gonzalo Mora-Jiménez³, Isaac A. Luévano-Reyes⁴, Luis García-Santander⁵, José Rodrigo Rojas⁶

¹Costa Rica Institute of Technology, Costa Rica; ²Anhalt University of Applied Sciences, Germany; ³, Costa Rica; ⁴, Mexico; ⁵University of Concepción, Concepción, Chile; ⁶Costa Rica Institute of Electricity, Costa Rica

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Pere ROCA I CABARROCAS
CNRS, Palaiseau, France

1CV.2.1

SiNx and AlOx as Alternative Dielectrics in Hole Selective Tunnelling Passivating Contacts

Shona McNab¹, Ailish Wratten², Edris Khorani², Nicholas Grant², John Murphy², Matthew Wright¹, Peter Wilshaw¹, Sebastian Bonilla¹

¹University of Oxford, Oxford, United Kingdom; ²University of Warwick, Coventry, United Kingdom

1CV.2.2

High-Efficiency PERL Solar Cells Using Simultaneous Laser Local Contact Opening and n+ Doping from POx/Al₂O₃ Passivation Stacks

Marco Ernst¹, Lachlan Black¹, Roel Theeuwes², Daniel Macdonald¹, Erwin Kessels²

¹ANU, Canberra, Australia; ²Eindhoven University of Technology, Eindhoven, Netherlands

1CV.2.3

P-Type TOPCon Solar Cells with n-Poly Rear Emitter

Shih-Peng Hsu¹, Chao-Ping Huang¹, Chaihung Tsai¹, Sung-Yu Chen¹

¹ITRI, Tainan, Taiwan

1CV.2.4

Fabrication of IBC Solar Cells with Efficiency Higher than 24% Using TOPCon Technology

Han-Chen Chang¹, Bo-Cheng Kung¹, Sung-Yu Chen¹, Ming-Tsun Kuo¹, Chong-Jye Huang¹

¹ITRI, Tainan, Taiwan

1CV.2.5

p- and n-Type Fireable Passivating Tunnel Oxide Contacts for Crystalline Silicon Solar Cells

Franz-Josef Haug¹, Mario Joe Lehmann¹, Sofia Libraro¹, Ezgi Genç¹, Audrey Morisset¹, Christophe Ballif¹

¹EPFL, Neuchâtel, Switzerland

- 1CV.2.6** **Edge Passivation for Double Side Poly-Si/SiO_x Passivated Contacts Solar Cells**
 Franck Dhainaut^{1,2}, Benoit Martel¹, Thibaut Desrues¹, Mickael Albaric¹, Olivier Palais², Sébastien Dubois¹
¹CEA, Le Bourget-du-Lac, France; ²CNRS, Marseille, France
- 1CV.2.7** **Industrial Feasible Screen Printed IBC Solar Cell Based on PECVD a-Si (N) Deposition on Large Area p-Type Substrates**
 Lejo Joseph Koduvelikulathu¹, Jan Lossen¹, A. Adrian¹, Dominik Rudolph¹, Razvan Roescu¹, Andreas Wolf², Bernd Steinhauser², Melanie Frettloeh², Thomas Pernau³, Helge Haverkamp³, Radovan Kopecek¹
¹ISC Konstanz, Germany; ²Fraunhofer ISE, Germany; ³centrotherm international, Germany
- 1CV.2.8** **nc-SiC Layers by PECVD for High Temperature Passivating Contacts**
 Ezgi Genç¹, Sofia Libraro¹, Mario Joe Lehmann¹, Audrey Morisset¹, Franz-Josef Haug¹, Christophe Ballif¹
¹EPFL, Neuchâtel, Switzerland
- 1CV.2.9** **Investigation on the Passivation Quality of Ex-situ Doped p+ and n+ Poly-Si Layers for IBC Solar Cells**
 Vaibhav Kuruganti¹, Radovan Kopecek², Sven Seren³, Olindo Isabella⁴, Valentin Dan Mihailitchi¹
¹ISC Konstanz, Konstanz, Germany; ²SCHMID Group, Freudenstadt, Germany; ³Delft University of Technology, Delft, Netherlands
- 1CV.2.10** **Analysis of Passivation Characteristics with Inserting Intrinsic poly-Si Layer on Passivating Contact Solar Cells**
 Haejung Lee¹, Dongjin Choi², Myeongseob Sim², Ji Yeon Hyun², Huiyeon Lee², Hoyoung Song², Changhyun Lee², Dongkyun Kang², Donghwan Kim², Yoonmook Kang¹, Hae-Seok Lee¹
¹Korea University, Seoul, Korea, Rep. of South; ²Korea University, Seoul, Korea, Rep. of South
- 1CV.2.11** **Fully Passivating Contact IBC Solar Cells Using Laser Processing**
 Florian Buchholz¹, Jonathan Linke¹, Christoph Peter¹, Jan Hoß¹, Jan Lossen¹, Radovan Kopecek¹
¹ISC Konstanz, Konstanz, Germany

1CV.2.12

Screen-Printed c-Si Solar Cells with poly-SiO_x Carrier Selective Passivating Contacts on Ultra-Thin Thermal Tunneling Oxide

Manvika Singh¹, Aswathy Amarnath¹, Guangtao Yang¹, Dong Zhang^{2,3}, Valerio Zardetto², Mehrdad Najafi², Adriana Creatore⁴, René Janssen³, Sjoerd Veenstra², Gianluca Coletti², Luana Mazzarella¹, Arthur W. Weeber^{1,2}, Miro Zeman¹, Olindo Isabella¹

¹Delft University of Technology, Delft, Netherlands; ²TNO, Eindhoven, Netherlands; ³Eindhoven University of Technology, Eindhoven, Netherlands

1CV.2.13

Recent Progress of POLO Back Junction Solar Cells

Byungsul Min¹, Lasse Nasebandt¹, Christina Hollemann¹, Dennis Bredemeier², Lennart Thiemann¹, Till Brendemühl¹, Karsten Bothe¹, Robby Peibst¹, Rolf Brendel^{1,2}

¹ISFH, Emmerthal, Germany; ²Leibniz University of Hannover, Hannover, Germany

1CV.2.14

An Al-Doped SiO₂ for Passivation of p-Type Surfaces in Silicon Solar Cells

Xinya Niu¹, Matthew Wright¹, Peter Wilshaw¹, Sebastian Bonilla¹

¹University of Oxford, Oxford, United Kingdom

1CV.2.15

The Influence of the AlO_x Deposition Temperature on the Passivation Mechanism of AlO_x/SiN_y:H Stacks

Fabian Geml¹, Sarah Sanz Alonso¹, Heiko Plagwitz¹, Giso Hahn¹

¹University of Konstanz, Konstanz, Germany

1CV.2.16

LPCVD n-Type Polycrystalline Silicon Passivating Contacts for Industrial Scale Crystalline Silicon Solar Cells

Hisham Nasser¹, Emine Hande Ciftçinar¹, Berkay Uygün¹, Hassan Osman¹, Ahmet Emin Keçeci¹, Hasan Hüseyin Canar¹, Sercan Aslan¹, Salar Habibpur Sedani¹, Ergi Dönerçark¹, Rasit Turan¹

¹ODTÜ-GÜNAM, Ankara, Turkey

1CV.2.17

Improving the Efficiency of PERC Solar Cells by Low Temperature Oxidation

Ahmet Emin Keçeci^{1,2}, Hasan Hüseyin Canar^{1,2}, Hasan Asav^{1,2}, Sümeyye Koçak Bütüner², Selin Seyrek^{1,2}, Bülent Arian², Gence Bektas^{1,2}, Rasit Turan^{1,2}

¹METU, Ankara, Turkey; ²ODTÜ - GÜNAM, Ankara, Turkey

1CV.2.18

Effect of Laser Contact Opening Fraction and Emitter Doping on n-Si Rear Junction Solar Cells

Ahmet Emin Keçeci^{1,2}, Gence Bektas^{1,2}, Hasan Hüseyin Canar^{1,2}, Hasan Asav^{1,2}, Sümeyye Koçak Bütüner¹, Selin Seyrek², Emine Hande Ciftçinar^{1,2}, Rasit Turan^{1,2}

¹ODTÜ - GÜNAM, Ankara, Turkey; ²METU, Ankara, Turkey

1CV.2.19

Hidden Tandem Solar Cells

Zbigniew Kuznicki¹

¹SEGTON Advanced Technology, France

1CV.2.34

Impact of Hydrogen Diffusion into ITO Layer on the Electrical Performance of SHJ Solar Cells

Ergi Dönerçark¹, Seda Kılıçkaya¹, Patrick Choulat^{2;3;4}, Milad Ghasemi^{1;5}, Arghavan Salimi^{1;5}, Devika Rajagopal^{2;3;4;6}, Salar Sedani^{1;5}, Konstantin Tsoi¹, Emine Hande Ciftçinar^{1;5}, Hariharsudan Sivaramakrishnan Radhakrishnan^{2;3;4}, Rasit Turan^{1;5}

¹ODTÜ - GÜNAM, Ankara, Turkey; ²Hasselt University, Hasselt, Belgium; ³Imec, Genk, Belgium; ⁴EnergyVille, Genk, Belgium; ⁵METU, Ankara, Turkey; ⁶KU Leuven, Heverlee, Belgium

1CV.2.35

Heterojunction Ge Solar Cells with a Record High Efficiency of 8.6%

Makoto Konagai¹, Kimihiko Saito², Yukimi Ichikawa¹, Naoki Suyama¹, Kazuyoshi Nakada¹, Ryoussuke Ishikawa¹

¹Tokyo City University, Tokyo, Japan; ²Fukushima University, Fukushima, Japan

1CV.2.36

Lithium Fluoride as an Interlayer in Transparent Selective Contacts for Silicon Heterojunction Solar Cells

Francesca Menchini^{1;2}, Luca Serenelli¹, Luca Martini¹, Enrico Salza¹, Pietro Mangiapane¹, Massimo Izzi¹, Mario Tucci¹

¹ENEA, Roma, Italy; ²University of Rome, Roma, Italy

1CV.2.37

Comparison of Amorphous Silicon Deposition Methods for Heterojunction Solar Cells

Carsten Strobel¹, Sebastian Leszczynski¹, Matthias Albert¹, Johann W. Bartha¹, Thomas Mikolajick¹, Frank Stahr², Olaff Steinke²

¹Dresden University of Technology, Dresden, Germany; ²FAP, Dresden, Germany

1CV.2.38

Evaporated Cu₂O as a hole-selective Contact for c-Si Solar Cells

Gabriel Bartholazzi Lugao de Carvalho¹, Daniel Macdonald¹, Lachlan Black¹

¹ANU, Canberra, Australia

1CV.2.39

Optimization of High – Mobility Doped Indium Oxide Films and its Transfer to Silicon Solar Cells as Transparent Conductive Electrode

Thomas Tom^{1;2}, Leonard Tutsch¹, Julian López-Vidrier², Jose Miguel Asensi Lopez², Martin Hermle¹, Joan Bertomeu², Martin Bivour¹

¹Fraunhofer ISE, Germany; ²University of Barcelona, Spain

- 1CV.2.40** **Temperature- and Illumination-Dependent Performance of Silicon Heterojunction Solar Cells with Bulk Resistivities over 1,000 $\Omega\cdot\text{cm}$**
 Anh Huy Tuan Le¹, Apoorva Srinivasa², Stuart Bowden², Ziv Hameiri¹, André Augusto²
¹UNSW, Sydney, NSW 2052, Australia; ²Arizona State University, Tempe, AZ 85287, United States
- 1CV.2.41** **High-Mobility IWO Films Deposited in Nonreactive Plasma by RF Sputtering**
 Francesca Menchini^{1,2}, Luca Serenelli¹, Luca Martini¹, Enrico Salza¹, Massimo Izzì¹, Mario Tucci¹
¹ENEA, Roma, Italy; ²University of Rome, Roma, Italy
- 1CV.2.42** **Catalytic-CVD Deposited Nanocrystalline Silicon Oxide Thin Films for the Application in Silicon Heterojunction Solar Cells**
 Yong Liu¹, Miao Yang¹, Xiaoning Ru¹, Minghao Qu¹, Xixiang Xu¹
¹LONGi Solar Technology, Xi'an, China
- 1CV.2.43** **Effect of Chemical Polishing on Textured Silicon Surface Conditioning and Impact on Heterojunction Cell Performance**
 Shrestha Bhattacharya¹, Ashutosh Pandey¹, Sourav Mandal¹, Vamsi Krishna Komarala¹
¹IIT Delhi, New Delhi, India
- 1CV.2.44** **Improving Silicon Heterojunction Solar Cell Performance with Double Layer ARC**
 Milad Ghasemi¹, Ergi Dönerçark¹, Arghavan Salimi¹, Seda Kılıçkaya¹, Mehmet Koç¹, Rasit Turan¹
¹ODTÜ- GÜNAM, ANKARA, Turkey
- 1CV.2.45** **Influence of Indium Tin Oxide Electronic Properties on Contact Resistivity with p-Type Amorphous Silicon**
 Sourav Mandal¹, Shahnawaz Alam¹, Anamika Anamika¹, Shrestha Bhattacharya¹, Ashutosh Pandey¹, Vamsi Krishna Komarala¹
¹IIT Delhi, New Delhi, India
- 1CV.2.46** **Hydrogenated SiO_y Interlayer Formed by Etching Al₂O₃ for MoO_x Hole-Selective Contact**
 Mike Ah Sen^{1,2}, Fatemeh S. Minaye Hashemi¹, Ruben Streekstra¹, Astrid Gutjahr¹, Jimmy Melskens¹, Agnes Mewe¹, Arthur Weeber^{1,2}
¹TNO, Petten, Netherlands; ²Delft University of Technology, Delft, Netherlands

1CV.2.47

Influence of Carrier Transport Barrier on Silicon Heterojunction Cell Performance With the Variation of Intrinsic Hydrogenated Amorphous Layer Thickness

Ashutosh Pandey¹, Shrestha Bhattacharya¹, Sourav Mandal¹, Shahnawaz Alam¹, Vamsi Krishna Komarala¹

¹*IIT Delhi, New Delhi, India*

1CV.2.48

Novel HJT Metallization Processes to Face the Silver Consumption Challenge

Nicola Frasson¹, Marco Gialazzo¹

¹*Applied Materials, Olmi di San Biagio di Callalta, Italy*

1CV.2.49

Characterization of the Crystallinity, Passivation and Conductivity of Nano-Crystalline Silicon Films for Si Heterojunction Solar Cells

Karl Ceulemans^{1;2;3;4}, Hariharsudan Sivaramakrishnan Radhakrishnan^{1;2;3}, Devika Rajagopal^{1;2;3;4}, Stefanie Sergeant⁵, Thomas Nuytten⁵, Jozef (Jef) Poortmans^{1;2;3}

¹*Hasselt University, Hasselt, Belgium*; ²*Imec, Genk, Belgium*; ³*Energyville, Genk, Belgium*; ⁴*KU Leuven, Heverlee, Belgium*; ⁵*Imec, Heverlee, Belgium*

1CV.2.50

Dopant-Free Interdigitated Back Contact Silicon Solar Cells with Efficiencies of 23.61%

Zhaolang Liu¹, Hao Lin¹, Zilei Wang¹, Liyan Chen¹, Taojian Wu¹, Yicong Pang¹, Lun Cai¹, Jian He¹, Pingqi Gao¹

¹*Sun Yat-sen University, Guang Zhou Shi, China*

1CV.2.51

Low Resistance with the High Transparency of Al-Doped ZnO TCO Thin-Films from ALD Procedure for c-Si-Based Passivated Contact Solar Cell Applications

Namitha Dsouza¹, Ashish K Singh¹, Rajesh Maurya¹, Ramakrishna Madaka¹, Narendra Bandaru¹, Rajesh Kanakala¹, MD Seraj Uddin Ansari¹, Jatindra K. Rath¹

¹*Indian Institute of Technology Madras, Madras, India*

Visual Presentations 1CV.3

17:00- 18:30 Feedstock, Crystallisation, Wafering and Defects in Silicon

Poster Area

Chairpersons:

Dennis BREDEMEIER
Leibniz University Hannover, Hannover, *Germany*

Marko TOPIC
University of Ljubljana, Ljubljana, *Slovenia*

1CV.3.1 Hydrogen Interactions in Silicon Studied by Temporary LeTID Recovery Experiments

Wolfram Kwapil^{1,2}, Tim Niewelt^{1,2,3}, Martin C. Schubert²

¹*University of Freiburg, Freiburg, Germany;* ²*Fraunhofer ISE, Freiburg, Germany;*

³*University of Warwick, Coventry, United Kingdom*

1CV.3.2 Pre-Hydrogenation for LeTID Suppression via an Understanding the Hydrogen Distribution in Cz Silicon Wafer

Myeongseob Sim¹, Dongjin Choi¹, Yujin Jung¹, Hyunjung Park¹, Yoonmook Kang², Donghwan Kim¹, Hae-Seok Lee²

¹*Korea University, Seoul, Korea, Rep. of South*

1CV.3.3 Light and Elevated Temperature Induced Degradation in Gallium- and Boron-Doped hpmc-Si Wafers Studied by Hyperspectral Photoluminescence Imaging

Torbjørn Mehl¹, Oda Goa Berge¹, Ingunn Burud¹, Rune Søndena², Espen Olsen¹

¹*Norwegian University of Life Sciences, Aas, Norway;* ²*Institute for Energy Technology, Kjeller, Norway*

1CV.3.4 Impact of a Renewed SiNx:H Passivation Layer and/or a Renewed Firing Step on LeTID and Regeneration

Andreas Schmid¹, Annika Zuschlag¹, Giso Hahn¹

¹*University of Konstanz, Konstanz, Germany*

1CV.3.5 Effect of Different AlOx Passivation Layers Deposited by APCVD and ALD on LeTID

Melanie Mehler¹, Fabian Geml¹, Andreas Schmid¹, Annika Zuschlag¹, Giso Hahn¹

¹*University of Konstanz, Konstanz, Germany*

- 1CV.3.6** **The Impact of Bulk Iron Contamination on the Surface Recombination of Silicon Wafers**
 Tien Le¹, Toni Pasanen², Lachlan Black¹, Hele Savin², Daniel Macdonald¹, Anyao Liu¹
¹ANU, Canberra, Australia; ²Aalto University, Espoo, Finland
- 1CV.3.7** **Fluorine Passivation of Ring Defects in Czochralski-Grown Silicon**
 Rabin Basnet¹, Hang Cheong Sio¹, Chang Sun¹, Hieu Nguyen¹, Daniel Macdonald¹
¹ANU, Canberra, Australia
- 1CV.3.8** **Modelling of Eddy-Current Measurement for Inhomogeneous Charge Carrier Depth Profile**
 David Krisztian^{1,2}, Ferenc Korsós¹, Martin Kovacs¹, Ferenc Ujhelyi¹, Péter Tüttő¹
¹Semilab, Budapest, Hungary; ²BME, Budapest, Hungary
- 1CV.3.9** **Evaluation of the Effect of Surface Structure on Flexibility of Si Wafers for Flexible c-Si Solar Cells**
 Koki Ide¹, Yutaka Hara², Tappei Nishihara¹, Ryo Yokogawa^{2,3}, Kyotaro Nakamura⁴, Yoshio Ohshita⁴, Tomoyuki Kawatsu⁵, Toshiki Nagai⁵, Noboru Yamada⁶, Yukio Miyashita⁶, Yuma Aoki⁶, Hayato Kobayashi⁶, Atsushi Ogura^{2,3}
¹Meiji University, Kawasaki, Japan; ²Meiji University, Kawasaki, Japan; ³Toyota Technological Institute, Nagoya, Japan; ⁴Komatsu NTC, Nanto, Japan; ⁵Nagaoka University of Technology, Nagaoka, Japan
- 1CV.3.10** **Mechanical Strength Testing of Mono-Si Wafers with Different Thickness**
 Nurhayat Yildirim¹, Burak Kaan Cihan¹, Kaan Görgişen¹, Fırat Es¹
¹Kalyon PV, Ankara, Turkey
- 1CV.3.11** **Optimization Wafer Thickness for a Large-Scale Module Production**
 Nurhayat Yildirim¹, Fırat Es¹, Kaan Görgişen¹, Burak Kaan Cihan¹, Ömer Yalçın¹
¹Kalyon PV, Ankara, Turkey
- 1CV.3.12** **Study of Diamond Wire Slicing Parameters by the 3D Visualization of a Multicrystalline Silicon Ingot**
 Sergey M. Karabanov¹, Oleg A. Belyakov¹, Andrey E. Serebryakov¹, Dmitry V. Suvorov¹, Andrey S. Karabanov¹
¹RSREU, Russian Federation

- 1CV.3.13** **Impact of Crucible-Coating-Silicon Feedstock System Quality on Electrical Properties of HEM Multicrystalline Silicon Ingot**
Yassine Chettat¹, Djamel Ouadjaout¹, Bouchehahm Abdelghani²
¹CRTSE, Algiers, Algeria
- 1CV.3.14** **Modelling Seed Joint Grain Boundaries in Cast Monocrystalline Silicon**
Shuai Yuan¹, Dongli Hu², Xuegong Yu¹, Lei Wang¹, Deren Yang¹
¹Zhejiang University, Hangzhou, China; ²Jiangsu GCL Silicon Material Technology Development, Xuzhou, China
- 1CV.3.15** **Study of the Influence of Electromagnetic Stirring of Silicon Melt on Multicrystalline Silicon Parameters**
Sergey M. Karabanov¹, Dmitry V. Suvorov¹, Oleg A. Belyakov¹, Evgeny V. Slivkin¹, Andrey S. Karabanov¹
¹RSREU, Russian Federation
- 1CV.3.16** **A New Technological and Environmentally Sustainable Long-Term Supply-Chain Solution for The Mass Production of High Purity Silica from Canada**
Doug Mcmillan¹, Brent Bullen²
¹University of Alberta, Edmonton, Canada; ²Queen's University, Kingston, Canada
- 1CV.3.17** **Understanding the Effect of Ambient Media on Laser Grooving of Silicon**
Tushar Ner¹, Pinal Rana¹, Deepak Marla¹
¹IIT Bombay, Mumbai, India
- 1CV.3.33** **Influence of the Growth Temperature and RF Power in p-Type nc-SiO_x:H Films on the Performance of Silicon Heterojunction (SHJ) Solar Cells**
Antonio de Jesus Olivares-Vargas¹, Pere Roca I Cabarrocas¹
¹LPICM, CNRS, Ecole Polytechnique, Palaiseau, France
- 1CV.3.34** **Transparent Electrode of ITO/AZO DBR-diffuser Structure to Implement Various and Vivid Colors for BIPV Windows**
Jung-Dae Kwon¹, Myunghun Shin², Soo-Won Choi¹
¹KITECH, 창원시, Korea, Rep. of South; ²76, Goyang-si, Korea, Rep. of South

Visual Presentations 3DV.1

08:30- 10:00 Module Design and Manufacturing Posters

Poster Area

Chairpersons:

Ioannis (John) TSANAKAS
CEA - INES, Le Bourget-du-Lac, *France*

Nicola PEARSALL
North Columbia University, Newcastle upon Tyne, *United Kingdom*

3DV.1.1

Fully Black and Reliable PV Modules with a Cost Effective Inkjet Coating of Cell Strings

Christian H. Schiller¹, Stephan Hoffmann¹, Mike Jahn¹, Angela De Rose¹, Martin Heinrich¹, Holger Neuhaus¹

¹Fraunhofer ISE, Freiburg, *Germany*

3DV.1.2

Application of SHJ and TOPCon Shingle Cells in Full-format and Integrated Solar Modules

Veronika Nikitina¹, Dirk Reinwand¹, Tobias Fellmeth¹, Sebastian Neven-du Mont¹, Daniel von Kutzleben¹, Torsten Roessler¹, Holger Neuhaus¹

¹Fraunhofer ISE, Freiburg im Breisgau, *Germany*

3DV.1.3

Photovoltaic Modules Encapsulated in Composite Material with Enhanced Recyclability

Gorka Imbuluzqueta¹, Jon Aizpurua¹, Juan Maria Hernandez¹, Naiara Yurrita¹, Werther Cambarau¹, Francisco J. Cano¹, Oihana Zubillaga¹

¹TECNALIA, San Sebastian, *Spain*

3DV.1.4

Influence of Micro- and Macrostructure of ECA on Contact Resistivity of ECA-Based Interconnects

Ignacia Devoto^{1,2}, Daniel Tune¹, Stephan Großer³, Tudor Timofte¹, Andreas Halm¹, Ralph Gottschalg^{2,3}

¹ISC Konstanz, Konstanz, *Germany*; ²Anhalt University of Applied Sciences, Köthen (Anhalt), *Germany*; ³Fraunhofer CSP, Halle (Saale), *Germany*

- 3DV.1.5** **Optimizing PV Modules via Functional Pigments in Solar Encapsulants**
Daniel Mann^{1,2}, Ryan van Zandvoort^{1,2}, Pj Pascal Buskens^{1,2,3}
¹TNO, Eindhoven, Netherlands; ²Brightlands Materials Center, Geleen, Netherlands; ³Hasselt University, Hasselt, Belgium
- 3DV.1.6** **Interconnection Technology for the Next Generation of (Temperature-Sensitive) Solar Cells such as Heterojunction and C-Si/Perovskite Tandem**
Yonas Zemen¹, Stefan Wendlandt², Lars Podlowski¹, Bernd Litzenburger¹
¹Solyco Technology, Berlin, Germany; ²PI Berlin, Berlin, Germany
- 3DV.1.7** **Paving the Way for low Breakage Rates in Industrial Production of N.I.C.E.-Wire Modules**
Pascal Leibiger¹, Christoph Pönisch¹, Thomas Seifert¹, Daniel Kray¹
¹University of Applied Sciences Offenburg, Offenburg, Germany
- 3DV.1.8** **1% Absolute Power Gain of Silicon Heterojunction Metal Wrap Through Laminates Produced in Industrial Pilot Line**
Marina Foti¹, Nicolas Guillevin², Anna J. Carr², Bas Van Aken², Francesco Rametta¹, Marcello Sciuto¹, Antonio Spampinato¹, Alfredo Di Matteo¹, Gianluca Coletti^{2,3}, Cosimo Gerardi¹
¹ENEL Green Power, Catania, Italy; ²TNO, Petten, Netherlands; ³UNSW, Sydney, Australia
- 3DV.1.9** **Processing and Demonstration of Pilot Scale Solar Heat Blocking Encapsulants for Increased Power Output and Lifetime of Crystalline Silicon PV**
Ryan van Zandvoort¹, Tatjana Vavilkin², Nicole Meulendijks¹, Daniel Mann¹, Pj Pascal Buskens¹
¹TNO, Netherlands; ²Soltech, Tienen, Belgium
- 3DV.1.10** **Novel Photovoltaic Module Design for Desert Climate**
Amir A. Abdallah¹, Kamal Mroue², Ayman Samara¹, Maulid M. Kivambe¹, Brahim Aissa¹, Benjamin Figgis¹, Juan Lopez Garcia¹, Stephan Großer³, Matthias Pander³, Bengt Jäckel^{3,4}, Klemens Ilse^{3,4}, Christian Hagendorf³, Matthias Ebert³
¹QEERI, Doha, Qatar; ²Fraunhofer CSP, Halle (Saale), Germany; ³Fraunhofer IMWS, Halle (Saale), Germany
- 3DV.1.11** **Shade-resistant PV Module Design to Increase Power and Energy Production of PV Modules under Partial Shading Conditions**
Hamed Hanifi¹, Waldemar Maier¹, Afshin Bakhtiari¹, Matthias Pander², Bengt Jäckel²
¹AE SOLAR, Königsbrunn, Germany; ²Fraunhofer CSP, Halle, Germany

3DV.1.12

2.5 Minutes Lamination Process and the Influences of the Degree of Cross-Linking and of the Humidity Degradation on PV Modules

Aksel Kaan Öz¹, Christine Wellens¹, Martin Heinrich¹, Holger Neuhaus¹, Martin Wiese¹, Sraisth Sraisth², Daniel Klaus²

¹Fraunhofer ISE, Freiburg, Germany; ²Robert Bürkle, Freudenstadt, Germany

3DV.1.13

Demonstrative BIPV Facades Realized with Novel Glass-free Colored Lightweight PV Modules

Fabiana Lisco¹, Gianluca Cattaneo², Alessandro Virtuani¹, Claudio del Pero³, Fabrizio Leonforte³, Niccolo Aste³, Matthieu Despeisse², Christophe Ballif¹

¹EPFL, Neuchâtel, Switzerland; ²CSEM, Neuchâtel, Switzerland; ³Polytechnic University of Milano, Milano, Italy

3DV.1.14

A New Typed Shingled Photovoltaic Module

Han Chang Liu¹, Wen-Kuei Lee¹, Mei-Hsiu Lin¹, Po-Yu Chou¹

¹ITRI, Taiwan

3DV.1.15

The Impacts of Different Flux Materials on the Performance of Photovoltaic Solar Modules

Meriç Çaliskan¹, Bedrettin Aydoğan¹, Merve Kaya¹, Nurullah Alper Sütçü¹, Firat Es¹

¹Kalyon PV, Ankara, Turkey

3DV.1.16

Laser Processes for Perovskite Modules: Influence of Pulse Duration and Wave Length Onto the Process Quality to Reduce Production Costs

Stefan Bergfeld^{1,2}

¹FH Aachen University of Applied Sciences, Germany; ²Bergfeld Lasertech, Aachen, Germany

3DV.1.17

Influence of the Lamination Pressure on the Adhesion, Degree of Cross-Linking, and Bubble Formation of PV Modules

Sraisth Sraisth¹, Aksel Kaan Öz², Daniel Klaus¹, Christine Wellens², Martin Heinrich²

¹Robert Bürkle, Freudenstadt, Germany; ²Fraunhofer ISE, Freiburg, Germany

3DV.1.18

Integration of Antenna for IoT Communication in Small Silicon Photovoltaic Module

Lasse Roer Wahlgreen¹, Martin Nordal Petersen¹, Peter Behrendsdorff Poulsen¹, Sune Thorsteinsson¹

¹Technical University of Denmark, Roskilde, Denmark

- 3DV.1.19** **Achieving Uniform Module Appearance While Increasing Module Efficiency: the Full Gapless Module Concept for Stringed IBC Solar Cells**
 Andreas Halm¹, Stefan Wendlandt², Tudor Timofte¹, Florian Buchholz¹
¹isc konstanz, konstantz, Germany; ²PI Berlin, Berlin, Germany
- 3DV.1.20** **Mitigating Cell Breakage and Shading Losses in Shingled Strings and Modules**
 Daniel Tune¹, Karl Wienands¹, Ingo Ullmann¹, Andreas Halm¹
¹ISC Konstanz, Germany
- 3DV.1.21** **Interconnection Approach for Busbar-Less Bifacial IBC Cells Based on Printed Solder Paste**
 Tobias Messmer¹, Haifeng Chu¹, Valentin Dan Mihailetschi¹, Razvan Roescu¹, Andreas Halm¹
¹ISC Konstanz, Konstanz, Germany
- 3DV.1.22** **Reducing Cut Losses of Interdigitated Back-Contact Solar Cells**
 Ning Chen¹, Florian Buchholz¹, Daniel Tune¹, Andreas Halm¹, Olindo Isabella², Valentin Dan Mihailetschi¹
¹ISC Konstanz, Germany, Germany; ²Delft University of Technology, Delft, Netherlands
- 3DV.1.23** **Interconnection Technology in PV Modules: Impact of Ribbons, Tab Connectors and Electrically Conductive Backsheet on Module Performance**
 Ammar Tummalieh¹, Balaramakrishna Paritala², Max Mittag¹, Holger Neuhaus¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany; ²University of Applied Sciences Jena, Jena, Germany
- 3DV.1.24** **Towards the Optimization of the Lamination of Eco-Designed Photovoltaic Modules; First Step : Relevant Thermomechanical Characterization of Polymers**
 Dylan Habans^{1,2}, Jean-Luc Bouvard², Billon Noëlle², Eeva Mofakhami¹, Aude Derrier¹
¹CEA, Le Bourget du Lac, France; ²CEMEF Mines ParisTech - PSL Research University, Sophia Antipolis, France
- 3DV.1.25** **Temperature Mapping Simulation of PV modules using COMSOL Multiphysics**
 Ayşe Çiğdem Besen¹, Ertan Arikan¹, Murat Aldemir¹
¹GTC Gunes, Turkey

- 3DV.1.26** **Indoor Photovoltaic Application with c-Si Solar Cell Using 3-D Structure**
 Yeon Hyang Sim¹, Min Ju Yun¹, Dong Yoon Lee¹, Seung I. Cha¹
¹Korea Electrotechnology Research Institute, Changwon-si, Korea, Rep. of South
- 3DV.1.40** **Performance Analysis of Power Optimizers from Different Manufacturers by Indoor Lab Testing and High-resolution Shading Simulation**
 Cyril Allenspach¹, Arturo Bänziger¹, Andrin Schneider¹, Fabian Carigiet¹, Franz P. Baumgartner¹
¹ZHAW, Winterthur, Switzerland
- 3DV.1.41** **LCOE Reduction Approaches for Bifacial PV Plants**
 Ignacio Ballesteros García¹, Xavier Rodríguez², Adrià Ortega², Ana Milena Cruz Rodríguez¹, Andrea Ricci³, Luca Bellini³
¹Leitat, Spain; ²Convert Italia, Italy
- 3DV.1.42** **Horizontal Single Axis Tracker in Weathering Steel, a Solution with a Low Impact on the LCOE and LCA Index.**
 Giuseppe Demofonti¹
¹Convert Italia, Rome, Italy
- 3DV.1.43** **Stand-alone IoT Enabled Bifacial Irradiance Sensor for PV**
 Urban Barbič¹, Marko Jankovec¹, Marko Topic¹
¹University of Ljubljana, Ljubljana, Slovenia
- 3DV.1.44** **Multi-Wavelength DUSST: A Novel Concept of Optical Soiling Sensor:**
 Álvaro Fernández Solas¹, Leonardo Micheli¹, Florencia Almonacid-Cruz¹, Eduardo F. Fernández¹
¹University of Jaén, Jaén, Spain
- 3DV.1.45** **Fabrication of Flexible and Light-Weight Module with Crystalline Silicon Solar Cells**
 Tomihisa Tachibana¹, Katsuto Tanahashi¹, Yuji Ino¹, Katsuhiko Shirasawa¹
¹AIST, Koriyama, Japan
- 3DV.1.46** **Life Expectancy of PV Inverters and Optimizers in Residential PV Systems**
 Christof Bucher¹, David Joss¹
¹Bern University of Applied Sciences, Switzerland

Visual Presentations 5DV.2

10:30- 12:00 Energy System Integration; Storage / Sustainability, Environment, and Circularity of PV / Modelling and Scenarios for Renewables, Policy, Global Challenges / Costs, Economics, Finance and Markets / Regional Experiences; Combatting Energy Poverty / Societal Challenges; Citizens' Participation, Awareness

Poster Area

5DV.2.1

Solenco Power: Hydrogen Storage for AC and DC Networks

Francisco López¹, Dr. Hugo Vandendorpe¹

¹*Solenco Power, Turnhout, Belgium*

5DV.2.2

Batteries in Solar-driven Water Splitting System – Synergistic Efficiency Gain

Oleksandr Astakhov¹, LI-Chung Kin¹, Minoh Lee², Stefan Haas¹, Uwe Rau^{1,3}, Tsvetelina Merdzhanova¹

¹*Forschungszentrum Jülich, Jülich, Germany*; ²*University of Toronto, Toronto, Ontario, Canada*; ³*RWTH Aachen University, Aachen, Germany*

5DV.2.3

KALYON EV-ON Charge

Merve Tunçez¹, Ali Eren Kok¹, Duygu Kuzyaka¹, Firat Es¹

¹*Kalyon PV, Ankara, Turkey*

5DV.2.4

Transient Response and Non-Linear Capacity Variation Aware Unified Equivalent Circuit Battery Model

Dafang Zhao¹, Ittetsu Taniguchi¹, Francky Catthoor², Takao Onoye¹

¹*University of Osaka, Suita, Japan*; ²*KU Leuven, Leuven, Belgium*

5DV.2.5

Integrating Perovskite Photovoltaics and Nickel Cobalt Sulfide Catalysts for Efficient Hydrogen Evolution Reaction

Hongjae Shim¹, Jaesung Yun¹

¹*UNSW, Sydney, Australia*

5DV.2.6

Hydrogen Concept in the Commercial Sector with a H₂ Bus for the Use of PV Yield

Hannah Prinz¹, Henrik Te Heesen¹

¹*Environmental Campus Birkenfeld, Hoppstädten-Weiersbach, Germany*

5DV.2.7

Evaluating PV Integration Strategies Considering High Resolution Embedded CO₂ Emissions of Grid Electricity

Natasa Vulic¹, Martin Ruedisueli¹

¹*EMPA, Dübendorf, Switzerland*

- 5DV.2.8** **Solar Photovoltaic Floating Systems Assessment Through GIS-Multicriteria Analysis: a Case Study of the Marrakech-Safi Region' Dams in Morocco**
 Fatima-Zahra Ouchani^{1,2}, Ouafae Jbahi^{1,2}, Ahmed Alami Merrouni³, Samir Idrissi Kaitouni¹, Abdellatif Ghennioui¹, Zakaria Naimi¹, Mohamed Maaroufi²
¹Green Energy Park, Ben Guerir, Morocco; ²Mohammadia School of Engineers, Rabat, Morocco; ³Mohammed First University, Oujda, Morocco
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¹Free University of Berlin, Berlin, Germany; ²Ruhr University Bochum, Bochum, Germany; ³University of Liechtenstein, Vaduz, Liechtenstein; ⁴HZB, Berlin, Germany
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 Hanna Bartoszewicz-Burczy¹
¹Institute of Power Engineering, Warszawa, Poland
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 Thomas Nordmann¹, Ralph Lingel¹
¹TNC Consulting, Meilen, Switzerland
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¹Trier University of Applied Sciences, Berlin, Germany
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¹Forschungszentrum Jülich, Jülich, Germany; ²RWTH Aachen University, Aachen, Germany
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¹University of São Paulo, Sao Paulo, Brazil

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¹Institute of Technical Sciences of SASA, Beograd, Serbia
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¹University of Applied Sciences Offenburg, Offenburg, Germany
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¹University of Applied Sciences Offenburg, Offenburg, Germany
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 Jethro Betcke¹, Susanne Weyand¹, Alaa Alhamwi¹, Annekatrin Metz-Marconcini², Thomas Krauß², Seyedmajid Azimi², Marion Schroedter-Homscheidt¹
¹DLR- German Aerospace Center, Oldenburg, Germany; ²DLR- German Aerospace Center, Wessling, Germany
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¹Fraunhofer ISE, Freiburg, Germany
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 Wolfram Palitzsch¹, Ingo Röver²
¹LuxChemtech, Freiberg, Germany
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¹ODTÜ - GÜNAM, ANKARA, Turkey; ²Ilmenau University of Technology, ANKARA, Turkey
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¹Forschungszentrum Jülich, Erlange, Germany

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¹CEA, Le Bourget du Lac, France; ²bifa Environmental Institute, Augsburg, Germany; ³LuxChemtech, Freiberg, Germany
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¹UNSW, Sydney, Australia
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¹RSE, Milano, Italy
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¹Delft University of Technology, The Netherlands; ²HyET Solar The Netherlands, The Netherlands
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¹University of Antofagasta, Antofagasta, Chile; ²CEA, Le Bourget-du-Lac, France

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- ¹*Forschungszentrum Jülich, Jülich, Germany; ²Technical University of Darmstadt, Eindhoven, The Netherlands; ³University of Twente, Enschede, The Netherlands*
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- ¹*CNR, Bologna, Italy; ²University of Milano-Bicocca, Milan, Italy*
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- ¹*JPM Silicon, Braunschweig, Germany; ²TU Braunschweig, Germany*
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- ¹*TOMATO-GSL, Munich, Germany; ²Tokyo University of Science, Munich, Germany*

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Mohammad Dehghanimadvar¹, Nathan Chang¹, Renate Egan¹

¹UNSW, Sydney, Australia

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Chuan Ma¹, Dominik Rutz¹, Veronika Hofmeier¹, Rainer Janssen¹, Athanasios T. Balafoutis², Konstantinos Vaiopoulos², Claus Aage Grøn Sørensen³, Dimitris Manolakos⁴, Alex Koutsouris⁴, George Papadakis⁴, Magdalena Borzecka⁵, Daan Creupelandt⁶, Julio Román⁷, Vanja Bisevac⁸, Frank Oudshoorn⁹, Daniele Rossi¹⁰, Martyna Próchniak¹¹, Michail D. Kaminariaris¹², Zisis Tsiropoulos¹², Harm Brinks¹³, Barry Caslin¹⁴, Jorge Snej¹⁵, Mirentxu Asín¹⁶

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PV Will Shine in the New Clean Energy Transition Partnership

Stefan Nowak¹, Marcel Gutschner¹, Michael Hübner², Marko Topic³

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Winfried Hoffmann¹, Heinz-Werner Binzel²

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Jens Merten¹, Anis Jouini², Frédéric Storck³, Philippe Raffin⁴, Caroline Deforet⁵, Stephane Grazi⁶, Gilles Duissard⁷, Hervé Druon², Philippe Galez⁸

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Leonardo Micheli¹, Marios Theristis², Diego L. Talavera¹, Gustavo Nofuentes¹, Joshua S. Stein², Florencia Almonacid-Cruz¹, Eduardo F. Fernandez¹

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Rita Hogan Almeida¹, Celena Lorenzo¹, Luis Narvarte¹

¹UPM, Madrid, Spain

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Fuqiang Zhuang^{1,2}, Rodrigo Amaro e Silva¹, Thomas Carriere³, Benoit Gschwind¹, Yves-Marie Saint-Drenan¹, Philippe Blanc¹

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Philippe Macé¹, Elina Bosch¹, Gaëtan Masson¹, Monica Aleman¹, Adrien van Rechem¹, André Penas¹

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In my Backyard Please! Testing a Co-Design Approach to Increase Local Support for a Multifunctional Solar Park

Merel Enserink¹, Rudi Van Etteger¹, Lianne Polinder², Floor Govers², Marieke Rietbergen², Thijs Sepers³, Ruben Peuchen⁴, Koen Straver⁴, Leo Van der Knaap⁴, Jan De Jong⁴, Ilkay Cesar⁴

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Smart Strategies for the Transition in Coal Intensive Regions

Rita Mergner¹, Rainer Janssen¹, Dominik Rutz¹, Charalampos Malamatenios², Georgia Veziryianni², Dirk Knoche³, Anne Rademacher³, Rainer Schleppehorst³, Liliana Fonseca⁴, Rona Michie⁴, Angel Nikolaev⁵, Christian Doczekal⁶, Gregory (Greg) Arrowsmith⁷, Nicholas de la Vega⁷, Gloria Popescu⁸, Jasmina Mandic Lukic⁹, Igor Volchyn¹⁰, Dmytro Bondzyk¹⁰, Marcin Pietrzykowski¹¹, Marcin Chodak¹², Lee Guilfoyle¹³, Kenn Palmer¹³, Jan Frouz¹⁴, Marketa Hendrychova¹⁵, Sabina Irimie¹⁶

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Simple and Smart Communities for All

Rita Mergner¹, Dominik Rutz¹, Rainer Janssen¹, Angela Holzmann², Kerstin Schilcher³, Altan Sahin³, Natascha Fenz⁴, Ulfert Höhne⁴, Angel Nikolaev⁵, Mariya Trifonova⁵, Thekla Heinel⁶, Avigdor Burmeister⁶, Benjamin Dannemann⁷, Nikoloz Sumbadze⁸, Eszter Süle⁹, Slavica Robić¹⁰, Tijana Šimek¹⁰, Bence Kovacs¹¹, Krisztina Szabó¹²

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Domenico Vito¹

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Spatially Differentiated Assessment of Solar Park Potential in Germany Respecting Environmental, Socio-Technical and Socioeconomic Restrictions

Elham Fakhazadehshirazi¹, Christine Rösch¹

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Net-Metering Regulations and Sustainable Transition to Solar PV Technology – The Missing Behavioral Change in Pakistan

Iftikhar Shahid¹, Kafait Ullah², Clark Miller³, Muhammad Dawood⁴

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Italy 2050: a Pathway Towards 100% Renewables

Alessandro Virtuani¹

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How to Make a Solar PV-Based Energy Community Economically Attractive in Belgium?

Philippe Macé¹, Elina Bosch¹, Monica Aleman¹

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13:30- 15:00 PV Module Reliability

Poster Area

Chairpersons:

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Study of Abrasion Resistance of Structured PV Glass

Cristina Leyre Pinto Fuste¹, Jaione Bengoechea¹, Eugenia Zugasti¹

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PV Module Sand Abrasion Testing

Gerhard Mathiak¹, Jim Joseph John¹, Vivian Alberts¹

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An Exploratory Study on the Role of Sand Erosion on the Degradation of wet Insulation Resistance of Photovoltaic Backsheets in a Desert-Like Environment

Umang Desai¹, Aparna Singh¹

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Effect of Degradation Factors on Solar Module Encapsulant Materials

Hsin-Hsin Hsieh¹, Sih-Hong Chen¹, Wei-Lun Yang¹, Chiou-Chu Lai², Min-Tsung Kuan², Yi-Chun Liu²

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- 3DV.3.5 Identification of Backsheet Type of Silicon PV Modules by Fluorescence Patterns of EVA Encapsulant**
Oleksandr Stroyuk¹, Cosima Güttler¹, Claudia Buerhop-Lutz¹, Jens Hauch¹, Marius Peters¹
¹Forschungszentrum Jülich, Erlangen, Germany
- 3DV.3.6 Minimizing Crack Propagation in Cracked PV Backsheets with Repair Coatings**
Yuliya Voronko¹, Gabriele C. Eder¹, Wolfgang Mühleisen², Lukas Neumaier², Christian Breitwieser³, Sonja Feldbacher⁴, Gernot Oreski⁴
¹OFI, Wien, Austria; ²SAL Silicon Austria Labs, Austria; ³Rembrandtin Coatings, Austria; ⁴PCCL, Leoben, Austria
- 3DV.3.7 Pressure Cooker Test on PV Backsheets: Freestanding vs. Module-Aged**
Caroline Biedermann¹, Angelika Beinert¹, Daniel Philipp¹, Paul Gebhardt¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany
- 3DV.3.8 Challenges for Polycarbonate (PC) and Polymethylmethacrylate (PMMA) for the Use as flexible Front-Sheets in Photovoltaic Modules**
Sonja Feldbacher¹, Astrid Macher¹, Gernot Oreski¹
¹PCCL, Leoben, Austria
- 3DV.3.9 Determination of Activation Energy for the Degradation of Encapsulant (EVA/TPO) in C-Si Photovoltaic Modules**
Maruthi Avula¹, Baloji Adothu^{1,2}, Krishan Patel¹, Siddharth Singh¹, Sudhanshu Mallick¹
¹IIT Bombay, Mumbai, India; ²DEWA R&D Center, Dubai, United Arab Emirates
- 3DV.3.10 Properties of Transparent Backsheets Based on Polypropylene**
Eric Helfer¹, Astrid Macher¹, Gernot Oreski¹, Margit Lang¹, Peter Fuchs¹
¹PCCL, Leoben, Austria
- 3DV.3.11 The Fast and Quantitative Measurements of Barrier Properties in PV Polymer Films**
Anton Mordvinkin¹
¹Fraunhofer CSP, Halle (Saale), Germany
- 3DV.3.12 Compressive Shear Analysis of Encapsulant Glass Laminates - Comparison of EVA, POE and TPO**
Martin Tiefenthaler¹, Robert Pugstaller¹, Gernot M. Wallner¹
¹Johannes Kepler University, Linz, Austria

- 3DV.3.13** **Low Temperature Solar Cell Encapsulation with Novel Silicone Elastomer for Building Integrated PV**
 Guy Beaucarne¹, Mantas Zelba², Emmanuel Jadot³, Jonathan Curon³, Frédéric Gubbels³, Valérie Hayez³, Beatriz Sanabria Arenas³, Gregory Chambard³, Rimvydas Karoblis²
¹Dow Silicones Belgium, Seneffe, Belgium; ²Via Solis, Kaunas, Lithuania
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 Lukas Gerstenberg¹, Rohith Krishnan Bala Krishnan¹
¹Nordhausen University of Applied Sciences, Nordhausen, Germany
- 3DV.3.15** **A Screening Protocol to Assess the Stability of Inks used to Mask Metallic Interconnects in BIPV Modules**
 Alejandro Borja Block¹, Alessandro Virtuani¹, Christophe Ballif^{1,2}
¹EPFL, Neuchâtel, Switzerland; ²CSEM, Neuchâtel, Switzerland
- 3DV.3.16** **Stability Analysis on Shingled High-Efficiency BAPV Modules**
 Stefan Wendlandt¹, Carolyn Carrière², Luis Eduardo Alanis³, Veronika Nikitina³, Dirk Reinwand³
¹PI Berlin, Germany; ²CEA, France; ³Fraunhofer ISE, Germany
- 3DV.3.17** **Assessment of ECA to Ribbon Interconnection Stability by Current Path and Power Loss Imaging**
 Stephan Großer¹, Matthias Schak¹, Tudor Timofte², Marko Turek¹
¹Fraunhofer CSP, Halle (Saale), Germany; ²ISC Konstanz, Germany
- 3DV.3.18** **Assessment Approach of Interconnection Aging in Shingled Cell Modules**
 Stephan Großer¹, Matthias Schak¹, Matthias Pander¹, Marko Turek¹, Bengt Jäckel¹
¹Fraunhofer CSP, Halle (Saale), Germany
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 Barry Hartweg¹, Kathryn Fisher¹, Zhengshan Jason Yu¹, Zachary Holman¹
¹Arizona State University, Tempe, AZ, United States
- 3DV.3.20** **Are Glass-Free C-Si Lightweight PV Modules Resistant to Abrasion?**
 Fabiana Lisco¹, Farwa Bukhari², Adam Law², Luke Jones², Michael Walls², Christophe Ballif¹
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FEM Simulation of Influence of Different Polymeric Encapsulation Materials and Backsheets on Deformations in Strings of Shingled Solar Cells under Mechanical and Thermal Loading

Margit Lang¹, Gernot Oreski¹, Peter Fuchs¹, Eric Helfer¹, Andreas Halm², Markus Klenk³

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Study of Hot Spots in Partially Shaded PV Modules with Large-Area Wafers

Haifeng Chu¹, Constantin Klyk¹, Andreas Halm¹, Valentin Dan Mihailetchi¹

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Corrosion Testing of FPV Materials in Off-shore

Myenggil Gang¹, Dong-Chan Kim¹, Seong Dae Kim¹, Hyun-Jun Kim², Hyunsik Jo², Seungwook Shin³, Chang-Sub Won¹

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Effect of UV Preconditioning in a Sequential UV/DH Accelerated Test on Commercial P-Si Photovoltaic Encapsulated Cells

Julia Vincent^{1,2}, Venkata Ramana Posa¹, Ali Khouzam^{1,2}, Adrien Gomez¹, Fabien Delaleux¹, Olivier Riou¹, Pierre-Olivier Logerais¹

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Thermo-Mechanical Analysis of Si-based PV Modules and Experimental Validation with In-laminate Sensing Technology

Marta Casasola^{1,2,3}, Philippe Nivelles^{1,2,3}, Bin Luo^{1,2,3,4}, Jonathan Govaerts^{1,2,3}, Rik Van Dyck^{1,2,3,4}, Tom Borgers^{1,2,3}, Jozef (Jef) Poortmans^{1,2,3,4}, Loïc Tous^{1,2,3}, Michaël Daenen^{1,2,3}

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Mechanical Characterization of Glass Transparent Backsheet PV Modules via Modelling and Testing Methods

Meriç Çaliskan¹, Güven Korkmaz¹, Bedrettin Aydoğan¹, Firat Es¹

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Effects of Wind Load on the Mechanics of a PV Power Plant

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Lead-Free PV Modules: Industrial Realization and Evaluation of Environmental Impact

Paul Gebhardt¹, Timo Wenzel¹, Stephan Hoffmann¹, Lorenz Friedrich¹, Sina Herceg¹, Dilara Maria Subasi¹, Angela De Rose¹, Andreas Lorenz¹, Daniel Philipp¹

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Moisture Protection of Modules Containing Perovskite Solar Cells

Lori Postak¹, Mark Molinaro¹

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Monitoring of Electrical Performance and Material Stability of PV Modules with Repaired/Coated Backsheets

Anika Gassner^{1,2}, Karl Knöbl³, Markus Hilweg⁴, Christian Breitwieser⁵, Norbert Lenck⁶, Gabriele C. Eder¹

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The Preconditioning Effect of Uncured EVA Rolls on the Long-Term UV Exposure of Glass/Glass Modules

Luca Gnocchi¹, Alessandro Virtuani¹, Christophe Ballif¹

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Which Cell Technologies are more Resistant to LETID?

Andrew Fairbrother¹, Alejandro Borja Block¹, Olatz Arriaga Arruti¹, Christophe Ballif¹, Alessandro Virtuani¹

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Chemical and Morphological Characterization of PVDF Films used for Photovoltaic Backsheets

Chiara Barretta¹, Eric Helfer¹, Astrid Macher¹, Márton Bredács¹, Abdulkarim Gök², Gernot Oreski¹

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Experimental Study of Non-uniform Mechanical Loads and Deformation on Photovoltaic Module

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Measuring and Modeling the Rate of Power Loss in N-PERT Cells Associated with PID-P as a Function of Encapsulant Resistivity and Irradiance

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Visual Presentations 1DV.4

15:15- 16:45 Characterisation & Simulation of solar cells

Poster Area

Chairpersons:

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1DV.4.2

A Simulation Study on IBC Solar Cells for Industrial Manufacturing

Gence Bektas^{1,2}, Selin Seyrek^{1,2}, Ahmet Emin Keçeci^{1,2}, Hasan Hüseyin Canar^{1,2}, Hasan Asav^{1,2}, Sümeyye Koçak Bütüner^{1,2}, Emine Hande Ciftçinar^{1,2}, Rasit Turan^{1,2}

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1DV.4.3

Development of Measurement Method for Diffusion Capacitance Characterization

Apostolos Bakovasilis^{1,2,3,4}, Rik Van Dyck^{1,2,3,5}, Wilmar Martinez^{4,6}, Jozef (Jef) Poortmans^{1,2,3}

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1DV.4.4

In-depth Exposure of New Phase in Poly-Silicon of TOPCon Device: is Phosphorus Bonded Oxygen Present?

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1DV.4.5

Characterization of the Dynamic Behavior of Different Solar Cell Technologies for Application in Visible Light Communication

Mirco Muttillio¹, Patrizio Manganiello¹, Olindo Isabella¹

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1DV.4.6

Meta-Light Funnel Arrays for Efficient Wideband Solar Light Harvesting for Photovoltaic Applications

Ashish Prajapati¹, Gil Shalev¹

¹*BGU, Be'er Sheva, Israel*

1DV.4.7

Cut out for Efficiency: A Detailed LBIC Study of Edge Recombination in Cut-Cell Silicon Photovoltaics

Miha Kikelj¹, Benjamin Lipovsek¹, Matevz Bokalic¹, Marko Topic¹

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1DV.4.8

Extraction of Interface States Density Distribution from the Capacitance Spectra of a-Si:H/c-Si Heterojunction Solar Cell

Jagannath Panigrahi¹, Ashutosh Pandey¹, Shrestha Bhattacharya¹, Sourav Mandal¹, Vamsi Krishna Komarala¹

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1DV.4.9

Analysis of Recombination Behavior of Polycrystalline on Oxide(POLO) Cells by Formation Conditions

Huiyeon Lee¹, Dongjin Choi¹, Changhyun Lee¹, Hoyoung Song¹, Haejung Lee¹, Yoonmook Kang¹, Hae-Seok Lee¹, Donghwan Kim¹

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1DV.4.10

Characteristics of PEDOT:PSS/Si Solar Cells with a Flat and Textured Interface

Sergii V. Mamykin¹, Iryna B. Mamontova¹, Tetiana Lunko¹, Olga Kondratenko¹, Natalia V. Kotova¹, V.R. Romanyuk¹

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1DV.4.11

Determination of Contact Resistivity Components of Poly-Si/SiO_x Passivated Contacts by Laser Structuring

Jan Lossen¹, Aditya Chaudhary¹, Mertcan Comak¹, Lejo Joseph Koduvelikulathu¹, Jan Hoß¹, Radovan Kopecek¹

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- 1DV.4.12** **Enabling Understanding of Hydrogen Passivation and Degradation in Topcon via Atom Probe Tomography**
Yifu Shi¹, J.-I. Polzin², Matthew Wright¹, Sebastian Bonilla¹, Michael Moody¹
¹University of Oxford, United Kingdom; ²Fraunhofer ISE, Germany
- 1DV.4.13** **Iron Quantification in Crystalline Silicon Solar Cells from Voc Measurements**
Axel Herguth¹
¹University of Konstanz, Konstanz, Germany
- 1DV.4.14** **Using Low Cost Scanners for Optical Inspection of Solar Cells**
Mattias K. Juhl¹, Binesh Puthen-Veetil¹, Muhammad Umair Khan², Giuseppe Scardera², David Payne¹
¹Macquarie University, Sydney, Australia; ²University of New South Wales, Australia
- 1DV.4.15** **Influence of Bulk Carrier Lifetime on Efficiency Recovery in Gated Solar Cells**
Anil Kumar¹, Nithin Chatterji³, Aldrin Antony⁴, Pradeep R. Nair¹
¹Indian Institute of Technology Bombay, India; ²Sardar Vallabhbhai National Institute of Technology Surat, India; ³Cochin University of Science of Technology, India
- 1DV.4.29** **Characterization of the Damaging Potential of High Throughput Cell Manufacturing Processes by Sensitive Strength Analysis**
Ringo Koepge¹, Stephan Großer¹
¹Fraunhofer IMWS, Halle, Germany
- 1DV.4.30** **Investigation of the Front Side Anti-Reflection Coating Layer on M10 PERC Solar Cells**
Cheng-Wen Kuo¹, Ta-Ming Kuan¹, Yung-Chih LI¹, Wei-Lo (Chris) Chueh¹, LI-Guo Wu¹, Shih-Chieh Lin¹, Cheng-Yeh Yu¹
¹, Hsinchu, Taiwan
- 1DV.4.31** **Different Behaviors of LETID in the M6/M10 PERC Silicon Solar Cells**
Min-An Tsai¹, Cheng-Wen Kuo², Yean-San Long¹, Cho Fan Hsieh¹, Ta-Ming Kuan³, Cheng-Yeh Yu², Teng-Chun Wu¹
¹ITRI, Chutung, Taiwan; ²TSEC, Taiwan; ³TS Visuals, Taiwan

- 1DV.4.32** **Low-area Laser-doped Selective Contacting Scheme for Industrial Solar Cells**
Yuchao Zhang¹, Li Wang¹, Ran Chen¹, Catherine Chan¹, Brett Hallam¹
¹UNSW, Sydney, Australia
- 1DV.4.33** **Transitioning to Higher Emitter Sheet Resistance for PERC Solar Cell Production**
Mehul Raval¹, Mehmet Siddik Memetemin², Guru Prasad A³, Mehmet Ender², Peter Fath¹
¹RCT Solutions, Konstanz, Germany; ²Kalyon PV, Turkey; ³centrotherm India, Bengaluru, India
- 1DV.4.34** **Influence of Metallization Screen Parameters on Silver Paste Consumption Reduction for Commercial Mono PERC Solar Cell Production**
Emircan Han^{1,2}, Mehul Raval³, Fatma Çambay Kuban¹, Sandeep Chandrill³, Mehmet Ender¹, Firat Es¹, Peter Fath³, Ahmet Aktas², Serhat Karyeyen²
¹Kalyon PV, Turkey; ²Gazi University, Ankara, Turkey; ³RCT Solutions, Konstanz, Germany
- 1DV.4.35** **Observation on Etching Chemicals Performance with Time by an Industrial Single Side Etching (SSE) Tool**
Sümeyye Koçak Bütüner¹, Ahmet Emin Keçeci^{1,2}, Hasan Hüseyin Canar^{1,2}, Hasan Asav^{1,2}, Gence Bektas^{1,2}, Bülent Arikian¹, Rasit Turan^{1,2}
¹ODTÜ - GÜNAM, Turkey; ²METU, Ankara, Turkey
- 1DV.4.36** **Every Cell needs a Beautiful Image: On-The-Fly Contacting Measurements for High-Throughput Production**
Leslie Kurumundayil¹, Klaus Ramspeck², Stefan Rein¹, Matthias Demant¹
¹Fraunhofer ISE, Freiburg im Breisgau, Germany; ²halm, Frankfurt am Main, Germany
- 1DV.4.37** **Overview of Wet-Chemical Solutions for Industrial Solar Cells with Efficiencies beyond 23%**
Damian Brunner¹, Sufan Xu¹, Weiwei Xie¹, Iron Wang¹, Caroline Scheiwe¹, Tobias Dannenberg¹, Tjark Harders¹, Jan Temmler¹, Mathias Kamp¹, Holger Kühnlein¹, Michael Passig¹, Martin Pretscher¹, Alexis Padiaditakis¹, Markus Sieber¹, Bendikt Straub¹
¹RENA Technologies, Freiburg, Germany
- 1DV.4.38** **Mass Production Vacuum Deposition Equipment for Silicon-Perovskite Tandem Solar Cells**
Simon Hübner¹, Torsten Dippell¹, Cheng Xuemei¹
¹SINGULUS TECHNOLOGIES, Kahl am Main, Germany

1DV.4.39

Effect of Adding a Second Immiscible Liquid on the Slip and Printing Behavior of Solar Cell Frontside Metallization Pastes

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¹Karlsruhe Institute of Technology - KIT, Karlsruhe, Germany

1DV.4.40

Single Sided High Throughput Sputter Process Technology for In-Situ Doped n-Type Amorphous Silicon Layers for High Efficiency TOPCon Solar Cells

Eric Schneiderlöchner¹, Uwe Graupner¹, Volker Linss¹, Tina Dietsch¹, Jens Baumann¹, Jan Hoß², Jonathan Linke², J.-I. Polzin³, Henning Nagel³, Martin Bivour³, Sebastian Mack³, Jan Lossen²

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1DV.4.41

Processing Response of Air Fired Copper Pastes Printed on Crystalline Silicon PERC Solar Cells

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¹Bert Thin Films, Louisville, United States; ²University of North Carolina Charlotte, Charlotte, United States

1DV.4.42

Oxygen Related Recombination Centers Induced by RPD ITO Deposition Process in CSC Solar Cells

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1DV.4.43

Industrially Feasible Cu-Based Paste for Crystalline Silicon Solar Cells via High-Temperature Contact Formation

Dongjin Choi¹, Soohyun Bae², Myeongseob Sim¹, Hyunjung Park¹, Donghwan Kim¹, Yoonmook Kang¹, Hae-Seok Lee¹

¹Korea University, Seoul, Korea, Rep. of South; ²KIER, Daejeon, Korea, Rep. of South

1DV.4.44

Industrially Feasible Mace Textured PERC Solar Cell Exceeding 20% Conversion Efficiency

Hasan Asav^{1,2}, Ahmet Emin Keçeci^{1,2}, Sümeyye Koçak Bütüner¹, Hasan Hüseyin Canar^{1,2}, Gence Bektas^{1,2}, Samim Gök⁴, Bülent Arikan¹, Rasit Turan^{1,2}

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1DV.4.45

Fine-Line Screen Printing Enables PERC Front-Side Metallization with only 20mg Silver Laydown

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1DV.4.46

Optimization of Electrical LID Regeneration for PERC Solar Cell Production

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1DV.4.47

Damage-free Laser Patterned Process Route for Cu-Electroplated Contacts on SHJ Solar Cells

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1DV.4.48

Enhancing the Durability of a Solar Cell Screen-Printable Gridlines Through the Addition of Surface-Engineered Carbon Nanotubes (CNTs) to a Commercial Front AG Paste

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1DV.4.49

Model for Contact Formation of Novel TeO₂ Containing Pb-Free Silver Paste on n+ and p+ Doped Crystalline Silicon

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1DV.4.50

Why Silver Must be Replaced by Plated Copper for Solar Cells Metallization?

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1DV.4.51

Evaluation of Innovative Glass-Based Printing Forms for Fine Line Metallization Using Stencil Printing and Parallel Dispensing

Andreas Lorenz¹, Sebastian Tepner¹, Katharina Gensowski¹, Timo Wenzel¹, Kiarash Karimi¹, Resul Akyüz¹, Marius Singler¹, Simon Auerbach¹, Ana Maria Jimenez Cardozo¹, L. Ney¹, Aaron Vogt², Sebastian Bechmann³, Florian Clement¹

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