SiliconPV 2022

12th International Conference on Crystalline Silicon Photovoltaics

npworkshop Konstanz 2022

bifiPV workshop 2022

March 28 – April 01, 2022

Konstanz, Germany/ Hybrid Event

PROGRAM

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SiliconPV 2022 is proud to be supported by the Federal Ministry for Economic Affairs and Climate Action, Germany.

Chairpersons' message

Dear friends of silicon photovoltaics,

Welcome to SiliconPV conference, nPV and bifiPV workshops in Konstanz and online!

After two years of no "real" or only online versions of SiliconPV conference, nPV and bifiPV workshops we have this year the opportunity to meet, discuss, eat/drink and argue again in person, and not only in a virtual surrounding. Personally, we missed these opportunities of spontaneous exchange of ideas a lot and look very much forward to be able to do it again. For people not being able to attend in person, the organizers of the conference have now experience in supporting the conference with an additional online format.

Like in previous years, the nPV Workshop is coupled to SiliconPV with an overlapping day of both events on Wednesday. And in addition, this time the bifiPV Workshop on Friday is also linked to the SiliconPV conference to enable all interested people to attend these events in a condensed way.

2020 and 2021 have been difficult times due to the COVID-19 situation, which affected our private life, as well as our professional situation in so many ways. Although it is still unclear whether the situation will change completely in 2022, there is hope that many things might evolve a little bit "back to normal".

The original plan to host SiliconPV 2022 and the nPV/bifiPV 2022 workshops in Hangzhou (China) unfortunately had to be abandoned due to the travel restrictions for foreign participants. Therefore, it was decided that the conference and the workshops will be hosted by University of Konstanz and ISC Konstanz in Konstanz (Germany).

Although tremendous progress could be achieved over the last years and decades with creating new ideas/processes/technologies and bringing a lot of them from the laboratory environment into the mass market, crystalline silicon photovoltaics is still a technology that bears a lot of opportunities to increase conversion efficiency and bring down levelized costs of electricity. This will add to the unbelievable progress we had seen in this field concerning growing numbers of installed power with new records of installed power every year. But this is only the beginning. This year, the PV industry has already added enough new PV capacity to reach a cumulative capacity of 1 TW, and we need to get all prepared for a 1TW annual production by 2028! We therefore celebrate a 1 TW party at ISC Konstanz during the conference/workshops week as well.

To fight global warming and all events related to this, we have to shift gears again globally and work together even more than in the past. SiliconPV 2022 as well as nPV and bifiPV workshops will add to this goal.

We therefore invited researchers around the world to hand in the results of their latest research in form of abstracts and present them to the conference audience. The abstracts have been evaluated in a blind review process by scientific experts in the field and the program has been put together strictly based on scientific quality. Oral and visual presentations will be valued equally to ensure that all accepted contributions will get the attention they deserve. The contributions can also be published in a regular journal to ensure global visibility. The scientific experts acted as reviewers in this process, too.

The conference topics range from material aspects, characterization, new cell concepts, process technologies, process integration, cell manufacturing, cell assembly to module technology, including the rapidly increasing activity on tandem approaches, where a high-bandgap partner is integrated above a silicon bottom cell to achieve conversion efficiencies beyond the limits of single-junction silicon cells.

Part of the nPV and the bifiPV workshops is dedicated to an industrial view of the growing number of installed PV power. We invited speakers from different companies along the value chain from around the world to present their latest developments.

We are convinced that you will enjoy the atmosphere of the conference as well as the location and would like to welcome you to the 12th SiliconPV conference, 11th nPV, and 8th bifiPV Workshops 2022 in beautiful Konstanz!

Giso Hahn,
Chair of SiliconPV 2022,
Pierre Verlinden,
Co-Chair of SiliconPV 2022

Barbara Terheiden,
Chair of nPV 2022
Yang Deren,
Co-Chair of nPV 2022

Radovan Kopecek,
Chair of bifiPV 2022
Mauro Pravettoni,
Co-Chair of bifiPV 2022

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Monday, March 28, 2022

08:30 - 10:00 Opening Session and First Highlights

Chairs: Giso Hahn (University of Konstanz) & Pierre Verlinden (Amrock)

08:30 Welcome to SiliconPV

Giso Hahn, University of Konstanz

08:45 Extended Talk: Contactless Measurement of Current-Voltage Characteristics for Silicon Solar Cells

Johannes Greulich[1], Wiebke Wirtz[1], Hannes Höffler[1], Mattias K. Juhl[2], Oliver Kunz[2], Appu Paduthol[2], Stefan Rein[1], Andreas W. Bett[3]

[1] *Fraunhofer ISE;* [2] *The University of New South Wales;* [3] *Albert-Ludwigs-Universität Freiburg*

Dr. Johannes Greulich

Johannes Greulich received the diploma degree in physics from the University of Freiburg, Germany, in 2010. He received a Ph.D. fellowship from the German Federal Environmental Foundation (Deutsche Bundesstiftung Umwelt) and the Ph.D. degree in physics in 2014 from the University of Freiburg, Germany for his work on electrical and optical simulation and characterization of crystalline silicon solar cells. Since 2015, he is Head of the Group for Inline Solar Cell Analytics and Simulation at the Fraunhofer Institute for Solar Energy Systems. His research interests include the development of optical and electrical simulation and characterization methods focusing on crystalline silicon solar cells.

09:15 Insulation Resistance in Relation to Distribution of Backsheet Types in Strings and Inverters

Claudia Buerhop-Lutz[1], Tobias Pickel[2], Oleksandr Stroyuk[2], Marius Peters[2], Jens Hauch[2]

[1] *Forschungszentrum Jülich GmbH;* [2] *HI ERN*

09:30 Towards High Efficiency TCO-Less SHJ Solar Cells

Can Han[1], Yifeng Zhao[1], Rudi Santbergen[1], Max van Duffelen[1], Paul Procel[1], Guangtao Yang[1], Miro Zeman[1], Luana Mazzarella[1], Olindo Isabella[1]

[1] *TU Delft*

09:45 Perovskite/Silicon Tandems: First Realization with Rear Textured p-Type High Temperature Passivating Contacts

Arnaud Walter[1], Brett Kamino[1], Ludovic Lauber[1], Soo-Jin Moon[1], Patrick Wyss[1], Christophe Allebé[1], Juan Diaz Leon[1], Antoine Descoeudres[1], Sylvain Nicolay[1], Christophe Ballif[1], Andrea Ingenito[1]

[1] *CSEM SA*

10:00 - 10:30 Coffee Break

10:30 - 12:00 Influence and Detection of Hydrogen in c-Si

Chairs: Arthur Weeber (TNO Energy Transition) & Abigail Meyer (Colorado School of Mines/NREL)

10:30 Non-cryogenic Infrared Absorption Spectroscopy for Direct Boron-Hydrogen Pair Quantification

Jochen Simon[1], Axel Herguth[1], Giso Hahn[1]

[1] *University of Konstanz*

10:45 Observations of Hydrogen-Induced Contact Resistance in TOPCon and PERC Solar Cells

Donghao Liu[1], Phillip Hamer[2], Matthew Wright[1], Peter Wilshaw[1], Sebastian Bonilla[1]

[1] *University of Oxford;* [2] *The University of New South Wales*

11:00 Influence of Highly Doped Layers on Hydrogen In-diffusion into Crystalline Silicon

Christian Fischer[1], Andreas Schmid[1], Axel Herguth[1], Annika Zuschlag[1], Giso Hahn[1]

[1] *University of Konstanz*

11:15 Controlling the Hydrogen Concentration in Boron and Gallium Doped Silicon Wafers

Rune Søndenå[1], Philip Michael Weiser[2], Frank Mosel[3], Per-Anders Hansen[1], Eduard Monakhov[2]

[1] *IFE;* [2] *UiO;* [3] *PVA Crystal Growing Systems GmbH*

11:30 Towards Accurate Atom Scale Characterization of Hydrogen Passivation of Interfaces in TOPCon Architectures

Yifu Shi[1], Sebastian Bonilla[1], Matthew Wright[1]

[1] *University of Oxford*

11:45 Excellent Surface Passivation of Textured n+-doped Silicon by PO_x/Al_2O_3 Stacks

Roel Theeuwes[1], Jimmy Melskens[2], Lachlan Black[3], Wolfhard Beyer[4], Willem-Jan Berghuis[1], Bart Macco[1], Erwin Kessels[1]

[1] *Eindhoven University of Technology;* [2] *TNO;* [3] *The Australian National University;* [4] *Forschungszentrum Jülich GmbH*

12:00 - 13:00 Lunch Break

13:00 - 14:30 On-site Poster Session I

The poster numbers are based on topics:

- A Carrier selective contacts, metallization and contact formation
- B Cell and module characterization
- C Cell and module simulation
- D Cleaning, etching, layer deposition technologies, surface morphology and surface passivation
- E Customized modules for buildings, vehicles and other special applications
- F Digitalization, data processing and machine learning in PV
- G High and record efficiency devices
- H Junction formation
- I Module processing and materials
- J Module reliability and energy yield
- K New manufacturing tools
- L nPV on Wednesday
- M Process integration and low-cost manufacturing
- N Si-based tandem cells in combination with perovskites, III-V and alternative materials
- O Silicon material and defect engineering
- P Wafering technologies and direct-wafer production

A-01 Laser-Crystallization of Passivating Contacts for Silicon Wafer Solar Cells

Annett Gawlik[1], Raphael Glatthaar[2], Andrea Dellith[1], Guobin Jia[1], Jan Dellith[1], Barbara Terheiden[2], Jonathan Plentz[1]

[1] *Leibniz Institute of Photonic Technology IPHT;*
[2] *University of Konstanz*

A-03 Structure and Electronic Properties of Nanopores in Si PV Devices with PLEO Contacts

Harvey Guthrey[1], Caroline Lima Salles[1], William Nemeth[1], David Young[1], Sumit Agarwal[1], Pauls Stradins[1]

[1] *NREL*

A-05 Development of Gallium Nitride as Electron Contact for Silicon Heterojunction Solar Cells

Julien Hurni[1], Mathieu Boccard[1], Davi Febba[1], Jonathan Thomet[1], Franz-Josef Haug[1], Aicha Hessler[1], Christophe Ballif[1]

[1] *EPFL - Photovoltaics and Thin Film Electronics Laboratory*

A-07 Mapping the Transport Paths in Silicon Passivating Contacts with Conductive AFM Tomography

Matej Hyvl[1], Gizem Nogay[2], Philipp Loper[3], Franz-Josef Haug[3], Quentin Jeangros[3], Antonin Fejfar[1], Christophe Ballif[3]

[1] *Institute of Physics, AS CR;* [2] *PV-Center, Centre Suisse d' Électronique et de Microtechnique (CSEM);* [3] *Photovoltaics and Thin-Film Electronics Laboratory (PV-Lab), EPFL*

A-09 Suppressed Degradation of Passivation Performance in Titanium Oxide/Crystalline Silicon Heterostructure by Metallization Using Titanium Nitride Interlayer

Tetsuya Inoue[1], Kazuhiro Gotoh[1], Yasuyoshi Kurokawa[1], Noritaka Usami[1]

[1] *Nagoya University*

A-10 Ultrathin Parasitic SiOz Layer Formation at Annealed Wet-Chemical NiO_x/Si Interfaces in Perovskite/Si Tandem Solar Cells

Stefan Lange[1], Bastian Fett[2], Angelika Hähnel[1], Volker Naumann[1], Bettina Herbig[2], Christian Hagendorf[1]

[1] *Fraunhofer CSP;* [2] *Fraunhofer Institute for Silicate Research ISC*

A-12 Laser Melting of Aluminium Kitchen Foil for Solar Cell Metallisation

Mong Hin Reggie Leung[1], Ruy Sebastian Bonilla[1], Matthew Wright[1], Mingzhe Yu[1], Yifu Shi[1]

[1] *University of Oxford*

A-14 Interactions between Aluminium and Poly-Si based Contact Stacks during Fire-through Metallization

Sofia Libraro[1], Mario Lehmann[1], Juan J. Diaz Leon[2], Christophe Allebé[2], Antoine Descoeudres[2], Andrea Ingenito[2], Aïcha Hessler-Wyser[1], Franz-Josef Haug[1], Christophe Ballif[1]

[1] *École Polytechnique Fédérale de Lausanne (EPFL);*
[2] *Swiss Center for Electronics and Microtechnology (CSEM)*

A-16 Dopant-Free Silicon Solar Cells on n-Type Cz Wafers with Wet-Chemically Grown SiOx Passivation Layer

Hisham Nasser[1], Basil Eldeeb[1], Emine Hande Çiftpınar[1], Ergi Dönerçark[1], Mona Zolfaghari Borra[1], Rasit Turan[1]

[1] *The Center for Solar Energy Research and Applications (ODTÜ-GÜNAM)*

A-18 Self-Assembled Organic Molecule Modified Electron Selective Contacts for Heterojunction Solar Cells

Elif Sarıgül Duman[1], Markus Kohlstädt[1], Christian Reichel[1], Leonard Tutsch[1], Martin Bivour1, Martin Hermle[1]

[1] *Fraunhofer ISE*

A-20 PECVD Plasma-SiO_x/poly-SiO_x Passivating Contacts

Zhirong Yao[1], Guangtao Yang[1], Can Han[1], Paul Procel[1], Yifeng Zhao[1], Liqi Cao[1], Roald Kolk[1], Luana Mazzarella[1], Miro Zeman[1], Olindo Isabella[1]

[1] *TU Delft*

A-21 Controlled Dielectric Breakdown to Form Pin-Hole Passivated Contacts

David Young[1], William Nemeth[1], Pauls Stradins[1]

[1] *NREL*

A-22 Optimising Metallisation Designs to Improve Silver Utilisation

Yuchao Zhang[1], Moonyong Kim[1], Li Wang[1], Brendan Wright[1], Catherine Chan[1], Brett Hallam[1]

[1] *The University of New South Wales*

B-01 Optimization of Front and Rear Surface Dielectric Passivation Layers for Ion-Implanted PERC Solar Cells

Gence Bektas[1], Hasan Hüseyin Canar[1], Ahmet Emin Keçeci[1], Hasan Asav[1], Sümeyye Koçak Bütüner[1], Selin Seyrek[1], Raşit Turan[1]

[1] *ODTÜ-GÜNAM*

B-03 Temperature and Irradiance Dependency of Capacitance Effects in New Generation High Efficiency PV Modules

Gabi Friesen[1], Ebrar Ozkalay[1], Flavio Valoti[1], Giovanni Bellenda[1], Mauro Caccivio[1]

[1] *University of Applied Sciences and Arts of Southern Switzerland, SUPSI-PVLab*

B-05 Characterization of Thin-Film Structures of Silicon Heterojunction Solar Cells with Inline Reflectance Spectroscopy

Saravana Kumar[1], Henri Vahlman[1], Sebastian Pingel[1], Ioan Voicu[1], Andreas Fischer[1], Anamaria Steinmetz[1], Jonas Haunschild[1], Stefan Rein[1]

[1] *Fraunhofer ISE*

B-07 Fill Factor Loss Analysis of Industrial Silicon Solar Cells for the Elevated Temperature Condition

Sang Hee Lee[1], Cheolwook Kwon[1], Kyuhyeon Im[1]

[1] *Korea Institute of Energy Research*

B-09 Light and Elevated Temperature Induced Degradation in Gallium- and Boron-doped hpmc-Si Wafers Studied by Hyperspectral Photoluminescence Imaging

Torbjørn Mehl[1], Oda Goa Berge[1], Ingunn Burud[1], Rune Søndenå[2], Espen Olsen[1]

[1] *Norwegian University of Life Sciences (NMBU);*
[2] *Institute for Energy Technology (IFE)*

B-11 Silicon Heterojunction Solar Cell Efficiency Improvement with Wide Optical Band Gap Amorphous Silicon Carbide Emitter

Arghavan Salimi[1], Ergi Dönerçark[2], Mehmet Koç[2], Rasit Turan[1]

[1] *METU/GUNAM;* [2] *GUNAM*

B-13 Evaluating Spectral Mismatch Correction for Multi-Coloured Photovoltaic Modules with Spot-Area Spectral Responsivity Measurements

Min Hsian Saw[1], Mauro Pravettoni[1]

[1] *National University of Singapore*

B-16 Towards the General Injection Dependence of the Distributed Series Resistance: The Influence of the Base Resistivity

Jan-Martin Wagner[1], Jürgen Carstensen[1], Rainer Adelung[1]
[1] *University of Kiel*

D-01 The Effect of SiN_x:H Stoichiometry on Electrical and Chemical Passivation of Al_2O_3/SiN_x:H Stack Layer on p-Type Silicon Wafers

Hasan Hüseyin Canar[1], Gence Bektas[1], Ahmet Emin Keçeci[1], Hasan Asav[1], Sümeyye Koçak Bütüner[1], Rasit Turan[1]
[1] *ODTÜ GÜNAM*

D-03 A Study of SiO_2/SiN_x Passivation Layer with Plasma Charging Technology for the p-Type Silicon Surface

Tae Kyung Lee[1], Kwan Hong Min[1], Hee-eun Song[1], Kyung Taek Jung[1], Sang Hee Lee[1], Sungeun Park[1]
[1] *Korea Institute of Energy Research*

D-05 Impact of Al_2O_3 ALD Growth and Properties on Passivation Quality of p-polySi/Al_2O_3 Stacks

Jimmy Melskens[1], Roel Theeuwes[2], Wolfhard Beyer[3], Mark Steltenpool[4], Erwin Kessels[2], Arthur Weeber[1], Agnes Mewe[1]
[1] *TNO;* [2] *Eindhoven University of Technology;* [3] *Forschungszentrum Jülich GmbH;* [4] *Levitech B.V.*

D-07 Atmospheric Pressure Gaseous-Phase Fabrication of Black Silicon for Photovoltaic Applications

Eleanor Shaw[1], Mohsen Goodarzi[1], Sebastian Bonilla[1], John Murphy[2], Nicholas Grant[2], Peter Wilshaw[1]
[1] *University of Oxford;* [2] *The University of Warwick*

E-01 Miniature Passivated Contact Silicon Solar Cells: From Electrically Detected Magnetic Resonance to Space

Abigail R. Meyer[1], San Theingi[2], Megan E. Phelan[3], David Needell[3], Kevin Hinkle[4], Kejun Chen[1], Matthew Hartenstein[1], Caroline Lima Salles de Souza[1], William Nemeth[2], Patrick Lenahan[4], Sumit Agarwal[5], Harry Atwater[3], Paul Stradins[2]
[1] *Colorado School of Mines / NREL;* [2] *NREL;* [3] *California Institute of Technology;* [4] *Penn State;* [5] *Colorado School of Mines*

F-02 Detection of Disconnected Strings in PV Power Plants Using Deep Learning Segmentation Algorithm in Aerial Infrared Thermography Images

Aline Kirsten Vidal de Oliveira[1], Mohammedreza Aghai[2], Ricardo Rüther[3]
[1] *Matheus Korbes Bracht;* [2] *Norwegian University of Science and Technology;* [3] *Universidade Federal de Santa Catarina*

G-01 Surface Passivation in Metallisation Gaps of Interdigitated Back-Contact Silicon Heterojunction (IBC SHJ) Solar Cells

Philipp Wagner[1], Alexandros Cruz[1], Lars Korte[1]
[1] *Helmholtz-Zentrum Berlin*

H-01 TCAD Simulation of Electrical Characteristics of Silicon Tunnel Junctions for Monolithically Integrated Silicon/ Perovskite Tandem Solar Cells

Guilherme Gaspar[1], João Serra[2], Jonas Kern[3], Matthias Müller[3]

[1] *FCiências.ID – Associação para a Investigação e Desenvolvimento de Ciências;* [2] *Universidade de Lisboa;* [3] *TU Bergakademie Freiberg, Institute of Applied Physics*

J-01 Solar Photovoltaic Tracking Systems for Electricity Generation

Mamadsho Ilolov[1], Khasan Karimov[1], Jamshed Rahmatov[1]

[1] *Center of Innovative Development of Sciences and New Technologies of NAS of Tajikistan*

J-03 Qualitative and Semi-Quantitative Analysis of Additives in Encapsulation Materials of PV Modules

Anton Mordvinkin[1], Susanne Neubauer[1], Robert Heidrich[1], Sylke Meyer[1], Ralph Gottschalg[1]

[1] *Fraunhofer CSP*

M-01 Design and Application of a Linear Acceleration Test Setup for Defect Diagnostics in High-Throughput Transportation Systems

Stephan Großer[1], Matthias Schak[1], Christian Hagendorf[1]

[1] *Fraunhofer CSP*

M-03 Upscaling of Perovskite/c-Si Tandem Solar Cells Using Industrial Adaptable Processing Tools

Zih-Wei Peng[1], Ke Xu[1], Alexandros Cruz Bournazou[1], Steve Albrecht[1], Bernd Stannowski[1]

[1] *Helmholtz-Zentrum Berlin*

N-03 Gas Immersion Laser Doping: n++ Phosphorus Doping on p+ Cz-Si Wafers with a Highly Doped p++ Emitter

Filipe Serra[1], Guilherme Gaspar[1], Ana Viana[1], Jayaprasad Arumughan[2], Ivo Costa[1], David Pêra[1], José Silva[1], Lasse Vines[3], João Serra[1], Killian Lobato[1]

[1] *Universidade de Lisboa;* [2] *ISC Konstanz;* [3] *University of Oslo*

O-01 A Fabrication Route for mc-UMG-Silicon-based Bifacial Solar Cells

Nerea Dasilva-Villanueva[1], Bo-Kyung Hong[1], Manuel Funes[1], David Fuertes Marrón[1], Carlos del Cañizo[1]

[1] *Instituto de Energía Solar (Universidad Politécnica de Madrid)*

O-03 PS-TDLS: Temperature-Dependent Lifetime Spectroscopy for Defect Characterization in Silicon

Sarra Dehili[1], Cyril Leon[1], Damien Barakel[1], Olivier Palais[1]

[1] *IM2NP*

O-05 Double-Side Poly-Si/SiO_x Passivating Contacts Solar Cells: Insights Into the Influence of Crystalline Silicon Wafers Properties

Thibaut Desrues[1], Adrien Danel[1], Adeline Lanterne[1], Sébastien Dubois[1]

[1] *Univ. Grenoble Alpes,CEA, LITEN, DTS, INES*

O-07 Roadmap Towards Sustainable SHJ Solar Cell Design

Moonyong Kim[1], Li Wang[1], Yuchao Zhang[1], Storm Drury[1], Robert Underwood[1], Brett Hallam[1]

[1] *The University of New South Wales*

O-08 Investigation of the Microstructure of Thick a-Si:H Layers for Laser Liquid Phase Crystallization

Maurice Nuys[1], Wolfhard Beyer[1], Stefan Haas[1], Hassan Ali Bosan[1]

[1] *Forschungszentrum Jülich GmbH*

O-09 Electrical Properties and Microstructure of Crystalline Silicon Ingots grown from Quartz Crucibles with and without Diffusion Barriers

Rune Søndenå[1], Gaute Stokkan[2], Rania Hendawi[3], Jochen Busam[3], Per-Anders Hansen[1], Benny Hallam[4], Marisa Di Sabatino Lundberg[3]

[1] *IFE;* [2] *SINTEF;* [3] *NTNU;* [4] *The Quartz Corporation*

P-02 n-Type Czochralski Ingot Growth Process and Investigation of Wafer Quality on IBC Cell Fabrication

Melis Özgüven[1], Nurhayat Yıldırım[1], Mehmet Konyar[1], Emre Uçar[1], Fırat Es[1]

[1] *Kalyon Solar Technologies (KalyonPV)*

P-04 Rear-Junction n-Type Cell Concept Utilizing PERC Process Sequence on Epitaxially-grown Base and Emitter

Clara Rittmann[1], Bernd Steinhauser[1], Marion Drießen[1], Armin Richter[1], Charlotte Weiss[1], Stefan Janz[1]

[1] *Fraunhofer ISE*

14:30 - 15:30 Cell Processing & Surface Passivation

Chairs: Robby Peibst (ISFH) & Agnes Mewe (TNO)

14:30 Printed Triangle-Shaped Contacts for Metallization of Silicon Solar Cells

Sebastian Tepner[1], Kiarash Karimi[1], Timo Wenzel[1], Linda Ney[1], Simon Auerbach[1], Michael Linse[1], Malte Schulz-Ruhtenberg[2], Sebastian Bechmann[3], Andreas Lorenz[1], Florian Clement[1]

[1] *Fraunhofer ISE;* [2] *LPKF Laser & Electronics AG;*
[3] *Christian Koenen GmbH*

14:45 Increasing Robustness of EpiWafer Transfer Process Leading to Carrier Lifetimes of 1.6 ms Using Large Scale Production Feasible Substrate Wafers

Yves Patrick Botchak Mouafi[1], Gabriel Micard[1], Juliane Muerter[1], Nena Birkle[2], Marion Driessen[3], Ralf Sorgenfrei[3], Charlotte Weiss[3], Barbara Terheiden[1]

[1] *University of Konstanz;* [2] *NexWafe GmbH;* [3] *Fraunhofer ISE*

15:00 Operation of Silicon Solar Cells with Very High Bulk Resistivities in Relevant Field Conditions of Illumination and Temperature

André Augusto[1], Anh Le Huy Tuan[2], Apoorva Srinivasa[1], Stuart Bowden[1], Ziv Hameiri[2]

[1] *Arizona State University;* [2] *The University of New South Wales*

15:15 Ion-Charged Dielectrics for Enhanced Silicon Surface Passivation

Matthew Wright[1], Isabel Al-Dhahir[1], Mingzhe Yu[1], Shona McNab[1], Katherine Collett[1], Peter Wilshaw[1], Sebastian Bonilla[1]

Presentation will be held by Sebastian Bonilla

[1] *University of Oxford*

15:30 - 16:00 Coffee Break

16:00 - 17:00 Degradation Phenomena in Solar Cells

Chairs: Jan Schmidt (ISFH) & Sébastien Dubois (CEA)

16:00 Deep-Level Defects in Ga-doped Silicon Crystals

Vladimir Markevich[1], Tarek Abdul Fattah[1], Joyce Ann T. De Guzman[1], Jose Coutinho[2], Nikolay V. Abrosimov[3], Jeff Binns[4], Iain Crowe[1], Matthew P. Halsall[1], Anthony R. Peaker[1]

[1] *University of Manchester;* [2] *University of Aveiro;*
[3] *Leibniz-Institut für Kristallzüchtung (IKZ);*
[4] *Nexcel Electronic Technology*

16:15 Atomic Structure of Defect Responsible for Light-Induced Efficiency-Loss in Monocrystalline Silicon Solar Cells in Warmer Climate Regions

Abigail Meyer[1], P. Craig Taylor[2], Vincenzo LaSalvia[3], Xue Wang[2], William Nemeth[3], Matthew Page[3], David L. Young[3], Sumit Agarwal[2], Paul Stradins[3]

[1] *Colorado School of Mines / NREL;* [2] *Colorado School of Mines;*
[3] *NREL*

16:30 Performance Degradation and Recovery of Ga-doped Cz-Si Solar Cells

Michael Winter[1], Dominic C. Walter[1], Byungsul Min[1], Robby Peibst[1], Rolf Brendel[1], Jan Schmidt[1]

[1] *Institute for Solar Energy Research Hamelin/Emmerthal (ISFH)*

16:45 Influence of the Addition of Aluminum in Boron-Doped Cz-Si on Degradation and Regeneration Kinetics

Melanie Mehler[1], Andreas Schmid[1], Annika Zuschlag[1], Giso Hahn[1], Matthias Trempa[2]

[1] *University of Konstanz;* [2] *Fraunhofer Institute for Integrated Systems and Device Technology*

17:00 - 18:00 Virtual Technical Tour - refer to page 47 for more information

Tuesday, March 29, 2022

08:30 - 10:00 Online Poster Session I

Please login to the online platform Scoocsv to visit the virtual poster booth.

A-02 Deposition and Properties of Sputtered Phosphorous Doped Amorphous Silicon Films for Passivating Contacts

Jens Baumann[1], Eric Schneiderlöchner[1], Jana-Isabelle Polzin[2]

[1] *VON ARDENNE GmbH;* [2] *Fraunhofer ISE*

A-04 Quantitative Evaluation of Passivation Performance after Electrode Deposition on TiO_x/Si Heterostructures by Photoluminescence Imaging

Shohei Fukaya[1], Kazuhiro Gotoh[1], Takuya Matsui[2], Hitoshi Sai[2], Yasuyoshi Kurokawa[1], Noritaka Usami[1]

[1] *Nagoya University;* [2] *National Institute of Advanced Industrial Science and Technology*

A-05 Development of Gallium Nitride as Electron Contact for Silicon Heterojunction Solar Cells

Julien Hurni[1], Mathieu Boccard[1], Davi Febba[1], Jonathan Thomet[1], Franz-Josef Haug[1], Aicha Hessler[1], Christophe Ballif[1]

[1] *EPFL - Photovoltaics and Thin Film Electronics Laboratory*

A-06 Optical Characterization of Carrier Density and Mobility in Laser-Doped p-Type Poly-Si Passivating Contacts

Franz-Josef Haug[1], Florian Buchholz[2], Jonathan Linke[2], Christophe Ballif[1]

[1] *EPFL - PVLAB;* [2] *ISC Konstanz*

A-07 Mapping the Transport Paths in Silicon Passivating Contacts with Conductive AFM Tomography

Matej Hyvl[1], Gizem Nogay[2], Philipp Loper[3], Franz-Josef Haug[3], Quentin Jeangros[3], Antonin Fejfar[1], Christophe Ballif[3]

[1] *Institute of Physics, AS CR;* [2] *PV-Center, Centre Suisse d' Électronique et de Microtechnique (CSEM);* [3] *Photovoltaics and Thin-Film Electronics Laboratory (PV-Lab), EPFL*

Presented by Antonín Fejfar

A-08 The Role of Masking Layers During Metallization of Poly-Si/SiO_x Contacts

Jonathan Linke[1], Jan Hoß[1], Jan Lossen[1], Radovan Kopecek[1], Florian Buchholz[1]

[1] *ISC Konstanz*

A-09 Suppressed Degradation of Passivation Performance in Titanium Oxide/Crystalline Silicon Heterostructure by Metallization Using Titanium Nitride Interlayer

Tetsuya Inoue[1], Kazuhiro Gotoh[1], Yasuyoshi Kurokawa[1], Noritaka Usami[1]

[1] *Nagoya University*

A-11 AlO_x and SiN_x Nanolayers for Hole-Selective Passivating Contacts

Shona McNab[1], Ailish Wratten[2], Edris Khorani[2], Matthew Wright[1], Nicholas Grant[2], John Murphy[2], Peter Wilshaw[1], Ruy Sebastian Bonilla[1]

[1] *University of Oxford;* [2] *University of Warwick*

A-12 Laser Melting of Aluminium Kitchen Foil for Solar Cell Metallisation

Mong Hin Reggie Leung[1], Ruy Sebastian Bonilla[1], Matthew Wright[1], Mingzhe Yu[1], Yifu Shi[1]

[1] *University of Oxford*

A-14 Interactions between Aluminium and Poly-Si based Contact Stacks during Fire-through Metallization

Sofia Libraro[1], Mario Lehmann[1], Juan J. Diaz Leon[2], Christophe Allebé[2], Antoine Descoeudres[2], Andrea Ingenito[2], Aïcha Hessler-Wyser[1], Franz-Josef Haug[1], Christophe Ballif[1]

[1] *École Polytechnique Fédérale de Lausanne (EPFL);*
[2] *Swiss Center for Electronics and Microtechnology (CSEM)*

A-15 Faster Firing Processes up to 20 m/min Belt Velocity

Daniel Ourinson[1], Gernot Emanuel[1], Mohammad Abazid[1], Florian Clement[1]

[1] *Fraunhofer ISE*

A-16 Dopant-Free Silicon Solar Cells on n-Type Cz Wafers with Wet-Chemically Grown SiO_x Passivation Layer

Hisham Nasser[1], Basil Eldeeb[1], Emine Hande Çiftpınar[1], Ergi Dönerçark[1], Mona Zolfaghari Borra[1], Rasit Turan[1]

[1] *The Center for Solar Energy Research and Applications (ODTÜ-GÜNAM)*

A-18 Self-Assembled Organic Molecule Modified Electron Selective Contacts for Heterojunction Solar Cells

Elif Sarıgül Duman[1], Markus Kohlstädt[1], Christian Reichel[1], Leonard Tutsch[1], Martin Bivour[1], Martin Hermle[1]

[1] *Fraunhofer ISE*

A-19 Effect of TCO Deposition Pressure on TCO/a-Si:H Interfaces and Final Silicon Heterojunction Solar Cell Performance

Yury Smirnov[1], Pierre-Alexis Repecaud[1], Leonard Tutsch[2], Ileana Florea[3], Pere Roca i Cabarrocas[3], Martin Bivour[2], Monica Morales-Masis[1]

[1] *University of Twente;* [2] *Fraunhofer ISE;* [3] *Ecole Polytechnique*

A-21 Controlled Dielectric Breakdown to Form Pin-Hole Passivated Contacts

David Young[1], William Nemeth[1], Pauls Stradins[1]

[1] *NREL*

B-01 Optimization of Front and Rear Surface Dielectric Passivation Layers for Ion-Implanted PERC Solar Cells

Gence Bektas[1], Hasan Hüseyin Canar[1], Ahmet Emin Keçeci[1], Hasan Asav[1], Sümeyye Koçak Bütüner[1], Selin Seyrek1[1], Rasit Turan[1]

[1] *ODTÜ-GÜNAM*

B-07 Fill Factor Loss Analysis of Industrial Silicon Solar Cells for the Elevated Temperature Condition

Sang Hee Lee[1], Cheolwook Kwon[1], Kyuhyeon Im[1]

[1] *Korea Institute of Energy Research*

B-08 Generalizing Axis Choice for Fitting J_os in Light of Band Gap Narrowing

Karoline Dapprich[1], Ronald Sinton[1], Cassidy Sainsbury[1], Harrison Wilterdink[1], Wes Dobson[1], Nicholas Degenhart[1]

[1] *Sinton Instruments*

B-10 Large Area Contact Free Photoluminescence Setup for On-site PV Module Characterization

Bernd Doll[1], Ian Marius Peters[2]

[1] *Friedrich Alexander Universität, i-MEET, WW6;*
[2] *Helmholtz Institute Erlangen-Nürnberg*

B-11 Silicon Heterojunction Solar Cell Efficiency Improvement with Wide Optical Band Gap Amorphous Silicon Carbide Emitter

Arghavan Salimi[1], Ergi Dönerçark[2], Mehmet Koç[2], Rasit Turan[1]

[1] *METU/GUNAM;* [2] *GUNAM*

B-12 Understanding the Impact of Local Shunts in Crystalline Silicon Solar Cells by Electroluminescence Measurements

Aloña Otaegi Aizpeolea[1], Eneko Cereceda[1], Vanesa Fano[1], Nekane Azkona[1], Federico Recart[1], José Rubén Gutiérrez[1], Juan Carlos Jimeno[1]

[1] *Institute of Microelectronic Technology*

B-13 Evaluating Spectral Mismatch Correction for Multi-Coloured Photovoltaic Modules with Spot-Area Spectral Responsivity Measurements

Min Hsian Saw[1], Mauro Pravettoni[1]

[1] *National University of Singapore*

B-16 Towards the General Injection Dependence of the Distributed Series Resistance: The Influence of the Base Resistivity

Jan-Martin Wagner[1], Jürgen Carstensen[1], Rainer Adelung[1]

[1] *University of Kiel*

D-01 The Effect of SiN_x:H Stoichiometry on Electrical and Chemical Passivation of Al_2O_3/SiNx:H Stack Layer on p-Type Silicon Wafers

Hasan Hüseyin Canar[1], Gence Bektas[1], Ahmet Emin Keçeci[1], Hasan Asav[1], Sümeyye Koçak Bütüner[1], Rasit Turan[1]

[1] *ODTÜ GÜNAM*

D-02 Role of Saw Damage Removal on Silicon Pyramid Vertex Angle Formation During Texturization

Shrestha Bhattacharya[1], Ashutosh Pandey[1], Sourav Mandal[1]

[1] *Indian Institute of Technology, Delhi*

D-03 A Study of SiO_2/SiN_x Passivation Layer with Plasma Charging Technology for the p-Type Silicon Surface

Tae Kyung Lee[1], Kwan Hong Min[1], Hee-eun Song[1], Kyung Taek Jung[1], Sang Hee Lee[1], Sungeun Park[1]

[1] *Korea Institute of Energy Research*

D-04 Investigation of the Microstructure Factor R* of Hydrogenated Amorphous Silicon Layers in Silicon Heterojunction Solar Cells

Benedikt Fischer[1], Andreas Lambertz[1], Weiyuan Duan[1], Wolfhard Beyer[1], Karsten Bittkau[1], Kaining Ding[1], Uwe Rau[1]

[1] *IEK-5 Forschungszentrum Juelich GmbH*

D-06 On the Fixed Charges in Multifunctional Doped APCVD Layers for Well Passivated Solar Cells

Fabian Geml[1], Sarah Sanz[1], Daniel Wurmbrand[1], Gabriel Micard[1], Heiko Plagwitz[1], Giso Hahn[1], Barbara Terheiden[1]

[1] *University of Konstanz*

D-07 Atmospheric Pressure Gaseous-Phase Fabrication of Black Silicon for Photovoltaic Applications

Eleanor Shaw[1], Mohsen Goodarzi[1], Sebastian Bonilla[1], John Murphy[2], Nicholas Grant[2], Peter Wilshaw[1]

[1] *University of Oxford; 2 The University of Warwick*

D-09 Understanding Hafnium Oxide Passivation for Silicon Solar Cells

Ailish Wratten[1], Sophie Pain[1], Nicholas Grant[1], David Walker[1], John Murphy[1]

[1] *University of Warwick*

F-02 Detection of Disconnected Strings in PV Power Plants Using Deep Learning Segmentation Algorithm in Aerial Infrared Thermography Images

Aline Kirsten Vidal de Oliveira[1], Mohammedreza Aghai[2], Ricardo Rüther[3]

[1] *Matheus Korbes Bracht;* [2] *Norwegian University of Science and Technology;* [3] *Universidade Federal de Santa Catarina*

F-03 State-of-the-art Deep Learning Anomaly Detection Method for Analyzing Electroluminescence Images of Solar Cells

Roya Rahimzadeh

PSE Instruments GmbH

G-01 Surface Passivation in Metallisation Gaps of Interdigitated Back-Contact Silicon Heterojunction (IBC SHJ) Solar Cells

Philipp Wagner[1], Alexandros Cruz1, Lars Korte[1]

[1] *Helmholtz-Zentrum Berlin*

J-04 Industrial EVA Encapsulated n-Type Crystalline Silicon Tunnel Oxide Passivating Contact Photovoltaic Modules with the Property of Light Induced Recovery of Potential-Induced-Degradation

Jun Chen[1], Bing Gao[1], Hehui Chen[1], Hua Li[1]

Presented by Bing Gao[1]

[1] *LONGi Solar Technology (Taizhou) Co., Ltd*

M-01 Design and Application of a Linear Acceleration Test Setup for Defect Diagnostics in High-Throughput Transportation Systems

Stephan Großer[1], Matthias Schak[1], Christian Hagendorf[1]

[1] *Fraunhofer CSP*

M-03 Upscaling of Perovskite/c-Si Tandem Solar Cells Using Industrial Adaptable Processing Tools

Zih-Wei Peng[1], Ke Xu[1], Alexandros Cruz Bournazou[1], Steve Albrecht[1], Bernd Stannowski[1]

[1] *Helmholtz-Zentrum Berlin*

M-04 Screen Printed Copper Paste for Metallization of IBC Solar Cells

Ning Chen[1], Dominik Rudolph[1], Haifeng Chu[1], Thomas Buck[1], Christoph Peter[1], Valentin D. Mihailetchi[1]

[1] *ISC Konstanz*

N-02 Optical Enhancement of Four Terminal Perovskite/Si Tandem Solar Cell using Anti Reflection Nanostructures and Coatings

Ali Hajjiah[1], Dalal Al Ibrahim[1] , Aliaa Hajiah[1]

[1] *Kuwait University*

N-04 Screen-Printing SiGe Layer on Si Substrate for III-V Solar Cell Application

Shota Suzuki[1], Moeko Matsubara[1], Takashi Kuroki[1], Hideaki Minamiyama[1], Marwan Dhamrin[1]

[1] *Toyo Aluminium K.K.*

N-05 Silicon Bottom Cell for 3-Terminal Perovskite/Silicon Tandem Solar Cells

Seyma Topcu[1], Matteo Schilirò[1], Pasky Wete[1], Kathrin Ohmer[1], Birgitt Winter[1], Renate Zapf-Gottwick[1], Stephanie Essig[1], Michael Saliba[1]

[1] *Institute for Photovoltaics, University of Stuttgart*

O-02 The Effects of Nano-boron Dopant with 3N Purity on Performance of Industrial Cz Grown p-Type Ingots, Wafers, Cells, and Modules

Fatma Çambay Kuban[1], Emre Uçar[1], Firat Es[1]

[1] *Kalyon Solar Technologies (KalyonPV)*

O-09 Electrical Properties and Microstructure of Crystalline Silicon Ingots Grown from Quartz Crucibles with and without Diffusion Barriers

Rune Søndenå[1], Gaute Stokkan[2], Rania Hendawi[3], Jochen Busam[3], Per-Anders Hansen[1], Benny Hallam[4], Marisa Di Sabatino Lundberg[3]

[1] *IFE;* [2] *SINTEF;* [3] *NTNU;* [4] *The Quartz Corporation*

10:00 - 10:30 Coffee Break

10:30 - 11:00 Invited Talk

Chair: Stephanie Essig (University of Stuttgart)

Monolithic Perovskite/Silicon Tandem Solar Cells: Towards High Outdoor Performance and Reliability

Stefaan De Wolf, KAUST

Prof. Stefaan de Wolf

Stefaan De Wolf received his Ph.D. degree in 2005 from the Katholieke Universiteit Leuven in Belgium, during which time he was also affiliated with IMEC. From 2005 to 2008, he was a researcher at the National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. In 2008, he joined Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland, as a team leader working on high-efficiency solar cells. Since September 2016 he has been an associate professor at KAUST in Saudi Arabia, focusing on high-efficiency silicon and perovskite solar cells and their combinations in perovskite/silicon tandem solar cells.

11:00 - 12:00 Si-Based Tandem Solar Cells

Chairs: Stephanie Essig (University of Stuttgart) & Stefaan de Wolf (KAUST)

11:00 Plated Copper Electrodes for Two-Terminal Perovskite Silicon Tandem Solar Cells

Thibaud Hatt[1], Özde Kabakli[1], Patricia Schulze[1], Armin Richter[1], Markus Glatthaar[1], Jonas Bartsch[1], Stefan Glunz[1]

[1] *Fraunhofer ISE*

11:15 Industrial Type Hydrogenated Indium Oxide TCOs as front Electrodes for Perovskite-Silicon Tandem Solar Cells

Alexandros Cruz[1], Zih-Wei Peng[1], Ke Xu[1], Florian Ruske[1], Alexander Steigert[1], Steve Albrecht[1], Bernd Stannowski[1]

[1] *Helmholtz-Zentrum Berlin*

11:30 Spectrometric Determination of Current Matching in Perovskite/Silicon Tandem Solar Cells

Alexander J. Bett[1], David Chojniak[1], Michael Schachtner[1], S. Kasimir Reichmuth[1], Patricia S. C. Schulze[1], Özde S. Kabakli[1], Patricia Schulze[1], Hunter King[2], Volker Sittinger[2], Florian Schindler[1], Jan Christoph Goldschmidt[1], Jochen Hohl-Ebinger[1], Gerald Siefer[1], Andreas W. Bett[1], Martin C. Schubert[1]

[1] *Fraunhofer ISE;* [2] *Fraunhofer Institute for Surface Engineering and Thin Films IST*

11:45 Introducing a Comprehensive Physical Modelling Framework for Tandem and Other PV Systems, Which Do Not Exist Yet

Malte R. Vogt[1], Carlos Ruiz Tobon[1], Alba Alcañiz[1], Paul Procel[1], Abdallah Nour El Din[1], Tim Stark[1], Zidan Wang[1], Elias Garcia Goma[1], Julen Garro Etxebarria[1], Hesan Ziar[1], Miro Zeman[1], Rudi Santbergen[1], Olindo Isabella[1]

[1] *TU Delft - PVMD*

12:00 - 13:00 Lunch Break

13:00 - 14:30 On-site Poster Session II

The poster numbers are based on topics:

A Carrier selective contacts, metallization and contact formation
B Cell and module characterization
C Cell and module simulation
D Cleaning, etching, layer deposition technologies, surface morphology and surface passivation
E Customized modules for buildings, vehicles and other special applications
F Digitalization, data processing and machine learning in PV
G High and record efficiency devices
H Junction formation
I Module processing and materials
J Module reliability and energy yield
K New manufacturing tools
L nPV on Wednesday
M Process integration and low-cost manufacturing
N Si-based tandem cells in combination with perovskites, III-V and alternative materials
O Silicon material and defect engineering
P Wafering technologies and direct-wafer production

A-02 Deposition and Properties of Sputtered Phosphorous Doped Amorphous Silicon Films for Passivating Contacts

Jens Baumann[1], Eric Schneiderlöchner[1], Jana-Isabelle Polzin[2]

[1] *VON ARDENNE GmbH;* [2] *Fraunhofer ISE*

A-04 Quantitative Evaluation of Passivation Performance after Electrode Deposition on TiO_x/Si Heterostructures by Photoluminescence Imaging

Shohei Fukaya[1], Kazuhiro Gotoh[1], Takuya Matsui[2], Hitoshi Sai[2], Yasuyoshi Kurokawa[1], Noritaka Usami[1]

[1] *Nagoya University; 2 National Institute of Advanced Industrial Science and Technology*

A-06 Optical Characterization of Carrier Density and Mobility in Laser-Doped p-Type Poly-Si Passivating Contacts

Franz-Josef Haug[1], Florian Buchholz[2], Jonathan Linke[2], Christophe Ballif[1]

[1] *EPFL - PVLAB;* [2] *ISC Konstanz*

A-08 The Role of Masking Layers During Metallization of Poly-Si/SiO_x Contacts

Jonathan Linke[1], Jan Hoß[1], Jan Lossen[1], Radovan Kopecek[1], Florian Buchholz[1]

[1] *ISC Konstanz*

A-11 AlO_x and SiN_x Nanolayers for Hole-Selective Passivating Contacts

Shona McNab[1], Ailish Wratten[2], Edris Khorani[2], Matthew Wright[1], Nicholas Grant[2], John Murphy[2], Peter Wilshaw[1], Ruy Sebastian Bonilla[1]

[1] *University of Oxford;* [2] *University of Warwick*

A-13 Influence of Firing Temperature on APCVD Poly-Si Properties for Fired Passivating Contacts

Tobias Okker[1], Raphael Glatthaar[1], Giso Hahn[1], Sven Seren[2], Barbara Terheiden[1]

[1] *University of Konstanz;* [2] *Schmid Group*

A-15 Faster Firing Processes up to 20 m/min Belt Velocity

Daniel Ourinson[1], Gernot Emanuel[1], Mohammad Abazid[1], Florian Clement[1]

[1] *Fraunhofer ISE*

A-17 Annealing and Firing Stability of in situ Boron-doped poly-Si Passivating Contacts

Jana-Isabelle Polzin[1], Frank Feldmann[2], Bernd Steinhauser[1], Martin Bivour[1], Martin Hermle[1]

[1] *Fraunhofer ISE;* [2] *Fraunhofer ISE (now with Solarlab Aiko Europe GmbH)*

A-19 Effect of TCO Deposition Pressure on TCO/a-Si:H Interfaces and Final Silicon Heterojunction Solar Cell Performance

Yury Smirnov[1], Pierre-Alexis Repecaud[1], Leonard Tutsch[2], Ileana Florea[3], Pere Roca i Cabarrocas[3], Martin Bivour[2], Monica Morales-Masis[1]

[1] *University of Twente;* [2] *Fraunhofer ISE;* [3] *Ecole Polytechnique*

B-02 HJT Shingle Modules Reliability and Temperature Coefficients

Carolyn Carriere[1], Romain Couderc[1], Samuel Harrison[1], Armand Bettinelli[1], Eszter Voroshazi[1]

[1] *CEA INES*

B-04 Designing the SERIS Testing Dome for Accurate Electrical Characterization of Photovoltaic Modules

Wei Jie Chew[1], Min Hsian Saw[1], Stephen Tay[1], Mauro Pravettoni[1]

[1] *National University of Singapore*

B-06 LED Solar Simulators – Spectral Adjustment Procedures for Tandem Solar Cells

David Chojniak[1], Alexander Bett[1], Jochen Hohl-Ebinger[1], Kasimir Reichmuth[1], Michael Schachtner[1], Gerald Siefer[1]

[1] *Fraunhofer ISE*

B-08 Generalizing Axis Choice for Fitting J_os in Light of Band Gap Narrowing

Karoline Dapprich[1], Ronald Sinton[1], Cassidy Sainsbury[1], Harrison Wilterdink[1], Wes Dobson[1], Nicholas Degenhart[1]

[1] *Sinton Instruments*

B-10 Large Area Contact Free Photoluminescence Setup for On-site PV Module Characterization

Bernd Doll[1], Ian Marius Peters[2]

[1] *Friedrich Alexander Universität, i-MEET, WW6;*
[2] *Helmholtz Institute Erlangen-Nürnberg*

B-12 Understanding the Impact of Local Shunts in Crystalline Silicon Solar Cells by Electroluminescence Measurements

Aloña Otaegi Aizpeolea[1], Eneko Cereceda[1], Vanesa Fano[1], Nekane Azkona[1], Federico Recart[1], José Rubén Gutiérrez[1], Juan Carlos Jimeno[1]

[1] *Institute of Microelectronic Technology*

B-14 Impedance Spectroscopy Characterization of Silicon Heterojunction Solar Cells: Observation of Trap States Distribution

Jagannath Panigrahi[1], Ashutosh Pandey[1], Shrestha Bhattacharya[1], Sourav Mandal[1], Vamsi K. Komarala[1]

[1] *Indian Institute of Technology Delhi*

B-15 An Elemental Study on Wide Band Gap a-SiC_x:H Thin Films for Silicon-Based Photovoltaics

Salar H. Sedani[1], Ergi Dönerçark[1], Rasit Turan[1]

[1] *ODTÜ-GÜNAM*

B-17 Improved Lab-to-Fab Solar Cell Performance Assessment by Statistical Data Analysis in an Automated, High-Throughput Metrology Line

Marko Turek[1], Stephan Hensel[1], David Hevisov[1], Ch. Hagendorf[1]

[1] *Fraunhofer CSP*

C-01 Mechanical Strength Analysis of Framed Glass-Transparent Backsheet PV Modules

Meriç Çalıskan[1], Murat Batuhan Günaydın[1], Fırat Es[1]

[1] *Kalyon Solar Technologies (KalyonPV)*

D-02 Role of Saw Damage Removal on Silicon Pyramid Vertex Angle Formation During Texturization

Shrestha Bhattacharya[1], Ashutosh Pandey[1], Sourav Mandal[1]

[1] *Indian Institute of Technology, Delhi*

D-04 Investigation of the Microstructure Factor R* of Hydrogenated Amorphous Silicon Layers in Silicon Heterojunction Solar Cells

Benedikt Fischer[1], Andreas Lambertz[1], Weiyuan Duan[1], Wolfhard Beyer[1], Karsten Bittkau[1], Kaining Ding[1], Uwe Rau[1]

[1] *IEK-5 Forschungszentrum Juelich GmbH*

D-06 On the Fixed Charges in Multifunctional Doped APCVD Layers for Well Passivated Solar Cells

Fabian Geml[1], Sarah Sanz1, Daniel Wurmbrand[1], Gabriel Micard[1], Heiko Plagwitz[1], Giso Hahn[1], Barbara Terheiden[1]

[1] *University of Konstanz*

D-08 Understanding of Silicon Surface Passivation with Intrinsic Amorphous Silicon by Ambient and Vacuum Annealing Condition

Ashutosh Pandey[1], Shrestha Bhattacharya[1], Sourav Mandal[1], Jagannath Panigrahi[1]

[1] *Indian Institute of Technology, Delhi*

D-09 Understanding Hafnium Oxide Passivation for Silicon Solar Cells

Ailish Wratten[1], *Sophie Pain*[1], *Nicholas Grant*[1], *David Walker*[1], *John Murphy*[1]

[1] *University of Warwick*

E-02 Sol-gel Coated 1D Photonic Crystal Structures for Colored PV

Matas Rudzikas[1], Jolanta Doneliene[2], Juras Ulbikas[3], Arunas Setkus[1]

[1] *Center for Physical Sciences and Technology;*
[2] *The Applied Institute for Prospective Technologies;*
[3] *The Applied Research Institute for Prospective Technologies*

F-01 Further Development of a Laser-Tool Towards a Self-Regulating Manufacturing Plant

Kathrin Ohmer[1], Sofya Svetlosanova[1], Fabian Böttinger[2], Matteo Schilirò[1], Renate Zapf-Gottwick[1]

[1] *Institute for Photovoltaics, University of Stuttgart;*
[2] *Fraunhofer Institute for Manufacturing Engineering and Automation (IPA)*

F-03 State-of-the-art Deep Learning Anomaly Detection Method for Analyzing Electroluminescence Images of Solar Cells

Roya Rahimzadeh

PSE Instruments GmbH

I-01 Damp Heat Ageing Behavior of Glass/Encapsulant Laminates – Systematic Comparison of EVA and POE Encapsulants

Martin Tiefenthaler[1], Robert Pugstaller[1], Gernot Wallner[1]

[1] *Johannes Kepler University Linz*

J-02 Light-weight, Flexible SHJ Modules and Reliability Performance

Lukas Braun

Forschungszentrum Jülich GmbH

J-04 Industrial EVA Encapsulated n Type Crystalline Silicon Tunnel Oxide Passivating Contact Photovoltaic Modules with the Property of Light Induced Recovery of Potential-Induced-Degradation

Jun Chen[1], Bing Gao[1], Hehui Chen[1], Hua Li[1]

Presented by Bing Gao[1]

[1] *LONGi Solar Technology (Taizhou) Co., Ltd*

K-01 Statistical Data Analysis Revealing the Improvement Potential of Laser-Enhanced Contact Optimization (LECO_finish) of Solar Cells

Eve Krassowski[1], Marko Turek[2], David Hevisov[2], Stephan Großer[2]

[1] *CE Cell Engineering GmbH;* [2] *Fraunhofer CSP*

L-01 The Research Progress and Industrial Status of n-Type Bifacial TOPCon Technology in Jolywood

Jia Chen

Jolywood (Taizhou) Solar Technology Co.,Ltd.

M-02 Lowering the Indium Consumption in Hetero-Junction Solar Cells with a Low-Frequency PECVD Capping Layer

Raphaël Cabal[1], Frédéric Jay[1], Karine Aumaille[1], Christine Denis[1]

[1] *CEA-INES*

M-04 Screen Printed Copper Paste for Metallization of IBC Solar Cells

Ning Chen[1], Dominik Rudolph[1], Haifeng Chu[1], Thomas Buck[1], Christoph Peter[1], Valentin D. Mihailetchi[1]

[1] *ISC Konstanz*

N-01 ALD-grown SnO_2 for Perovskite/Silicon Tandem Solar Cells

Félix Gayot[1], Elise Bruhat[2], Matthieu Manceau[1], Eric De Vito[3], Denis Mariolle[4], Stéphane Cros[1]

[1] *Univ. Grenoble Alpes, INES;* [2] *CEA INES;* [3] *Univ. Grenoble Alpes, CEA, LITEN;* [4] *Univ. Grenoble Alpes, CEA, LETI*

N-02 Optical Enhancement of Four Terminal Perovskite/Si Tandem Solar Cell using Anti Reflection Nanostructures and Coatings

Ali Hajjiah[1], Dalal Al Ibrahim[1], Aliaa Hajiah[1]

[1] *Kuwait University*

N-04 Screen-Printing SiGe Layer on Si Substrate for III-V Solar Cell Application

Shota Suzuki[1], Moeko Matsubara[1], Takashi Kuroki[1], Hideaki Minamiyama[1], Marwan Dhamrin[1]

[1] *Toyo Aluminium K.K.*

N-05 Silicon Bottom Cell for 3-Terminal Perovskite/Silicon Tandem Solar Cells

Seyma Topcu[1], Matteo Schilirò[1], Pasky Wete[1], Kathrin Ohmer[1], Birgitt Winter[1], Renate Zapf-Gottwick[1], Stephanie Essig[1], Michael Saliba[1]

[1] *Institute for Photovoltaics, University of Stuttgart*

O-02 The Effects of Nano-boron Dopant with 3N Purity on Performance of Industrial Cz Grown p-Type Ingots, Wafers, Cells, and Modules

Fatma Çambay Kuban[1], Emre Uçar[1], Firat Es[1]

1 Kalyon Solar Technologies (KalyonPV)

Presented by Güven Korkmaz.

O-04 Various Impacts of Firing Temperature on Crystalline Silicon

Christian Fischer[1], Annika Zuschlag[1], Giso Hahn[1]

[1] *University of Konstanz*

O-06 Density Functional Theory to Calculate Accurate Defect Energy Levels in Silicon

Fiacre Rougieux[1], Md. Hanower Hossain[1], Bram Hoex[1]

[1] *The University of New South Wales*

P-01 Physical Device Simulation of Solar Cell based on Thin Si Wafer with an improved Light Absorption Scheme

Haris Mehmood

Information Technology University of the Punjab (ITU)

P-03 Monitoring of Porous Silicon Layers for Epitaxial Wafer Production Using Inline Reflectance Spectroscopy

Henri Vahlman[1], Saed Al-Hajjawi[1], Jonas Haunschild[1], Nico Wöhrle[1], Maxi Richter[2], Lukas Jablonka[2], Hans Schremmer[3], Stefan Rein[1]

[1] *Fraunhofer ISE;* [2] *Nexwafe GmbH;* [3] *Meyer Burger GmbH*

14:30 - 15:30 Modules and Systems

Chairs: Radovan Kopecek (ISC Konstanz) & Ralf Preu (Fraunhofer ISE)

14:30 Debonding of Encapsulant/Glass Laminates in Hot/Humid Environment - Evaluation of UV-Transparent EVA and POE

Gabriel Riedl[1], Robert Pugstaller[1], Gernot Wallner[1]

[1] *Johannes Kepler University Linz*

14:45 Analysis of Soiling of a 10-Year Installation in the Urban Environment and Tropical Climate

Li Wan[1], Amit Singh Rajput[2], Mauro Pravettoni[3]

Presented by Mauro Pravettoni[3]

[1] *Vidyasirimedhi Institute of Science and Technology;*
[2] *Solar Energy Research Institute of Singapore;*
[3] *National University of Singapore*

15:00 Toward a Virtual PV Plant

Ian Marius Peters[1], Lukas Bommes[1], Tobias Pickel[1], Claudia Buerhop[1], Jens Hauch[1], Christoph Brabec[1]

[1] *FZ Jülich HI ERN*

15:15 Prefab Approach to Mass Customization of Integrated PV

Victor Rosca[1], Nicolas Guillevin[1], Lars A.G. Okel[1], Bonna K. Newman[1]

[1] *TNO*

15:30 - 16:00 Coffee Break

16:00 - 16:45 Passivating Contacts I

Chairs: Stefan Glunz (Fraunhofer ISE) & Stefan Bonilla (University of Oxford)

16:00 Al-Doped Zinc Oxide as a Passivating Conductive Contact Layer for PERC, TOPCon and Perovskite Tandem Cells

Bart Macco[1], Bart van Pelt[1], Nga Phung[1], Erwin Kessels[1]

[1] *Eindhoven University of Technology*

16:15 SiC by PECVD for High-Temperature Passivating Contacts

Ezgi Genç[1], Sofia Libraro[1], Audrey Morisset[1], Mario Lehmann[1], Franz-Josef Haug[1], Christophe Ballif[1]

[1] *EPFL - PVLAB*

16:30 Insights into MoOx/i-aSi:H Interface for High Efficiency Solar Cells

Paul Procel[1], Alba Alcaniz Moya[1], Liqi Cao[1], Luana Mazzarella[1], Yifeng Zhao[1], Can Han1, Guangtao Yang[1], Rudi Santbergen[1], Miro Zeman[1], Olindo Isabella[1]

[1] *TU Delft*

16:45 - 17:00 Short Break

17:00 - 18:15 Characterization & Simulation

Chair: Axel Herguth (University of Konstanz) & Tim Niewelt (University of Warwick)

17:00 Non-destructive Spatially Resolved Characterization of Porous Silicon Layer Stacks

Gabriel Micard[1], Yves Patrick Botchak Mouafi[1], Barbara Terheiden[1]

[1] *University of Konstanz*

17:15 Probing the Interface State Densities Near Band Edges from Inductively Coupled Measurements of Sheet Resistance

Mingzhe Yu[1], Matthew Wright[1], Mohsen Goodarzi[1], Pietro Altermatt[2], Sebastian Bonilla[1]

[1] *University of Oxford; 2 Trina Solar*

17:30 Current Paths and Temperature Distributions during Laser Enhanced Contact Optimization (LECO)

Hannes Höffler[1], Felix Simon[1], Johannes Greulich[1], Eve Krassowski[2]

[1] *Fraunhofer ISE;* [2] *CE Cell Engineering GmbH*

17:45 Integrated Measurement of the Actual and Small Perturbation Lifetimes with Improved Accuracy

Dávid Krisztián[1], Ferenc Korsós[1], Péter Tütto[1], Eniko Kis[1], Gábor Paráda[1]

[1] *Semilab Co. Ltd.*

18:00 Improved Auger Recombination Models: Consequences for c-Si Solar Cells

Lachlan Black[1], Daniel Macdonald[1]

[1] *Australian National University*

19:00 - 21:00 Conference Dinner - refer to page 46 for more information

Wednesday, March 30, 2022

08:30 - 10:00 Online Poster Session II

A-01 Laser-Crystallization of Passivating Contacts for Silicon Wafer Solar Cells

Annett Gawlik[1], Raphael Glatthaar[2], Andrea Dellith[1], Guobin Jia[1], Jan Dellith[1], Barbara Terheiden[2], Jonathan Plentz[1]

[1] *Leibniz Institute of Photonic Technology IPHT;*
[2] *University of Konstanz*

A-03 Structure and Electronic Properties of Nanopores in Si PV Devices with PLEO Contacts

Harvey Guthrey[1], Caroline Lima Salles[1], William Nemeth[1], David Young[1], Sumit Agarwal[1], Pauls Stradins[1]

[1] *NREL*

A-10 Ultrathin Parasitic SiOz Layer Formation at Annealed Wet-Chemical NiO_x/Si Interfaces in Perovskite/Si Tandem Solar Cells

Stefan Lange[1], Bastian Fett[2], Angelika Hähnel[1], Volker Naumann[1], Bettina Herbig[2], Christian Hagendorf[1]

[1] *Fraunhofer CSP;* [2] *Fraunhofer Institute for Silicate Research ISC*

A-13 Influence of Firing Temperature on APCVD Poly-Si Properties for Fired Passivating Contacts

Tobias Okker[1], Raphael Glatthaar[1], Giso Hahn[1], Sven Seren[2], Barbara Terheiden[1]

[1] *University of Konstanz; 2 Schmid Group*

A-17 Annealing and Firing Stability of in situ Boron-doped poly-Si Passivating Contacts

Jana-Isabelle Polzin[1], Frank Feldmann[2], Bernd Steinhauser[1], Martin Bivour[1], Martin Hermle[1]

[1] *Fraunhofer ISE;* [2] *Fraunhofer ISE (now with Solarlab Aiko Europe GmbH)*

A-20 PECVD Plasma-SiO_x/poly-SiO_x Passivating Contacts

Zhirong Yao[1], Guangtao Yang[1], Can Han[1], Paul Procel[1], Yifeng Zhao[1], Liqi Cao[1], Roald Kolk[1], Luana Mazzarella[1], Miro Zeman[1], Olindo Isabella[1]

[1] *TU Delft*

A-22 Optimising Metallisation Designs to Improve Silver Utilisation

Yuchao Zhang[1], Moonyong Kim[1], Li Wang[1], Brendan Wright[1], Catherine Chan[1], Brett Hallam[1]

[1] *The University of New South Wales*

B-02 HJT Shingle Modules Reliability and Temperature Coefficients

Carolyn Carriere[1], Romain Couderc[1], Samuel Harrison[1], Armand Bettinelli[1], Eszter Voroshazi[1]

1 CEA INES

B-03 Temperature and Irradiance Dependency of Capacitance Effects in New Generation High Efficiency PV Modules

Gabi Friesen[1], Ebrar Ozkalay[1], Flavio Valoti[1], Giovanni Bellenda[1], Mauro Caccivio[1]

[1] *University of Applied Sciences and Arts of Southern Switzerland, SUPSI-PVLab*

B-04 Designing the SERIS Testing Dome for Accurate Electrical Characterization of Photovoltaic Modules

Wei Jie Chew[1], Min Hsian Saw[1], Stephen Tay[1], Mauro Pravettoni[1]

Presented by Mauro Pravettoni[1]

[1] *National University of Singapore*

B-05 Characterization of Thin-Film Structures of Silicon Heterojunction Solar Cells with Inline Reflectance Spectroscopy

Saravana Kumar[1], Henri Vahlman[1], Sebastian Pingel[1], Ioan Voicu[1], Andreas Fischer[1], Anamaria Steinmetz[1], Jonas Haunschild[1], Stefan Reinv

[1] *Fraunhofer ISE*

B-06 LED Solar Simulators – Spectral Adjustment Procedures for Tandem Solar Cells

David Chojniak[1], Alexander Bett[1], Jochen Hohl-Ebinger[1], Kasimir Reichmuth[1], Michael Schachtner[1], Gerald Siefer[1]

[1] *Fraunhofer ISE*

B-09 Light and Elevated Temperature Induced Degradation in Gallium- and Boron-doped hpmc-Si Wafers Studied by Hyperspectral Photoluminescence Imaging

Torbjørn Mehl[1], Oda Goa Berge[1], Ingunn Burud[1], Rune Søndenå[2], Espen Olsen[1]

[1] *Norwegian University of Life Sciences (NMBU);*
[2] *Institute for Energy Technology (IFE)*

B-14 Impedance Spectroscopy Characterization of Silicon Heterojunction Solar Cells: Observation of Trap States Distribution

Jagannath Panigrahi[1], Ashutosh Pandey[1], Shrestha Bhattacharya[1], Sourav Mandal[1], Vamsi K. Komarala[1]

[1] *Indian Institute of Technology Delhi*

B-15 An Elemental Study on Wide Band Gap a-SiC_x:H Thin Films for Silicon-Based Photovoltaics

Salar H. Sedani[1], Ergi Dönerçark[1], Rasit Turan[1]

[1] *ODTÜ-GÜNAM*

B-17 Improved Lab-to-Fab Solar Cell Performance Assessment by Statistical Data Analysis in an Automated, High-Throughput Metrology Line

Marko Turek[1], Stephan Hensel[1], David Hevisov[1], Ch. Hagendorf[1]

[1] *Fraunhofer CSP*

C-01 Mechanical Strength Analysis of Framed Glass-Transparent Backsheet PV Modules

Meriç Çalıskan[1], Murat Batuhan Günaydın[1], Fırat Es[1]

[1] *Kalyon Solar Technologies (KalyonPV)*

D-05 Impact of Al_2O_3 ALD Growth and Properties on Passivation Quality of p-polySi/Al_2O_3 Stacks

Jimmy Melskens[1], Roel Theeuwes[2], Wolfhard Beyer[3], Mark Steltenpool[4], Erwin Kessels[2], Arthur Weeber[1], Agnes Mewe[1]

[1] *TNO;* [2] *Eindhoven University of Technology;*
[3] *Forschungszentrum Jülich GmbH;* [4] *Levitech B.V.*

D-08 Understanding of Silicon Surface Passivation with Intrinsic Amorphous Silicon by Ambient and Vacuum Annealing Condition

Ashutosh Pandey[1], Shrestha Bhattacharya[1], Sourav Mandal[1], Jagannath Panigrahi[1]

[1] *Indian Institute of Technology, Delhi*

E-01 Miniature Passivated Contact Silicon Solar Cells: From Electrically Detected Magnetic Resonance to Space

Abigail R. Meyer[1], San Theingi[2], Megan E. Phelan[3], David Needell[3], Kevin Hinkle[1], Kejun Chen[1], Matthew Hartenstein[1], Caroline Lima Salles de Souza[1], William Nemeth[2], Patrick Lenahan[4], Sumit Agarwal[5], Harry Atwater[3], Paul Stradins[2]

[1] *Colorado School of Mines / NREL;* [2] *NREL;* [3] *California Institute of Technology;* [4] *Penn State;* [5] *Colorado School of Mines*

E-02 Sol-gel Coated 1D Photonic Crystal Structures for Colored PV

Matas Rudzikas[1], Jolanta Doneliene[2], Juras Ulbikas[3], Arunas Setkus[1]

[1] *Center for Physical Sciences and Technology;*
[2] *The Applied Institute for Prospective Technologies*

F-01 Further Development of a Laser-Tool Towards a Self-Regulating Manufacturing Plant

Kathrin Ohmer[1], Sofya Svetlosanova[1], Fabian Böttinger[2], Matteo Schilirò[1], Renate Zapf-Gottwick[1]

[1] *Institute for Photovoltaics, University of Stuttgart;* [2] *Fraunhofer Institute for Manufacturing Engineering and Automation (IPA)*

H-01 TCAD Simulation of Electrical Characteristics of Silicon Tunnel Junctions for Monolithically Integrated Silicon/ Perovskite Tandem Solar Cells

Guilherme Gaspar[1], João Serra[2], Jonas Kern[3], Matthias Müller[3]

[1] *FCiências.ID – Associação para a Investigação e Desenvolvimento de Ciências;* [2] *Universidade de Lisboa;*
[3] *TU Bergakademie Freiberg, Institute of Applied Physics*

I-01 Damp Heat Ageing Behavior of Glass/Encapsulant Laminates – Systematic Comparison of EVA and POE Encapsulants

Martin Tiefenthaler[1], Robert Pugstaller[1], Gernot Wallner[1]

[1] *Johannes Kepler University Linz*

J-01 Solar Photovoltaic Tracking Systems for Electricity Generation

Mamadsho Ilolov[1], Khasan Karimov[1], Jamshed Rahmatov[1]

[1] *Center of Innovative Development of Sciences and New Technologies of NAS of Tajikistan*

J-02 Light-weight, Flexible SHJ Modules and Reliability Performance

Lukas Braun

Forschungszentrum Jülich GmbH

J-03 Qualitative and Semi-Quantitative Analysis of Additives in Encapsulation Materials of PV Modules

Anton Mordvinkin[1], Susanne Neubauer[1], Robert Heidrich[1], Sylke Meyer[1], Ralph Gottschalg[1]

[1] *Fraunhofer CSP*

K-01 Statistical Data Analysis Revealing the Improvement Potential of Laser-Enhanced Contact Optimization (LECO_ finish) of Solar Cells

Eve Krassowski[1], Marko Turek[2], David Hevisov[2], Stephan Großer[2]

[1] *CE Cell Engineering GmbH;* [2] *Fraunhofer CSP*

L-01 The Research Progress and Industrial Status of n-Type Bifacial TOPCon Technology in Jolywood

Jia Chen

Jolywood (Taizhou) Solar Technology Co.,Ltd.

M-02 Lowering the Indium Consumption in Hetero-Junction Solar Cells with a Low-Frequency PECVD Capping Layer

Raphaël Cabal[1], Frédéric Jay[1], Karine Aumaille[1], Christine Denis[1]

[1] *CEA-INES*

N-01 ALD-grown SnO_2 for Perovskite/Silicon Tandem Solar Cells

Félix Gayot[1], Elise Bruhat[2], Matthieu Manceau[1], Eric De Vito[3], Denis Mariolle[4], Stéphane Cros[1]

[1] *Univ. Grenoble Alpes, INES;* [2] *CEA INES;* [3] *Univ. Grenoble Alpes, CEA, LITEN;* [4] *Univ. Grenoble Alpes, CEA, LETI*

N-03 Gas Immersion Laser Doping: n++ Phosphorus Doping on p+ Cz-Si Wafers with a Highly Doped p++ Emitter

Filipe Serra[1], Guilherme Gaspar[1], Ana Viana[1], Jayaprasad Arumughan[2], Ivo Costa[1], David Pêra[1], José Silva[1], Lasse Vines[3], João Serra[1], Killian Lobato[1]

[1] *Universidade de Lisboa;* [2] *ISC Konstanz;* [3] *University of Oslo*

O-01 A Fabrication Route for mc-UMG-Silicon-based Bifacial Solar Cells

Nerea Dasilva-Villanueva[1], Bo-Kyung Hong[1], Manuel Funes[1], David Fuertes Marrón[1], Carlos del Cañizo[1]

[1] *Instituto de Energía Solar (Universidad Politécnica de Madrid)*

O-03 PS-TDLS: Temperature-Dependent Lifetime Spectroscopy for Defect Characterization in Silicon

Sarra Dehili[1], Cyril Leon[1], Damien Barakel[1], Olivier Palais[1]

[1] *IM2NP*

O-04 Various Impacts of Firing Temperature on Crystalline Silicon

Christian Fischer[1], Annika Zuschlag[1], Giso Hahn[1]

[1] *University of Konstanz*

O-05 Double-Side Poly-Si/SiO_x Passivating Contacts Solar Cells: Insights Into the Influence of Crystalline Silicon Wafers Properties

Thibaut Desrues[1], Adrien Danel[1], Adeline Lanterne[1], Sébastien Dubois[1]

[1] *Univ. Grenoble Alpes,CEA, LITEN, DTS, INES*

O-06 Density Functional Theory to Calculate Accurate Defect Energy Levels in Silicon

Fiacre Rougieux[1], Md. Hanower Hossain[1], Bram Hoex[1]

[1] *The University of New South Wales*

O-07 Roadmap Towards Sustainable SHJ Solar Cell Design

Moonyong Kim[1], Li Wang[1], Yuchao Zhang[1], Storm Drury[1], Robert Underwood[1], Brett Hallam[1]

[1] *The University of New South Wales*

P-01 Physical Device Simulation of Solar Cell based on Thin Si Wafer with an Improved Light Absorption Scheme

Haris Mehmood

Information Technology University of the Punjab (ITU)

P-02 n-Type Czochralski Ingot Growth Process and Investigation of Wafer Quality on IBC Cell Fabrication

Melis Özgüven[1], Nurhayat Yıldırım[1], Mehmet Konyar[1], Emre Uçar[1], Fırat Es[1]

[1] *Kalyon Solar Technologies (KalyonPV)*

Presented by Mete Günöve

P-03 Monitoring of Porous Silicon Layers for Epitaxial Wafer Production Using Inline Reflectance Spectroscopy

Henri Vahlman[1], Saed Al-Hajjawi[1], Jonas Haunschild[1], Nico Wöhrle[1], Maxi Richter[2], Lukas Jablonka[2], Hans Schremmer[3], Stefan Rein[1]

[1] *Fraunhofer ISE;* [2] *Nexwafe GmbH;* [3] *Meyer Burger GmbH*

P-04 Rear-Junction n-Type Cell Concept Utilizing PERC Process Sequence on Epitaxially-grown Base and Emitter

Clara Rittmann[1], Bernd Steinhauser[1], Marion Drießen[1], Armin Richter[1], Charlotte Weiss[1], Stefan Janz[1]

[1] *Fraunhofer ISE*

10:00 - 10:30 Coffee Break

10:30 - 10:45 Opening Session nPV Workshop

10:30 Welcome to the nPV Workshop 2022

Barbara Terheiden, University of Konstanz &
Deren Yang (Zhejiang University)"

10:45 - 12:00 Processing of n-Type Solar Cells

Chairs: Barbara Terheiden (University of Konstanz) & Deren Yang (Zhejiang University)

10:45 Filament Stretching During Parallel Dispensing - A Way to Reduce Ag Consumption in SHJ Metallization

Katharina Gensowski[1], Maximilian Much[1], Melanie Palme[1], Ana-Maria Jimenez[1], Elisabeth Bujnoch[1], Kazuo Muramatsu[2], Sebastian Tepner[1], Florian Clement[1]

[1] *Fraunhofer ISE;* [2] *NAMICS Corporation*

11:00 Topcon Solar Cells with Plated Contacts on Poly-Si Thickness Below 100 nm

Sven Kluska[1], Benjamin Grübel[1], Christian Schmiga[1], Gisela Cimiotti[1], René Haberstroh[1], Stefan Schelllinger[1], Varun Arya[1], Bernd Steinhauser[1], Mathias Kamp[2], Stephen Fox[3], Damian Brunner[2]

[1] *Fraunhofer ISE;* [2] *Rena Technologies GmbH;* [3] *Jinko Solar Co. Ltd*

11:15 Industrial High-Efficiency Tunnel Oxide Passivated Contact Solar Cells with Ozone-Gas Oxidation SiOx and Tube PECVD Deposited Polysiliconsummary

Jichun Ye[1], Yuheng Zheng[2], BaoJie Yan[1]

[1] *Ningbo Institute of Materials Technology and Engineering*

11:30 Ion Implantation Investigation for the Passivation of Cut Edge Solar Cells

Cyril Leon[1], Damien Barakel[1], Frank Torregrosa[2], Laurent Roux[2], Thomas Regrettier[3], Vitalie Burlac[3], Olivier Palais[1]

[1] *IM2NP;* [2] *Ion Beam Services (IBS);* [3] *Voltec Solar*

11:45 Process Optimization and Characterization for Half-cell Cutting and Advantages of Processing Half-cut As-cut Wafers in SHJ Cell Manufacturing

Jun Zhao[1], Jacques Levrat[1], Gabriel Christmann[1], Bertrand Paviet-Salomon[1]

[1] *CSEM*

12:00 - 13:00 Lunch Break

13:00 - 14:15 SHJ Cells

Chairs: Franz-Josef Haug (EPFL) & Barbara Terheiden (University of Konstanz)

13:00 Approaches for SHJ Cells with Low or No Indium Content

Stefan Janke

Helmholtz-Zentrum Berlin / PVcomB

13:15 Thin n-Type Nanocrystalline Silicon for Rear-Junction Application in Heterojunction Solar Cells

Luca Antognini[1], Corentin Sthioul[1], Vincent Paratte[1], Julie Dréon[1], Deniz Türkay[1], Laurie-Lou Senaud[2], Christophe Ballif[1], Mathieu Boccard[1]

[1] *EPFL - PVLAB;* [2] *CSEM*

13:30 ITO/AZO/ITO Stack as Front TCO Layer for Rear-Junction Silicon Heterojunction Solar Cells

Quntao Tang[1], Andreas Lambertz[1], Karsten Bittkau[1], Andrei Salavei[1], Kaining Ding[1]

[1] *IEK-5 Forschungszentrum Juelich GmbH*

13:45 Assessing Current-Voltage Measurements of Busbarless Solar Cells

Michael Rauer[1], Alexander Krieg[1], Andreas Fell[1], Sebastian Pingel[1], Nico Wöhrle[1], Johannes Greulich[1], Stefan Rein[1], Jochen Hohl-Ebinger[1]

[1] *Fraunhofer ISE*

14:00 Determination of Base Doping Concentration and Hysteresis Correction for Current-Voltage Characteristics

Tobias Kemmer[1], Johannes Greulich[1], Alexander Krieg[1], Stefan Rein[1]

[1] *Fraunhofer ISE*

14:15 - 14:30 Short Break

14:30 - 15:30 Passivating Contacts II

Chairs: Pierre Verlinden (Amrock) & Frank Feldmann (Solarlab Aiko Europe)

14:30 Electrical Analysis of Pulsed Laser Annealed Poly-Si:Ga/SiO_x Passivating Contacts

Kejun Chen[1], Enrico Napolitani[2], Matteo De Tullio[2], Francesco Sgarbossa[2], Chun-Sheng Jiang[3], Harvey Guthrey[3], San Theingi[3], William Nemeth[3], Matthew Page[3], Paul Stradins[3], Sumit Agarwal[4], David Young[3]

[1] *NREL; Colorado School of Mines;* [2] *Università degli Studi di Padova;* [3] *NREL;* [4] *Colorado School of Mines*

14:45 Sputtered Poly-Si for the Formation of Passivating Contacts at the Rear of Large Area N-PERT C-Si Solar Cells

Christophe Allebé[1], Antoine Descoeudres[1], Juan Jose Diaz Leon[1], Andrea Ingenito[1], Simon Hübner[2], Torsten Dippell[2], Bertrand Paviet-Salomon[1], Christophe Ballif[1]

[1] *CSEM;* [2] *Singulus Technologies AG*

15:00 Will Pinholes for SiO_x/poly-Si Passivating Contact Enhance the Passivation Quality?

Guangtao Yang[1], Remon Gram[1], Paul Procel[1], ZhiRong Yao[1], Can Han[1], YiFeng Zhao[1], Liqi Cao[1], Luana Mazzarella[1], Miro Zeman[1], Olindo Isabella[1]

[1] *TU Delft*

15:15 In Situ Monitoring of High-Temperature Passivating Contact Fabrication via X-ray Scattering

Audrey Morisset[1], Theodosios Famprikis[2], Franz-Josef Haug[1], Andrea Ingenito[3], Christophe Ballif[1], Lars Bannenberg[2]

[1] *EPFL STI IMT PV-LAB;* [2] *TU Delft - Reactor Institute;* [3] *CSEM PV-Center*

15:30 - 16:00 Coffee Break

16:00 - 17:30 From n-Type Cells to n-Type Modules

Chairs: Delfina Muñoz (CEA) & Mauro Pravettoni (SERIS)

16:00 Kinetics of High Intensity Illuminated Annealing of n-Type SHJ Solar Cells: 0.4%abs Efficiency Gain in One Second

Matthew Wright[1], Moonyong Kim[2], Anastasia Soeriyadi[2], Dmitry Andronikov[3], Ilia Nyapshaev[3], Sergey Abolmasov[3], Alexey Abramov[3], Sebastian Bonilla[1], Brett Hallam[2]

[1] *University of Oxford;* [2] *The University of New South Wales;* [3] *R&D Center TFTE LLC*

16:15 LS-Effects on Full-Area and Half-Cut SHJ Solar Cells

Sebastian Pingel[1], Ioan Voicu[1], Karin Zimmermann[1], Winfried Wolke[1], Leonard Tutsch[1], Sebastian Roder[1], Timo Wenzel[1], Denis Erath[1], Anna Münzer[1], Puzant Baliozian[1], Armin Richter[1], Martin Bivour[1], Anamaria Steinmetz[1]

[1] *Fraunhofer ISE*

16:30 From Femtoseconds to Gigaseconds: The SolDeg Project to Analyze Si Heterojunction Cell Degradation with Machine Learning

Gergely Zimanyi[1], Davis Unruh[1], Zitong Zhao[1], Reza Vatan Meidanshahi[2], Stephen Goodnick[2]

[1] *UC Davis Physics;* [2] *School of Engineering*

16:45 Temperature Dependence of Light-Enchanced Series Resistance, Fill Factor and Efficiency of a-Si:H/c-Si Heterojunction Solar Cells

Moustafa Ghannam

Kuwait University

17:00 Artificial Lab Degradation Effects in n-Type Modules – Surface Polarization (PID-p)

Friederike Kersten[1], Sven Rißland[1], Christian Taubitz[1], Gerrit Laube[1], Sven Wasmer[1], Jörg W. Müller[1], Daniel J. W. Jeong[1]

[1] *Hanwha Q CELLS GmbH*

17:15 Towards an Industrial In-line Solution for Efficient Post-Treatment of Silicon Heterojunction Solar Cells

Jordi Veirman[1], Jean-Sébastien Caron[1], Tristan Gageot[1], Pedro Jeronimo[1], Sylvain De Vecchi[1], Romain Soulas[1], Wilfried Favre[1], Alessandro Voltan[2], Marcello Sciuto[3], Marina Foti[3], Antonino Ragonesi[3], Francesco Rametta[3]

[1] *CEA INES;* [2] *Applied Materials;* [3] *Enel Green Power*

17:30 - 18:00 Closing Session SiliconPV 2022

Chairs: Giso Hahn (University of Konstanz) & Arthur Weeber (TNO Energy Transition)

17:30 Closing SiliconPV

Giso Hahn, University of Konstanz

17:40 SiliconPV Award Ceremony for the Best 10 Abstracts and the Best Posters

Giso Hahn, University of Konstanz

The award ceremony is sponsored by Sinton Instruments.

Thank you!

17:50 Announcement of SiliconPV 2023

Arthur Weeber, INO Energy Transition

Thursday, March 31, 2022

08:30 - 08:40 Opening Session bifiPV Workshop

08:30 Summary of nPV R&D / Outlook for nPV Industry
Barbara Terheiden, University of Konstanz

08:35 Opening of bifiPV2022
Mauro Pravettoni, National University of Singapore &
Radovan Kopecek, ISC Konstanz

08:40 - 10:00 Silicon Material

Chairs: Barbara Terheiden (University of Konstanz) & Jan Schmidt (ISFH)

08:40 Silicon Development at LONGI
Yichun(YC) Wang, LONGi Green Energy Technology Co., Ltd.

09:00 Application of 12 Inch Silicon Wafer in Photovoltaic Industry
Lin Wang, Zhonghuan Semiconductor Co., Ltd

09:20 Ingot Production in a Vertical Integrated GW PV Factory
Melis Çetmeli, Kalyon PV

09:40 NexWafe‘s Direct Gas-to-Wafer Manufacturing
Davor Sujita, NexWafe GmbH

10:00 - 10:30 Coffee Break

10:30 - 11:50 Solar Cell Production

Chairs: Deren Yang (Zhejiang University) & Matthieu Despeisse (CSEM)

10:30 Industrial Application of n-Type Bifacial TOPCon Technology
Jia Chen, Jolywood (Taizhou) Solar Technology Co.,Ltd.

10:50 The TOPCon Solar Cell Development from Lab to Production at Trina Solar
Zhiqiang Feng, Trinasolar Co.,Ltd

11:10 HJT Mass Production in Huasun
Wenjing Wang, Huasun Energy

11:30 Recent Progress of QCells' High Efficiency Solar Cell Development

Jörg W. Müller, Hanwha Q CELLS GmbH

11:50 - 13:00 Lunch Break

13:00 - 14:20 Advanced Production Technologies

Chairs: Loic Tous (imec) & Olindo Isabella (TU Delft)

13:00 Wet Chemical Processes for High Efficiency Devices

Holger Kuehnlein, RENA Technology GmbH

13:20 Updates on APCVD Processing for TOPCon Structures and Laser Doping

Christian Buchner, Gebr. Schmid GmbH

13:40 Advanced Laser Cutting Equipment for n-Type Cells

Michael Grimm, 3DMicromac AG

14:00 How to Bring Copper to PV Industry

Marco Balucani, Rise Technology S.r.l.

14:20 - 15:20 Modules and Systems I

Chairs: Radovan Kopecek (ISC Konstanz) & Arthur Weeber (TNO Energy Transition)

14:20 PV for the Next Generation

Bonna K. Newman, TNO Energy Transition

14:40 Technological Edge to Drive Meyer Burger's European Solar Production Rebuild

Gunter Erfurt, Meyer Burger Technology AG

15:00 VIPV: The Next Challenges of Solar Integration

Matthieu Baudrit, Sono Motors GmbH

15:20 - 15:50 Coffee Break

15:50 - 16:30 Modules and Systems II

Chairs: Radovan Kopecek (ISC Konstanz) & Arthur Weeber (TNO Energy Transition)

15:50 Need of Highly Bifacial Modules for Vertical PV Systems
Peter Bendix, next2sun GmbH

16:10 ZEBRA: Achieving Higher Energy Yield with n-Type IBC Modules
Lisa Hirvonen, FuturaSun s.r.l.

16:30 - 17:30 Circular Economy

Chairs: Delfina Munoz (CEA) & Stefan Glunz (Fraunhofer ISE)

16:30 Challenges and Opportunities for Terawatt-Scale Deployment of n-Type Solar Cell Technologie
Brett Hallam, University of New South Wales

16:50 A Circular Model Integrated in the PV Value Chain from Concept to Field Experience
Claire Agraffeil, CEA

17:10 High Tech Products Need High Tech Recycling
Wolfram Palitzsch, LuxChemtech GmbH

17:30 - 18:00 Closure of nPV Workshop

17:30 Closing Remarks
Barbara Terheiden, University of Konstanz

17:40 Next nPV Workshop
Olindo Isabella, TU Delft

17:50 1 TeraWatt-Party
Radovan Kopecek, ISC Konstanz

19:00 - 00:00 1 TW Party refer to page 47 for more information

Friday, April 01, 2022

08:30 - 08:40 Opening

08:30 Summary of bifiPV Day 1 and Outlook on bifiPV Day 2
Radovan Kopecek, ISC Konstanz

08:40 - 10:00 Overview, Bifacial Modules and Systems

Chairs: Joris Libal (ISC Konstanz) & Arthur Weeber (TNO Energy Transition)

08:40 bifiPV2022: Technology, Application and Economy
Radovan Kopecek, ISC Konstanz

09:00 Bifacial Module Tiger Neo Pro
Xinyu Zhang, Zhejiang Jinko Solar Co. Ltd

09:20 Advanced Tracking
Francisco Javier Torrano, Soltec Energías Renovables S.L.U

09:40 Bifacial AgriPV: The Technology for Fast Energy Transition in EU
Constantin Klyk, ISC Konstanz

10:00 - 10:30 Coffee Break

10:30 - 12:10 Bifacial Systems and Energy Yield Simulation

Chairs: Radovan Kopecek (ISC Konstanz) & Markus Klenk (ZHAW)

10:30 Integrating 3D PV Design and Yield Simulation: Challenges and Opportunities
Imre Horváth, PVcase

10:50 Bifacial Vertical PV System for Flat Roofs
Lars Podlowski, Solyco Technology GmbH

11:10 1.3GW Bifacial PERC HSAT System in Karapinar
Firat Es, Middle East Technical University

11:30 Vertical Bifacial PV for Noise Blocking Applications
Minne de Jong, TNO Energy Transition

11:50 Energy Yield Measurements and SAM Simulations
Silvana Ovaitt, NREL

12:10 - 13:00 Lunch Break

13:00 - 14:40 New Devices, Standards, Measurements

Chairs: Lars Podlowski (Solyko) & Firat Es (Kalyon PV)

13:00 Bifacial Tandem Solar Cell with High Efficiency Si p-PERT Sub-cell
Lev Kreinin, SolAround

13:20 Industrial Bifacial Measurements
Britta Mette, Wavelabs

13:40 Bifacial Measurements and Testing
Pepijn Veling, Eternalsun Spire

14:00 Standards, Qualification and Testing
Jörg Althaus, TÜV Rheinland

14:20 Outdoor Testing
Jenya Meydbray, PVEL

14:40 - 15:00 Coffee Break

15:00 - 16:00 Panel Discussion

Chairs: Itai Suez (Silfab) &
Radovan Kopecek (ISC Konstanz)

15:00 Future of Bifacial Technology: Opportunities and Challenges
NREL, PVEL, Jinko, Wavelabs, Eternalsun, Kalyon, Soltec

16:00 - 16:30 Closure of bifiPV Workshop

16:00 Closure
Radovan Kopecek, ISC Konstanz

16:15 Next bifiPV Workshop 2022
Firat Es, Kalyon

Side Events

Conference Dinner

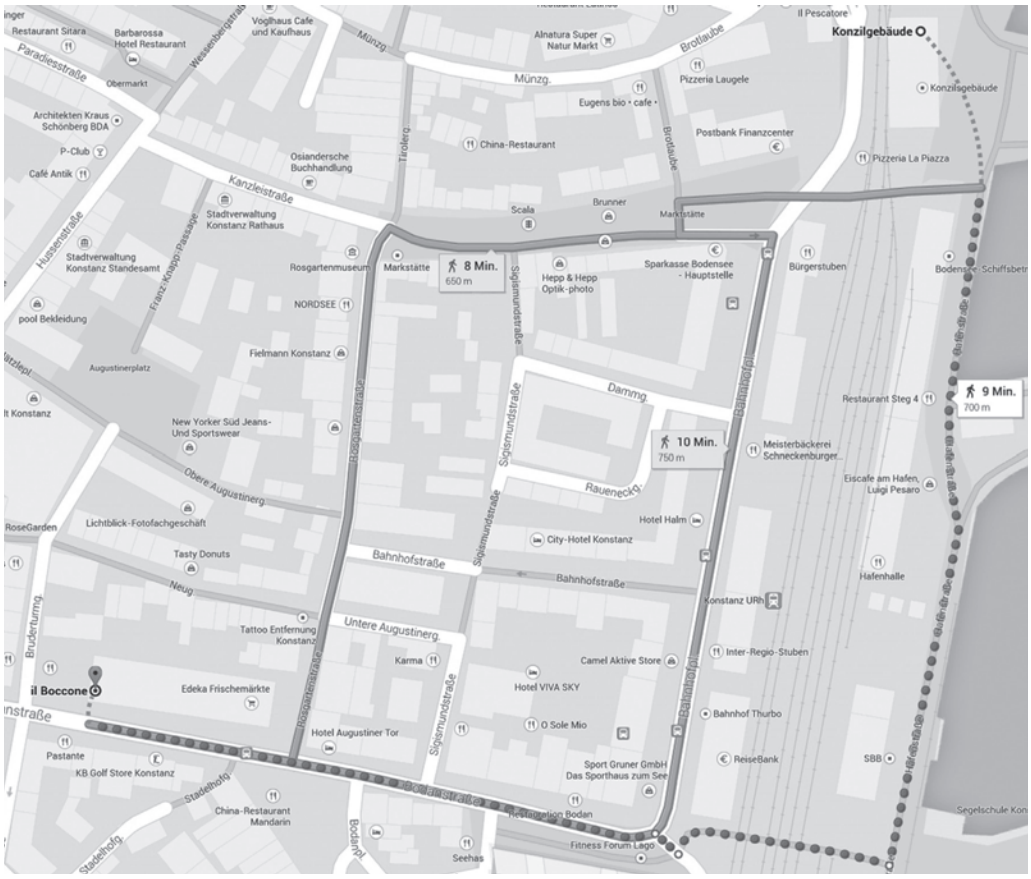
The SiliconPV Conference Dinner will take place at the il Boccone restaurant, located in the heart of the city, just a 10-minute walk from the conference venue. Enjoy Italian cuisine in a stylish and bright ambience. The Italian flair invites you to network and enjoy with other participants!

Day: Tuesday, March 29, 2022

Time: 19:00 – 24:00 (CEST)

Fee: The dinner is included in all SiliconPV tickets, pre-registration is required.

Location: Il Boccone Restaurant
Bodanstr. 20-26
78462 Konstanz
www.ilboccone.de



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Virtual Technical Tour

The SiliconPV technical tour on Monday will offer you insights in the facilities of the University of Konstanz. Researchers of the university will present examples of their current research foci. Gain direct insight into their work and take the opportunity to ask questions.

Day: Monday, March 28, 2022
Time: 17:00 - 18:00 (CEST)

The technical tour will be held online, thus being available for on-site and online participants alike. Participants attending the conference in Konstanz will get together in the conference room for the tour.

1TW Party

Right after the nPV workshop, ISC Konstanz will open its doors for a 1TW Party with music, food and drinks. We will celebrate together that PV became the “king of energy markets”, which in 2022 will sum up to total installations of 1TWp!

Date: Thursday, March 31, 2022
Time: 19:00 – 24:00 (CEST)
Fee: free of charge, pre-registration is required
Location: ISC Konstanz, Rudolf-Diesel-Straße 15, 78467 Konstanz

General Information

Registration

Each participant has to register in person at the registration desk to collect a conference bag and name badge before attending any sessions. Please make sure to wear your badge for admission to all sessions and side events. Participants who have lost their badge should report to the registration desk.
Registration times are on Sunday, March 27, from 17:00–19:00 during the Welcome Reception and during conference hours, starting on Monday, March 28 at 7:45 and the following days at 8:00.

Posters

Posters will be displayed on-site at the conference venue as well as online.
On Tuesday and Wednesday the conference day starts with online poster sessions. All attendees are asked to login to Scoocs and visit the online poster exhibition. It is recommended to dial in from your hotel room / home.
For poster authors attending on site:
Please mount your poster before the start of the first poster session and do not remove it until the end of the conference. The posters are an important part of the scientific program and should be displayed the whole time. Please remove your poster before you leave. Remaining posters will be discarded.
You are asked to attend your respective on-site poster session as well as the online poster session.
This year there will be an online poster award for the scientists with the best online poster. Criteria are: design, scientific quality and overall presentation. Therefore, be at your booth during your online poster session to present your poster!
The awardees will be announced in the closing session. We thank Sinton Instruments for sponsoring the award.

Information for Speakers On-site

All presentations must be handed in at the Media Upload Desk one hour before your session starts. You will not be able to display your presentation directly from your laptop computer or USB flash drive. Our technical support team will welcome you at the Media Upload Desk during all conference days, starting at 8:00.
Please meet your session chairs inside the conference room at least 10 minutes prior to the beginning of your oral session to acquaint yourself with the technical equipment. To introduce you during the session, please provide the chair with a short CV (2-3 sentences).

List of Participants

Registered participants may download a list of participants on the conference website, www.siliconpv.com. The login and password sent to you during registration will be required to gain access to the download area.

Certificate of Attendance

A certificate of attendance for participants will only be available on-site at the registration desk and cannot be issued after the conference.

Contact Participants

SiliconPV offers a contact opportunity for conference participants in its internal area on the conference website, www.siliconpv.com. Log in with your password and contact other participants by e-mail.

All participants who want to use the contact feature can confirm their admission to receive e-mails from other conference participants. The first contact will occur indirectly via the conference system in the Internal Area. No personal data will be handed out.

Conference Proceedings

The proceedings will be published with AIP, the American Institute of Physics (www.aip.org), after the conference, covering papers with sufficient scientific quality. This collaboration will provide optimum visibility of the proceedings and ensure that the authors' publications remain traceable and citable. Final online papers will be accessible on the AIP website and contain an ISBN number for the conference volume as well as individual DOI numbers for each paper.

Full papers of the twenty best abstracts will be published in Elsevier's peer reviewed journal Solar Energy Materials & Solar Cells (SOLMAT).

WiFi Access

WiFi will be available free of charge in the whole conference area
WiFi network: KonzilOG
Password: konzil2014

Notes

We look forward to meeting you in Delft next year!

SiliconPV 2023
13th International Conference on Crystalline Silicon Photovoltaics

npworkshop Delft 2023

Advanced technologies, materials and concepts for crystalline Si solar cells and modules

April 11 – 14, 2023 | Delft, The Netherlands

ScientificTopics: Silicon material and defect engineering + Wafering technologies and direct-wafer production + Junction formation + Cleaning, etching, layer deposition technologies, surface morphology and surface passivation + Carrier selective contacts, metallization and contact formation + Advanced light management + Cell and module characterization + Cell and module simulation + Digitalization, data processing and machine learning in PV + Processintegration and low-cost manufacturing + New manufacturing tools + Si-based tandem cells in combination with perovskites, III-V and alternative materials + Module processing and materials + Module reliability and energy yield + Module circularity and technologies to reduce the carbon footprint + Customized modules for buildings, vehicles and other special applications + High and record efficiency devices + nPV on Wednesday

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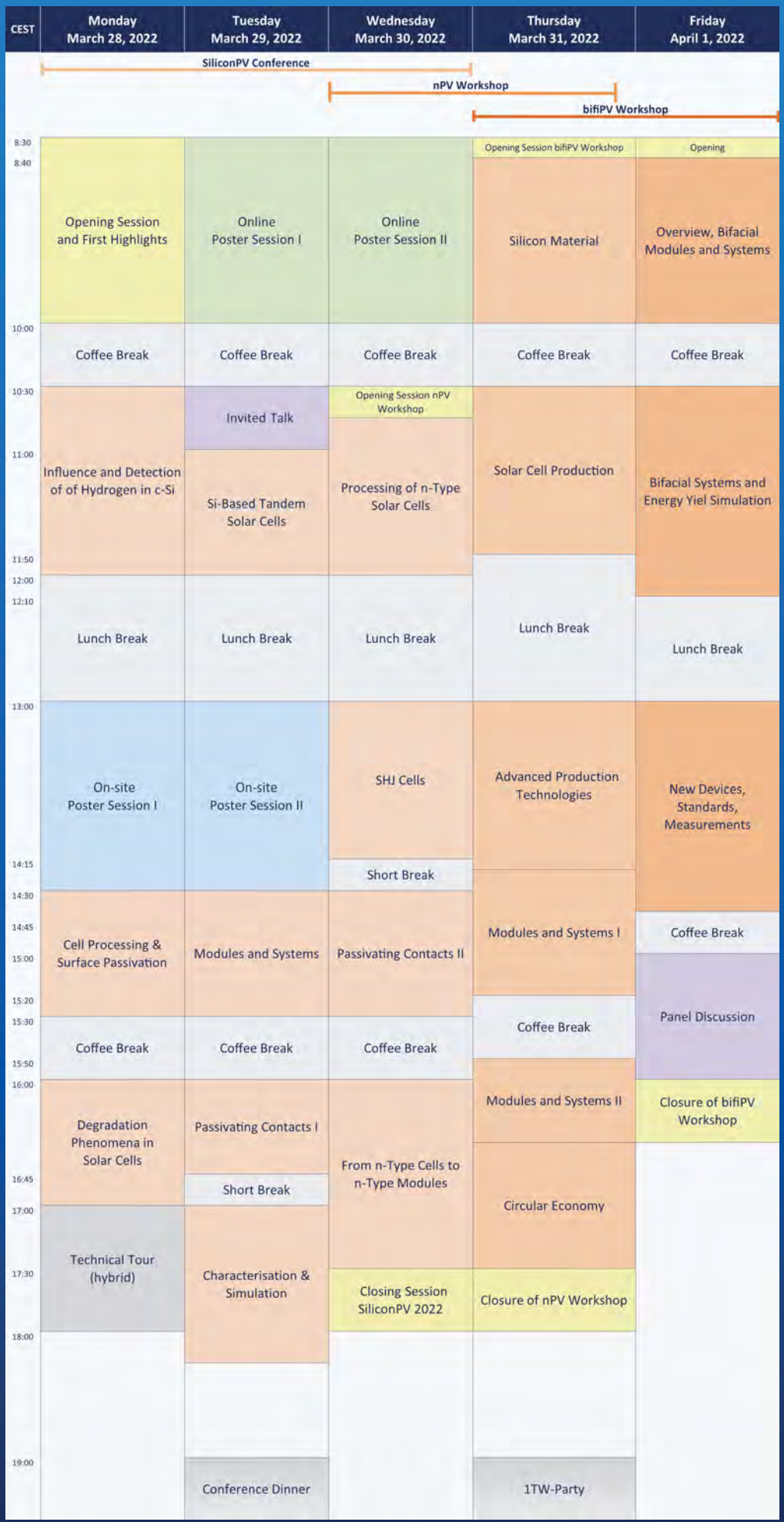
OVERVIEW


CEST
Monday March 28, 2022
Tuesday March 29, 2022
Wednesday March 30, 2022
Thursday March 31, 2022
Friday April 1, 2022
SiliconPV Conference
nPV Workshop
bifiPV Workshop
8:30
8:40
10:00
10:30
11:00
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19:00
Opening Session and First Highlights
Online Poster Session I
Online Poster Session II
Opening Session bifiPV Workshop
Silicon Material
Opening
Overview, Bifacial Modules and Systems
Coffee Break
Coffee Break
Coffee Break
Coffee Break
Coffee Break
Invited Talk
Opening Session nPV Workshop
Influence and Detection of of Hydrogen in c-Si
Si-Based Tandem Solar Cells
Processing of n-Type Solar Cells
Solar Cell Production
Bifacial Systems and Energy Yiel Simulation
Lunch Break
Lunch Break
Lunch Break
Lunch Break
Lunch Break
On-site Poster Session I
On-site Poster Session II
SHJ Cells
Short Break
Advanced Production Technologies
New Devices, Standards, Measurements
Cell Processing & Surface Passivation
Modules and Systems
Passivating Contacts II
Modules and Systems I
Coffee Break
Coffee Break
Coffee Break
Coffee Break
Panel Discussion
Degradation Phenomena in Solar Cells
Passivating Contacts I
Short Break
From n-Type Cells to n-Type Modules
Modules and Systems II
Closure of bifiPV Workshop
Circular Economy
Technical Tour (hybrid)
Characterisation & Simulation
Closing Session SiliconPV 2022
Closure of nPV Workshop
Conference Dinner
1TW-Party