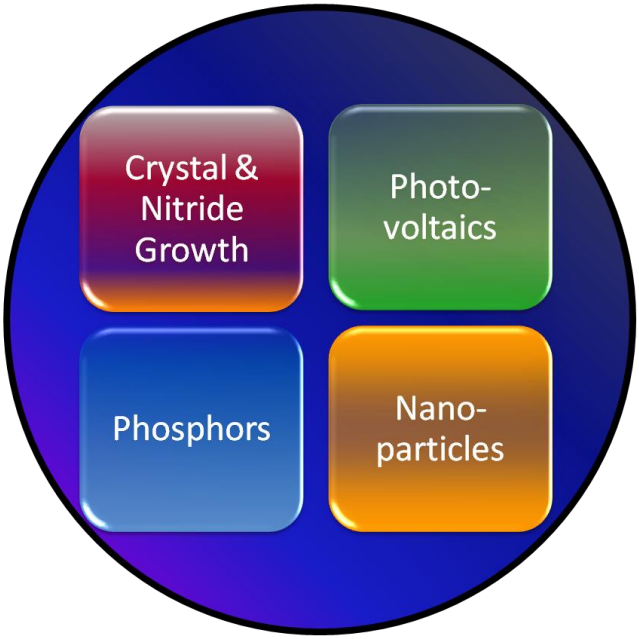
Friedrich-Alexander-Universität
Technische Fakultät

Department of Materials Science and Engineering

Materials for Electronics and Energy Technology



ANNUAL REPORT 2021

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PD Dr. Miroslaw Batentschuk
Prof. Dr. Wolfgang Heiss
Prof. Dr. Olga Kasian
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Prof. Dr. rer. nat. Albrecht Winnacker

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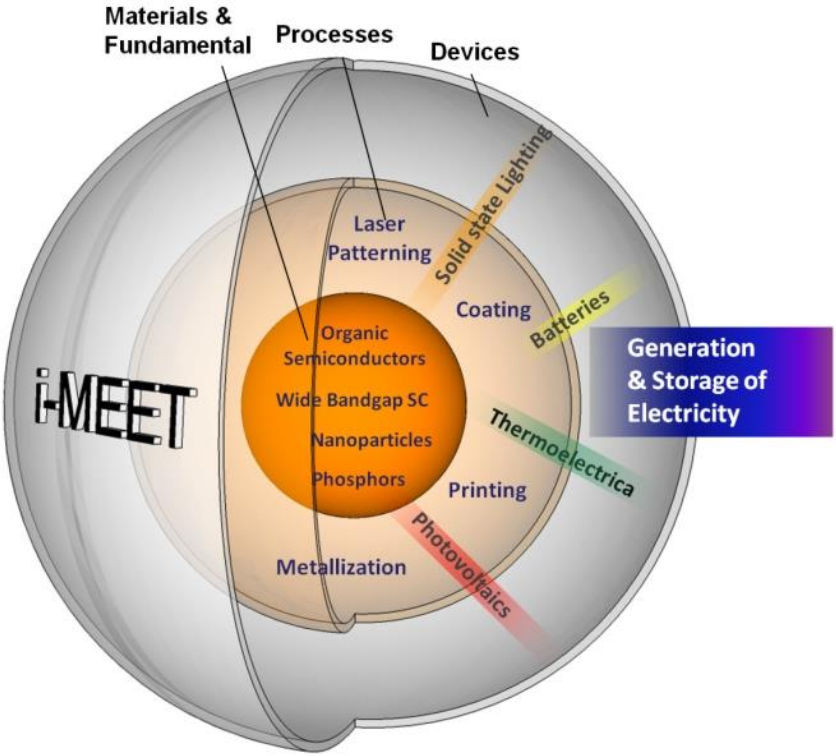
1. Vorwort

Herzlichen Dank an unsere Studenten, Doktoranden, Mitarbeiter und Gruppenleiter für ihre fantastischen Leistungen in 2021. Gemeinsam haben wir auch das zweite Coronajahr bewältigt!
Ich möchte allen danken, die mit unermüdlichen Einsatz und akribischer Genauigkeit für eine rigorose Umsetzung der Corona Richtlinien gesorgt haben, Vorlesungen für das Internet designt und gehalten haben, unsere Praktika digitalisiert haben und sogar die Durchführung der Next Generation Solar Energy Conference 2021, gemeinsam mit dem NREL (ngse.info) meistern konnten. Ca 1000 Teilnehmer während der dreitägigen Konferenz teilten unsere Begeisterung für wissenschaftlichen Strategien um den "detailed balance limit" für Single Junction Solarzellen zu überwinden.
Besonders herzlichen Dank an unser Verwaltungsteam und unsere technischen Angestellten – ohne sie wäre es nicht möglich, das i-MEET so erfolgreich zu führen. Ihnen allen, den Kooperationspartnern und Unterstützern des i-MEET danke ich für die erfolgreiche Zusammenarbeit in 2021 und wünsche viel Spaß beim Lesen unseres Tätigkeitsberichts.

Many thanks to our undergraduates, graduate students, staff, and group leaders for their fantastic accomplishments in 2021. Together we have successfully managed the second Coronayear!
I would like to thank everyone who worked tirelessly and meticulously to ensure rigorous implementation of Corona policies, designed and delivered lectures digitally, digitized our lab courses and supported the successful delivery of the 2021 Next Generation Solar Energy Conference with NREL (ngse.info). About 1000 participants shared our fascination for scinetific concepts allowing to overcome the detailed balance limit for single junction solar cells.
Special thanks to our administrative team and our technical staff - without them, it would not be possible to run i-MEET that successfully. I would like to thank all of you, the cooperation partners and supporters of the i-MEET for the successful cooperation in 202 and hope you enjoy reading our activity report.

Best, Christoph Brabec

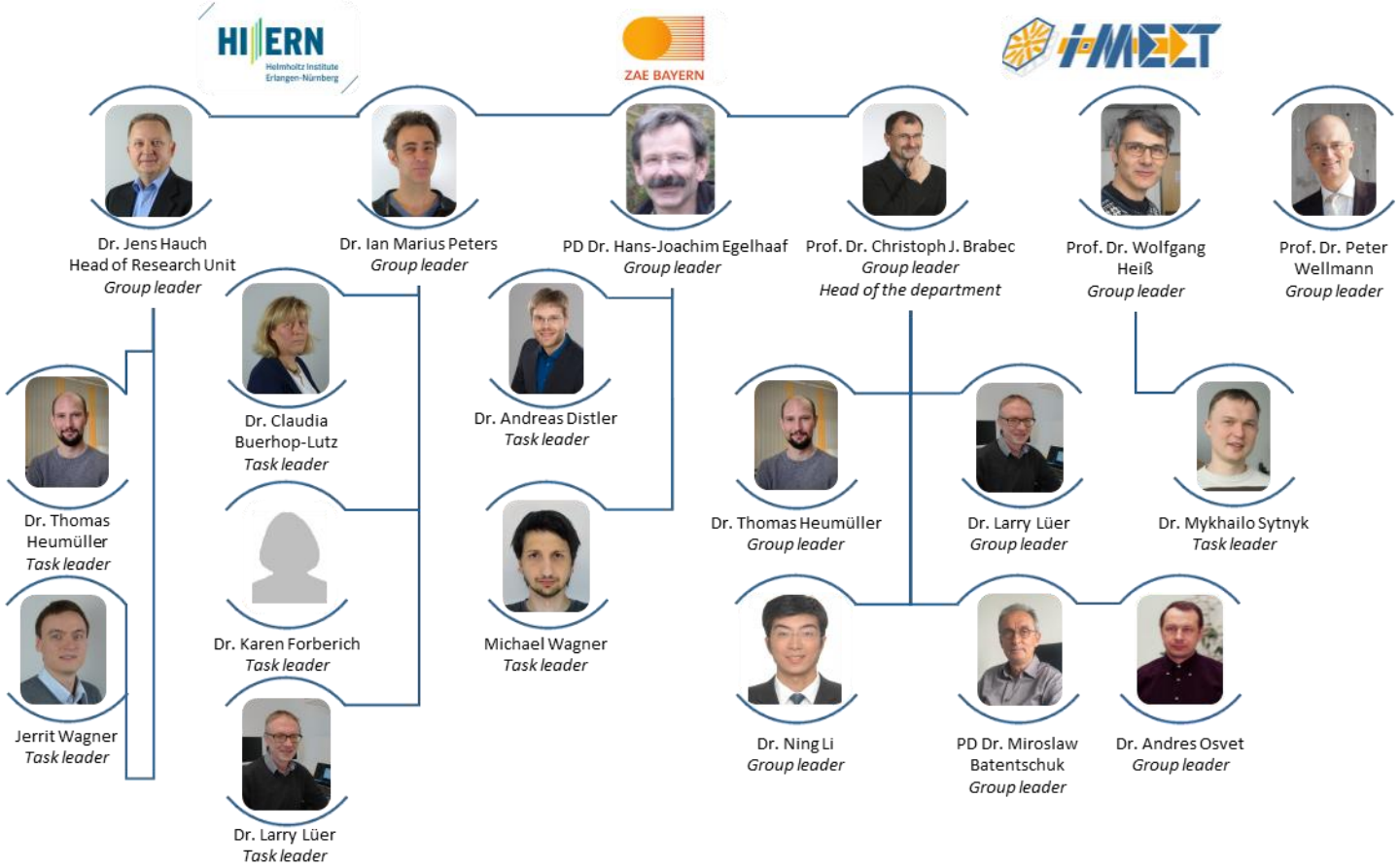
Please note that some of our highlights can be found on i-MEET's youtube channel i-MEET Lab.
(https://www.youtube.com/channel/UC6RHRl5xyzL1b-lcJ6FG3PA).
Please note also our alumni network at LinkedIn (Institute i-MEET).



(Christoph J. Brabec) (Peter Wellmann) (Wolfgang Heiss)

(Albrecht Winnacker) (Miroslaw Batentschuk)

Erlangen, May 2022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ZAE BAYERN
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Group leader
Dr. Ian Marius Peters
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Dr. Andreas Distler
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Jerrit Wagner
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Dr. Karen Forberich
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Michael Wagner
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PD Dr. Miroslaw Batentschuk
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Dr. Andres Osvet
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Dr. Larry Lüer
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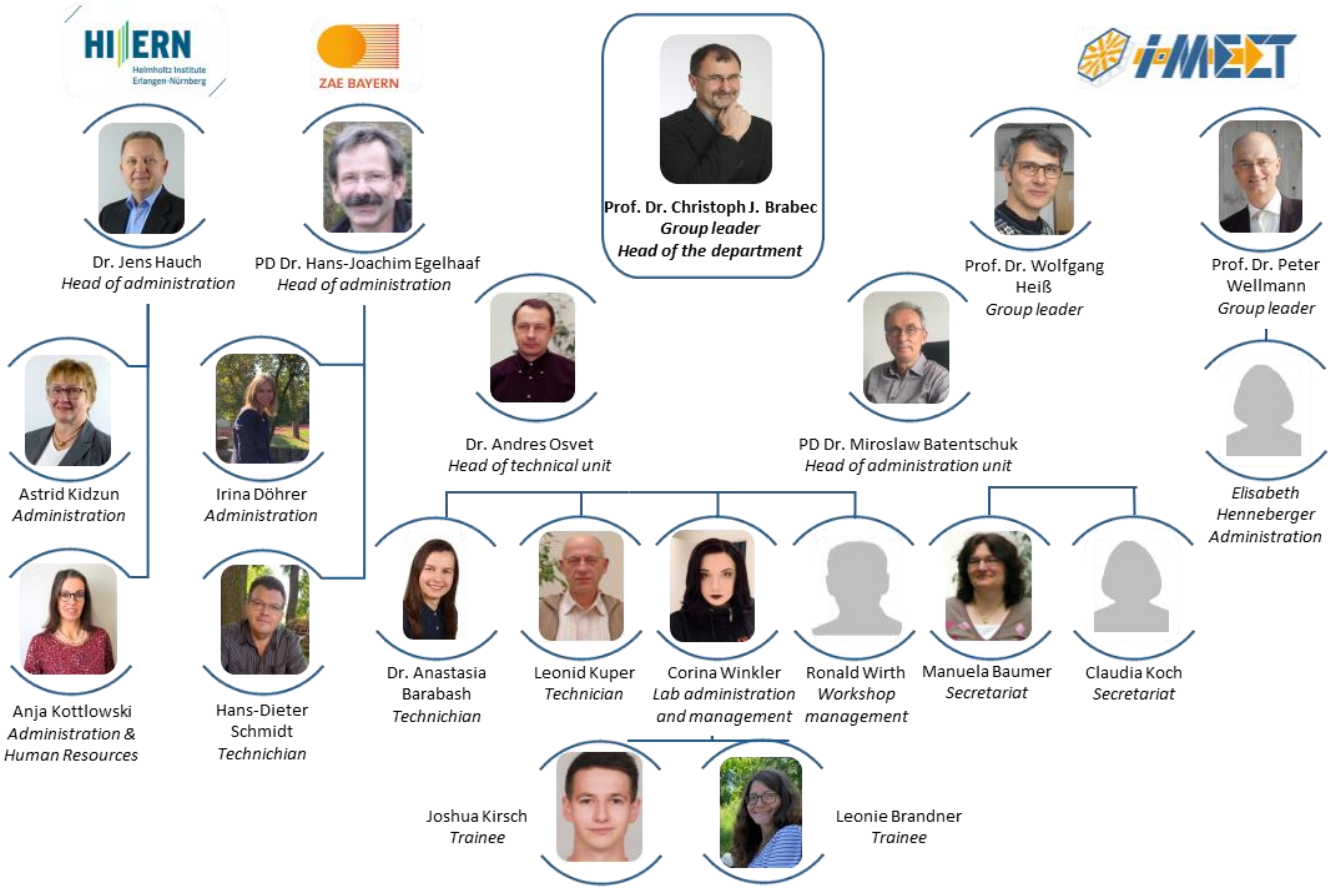
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Claudia Koch
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Leonie Brandner
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2. Members of the Chair

Professors

Prof. Dr.
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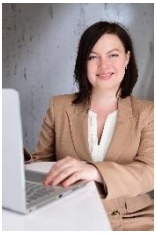
Head of the chair

Prof. Dr.
Wolfgang Heiss



Prof. Dr.
Olga Kasian

Prof. Dr.-Ing.
Peter Wellmann

Professors emeritus

Prof. Dr. rer. nat.
Georg Müller

Prof. Dr. rer. nat.
Albrecht Winnacker

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Miroslaw Batentschuk

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Anastasia Barabash

Leonie Brandner

Joshua Kirsch

Leonid Kuper

Hans-Dieter Schmidt

Corina Winkler

Ronald Wirth

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Solar and Semiconductor Devices (SSD)

(Scientifical staff, doctoral candidates)

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Group leader

PD Dr.
Miroslaw
Batentschuk
Group leader

Dr.-Ing.
Thomas Heumüller

Group leader

Dr.
Ning Li

Group leader

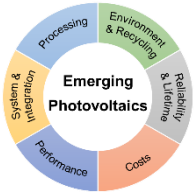
Dr.
Larry Lüer
Group leader

Dr.
Andres Osvet
Group leader

Research of the group is devoted to the design, simulation, processing and analysis of modern innovative semiconductors, electronic materials as well as advanced devices. Next generation concepts for electronic devices and future light harvesting techniques complete our research focus.

Development of low cost, long lived and highly efficient printed solar cells is one major vision of this research group. This includes the development of stable and efficient materials, the development of printed multilayer tandem technologies, ternary sensitization and controlling microstructure formation. Advanced organic semiconductors, p-type & n-type interface layers, printed transparent / opaque electrodes, flexible substrates and low cost barriers are further activities of this research group.

Organic semiconductors, perovskite hybrid composite semiconductors as well as colloidal quantum dots are the material fundament of our device engineering and process development activities. Further activities include low temperature processed chalcogenides and kesterites.



The **Device** Group at i-MEET focuses on the development of solution-processed emerging photovoltaic devices with excellent performance and device stability, in particular for organic- and perovskite-based photovoltaic technologies. In order to develop efficient, cheap and stable optoelectronic devices, we explore advanced materials, novel device architectures and characterize relevant fundamental and loss mechanisms. In close collaboration with partner groups at i-MEET, HI-ERN and ZAE Bayern, the scientific research findings obtained by the Device Group will help further promote the industrialization of emerging photovoltaic technologies.

Research of **Materials for optoelectronic applications** group is focused on the development of phosphors for light conversion, on semiconductors for optical or x-ray detectors and light-emitting devices, and other functional materials used in optoelectronics. The applications of the light conversion phosphors range from LED-based ambient or horticultural lighting to liquid crystal displays. A specific application is harvesting the ultraviolet and infrared solar emission in solar cells, based on transforming the emission by up- or downconversion effect into the most efficient spectral range of a solar cell. The materials can be roughly divided into rare-earth or transition metal doped inorganic phosphors on one hand, and semiconductor quantum dots, thin films, and micropowders on the other hand.

The **Lifetime group** develops novel characterization methods and device architectures to improve the long-term stability of organic solar cells. Advanced optical and electrical time resolved measurements are combined with in-situ stability testing under controlled atmosphere, illumination and temperature.

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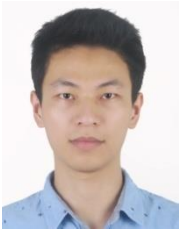

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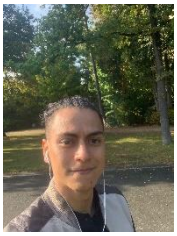

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Solution-Processed-Semiconductor-Materials (SOPSEM)

(Scientifical staff, doctoral candidates)

Prof. Dr.
Wolfgang Heiss
Group leader

Dr.
Mykhailo Sytnyk
Task leader

SOPSEM

Solution processed semiconductor materials are synthesized as a basis for the development of electronic devices. The materials include colloidal nanocrystal quantum dots and metal-halide perovskites. For the perovskites their epitaxial growth has been achieved by inkjet printing on various substrates, as a first step towards the development of epitaxial heterostructures. Micro-crystallites of perovskites are grown to provide laser cavities, which exhibit lasing under optical pumping. Metal-oxide nanocrystals are applied as electrochromic materials, exhibiting within an electrochromic device color changes upon intercalation or de-intercalation of Li-ions. For their application as electrodes

in the devices, films of the colloidal nanocrystals are prepared, whose function rely heavily on ligand treatments procedures which are developed in our group. The resulting electrochromic devices have the potential to be used in smart windows, providing diming from sun light upon electrical activation. PbS nanocrystals are synthesized and applied as absorber in infrared-photodiodes and solar cells. For their fabrication within a single deposition step the ink formulation is of uppermost importance. Solvent mixtures are applied, in order to allow the deposition of ~ micron thick films within a single step, which are smooth, free of cracks and contain a minimum amount of organic residuals. Such inks are usable not only by spin coating but also by doctor blade deposition, enabling the scaling of the device fabrication to large areas. They are used for the development of infrared solar cells and photodetector arrays.

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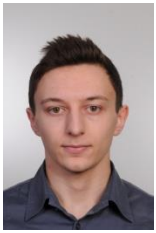

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Crystal Growth Lab (CGL)

(Scientifical staff, doctoral candidates)

Prof. Dr.-Ing. Peter Wellmann
Group leader

In the Crystal Growth Lab @ FAU headed by Prof. Dr.-Ing. Peter Wellmann, the research activities are devoted to modern topics in semiconductor technology and include crystal growth, epitaxy and characterization of various electronic materials.
Since December 2017 the successful activities of Crystal Growth Lab are listed by the European Union as a Key Enabling Technology (KET) Centre on "FAU – Industrial Services in Crystal Growth of SiC".
The R&D activities of the Crystal Growth Lab lie in the areas of materials for **power electronics**, **energy saving** & **novel photonic applications** with a major focus on the semiconductor **SiC**:

- SiC for **power electronic** devices is a key player for **energy saving**. The lab focuses on bulk of SiC using the **PVT method** and the newly developed **CS-PVT process**.
- SiC for **novel photonics** includes applications like **optical waveguides**, **quantum information**, **intermediate bandgap solar cells**, **photocatalytic water splitting** and **fluorescent SiC**. The lab focuses on bulk like materials and thin films processed using the **CS-PVT** process as well as **Chemical Vapor Deposition**.
- The lab environment covers all processing steps from the **synthesis** of the SiC source material, the **crystal growth** process of SiC boules and thin films, grinding and **wafering**, as well as **wafer inspection**.
- In the field of **semiconductor characterization**, a large variety of **electrical**, **spectroscopic** and **structural** techniques are used which serve the better understanding of materials processing. Special emphasis is put on **topographic**/**mapping** methods.

- As a future material system, the synthesis and layer deposition of **chalcogenide perovskites** like $BaZrS_3$, $BaZrSe_3$, $BaSrS_3$, $BaSrSe_3$ are investigated.
- Other topics investigated in the lab include (i) **ammonothermal growth** of nitride semiconductors like **GaN**, (ii) **CIGSSe** and **CZTSSe** thin film solar cell materials recently, (iii) **printed electronic** layers using nanoparticles and hybrid organic semiconductor & nanoparticle composites, (iv) **hybrid nanomagnet-semiconductor structures**, (v) **rare earth doped semiconductors** and (vi) **semiconductor superlattices** and quantum dot structures.

In all fields service for industrial and institutional partners may be provided.

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Solar Factory of the Future (SFF)

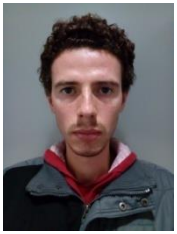
(Scientifical staff, doctoral candidates)

PD Dr.
Hans-Joachim Egelhaaf
Group leader

Dr.
Andreas Distler
Task leader

Dr.
Michael Wagner
Group leader

The “Solar Factory of the Future” develops advanced concepts of printed photovoltaic (PV) modules and of high-throughput-processes for their production. The main goal of our activities is the upscaling of highly efficient small size solar cells to industrially viable roll-to-roll (R2R) producible large area solar modules at minimum efficiency losses. This involves: the formulation of inks based on green solvents, the optimization of R2R printing and coating processes, the development of advanced patterning processes for high efficiency organic and perovskite solar modules by laser ablation and ink jet printing, development of novel concepts for the encapsulation of printed PV modules, and the integration of our modules in mobile applications and in building integrated PV installations.



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Helmholtz-Institut Erlangen-Nürnberg (HI ERN)

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Dr-Ing.
Thomas Heumüller
Task leader

Dr
Ning Li
Task leader

Dr.
Larry Lüer
Task leader

MSc
Jerrit Wagner
Task leader

The research unit „High Throughput Methods in Photovoltaics" at the HI ERN aims to develop materials, processes and technologies fostering a sustainable and significant cost degression of photovoltaic technology, from small non-gird connected energy harvesting to large scale energy production and from the Watt scale to the Terawatt scale. The research combines achievements from automated materials research, digitization, simulation and big-data methods with the specialized knowledge of Photovoltaic technology. The research unit is a cooperation between the Bavarian Center for Applied Energy Research (ZAE Bayern), the Friedrich-Alexander-University Erlangen-Nuremberg (FAU) and HI ERN and performs its research in two active research groups:

- High Throughput Materials and Devices for PV
- High Throughput Characterization and Modelling for PV

With their research the groups address specific challenges in the fields of materials and device development, highly productive processes for the manufacture of PV-modules as well as the maintenance and operations of very large-scale solar power plants.

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Bernd Doll
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Dr.
Xiaoyan Du
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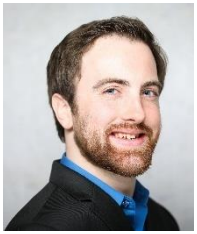

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Chao Liu
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External doctoral candidates

Fabian Carigiet
MSc
ZHAW

Sarah Deumel
MSc
Siemens Healthineers

Tobias Hübner
MSc
Osram

Visitors

Bayerischer Rundfunk (15.04.21)

Avancis GmbH (11.05.2021)

ACP Systems AG (09.09.2021)

CDU Delegation (18.10.2021)

Stadtverführungen Nürnberg (18.10.2021)

Fa. Epishine (11.11.2011)

Prof. Dr. Serdar Sariciftci, Linz Institute for Organic Solar Cells (LIOS), Physical Chemistry, Johannes Kepler University Linz (11.11.2011)

Schüler des Hermann-Kesten-Kollegs Nürnberg (11.11.2021)

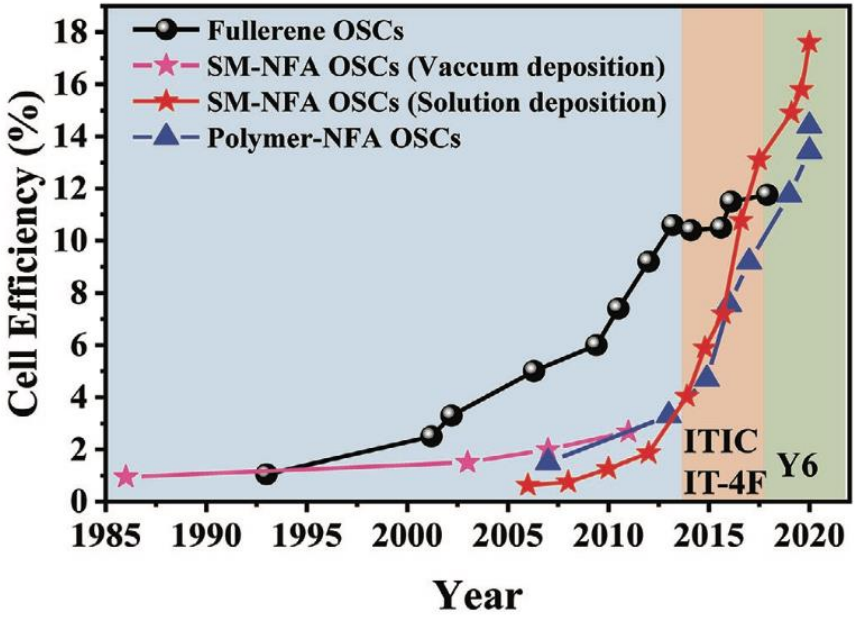
Prof. Dr. Wolfgang Arlt, Department Chemie- und Bioingenieurwesen (CBI) Lehrstuhl für Thermische Verfahrenstechnik (TVT), FAU (17.11.2021)

Christog Erban und Maksim Toropov, Fa. Sunnovation, (10.2021)

Lukas Zdražil, Department of Physical Chemistry, Faculty of Science, University of Olomouc, Czech Republic

3. Highlights 2021

Paul takes the leadership in publishing a review on historic and future NFA developments on behalf of Advanced Energy Materials 10th anniversary



The emergence of a family of materials-the nonfullerene acceptors (NFAs) – has rocked OPV science and technology during the last 5 years. NFAs have delivered a discontinuous advance in cell efficiencies, with the significant milestone of 20% now in sight. These materials challenge the accepted wisdom of how organic solar cells work and force new thinking in areas such as morphology, charge generation and recombination. This perspective provides a historical context for the development of NFAs, and also addresses current thinking in these areas but also critically questions how far can they can be further pushed, and whether they will deliver on equally important metrics such as stability.

ADVANCED ENERGY MATERIALS
www.advenergymat.de

A History and Perspective of Non-Fullerene Electron Acceptors for Organic Solar Cells

Ardalan Armin, Wei Li, Oskar J. Sandberg, Zuo Xiao, Liming Ding, Jenny Nelson, Dieter Neher, Koen Vandewal, Safa Shoaee, Tao Wang, Harald Ade, Thomas Heumüller, Christoph Brabec, and Paul Meredith**

Organic solar cells are composed of electron donating and accepting organic semiconductors. Whilst a significant palette of donors has been developed over three decades, until recently only a small number of acceptors have proven capable of delivering high power conversion efficiencies. In particular the fullerenes have dominated the landscape. In this perspective, the emergence of a family of materials–the non-fullerene acceptors (NFAs) is described. These have delivered a discontinuous advance in cell efficiencies, with the significant milestone of 20% now in sight. Intensive international efforts in synthetic chemistry have established clear design rules for molecular engineering enabling an ever-expanding number of high efficiency candidates. However, these materials challenge the accepted wisdom of how organic solar cells work and force new thinking in areas such as morphology, charge generation and recombination. This perspective provides a historical context for the development of NFAs, and also addresses current thinking in these areas plus considers important manufacturability criteria. There is no doubt that the NFAs have propelled organic solar cell technology to the efficiencies necessary for a viable commercial technology–but how far can they be pushed, and will they also deliver on equally important metrics such as stability?

1. Introduction

Photovoltaics based upon earth abundant, low embodied energy semiconductors have been the source of intense research and innovation efforts for nearly four decades. One technology which has long promised this apparent renewable energy Nirvana is organic photovoltaics (commonly referred to as OPV)–with the light harvesting component being sub-micron layers of solution processed[1] or low temperature vacuum deposited organic semiconductors.[2] The first functional organic solar cell was reported as far back as 1986–this was a two-layer heterojunction based upon copper phthalocyanine and a perylene tetracarboxylic derivative.[3] This architecture is directly analogous to a conventional p–n inorganic semiconductor junction, but with some key differences, notably: i) the organic semiconductors in question are molecular not banded solids; ii) the device is excitonic at room temperature since the low dielectric constants of the constituent semiconductors are not

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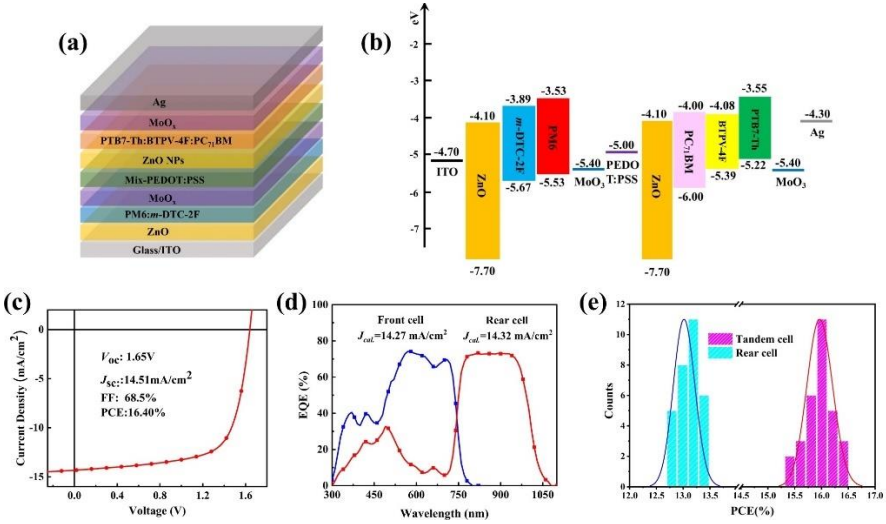
Yongfang's new NIR acceptor pushes the bandgap of OPV towards 1.2 eV and enables well performing tandem cells



Yongfang extended the pi-conjugation of Y6 by inserting a double bond between the central core and end groups and pushed the optical bandgap to 1.21 eV (BTPV-4F). The single-junction devices based on this novel acceptor achieved a short-circuit current density of 28.9 mA cm−2, and provide ideal conditions for current matching in tandems. The resulting tandem devices reached a high power conversion efficiency beyond 16 % (16.4 % uncertified) and exhibited as well good photostability. Very curious to find out what happens when introducing further double bonds into these molecules – achieving bandgaps comparable to the one of silicon appears to be within reach

nature COMMUNICATIONS

ARTICLE

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High performance tandem organic solar cells via a strongly infrared-absorbing narrow bandgap acceptor

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Tandem organic solar cells are based on the device structure monolithically connecting two solar cells to broaden overall absorption spectrum and utilize the photon energy more efficiently. Herein, we demonstrate a simple strategy of inserting a double bond between the central core and end groups of the small molecule acceptor Y6 to extend its conjugation length and absorption range. As a result, a new narrow bandgap acceptor BTPV-4F was synthesized with an optical bandgap of 1.21 eV. The single-junction devices based on BTPV-4F as acceptor achieved a power conversion efficiency of over 13.4% with a high short-circuit current density of 28.9 mA cm^{-2}. With adopting BTPV-4F as the rear cell acceptor material, the resulting tandem devices reached a high power conversion efficiency of over 16.4% with good photostability. The results indicate that BTPV-4F is an efficient infrared-absorbing narrow bandgap acceptor and has great potential to be applied into tandem organic solar cells.

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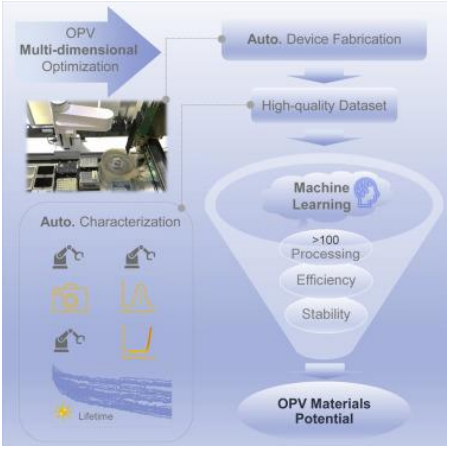
Xiaoyan publishes automated OPV device processing and modelling on AMANDA in Joule



Self-driven laboratories are current discussed as a fast and reliable methodology to overcome the limitation of classical high-throughput experimentation. In his most recent article in Advanced Materials, Stefan challenged a robot based high throughput process to identify the most photostable composition for multicomponent polymer blends as required for OPV. Stefan developed a method for automated film formation which allows the fabrication of up to 6000 films per day. Loic, Florian and Alan Guzik from the University of Toronto supported equipping our automated experimentation platform with a Bayesian optimization algorithm, and together we constructed a self-driven laboratory that autonomously evaluates measurements to design and execute the next experiments. To demonstrate the potential of these methods, a 4D parameter space of quaternary OPV blends was mapped and optimized for photostability. While with conventional approaches, roughly 100 mg of material would be necessary, the robot-based platform can screen 2000 combinations with less than 10 mg, and machine-learning-enabled autonomous experimentation identifies stable compositions with less than 1 mg

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Joule

CellPress

Article

Elucidating the Full Potential of OPV Materials Utilizing a High-Throughput Robot-Based Platform and Machine Learning

Xiaoyan Du,[1,2,6,7,*] Larry Lüer,[1,6] Thomas Heumueller,[1,2] Jerrit Wagner,[1,2] Christian Berger,[1,2] Tobias Osterrieder,[2] Jonas Wortmann,[2] Stefan Langner,[1,2] Uyxing Vongsaysy,[3] Melanie Bertrand,[3] Ning Li,[1,2] Tobias Stubhan,[4] Jens Hauch,[1] and Christoph J. Brabec[1,2,5,*]

SUMMARY

Evaluating the potential of organic photovoltaic (OPV) materials and devices for industrial production is a multidimensional optimization process with an incredibly large parameter space. Here, we demonstrate automated OPV material and device characterization in terms of efficiency and photostability. Gaussian process regression (GPR) prediction based on optical absorption features guided the optimization process with promising prediction accuracy for PV parameters and burn-in losses. With ~100 process conditions, screening for efficiency and photostability can be finished within 70 h. The highest power conversion efficiency (PCE) of 14% was achieved by fully automated device fabrication in air with a model material system PM6:Y6. Improving molecular ordering has been identified as the most promising motif for further efficiency optimization. Thin active layers combined with medium thermal annealing temperature are favorable to simultaneously improve efficiency and suppress burn-in losses. The platform and protocol may be expanded to any solution-processed organic semiconductor and interface materials.

INTRODUCTION

Excellent device performance and stability are vital for the industrial viability of organic photovoltaic (OPV), which is considered to be a promising renewable energy source for a decentralized power supply in the near future. With significant advances in the development of novel materials in recent years, lab cells with power conversion efficiencies (PCEs) > 15% have been achieved with several material systems in combination with non-fullerene acceptors (NFAs),[1–7] which further enhance the potential for real applications. Thanks to the inherent flexibility in materials design for synthetic semiconductors, an extensive library of promising organic semiconductors is available and is still growing rapidly.[8,9] With advances in NFAs,[10,11] there is still a large opportunity to further improve the PCE in combination with existing and newly developed donor materials. Optimization of bulk-heterojunction (BHJ) OPVs toward excellent device performance and stability is a multi-dimensional parameter space exploration, which requires significant effort and time in order to fully understand the potential of a given material system. Experimentally investigated parameters, which are filtered through physical insights, are several orders of magnitude less than a full parameter space spanned by the possible process and material variations, nevertheless, a significant amount of parameter variations is demanded for optimization.

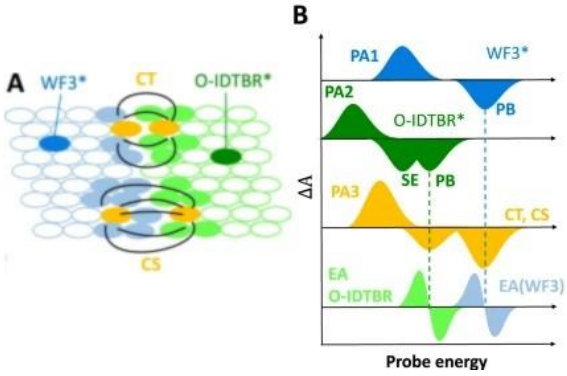
Context & Scale

Evaluating the potential of OPV materials and devices for industrial viability is a multi-dimensional, large parameter space exploration. Manual experimentation is extremely limited in throughput and reproducibility. Automated platforms for fabricating and characterizing functional devices have the potential to accelerate experimentation speed with precise process control. Here, we demonstrate a multi-target evaluation of OPV materials at the full-device level with an automated platform called "AMANDA Line One." Over 100 processing variations are automatically screened, which allows a reliable evaluation in terms of efficiency and photostability. The high-quality dataset enables a promising prediction of performance with Gaussian process regression. The platform and methodology can be generalized to broad research areas including, but not limited to, other solution-processed PV technologies, light emitting diode, photodetectors, and transistors.

i-MEET is developing transparent and efficient organic and perovskite solar modules for window integration in a European project consortium with 8 partners from 7 European countries – CITYSOLAR

Transparent photovoltaics (TPV) possesses a huge untapped potential in the harvesting of solar energy where it readily can be embedded in buildings applications worldwide. TPV will increase the utilization of renewable energy directly where it is needed and play a crucial role for the sustainable transformation of the energy sector in large cities. In the CITYSOLAR project, a new breakthrough concept for TPV will be developed by exploiting the combined use of emerging technologies, namely multi-junction solar modules developed from near-ultraviolet perovskite and near-infrared organic solar cells. CITYSOLAR brings together world-leading European academic and industrial players, some with key intellectual property, together with two non-EU partners belonging to Mission Innovation countries specialized in the synthesis of advanced materials for hybrid and organic solar cells. The consortium will develop highly efficient and transparent solar cells and modules to increase the performance of available TPV technologies by 50%, and via innovative integration schemes present a route for its use in building integrated PV (BIPV) applications.

Nicola´s work on unravelling the impact of energy aligned interfacial states lines out how to further improve organic solar cells



Nicola (and many colleagues) combine device and spectroscopic data to model the thermodynamics of charge separation and extraction, revealing that the relatively high performance of the devices arises from an optimal adjustment of the CT state energy, which determines how the available overall driving force is efficiently used to maximize both exciton splitting and charge separation. The model proposed is universal for donor:acceptor (D:A) with low driving forces and predicts which D:A will benefit from a morphology optimization for highly efficient OSC.

nature COMMUNICATIONS

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Adjusting the energy of interfacial states in organic photovoltaics for maximum efficiency

Nicola Gasparini[1,2,14✉], Franco V. A. Camargo[3,14], Stefan Frühwald[4], Tetsuhiko Nagahara[3,5], Andrej Classen[2], Steffen Roland[6], Andrew Wadsworth[7], Vasilis G. Gregoriou[8,9], Christos L. Chochos[8,10], Dieter Neher[6], Michael Salvador[11], Derya Baran[11], Iain McCulloch[7,11], Andreas Görling[4], Larry Lüer[2✉], Giulio Cerullo[3] & Christoph J. Brabec[2,12,13✉]

A critical bottleneck for improving the performance of organic solar cells (OSC) is minimising non-radiative losses in the interfacial charge-transfer (CT) state via the formation of hybrid energetic states. This requires small energetic offsets often detrimental for high external quantum efficiency (EQE). Here, we obtain OSC with both non-radiative voltage losses (0.24 V) and photocurrent losses (EQE > 80%) simultaneously minimised. The interfacial CT states separate into free carriers with ≈40-ps time constant. We combine device and spectroscopic data to model the thermodynamics of charge separation and extraction, revealing that the relatively high performance of the devices arises from an optimal adjustment of the CT state energy, which determines how the available overall driving force is efficiently used to maximize both exciton splitting and charge separation. The model proposed is universal for donor:acceptor (D:A) with low driving forces and predicts which D:A will benefit from a morphology optimization for highly efficient OSC.

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OPV roadmap

Photovoltaic technologies emerge rapidly and fascinates us more and more entering our daily life in different aspects. The perspectives of organic photovoltaics as flexible, colourful and semi-transparent modules available ubiquitously discussed by Christoph Brabec, Andreas Distler and Hans-Joachim Egelhaaf in “The 2021 flexible and printed electronics roadmap”. The roadmap issue was coordinated by Ronald Österbacka from Pritzker School of Molecular Engineering, University of Chicago allows us to feel the heartbeat of the latest progress and trends in different fields of the printed electronics.

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Flexible and Printed Electronics

ROADMAP

The 2021 flexible and printed electronics roadmap

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Keywords: flexible and printed electronics, roll-to-roll printing, organic light emitting diodes, organic photovoltaics, thin film transistors, sensors, e-textiles

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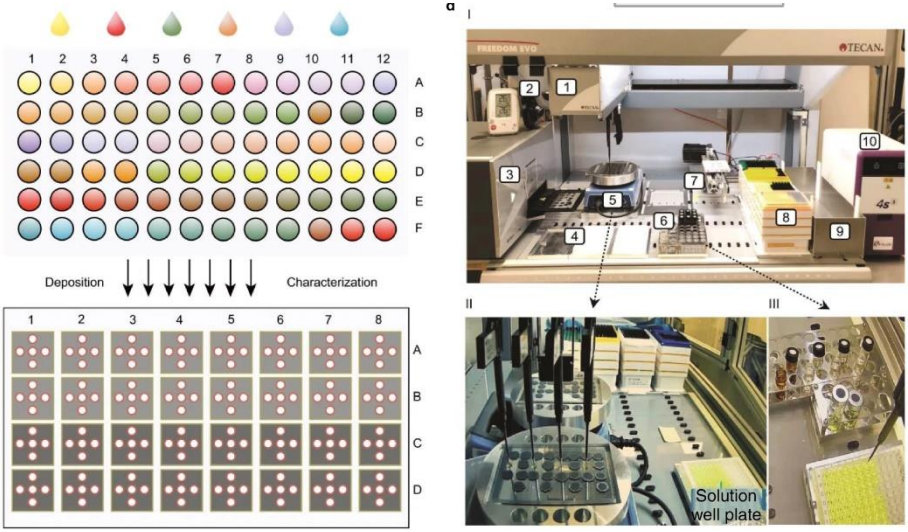
Abstract

This roadmap includes the perspectives and visions of leading researchers in the key areas of flexible and printable electronics. The covered topics are broadly organized by the device technologies (sections 1–9), fabrication techniques (sections 10–12), and design and modeling

Yicheng's article on high-throughput robotic learning of hybrid perovskite materials featured by the Nature Communications!



Yicheng's article "Discovery of temperature-induced stability reversal in perovskites using high-throughput robotic learning" published in Nature Communications is highlighted as the Featured article! The Editors' Highlights pages aim to showcase the 50 best papers recently published in an area.

Yicheng et al. use a high-throughput robotic platform, combined with machine learning, such as correlation analysis, model regression and SHAP evaluation to study the stability of organic-inorganic hybrid perovskite materials with mixed cations (K/Rb/Cs/MA/FA-PbI3). The effect of the ratio of organic cations (MA/FA) and inorganic cations (Cs/Rb) on the stability of chalcogenide was found to be significantly dependent on the aging temperature. At high temperatures (> 100 °C), the doping of inorganic cations improves the photothermal stability of the films, while the doping of organic cations reduces the photothermal stability of the films; at low temperatures (< 100 °C), this effect is evidently reversed. Further theoretical studies show that this stability inversion is caused by differences in the kinetic constants and kinetic activation energies in decomposition. Since the majority of perovskite-based devices operate at <100 °C, it is recommended that photothermal stable FAPbI3-based perovskite materials should be doped with at least 10 mol.% MA and at most 5 mol.% Cs/K/Rb.

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ARTICLE

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Discovery of temperature-induced stability reversal in perovskites using high-throughput robotic learning

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Stability of perovskite-based photovoltaics remains a topic requiring further attention. Cation engineering influences perovskite stability, with the present-day understanding of the impact of cations based on accelerated ageing tests at higher-than-operating temperatures (e.g. 140°C). By coupling high-throughput experimentation with machine learning, we discover a weak correlation between high/low-temperature stability with a stability-reversal behavior. At high ageing temperatures, increasing organic cation (e.g. methylammonium) or decreasing inorganic cation (e.g. cesium) in multi-cation perovskites has detrimental impact on photo/thermal-stability; but below 100°C, the impact is reversed. The underlying mechanism is revealed by calculating the kinetic activation energy in perovskite decomposition. We further identify that incorporating at least 10 mol.% MA and up to 5 mol.% Cs/Rb to maximize the device stability at device-operating temperature (<100°C). We close by demonstrating the methylammonium-containing perovskite solar cells showing negligible efficiency loss compared to its initial efficiency after 1800 hours of working under illumination at 30°C.

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Concepts and Strategies towards Energy Autonomous Mobility

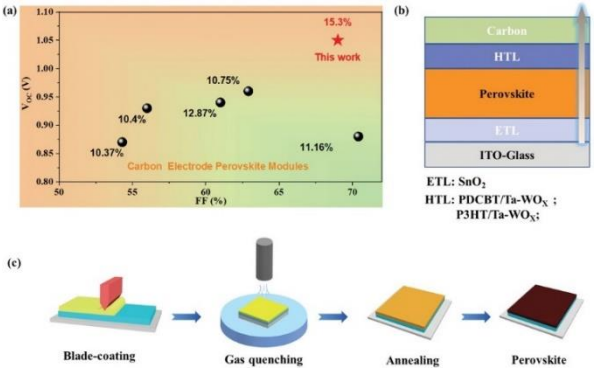
Only few years ago, the concept of autonomously driving cars has been regarded as a science fiction scenario which never will leave the halls of Hollywood. But, by today, first autonomous cars are driving on our roads, thanks to rapid development of the camera and sensor technology as well as to enormous progress in artificial intelligence (AI) and machine learning (ML). But autonomous technologies should not be only understood as "autonomously driving". Instead, the concept of autonomous mobility has to be extended towards energy autonomy.

At most promising aspect of energy autonomous mobility was recently demonstrated by our model blimp. Hans Egelhaaf and his team have equipped a zeppelin with light weight organic solar cells to power the battery storage and to explore the correlation between sun hours and energy autonomous flight duration. Christoph Pflaum and his team from the department of computational science has developed an algorigthm to calculate the optimum flight path for a solar powered blimp, maximizing sun hours and exploiting wind conditions. The FAU solar blimp is a first example that interdisciplinary innovation will be the driving force towards truly energy autonomous mobility

iMEET's "Solar Factory of the Future" on the Bavarian Future Council's OnlineCongress "Climate 2030. Sustainable Innovations."

The head of the Solar Factoy of the Future PD Dr Hans-Joachim Egelhaaf took part in the Bavarian Future Council's OnlineCongress "Climate 2030. Sustainable Innovations. He explained how printed photovoltaics is produced, why it offers unique advantages for building integration and how it will turn urban areas into hot spots of renewable energy production. The video is present on the i-MEET homepage.

Solarfactory of the Future (SFF) demonstrates fully printed Perovskite modules with over 15 % PCE and remarkable environmental stability



Fu and Hans from the SFF are taking perovskite processing to the next level. After having demonstrated that printed Carbon electrodes are the most interesting alternative to evaporated or sputtered top electrodes, Fu optimized the perovskite layer and was able to align the interfaces between the absorber and the HTL such that he achieved a cell PCE of over 18 % and a module PCE of 15 % for all solution processed devices. Devices stored outside did not change performance at all during a monitoring period of almost one year (5000 hrs). To continue the technology development from our previous work we selected an MA based perovskite for this work, well knowing that MA based precursors with a content of > 20 % tend to temperature instabilities. The next major objective for the SFF will be to demonstrate modules with these efficiencies which are equally stable for 1000 hrs under 85 °C!

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Low Temperature Processed Fully Printed Efficient Planar Structure Carbon Electrode Perovskite Solar Cells and Modules

Fu Yang, Lirong Dong, Dongju Jang, Begench Saparov, Kai Cheong Tam, Kaicheng Zhang, Ning Li, Christoph J. Brabec, and Hans-Joachim Egelhaaf**

Scalable deposition processes at low temperature are urgently needed for the commercialization of perovskite solar cells (PSCs) as they can decrease the energy payback time of PSCs technology. In this work, a processing protocol is presented for highly efficient and stable planar n–i–p structure PSCs with carbon as the top electrode (carbon-PSCs) fully printed at fairly low temperature by using cheap materials under ambient conditions, thus meeting the requirements for scalable production on an industrial level. High-quality perovskite layers are achieved by using a combinatorial engineering concept, including solvent engineering, additive engineering, and processing engineering. The optimized carbon-PSCs with all layers including electron transport layer, perovskite, hole transport layer, and carbon electrode which are printed under ambient conditions show efficiencies exceeding 18% with enhanced stability, retaining 100% of their initial efficiency after 5000 h in a humid atmosphere. Finally, large-area perovskite modules are successfully obtained and outstanding performance is shown with an efficiency of 15.3% by optimizing the femtosecond laser parameters for the P2 line patterning. These results represent important progress toward fully printed planar carbon electrode perovskite devices as a promising approach for the scaling up and worldwide application of PSCs.

1. Introduction

Even though a high power conversion efficiency (PCE) of 25.5% has been reported for organometallic halide perovskite solar cells (PSCs), successful commercialization of this photovoltaic technology still lacks large-scale manufacturing methods which on one hand significantly reduce the production cost of PSCs and on the other hand do not cause a substantial loss of efficiency.[1] Besides high efficiency and longevity, cost competitive PSCs must meet two further essential requirements: they must not contain expensive materials and they must be processed by high-throughput sheet-to-sheet (S2S) or roll-to-roll (R2R) processes with low capex and low operating cost.[2]

Reducing the bill of materials (BOM) is essential, as most efficient lab-size PSCs comprise noble metal electrodes (e.g., gold and silver) and expensive hole transport materials (e.g., spiro-OMeTAD), which dominate the material costs and are thus not acceptable for large-scale applications.[3] Furthermore, thermally evaporated gold and silver electrodes cause significant energy consumption and thus limit the energy payback time of the photovoltaic technology. Even worse, they deteriorate cell performance, due to migration of halogen atoms from the perovskite layer to form gold and silver halides.[4] Therefore, carbon has been employed as the counter electrode, reducing material cost, improving device stability, simplifying the device fabrication process, and thus, enabling large-scale processing of PSCs.[5]

In addition to reducing the BOM, sheet-to-sheet and especially roll-to-roll printing processes are proven to reduce production costs compared to vacuum-based processes. Thus, up-scalable manufacturing technologies for PSCs must be fully compatible to

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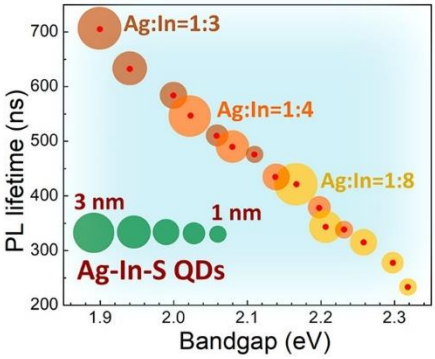
Oleksandr demonstrates the power of our high throughput transient PL setup



Oleksandr investigated brightly luminescent, composition- and size-selected aqueous Ag–In–S (AIS) and core/shell AIS/ZnS (ZAIS) quantum dots (QDs) by high-throughput time-resolved photoluminescence (TRPL). Both QD size and QD composition effects were probed independently by using an automated high-throughput TRPL setup. Linear relationships were found between the average PL lifetimes of AIS and ZAIS QDs and their respective bandgaps (Eg). This is a strong indication that the dynamics of radiative recombination is governed by the energetics of the QD excited state irrespective of which factor is affecting the QD bandgap, i.e., their size or composition

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Article

High-Throughput Time-Resolved Photoluminescence Study of Composition- and Size-Selected Aqueous Ag−In−S Quantum Dots

Oleksandr Stroyuk,* Oleksandra Raievska, Christian Kupfer, Dmytro Solonenko, Andres Osvet, Miroslaw Batentschuk, Christoph J. Brabec, and Dietrich R. T. Zahn

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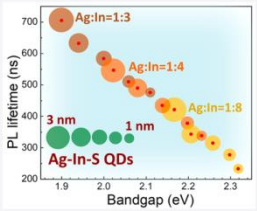
ABSTRACT: Brightly luminescent, composition- and size-selected aqueous Ag−In−S (AIS) and Zn-diffused core/shell AIS/ZnS (ZAIS) quantum dots (QDs) were studied by high-throughput time-resolved photoluminescence (TRPL). Both QD size and QD composition effects on the photophysical properties of AIS (ZAIS) were probed independently by using an automated high-throughput TRPL setup. Linear relationships were found between the average PL lifetimes of AIS and ZAIS QDs and their respective bandgaps (E_g) indicating that the dynamics of the radiative recombination is governed mostly by the energy of the QD excited state irrespective of which factor is varied affecting the QD bandgap, i.e., their size or composition. The rate constants of radiative and nonradiative recombination were evaluated as a function of E_g forming continuous dependences for the entire AIS and ZAIS QD families. The rate of nonradiative recombination increases steeply for smaller QDs with E_g > 2.2 eV for both core AIS and core/shell ZAIS QDs, indicating that the interfacial electron transfer is the major contributor to the observed dependence. A strong decrease of the PL lifetime of AIS (and ZAIS) QDs in dense QD films or QDs incorporated into polyvinylpyrrolidone films was observed as compared to colloidal solutions. A reversible character of this effect upon polymer film dissolution shows that such behavior originates from energy (or electron) transfers among the QDs brought into close contact in the films. This phenomenon is expected to be of significance for the application of ternary QDs as a light-harvesting material.



INTRODUCTION

Ternary indium-based metal−chalcogenide nanocrystals (NCs), such as $CuInS_2$ (CIS) or $AgInS_2$ (AIS), reveal an unprecedented variability of composition, morphology, and properties that has no analogues among traditionally studied binary chalcogenide NCs.[1−6] This variability stems from a uniquely high tolerance of the lattice of ternary NCs to large deviations from stoichiometry as well as to doping and substitutions.[2,3] Each of the three components of the ternary QDs can be subject to substitutions, for example copper for silver or mercury, indium for gallium, and sulfur for selenide, resulting in a broad gamut of compositions even for the cases of stoichiometric chalcopyrite compounds. Additionally, the chalcopyrite structure remains largely stable and unchanged upon broad variations in M^I to In^{III} and M^I to X ratios (M^I = Cu, Ag, X = S, Se). At that, the strongly nonstoichiometric CIS and AIS compounds often demonstrate much superior functional (luminescent, photochemical, electrochemical, etc.) properties as compared to the stoichiometric counterparts.[2,3] For each particular QD composition and stoichiometry, additional doping can be performed to further tailor the optical and electronic properties of the ternary compounds. In particular, CIS and AIS core NCs are inadvertently doped with Zn^{II} when a ZnS shell is deposited onto ternary cores, resulting in a modification of spectral responses and photophysical behavior.[1−3,7] Copper doping and substitution allows the spectral sensitivity range in AIX NCs[1,3,8] to be tuned.

In the case of NCs revealing size-dependent electronic properties, quantum dots (QDs), the above-discussed variability is further expanded by the possibility of affecting the QD properties via changing their size at a constant composition.[2,3] The current state-of-the-art in the colloidal synthesis of CIS, AIS, and related QDs, both in organic media and in aqueous solutions, allows a reliable control over the size and size distributions of ternary QDs to be achieved. This control can further be extended by applying postsynthesis treatments, such as size-selective precipitation or various kinds of size-selective etching.[3]

Based on modern synthetic protocols, a large array of nanoobjects with strongly different optical and electronic properties can be produced even within a sole composition.

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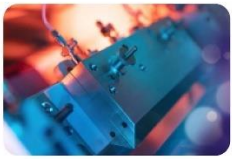
Exciting world of organic photovoltaics – research in the Solarfactory of the future



The exciting world of organic photovoltaics
ZAE Bavaria / Friedrich-Alexander-University Erlangen-Nürnberg

In addition to basic research, field application is a major cornerstone in research activity. One very special project carried out in collaboration with Energie Campus Nürnberg and ZAE is the Zeppelin. It was launched as a student project and is intended to monitor solar parks in the future using infrared cameras and identify faulty modules. The Zeppelin will autonomously fly over the solar park and then automatically evaluate the collected data. The video about the project are available in both English and German, don't hesitate to take a look at our homepage!

Let's "drain" our sun!

Thanks to our colleagues Julian and Vanessa, we can enjoy this interesting video clip. "Let's "drain" our sun!" is a video that was presented on the WW-internal "Science Slam" on this year's digital Sommerfest. The main topic of the video is transparent solar cells or selective absorbers and their different applications in energy production. The video is available at i-MEET homepage.

FAIRmat: A Treasure Box of Material Data

FAU is involved with two projects in the FAIRmat project, which was approved on Friday, 2 July 2021 by the Joint Science Conference (GWK) in a multi-stage competition of the National Research Data Infrastructure (NFDI). The project will receive funding to build an infrastructure that makes it possible to make materials science data FAIR: findable, accessible, interoperable and re-purposable. This will enable researchers in Germany and beyond to store, share, find and analyse data over the long term. During the five-year term, a total of 60 project leaders from 34 German institutions will work together in the FAIRmat consortium.

The findings from condensed matter physics, chemistry and materials science have a decisive impact on the wealth and lifestyle of our society: new products and goods in the fields of energy, environment, health, mobility and IT depend on improved or even novel materials. The enormous amounts of research data produced daily in these scientific fields are therefore a treasure of the 21st century. However, this treasure is worth little if the data is not comprehensively described and made available. How can we refine this raw material, i.e. turn the data into knowledge and value? For this, a FAIR data infrastructure is a must.

This is where FAIRmat (“FAIR Data Infrastructure for Condensed-Matter Physics and the Chemical Physics of Solids”) comes in. By setting up a FAIR research data infrastructure for the above-mentioned fields, the consortium aims to recover the treasure of material data and thus contribute to a fundamental change in science and research. FAIRmat’s deputy spokesperson Matthias Scheffler from the Fritz Haber Institute of the Max Planck Society explains: “We interpret the acronym FAIR in a future-oriented way: Research data should be discoverable (Findable) and ready for Artificial Intelligence (Artificial-Intelligence Ready). This new perspective will

advance scientific culture and practice. It will not replace scientists – but researchers who use such a FAIR infrastructure can replace those who don't."

FAU is active in the FAIRmat consortium with two projects. Prof. Heiko B. Weber and Dr. Michael Krieger from the Department of Applied Physics, together with Heinz Junkes from the Fritz Haber Institute in Berlin, are developing a universal and easy-to-configure software environment for measurement data acquisition and documentation. "In our field of research, measurement set-ups with numerous special measurement devices are often required – each adapted to the experimental problem," explains Prof. Weber. "This diversity requires adaptable and easy-to-configure software for experiment control and data acquisition." But it's not just about the raw data. The experiment description including all settings of the laboratory equipment used, the so-called metadata, is also necessary. This is the only way to document the experiment completely and FAIR, and the valuable measurement data can also be used by other scientists. "We have already been using prototype software for experiment control with uniform and documented data output developed by us for years," says Dr Krieger. "In the FAIRmat project, we will bring this successful concept together with the open-source Experimental Physics and Industrial Control System (EPICS), which will take over the recording of data and metadata, storage, archiving and provision of research data in accordance with the standards to be developed in FAIRmat."

In the second sub-project at FAU, Prof. Christoph Brabec from the Chair of Materials Science, who also heads high-throughput photovoltaic research at the Helmholtz Institute Erlangen – Nuremberg as Director of the Jülich Research Centre, will test, apply and further develop FAIRmat data collection in the field of semiconductors for optoelectronic applications in practice together with Dr. Thomas Unold from the Helmholtz Zentrum Berlin. Prof. Brabec: "The goal is to build up a material encyclopaedia by means of automated and, in future, autonomous laboratories. With the help of the FAIR principle in data and metadata processing, optimisation algorithms of machine learning can directly access the data and suggest and also execute new experiments or tests in real time. Using optoelectronics as an example, the aim is to discover and research highly efficient, cost-effective and non-toxic semiconductors with optimal properties for devices and systems for the generation and conversion of renewable energy."

The FAIRmat consortium is part of the National Research Data Infrastructure (NFDI). The NFDI is a nationwide network currently being set up and funded by the federal and state governments with up to 90 million euros per year from 2019 to 2028 to systematically manage research data.

FAIRmat covers a broad spectrum of research areas in physics and related fields, and the basic concepts and measurement techniques, working methods and research data are correspondingly diverse and heterogeneous. Here, the need for a FAIR data infrastructure is extremely urgent. FAIRmat promotes the efficient sharing of research data (sharing is caring!) and its preparation for reuse and analysis by artificial intelligence (AI) tools. In this way, FAIRmat enables a new level and quality of science.

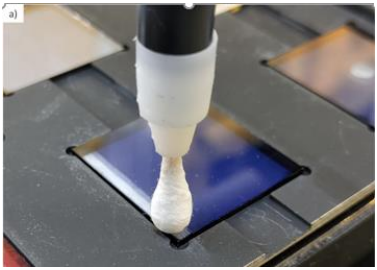
In doing so, the consortium is pursuing a bottom-up approach that is oriented towards the needs of scientists and is already receiving great support from the community. For example, FAIRmat is just as well integrated into the Condensed Matter Section of the German Physical Society as it is into the Max Planck Society (e.g. Big Data Network, CPTS), and into a large number of universities and institutes as well as international activities.

"Of course, we are now looking for highly motivated scientists from domain sciences and IT who share our enthusiasm for a paradigm shift in fundamental materials science to join our team and realise the FAIRmat principles together," says FAIRmat's spokesperson Claudia Draxl.

To learn more about FAIRmat, visit https://www.fair-di.eu/fairmat

To become part of the FAIRmat team, visit: https://nomad-lab.eu/career To learn more about the NFDI, visit ww.dfg.de/nfdi

Jerrit shows the power of automation for solar cell research with AMANDA



Jerrit discusses the vision of Materials Acceleration Platforms and AMANDA and shows the advantages of an automated and integrated system. As an example, PM6:Y6 bulk-heterojunction system was optimized in air and achieved efficiencies for ambient atmosphere processing of up to 13.7% under AM1.5 illumination.

J Mater Sci (2021) 56:16422–16446

Computation & theory

The evolution of Materials Acceleration Platforms: toward the laboratory of the future with AMANDA

Jerrit Wagner[1,2,*], Christian G. Berger[1,2], Xiaoyan Du[1,2], Tobias Stubhan[3], Jens A. Hauch[1,2,*], and Christoph J. Brabec[1,2]

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ABSTRACT

The development of complex functional materials poses a multi-objective optimization problem in a large multi-dimensional parameter space. Solving it requires reproducible, user-independent laboratory work and intelligent preselection of experiments. However, experimental materials science is a field where manual routines are still predominant, although other domains like pharmacy or chemistry have long used robotics and automation. As the number of publications on Materials Acceleration Platforms (MAPs) increases steadily, we review selected systems and fit them into the stages of a general material development process to examine the evolution of MAPs. Subsequently, we present our approach to laboratory automation in materials science. We introduce AMANDA (Autonomous Materials and Device Application Platform - www.amanda-platform.com), a generic platform for distributed materials research comprising a self-developed software backbone and several MAPs. One of them, LineOne (L1), is specifically designed to produce and characterize solution-processed thin-film devices like organic solar cells (OSC). It is designed to perform precise closed-loop screenings of up to 272 device variations per day yet allows further upscaling. Each individual solar cell is fully characterized, and all process steps are comprehensively documented. We want to demonstrate the capabilities of AMANDA L1 with OSCs based on PM6:Y6 with 13.7% efficiency when processed in air. Further, we discuss challenges and opportunities of highly automated research platforms and elaborate on the future integration of additional techniques, methods and algorithms in order to advance to fully autonomous self-optimizing systems—a paradigm shift in functional materials development leading to the laboratory of the future.

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Springer

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Organic solar modules in the permanent exhibition of the Deutsches Museum Nuremberg

The German Museum Nuremberg – The Museum of the Future was ceremoniously opened in Nuremberg's Old Town on 17.09.2021. Through many hands-on activities, visitors gain an exciting insight into the future of technology and society. The museum is divided into five thematic areas:

1 Work and everyday life

2 Body and Mind

3 System City

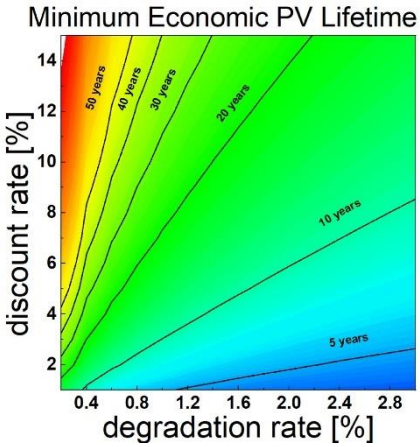
4 System Earth

5 Space and Time

The Nuremberg Energy Campus is also represented in the Deutsches Museum Nuremberg. The pioneering printed organic solar modules from the solar factory of the future are represented in the museum with their own exhibits. Visitors can test how much light can be converted into energy and how the different colors of the solar modules affect energy conversion. The solar modules can be seen in the System Earth area.

The installation on the left consists of a Si-module and 3 organic modules of different colors. By switching light sources of different colors on and off and by sliding different color filters in front of the modules, the effect of the absorption spectrum of the modules on the resulting power under specific illumination conditions can be investigated. The installation on the right consists of two organic PV modules with different transparencies. Upon illumination, the module with higher transparency provides less power, thus demonstrating the law of energy conservation.

Can photovoltaic modules operate continuously?



As photovoltaic applications and installations enter almost every aspect of daily life we need to ask ourselves „how to keep it working longer?“ And what is better, to exchange 20 years old module for the new one, or to invest in maintenance and keep the module running? Is it possible for the module to run for 40 or even 50 years? In his recent publication Dr. Ian Marius Peters answers these questions and introduces an economic steady-state model that supports the idea of systems operating continuously instead of operating for a fixed period.

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Joule

CellPress

Article

The value of stability in photovoltaics

Ian Marius Peters,[1,4,*] Jens Hauch,[1,2] Christoph Brabec,[1,2] and Parikhit Sinha[3]

SUMMARY

Warranties for photovoltaic modules last 25 years. The same duration is frequently used when predicting economic performance. Yet, many modules still produce more than 80% of their original power after 25 years, and there is no economic reason to retire them. Here, we adopt a different mindset: photovoltaic installations are operated indefinitely with maintenance at regular intervals. We reflect this view in a steady-state economic model. We find that in this view, maintenance gains in value—33% compared with a 30-year lifetime—and time constraints for maintenance are lifted. We also find that stability becomes even more important. Reducing annual degradation from 0.5% to 0.2% entails a 12 ct/Watt cost entitlement, increases the economically useful lifetime by a factor of 1.69, defers end of life by decades, and reduces resources and infrastructure needed for recycling by 40%. We foresee that modules installed today should ideally be operated for 50 years.

Context & scale

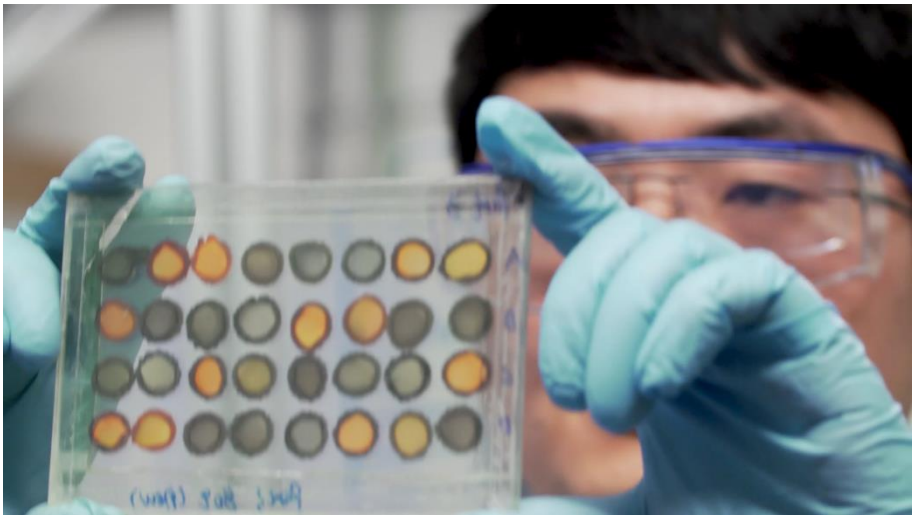
We explore the implications of adopting a long-term perspective about PV installations. At the end of the designated lifetime of a PV system, which is often assumed to be 25 or 30 years, many PV modules still operate at high fractions of their initial power. Economically, there is no reason to discontinue the operation of such modules, and even less so from a sustainability point of view. Here, we introduce an economic model for PV operation that assumes perpetual operation with maintenance at regular intervals. When adopting such a long-term view, we find that greater investments for keeping the installation in good shape pay-off compared with a mindset with limited lifetime. We also find that module stability becomes more important for economic evaluation. Inferior stability cannot be compensated by lower module prizes and can only be compensated by much higher efficiency. Finally, we predict that modules installed today should be operated for 50 years before they are replaced.

INTRODUCTION

When looking at projections of a photovoltaic (PV) system's lifetime, one will frequently encounter durations between 20 and 30 years. These durations are used, for example, when calculating the levelized cost of electricity (LCOE) or similar economic metrics. Probably the main motivation for assuming this lifetime is the performance warranty for PV modules given by manufacturers, which is usually 25 years today. In the early 2000s, the assumed system lifetimes of 20 years may also have been motivated by the Renewable Energy Source Act, which came into force in Germany on April 1st, 2000 and guaranteed a technology-specific feed-in tariff for 20 years for every kWh generated by a renewable electricity source.[1] A feed-in-tariff was already enacted in 1991 through the Electricity Feed-in Act, but only after the 2000 version, PV installations in Germany took off.[2] Performance warranties for PV modules were given since the late 1970s with Solarex providing a 1-year warranty on its products in 1977.[3] Within 20 years, warranties extended to 25 years, a value on which they have plateaued. Only recently, a few companies, such as Silfab and First Solar, have started to offer 30 years performance warranties.[4,5]

The duration of a performance warranty says little about performance reduction, and additional information about the guaranteed performance level of a solar panel at the end of life is needed. Guaranteed performance values for different manufacturers range from 80% to Sun Power's 94% of the original power after 25 years.[6] Furthermore, solar panels come with a product warranty in addition to the performance warranty. The product warranty specifies until when the manufacturer will ship a replacement in case of module failure. This warranty ranges between 5 and 25 years.[7] Figure 1 gives an overview of warranty durations and guaranteed performances. The measured performance of PV systems is in line with guaranteed PRs. Jordan et al.[8] compiled annual degradation rates for 384

Perovskite solar cell with ultra-long durability



Perovskites are the greatest hope for the solar modules of the future. Until now, the biggest obstacle for practical use has been the short lifetime. Yicheng and co-authors presented the solar cell that impresses with its extraordinary stability. The illuminated cell survived 1450 hours at elevated temperatures around 65 degrees Celsius in the
laboratory and remained largely stable throughout the entire test period! At the end, it still had 99 percent of the initial efficiency. “A long-term prognosis is always difficult. But the perovskite solar cell we have now developed could certainly be operated for over 20 000 hours under normal circumstances,” estimates Prof. Brabec. To find the right material, hundreds of different perovskite mixtures were systematically tested for their suitability using high-throughput methods. The researchers then used the best ones to build their cells.
“To improve stability at the contact point, we packed the entire electrode in a kind of protective shell,” says Yicheng. A new double-layer conducting polymer structure, the bottom side of which is undoped and the top side doped with a non-ionic dopant. On the one hand, this architecture protects the very sensitive interface of the perovskite and, on the other hand, enables extraordinarily stable ohmic contacts, even at elevated temperatures.

nature energy

ARTICLES

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A bilayer conducting polymer structure for planar perovskite solar cells with over 1,400 hours operational stability at elevated temperatures

Yicheng Zhao[1,2,5]✉, Thomas Heumueller[1,2,5], Jiyun Zhang[1,2,5], Junsheng Luo[2,3], Olga Kasian[2,4], Stefan Langner[1,2], Christian Kupfer[2], Bowen Liu[2], Yu Zhong[2], Jack Elia[2], Andres Osvet[2], Jianchang Wu[1], Chao Liu[2], Zhongquan Wan[3], Chunyang Jia[3], Ning Li[1,2], Jens Hauch[1] and Christoph J. Brabec[1,2]✉

The long-term stability of perovskite solar cells remains a challenge. Both the perovskite layer and the device architecture need to endure long-term operation. Here we first use a self-constructed high-throughput screening platform to find perovskite compositions stable under heat and light. Then, we use the most stable perovskite composition to investigate the stability of contact layers in solar cells. We report on the thermal degradation mechanism of transition metal oxide contact (for example, Ta-WO_x/NiO_x) and propose a bilayer structure consisting of acid-doped polymer stacked on dopant-free polymer as an alternative. The dopant-free polymer provides an acid barrier between the perovskite and the acid-doped polymer. The bilayer structure exhibits stable ohmic contact at elevated temperatures and buffers iodine vapours. The unencapsulated device based on the bilayer contact (with a MgF_2 capping layer) retains 99% of its peak efficiency after 1,450 h of continuous operation at 65 °C in a N_2 atmosphere under metal-halide lamps. The device also shows negligible hysteresis during the entire ageing period.

Planar heterojunction perovskite solar cells based on formamidinium-lead-iodide ($FAPbI_3$) perovskites is a promising photovoltaic technology[1–12]. State-of-the-art devices are based on mixed-cation, mixed-halide perovskite absorbers with delicate passivation, showing a T_{80} lifetime (the time required to lose 20% of the initial absorbance) greater than 1,000 h under illumination at 60–70 °C (refs. [1,4,6,7,9,13–17]). Unfortunately, the lifespan of planar heterojunction perovskite solar cells (PSCs) still lags far behind industrial silicon solar cells that guarantee a 0.5% annual degradation rate[18,19], particularly when working at elevated temperatures (60–85 °C) (refs. [1,6,15,20–30]). The instability mechanisms include ion migration, perovskite decomposition and so on[9,12,15,30–35]. Although ion migration is inevitable in perovskites, equilibrium ionic potential could terminate the ionic accumulation after several minutes or hours[12,30,31,35,36]; its negative impact on device performance can be minimized by adopting suitable electron transport layers (ETLs), hole-transport layers (HTLs) and so on[7,11,33,37–39]. The migration of ionic dopants in ETLs or HTLs can be removed using ionic dopant-free HTLs, such as acid-doped HTLs or metal oxides, as reported by our group and others[9,40–43]. Regarding the decomposition of the perovskite layer, compositional engineering is key to maximizing the energy barrier of perovskite decomposition. Although there are intensive studies on perovskite compositional engineering, a reliable conclusion remains hard to be drawn from the literature due to a large variation in processing/ageing conditions from lab to lab. With these understandings on device instabilities, longer-lasting planar perovskite solar cells can be achieved only by a holistic stabilization strategy that considers both stable perovskite films and robust device architectures.

Here we report ultra-stable planar perovskite solar cells using a bilayer conducting polymer-based architecture together with stable perovskite absorbers. Stable perovskites are obtained by high-throughput screening of 160 kinds of perovskites with graded screening criteria. The whole device architecture is composed of indium tin oxide (ITO)/ETL/perovskite/dopant-free polymer/acid-doped polymer/Au. Dopant-free polymers inhibit the unfavourable acid attack on the perovskite surface caused by acid-doped polymers; meanwhile, acid-doped polymer serves as an interconnection layer for efficient and stable ohmic contacts with metal electrodes owing to its high conductivity. Combined with a stable perovskite layer, we finally realized a stabilized efficiency of 20.9% for planar heterojunction devices that retain nearly 99% ± 3% of their initial efficiency and 97% ± 3% of their peak efficiency, statistically, after 1,250 h of continuous operation at 60–65 °C under metal-halide lamps. By further sealing the device with MgF_2 using thermal evaporation, the device retains nearly 100% ± 1% of its peak efficiency, statistically, after 1,450 h of continuous work at 65 °C, representing some of the best stability data for n–i–p planar perovskite solar cells.

High-throughput screening for stable perovskites

Considering stable perovskite absorbers are prerequisites for stable PSCs, we first screened 160 kinds of perovskite compositions for photothermal-stable perovskites using our robotic system[44–46]. The schematic of the automated platform, which is capable of

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Congratulations to our colleagues with their PhD defenses

Many i-MEETers have passed their PhD examinations during the 2021 with excellent success and already have made the first step in the professional career. We've shared together this exciting moment that summarized around 4 years of their intensive research and hard work. We cordially congratulate Matthias Arzig (*Untersuchung der Wachstumskinetik von SiC mithilfe der in-situ Computertomographie des Gasphasenkristallisationsprozesses und der Modellierung der Wachstumsbedingungen*), Seyed Amir Hashemi Jazi (*A contactless Solid Surface Temperature Determination Using Phosphor Thermometry)* and Michael Schöler (*Sublimationswachstum von 3C-SiC Einkristallen auf freistehenden 3C-SiC Keimschichten)* for successfully finishing their PhD studies.

Matthias Arzig

Seyed Amir Hashemi Jazi

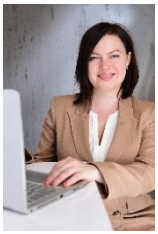
Michael Schöler

Within the last five years **André** worked on developing the fundamental imaging techniques allowing to identify the vertical position of a defect in a thin film solar cell. Most importantly, Andre demonstrated that his methodology can uniquely assign a defect to a specific layer of a solar cell, and thus distinguish whether defect-assisted lossed origin from the bulk or the interface layer. Further scientific impact was created by successfully extending his technique towards tandem solar cells and, in an outlook, to modules as well. He competed the thesis with a remarkable defense and received the best possible grades. André's PhD work, titled "Imaging of artificial defects in organic solar cells" will be

published online via FAU´s PhD database degradation phenomena with water ingress during inline measurements.

Yakun successfully finsihed her PhD with a most impressive exam this Friday, 12.11 with excellent grades! During her thesis Yakun worked her thesis on the so called “double cable materials” or “single component organic solar cells”, where the donor and acceptor are covalently linked to each other, allowing to surpass macroscopic phase separation in thin film composites. Yakun recognized the major benefits of these systems engineered corresponding device architectures which allowed her to surpass the current records in stability for organic solar cells. For the exam, Yakun invited Prof. Serdar Sariciftci and Prof. Rene Janssen, who are among the pioneers of the double cable concept, dating back to the first European project on organic photovoltaics from 1998 to 2001. Prof. Dirk Guldi, Prof. Wolfgang Heiss and myself completed the prominent expert examination committee. Having such a number of world-wide leading experts in the committee is a huge challenge for a PhD candidate, and I am very proud to say that Yakun mastered this challenge in the best possible way! Chapeau, Yakun!

Welcome to the family!



Dr. Olga Kasian

Dr. Olga Kasian, research associate and head of the junior research group “Material Transformations in Electrocatalysis” at HI-ERN and Helmholtzcenter Berlin (HZB), has joined i-MEET in 2021 as University Professor of Materials for Electrochemical Energy Conversion.

We are also happy to welcome Dr. Maria Hammer and Dr. Vincent Marc Le Corre

Dr. Maria Hammer

Dr. Vincent Marc Le Corre

PhD students

Vanessa Arango

Ecem Aydan

Ezgi Nur Güler

YingLok Lee

Zijian Peng

Juan Sebastian Rocha Ortiz

Abdus Saboor

Fahimeh Shahvaranfard

Qian Xie

Difei Zhang

Shuyu Zhou

At the same time Yicheng Zhao and Mykhailo Sytnyk joined HI ERN, and André Karl joined IEK-9, Fundamentals of Electrochemistry at the Research Centre Jülich. Shuai Gao, Niall Killilea, Johannes Köhler, Li Nian left.

Shuai Gao

Dr. André Karl

Niall Killilea

Johannes Köhler

Dr.-Ing. Ulrike Künecke

Dr. Li Nian

Dr. Mykhailo Sytnyk

Dr. Yicheng Zhao

4. Bachelor Theses

Burak Baydar (Egelhaaf)
Hochdurchsatzoptimierung gedruckter Solarzellen mittels Rolle-zu-Rolle-Verfahren

Lara Kefer (Egelhaaf)
From Organic Photovoltaic Cells to Modules – Evaluation and Simulation of the Different Loss Mechanisms

Matthias Mai (Batentschuk)
Untersuchung von Photovoltaikmodulen mit Zellrissen bei Vibrations- und zyklischen Belastungen

Benedict Hanisch (Brabec/Li/He)
Characterization of the Exciton Splitting Efficiency of Single-Component Materials of Organic Photovoltaic Applications

Julian Zöcklein (Brabec/Buerhop-Lutz/Stroyuk)
Wet leakage insulation behaviour of water exposed Silicon PV modules with different backsheet materials

Lewin Leihkamm (Brabec/Buerhop-Lutz/Stroyuk)
Spectroscopic analysis of water ingress in polymer components of photovoltaic modules

Christian Gold (Batentschuk, Lehrstuhl für Elektronische Bauelemente)
Entwicklung eines chemisch-mechanischen Polierverfahrens von Aluminiumnitridscheiben für die Epitaxieherstellung

Claudia Heinzl (Batentschuk, Lehrstuhl für Kristallographie und Strukturphysik)
Untersuchung des Einflusses der Oberflächenrauigkeit auf die Reflexpositionen bei Röntgendiffraktometrie unter streifendem Einfall

5. Master Theses

Ezgi Nur Güler (Egelhaaf)
Development of solution processable bottom electrodes for OPV modules

Lena Merz (Egelhaaf)
Manufacturing dielectric mirrors from the liquid phase – transfer from spin-coating to roll-to-roll slot die coating

Kaushik Senguttuvan (Egelhaaf)
Investigations into the energy recovery potential of glass facade and window-integrated PV

Laura Manuel (Wellmann/Freund)
Synthesis of the Chalcogenide Perovskite $BaZr(SxSe_{1-x})_3$ Using Electrodeposition

Michael Kellner (Wellmann/Freund)
Untersuchung der Phasenbildung von BaZrS3 mithilfe der Dynamischen Differenzkalometrie und der thermogravimetrischen Analyse

Valerie Levine (Brabec/Heumüller)
Automated Data Evaluation for Screening Novel OPV Materials

Lena Merz (Egelhaaf)
Manufacturing dielectric mirrors from the liquid phase – transfer from spin-coating to roll-to-roll slot die coating"

Ezgi Nur Güler (Brabec/ Egelhaaf/Distler)
Development of solution-processed bottom electrodes for OPV modules

Adrian Valenas (Brabec/ Lüer)
Reversible performance degradation in perovskite solar cells

Mikołaj Piotrowski (Brabec/ Lüer/ Osvet)
Photoluminescence study of recombination mechanisms in methylammonium lead iodide

Sophie Mull (Brabec)
Optimierung der Fertigungslinie der CAL4 -Diode mittels automatischer optischer Inspektion

Christian Huse (Brabec/ Hepp)
Electrical characterisation and imaging of potential induced degradation in intentionally contaminated silicon solar cells

Simon Hassel (Heiss)
Evaluierung der Potentialverteilung auf der Metallisierung von Leistungshalbleitern unter Berücksichtigung von Alterungsvorgängen im aktiven Lastwechsel

Robin Basu (Heiss)
Solar cells from lead sulfide quantum dots

Dominik Glaser (Heiss)
Untersuchung der Porosität in Sinterschichten in Abhängigkeit des Sinterprozesses und der Sintermaterialien und deren Einfluss auf die Folgeprozesse

Darius Hoffmeister (Brabec/Daum)
A nanoparticle-based coating method for layer-by-layer structuring of highly efficient organic solar cells

Tobias Osterrieder (Brabec/ Heumüller)
Investigation and Optimization of quaternary Organic Solar Cells by utilizing HTE and Bayesian Optimizer in a semi-autonomous laboratory approach

Felix Schröder (Heiss)
Synthetic Image Augmentation in Through Hole PCB Assembly via Deep Generative Models

Yao Guan (Brabec/Lüer)
Machine Learning Assisted Fast Measurement of Transient Absorption Kinetics

Sven Strüber (Wellmann/Steiner)
Topographische Charakterisierung der Defektverteilung in 4H-SiC Halbleiterscheiben mithilfe von KOH-Defektätzen und zerstörungsfreien optischen Messmethoden

Manuel Materna (Wellmann)
Entwicklung einer Messmethodik für die Bestimmung der Reaktionskinetik von Gas-Feststoffreaktionen bei Temperaturen bis zu 2500°C

6. Doctoral Theses

Doctoral Theses in Preparation

Ali, Amjad (Batentschuk, i-MEET)
Developement of phosphors for light conversion in solar panels

Arango Marin, Vanessa (Brabec/Hauch, i-MEET)
Development of a high throughput screening routine for printed photovoltaics

Berger, Christian (Brabec, ZAE)
IT systems and infrastructure for the world wide materials genome

Carigiet, Fabian (Brabec, Zürcher Hochschule für Angewandte Wissenschaften)
Inductive Power Transfer for Photovoltaic Modules

Classen, Andrej (Brabec, i-MEET)
Investigation of factors limiting the performance of organic solar cells

Elshaimaa, Darwish (Batentschuk, i-MEET)
Nanomaterials for photovoltaics and energy applications

Daum, Manuel (Heumüller / Brabec, i-MEET)
Nanoparticle based processes and structures for organic solar cells

Deumel, Sarah (Heiss, i-MEET)
Metallorganische Perowskite für die Röntgendetektion

Doll, Bernd (Brabec/Peters, i-MEET)
Towards monitoring of large-scale photovoltaic installations with advanced high throughput luminescence imaging

Dong, Lirong (Egelhaaf, i-MEET)
Interface engineering for the perovskite devices

Elia, Jack (Batentschuk/Brabec, i-MEET)
Liquid Phase Epitaxy of Perovskite-Halides and Garnets

Elsayed, Hany (Heiss, i-MEET)
Lasers based on Organo-Metal-Halide Perovskites

Feroze, Sarmad (Egelhaaf, ZAE)
Building Integrated Organic Photovoltaics

Freund, Tim (Wellmann, i-MEET)
Phase Formation and Synthesis of Chalkogenide Perovskite Thin Films

Garcia Cerrillo, José (Brabec/Egelhaaf, i-MEET)
Fabrication of multication-, mixed halide-perovskite/silicon tandem solar cells by partial processing in air

Haffner-Schirmer, Julian (Egelhaaf, i-MEET)
Development of a pump-probe based inline inspection method for printed photovoltaics

Hu, Huiying (Brabec/Osvet, i-MEET)
Stability of perovskite NCs based thin films for display and lighting

Hübner, Tobias (Brabec, OSRAM Opto Semiconductors GmbH)
Tintenstrahldrucken von Indium-Phosphid basierten Quantepunkt-Leuchtdioden

Ihle, Jonas (Wellmann, i-MEET)
Semi-insulating and high-purity SiC

Jang, DongJu (Egelhaaf, ZAE)
In situ approaching on perovskite crystallization

Kalancha, Violetta (Brabec/Forberich, i-MEET)
Investigation of Hybrid Silver Nanowire Electrodes

Killilea, Niall (Heiss, i-MEET)
Inkjet printed phototransistors

Kollmuß, Manuel (Wellmann, i-MEET)
Sublimation-Epitaxy of cubic silicon carbide "bulk" material with 100 mm diameter

Kong, Mengqin (Brabec/ Batentschuk, i-MEET)
Design and fabrication of high-efficiency transparent luminescent solar concentrator for smart window application

Köhler, Johannes (Wellmann, i-MEET)
CVD crystal growth of 3C-SiC thin films for optical waveguides

Kupfer, Christian (Brabec/Osvet, i-MEET)
Development of a high-throughput method for the synthesis, characterization and processing of new semiconducting perovskite compounds

Langner, Stefan (Brabec/Hauch, i-MEET)
Ink formulation and high-throughput experimentation in organic photovoltaics

Liu, Chao (Li/Brabec, i-MEET)
Design, Characterization and Application of Interfaces for Efficient Organic Solar Cells

Mashkov, Oleksandr (Heiss, i-MEET)
Pigment Nanocrystals for Energy and Energy Saving Applications

Meng, Wei (Brabec/Li, i-MEET)
Interface engineering for high-efficiency perovskite solar cells

Mohsun, Mohammed Kasim (Egelhaaf, i-MEET)
Printed barriers for the encapsulation of printed organic

Peng, Zijian (Brabec/Li, i-MEET)
High-throughput engineering of perovskite materials and devices towards excellent efficiency and stability

Qiu, Shudi (Egelhaaf, i-MEET)
In-situ monitoring of perovskite film formation

Rehm, Viktor (Heiss, i-MEET)
Solution Procesed Ferroelectrics in Photovoltaic Devices

Shahvaranfard, Fahimeh (Brabec/Li, i-MEET)
Modification of low dimensional nanostructured TiO_2 for energy application

Steinberger, Marc (Egelhaaf/Distler, ZAE)
Inkjetprinting of Photovoltaic modules

Steiner, Johannes (Wellmann, i-MEET)
Quantitative characterization and prediction of dislocation behavior in high-purity SiC

Tam, Kai Cheong (Brabec, ZAE)
Ink-jet printing on organic imaging device

These, Albert (Brabec, i-MEET)
Defect Engineering in Perovskites

Tian, Jingjing (Brabec/Li, i-MEET)
Development of highly efficient and stable wide bandgap inverted all-inorganic perovskite solar cells for tandem applications

Wachsmuth, Josua (Egelhaaf/Distler, ZAE)
Solution-Processed HTL-Layers for NFA-based Organic Solar Cells

Wang, Rong (Brabec/Li, i-MEET)
Exploring the properties of Donor-Acceptor interface in organic solar cells

Weitz, Paul (Brabec/ Heumüller, i-MEET)
Design and characterization of nanoparticle based organic solar cells

Wortmann, Jonas (Brabec, i-MEET)
High Throughput Production and Characterization of Organic Solar Cells

Xie, Qian (Brabec/ Li, i-MEET)
High-performance and stable all-polymer organic solar cells with different linking units

Xie, Zhiqiang (Brabec/ Osvet, i-MEET)
Aerosol printed perovskite memristors for neuromorphic computing

Xu, Junyi (Brabec/ Heumüller, i-MEET)
Organic nanoparticles as the transport layer for solar cells

YousefiAmir, AminAbbas (Heiss, i-MEET)
Inkjet printed Nanocrystal Detectors

Zhang, Heyi (Brabec/Li/Osvet, i-MEET)
Solution Growth of Crystalline Perovskite Layers for Optoelectronics

Zhang, Jiyun (Brabec/Hauch, i-MEET)
Synthesis of Functional Photovoltaic Materials by a Robot Based High Throughput Approach

Zhang, Kaicheng (Brabec/Li, i-MEET)
Development and Characterization of Novel Interfaces for Organic and Perovskite Solar Cells

7. Doctoral Theses Completed

06.04.2021
Seyed Amir Hashemi Jazi (Brabec, i-MEET)
A contactless Solid Surface Temperature Determination Using Phosphor Thermometry

09.06.2021
Matthias Arzig (Wellmann, i-MEET)
Untersuchung der Wachstumskinetik von SiC mithilfe der in-situ Computertomographie des Gasphasenkristallisationsprozesses und der Modellierung der Wachstumsbedingungen

19.07.2021
André Karl (Brabec/Osvet, i-MEET)
Imaging of artificial defects in organic solar cells

26.07.2021
Michael Schöler (Wellmann, i-MEET)
Sublimationswachstum von 3C-SiC Einkristallen auf freistehenden 3C-SiC Keimschichten

12.11.2021
Yakun He (Brabec/Li, i-MEET)
Stability and photophysics investigation of organic solar cells based on single component materials

8. Awards

We cordially congratulate:

Ezgi Nur Güler with receiving EnCN Energiepreis

Darwish Elshaimaa "Funds from Gender and diversity office to spent one year at Rice University , Texas, USA in addition to the DAAD funds"

Chao Liu SAOT Student and Innovation Award 2021 in the topic "Optical Materials and Systems", Erlangen, Germany

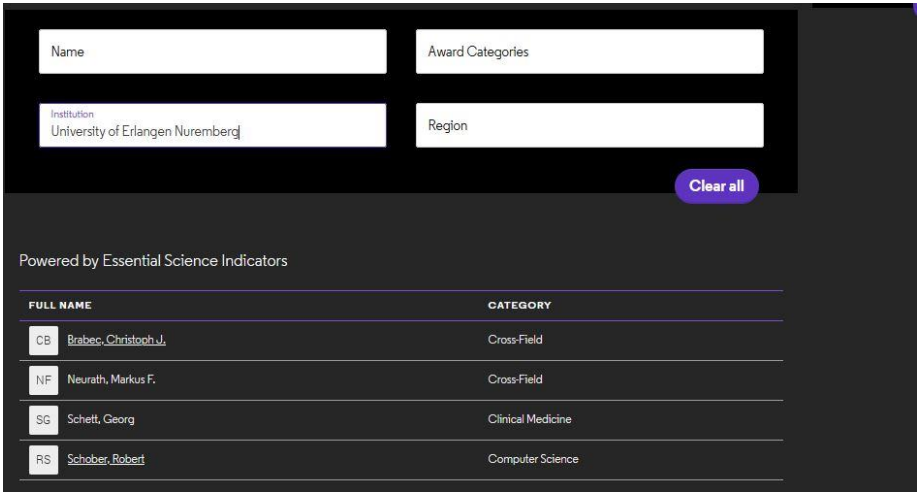
Saskia Schimmel Feodor Lynen Research Fellowship (Alexander von Humboldt-Foundation)

Dr. Osbel Almora Rodríguez, who finished his thesis last summer in i-MEET, obtained the "EXTRAORDINARY AWARD OF DOCTORATE in the Branch of Sciences" for the 2019/2020 Doctoral School call of Universitat Jaume I of Castelló.
The thesis was titled "Hysteresis and Capacitive Features of Perovskite Solar Cells" and supervised by Professor Germà Garcia Belmonte at Universitat Jaume I, Castelló, Spain, and professor Christoph J. Brabec at the Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany. During his doctoral studies he authored 12 articles included in the PhD dissertation, 15 papers in other research activities or as a coauthor and 1 book chapter.

Christoph is highly cited researcher 2021!

For the ninth time in a row, Prof. Brabec is recognised by Clarivate as a highly cited researcher. The list represents the top 1% of the world's most influential scientists in their field based on the analysis of the most cited publications over the last 10 years. Christoph is nominated in the cross-field category, which means that his influence already goes beyond the field of materials science. It is interesting to note that Germany ranks first in the EU among countries by the number of highly cited

researchers. The full list of highly cited researchers can be found on the Clarivate website.



9. Publications

(Full Papers and Conference Proceedings)

Kaicheng Zhang, Karen Forberich, Larry Lüer, José Garcia Cerrillo, Wei Meng, Xiaoyan Du, Vincent M. Le Corre, Yicheng Zhao, Tianqi Niu, Qifan Xue, L. Jan Anton Koster, Ning Li, Christoph J. Brabec
Understanding the Limitations of Charge Transporting Layers in Mixed Lead–Tin Halide Perovskite Solar Cells
*Adv. Energy Sustainability Res, **in press**, Article number 2100156, 2021*
DOI: 10.1002/aesr.202100156

Yicheng Zhao, Thomas Heumueller, Jiyun Zhang, Junsheng Luo, Olga Kasian, Stefan Langner, Christian Kupfer, Bowen Liu, Yu Zhong, Jack Elia, Andres Osvet, Jianchang Wu, Chao Liu, Zhongquan Wan, Chunyang Jia, Ning Li, Jens Hauch, Christoph J. Brabec
A bilayer conducting polymer structure for planar perovskite solar cells with over 1,400 hours operational stability at elevated temperatures nature research
*Appl. Phys. Lett, **119**, Article number 230501, 2021*
DOI: 10.1038/s41560-021-00953-z

Hany A. Afify, Mykhailo Sytnyk, Shuyu Zhou, Andres Osvet, Christoph J. Brabec, Jędrzej Korczak, Andrzej Szczerbakow, Tomasz Story, and Wolfgang Heiss
Perspectives of solution epitaxially grown defect tolerant lead-halide-perovskites and lead-chalcogenides
*Appl. Phys. Lett, **119**, Article number 230501, 2021*
DOI: 10.1063/5.0068665

Kai Cheong Tam, Peter Kubis, Philipp Maisch, Christoph J. Brabec, Hans-Joachim Egelhaaf
Fully printed organic solar modules with bottom and top silver nanowire electrodes
*Prog Photovolt Res Appl., **in press**, 2021*
DOI: 10.1002/pip.3521

Marc Steinberger, Andreas Distler, Christoph J. Brabec, and Hans-Joachim Egelhaaf
Improved Air Processability of Organic Photovoltaics Using a Stabilizing Antioxidant to Prevent Thermal Oxidation
*J. Phys. Chem. C, **126(1)**, pp.21-29, 2021*
DOI: 10.1021/acs.jpcc.1c07050

Kai Cheong Tam, Hirotoshi Saito, Philipp Maisch, Karen Forberich, Sarmad Feroze, Yutaka Hisaeda, Christoph J. Brabec, Hans-Joachim Egelhaaf
Highly Reflective and Low Resistive Top Electrode for Organic Solar Cells and Modules by Low Temperature Silver Nanoparticle Ink
*RRL Solar, **in press**, Article number 2100887, 2021*
DOI: 10.1002/solr.202100887

Osbel Almora, Derya Baran, Guillermo C. Bazan, Christian Berger, Carlos I. Cabrera, Kylie R. Catchpole, Sule Erten-Ela, Fei Guo, Jens Hauch, Anita W. Y. Ho-Baillie, T. Jesper Jacobsson, Rene A. J. Janssen, Thomas Kirchartz, Nikos Kopidakis, Yongfang Li, Maria A. Loi, Richard R. Lunt, Xavier Mathew, Michael D. McGehee, Jie Min, David B. Mitzi, Mohammad K. Nazeeruddin, Jenny Nelson, Ana F. Nogueira, Ulrich W. Paetzold, Nam-Gyu Park, Barry P. Rand, Uwe Rau, Henry J. Snaith, Eva Unger, Lídice Vaillant-Roca, Hin-Lap Yip, Christoph J. Brabec
Device Performance of Emerging Photovoltaic Materials (Version 2)
*Adv. Energy Mater., **11(1)**, Article number 2002774, 2021*
DOI: 10.1002/aenm.202102526

Klaus Burlafinger, Sebastian Strohm, Christoph Joisten, Michael Woiton, Andrej Classen, Johannes Hepp, Thomas Heumüller, Christoph J. Brabec, Andreas Vetter
Accelerated lifetime testing of thin-film solar cells at high irradiances and controlled temperatures
*Prog Photovolt Res Appl., **in press**, 2021*
DOI: 10.1002/pip.3517

Jose Dario Perea, Diana Carolina Gasca, Ghisliane Echeverry-Prieto, Valentina Quiroga-Fonseca, Carolina Orozco-Donneys, Leidy Catherine Díaz-Montealegre, Alejandro Ortiz, Giovanny Molina, Daniel Cruz, Aaron Persad, Sai Nithin Redd-Kantareddy, Josua Wachsmuth, Thomas Heumueller, Christoph Brabec, Victor Alfonso Rodriguez-Toro, Carolina Salguero
Last Generation Solar Cells in Outer Space: A STEM Outreach Project with Middle and High School Students in Colombia
*European Journal of STEM Education, **12**, 2021*
DOI: 10.20897/ejsteme/11353

Olivier J. J. Ronsin, DongJu Jang, Hans-Joachim Egelhaaf, Christoph J. Brabec, and Jens Harting
Phase-Field Simulation of Liquid–Vapor Equilibrium and Evaporation of Fluid Mixtures
*ACS Appl. Mater. Interfaces, **13(47)**, pp. 55988-56003, 2021*
DOI: 10.1021/acsami.1c12079

Ian Marius Peters, Jens Hauch, Christoph Brabec, Parikhit Sinha
The value of stability in photovoltaics
*Joule, **5(12)**, pp. 3137-3153, 2021*
DOI: 10.1016/j.joule.2021.10.019

Oleksandr Stroyuk, Claudia Buerhop-Lutz, Andreas Vetter, Johannes Hepp, Jens Hauch, Ian Marius Peters, Christoph J. Brabec
Distinguishing between different types of multi-layered PET-based backsheets of PV modules with near-infrared spectroscopy
*Prog Photovolt Res Appl., **in press**, 2021*
DOI: 10.1002/pip.3465

Fahimeh Shahvaranfard, Ning Li, Saman Hosseinpour, Seyedsina Hejazi, Kaicheng Zhang, Marco Altomare, Patrik Schmuki, Christoph J. Brabec
Comparison of the sputtered TiO_2 anatase and rutile thin films as electron transporting layers in perovskite solar cells
*Nano Select, **in press**, 2021*
DOI: 10.1002/nano.202100306

Yakun He, Benedict Hanisch, Andres Osvet, Larry Lüer, Anna Aubele, Peter Bäuerle, Weiwei Li, Ning Li, Christoph J. Brabec
Quantitative Analysis of Charge Dissociation by Selectively Characterizing Exciton Splitting Efficiencies in Single Component Materials
*Israel Journal of Chemistry, **in press**, 2021*
DOI: 10.1002/ijch.202100068

Chao Liu, Roberto Félix, Karen Forberich, Xiaoyan Du, Thomas Heumüller, Gebhard J. Matt, Ening Gu, Jonas Wortmann, Yicheng Zhao, Yuanyuan Cao, Yakun He, Lei Ying, Alina Hauser, Marek F. Oszajca, Benjamin Hartmeier, Michael Rossier, Norman A. Lüchinger, Yi-Sheng Liu, Jinghua Guo, Kaiqi Nie, Regan G. Wilks, Julien Bachmann, Marcus Bär, Ning Li, Christoph J. Brabec
Utilizing the unique charge extraction properties of antimony tin oxide nanoparticles for efficient and stable organic photovoltaics
*Nano Energy, **89, Part A**, Article number 106373, 2021*
DOI: 10.1016/j.nanoen.2021.106373

Jerrit Wagner, Christian G. Berger, Xiaoyan Du, Tobias Stubhan, Jens A. Hauch, Christoph J. Brabec
The evolution of Materials Acceleration Platforms: toward the laboratory of the future with AMANDA
*Journal of Materials Science, **56**, pp. 16422-16446, 2021*
DOI: 10.1007/s10853-021-06281-7

Rui Sun, Tao Wang, Yao Wu, Meng Zhang, Yunlong Ma, Zuo Xiao, Guanghao Lu, Liming Ding, Qingdong Zheng, Christoph J. Brabec, Yongfang Li, and Jie Min
PEDOT:PSS-Free Polymer Non-Fullerene Polymer Solar Cells with Efficiency up to 18.60% Employing a Binary-Solvent-Chlorinated ITO Anode
*Advanced Functional Materials, **in press**, Article number 2106846, 2021*
DOI: 10.1002/adfm.202106846

Oleksandr Stroyuk, Oleksandra Raievska, Stefan Langner, Christian Kupfer, Anastasia Barabash, Dmytro Solonenko, Yuriy Azhniuk, Jens Hauch, Andres Osvet, Miroslaw Batentschuk, Dietrich R. T. Zahn, and Christoph J. Brabec
High-Throughput Robotic Synthesis and Photoluminescence Characterization of Aqueous Multinary Copper–Silver Indium Chalcogenide Quantum Dots
*Part. Part. Syst. Charact, **38(10)**, Article number 2100169, 2021*
DOI: 10.1002/ppsc.202100169

Bernd Doll, Johannes Hepp, Mathis Hoffmann, René Schüler, Claudia Buerhop-Lutz , Ian Marius Peters, Jens A. Hauch, Andreas Maier, and Christoph J. Brabec
Photoluminescence for Defect Detection on Full-Sized Photovoltaic Modules
*IEEE Journal of Photovoltaics, **in press**, 2021*
DOI: 10.1109/JPHOTOV.2021.3099739

Manuel Daum, Sarah Deumel, Mykhailo Sytnyk, Hany A. Afify, Rainer Hock, Andreas Eigen, Baolin Zhao, Marus Halik, Albert These, Gebhard J. Matt, Christoph J. Brabec, Sandro F. Tedde, Wolfgang Heiss
Self-Healing $Cs_3Bi_2Br_3I_6$ Perovskite Wafers for X-Ray Detection
*Advanced Functional Materials, **in press**, Article number 2102713, 2021*
DOI: 10.1002/adfm.202102713

Christoph J. Brabec, Martin Heeney, Youngkyoo Kim, Christine K. Luscombe
Preface to the Special Issue of ChemSusChem on Advanced Organic Solar Cells
*ChemSusChem, **14(17)**, pp 3426-3427, 2021*
DOI: 10.1002/cssc.202101600

Anna Aubele, Yakun He, Teresa Kraus, Ning Li, Elena Mena-Osteritz, Paul Weitz, Thomas Heumüller, Kaicheng Zhang, Christoph J. Brabec, Peter Bäuerle
Molecular Oligothiophene–Fullerene Dyad Reaching Over 5% Efficiency in Single-Material Organic Solar Cells
*Advanced Materials, **in press**, Article number 2103573, 2021*
DOI: 10.1002/adma.202103573

Christina Harreiss, Mingjian Wu, Stefan Langner, Stefanie Rechberger, Johannes Will, Christoph J. Brabec, Erdmann Spiecker
Correlative relationship between nanomorphology, crystallinity, texture and device efficiency of organic BHJ solar cells studied by energy-filtered TEM
*Microscopy and Microanalysis, **27(81)**, pp 390-392, 2021*
DOI: 10.1017/S1431927621001938

Naveen Kumar Tailor, Shaoni Kar, Pranjal Mishra, Albert These, Christian Kupfer, Hanlin Hu, Muhammad Awais, Makhsud Saidaminov, M. Ibrahim Dar, Christoph Brabec, and Soumitra Satapathi
Advances in Lead-Free Perovskite Single Crystals: Fundamentals and Applications
*ACS Materials Letters, **3(7)**, pp 1025-1080, 2021*
DOI: 10.1021/acsmaterialslett.1c00242

Yvan Bonnassieux, Christoph J Brabec, Yong Cao, Tricia Breen Carmichael, Michael L Chabinyc, Kwang-Ting Cheng, Gyoujin Cho, Anjung Chung, Corie L Cobb, Andreas Distler, Hans-Joachim Egelhaaf, Gerd Grau, Xiaojun Guo, Ghazaleh Haghiashtiani, Tsung-Ching Huang, Muhammad M Hussain, Benjamin Iniguez, Taik-Min Lee, Ling Li, Yuguang Ma, Dongge Ma, Michael C McAlpine, Tse Nga Ng, Ronald Österbacka, Shrayesh N Patel, Junbiao Peng, Huisheng Peng, Jonathan Rivnay, Leilai Shao, Daniel Steingart, Robert A Street, Vivek Subramanian, Luisa Torsi and Yunyun Wu
The 2021 flexible and printed electronics roadmap
*Flex. Print. Electron., **6(2)**, 23001, 2021*
DOI: 10.1088/2058-8585/abf986

Fabian Carigiet, Christoph J. Brabec, Franz P. Baumgartne
Long-term power degradation analysis of crystalline silicon PV modules using indoor and outdoor measurement techniques
*Renewable and Sustainable Energy Reviews, **144**, Article number 111005, 2021*
DOI: 10.1016/j.rser.2021.111005

Rong Wang, Dr. Larry Lüer, Stefan Langner, Dr. Thomas Heumueller, Karen Forberich, Heyi Zhang, Jens Hauch, Dr. Ning Li, Prof. Christoph J. Brabec
Understanding the Microstructure Formation of Polymer Films by Spontaneous Solution Spreading Coating with a High-Throughput Engineering Platform
*Chemsuschem, **14(17)**, pp. 3590-3598, 2021*
DOI: 10.1002/cssc.202100927

Lukas Bommes, Tobias Pickel, Claudia Buerhop-Lutz, Jens Hauch, Christoph Brabec, Ian Marius Peters
Computer vision tool for detection, mapping, and fault classification of photovoltaics modules in aerial IR videos
Prog Photovolt Res Appl., in press, 2021
DOI: 10.1002/pip.3448

Fatima Akhundova, Larry Lüer, Andres Osvet, Jens Hauch, Ian Marius Peters, Karen Forberich, Ning Li, and Christoph Brabec
Building process design rules for microstructure control in wide-bandgap mixed halide perovskite solar cells by a high-throughput approach
*Appl. Phys. Lett., **118**, Article number 243903, 2021*
DOI: 10.1063/5.0049010

Lukáš Zdražil, Sergii Kalytchuk, Michal Langer, Razi Ahmad, Jan Pospíšil, Oldřich Zmeškal, Marco Altomare, Andres Osvet, Radek Zbořil, Patrik Schmuki, Christoph J. Brabec, Michal Otyepka, and Štěpán Kment
Transparent and Low-Loss Luminescent Solar Concentrators Based on Self-Trapped Exciton Emission in Lead-Free Double Perovskite Nanocrystals
*ACS Appl. Energy Mater., **4(7)**, pp 6445-6453, 2021*
DOI: 10.1021/acsaem.1c00360

Rui Sun, Wei Wang, Han Yu. Zeng Chen, XinXin Xia, Hao Shen, Jing Guo, Mumin Shi, Yina Zheng, Yao Wu, Wenyan Yang, Tao Wang, Qiang Wu, Yang (Michael) Yang, Xinhui Lu, Jianlong Xia, Christoph J. Brabec, He Yan, Yongfang Li, Jie Min
Achieving over 17% efficiency of ternary all-polymer solar cells with two well-compatible polymer acceptors
*Joule, **5(16)**, pp 1548-1565, 2021*
DOI: 10.1016/j.joule.2021.04.007

Fu Yang, Lirong Dong, Dongju Jang, Begench Saparov, Kai Cheong Tam, Kaicheng Zhang, Ning Li, Christoph J. Brabec, Hans-Joachim Egelhaaf
Low Temperature Processed Fully Printed Efficient Planar Structure Carbon Electrode Perovskite Solar Cells and Modules
*Advanced Energy Materials, **11(28)**, Article number 2101219, 2021*
DOI: 10.1002/aenm.202101219

Iftikhar Ahmed Channa, Andreas Distler, Benedikt Scharfe, Sarmad Feroze, Karen Forberich, Benjamin Lipovšek, Christoph J Brabec and Hans-Joachim Egelhaaf
Solution processed oxygen and moisture barrier based on glass flakes for encapsulation of Organic (Opto-) Electronic Devices
*Flexible and Printed Electronics, **6(2)**, Article number 25006, 2021*
DOI: 10.1088/2058-8585/ac0716

Oleksandr Stroyuk, Oleksandra Raievska, Christian Kupfer, Dmytro Solonenko, Andres Osvet, Miroslaw Batentschuk, Christoph J. Brabec and Dietrich R. T. Zahn
High-Throughput Time-Resolved Photoluminescence Study of Composition- and Size-Selected Aqueous Ag–In–S Quantum Dots
*J. Phys. Chem. C, **125(22)**, pp 12185-12197, 2021*
DOI: 10.1021/acs.jpcc.1c02697

Tobias Hübner, Alexander F. Richter, Jochen Feldmann, Christoph J. Brabec, Norwin von Malm
Parasitic emission in inkjet-printed InP-based quantum dot light-emitting diodes
*Organic Electronics, **93**, Article number 106156, 2021*
DOI: 10.1016/j.orgel.2021.106156

Ning Li, Christoph Brabec
Branched Side Chains Improve Molecular Packing of Non-fullerene Acceptors
Science China-Chemistry, 2021
DOI: 10.1007/s11426-021-1034-4

Yakun He, Ning Li, Christoph J. Brabec
Single-Component Organic Solar Cells with Competitive Performance
*Organic Materials, **3(2)**, pp 228-244, 2021*
DOI: 10.1055/s-0041-1727234

Yicheng Zhao, Jiyun Zhang, Zhengwei Xu, Shijing Sun, Stefan Langner, Noor Titan Putri Hartono, Thomas Heumueller, Yi Hou, Jack Elia, Ning Li, Gebhard J. Matt, Xiaoyan Du, Wei Meng, Andres Osvet, Kaicheng Zhang, Tobias Stubhan, Yexin Feng, Jens Hauch, Edward H. Sargent, Tonio Buonassisi & Christoph J. Brabec
Discovery of temperature-induced stability reversal in perovskites using high-throughput robotic learning
*Nat Commun, **12**, Article number 2191, 2021*
DOI: 10.1038/s41467-021-22472-x

Wenyan Yang, Wei Wang, Yuheng Wang, Rui Sun, Jie Guo, Hongneng Li, Mumin Shi, Jing Guo, Yao Wu, Tao Wang, Guanghao Lu, Christoph J. Brabec, Yongfang Li, Jie Min
Balancing the efficiency, stability, and cost potential for organic solar cells via a new figure of merit
*Joule, **5(5)**, pp 1209-1230, 2021*
DOI: 10.1016/j.joule.2021.03.014

Nicola Gasparini, Franco V. A. Camargo, Stefan Frühwald, Tetsuhiko Nagahara, Andrej Classen, Steffen Roland, Andrew Wadsworth, Vasilis G. Gregoriou, Christos L. Chochos, Dieter Neher, Michael Salvador, Derya Baran, Iain McCulloch, Andreas Görling, Larry Lüer, Giulio Cerullo & Christoph J. Brabec
Adjusting the energy of interfacial states in organic photovoltaics for maximum efficiency
*Nat Commun, **12**, Article number 1772, 2021*
DOI: 10.1038/s41467-021-22032-3

Difei Zhang, Baobing Fan, Lei Ying, Ning Li, Christoph J. Brabec, Fei Huang, Yong Cao
Recent progress in thick-film organic photovoltaic devices: Materials, devices, and processing
*SusMat, **1(1)**, pp 4-23, 2021*
DOI: 10.1002/sus2.10

Mathis Hoffmann, Claudia Buerhop-Lutz, Luca Reeb, Tobias Pickel, Thilo Winkler, Bernd Doll, Tobias Würfl, Ian Marius Peters, Christoph Brabec, Andreas Maier, Vincent Christlein
Deep Learning-based Pipeline for Module Power Prediction from EL Measurements
*Prog Photovolt Res Appl., **29(8)**, pp 920-935, 2021*
DOI: 10.1002/pip.3416

Xiaoyan Du, Larry Lüer, Thomas Heumueller, Jerrit Wagner, Christian Berger, Tobias Osterrieder, Jonas Wortmann, Stefan Langner, Uyxing Vongsaysy, Melanie Bertrand, Ning Li, Tobias Stubhan, Jens Hauch, Christoph J. Brabec
Elucidating the Full Potential of OPV Materials Utilizing a High-Throughput Robot-Based Platform and Machine Learning
*Joule, **5(2)**, pp 495-506, 2021*
DOI: 10.1016/j.joule.2020.12.013

Hans-Joachim Egelhaaf, Christoph J. Brabec, Marcel Neberich, Kaushik Senguttuvan, Felix Hoga, Günther Kießling, Matthias Braun, Susanna Bordin, Michael Wagner, Andreas Distler, Sarmad Feroze, Arno Dentel
Fassadenelemente mit organischer Photovoltaik
*BWK ENERGIE, **73(7-8)**, pp 16-21, 2021*
DOI: 10.37544/1618-193X-2021-7-8-16

Oleksandr Stroyuk, Oleksandra Raievska, Dmytro Solonenko, Christian Kupfer, Andres Osvet, Miroslaw Batentschuk, Christoph J. Brabec and Dietrich R. T. Zahn
Spontaneous alloying of ultrasmall non-stoichiometric Ag–In–S and Cu–In–S quantum dots in aqueous colloidal solutions
*RSC Adv., **11**, pp 21145-21152, 2021*
DOI: 10.1039/D1RA03179A

Zhenrong Jia, Shucheng Qin, Lei Meng, Qing Ma, Indunil Angunawela, Jinyuan Zhang, Xiaojun Li, Yakun He, Wenbin Lai, Ning Li, Harald Ade, Christoph J. Brabec, Yongfang Li
High performance tandem organic solar cells via a strongly infrared-absorbing narrow bandgap acceptor nature research
*Nat Commun, **12**, Article number 178, 2021*
DOI: 10.1038/s41467-020-20431-6

Ardalan Armin, Wei Li, Oskar J. Sandberg, Zuo Xiao, Liming Ding, Jenny Nelson, Dieter Neher, Koen Vandewal, Safa Shoaee, Tao Wang, Harald Ade, Thomas Heumüller, Christoph Brabec, Paul Meredith
A History and Perspective of Non-Fullerene Electron Acceptors for Organic Solar Cells
*Advanced Energy Materials, **11(15)**, Article number 2003570, 2021*
DOI: 10.1002/aenm.202003570

Albert These, Neamul H. Khansur, Osbel Almora, Larry Luer, Gebhard J. Matt, Udo Eckstein, Anastasia Barabash, Andres Osvet, Kyle G. Webber, Christoph J. Brabec
Characterization of Aerosol Deposited Cesium Lead Tribromide Perovskite Films on Interdigited ITO Electrodes
*Advanced Electronic Materials, **7(3)**, Article number 2001165, 2021*
DOI: 10.1002/aelm.202001165

Jinlong Hu, Xin Xu, Yijun Chen, Shaohang Wu, Zhen Wang, Yousheng Wang, Xiaofang Jiang, Boyuan Cai, Tingting Shi, Christoph J. Brabec, Yaohua Mai, Fei Guo
Overcoming photovoltage deficit via natural amino acid passivation for efficient perovskite solar cells and modules
*J. Mater. Chem. A, **9**, pp. 5857-5865, 2021*
DOI: 10.1016/j.matt.2021.01.008

Shijing Sun, Armi Tiihonen, Felipe Oviedo, Zhe Liu, Janak Thapa, Yicheng Zhao, Noor Titan P. Hartono, Anuj Goyal, Thomas Heumueller, Clio Batali, Alex Encinas, Jason J. Yoo, Ruipeng Li, Zekun Ren, I. Marius Peters, Christoph J. Brabec, Moungi G. Bawendi, Vladan Stevanovic, John Fisher III, Tonio Buonassisi
A data fusion approach to optimize compositional stability of halide perovskites
*Matter, **4(4)**, pp. 1305-1322, 2021*
DOI: 10.1016/j.matt.2021.01.008

Osbel Almora, Julius Wiegand, Pilar López-Varo, Gebhard J. Matt, Christoph J. Brabec
Degradation through Directional Self-Doping and Homogeneous Density of Recombination Centers Hindered by 1,8-Diiodooctane Additive in Non-Fullerene Organic Solar Cells
*Advanced Energy Materials, **5(4)**, Article number 2100022, 2021*
DOI: 10.1002/aenm.202100022

Osbel Almora, Carlos I. Cabrera, Jose Garcia-Cerrillo, Thomas Kirchartz, Uwe Rau, Christoph J. Brabec
Quantifying the Absorption Onset in the Quantum Efficiency of Emerging Photovoltaic Devices
*Solar RRL, **5(4)**, Article number 2100024, 2020*
DOI: 10.1002/solr.202100024

Osbel Almora, Derya Baran, Guillermo C. Bazan, Christian Berger, Carlos I. Cabrera, Kylie R. Catchpole, Sule Erten-Ela, Fei Guo, Jens Hauch, Anita W. Y. Ho-Baillie, T. Jesper Jacobsson, Rene A. J. Janssen, Thomas Kirchartz, Nikos Kopidakis, Yongfang Li, Maria A. Loi, Richard R. Lunt, Xavier Mathew, Michael D. McGehee, Jie Min, David B. Mitzi, Mohammad K. Nazeeruddin, Jenny Nelson, Ana F. Nogueira, Ulrich W. Paetzold, Nam-Gyu Park, Barry P. Rand, Uwe Rau, Henry J. Snaith, Eva Unger, Lídice Vaillant-Roca, Hin-Lap Yip, and Christoph J. Brabec
Device Performance of Emerging Photovoltaic Materials (Version 1)
*Advanced Energy Materials, **11(11)**, Article number 2002774, 2020*
DOI: 10.1002/aenm.202002774

Fu Yang, Dongju Jang, Lirong Dong, Shudi Qiu, Andreas Distler, Ning Li, Christoph J. Brabec, Hans-Joachim Egelhaaf
Upscaling Solution-Processed Perovskite Photovoltaics
*Advanced Energy Material, **11(42)**, Article number 2101973, 2021*
DOI: 10.1002/aenm.202101973

Sebastian Lucas, Jochen Kammerer, Martin Pfannmöller, Rasmus R. Schröder, Yakun He, Ning Li, Christoph J. Brabec, Tim Leydecker, Paolo Samorì, Tomasz Marszalek, Wojchiech Pisula, Elena Mena-Osteritz, and Peter Bäuerle
Molecular Donor-Acceptor Dyads for Efficient Single-Material Organic Solar Cells
*Solar RRL, **5(1)**, Article number 2000653, 2021*
DOI: 10.1002/solr.202000653

La Via, Francesco, Massimo Zimbone, Corrado Bongiorno, Antonino La Magna, Giuseppe Fisicaro, Ioannis Deretzis, Viviana Scuderi, Cristiano Calabretta, Filippo Giannazzo, Marcin Zielinski, Ruggero Anzalone, Marco Mauceri, Danilo Crippa, Emilio Scalise, Anna Marzegalli, Andrey Sarikov, Leo Miglio, Valdas Jokubavicius, Mikael Syväjärvi, Rositsa Yakimova, Philipp Schuh, Michael Schöler, Manuel Kollmuss, and Peter Wellmann
New Approaches and Understandings in the Growth of Cubic Silicon Carbide. *Materials 2021, **14**, 5348*.
DOI: 10.3390/ma14185348

Matthias Arzig, Ulrike Künecke, Michael Salamon, Norman Uhlmann, Peter J. Wellmann
Influence of the growth conditions on the formation of macro-steps on the growth interface of SiC-Crystals, *Journal of Crystal Growth, **576(12)**, 126361, 2021*
DOI: 10.1016/j.jcrysgro.2021.126361

Sarah Deumel, Albert van Breemen, Gerwin Gelinck, Bart Peeters, Joris Maas, Roy Verbeek, Santhosh Shanmugam, Hylke Akkerman, Eric Meulenkamp, Judith E. Huerdler, Manognya Acharya, Marisé García-Batlle, Osbel Almora, Antonio Guerrero, Germà Garcia-Belmonte, Wolfgang Heiss, Oliver Schmidt & Sandro F. Tedde
High-sensitivity high-resolution X-ray imaging with soft-sintered metal halide perovskites. *Nat Electron **4**, 681–688* (*2021*).
DOI: 10.1038/s41928-021-00644-3

Marisé García-Batlle, Sarah Deumel, Judith E. Huerdler, Sandro F. Tedde, Antonio Guerrero, Osbel Almora, and Germà Garcia-Belmonte
Mobile Ion-Driven Modulation of Electronic Conductivity Explains Long-Timescale Electrical Response in Lead Iodide Perovskite Thick Pellets. *ACS Appl. Mater. Interfaces 2021, 13, 30, 35617–35624*
DOI: 10.1021/Acsami.1c06046

Mathis Hoffmann, Thomas Köhler, Bernd Doll**, Frank Schebesch, Florian Talkenberg, Marius Ian Peters, Christoph J. Brabec, Andreas Maier, Vincent Christlein**
Joint Superresolution and Rectification for Solar Cell Inspection, *IEEE Journal of Photovoltaics, vol. **11**, no. 4, pp. 1051-1058, 2021*.
DOI: 10.1109/JPHOTOV.2021.3072229

Hoffmann M, Hepp J, Doll B**, Buerhop-Lutz C, Peters IM, Brabec C, Maier A, Christlein V.**
Module-Power Prediction from PL Measurements using Deep Learning
IEEE 48th Photovoltaic Specialists Conference (PVSC), 2021, pp. 0827-0830.
DOI: 10.1109/PVSC43889.2021.9519005.

He, Y., Wang, B., Lüer, L., Feng, G., Osvet, A., Heumüller, T., Liu, C., Li, W., Guldi, D. M., Li, N., & Brabec, C. J.
Unraveling the Charge-Carrier Dynamics from the Femtosecond to the Microsecond Time Scale in Double-Cable Polymer-Based Single-Component Organic Solar Cells, *Advanced Energy Materials, 2103406, 2021*
DOI: 10.1002/aenm.202103406

Lucas, S., Kammerer, J., Pfannmöller, M., Schröder, R. R., He, Y., Li, N., Brabec, C. J., Leydecker, T., Samorì, P., Marszalek, T., Pisula, W., Mena-Osteritz, E., & Bäuerle, P.
Molecular donor–acceptor dyads for efficient single-material organic solar cells. *Solar RRL, 5(1), 2000653, 2021*
DOI: 10.1002/solr.202000653

B. Fan, F. Lin, J. Oh, H. Fu, W. Gao, Q. Fan, Z. Zhu,W. J. Li, N. Li, L. Ying, F. Huang, C. Yang, A. K.-Y. Jen
Enabling High Efficiency Of Hydrocarbon-solvent processed organic solar cells through balanced charge generation and non-radiative loss. *Advanced Energy Materials 2021, **11**, 2101768*
DOI 10.1002/aenm.202101768

X. Du, N. Li, L. Ding
Solution-processed tandem organic solar cells. *Journal of Semiconductors 2021, **42**, 110201*.
DOI 10.1088/1674-4926/42/11/110201

J. Wang, X. Wu, Y. Liu, T. Qin*, K. Zhang, N. Li, J. Zhao, R. Ye, Z. Fan, Z. Chi, Z. Zhu
Dopant-free hole-transporting material with enhanced intermolecular interaction for efficient and stable n-i-p perovskite solar cells. *Advanced Energy Materials 2021, **11**, 2100967*.
DOI 10.1002/aenm.202100967

H.-Q. Wang, S. Wang, L. Chen, Z. Yin, S. Mei, Y. Zhong, Y. Yao, N. Li, J. Wang, W. Song
Understanding degradation mechanisms of perovskite solar cells due to electrochemical metallization effect. *Solar Energy Materials & Solar Cells 2021, **230**, 111278*.
DOI 10.1016/j.solmat.2021.111278

D. Zhang, W. Zhong, L. Ying, B. Fan, M. Li, Z. Gan, Z. Zeng, D. Chen, N. Li, F. Huang, Y. Cao
Overcoming incompatibility of donors and acceptors by constructing planar heterojunction organic solar cells. *Nano Energy 2021, 85, 105957*.
DOI 10.1016/j.nanoen.2021.105957

Bresolí-Obach, R., Massad, W.A., Abudulimu, A., Lüer, L., Flors, C., Luis, J.G., Rosquete, L.I., Grillo, T.A., Anamimoghadam, O., Bucher, G., Nonell, S. 9-Aryl-phenalenones: Bioinspired thermally reversible photochromic compounds for photoswitching applications in the pico-to milliseconds range. *Dyes and Pigments, **186**, Article number 109060, 2021*
DOI: 10.1016/j.dyepig.2020.109060

Schimmel, S.; Tomida, D.; Ishiguro, T.; Honda, Y.; Chichibu, S.; Amano, H. Numerical Simulation of Ammonothermal Crystal Growth of GaN—Current State, *Challenges, and Prospects, Crystals, **11**, 356, 2021*

DOI: 10.3390/cryst11040356

Schimmel, S.; Tomida, D.; Saito, M.; Bao, Q.; Ishiguro, T.; Honda, Y.; Chichibu, S.; Amano, H.
Boundary Conditions for Simulations of Fluid Flow and Temperature Field during Ammonothermal Crystal Growth—A Machine-Learning Assisted Study of Autoclave Wall Temperature Distribution. *Crystals, **11**, 254, 2021*

V. Gorbenko, T. Zorenko, S. Witkiewicz-Łukaszek, A. Shakhno, A. Osvet, M. Batentschuk, A. Fedorov, Y. Zorenko
Crystallization and Investigation of the Structural and Optical Properties of Ce^{3+}-Doped $Y_{3-x}Ca_xAl_{5-y}Si_yO_{12}$ Single Crystalline Film Phosphors, *Crystals. 11 (2021)*.
DOI: 10.3390/CRYST11070788

Künecke U., Schuster M., Wellmann P.
Analysis of compositional gradients in $Cu(In,Ga)(S,Se)_2$ solar cell absorbers using energy dispersive x-ray analysis with different acceleration energies. *Materials, 2021*
DOI: 10.3390/ma14112861

Schöler M., La Via F., Mauceri M., Wellmann P.
Overgrowth of Protrusion Defects during Sublimation Growth of Cubic Silicon Carbide Using Free-Standing Cubic Silicon Carbide Substrates. *Crystal Growth and Design, **21, 7**, 4046–4054, 2021*
DOI: 10.1021/acs.cgd.1c00343

Conference Proceedings

Albert J.J.M. van Breemen, Bart Peeters, Joris Maas, Hylke B. Akkerman, Eric A. Meulenkamp, Gerwin H. Gelinck, Sarah Deumel, Judith E. Huerdler, Sandro F. Tedde
Combining high resolution and sensitivity in X-ray detectors using perovskites ESSENCE
ATTRACT Final Conference, 22 September, 2020.

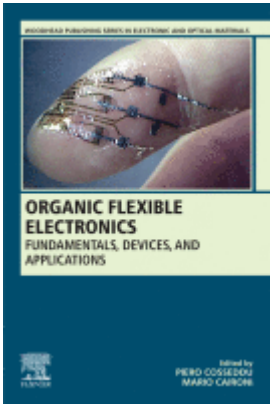
Bernd Doll, Johannes Hepp, Mathis Hoffmann, Florian Talkenberg, Renè Schüler, Manuel Baier, Claudia Buerhop-Lutz, Dirk Tegtmeyer, Ian Marius Peters, Jens Hauch, Christoph J. Brabec
Outdoor photoluminescence of large area photovoltaic modules
Conference Proc. SPIE Volume 11809, Organic, Hybrid, and Perovskite Photovoltaics XXII, 118091C, 2021, San Diego, California, United States
DOI: 10.1117/12.2593894

Yakun He, Peter Bäuerle, Weiwei Li, Thomas Heumüller, Ning Li, Christoph Brabec
Ultra-stable single component organic solar cells under thermal and/or illumination pressure: the next superior organic photovoltaics? *Proceedings of 13th Conference on Hybrid and Organic Photovoltaics (HOPV21)*
DOI: 10.29363/nanoge.hopv.2021.007

Mohd-Khairulamzari Hamjah, Marc Steinberger, Kai Cheong Tam, Hans-Joachim Egelhaaf, Christoph J. Brabec, Joerg Franke
Aerosol jet printed AgNW electrode and PEDOT:PSS layers for organic light-emitting diode devices fabrication
14th International Congress Molded Interconnect Devices (MID), 2021, pp. 1-4, 2021
DOI: 10.1109/MID50463.2021.9361616

10. Books

Philipp Maisch, Kai Cheong Tam, DongJu Jang, Marc Steinberger, Fu Yang, Christoph J. Brabec, Hans-Joachim Egelhaaf



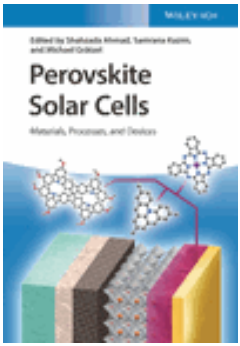
Inkjet printed organic and perovskite photovoltaics—review and perspectives
Book Chapter In Woodhead Publishing Series in Electronic and Optical Materials,Organic Flexible Electronics. Edited By Piero Cosseddu, Mario Caironi, Woodhead Publishing, Chapter 10, pp. 305-333, 2021

ISBN: 9780128188903
DOI: 10.1016/B978-0-12-818890-3.00010-2

Iftikhar Ahmed Channa, Andreas Distler, Christoph J. Brabec, Hans-Joachim Egelhaaf

Solution-coated barriers for organic electronics
Book Chapter In Organic Flexible Electronics. Fundamentals, Devices, and Applications. Woodhead Publishing Series in Electronic and Optical Materials Cosseddu, Mario Caironi, Woodhead Publishing, Chapter 9, pp. 249-303, 2021

ISBN: 9780128188903
DOI: 10.1016/B978-0-12-818890-3.00009-6

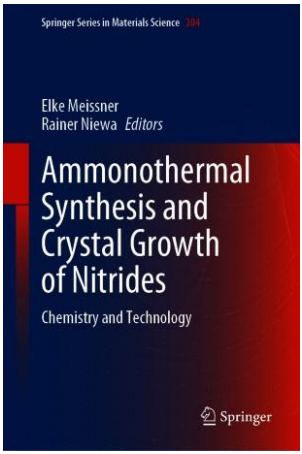


Dongju Jang, Fu Yang, Lirong Dong, Christoph J. Brabec, Hans-Joachim Egelhaaf

Upscaling of Perovskite Photovoltaics
Book Chapter In Perovskite Solar Cells: Materials, Processes, and Devices. Editor(s):Michael Grätzel, Shahzada Ahmad, Samrana Kazim. Wiley-VCH GmbH, Chapter 14, pp. 453-496, 2021

Online ISBN: 9783527825790 Print ISBN: 9783527347155
DOI: 10.1002/9783527825790.ch14

Schimmel, S. and Wellmann, P.



In situ Visualization of the Ammonothermal Crystallization Process by X-ray Technology
Book Chapter In: Ammonothermal Synthesis and Crystal Growth of Nitrides – Chemistry and Technology
Ed.: Meissner, E. and Niewa, R. Springer Series in Materials Science, Chapter 10, Vol.304 Springer International Publishing AG, 2021.

ISBN 978-3-030-56304-2

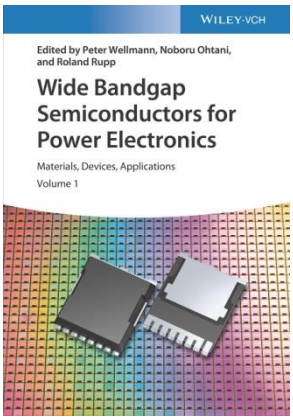
DOI: 10.1007/978-3-030-56305-9_10

Schlücker, E., Schimmel, S. and Wellmann, P.

Special equipment for ammonothermal processes.
Book Chapter In: *Ammonothermal Synthesis and Crystal Growth of Nitrides – Chemistry and Technology*
Ed.: Meissner, E. and Niewa, R., Springer Series in Materials Science, Chapter 17, Vol. 304, Springer International Publishing AG, 2021.

ISBN 978-3-030-56304-2

DOI: 10.1007/978-3-030-56305-917



Peter Wellmann, Michael Schöler, Philipp Schuh, Mike Jennings, Fan Li, Roberta Nipoti, Andrea Severino, Ruggero Anzalone, Fabrizio Roccaforte, Massimo Zimbone, Francesco La Via

Status of 3C-SiC growth and device technology
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11. Presentations at Conferences, Workshops, Events

Arango Marin, Vanessa

08.07.2021
Digitalen WW Sommerfest mit Science Slam, online
Talk: *Development of a high throughput screening routine for printed photovoltaics*

24.11.2021
BAYLAT AUGM 1st PhD Student Symposium on Materials for Energy, Environment and Health, online
Talk: *Development of a high throughput screening routine for printed photovoltaics*

Arzig, Matthias

24-28.10.2021
European Conference on Silicon Carbide and Related Materials, France
Talk: *Analysis of the morphology of the growth interface as a function of the gas phase composition during the PVT growth of silicon carbide*

24.11.2021
BAYLAT AUGM 1st PhD Student Symposium on Materials for Energy, Environment and Health, online
Talk: *Development of a high throughput screening routine for printed photovoltaics*

Batentschuk, Miroslaw

17.09.2021
11th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation, Bydgoszcz, Poland
Invited Talk: *New Phosphors for High Temperature Thermometry*

Brabec, Christoph J.

28.01.2021
Department Seminar at Ruhr University Bochum, ICAMS (Interdisciplinary Center for Advanced Materials Simulation), Bochum (digital), Germany
Invited talk: *AMANDA Line 1: A Prototype Line for Automated Materials Innovation*

09.03.2021
Molecular Foundry, Berkley, US
Invited talk*: Accelerating material science with robot based and AI enabled autonomous research lines*

10.03.2021
Forum for Clean Energy - 10 years after Fukushima, Hongkong
Plenary talk: *A "World Without Wires": How to Accelerate the Development of Printed Photovoltaic Technologies*

16-17.05.2021
ISAF ISF annual conference (virtual IEEE conference)
Tutorial Talk**:** *Accelerating Halide (and Halide Ferroelectric) Perovksite Materials for Next Generation Solar Energy Concepts*

15.04.2021
Helmholtz Tandem Workshop, virtual conference, Germany
Invited Talk: *Translating lessons from OPV to perovskites PV: how to accelerate the development of a market ready technology*

26.05.2021
HOPV, Valencia (virtual conference), Spain
Invited Talk: *Discovering hidden relations in organic semiconductor composites - a concept to accelerate the development of organic PV*

22.06.2021
Annual AMOLF Symposium on Light Management in Photovoltaic Materials, Netherlands
Invited Talk: *Exploring Complex Microstructure Relations in Functional Materials by Basic Optical Methods*

28.09.2021
FAIR-DI workshop, Louvain-la-Neuve, France (hybrid conference)
Invited Talk*: Big Data Strategies & Solar Energy*

10.10.2021
KSC KAUST, Saudi Arabia
Invited Talk: *Accelerating Solar Energy with Big Data Strategies*

10.10.2021
nanoGe Fall 21; virtual conference
Invited Talk: *Accelerating the OPV technology roadmap*

21.10.2021
GdCH Würzburg, Germany
Invited Talk: *Next generation solar energy*

23.10.2021
"Gscheid Schlau" - Lange Nacht der WIssenschaften, virtual conference, Nürnberg, Germany
Invited Talk: *Was kann die PV in Deutschland leisten*

19.11.2021
Annual Symposium of technical Faculty, FAU, Erlangen, Germany
Plenary talk: *Photovoltaik - von der Milli-Watt-Optimierung im Labor zu einer TeraWatt-Technologie auf der Freifläche: Was können wir für die Zukunft erwarten?*

22.11.2021
3rd Materials Chain International Conference, Germany (Virtual conference)
Invited talk: *Accelerating Perovksites: Towards Stable Composites and Devices*

6.12.2021
EN05, MRS Boston, USA (virtual conference)
Invited talk: *Engineering Long Lived Perovskite Solar Cells - The Role of Cation Induced Temperature Destabilization*

6.12.2021
DN01, MRS Boston, USA (virtual conference)
Invited talk: *On the transition from automated to autonomous material optimization*

8.12.2021
Croucher Advanced Studies, Hongkong (hybrid)
Plenary talk: *Accelerating Solar Materials by autonomous research lines*

15.12.2021
5th Materials Genome Engineering, Zhengzhou, China (hybrid)
Invited talk: *Accelerating Solar Semiconductors with autonomous research lines*

Deumel, Sarah

18-22.09.2021
NanoGe Fall Meeting, online
Contributed talk: *Sub-nanogray detection limit in methylammonium lead triiodide X-ray imaging detectors*

Distler, Andreas

11.11.2021
Emerging Topics Workshop, Erlangen, Germany
Talk: *Scaling Efficiencies from mm² to m²*

Doll, Bernd

01.08.2021
SPIE Optics and photonics, San Diego, 2021, online
Poster: *Outdoor photoluminescence of large area photovoltaic modules*

20-25.06.2021
IEEE PVSC 2021, 2021, online
Poster: *Luminescence Analysis of PV-Module Soiling in Germany*

Du, Tian

11.11.2021
Emerging Topics Workshop, Erlangen, Germany
Talk: *Towards efficient, fully printable perovskite solar cells and modules*

02.12.2021
EnCN Annual Conference 2021, Nuremberg, Germany, online
Talk: *Towards fully printable metal halide perovskite solar cells and modules*

Egelhaaf, Hans-Joachim

01.07.2021
High Throughput PV Summer Seminar i-MEET/FAU, Erlangen-Nuremberg (digital), Germany
Invited talk: *Recent Advances in High Throughput Process Development*

22-24.10.2021
"Gscheid Schlau" - Lange Nacht der WIssenschaften, virtual conference, Nürnberg, Germany
Invited Talk: *Solarmodule aus dem Drucker - Die Solarfabrik der Zukunft*

11.11.2021
Lecture to pupils of the Hermann-Kesten-Kolleg Nuremberg
Talk: *Solarmodule aus dem Drucker - Organische Photovoltaik*

24.11.2021
HOPE-PV 2021, Chernogolovka, Russland/online
Talk**:** *High Throughput Production of Printed Photovoltaics*

02.12.2021
EnCN Annual Conference 2021, virtual conference, Nuremberg, Germany
Talk: *Photovoltaik aus dem Drucker: Städte unter Strom*

Freund, Tim

20.09.2021
EMRS Fall Meeting 2021, online
Talk: *Vacuum Processing of Chalcogenide Perovskite based Thin Films*
Poster: *Electrodeposition for the Fabrication of $BaZr(SeS)_3$ based Thin Films*

03.06.2021
EMRS Spring Meeting 2021, online
Poster: *Vacuum Processing of Chalcogenide Perovskite based Thin Films*

Güler, Ezgi Nur

05. – 08.07.2021
14th International Symposium on Flexible Organic Electronics (ISFOE21), Thessaloniki, Greece/online
Talk: *Fully Solution-Processed, Light-Weight, and Ultraflexible Organic Solar Cells*

02.12.2021
EnCN Annual Conference 2021, online
Talk: *Fully Solution-Processed, Light-Weight, and Ultraflexible Organic Solar Cells*

He, Yakun

24.05.2021
International Conference on Hybrid and Organic Photovoltaics (HOPV21), online
Talk: *Ultra-stable single component organic solar cells under thermal and/or illumination pressure: the next superior organic photovoltaics?*

7-9.12.2021
Croucher ASI 2021. Frontier of Organic Semiconductors from Challenges to Opportunities City University of Hong Kong, online
Talk: *Ultrastable single-component materials: the next frontier for organic solar cells*

10.12.2021
SFB 953 Berichtseminar, online
Talk: *Stability and photophysics investigation of organic solar cells based on single-component materials*

16.12.2021
SCUT-FAU Joint Workshop 2021, online
Talk: *Unraveling the charge-carrier dynamics in double-cable polymer-based single-component organic solar cells*

Hepp, Johannes

09.09.2021
EU PVSEC 2021, online
Talk: *Influence of Intentional Alkali Metals and Alkaline Earth Metal Contamination on PID of Silicon Solar Cells*

Ihle, Jonas

24-28.10.2021
European Conference on Silicon Carbide and Related Materials, France
Poster: *In-situ monitoring of unintentionally released nitrogen gas in the initial PVT Silicon Carbide growth process using mass spectrometry*

Kalancha, Violetta

29.04.2021
GRK evening 1896, online
Talk: *Stable SnOx/Ag NWs core-shell networks for high temperature electrode applications*

Kollmuß, Manuel

24-28.10.2021
European Conference on Silicon Carbide and Related Materials, France
Poster: *Large area growth of cubic silicon carbide using closed space PVT by application of homoepitaxial seeding*
Poster: *Chemical Vapor Deposition of 3C-SiC on [100] oriented Silicon at low Temperature < 1200°C for photonic applications*

Li, Ning

11.11.2021
Emerging Topics Workshop, i-MEET/HI-ERN
Talk: *Material Concepts to Address Instability of Organic Solar Cells*

Lüer, Larry

07.09.2021
European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC 2021), online
Contributed talk: *Power Prediction of Si Photovoltaic Modules by Electroluminescent Images: Assessing the Physics Learned by a CNN*

16.12.2021
SCUT-FAU Joint Workshop 2021, online
Contributed talk: *Predicting Device Performance and Stability from Optical Spectra in High Throughput Experimentation*

Mashkov, Oleksandr

28-29.07.2021
Energy Sciences for Europe's Green Deal online
Talk: *Water-based Prussian blue ink optimization by using high-throughput robotic system for electrochromic smart windows*
Poster: *Exfoliated carbon nitride/hydrogen-bonded organic pigment heterostructures for hydrogen peroxide generation*

Osvet, Andres

09.05.2021
iPEN, Innovative Photonics Education in Nanotechnology, Colloquial Talks, online
Talk: *Laser Processing in Photovoltaics*

Schimmel, Saskia

01-04.03.2021
8th Asian Conference on Crystal Growth and Crystal Technology, online
Talk: *Evaluation of realistic boundary conditions for simulations of ammonothermal GaN crystal growth*

16 – 19.03.2021
68th JSAP Spring Meeting, online
Talk: *Simulation of the global thermal field in a setup for ammonothermal growth of GaN*

16.06.2021
Advanced Materials Conference - To innovate in the future, the journey starts here (organized by the Portuguese Ministry of Science, Technology and Higher Education), online
Talk: *Artificial Intelligence in the Materials Research*

Steinberger, Marc

23.-25.03.2021
Organic and Printed Electronics Exhibition (LOPEC), online
Talk: *Inkjetprinting of OLEDs on 3D surfaces*

30.11-02.12.2021
2021 MRS Fall Meeting & Exhibition Boston, Boston, USA
Talk: *Improved Air Processability of Organic Photovoltaics by Using a Stabilizing Antioxidant to Prevent Thermal Oxidation*
Talk: *Inkjet Printing of Organic Electronics on 3D Objects*

Steiner, Johannes

27.10.2021
13th European Conference on Silicon Carbide and Related Materials (ECSCRM2020/2021), France
Talk: *Improved Air Processability of Organic Photovoltaics by Using a Stabilizing Antioxidant to Prevent Thermal Oxidation*
Poster: *Applicability of a flat-bed birefringence setup for the determination of bulk properties of silicon carbide wafers*

Wagner, Michael

02.12.2021
EnCN Annual Conference 2021, Nuremberg/online
Talk: High Throughput Material Screening of Organic Solar Cells on a Roll-to-Roll machine

16.12.2021
SCUT-FAU Joint Workshop 2021, Erlangen-Nuremberg/online
Talk: *High Throughput Material Screening of Organic Solar Cells on a Roll-to-Roll machine*

Weitz, Paul

16.12.2021
SCUT-FAU Joint Workshop 2021, online
Talk: *Influence of Light Spectrum and Intensity on the Photodegradation of OSCs*

Wellmann, Peter

11.-15.01.2021
14th World Congress in Computational Mechanics and ECCOMAS Congress in Paris, virtual conference
Talk: *Quantitative determination of high temperature materials properties for the computer simulation of the physical vapor transport growth of SiC*

01.-03.02.2021
Virtual Workshop on Materials Science and Advanced Electronics Created by Singularity, Japan
Invited Talk: *Sublimation growth of 3C-SiC bulk crystals*

05.05.2021
EU-CHALLENGE Webinar (100 expert attendees from around the globe)
Invited Talk: *Sublimation growth of SiC bulk crystals*

18.05.2021
University of Jordan
Invited Talk: *Power Electronic Semiconductor Materials Beyond Silicon: SiC, GaN, Ga203 and Diamond*

16.06.2021
Advanced Material Conference - To innovate in the future, the journey starts here, Portuguese Presidency of EU (2021PORTUGAL.EU)
Invited Talk: *Advanced Functional Materials for Electronics: Beyond Si - The eminent role of the (ultra) wide bandgap materials SiC, GaN, AlN, □-Ga_2O_3 and Diamond*

24.-28.10.2021
ECSCRM 2020-2021: European Conference on SiC and Related Materials, Tours,
Invited Talk: *Review of Sublimation growth of SiC bulk crystals*

Zhao, Yicheng

08-11.11.2021
10th SolTech Conference, Munich, Germany
Talk: *Stability reversal in mixed-cation metal-halide perovskite materials*

07-09.12.2021
CityU Croucher ASI, Hong Kong
Talk: *Gradient high-throughput screening for stable metal-halide perovskite materials*

14-16.12.2021
The 5th Forum of Materials Genome Engineering, Guangzhou
Talk: *High-throughput engineering + interpretable machine learning for stable metal-halide perovskite materials*

Participation in the Summer/Winter schools, scientific courses (extra ones), etc:

Deumel, Sarah

Medical Device Regulation, ZiMT

Kalancha, Violetta

Event: **Course. PhD, and next?**
Date: 27-29.01 2021
Location: online, from NaturalScience.Careers

Event: **Online-Webinar: Effective Negotiation**
Date: 12.02.2021
Location: online, from Karriereservice.de

Location: Bodenwöhr, 20.09.2021-23.09.2021
Talk: "**Stable SnOx/Ag NWs core-shell networks for high temperature electrode applications**"

Event: Workshop: How to Publish a Paper
Location: Bodenwöhr, 20.09.2021
Location: online, by Prof. Christoph Brabec

Event: **Online-Workshop: My career in Academia**
Date: 09.12.2021
Location: online, from Graduate Center and Young Researchers Support

Rehm, Viktor

Lectures: Metal halide perovskite single crystal growth and applications;

Tutorials: Efficient rectifier circuits ensuring stable voltage supply; Continuum Material Modeling, and Exploration of Computational Material Modeling with MatLab; Vibrational and Optical Spectroscopy of Perovskites, and Raman Spectroscopy of Perovskite Crystals; Introduction to Density Functional Theory, and Atomistic Simulations DIY;

Workshops: Career inside and outside of academia

Japanese Preparation Course

These, Albert

30th Kronacher Impedanztage 2021

12. Seminar Presentations

20.01.2021
Dr. Larry Lüer
Bayesian Optimization in Automatic and Manual Workflows

27.01.2021
Valerie Levine, (Master Thesis, supervisors Dr. Thomas Heumüller and Prof. Dr. Christoph Brabec)
Automated Data Evaluation for Screening Novel OPV Materials
Boxue Zhang, M.Sc, (guest talk, Jilin University, China)
Interface Engineering for Highly Efficient Perovskite Solar Cells: Role of Surface Passivation

10.02.2021
Lena Merz, (Master Thesis, supervisor PD Dr. Hans-Joachim Egelhaaf)
Process Development of molten Perovskite-Layers
Matthias Popp, M.Sc, (guest talk, FAU)
The squeezable nanojunction technique – A multi-physics experiment bridging the gap from scanning probe microscopes to solid state devices?

17.02.2021
Kaicheng Zhang, (annual PhD report)
Bulk and Surface Passivation in Mixing Lead-Tin Narrow-bandgap Perovskite towards Highly Efficient and Stable Solar Cells
Tian-Jiao Wen, M.Sc, (guest talk, Department of Polymer Science and Engineering, Zhejiang University, Hangzhou, China)
Simple Non-fused Electron Acceptors Leading to Organic Photovoltaics with High Practical Figure-of-Merits
Prof. Dr. Timothy P. Bender, (guest talk, Department of Chemical Engineering and Applied Chemistry, University of Toronto)
Boron subphthalocyanines and subnaphthalocyanines for organic photovoltaics: their ambient stability, the influence of halogens, the mixed alloys, their sustainability, and using computational modeling to accelerate their development

24.02.2021
Dr. Javed Iqbal, (guest talk, Department of Chemistry, University of Agriculture, Faisalabad, Pakistan)
Combining the Strengths of Designing and Synthesis of Functional Materials

26.02.2021
Dr. Peng-Qing Bi, (guest talk, Institute of Chemistry Chinese Academy of Sciences (ICCAS), China)
Optimizing the nanomorphology and molecular structure towards high-performance and low-cost photovoltaic cells

03.03.2021
Tobias Hübner, (annual PhD report)
Inkjet-printing of Nickeloxide-Nanoparticles for Quantum Dot LEDs

10.03.2021
Hongwei Zhu, (guest talk, Tianjin University)
Perovskite defect passivation and high efficiency devices fabrication

17.03.2021
Manuel Daum, (annual PhD report)
Stabilization of alcohol-based polymer semiconductor nanoparticle dispersions

24.03.2021
Matthias Mai, (Bachelor Thesis, supervisor. PD. Dr. Miroslaw Batentschuk)
Untersuchung von Photovoltaikmodulen mit Zellrissen bei Vibrations- und zyklischen Belastungen
Ezgi Nur Güler, (Master Thesis, supervisors. Prof. Dr. Christoph Brabec, PD Dr. Hans Egelhaaf, Dr. Andreas Distler)
Development of solution-processed bottom electrodes for OPV modules

28.04.2021
Adrian Valenas, (Master Thesis, supervisors. Prof. Dr. Christoph Brabec, Dr. Larry Lüer)
Concept of measurement standardization for image recognition analysis of thin film solar cells
Mikołaj Piotrowski, (Master Thesis, supervisors. Prof. Dr. Christoph Brabec, Dr. Larry Lüer, Dr. Andres Osvet)
Photoluminescence study of recombination mechanisms in methylammonium lead iodide

05.05.2021
Laser and XRD safety instructions, Dr. Andres Osvet
Tino Lukas, (guest talk, Oxford University, Photovoltaic and Optoelectronic Device Group, UK)
Carbon-based electrode materials for stable perovskite solar cells

19.05.2021
Dr. Thomas D. Anthopoulos, (guest talk, King Abdullah University of Science andTechnology (KAUST), KAUST Solar Center (KSC), Saudi Arabia)
Strategies for Increasingthe Efficiency of Organic Solar Cells

26.05.2021
Sophie Mull, , (Master Thesis, supervisor. Prof. Dr. Christoph Brabec)
Optimierung der Fertigungslinie der CAL4 -Diode mittels automatischer optischer Inspektion

30.06.2021
Christian Huse, (Master thesis, supervisors: Prof. Dr. Christoph Brabec, Dr. Johannes Hepp)
Electrical characterisation and imaging of potential induced degradation in intentionally contaminated silicon solar cells

21.07.2021
Burak Baydar, (Bachelor thesis, supervisors: PD. Dr. Hans-Joachim Egelhaaf, Michael Wagner)
Hochdurchsatzoptimierung gedruckter Solarzellen mittels Rolle-zu-Rolle-Verfahren

04.08.2021
Simon Hassel (Master thesis, supervisor: Prof. Dr. Wolfgang Heiss)
Evaluierung der Potentialverteilung auf der Metallisierung von Leistungshalbleitern unter Berücksichtigung von Alterungsvorgängen im aktiven Lastwechsel

08.09.2021
Robin Basu, (Master Thesis, supervisor. Prof. Dr. Wolfgang Heiss)
Solar cells from lead sulfide quantum dots
Dominik Glaser, (Master Thesis, supervisor. Prof. Dr. Wolfgang Heiss)
Untersuchung der Porosität in Sinterschichten in Abhängigkeit des Sinterprozesses und der Sintermaterialien und deren Einfluss auf die Folgeprozesse

15.09.2021
Darius Hoffmeister, (Master thesis, supervisors: Prof. Dr. Christoph Brabec, Manuel Daum)
A nanoparticle-based coating method for layer-by-layer structuring of highly efficient organic solar cells

22.09.2021
Adrian Valenas, (Master thesis, supervisors: Prof. Dr. Christoph Brabec, Dr Larry Lüer)
Reversible performance degradation in perovskite solar cells
Tobias Osterrieder, (Master thesis, supervisors: Prof. Dr. Christoph Brabec, Dr. Thomas Heumüller)
Investigation and Optimization of quaternary Organic Solar Cells by utilizing HTE and Bayesian Optimizer in a semi-autonomous laboratory approach

29.09.2021
Kaicheng Zhang, (annual PhD report),
Understanding the limitations of charge transporting layers in mixed lead-tin halide perovskite solar cells
Felix Schröder, (Master thesis, supervisor: Prof. Dr.Wolfgang Heiss)
Synthetic Image Augmentation in Through Hole PCB Assembly via Deep Generative Models

13.10.2021

Benedict Hanisch, (Bachelor thesis, supervisors: Prof. Dr. Christoph Brabec, Dr. Ning Li, Yakun He)
Characterization of the Exciton Splitting Efficiency of Single-Component Materials of Organic Photovoltaic Applications
Jingjing Tian, (annual PhD report),
Quantifying Open-Circuit Voltage Losses in $CsPbI_2Br$ Inorganic Perovskite Solar Cells

20.10.2021

Wei Meng, (annual PhD report)
Interface engineering for perovskite solar cells

27.10.2021

Julian Zöcklein, (Bachelor thesis, supervisors: Prof. Dr. Christoph Brabec, Dr. Claudia Buerhop-Lutz und Dr. Oleksandr Stroyuk)
Wet leakage insulation behaviour of water exposed Silicon PV modules with different backsheet materials

03.11.2021

Dr. Ian Marius Peters
Cost relations of tandem solar cells - a marriage of equals

17.11.2021

José Garcia Cerillo, (annual PhD report),
Attaining the short circuit current matching in organic/perovskite tandem solar modules with non-complementary band gaps

01.12.2021

Renjun Guo, (Guest talk, Technische Universität München),
From fabrication to degradation of solar cells. An in-situ study based on synchrotron radiation

15.12.2021

Lewin Leihkamm, (Bachelor thesis, supervisors: Prof. Dr. Christoph Brabec, Dr. Claudia Buerhop-Lutz und Dr. Oleksandr Stroyuk),
Spectroscopic analysis of water ingress in polymer components of photovoltaic modules
Yao Guan, (Master thesis, supervisor: Dr. Larry Lüer, Prof. Dr. Christoph Brabec)
Machine Learning Assisted Fast Measurement of Transient Absorption Kinetics

17.12.2021

Dr. Osbel Almora Rodríguez, (guest talk, Institute of Advanced Materials (INAM), Spain)
Light intensity modulated spectroscopic methods in photovoltaics

Guest Talks 2021

27.01.2021
Boxue Zhang, M.Sc, (guest talk, Jilin University, China)
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Prof. Dr. Timothy P. Bender, (guest talk, Department of Chemical Engineering and Applied Chemistry, University of Toronto)
Boron subphthalocyanines and subnaphthalocyanines for organic photovoltaics: their ambient stability, the influence of halogens, the mixed alloys, their sustainability, and using computational modeling to accelerate their development

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Combining the Strengths of Designing and Synthesis of Functional Materials

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Optimizing the nanomorphology and molecular structure towards high-performance and low-cost photovoltaic cells

10.03.2021
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Development of solution-processed bottom electrodes for OPV modules

05.05.2021
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Dr. Thomas D. Anthopoulos, (guest talk, King Abdullah University of Science andTechnology (KAUST), KAUST Solar Center (KSC), Saudi Arabia)
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01.12.2021

Renjun Guo, (Guest talk, Technische Universität München),
From fabrication to degradation of solar cells. An in-situ study based on synchrotron radiation

17.12.2021

Dr. Osbel Almora Rodríguez, (guest talk, Institute of Advanced Materials (INAM), Spain)
Light intensity modulated spectroscopic methods in photovoltaics

13. Conferences organized by Members of the Institute

Brabec, Christoph

6-8.12.2021
Conference (Full name): The 6th International Conference on Next Generation Solar Energy (NGSE5)
Location: online conference
16.12.2021
Conference (Full name): The FAU-SCUT joint workshop 2021
Location: online

Li, Ning

6-8.12.2021
Conference (Full name): International Conference on Next Generation Solar Energy (NGSE6)
Location: online
16.12.2021
Conference (Full name): The FAU-SCUT joint workshop 2021
Location: online

The 6th International Conference on Next Generation Solar Energy (NGSE6)

The Next Generation Solar Energy (NGSE) is an international conference series organized by the Friedrich-Alexander University Erlangen-Nuremberg (FAU), the Helmholtz Institute Erlangen-Nuremberg for Renewable Energies (HI ERN) in collaboration with other international institutions. It consists of an annual conference organized in December as well as a PhD-Postdoc series organized twice a month.

This year the conference (NGSE6) was held 6th – 8th of December 2021 in close collaboration between the FAU, HI ERN, the National Renewable Energy Labs (NREL), the Erlangen Graduate School of Excellence in Optical Technologies (SAOT) and the International Research Training Group "Energy Conversion Systems: From Materials to Devices" (IGK 2495).

NGSE6 focused on the topic "Concepts to break the Detailed-Balance Limit in Photovoltaics". As Silicon approaches this limit in the laboratory and in practical applications of solar cells, new concepts are needed that allow for Photovoltaics to go beyond these limits. The NGSE6 this year was an expert forum for discussing concepts to do this. A program with 18 world leading scientists in this area was put together with 4 Tutorials and 14 invited talks on Detailed-balance Limit and Fundamentals, Multiple Exciton Generation, Up and Down Conversion, Singlet Fission, Hot Electron Capture and Emerging Concepts.

Due to Corona the conference was held virtually again in 2021. This allowed us to reach a large international audience of more than 1000 listeners over the three days with this highly specialized topic. The conference offered an excellent opportunity to learn about latest developments and current projects in the field of photovoltaics and to exchange ideas and experiences with experts from around the world.

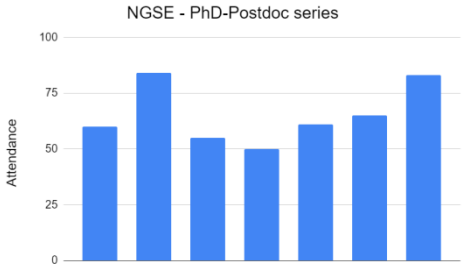
This year, NGSE6 also expanded to a Latin American context (NGSE-LatAm) by offering a special three-day program in Spanish language. The NGSE-LatAm offered a tutorial program in the area of novel photovoltaic technologies in order to enhance, update and expand the academic training of a greater number of Latin and Hispanic students. The NGSE-LatAm is also an opportunity to make the scientific, technical and productive capabilities in Latin America visible, with an emphasis on the investigation and implementation of photovoltaic energy. The topics of the NGSE LatAm will be focused on (i) Organic PV & Perovskite PV (ii) nanostructured PV, (iii) next-generation PV, and (iv) Innovative Photovoltaic Applications.

The Next Generation Solar Energy (NGSE) PhD-Postdoc series

The Next Generation Solar Energy (NGSE) PhD-Postdoc series (https://www.ngse.info/phd-postdoc-series/) has started in close collaboration of i-MEET and HI ERN and aims to promote the work of Emerging Scientists (PhD students and Postdocs) in the field of solar energy. While a lot of talks in mainstream conferences are given by professors or group leaders, here only early career researchers will present in order to promote a new generation of promising scientists.

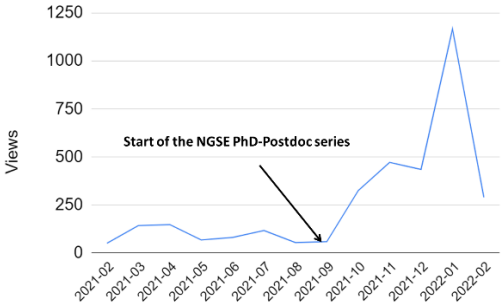
The series will provide a platform for experienced scientists to give feedback and challenge the young generation, but also to scout for future potential collaborators and colleagues. This series aims to facilitate discussions and to allow for deeper insights into phenomena as well as characterization techniques. As such, presentations will focus on clearly defined topics covered in-depth, rather than a list of big achievements. The organization of the series and the selections of the future speakers is made by a committee (to be announced) also composed of early career researchers as well as past speakers.

Presentations are given on the second and fourth Wednesday of every month at 5 PM (GMT+2) Berlin time which is 8 AM (GMT-7) Los Angeles time, 11 AM (GMT-4) Montreal, 11 PM (GMT+8) Beijing. The talks are held online (via Zoom) to ensure that researchers from around the world can present and attend. Talks last between 20 to 30 min (max) followed by 10 min of questions. With the speakers' permission (embargo period possible) the talks will be recorded and uploaded to a dedicated YouTube channel. At the end of every academic year a vote (50% community vote 50% committee) will be organized to select and award the "NGSE – Best Speaker of the Year". Attendance throughout the series has been relatively stable with an averaged attendance of **65** people. In total over **475** people registered for at least one of the talk.



Attendance of the series

With the launch of the NGSE – PhD-Postdoc series the YouTube channel of the group i-MEET lab (https://www.youtube.com/channel/UC6RHRl5xyzL1b-lcJ6FG3PA) has been a lot more active with the publication of the talks from the series twice a month. The videos from the talks of our NGSE - Emerging Topics Workshop (https://www.ngse.info/emerging-topics-workshop/) are also available on the channel. This lead to a greatly increased traffic on the channel with the most popular video being the work of Dr. Yicheng Zhao that now cumulates over a **1000 views**.



Views of the i-MEET youtube channel

Christian Wolff

22-Sep-2021:

Light management in perovskite single- and multi-junction solar cells.

As perovskites have improved in both efficiency and stability through composition- and process-engineering, their higher efficiencies become limited by extrinsic factors such as their ability to absorb light and convert these photons into usable energy. To reduce reflection losses flat surfaces must be avoided. I will present randomly textured nanometer- and micrometer-sized structures in solution or vapor deposited lead halide perovskites and how these enable flat and almost loss-free photon-to-current spectra. The devices collect ~95% of all incoming light above bandgap. I'll close by showing how these textures are embedded into efficient single-junctions and two-terminal tandem devices and our approaches and pitfalls when trying to upscale the processes to wafer size.

Jarla Thiesbrummel

13-Oct-2021:

Universal Current Losses in Perovskite Solar Cells Due to Mobile Ions

We investigated the origin of current losses in perovskite solar cells, using a combination of voltage dependent photoluminescence (PL) timeseries and various charge extraction measurements. It was demonstrated that Pb/Sn-

perovskite devices suffer from a reduction in the charge extraction efficiency within the first few seconds of operation, which leads to a loss in current and lower maximum power output. In addition, the emitted PL from the device rises on the exact same timescales due to the accumulation of electronic charges in the active layer. Using transient charge extraction measurements, we showed that these observations cannot be explained by doping-induced electronic charges but by the movement of mobile ions toward the perovskite/transport layer interfaces, which inhibits charge extraction due to band flattening. Finally, we generalized these findings to lead-based perovskites, showing that the loss mechanism is universal.
I will discuss the negative role mobile ions play in perovskite solar cells and how our findings pave the path towards understanding and mitigating a key loss mechanism. Furthermore, I will also give an outlook on what our results mean for perovskite-based tandem solar cells and I will present our recent progress on the development of these devices.

Moritz Futscher

27-Oct-2022:

Ion migration in halide perovskites: Opportunities and challenges.

Halide perovskites have proven to be a promising candidate for high-efficiency solar cells, light-emitting diodes, and X-ray detectors, overcoming limitations of inorganic semiconductors. However, unlike classical inorganic semiconductors, halide perovskites are mixed ionic-electronic conductors, and their ionic conductivity has been shown to increase under device operating conditions. In this talk, I will discuss the important consequences of this mixed conductivity for (opto)electronic measurement techniques. I will further show how to distinguish between ionic and electronic effects using transient techniques, and highlight some recent developments to utilize the mixed conductivity of halide perovskites in applications such as Li-ion batteries and resistive switches.

Felix Lang

10-Nov-2021:

Perovskite-based Tandem Photovoltaics for Near-Earth, Moon, Mars and Deep Space Applications From Radiation Tolerance to Open Challenges

Efficient perovskite-based multijunction solar cells with a high efficiency-to-mass ratio promise a next-generation of lightweight, flexible solutions to power private space exploration, low-cost space missions, as

well as future habitats on the Moon and Mars.
This presentation will review the potential of perovskite-based multijunction solar cells – be it perovskite/silicon, perovskite/CIGS, or perovskite/perovskite – for space applications. I will show that current state-of-the-art systems already offer unparalleled power-to-weight ratios and then focus on radiation tolerance, a crucial prerequisite for any space application.
Monolithic perovskite/perovskite tandem PV especially exhibit an extraordinary resilience to the harsh radiation environment in space. I will present tests under 68 MeV proton irradiation that reveal negligible degradation (< 6%) at a dose of 1013 p+/cm2 where even III-V semiconductor-based space PV degrade >22%. Interestingly there are quite distinct degradation mechanisms between the two systems. High-spatial-resolution PL microscopy, for example, reveals defect clusters in GaAs being responsible for the degradation of current space-PV. On the contrary, there is negligible reduction in PL of the individual perovskite subcells. In fact, bare low-gap and high-gap perovskite absorbers exhibit identically high VOC, FF, and efficiency potentials after irradiation, rendering all-perovskite tandems highly interesting for thin, lightweight, large-area space PV modules & solar blankets.
Lastly, I will discuss open challenges regarding the many extremes in outer space, from UV-A, UV-B & VUV to extreme temperature cycles, Atomic-Oxygen, and LILT conditions.

Lorena Perdigón Toro

24-Nov-2021:

What have we learned so far from state-of-the-art organic solar cells?

Organic solar cells (OSCs) have experienced renewed and rapidly growing interest in the last five years due to the development of a new generation of n-type small molecules, known as non-fullerene acceptors (NFAs). NFAs have enabled efficiencies to increase to above 18%, with a 20% now within reach. In the beginning of 2019, the blend of the donor polymer PM6 with the NFA Y6 caught everyone's attention, because of its high and reproducible performance. In Potsdam, we aimed to learn more about PM6:Y6 blend by focusing on free charge generation and recombination and the emission properties of the species involved in these processes. Here, I will present the main results and conclusions from these studies and point to issues and questions, which still need to be addressed.

26-Jan-2022:

Taking a closer look: the power of optical microscopy to unravel the complex world of two-dimensional perovskites.

Simon Kahmann

Abstract:

Studied since the 1980's, research on two-dimensional perovskites has only recently exploded in the shadow of their 3D counterparts. Now, these compounds are studied for improved performance and stability of solar cells, light-emitting devices, scintillators, gas detectors, and many more applications. As a consequence of their two-dimensional nature, they are also prime candidates for studying fundamental exciton physics.

Liberated from the tight constraints of the Goldschmidt tolerance factor, the field produces an ever-growing library of potential spacer cations. Whereas early work was mostly based on simple primary amines with alkyl chains or a benzene ring, current efforts include heteroatoms, complex aromatic systems, chiral molecules, and bifunctional spacers.

I shall introduce some of the interesting aspects of 2D perovskites beyond their use in PV applications. In particular, I shall address currently debated topics regarding their bright luminescence: what is the origin of broad emission bands? Is Kasha's rule broken? And what's the matter with Dion-Jacobson compounds?

Besides such fundamental questions, I'll use these studies to illustrate the power of optical microscopy experiments for research in energy materials – be they low-dimensional, perovskites, or organic.

High Throughput PV Summer Seminar 2021

On July 1st our annual High Throughput PV Summer Seminar took place. This time the seminar was held digital. The group leaders highlighted challenges and achievements in the high-throughput research at HIERN, i-MEET and ZAE this year. The program of the workshop was:

Lecture 1: Prof. Brabec, High Throughput Methods in Energy Materials Research –a practical approach at HIERN.

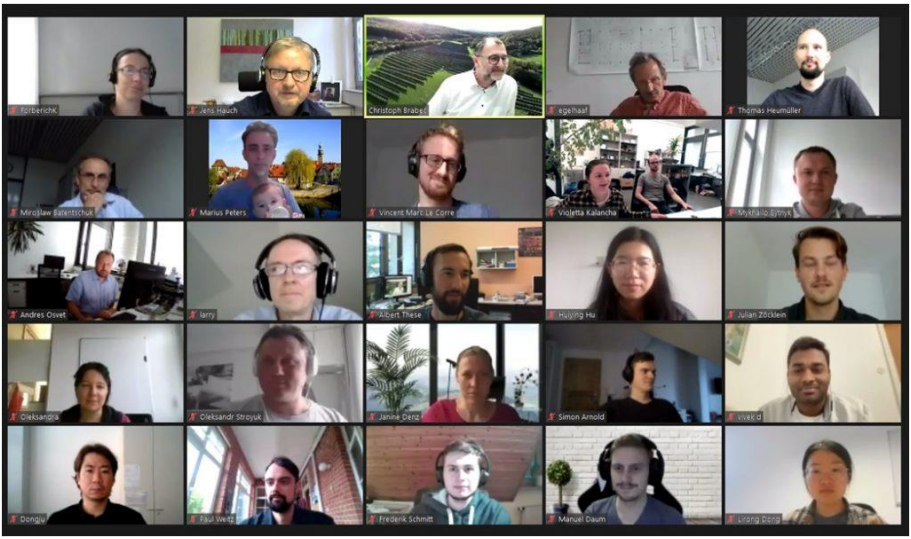
Lecture 2 –Dr. Jens Hauch, HI ERN –Automated and Autonomous Materials and Device Development Platform for Solution Processed Semiconductor Devices

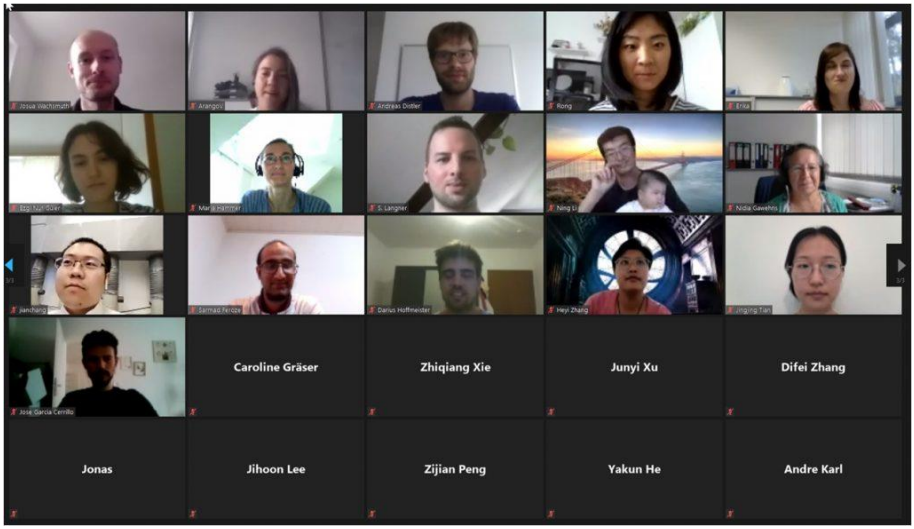
Lecture 3 –Dr. Doz. Hans-Joachim Egelhaaf, ZAE Bayern –Recent Advances in High Throughput Process Development

Lecture 4 –Dr. Karen Forberich, HI ERN –Advances in High Throughput Simulation of PV Devices

Lecture 5 –Dr. Thomas Heumüller, HI ERN/FAU -High Throughput Stability Testing for Organic Photovoltaics

Lecture 6 –Dr. Marius Peters, HI ERN –High Throughput Failure Analysis in PV-Modules for Real World Systems





Participants of the High Throughput PV Summer Seminar 2021

14. Cooperation in Committees

Batentschuk, Miroslaw

Internship Committee of the Material Department, Friedrich-Alexander University Erlangen-Nürnberg

Study Commission of the Department of Material Science, Friedrich-Alexander University Erlangen-Nürnberg

Practical Course Commission of the Department of Material Science, Friedrich-Alexander University Erlangen-Nürnberg

Brabec, Christoph J.

Activities for the Friedrich-Alexander University Erlangen - Nürnberg (FAU):

Member of the Material Science Department´s Steering Committee

Spokesman of the Material Science Courses, Friedrich-Alexander University Erlangen-Nürnberg

Representative of the Material Science Department in the Faculty´s Commission of Studying

National Activities:

Scientific Director Department Renewable Energies, ZAE Bayern, Erlangen

Member of the EnCN Science Board (Energy Campus Nürnberg)

International Activities:

Honorary Professor at the University of Groningen

Director at the Forschungszentrum Jülich (FZJ) for Highthroughput Methods in Photovoltaics – Helmholtz Institute Erlangen-Nürnberg (HI-ErN)

Member of Scientific Board of the PE graduate school, Imperial College, London

Member of the Scientific Advising Board, CRANN AMBER, Trinity College Dublin, Ireland

Member of the Scientific Board of the International Conference on Organic Electronics (ICOE)

Head of the Organization Board of the Next Generation Solar Energy Conference (NGSE)

Member of two European INFRAIA consortia

Member of the Management Committee Member of 3 GPV School

Services to the Community:

Serving as expert referee for European Community - European Research Council (ERC Awards)

Chairman of the Editorial Board “Advanced Energy Materials”, Wiley VCH

Member of the Editorial Board of “Progress in Photovoltaics”, Wiley VCH

Member of the Editorial Board of “Emerging Materials Research”, ICE publishing

Serving as referee for several funding organizations, among them the Austrian Science Fund (FWF), for the German Research Foundation (DFG), the Baden-Württemberg Stiftung, and for more than 15 top ranked journals in the field of materials, semiconductors and energy (Nature Family, EES, Advanced Family)

Carigiet, Fabian

Paper Reviewer Expert and member of the International Scientific Committee of the EU PVSEC

Kalancha, Violetta

Center for Nanoanalysis and Electron Microscopy, GRK1896

Li, Ning

Organizing committee for the 5th NGSE conference, Guangzhou, China & Nürnberg, Germany.
Member of the Editorial Board of "Journal of Semiconductors", IOPscience

Wellmann, Peter

President of E-MRS (European Materials Research Society)
Senate Member of E-MRS
Member of the E-MRS executive committee
Co-chair of the development commission of IUMRS
Board member of the Joint Institute of Advanced Materials and Processes (ZMP, FAU)
Organizer: Europa-Afrika Zusammenarbeit Materialwissenschaft
Treasurer of Deutsche Gesellschaft für Kristallzüchtung und Kristallwachstum (DGKK e.V.)
Reviewer for Journal of Crystal Growth, Journal of Crystal Growth & Design, Journal of Crystal Research and Technology und Journal of Thin Solid Films
Member Editorial board Nature Applied Sciences by Springer

15. Research Projects

Deutsche Forschungsgemeinschaft DFG: MA 6617/1-1
18.06.2018 – 30.06.2021
Bleifreie Perovskite für die Röntendetektion

PV-ZUM – DynaSol, Zentrales Innovationsprogramm Mittelstand
bis 31.07.2020
Transientes Photoelektronisches Messverfahren

China Scholarship Council (China)

CSC grant No. 201206130055
Design and Fabrication of organic solar cells based on solution-processed small molecules (Ke, Lili)

CSC grant:
He, Yakun
Liu, Chao

Deutsche Forschungsgemeinschaft DFG WE 2107/12-1 (Germany)
01.04.2016 – 31.03.2020
Analyse der Wachstumskinetik während der Hochtemperatur-Kristallzüchtung von SiC unter Anwendung der Computertomographie zur in-situ 3D Visualisierung der Wachstumsphasengrenze

EnCN2 (Germany)
01.01.2017 – 31.12.2021
Erneuerbare EnergieträgerTechnologien im urbanen Umfeld (EET) Speicher A

EU CHALLENGE 720827
01.01.2017 – 30.06.2021
3C-SiC Hetero-epitaxiALLy grown on silicon compliancE substrates and 3C-SiC substrates for sustaiNable wide-band-Gap powEr devices

Projektträger Jülich 0324154D (Germany)
01.11.2017 – 30.09.2020
Verbundvorhaben: MYCIGS - Energieertragsoptimierte Cu (In,Ga)(S,Se)$_2$-Dünnschichtsolarmodule durch gezielte Steuerung der Ertragsparameter; Teilvorhaben: Materialwissenschaftliche Charakterisierung

PV-ZUM DynoSol (BMWi) (Germany)
01.05.2017 – 30.04.2020

SFB 953 B01 (Germany)
Synthetic Carbon Allotropes

Deutsche Forschungsgemeinschaft DFG (Germany)
2017 –2021
Smarte und Schaltbare Fenster, in collaboration with EnCN

International Research and Training Group GRK 2495, DFG (Germany)
2020 –2025
Solution Processed Ferroelectrics in Photovoltaic Devices

GRK 1896, DFG (Germany)
In situ microscopy with electrons, X-rays and scanning probes

Deutsche Forschungsgemeinschaft DFG-EIN-SBH: AOBJ: 670990 (Germany)
01.10.2020–30.09.2022
Analyse der Wachstumskinetik während der Kristallzüchtung von SiC auf großen Kristalldurchmessern unter Anwendung der μ-Computer-Laminographie zur in-situ 3D Visualisierung der Wachstumsphasengrenze

EU, 8. Rahmenprogramm Horizon 2020, Teilprojekt (899679)
01.10.2020- 31.03.2024
CMOS compatible and ultra broadband on-chip SiC frequency comb (SiComb)

Deutsche Forschungsgemeinschaft DFG: Teilprojekt (399073171) (Germany)
01.01.2020-31.12.2022
IGK 2495: Energy conversion systems: From Materials to Devices, Teilprojekt I: Growth of Single Crystal Transition Metal Perovskite Chalcogenides

Deutsche Forschungsgemeinschaft DFG-EIN-SBH: AOBJ: 646355 (Germany)
01.01.2018-31.12.2021
Quantitative Charakterisierung und Vorhersage von Versetzungsverhalten in hochreinem SiC

Bundesministerium für Wirtschaft und Technologie (BMWi), (ZF4506004RE8) (Germany)
20.12.2018-30.06.2021
Entwicklung eines Wachstumsprozesses für SiC-Wafer mit Durchmessern größer 10cm unter Anwendung der neuen SiC-Quellenmaterialien

Bundesministerium für Wirtschaft und Technologie (BMWi), (0324154D) (Germany)
01.10.2017-30.06.2021
MYCIGS: Energieertragsoptimierte Cu(In,Ga)(S,Se)2-Dünnschichtsolarmodule durch gezielte Steuerung der Ertragsparameter Materialwissenschaftliche Charakterisierung

Leadership in Enabling & Industrial Technologies (LEIT), Teilprojekt (720827)
01.01.2017-30.06.2021
CHALLENGE: 3C-SiC Hetero-epitaxiALLy grown on silicon compliancE substrates and 3C-SiC substrates for sustaiNable wide-band-Gap powEr devices

EU Project 952911 "Booster"
2020-2024
Boost Of Organic Solar Technology for European Radiance

i-PEN Project (EU and Israel)
Photonic Education in Nanotechnology

Deutsche Forschungsgemeinschaft DFG, BR4031/20-1 (Germany)
09.2020 –08.2023
Prozess-Struktur Relationen für die lösungsmittel-basierte organische Photovoltaik

Deutsche Forschungsgemeinschaft DFG, BR4031/20-1 (Germany)
09.2020 –08.2023
Prozess-Struktur Relationen für die lösungsmittel-basierte organische Photovoltaik

European Union's Horizon 2020 research and innovation programme, CITYSOLAR, 101007084
08.2020 –07.2023
Energy harvesting in cities with transparent and highly efficient windowintegratedmulti-junction solar cells

Bundesministerium für Wirtschaft und Technologie (BMWi), (PIASOL, ZF4506012DB9) (Germany)
01.11.2019 –31.10.2021
Integration eines Ladungsträgerlebensdauermessgeräts in eine R2R-Produktionsanlage zur Inline-Qualitätskontrolle für gedruckte Halbleiter

Bundesministerium für Wirtschaft und Technologie (BMWi), (PV-IL, ZF4506011DF9) (Germany)
01.04.2020 –31.03.2022
Entwicklung der Laserparameter für die Inline-Strukturierung von gedruckten Solarmodulen

Bayerisches Staatsministerium für Wissenschaft und Kunst (D7-F5121.3.6.3.4), (Germany)
Solar Technologies go Hybrid (SolTech)

Bayerisches Staatsministerium für Wissenschaft und Kunst (iPV4.0), (Germany)
08.2018 –07.2021
Laboranalyse von Degradationsmechanismen unter beschleunigter Alterung und Entwicklung geeigneter feldtauglicher bildgebender Detektionsverfahren und Entwicklung und Evaluation eines Algorithmus zur Fehlerdetektion und Prognostizierung der Ausfallwahrscheinlichkeit (iPV4.0)

Bayerisches Staatsministerium für Wissenschaft und Kunst (EB1022), (Germany)
01.08.2018 –31.07.2022
Modulanalytik und Fehlerauswertung (optiCIGS_II)

Bundesministerium für Wirtschaft und Technologie (BMWi), (CESSY) (Germany)
01.2018 –06.2020
Entwicklung eines High-End-Solarkollektors mit bisher unerreichtem erhöhtem nutzbarem Temperaturniveau für maximalen Nutzungsgrad der Energie aus dem Sonnenlicht; Auswahl PV-fähiger Materialien, Validierung diverser Befestigungsmöglichkeiten, Fixierung variabler Werte für die Testläufe, Lastfallsimulationen, Prototypenbau (CESSY)

Bundesministerium für Wirtschaft und Technologie (BMWi), (Low Haze Schichten R2R auf Folie) (Germany)
01.2019 –06.2020
Herstellung von Silbernanodrähten mit reduziertem Durchmesser und deren Verwendung in Formulierungen zur Rolle-zu-Rolle Beschichtung von Folien mit den Funktionalitäten transparent, leitfähig und niedrigem Haze (Low Haze Schichten R2R auf Folie)

Bayerisches Staatsministerium für Wissenschaft und Kunst (EnCN EET TP2), (Germany)
2017 –2021
Erneuerbare Energieträger-Technologien "Zerstörungsfreie und bildgebende Analyse" (EnCN EET_TP2)

Deutsche Forschungsgemeinschaft DFG, BR 4031/21-1 (Germany)
01.05.2021 - 30.04.2024
Verständnis der Quanteneigenschaften von angeregten Zuständen an der Donator-Akzeptor-Grenzfläche - auf dem Weg zu effizienten organischen Soalrzellen mit minimalem Energieverlust „EXTRAORDINAIRE“

Deutsche Forschungsgemeinschaft DFG, BR 4031/22-1 (Germany)
01.01.2022 - 31.12.2024
Entwicklung und Erforschung von effizienten und strahlungsresistenten organischen Solarzellen für Raumfahrtanwendungen basierend auf einer KI angeleiteten Hochdurchsatz Forschungsstrategie „RADIATION HARDNESS“

Das Zentrale Innovationsprogramm Mittelstand (ZIM) des Bundesministeriums für Wirtschaft (AiF) (Germany)
2021-2023
Entwicklung von neuartigen Silizium Solarmodulen mit internen optisch aktiven Schichten zwecks Steigerung des Wirkungsgrades um 5 %

Deutsche Forschungsgemeinschaft DFG WE 2107/15-1 AOBJ: 646355 (Germany)
01.01.2018-31.03.2022
Quantitative Charakterisierung und Vorhersage von Versetzungsverhalten in hochreinem SiC

Bundesministerium für Wirtschaft und Technologie (BMWi), (ZF4506004RE8)
(Germany)
20.12.2018-30.06.2021
Entwicklung eines Wachstumsprozesses für SiC-Wafer mit Durchmessern größer 10cm unter Anwendung der neuen SiC-Quellenmaterialien

Das Zentrale Innovationsprogramm Mittelstand (ZIM) des Bundesministeriums für Wirtschaft
01.05.2021 – 30.04.2023
PV-CO2

Chinesisch-Deutsches Zentrum für Wissenschaftsförderung
01.01.2021-31.12.2023
Sino-German Center

Deutsche Forschungsgemeinschaft DFG
01.09.2020 - 31.08.2023
Prozess-Struktur Relationen für die lösungsmittelbasierte organische Photovoltaik

ARMOR SPF
01.05.2021-30.04.2023
Development of Printed Perovskite Solar Modules

Das Zentrale Innovationsprogramm Mittelstand (ZIM) des Bundesministeriums für Wirtschaft
01.12.2021 – 30.11.2023
OPV4IoT

Das Zentrale Innovationsprogramm Mittelstand (ZIM) des Bundesministeriums für Wirtschaft
01.03.2020-28.02.2022
Photoinduzierte Ladungsträgerdynamik als Qualitätskriterium in der Halbleiterproduktion (PIASOL)

16. Teaching

Winter Term 2020/21

Lectures (VORL)

Advanced Semiconductor Materials - Excited States and Charge Transport in Organic Semiconductors [ASM-ES-ChT-OE], *H.-J. Egelhaaf, Ch. J. Brabec*

Advanced Semiconductor Technologies - Materials for Organic Electronics [AST-MatOE], *M. Halik*

Advanced Semiconductors Introduction: Devices & Applications [ASI - D&A], *Ch. J. Brabec*

Advanced Semiconductors Introduction: Fundamentals [ASI - F], *W. Heiss*

Crystal Growth 1 - Fundamentals of Crystal Growth and Semiconductor Technology [CG-1], *P. Wellmann*

Grundlagen der Halbleiterphysik [GHl], *W. Heiss*

Materialien der Elektronik und der Energietechnik [MEET-V], *P. Wellmann*

Materialien und Bauelemente für die Optoelektronik und Energietechnologie: Grundlagen [OpEt-G], *Ch. J. Brabec*

Nanospektroskopie [NanoSpek], *W. Heiss, M. Batentschuk*

Phosphors for Light Conversion in Photovoltaic Devices and LEDs [Ph-PV-LED], *M. Batentschuk*

Photo Physics and Electronic Transport [PhPhys], *H.-J. Egelhaaf*

Photo Physics and Electronic Transport (Extension) [PhPhys_ext], *H.-J. Egelhaaf*

Technische Grundlagen medizinischer Diagnostikverfahren [TGmD], *M. Thoms*

Werkstoffe und Verfahren der medizinischen Diagnostik I [WVmDI], *M. Thoms*

Werkstoffkunde für Studierende der Elektrotechnik (EEI) [Werkstoffk.(ET)], *P. Wellmann*

Exercises and laboratory courses (PR, PJS, SL, UE)

Advanced Semiconductor Technologies - Characterization and Advanced Defect Imaging of PV Modules and Systems [AST-DefIm-PR], *Ch. J. Brabec, J. Hauch*

Advanced Semiconductor Technologies - Manufactoring and Characterization of Phosphors and Dielectric Mirrors [AST-PhosMirr-PR], *M. Batentschuk*

Advanced Semiconductor Technologies - Photovoltaic Systems for Power Generation - Design Implementation and Characterization [AST-PVS-Design], *Ch. J. Brabec, J. Hauch*

Advanced Semiconductor Technologies - Synthesis of Carbon Quantum Dots [AST-QD], *W. Heiss*

Crystal Growth - Lab Work 1 Crystal Growth, *P. Wellmann*

Crystal Growth - Lab Work 2 Semiconductor Technology, *P. Wellmann*

Lab Work Characterization and Advanced Defect Imaging of PV Modules and Systems [LW - Ch&Im], *A. Osvet, J. Hauch*

Lab Work Organic Electronics [OE-Pra-MWT], *Th. Heumüller*

Lab Work Organic Electronics NT [OE-Pra-NT], *N.N.*

Lab Work Solution Processed Electronics [LW-SP-El], *A. Osvet*

Praktikum Materialien der Elektronik und der Energietechnologie (5.Sem.) [PR2-ET], *P. Wellmann*

Nano-Bauelemente-Sensoren, MEMS, Micromachining [(NanoDev)], *O. Kasian*

Praktikum Funktionswerkstoffe in der Energietechnologie [FEt-Pra], *P. Wellmann*

Praktikum Nanotechnologie 2 (Master) [NT2-Pra], *W. Heiss, E. Spiecker*

Praktikum Transporteigenschaften in HL [TrEHl-Pra], *A. Osvet*

Praktikum Wahlfach Crystal Growth [WCrGr-Pra], *P. Wellmann*

Praktikum Werkstoffe 2 [PW 2], *M. Batentschuk*

Projektarbeit - Arbeitsgemeinschaft Kristallisation von SiC und CIS [AGK-Sem1], *P. Wellmann*

Projektarbeit -Arbeitsgemeinschaft Organische Photovoltaik [OPV-AG-Sem], *Ch. J. Brabec*
Projektarbeit –Arbeitsgemeinschaft Solution Processed Semiconductors [SPS_AG-Sem],
W. Heiss

Übung Nano Devices [(ÜbNanoDev)], *N.N.*

Vorbesprechung Masterstudium i-MEET WS 20/21, *Ch. J. Brabec, M. Batentschuk, W. Heiss, P. Wellmann, H.-J. Egelhaaf, A. Osvet*

Seminars (AWA, SEM, TUT)

Advanced Semiconductor Technologies - Solution Processed Semiconductor Materials [AST-SPS-PR], *W. Heiss*

Anleitung zur wissenschaftlichen Arbeit - Accelerated lifetime testing of materials and devices [AnwA - Lifetime-Test], *Ch.J. Brabec, Th. Heumüller*

Anleitung zur wissenschaftlichen Arbeit - Devices [AnwA - Dev], *Ch.J. Brabec, N. Li*

Anleitung zur wissenschaftlichen Arbeit - High Throughput Characterisation and Modelling [AnwA - HT-Ch-Mod], *Ch.J. Brabec,M. Peters*

Anleitung zur wissenschaftlichen Arbeit - High Throughput Material and device Research for photovoltaics [AnwA - HT-Mat-Res], *Ch.J. Brabec, J. Hauch*

Anleitung zur wissenschaftlichen Arbeit - Materials for Optoelectronics [AnwA - Materials], *A. Osvet, Ch.J. Brabec, M. Batentschuk*

Anleitung zur wissenschaftlichen Arbeit - Solution Processing of Semiconductors [AnwA-SolPro-SC], *H.-J. Egelhaaf*

Anleitung zur wissenschaftlichen Arbeit- Solution-Processed-Semiconductor-Materials [AnwA- SOPSEM], *W. Heiss*

Electronic Materials – Tutorium [EM - Tut], *N. Li, Ch.J. Brabec*

eTutorial - Materialien der Elektronik und Energietechnik (5. Sem) [eTUT-WET], *P. Wellmann*

eTutorial Werkstoffkunde für EEI (1. Sem) [eTUT-WW-EEI], *P. Wellmann*

Kern-/ Nebenfachseminar i-MEET [KF/NF-iMEET-Sem], *Ch. J. Brabec*

Neuere Fragen zu Werkstoffen der Elektronik und Energietechnologie (Lehrstuhl-Seminar) [iMEET-Sem], *Ch. J. Brabec, M. Batentschuk, K. Forberich*

Seminar "Organic Electronics" [OE-Sem2], *A. Osvet.*

Seminar and Conference Participation on Solar Energy [Sem&Conf_SE], *Ch. J. Brabec, N. Li, J. Hauch*

Seminar über "Solution Processed Semiconductors" [SoPS-Sem], *W. Heiss*

Seminar über Bachelor- und Masterarbeiten [BMBr-Sem], *Ch. J. Brabec*

Seminar über Bachelor-, Master und Doktorarbeiten – Crystal Growth [BMD-CG-Sem], *P. Wellmann*

Summer Term 2021

Lectures (VORL)

Advanced Semiconductor Technologies - Processing (including Lab Work Organic Electronics Processing) [AST-Processing], *H.-J.Egelhaaf, Ch.J.Brabec*

Advanced Semiconductor Technologies - Solution Processed Devices / Applications [AST-SPDev-Appl]. *Ch.J. Brabec, Th.Heumüller*

Advanced Semiconductors Introduction: Characterization [ASI - Ch], *W. Heiss*

Devices, *Ch.J. Brabec, Th. Heumüller*

Crystal Growth - Numerical Simulation of the Crystal Growth Process using COMSOL Multi-Physics [CGL-Comsol], *P. Wellmann*

Crystal Growth 2 - Electronic Devices & Materials Properties/Processing, Epitaxial Growth [CG-2], *P. Wellmann*

Crystal Growth 2 - Wide Bandgap Semiconductors, *P. Wellmann*

Elektrische, magnetische und optische Eigenschaften - Energietechnik, *W. Heiss*

Elektrische, magnetische, optische Eigenschaften [EMO], *Ch.J. Brabec*

Halbleitercharakterisierung, *W. Heiss*

Kolloidale Nanokristalle [KNKr], *W. Heiss*

Leuchtstoffe/Phosphors, *M. Batentschuk, A. Winnacker*

Materialien und Bauelemente für die Optoelektronik und Energietechnologie: Anwendung [WET II], *Ch. J. Brabec*

Thin films: processing, characterization and functionalities, *H.-J. Egelhaaf*

Thin films: processing, characterization and functionalities (Extension), *H.-J. Egelhaaf*

Werkstoffe der Elektronik in der Medizin [WEM-V/Ü], *M. Batentschuk, A. Winnacker*

Werkstoffe und Verfahren der medizinischen Diagnostik II [WVmD II], *M. Thoms*

Exercises and laboratory courses (EX, PJS, PR, UE)

Advanced Semiconductor Technologies - Processing (including Lab Work Organic Electronics Processing) [AST-Processing], *H.-J.Egelhaaf, Ch.J.Brabec*

Advanced Semiconductor Technologies - Solution Processed Devices / Applications [AST-SPDev-Appl]. *Ch.J. Brabec, Th.Heumüller*

Crystal Growth - Lab Work 2 Semiconductor Technology, *P. Wellmann*

Crystal Growth 1/2 - Lab Work Crystal Growth [WCrGr-Pra], *P. Wellmann*

Crystal Growth - Numerical Simulation of the Crystal Growth Process using COMSOL Multi-Physics [CGL-Comsol], *P. Wellmann*

Devices, *Ch.J. Brabec, Th. Heumüller*

Exkursionen, *P. Wellmann*

Kernfachpraktikum I, Werkstoffe der Elektronik und Energietechnologie, *M. Batentschuk*

Kernfachpraktikum II, Wahlfach Organic Electronics, *N.N.*

Lab Work Organic Electronics, *N.N.*

Lab Work Organic Electronics, [OE-Pra-MWT], *K. Forberich, Th. Heumüller*

Lab Work Manufacturing and Characterization of Phosphors and Storage Phosphors [LW-Phosphors], *A. Osvet*

Lab Work Thin Film Semiconductors [LW- ThFS], *A. Osvet*

Materialien und Bauelemente für die Optoelektronik und Energietechnologie: Anwendung [WET II], *Ch. J. Brabec*

Praktikum Eigenschaften von Leuchtstoffen [PREgsLs], *M. Batentschuk*

Projektarbeit - Arbeitsgemeinschaft Organische Photovoltaik [OPV-AG-Sem], *Ch. J. Brabec*

Werkstoffe der Elektronik in der Medizin [WEM-V/Ü], *M. Batentschuk, A. Winnacker*

Seminars (SEM, SL)

Anleitung zur wissenschaftlichen Arbeit - Accelerated lifetime testing of materials and devices [AnwA - Lifetime-Test], *Ch.J. Brabec, Th. Heumüller*

Anleitung zur wissenschaftlichen Arbeit - Devices [AnwA - Dev], *Ch.J. Brabec, N. Li*

Anleitung zur wissenschaftlichen Arbeit - High Throughput Characterisation and Modelling [AnwA - HT-Ch-Mod], *Ch.J. Brabec, M. Peters*

Anleitung zur wissenschaftlichen Arbeit - High Throughput Material and device Research for photovoltaics [AnwA - HT-Mat-Res], *Ch.J. Brabec, J. Hauch*

Anleitung zur wissenschaftlichen Arbeit - Materials for Optoelectronics [AnwA - Materials], *A. Osvet,Ch. J. Brabec, M. Batentschuk*

Anleitung zur wissenschaftlichen Arbeit - Solution Processing of Semiconductors [AnwA-SolPro-SC], *H.-J. Egelhaaf*

Anleitung zur wissenschaftlichen Arbeit- Solution-Processed-Semiconductor-Materials [AnwA- SOPSEM], *W. Heiss*

How to start a company, *Ch. J. Brabec, J. Hauch*

Neuere Fragen zu Werkstoffen der Elektronik und Energietechnologie (Lehrstuhl-Seminar) [iMEET-Sem], *Ch. J. Brabec, M. Batentschuk, A. Osvet*

Seminar "Solution Processed Semiconductors" [SoPS-Sem], *W. Heiss*

Seminar über Bachelor- und Masterarbeiten, *Ch. J. Brabec*

Seminar über Bachelor- und Masterarbeiten _Devices [SEM-Dev], *N. Li*

Solar Energy Seminar [So-En-Sem], *J. Hauch, Ch. J. Brabec*

Vorbesprechung zum Masterstudium am i-MEET [iMEET-Vb-Ma], *M. Batentschuk, Ch. J. Brabec, W. Heiss, P. Wellmann, H.-J. Egelhaaf*

Winter Term 2021/2022

Lectures (VORL)

Advanced Semiconductor Materials - Excited States and Charge Transport in Organic Semiconductors [ASM-ES-ChT-OE], *H.-J. Egelhaaf. Ch. J. Brabec*

Advanced Semiconductor Technologies - Materials for Organic Electronics [AST-MatOE], *M. Halik*

Advanced Semiconductor Technologies - Photovoltaic Systems for Power Generation - Design Implementation and Characterization [AST-PVS-Design], *Ch. J. Brabec, J. Hauch*

Advanced Semiconductors Introduction: Devices & Applications [ASI - D&A], *A. Osvet, Ch. J. Brabec*

Advanced Semiconductors Introduction: Fundamentals [ASI - F] , *W. Heiss*

Crystal Growth 1 - Fundamentals of Crystal Growth and Semiconductor Technology [CG-1], *P. Wellmann*

Grundlagen der Halbleiterphysik [GHl], *W. Heiss*

Materialien der Elektronik und der Energietechnik (5. Sem), [MEET-V]*P. Wellmann*

Materialien und Bauelemente für die Optoelektronik und Energietechnologie: Grundlagen [OpEt-G], *Ch. J. Brabec*
Nano-Bauelemente-Sensoren, MEMS, Micromachining [(NanoDev)], *O. Kasian*

Nanospektroskopie [NanoSpek], *W. Heiss, M. Batentschuk*

Phosphors for Light Conversion in Photovoltaic Devices and LEDs [Ph-PV-LED], *M. Batentschuk*

Photo Physics and Electronic Transport [PhPhys], *H.-J. Egelhaaf*

Photo Physics and Electronic Transport (Extention) [PhPhys_ext], *H.-J. Egelhaaf*

Technische Grundlagen medizinischer Diagnostikverfahren [TGmD], *M. Thoms*

Werkstoffe und Verfahren der medizinischen Diagnostik I [WVmDI], *M. Thoms*

Werkstoffkunde für Studierende der Elektrotechnik (EEI) [Werkstoffk.(ET)], *P. Wellmann*

Exercises and laboratory courses (PR, PJS, SL, UE)

Advanced Semiconductor Technologies - Characterization and Advanced Defect Imaging of PV Modules and Systems [AST-DefIm-PR], *Ch. J. Brabec, J. Hauch*

Advanced Semiconductor Technologies - Manufactoring and Characterization of Phosphors and Dielectric Mirrors [AST-PhosMirr-PR], *M. Batentschuk*

Advanced Semiconductor Technologies - Photovoltaic Systems for Power Generation - Design Implementation and Characterization [AST-PVS-Design], *Ch. J. Brabec, J. Hauch*

Advanced Semiconductor Technologies - Synthesis of Carbon Quantum Dots [AST-QD], *W. Heiss*

Crystal Growth - Lab Work 1 Crystal Growth, *P. Wellmann*

Crystal Growth - Lab Work 2 Semiconductor Technology, *P. Wellmann*
Excercises Photovoltaic systems – Fundamentals (CEP) (Ex-PVS-F) [Ex-AST-PVS-Design], *K. Forberich, Ch. J. Brabec, A. Osvet*

Exercices Phosphors for Light Conversion in Photovoltaic Devices and LEDs (CEP) (Ex-PVS-LC) [Ex-Ph-PV-LED], *M. Batentschuk, A. Osvet*

Lab Work Characterization and Advanced Defect Imaging of PV Modules and Systems [LW - Ch&Im], *A. Osvet, J. Hauch*

Lab Work Organic Electronics [OE-Pra-MWT], *Th. Heumüller*

Lab Work Organic Electronics NT [OE-Pra-NT], *N.N.*

Lab Work Solution Processed Electronics [LW-SP-El], *Th. Heumüller, A. Osvet*

Praktikum Materialien der Elektronik und der Energietechnologie (5. Sem.) [PR2-ET], *P. Wellmann*

Nano-Bauelemente-Sensoren, MEMS, Micromachining [(NanoDev)], *O. Kasian*

Praktikum Funktionswerkstoffe in der Energietechnologie [FEt-Pra], *P. Wellmann*

Praktikum Nanotechnologie 2 (Master) [NT2-Pra], *W. Heiss, E. Spiecker*

Praktikum Transporteigenschaften in HL [TrEHl-Pra], *A. Osvet*

Praktikum Wahlfach Crystal Growth [WCrGr-Pra], *P. Wellmann*

Praktikum Werkstoffe 2 [PW 2], *M. Batentschuk*

Projektarbeit - Arbeitsgemeinschaft Kristallisation von SiC und CIS [AGK-Sem1], *P. Wellmann*

Projektarbeit -Arbeitsgemeinschaft Organische Photovoltaik [OPV-AG-Sem], *Ch. J. Brabec*
Projektarbeit –Arbeitsgemeinschaft Solution Processed Semiconductors [SPS_AG-Sem], *W. Heiss,*

Übung Nano Devices [(ÜbNanoDev)], *N.N.*

Vorbesprechung Masterstudium i-MEET [VB-Master-i-MEET], *Ch. J. Brabec M. Batentschuk, P. Wellmann, W. Heiss, H.-J. Egelhaaf, A. Osvet*

Seminars (AWA, SEM, TUT)

Advanced Semiconductor Technologies - Solution Processed Semiconductor Materials [AST-SPS-PR], *W. Heiss*

Anleitung zur wissenschaftlichen Arbeit - Accelerated lifetime testing of materials and devices [AnwA - Lifetime-Test], *Ch. J. Brabec, Th. Heumüller*

Anleitung zur wissenschaftlichen Arbeit - Devices [AnwA - Dev], *Ch. J. Brabec, N. Li*

Anleitung zur wissenschaftlichen Arbeit - High Throughput Characterisation and Modelling [AnwA - HT-Ch-Mod], *Ch.J. Brabec, M. Peters*

Anleitung zur wissenschaftlichen Arbeit - High Throughput Material and device Research for photovoltaics [AnwA - HT-Mat-Res], *Ch.J. Brabec, J. Hauch*

Anleitung zur wissenschaftlichen Arbeit - Materials for Optoelectronics [AnwA - Materials], *A. Osvet,Ch. J. Brabec, M. Batentschuk*

Anleitung zur wissenschaftlichen Arbeit - Solution Processing of Semiconductors [AnwA-SolPro-SC], *H.-J. Egelhaaf*

Anleitung zur wissenschaftlichen Arbeit- Solution-Processed-Semiconductor-Materials [AnwA- SOPSEM], *W. Heiss*

Electronic Materials – Tutorium [EM - Tut], *N. Li, Ch. J. Brabec*

eTutorial - Materialien der Elektronik und Energietechnik [5.Sem], [eTUT-WET], *P. Wellmann*

eTutorial Werkstoffkunde für EEI (1. Sem) [eTUT-WW-EEI], *P. Wellmann*

Hauptseminar MWT/NT M12-WW6 [HS-MWT-NT-WW6], *Ch. J. Brabec, P. Wellmann, W. Heiss, A. Osvet, N. Li*

Kern-/ Nebenfachseminar i-MEET [KF/NF-iMEET-Sem], *Ch. J. Brabec, A. Osvet*

Literaturrecherche und Arbeitstechniken M12-MWT-WW6 [LitRe-MWT-WW6], *Ch. J. Brabec, W. Heiss, P. Wellmann, A. Osvet, N. Li, M. Batentschuk*

Literaturrecherche und Arbeitstechniken M12-NT-WW6 [LitRe-NT-WW6], *Ch. J. Brabec, W. Heiss, A. Osvet, N. Li, P. Wellmann, O. Kasian*

Neuere Fragen zu Werkstoffen der Elektronik und Energietechnologie (Lehrstuhl-Seminar) [iMEET-Sem], *Ch. J. Brabec, K. Forberich, M. Batentschuk*

Seminar and Conference Participation on Solar Energy [Sem&Conf_SE], *J. Hauch, N. Li, Ch. J. Brabec*

Seminar über "Solution Processed Semiconductors" [SoPS-Sem], *W. Heiss*

Seminar über Bachelor- und Masterarbeiten [BMBr-Sem], *Ch. J. Brabec*

Seminar über Bachelor-, Master und Doktorarbeiten – Crystal Growth [BMD-CG-Sem], *P. Wellmann*

17. Addresses and Maps

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By train:
Railway station **Erlangen.**
Bus line No. 287 direction **"Sebaldussiedlung"**. Bus stop **"Technische Fakultät".** 50 meters to a layout plan; search for **"Insitut für Werkstoffwissenschaften"**.

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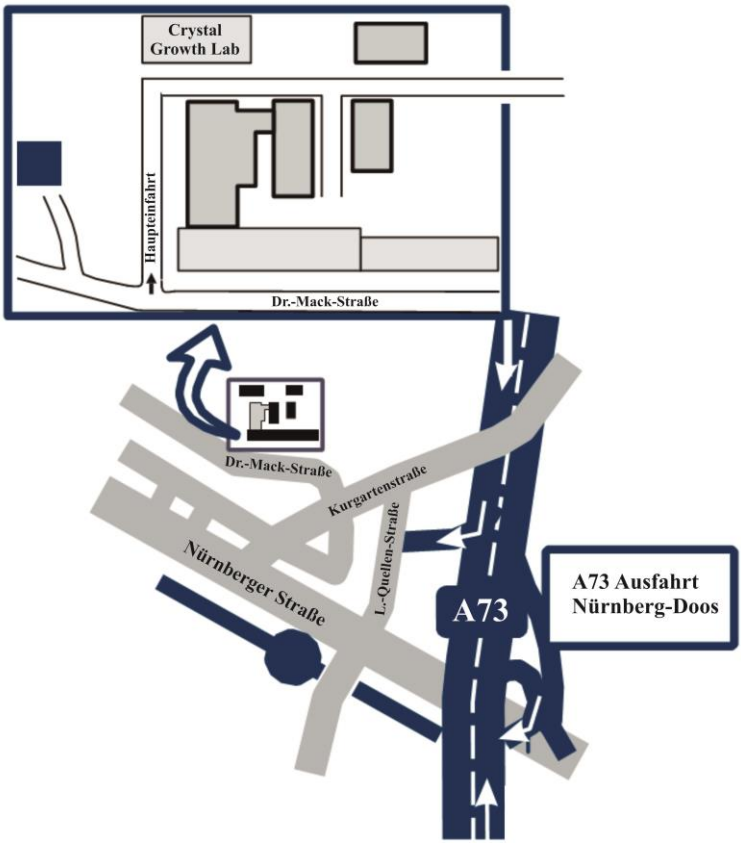

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