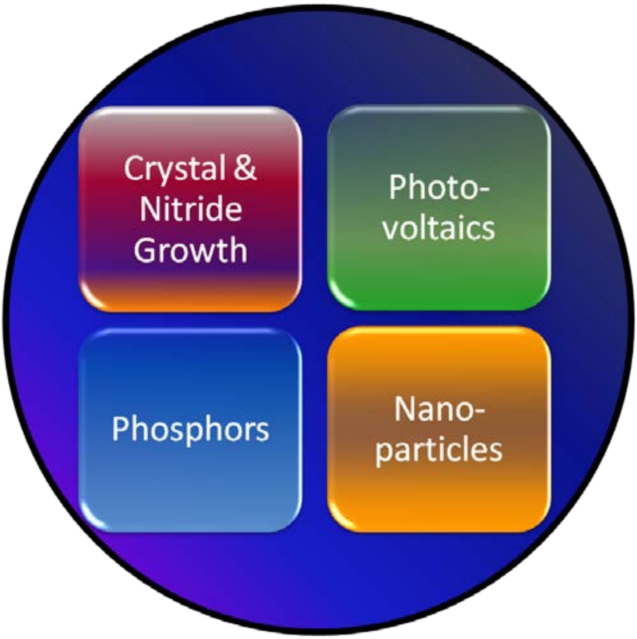
Friedrich-Alexander-Universität
Technische Fakultät

Department of Materials Science and Engineering

Materials for Electronics and Energy Technology



ANNUAL REPORT 2022

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PD Dr. Miroslaw Batentschuk
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Prof. Dr. Olga Kasian
Prof. Dr.-Ing. Peter Wellmann
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1. Vorwort

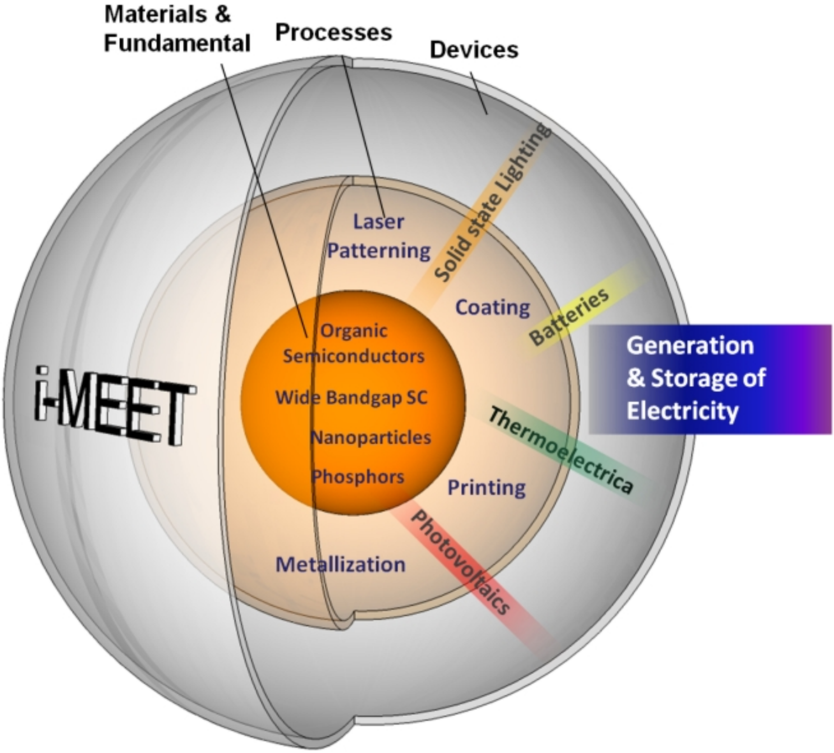
2022 war ein Jahr der großen Ereignisse. Die Coronaregelungen wurden weltweit zurückgefahren und der wissenschaftliche Austausch auf Konferenzen hat neuen Schwung in das akademische Leben gebracht. Doch der Ukrainekrieg hat die gerade wiedergewonnenen Freiheiten wieder eingeschränkt. Die darauffolgende Energiekrise und Inflation hat uns alle, privat als auch beruflich, massiv betroffen und die Grenzen der aktuellen globalen Modelle der Energieversorgung in Frage gestellt. Was sonst kann man aus der Krise schliessen außer dass der Ausbau der erneuerbaren Energien dramatisch beschleunigt werden muss.
Herzlichen Dank an unsere Studenten, Doktoranden, Mitarbeiter und Gruppenleiter, die mit ihren fantastischen Leistungen 2022 zu einem erfolgreichen Jahr gestaltet haben.
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 2022 und wünsche viel Spaß beim Lesen unseres Tätigkeitsberichts.

2022 was another year full of surprises and big events. The fight against Corona was so successful that the worldwide regulations could be taken back. Scientific exchange at conferences has become possible again, refueling our passion and fire for academic and applied research. Just when we started to enjoy the bit more of freedom, war in Ukraine restricted our life in multiple aspects. The corresponding energy crisis, the inflation, the support for refugees - that all has affected us privately but also in our professional life. The crisis further showed us the limitation of our energy system, which was believed to be globally stable while it actually was depending on single players. There is only one conclusion from that crisis - we need to rebuild our energy system under the aspects of national security and become more independent. Accelerating the build-up of renewable energy capacities is the only answer to that learnings.
At that stage I want to thank undergraduates, graduate students, staff, and group leaders for their fantastic accomplishments in 2022. Together we have accomplished a very successful year.
i-MEET is very proud of our students and postdocs. Nevertheless, it is always sad to see our most excellent researchers leaving. Yakun is building her career at KAUST, Xiaoyan and Yicheng have accepted calls for professorship positions to SDU and UESTC respectively, and, after so many years, Ning has accepted a professorship position at SCUT.
Many thanks to our NGSE team (ngse.info), Karen, Vincent, Ning and Jens who made this years NGSE a big success. Let me also acknowledge the NGSE early career presentation series, which was brought to life by Vincent. I want to thank Osbel and Karen for their efforts to coordinate the emerging-PV platform (emerging-pv.org). The curated date set on record performing solar cells has made it into the second year and will be continuously expanded to new features.

Finally, big thanks to the Solar TAP team, who allowed us to win the outstanding prestigious Helmholtz grant on accelerating photovoltaics technology transfer into industry. Driving that project to the breakthrough we are envisaging will take all our resources for the next three years.
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 i-MEET for the successful cooperation in 2022 and hope you enjoy reading our activity report.

Best, Christoph Brabec

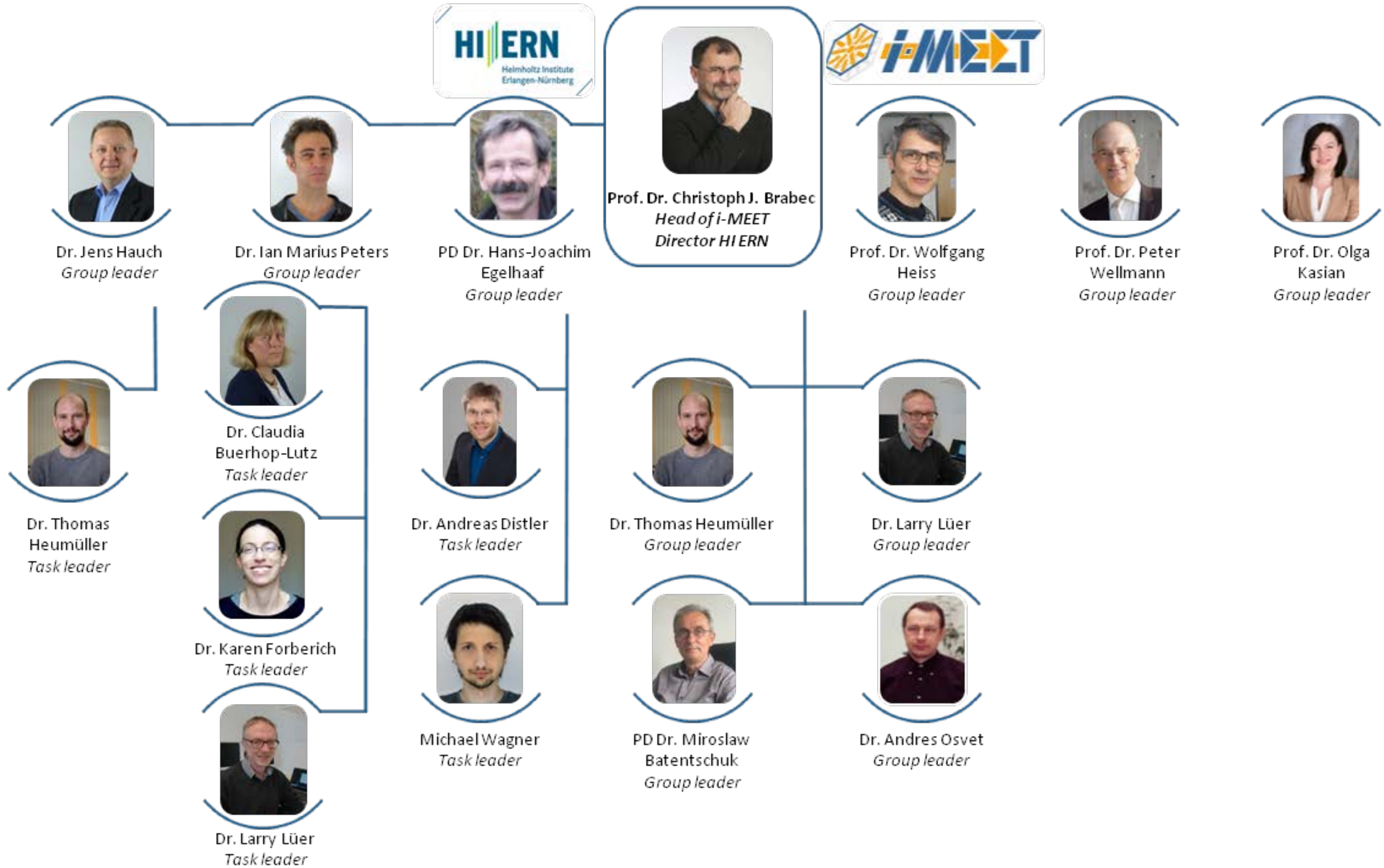
Please note that some of our highlights can be found on i-MEET's youtube channel i-MEET Lab.
(https://www.youtube.com/channel/UC6RHRl5xyzL1b-lcJ6FG3PA).
Please note also our alumni network at LinkedIn (Institute i-MEET).



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

(Albrecht Winnacker) (Olga Kasian) (Miroslaw Batentschuk)

Erlangen, July 2023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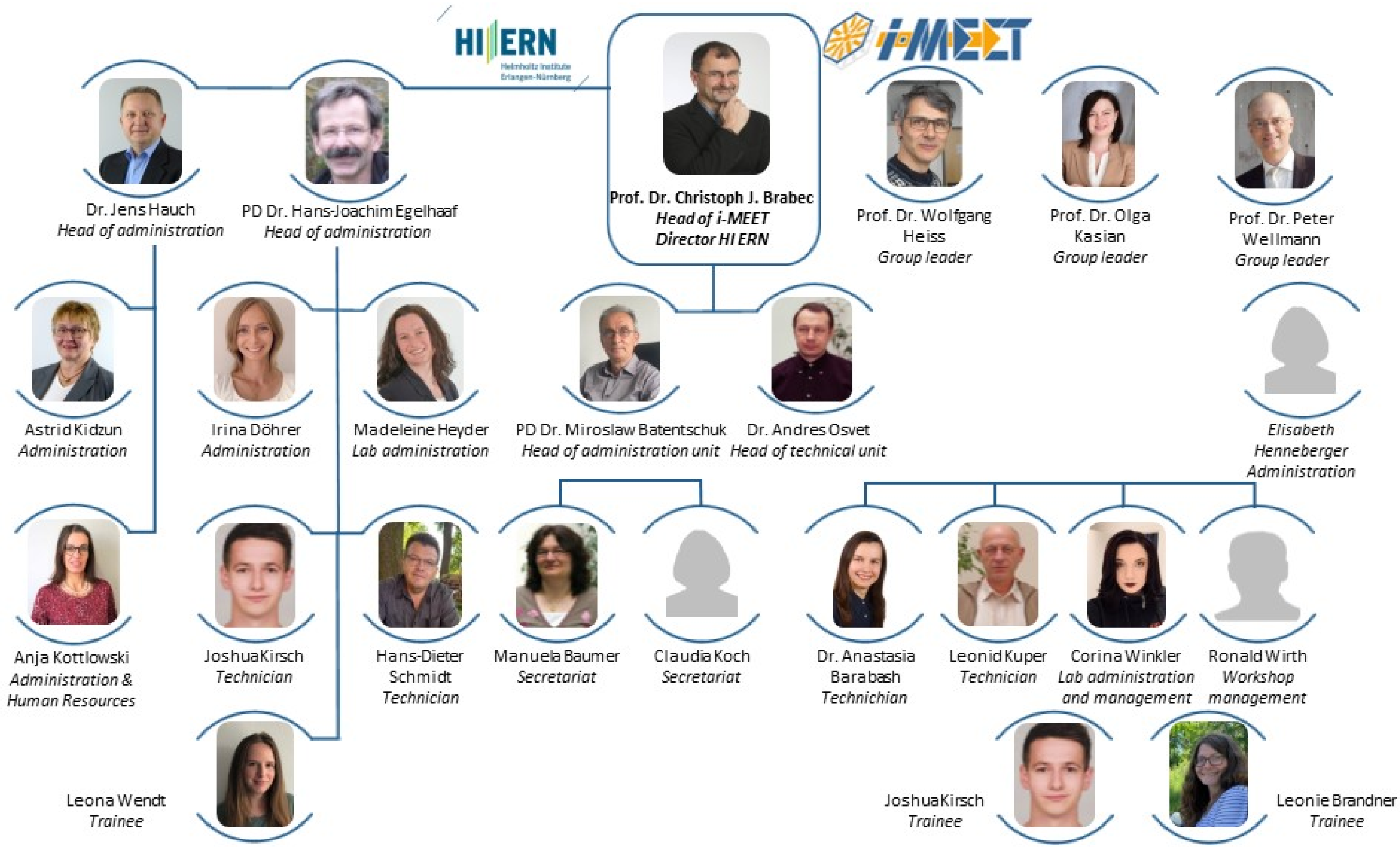
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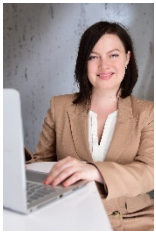
Head of the chair

Prof. Dr.
Wolfgang Heiss



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Olga Kasian

Prof. Dr.-Ing.
Peter Wellmann

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Georg Müller

Prof. Dr. rer. nat.
Albrecht Winnacker

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Jens Hauch

Dr.-Ing.
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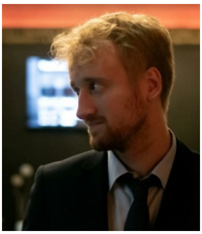

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Larry Lüer

Dr.
Andres Osvet

Dr.
Marius Peters

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Dr.
Anastasia Barabash

Leonie Brandner

Joshua Kirsch

Leonid Kuper

Hans-Dieter Schmidt

Corina Winkler

Ronald Wirth

Solar and Semiconductor Devices (SSD)

(Scientifical staff, doctoral candidates)

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Miroslaw
Batentschuk
Group leader

Dr.-Ing.
Thomas Heumüller

Group leader

Dr.
Ning Li
Visiting Professor
Associated group leader

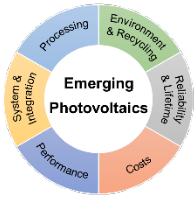
Dr.
Larry Lüer
Group leader

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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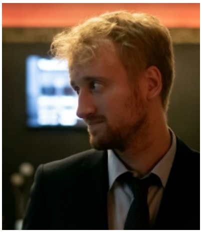

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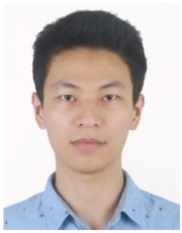

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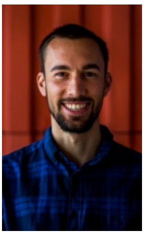

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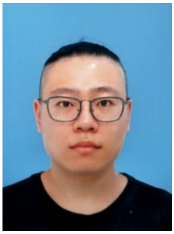

Endong Zhang
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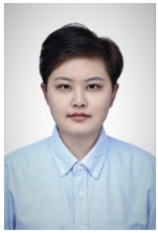

Heyi Zhang
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Kaicheng Zhang
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Doctoral candidate
i-MEET

Solution-Processed-Semiconductor-Materials (SOPSEM)

(Scientifical staff, doctoral candidates)

Prof. Dr.
Wolfgang Heiss
Group leader

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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Guest scientist
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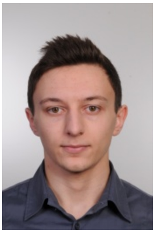

Viktor Rehm
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Shuyu Zhou
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Materials for Electrochemical Energy Conversion

(Scientifical staff, doctoral candidates)

Prof. Dr.
Olga Kasian
Group leader

The main research focus of the group is placed on the materials for electrochemical energy conversion and storage. We aim at understanding of the structure-function relationships in electrocatalysis and dynamic transformations of the catalytic surfaces under the reaction conditions. The group explores structural and compositional changes of model electrode surfaces induced by the electrocatalytic reactions and their impact on the mechanism and kinetics. This is achieved by combination of various ex situ and in situ methods.

The major research task is to provide a detailed mechanistic understanding of chemical processes ongoing at complex and dynamic interfaces, with a special focus on electrocatalysis for energy conversion and storage, aiming to overcome stability limits of the catalyst materials.

The scope of methods includes variety of physical vapor deposition techniques, advanced electrochemical characterization methods, atom probe tomography and X-ray photoelectron spectroscopy including synchrotron based methods.

Leopold Lahn
MSc
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FAU
Friedrich-Alexander-Universität
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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.

Matthias Arzig
MSc
Doctoral candidate
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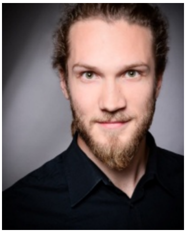

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Helmholtz-Institut Erlangen-Nürnberg (HI ERN)

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PD Dr.
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Dr.
Ian Marius Peters
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Dr.
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Dr-Ing.
Thomas Heumüller
Task leader

Dr.
Ning Li
Guest researcher

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-grid 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 Friedrich-Alexander-University Erlangen-Nuremberg (FAU) and HI ERN and performs its research in three active research groups:

- High Throughput Materials and Devices for PV
- High Throughput Characterization and Modelling for PV
- High Throughput Processing / Solar Factory of the Future

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.
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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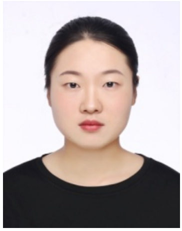

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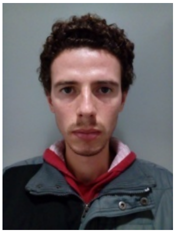

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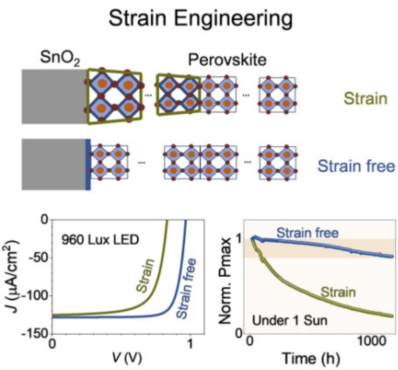
3. Highlights 2022

Wei demonstrates the effect of strain at buried interfaces in halide perovskite photovoltaics



Wei managed to process perovskite solar cells with different levels of strains embedded at the interface to the substrate. Interestingly, device performance under 1 sun was not that different, however, when going to low light or when looking into the stability, we started to see a clear trend. The paper just got published in Joule (DOI 10.1016/j.joule.2022.01.011)!

Please cite this article in press as: Meng et al., Revealing the strain-associated physical mechanisms impacting the performance and stability of perovskite solar cells, Joule (2022), https://doi.org/10.1016/j.joule.2022.01.011

Joule

CellPress

Article

Revealing the strain-associated physical mechanisms impacting the performance and stability of perovskite solar cells

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SUMMARY

Identification and investigation of strain at buried interfaces in halide perovskite photovoltaics are crucial for directing research on the performance and stability of perovskite solar cells. In this work, we find a gradual shift in the band gap of up to 60 meV over a perovskite layer thickness of 300 nm caused by interfacial strain. This graded band gap is desired insofar as it relates to the aspect of device engineering. However, in parallel, the increased defect density causes charge recombination at the buried interface. These two effects compensate for each other, resulting in an overall performance improvement under standard 1 sun illumination. Nevertheless, the disadvantage of enhanced defect density is clearly observed at low-light intensities, where the device performance becomes dominated by charge recombination and ion migration. Moreover, the strained interfaces are proven to induce enhanced defect densities, causing significantly accelerated device degradation under illumination as well as in the dark.

INTRODUCTION

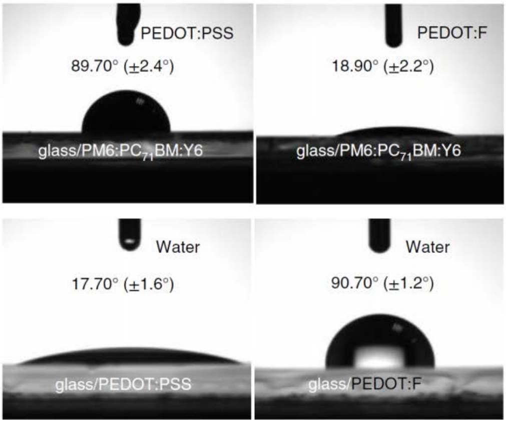
In the past few years, hybrid organic-inorganic perovskite semiconductors have emerged as one of the most promising materials for photovoltaic applications owing to their excellent optoelectronic properties.[1] Significant efforts, such as interface engineering, composition engineering, and process engineering, have been devoted to improving the power conversion efficiency (PCE) of perovskite solar cells.[2–5] The recent record efficiency of 25.5% for perovskite solar cells has already surpassed the benchmark efficiency values of commercial solar panels based on silicon or inorganic thin films.[6,7] However, the relatively poor intrinsic stability of perovskites, such as being sensitive to moisture, oxygen, and ultraviolet light, remains a challenge for commercialization of perovskite photovoltaics, which needs to be urgently understood and addressed.[8–10] In addition to the conventional power plant applications, perovskites are promising candidates for low-light and scattered-light harvesting[11–13] owing to their excellent defect tolerance[14–16] and optoelectronic properties under low-light conditions.[17–21]

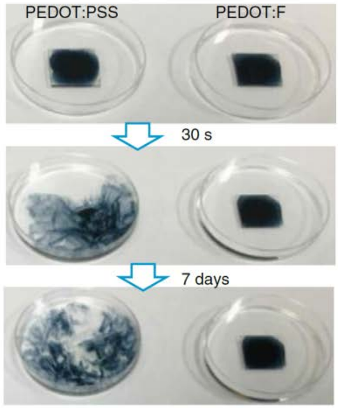
Recently, the residual strain at the buried interface causing lattice distortion of the microscopic crystal structure, and further affecting the optoelectronic properties of perovskite films, has drawn an increasing amount of attention. Strain engineering has been developed as a novel approach to enhance the performance and stability of perovskite solar cells.[22–28] When a crystal is compressed or stretched, the resulting deformation is called strain. The strain in the polycrystalline perovskite films is

Context & scale

The management of strain in halide perovskite films, together with a deeper understanding of its mechanisms, bears tremendous opportunities for further enhancement in the power conversion efficiency and stability of perovskite solar cells. Here, the distribution of strain inside the perovskite film is systematically investigated through a combination of temperature-dependent photoluminescence, thickness-dependent photoluminescence, and photoluminescence imaging techniques. The impacts of strain on charge-transfer, recombination processes as well as the film stability under various illumination conditions are analyzed. Our work provides new insights into the presence and influence of strain at the buried interfaces in halide perovskite photovoltaics and reveals the strain-associated physical mechanisms impacting the device performance and stability of perovskite solar cells.

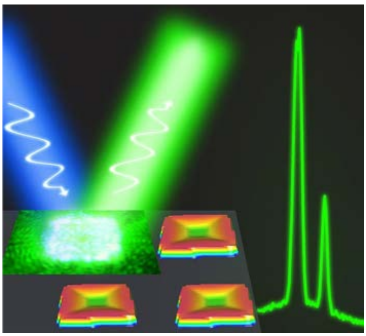
Yinhua demonstrates alcohol-dispersed conducting polymer complex for fully printable organic solar cells with improved stability





Congrats to Yinhua for our recent Nat Energy paper (DOI 10.1038/s41560-022-00997-9) on a novel PEDOT:F, that can be processed from alcohol! That PEDOT:F overcomes the incompatibility between most NFAs and PEDOT and represents a scalable printed alternative to evaporated MoOx. Both, efficiency and lifetime for this PEDOT:F are at the state of the art, as demonstrated by fully printed cells and modules with two Ag NW electrodes!

SOPSEM group demonstrates high-quality epitaxial growth of oriented perovskite microcrystallites



Hany Afify from the SOPSEM team and colleagues from i-MEET, with the support of several groups from FAU (Prof. Brabec, Prof. Unruh, Prof. Guldi) have demonstrated (DOI 10.1002/adom.202200237) the first solution epitaxially grown perovskite micro-resonators exhibiting laser emission. The observed thresholds are comparable to those obtained with vapor deposition methods. Astonishing is the stability of the lasing, which is the best reported for devices kept in air. These findings are also enabled by the use of single crystalline PbS substrates, grown in Poland, providing relatively high heat conductance and thus facilitating device cooling. In addition, the results demonstrate the power of solution processed epitaxial growth and possibly represent a first step towards electrically driven devices, since the substrates are highly conducting semiconductors

ARTICLES
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An alcohol-dispersed conducting polymer complex for fully printable organic solar cells with improved stability

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Efficient and stable organic solar cells via full coating are highly desirable. Poly(3,4-ethylenedioxythiophene):polystyrene sulfonate (PEDOT:PSS) is a classic conducting polymer complex and widely used for hole collection in fully printable devices. However, PEDOT:PSS is typically dispersed in water and exhibits strong acidity that deteriorates device efficiency and stability. Here we report an alcohol-dispersed formulation (denoted as PEDOT:F) by adopting perfluorinated sulfonic acid ionomers as counterions. The ionomers have a special advantage of having two solubility parameters and can be dispersed in water or alcohols, which enables us to prepare PEDOT:F formulations dispersed in alcohols. The alcohol-dispersed formulation has good wetting properties and low acidity, which avoids the drawbacks of aqueous PEDOT:PSS. Fully printable organic photovoltaics (from bottom electrode to top electrode) based on PEDOT:F were obtained with a power conversion efficiency of 15% and could retain 83% of the initial efficiency under continuous illumination at maximum power point tracking for 1,330 h.

Full printing or coating of organic solar cells (OSCs) from the bottom electrode to the top electrode is highly desirable for achieving cost-effective, high-throughput and large-area manufacturing[1–5]. However, the performance and stability of fully printed OSCs still lag behind those of devices with vacuum-deposited metal electrodes[6–8]; their power conversion efficiencies (PCEs) are approximately 10% (refs. [9–15]). A key challenge is the absence of a stable and high-performance printable hole-transporting layer (HTL) between the emerging non-fullerene active layers and solution-processed top electrode. A qualified printable HTL must be electrically capable of hole transport/collection and simultaneously must be compatible with other layers in terms of processing, including orthogonality and wettability.

The conducting polymer poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) is a widely used printable HTL with the advantages of high conductivity, optical transparency and easy coating without the need for harsh post-treatments on the fabricated film[16–18]. However, PEDOT:PSS is water-based and has strong acidity that causes issues in devices.

The classic PEDOT:PSS formulations, that is, AI 4083 and PH1000, exhibit a pH range of 1.0–2.5 in water. In a recent review, Cameron et al.[19] comprehensively discussed the damaging effects of the acidity in PEDOT:PSS on organic devices. Acidic PEDOT:PSS can react and degrade the electrodes of indium tin oxide and silver nanowires (AgNWs), and the electron-transporting layer of ZnO. De Jong et al.[20] detected a high indium content in PEDOT:PSS films using Rutherford backscattering spectrometry. Kim et al.[21] reported that acidic PEDOT:PSS induces an increase in the sheet resistance of AgNWs upon thermal annealing. In addition, the acidic moieties can protonate the organic active layers. Van der Poll et al.[22] reported that pyridyl[2,1,3]thiadiazole in the active layer is protonated by PEDOT:PSS, which results in a reduction in performance. Du et al.[23] also reported that acidic PEDOT:PSS reacts with nitrogen-containing polymer donors (such as pDPP5T-2 and PThBDTP), and the reaction causes performance degradation. Inorganic (NaOH[24]) and organic (2-dimethylaminoethanol[25]) bases were added into the PEDOT:PSS formulations to neutralize their acidity. These strategies can suppress the degradation of the electrodes and active layers. However, the neutralization of PEDOT:PSS simultaneously reduces its doping level and causes negative effects on the electrical properties with decreased electrical conductivity and reduced work function.

PEDOT:PSS is processed from water. Moisture is regarded as one of the main causes of device degradation[26]. Moisture ingress is prone to occur at the interfaces and causes degradation of charge extraction at those interfaces[27,28]. In addition to interfaces, it has also been reported that water can penetrate into nanovoids in the organic semiconductor thin films. Nanovoids with absorbed water molecules are believed to cause charge carrier traps by forming hydrogen-bonding interactions between water and the polymer chain that locally change the conformation of the chain[29] or by dielectric effects from the water-absorbed nanovoids[30]. In addition, water has a high surface tension of approximately 72 $mN\,m^{-1}$ at 25 °C. That causes a de-wetting issue when it is coated onto hydrophobic organic active layers in inverted devices;[31] surfactants are added into aqueous dispersions to reduce the surface tension and improve its wetting property. However, the added surfactants typically remain in the films and negatively impact the long-term stability and efficiency of the devices[31].

These issues of acidity, moisture and de-wetting influence the device efficiency and stability. The issues are related to the water: the strong acidity is due to the high dissociation rate of poly(styrenesulfonic acid) (PSSH) in water, and the de-wetting is due to the high surface tension of water. In early literature[32], it was

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Highly Stable Lasing from Solution-Epitaxially Grown Formamidinium-Lead-Bromide Micro-Resonators

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High-quality epitaxial growth of oriented microcrystallites on a semiconductor substrate is demonstrated here for formamidinium lead bromide perovskite, by drop casting of precursor solutions in air. The microcrystallites exhibit green photoluminescence at room temperature, as well as lasing with low thresholds. Lasing is observed even though the substrate is fully opaque at the lasing wavelengths, and even though it has a higher refractive index as the perovskite active material. Moreover, the lasing is stable for more than 10^9 excitation pulses, which is more than what is previously achieved for devices kept in the air. Such highly stable lasing under pulsed excitation represents an important step towards continuous mode operation or even electrical excitation in future perovskite-based devices.

1. Introduction

Epitaxial growth provides oriented and crystalline structures on top of a single crystalline substrate. Inspired by the great success of epitaxial growth of conventional inorganic semiconductors for (opto) electronics, there are various attempts to obtain single-crystalline structures by the epitaxial growth of metal halide perovskites (MHPs), as promising materials for optoelectronic applications. While most attempts have been pursued by some ways of chemical vapor deposition (CVD) on various substrates and also by molecular beam epitaxy,[1–8] albeit with elaborate equipment, the advantages of the MHPs are enrolled by solution processing them. Solution epitaxy is an inexpensive and facile approach to obtain high-quality films and microstructures. Simple techniques such as spin coating delivered already epitaxial crystalline films operating as highly sensitive photodetectors.[9] Thereafter, spin coating was introduced by Kelso et al., as a general technique for the epitaxial growth of inorganic

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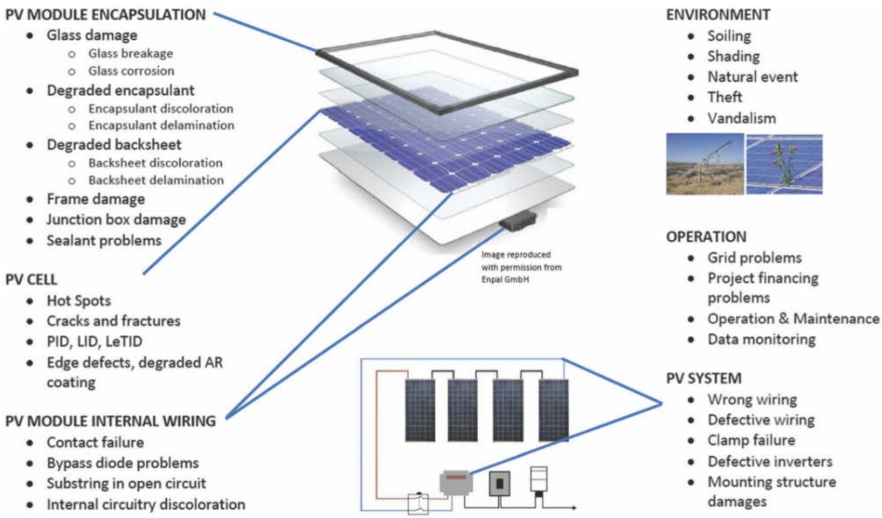
Bringing back PV manufacturing to Europe

Several European research institutes, among them HIERN, and companies are sharing their thoughts how to build a European PV industry. Watch a movie full of information but also visions what is required to guarantee an independent and sustainable PV supply for Europe.

Review on defects and performance of Si PV modules in the field



The importance of solar panels cannot be overestimated. And it is also important to ensure their proper maintenance. Big paper by Janine and Marius (DOI 10.1039/D2EE00109H) – a most comprehensive review (summarizing the data on about 200 outdoor PV plants from about 80 reports) on the frequency and likeliness that PV modules fail in operation.

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Defects and performance of Si PV modules in the field – an analysis

J. Denz,[a] J. Hepp,[b] C. Buerhop,[a] B. Doll,[b] J. Hauch,[c] C. J. Brabec[b] and I. M. Peters[a]

Photovoltaic installations will likely become one of the major power sources in the 21st century and we need photovoltaic modules to operate reliably. In this review, we explore what is known today about the status of installed crystalline silicon photovoltaic modules in the world, how different sources classify module defects, and what we might deduce for future installations. Looking at more than 200 results from 132 installations and 79 reports, we find that PV modules in general are robust in outdoor operation, with about one in 250 modules failing completely each year. About one in ten modules will develop a defect resulting in greater than expected power loss throughout their lifetime, and practically every module will develop visually perceivable alterations. We observe no trends of changes over time in these findings, hence there is no indication that future performance will deviate dramatically. We note though that more information is needed. Available studies represent a module fleet with greater age than current installations, and are over-representing multicrystalline – compared to monocrystalline silicon, and AL-BSF – compared to PERC cell architectures. Studies from Asia and Africa and from tropical climates are underrepresented. A major challenge in the analysis was the variety of metrics used. To facilitate easier comparison, we propose reporting guidelines.

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Broader context

Photovoltaics (PV) will play a key role in the energy transition towards a sustainable global power supply. The main functional unit in a PV power station is the photovoltaic module, also called a solar panel. The reliability and predictability of PV power stations depend on the robustness and persistence of photovoltaic modules. During operation, PV modules develop a variety of defects that may impede performance to various degrees. In this analysis, we explore our current knowledge about the nature and quantity of defects in field-operated modules. We summarize and compare results from over 200 studies including more than 3GW of installed photovoltaic modules ranging over a period of more than 30 years. We find that the majority of modules performs well and within expectations, despite developing visible defects. Yet, about one in ten modules has developed a defect that results in abnormally high performance losses, and about one in every 250 modules fails catastrophically each year. We note that available data is biased as to the included photovoltaic technologies and with respect to locations – most studies were done in the US and Europe. To improve the comparability of future studies, we propose a set of reporting rules.

Introduction

Photovoltaic (PV) power has become one of our most important sources of electricity. Solar and wind are projected to become the major power sources in the 21st century,[1] with solar about to reach the terawatt-scale of worldwide installed capacity.[2] While overall reliability of PV modules is high, as is evident from long-term performance observations[3,4] and from warranty periods of up to 30 years,[4] PV plants experience varying degrees of power loss. The company DNV, for example, found a median performance gap of 3.1% between expected and actual PV power output for PV plants in the USA with a total capacity of 1.2 GW.[5] During fabrication, during installation, and during decades of exposure to stresses from outdoor operation, PV modules may acquire a variety of defects. Fig. 1 gives an overview of possible defects in different parts of the module and plant.

As photovoltaic installations mature, the question arises as to how important these defects are. How many modules carry one or several defects? How relevant are they for the reliable generation of PV electricity? In this review, we will present an

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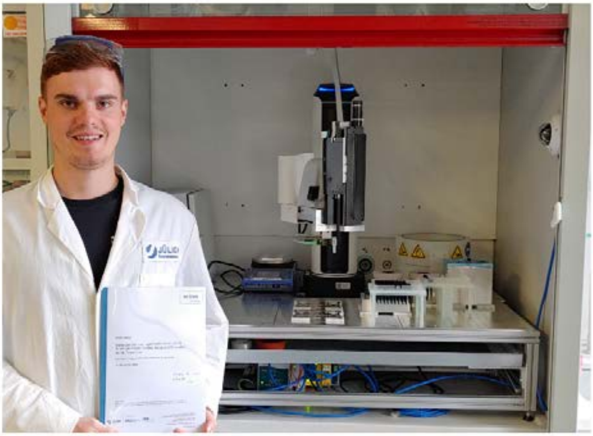
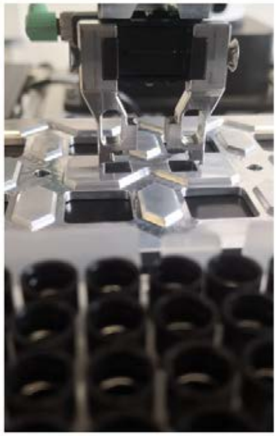
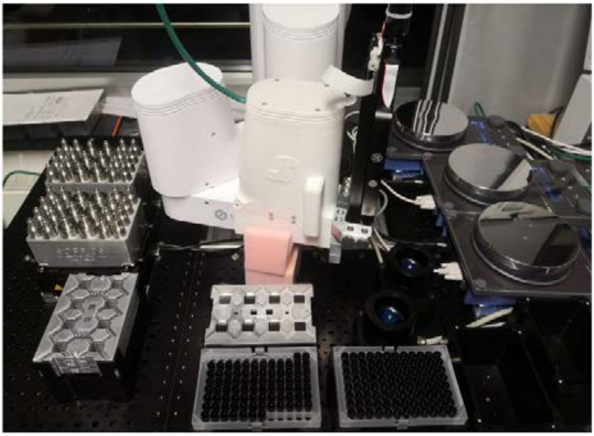
Simon's user proposal for Lawrence Berkeley National Laboratory's Molecular Foundry got accepted







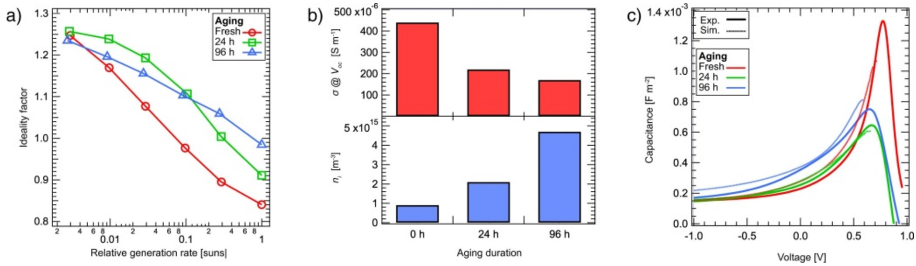
For his master's thesis, Simon will be joining the group of Dr. Carolin Sutter-Fella at the Molecular Foundry, located at the Lawrence Berkeley National Laboratory in Berkeley, California. The goal of this project is to utilize high throughput screening and in situ characterization techniques to further study the effects of A-site cations on the crystallization pathway of α-FAPbI3 based perovskite thin films in air. The Foundry acquired the robotic spin coating platform SpinBot One by SCIPRIOS which enables automated, reproducible, and high throughput synthesis of perovskite thin films. It consists of a robotic pipette channel, multiple spin coaters, hot plates, heatable solution shakers, quenching possibilities, and a characterization unit to efficiently vary both chemical compositions and thin film synthesis parameters.

Carolin’s group provides great experience with optical absorption-based in situ characterization techniques. So, candidates of interests that stood out during the SpinBot One investigation, will be further studied with multimodal in situ probes to gain a better understanding of the structure-property relationships of α-$FAPbI_3$ based perovskite thin films. This project starts in July and is supported by the Bavaria California Technology Center BaCaTeC

i-MEET participating in the Next-Generation V+PV Materials Conference

Live conferences are coming back. And of course we couldn’t resist attending a PV conference at the University of Gronningen. It was a great time and fantastic speakers!

How to reach stable non-fullerene acceptor solar cells?



Stability is one of the most important challenges facing material research for organic solar cells on their path to further commercialization. Our recent article in Nature Communications (DOI: 10.1038/s41467-022-31326-z) focuses on degradation mechanisms of inverted photovoltaic devices in the high-performance material system PM6:Y6. In cooperation with the colleagues from Chemnitz and Dresden Universities we show that despite the most stable material properties, the formation of trap states upon thermal degradation with their impact on non-radiative recombination and transport limitations remain the key issue to be addressed for improving the state-of-the-art organic solar cells stability

nature COMMUNICATIONS

ARTICLE

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Traps and transport resistance are the next frontiers for stable non-fullerene acceptor solar cells

Christopher Wöpke[1], Clemens Göhler[1], Maria Saladina[1], Xiaoyan Du[2,3], Li Nian[2,4], Christopher Greve[5], Chenhui Zhu[6], Kaila M. Yallum[7], Yvonne J. Hofstetter[8,9], David Becker-Koch[8,9], Ning Li[2,3,10], Thomas Heumüller[2,3], Ilya Milekhin[1], Dietrich R. T. Zahn[1], Christoph J. Brabec[2,3], Natalie Banerji[7], Yana Vaynzof[8,9], Eva M. Herzig[5], Roderick C. I. MacKenzie[11] & Carsten Deibel[1✉]

Stability is one of the most important challenges facing material research for organic solar cells (OSC) on their path to further commercialization. In the high-performance material system PM6:Y6 studied here, we investigate degradation mechanisms of inverted photovoltaic devices. We have identified two distinct degradation pathways: one requires the presence of both illumination and oxygen and features a short-circuit current reduction, the other one is induced thermally and marked by severe losses of open-circuit voltage and fill factor. We focus our investigation on the thermally accelerated degradation. Our findings show that bulk material properties and interfaces remain remarkably stable, however, aging-induced defect state formation in the active layer remains the primary cause of thermal degradation. The increased trap density leads to higher non-radiative recombination, which limits the open-circuit voltage and lowers the charge carrier mobility in the photoactive layer. Furthermore, we find the trap-induced transport resistance to be the major reason for the drop in fill factor. Our results suggest that device lifetimes could be significantly increased by marginally suppressing trap formation, leading to a bright future for OSC.

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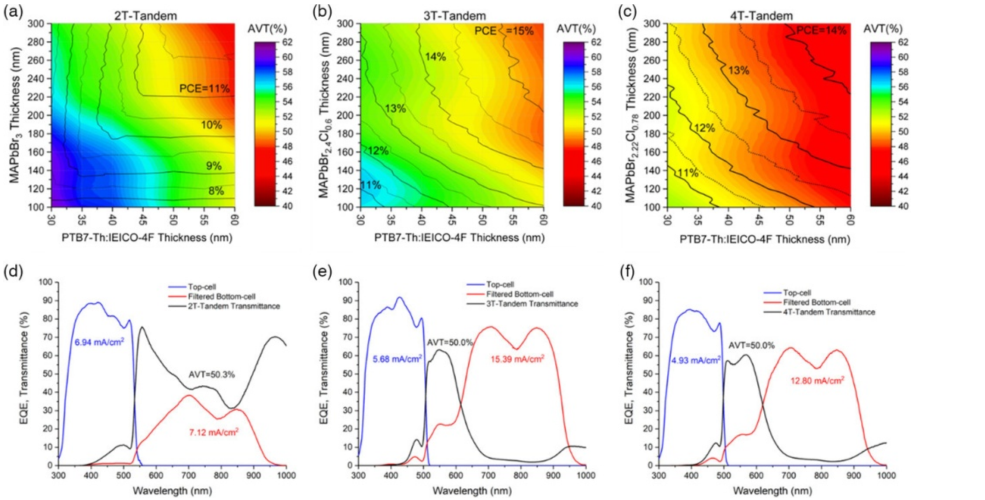
A deeper look into the design of highly efficient semitransparent perovskite/organic tandem solar cells



Solar cells transparent in the visible range are highly requested for integration in see-through photovoltaic (PV) applications such as building glass façades or greenhouse roofs. The development of advanced transparent PV can fully exploit the tandem technology where the top cell absorbs the near-ultraviolet solar spectrum while the bottom one absorbs the near-infrared part. In our Solar RRL publication (DOI 10.1002/solr.202200242), a possible implementation of this tandem PV paradigm, namely, the tandem structure composed of a high-bandgap halide perovskite solar cell and a low-bandgap organic solar cell, is considered.

Solar RRL
www.solar-rrl.com

Design of Highly Efficient Semitransparent Perovskite/Organic Tandem Solar Cells

*Daniele Rossi, Karen Forberich, Fabio Matteocci, Matthias Auf der Maur, Hans-Joachim Egelhaaf, Christoph J. Brabec, and Aldo Di Carlo**

Solar cells transparent in the visible range are highly requested for integration in see-through photovoltaic (PV) applications such as building glass façades or greenhouse roofs. The development of advanced transparent PV can fully exploit the tandem technology where the top cell absorbs the near-ultraviolet solar spectrum while the bottom one absorbs the near-infrared part. Herein, a possible implementation of this tandem PV paradigm, namely, the tandem structure composed of a high-bandgap halide perovskite solar cell and a low-bandgap organic solar cell, is considered. Electro-optical simulation results based on parameters calibrated on experimental data show that an efficiency of 15% can be achieved with an average visible transmittance above 50%. This can be obtained considering the halide perovskite with mixed chlorine and bromine anions, a nonfullerene-based bulk heterojunction, a well-calibrated light management, and a three-terminal configuration of the tandem.

1. Introduction

Building-integrated photovoltaics (BIPV) represents one of the most effective and innovative solutions capable to meet the nearly zero energy building (NZEB) policy widely promoted in the last decades by the European Union.[1] In this context, transparent photovoltaic (TPV) technologies offer an additional opportunity to generate electricity through see-through glass façades and windows. TPV could indeed guarantee good power conversion efficiency (PCE) and average visible transmittance (AVT) of over 50%, as often required in facades and window applications.[1] Over the years, several TPV approaches have been proposed. The use of thin films can be exploited to reduce the absorption in the visible range. As an alternative wavelength-selective approach, highly efficient ultraviolet (UV) and near-infrared (NIR) photoactive materials can be employed and, in particular, combined to reduce absorption in the visible range and consequently increase the AVT.

As fully organic semitransparent solar cells have recently attracted great attention due to the high efficiency reported,[2–4] semitransparent tandem solar cells represent a promising candidate for new efficiency/AVT breakthroughs. In tandem structures, solar cells consisting of two or multiple photoactive layers with different bandgaps are used to selectively absorb different wavelength regions of the solar spectrum. Furthermore, it has been demonstrated that tandem architectures provide better light management than single-cell devices, allowing to reduce the total loss induced by reflection and parasitic absorption.[5] To this end, the ease in bandgap tuning of a wide class of organic materials, such as the low-bandgap NIR-absorbing small molecules and polymers, and of high-bandgap perovskites for UV absorption, such as methylammonium and formamidinium lead bromide/chloride ($MAPbBr_{3-x}Cl_x$ and $FAPbBr_{3-x}Cl_x$), makes these materials suitable for semitransparent tandem PV applications.[6] This is demonstrated by the record efficiency of 9.8%[7] for a semitransparent organic solar cell (ST-OSC) based on the PTB7-Th:FOIC:PC_{71}BM BHJ and 7.5%[8] for a $FAPbBr_{2.81}Cl_{0.19}$-based semitransparent perovskite solar cell (ST-PSC).

In the last decade, the PCE and AVT of semitransparent tandem solar cells have been dramatically improved due to the choice of innovative organic and hybrid absorbers and their optimization in terms of thickness and coating techniques. In fact, the efficiency of 3.07% and AVT = 40% obtained using low- and high-bandgap solid-state dye-sensitized solar cells (SS-DSSC)[9] has been rapidly surpassed by fully organic tandem devices (UV-OSC/NIR-OSC) with performance increase up to 8% and AVT = 45%[10] and more recently achieving the current record using perovskite and organic solar cells (UV-PSC/NIR-OSC)

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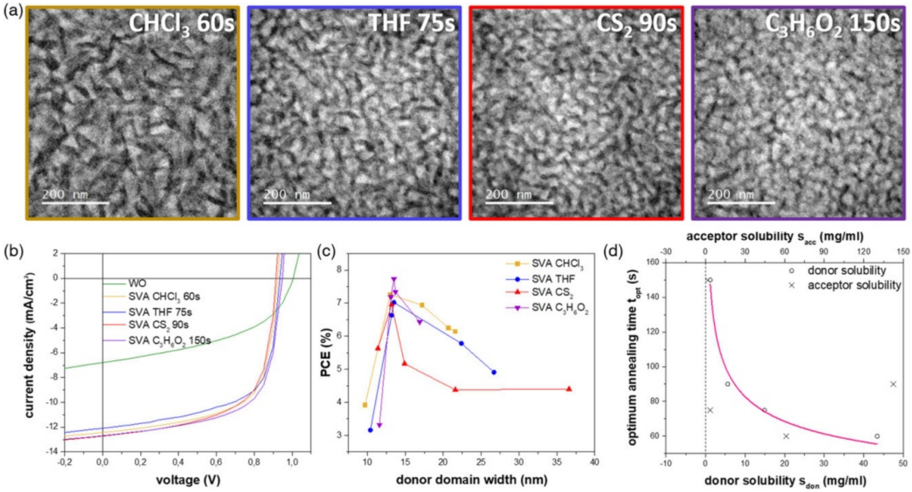
Understanding and Controlling the Evolution of Nanomorphology and Crystallinity of Organic Bulk-Heterojunction Blends with Solvent Vapor Annealing



Solvent vapor annealing (SVA) has established itself as a highly efficient post-treatment process for enhancing power conversion efficiency (PCE). In cooperation with the Prof Spiecker group and CENEM we investigate (DOI 10.1002/solr.202200127) the mechanisms of the SVA process of Organic Bulk-Heterojunction Blends. Thanks to the systematic EFTEM study by Christina we could measure the nm crystal growth kinetics from solvent vapor annealing. It really sets the standards on high resolution TEM imaging for organics!

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Understanding and Controlling the Evolution of Nanomorphology and Crystallinity of Organic Bulk-Heterojunction Blends with Solvent Vapor Annealing

*Christina Harreiß, Stefan Langner, Mingjian Wu, Marvin Berlinghof, Stefanie Rechberger, Johannes Will, Michele Conroy, Ursel Bangert, Tobias Unruh, Christoph J. Brabec, and Erdmann Spiecker**

Solvent vapor annealing (SVA) has been shown to significantly improve the device performance of organic bulk-heterojunction solar cells, yet the mechanisms linking nanomorphology, crystallinity of the active layer, and performance are still largely missing. Here, the mechanisms are tackled by correlating the evolution of nanomorphology, crystallinity, and performance with advanced transmission electron microscopy methods systematically. Model system of DRCN5T:PC_{71}BM blends are SVA treated with four solvents differing in their donor and acceptor solubilities. The choice of solvent drastically influences the rate at which the maximum device efficiency establishes, though similar values can be achieved for all solvents. The donor solubility is identified as a key parameter that controls the kinetics of diffusion and crystallization of the blend molecules, resulting in an inverse relationship between optimal annealing time and donor solubility. For the highest efficiency, optimum domain size and single-crystalline nature of DRCN5T fibers are found to be crucial. Moreover, the π–π stacking orientation of the crystallites is directly revealed and related to the nanomorphology, providing insight into the charge carrier transport pathways. Finally, a qualitative model relating morphology, crystallinity, and device efficiency evolution during SVA is presented, which may be transferred to other light-harvesting blends.

1. Introduction

Organic bulk heterojunction (BHJ) solar cells have attracted great attention over the past years due to their low cost and simple fabrication, their high flexibility, and their scalability.[1–6] One key issue in further improving the device efficiency of such BHJ solar cells is getting an in-depth understanding of how the nanomorphology of the active layer can be engineered in a controlled way. This is important since the nanomorphology determines the charge separation at the donor-acceptor interfaces and the subsequent electron and hole transport to the respective electrodes. Hence, it decisively influences the device's performance.[7–9] For efficient exciton diffusion and dissociation, the formation of a bicontinuous donor and acceptor network with domain sizes in the range of the exciton diffusion length is of urgent need. The nanomorphology can be varied and adjusted by several strategies like thermal annealing (TA),[10–12] solvent vapor annealing (SVA),[10,12,13] the addition of additives[10,12,14] or a combination of those techniques.[15] In particular, SVA has established itself as a highly efficient post-treatment process for enhancing power conversion efficiency (PCE).[15–18]

In the case of SVA, the active layer is exposed to a saturated solvent vapor that diffuses into the blend structure and leads to a phase separation and reorganization of donor and acceptor phases. This process is influenced by the solubility of the donor and acceptor in the respective solvent vapor, the partial pressure of the solvent, and the time of exposure.[16,19]

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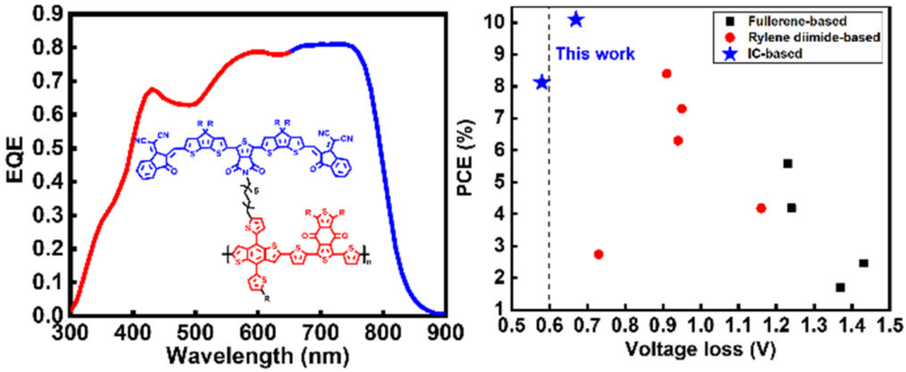
Double-Cable Conjugated Polymers for Single-Component Organic Solar Cells



Our beautiful and very successful cooperation with Weiwei from Beijing University of Chemical Technology on double conjugated polymers delivering 10 % for the first time. From 1998 – 2000, the first European Project on organic solar cells (Molecular Plastic Solar Cells) concluded that double cable polymers are too complex to control microstructure formation. 20 years after that, Weiwei shows (DOI 10.1002/anie.202209316) how to overcome these limitations by advanced material design!

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Solar Cells

Double-Cable Conjugated Polymers with Pendent Near-Infrared Electron Acceptors for Single-Component Organic Solar Cells

*Shijie Liang[+], Baiqiao Liu[+], Safakath Karuthedath, Jing Wang, Yakun He, Wen Liang Tan, Hao Li, Yunhua Xu, Ning Li, Jianhui Hou, Zheng Tang, Frédéric Laquai, Christopher R. McNeill, Christoph J. Brabec, and Weiwei Li**

Abstract: Double-cable conjugated polymers with near-infrared (NIR) electron acceptors are synthesized for use in single-component organic solar cells (SCOSCs). Through the development of a judicious synthetic pathway, the highly sensitive nature of the 2-(3-oxo-2,3-dihydroinden-1-ylidene)malononitrile (IC)-based electron acceptors in basic and protonic solvents is overcome. In addition, an asymmetric design motif is adopted to optimize the packing of donor and acceptor segments, enhancing charge separation efficiency. As such, the new double-cable polymers are successfully applied in SCOSCs, providing an efficiency of over 10% with a broad photo response from 300 to 850 nm and exhibiting excellent thermal/light stability. These results demonstrate the powerful design of NIR-acceptor-based double-cable polymers and will enable SCOSCs to enter a new stage.

Introduction

Double-cable conjugated polymers are one class of conjugated polymers that contain electron donor (D) as the conjugated backbone and electron acceptor (A) as side units, in which the D/A molecular heterojunction can separate bounded excitons into free charges.[1] Therefore, double-cable polymers can be applied to single-component organic solar cells (SCOSCs),[2] showing the advantage of superior device stability compared to bulk-heterojunction organic solar cells (BHJOSCs) with physically mixed D/A systems.[3] In addition, the precise control of D/A separation enabled by the double-cable polymer design allows such materials to act as model systems to study the photoelectrical conversion process. For example, a larger D/A distance has been shown to reduce non-radiative recombination losses and voltage losses in OSCs.[4] These merits demonstrate the great potential application of SCOSCs.

Although double-cable conjugated polymers have been reported over two decades, the power conversion efficiencies (PCEs) based on these polymers were always below 5%.[5] This was mainly due to the limited material species, among which fullerene derivatives have always been used as pendant side units (Figure 1a). Rylene dimides, such as

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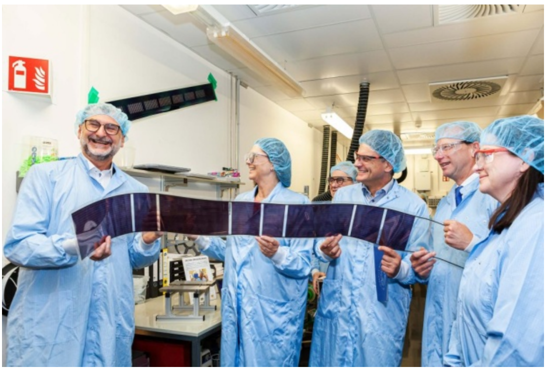
i-MEET participating in 23rd Sede Boqer Symposium on Solar Electricity Production

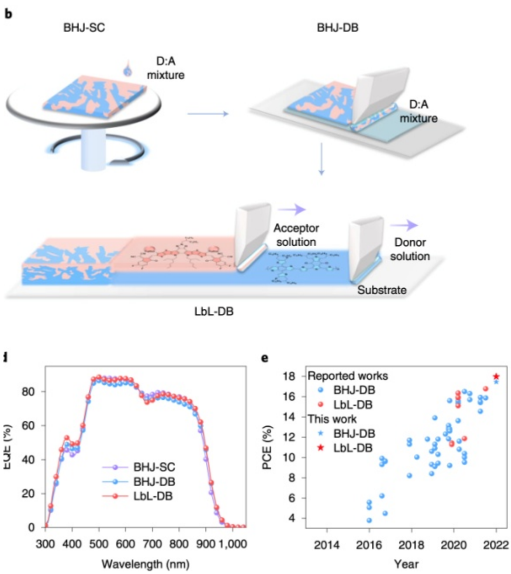
Christoph gave a talk at the 23rd Sede Boqer Symposium on Solar Electricity Production at the Ben-Gurion University. Eugene Katz and the Solar Institute team did a terrific job in organizing the 23rd summit, after two years of Corona enforced delays. Fantastic talks and so great to see many of our colleagues again!

Our printed solar cells make you happy – and don't require a prescription



During the visit of the delegation of the Bavarian Parliament at the EnCN in October, led by President Ilse Aigner, the members were able to see for themselves the progress made at the "solar factory of the future" (SFF under the leadership of Dr. Hans Egelhaaf)). Thereby our visitors (in the image on the left the president of the Bavarian parliament, Ilse Aigner and Prof. Dr. Joachim Hornegger, president of FAU) noticed the positive effect of organic solar cells – they are efficient, flexible, colorful and make you smile

High-speed sequential deposition of photoactive layers for organic solar cell manufacturing



Great work from Jie and Yongfang (DOI 10.1038/s41560-022-01140-4) pushing sequential deposition of donor-acceptor composites to the limits in web speed. Sequential processing of interdiffused bilayers opens even more advantages. This concept overcomes the necessity of mutual solubility of the donor and acceptor and opens a much wider space of available green processing solvents! Seems we are ready to printing km2 of NFA based organic solar cells!

nature energy

Article

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High-speed sequential deposition of photoactive layers for organic solar cell manufacturing

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Check for updates

Rui Sun[1], Tao Wang[1], Xinrong Yang[1], Yao Wu[1], Yang Wang[2], Qiang Wu[1], Maojie Zhang[2], Christoph J. Brabec[3], Yongfang Li[2] and Jie Min[1]

Despite the great success of organic photovoltaics in terms of device efficiency and stability at the laboratory scale, pressing demand for high-throughput and cost-effective solutions remains unresolved and rarely reported. Here we propose that a sequential-deposition, blade-coating approach using donor and acceptor materials can facilitate high-speed fabrication of photoactive layers while maintaining device performance. The sequential-deposition-processed blend and thickness of its designed PM6:T8 system can be optimized by the fine-tuning of the solution concentrations and coating speeds. We show that this strategy can be applied to a non-halogenated solvent and under high-humidity conditions. This high-speed approach is applicable to other non-fullerene photovoltaic systems and the slot-die coating technique. Techno-economic analysis suggests that this strategy can decrease the minimum sustainable price of module manufacturing. Overall, this work represents a step towards the scalable, cost-effective manufacturing of organic photovoltaics with both high performance and high throughput.

Solution-processed organic photovoltaics (OPVs) represent one of the most promising photovoltaic technologies for clean and renewable energy sources[1–4]. One main advantage of OPV materials is their solution processability, which opens the door to high-throughput and low-cost roll-to-roll (R2R) technologies for the commercialization of OPVs[5–8]. Great progress has been made in improving the power conversion efficiencies (PCEs) to over 18–19%[9], drawing on significant achievements in material design[9–11] and interface and device engineering[12,13]. Moreover, recent improvements in the multiple stability boundaries of OPVs by reducing the effects of degradation induced by internal and external factors have been facilitated[14–18]. Many non-fullerene systems with both market-competitive device efficiency and stability have been developed on a laboratory scale[15,17,19]. Considering that both efficiency and stability are now reaching such consistently high levels, scalable manufacturing issues with low production costs are becoming more prominent and are critical to OPV applications.

More current research has focused on reducing the cost of functional materials as part of the production cost through various methods[20–22]. However, research on reducing production costs via low-energy consumption and high-throughput manufacturing processes is rare. One main reason is that transforming OPV materials from solution into reliable industrial-scale, solid-state photoactive layers remains a vital challenge[23]. Current experimental processing techniques for the film formations of bulk heterojunction (BHJ) photoactive layers, including spin coating (SC), doctor blading (DB)[24–26], spray coating[27], ink-jet printing[28], slot-die coating (SDC)[29] and so on[14,30–32], do not comply with the required technical and economic conditions for convenient scaling into high-throughput, industrial manufacturing. In most cases, these processing techniques are only considered

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Lead-free halide perovskites review is published

Congratulations to Oleks, Oleksandra, Jens, and Christoph for publishing a Minireview on lead-free halide perovskites with ultimate photoluminescence (PL) quantum yields in Angewandte Chemie! Being a current “hot” topic, doping/alloying of halide lead-free perovskites is recognized as a pathway to highly efficient phosphors with PL quantum yields of up to 100% with a unique combination of spectral properties ideal for many light-harvesting applications. The Minireview (DOI 10.1002/anie.202212668) outlines the state-of-the-art in doped lead-free perovskite phosphors, provides an analysis of factors determining the efficiency and spectral parameters of their broadband emission, and highlights the most relevant challenges and promising concepts in this rapidly developing research area.

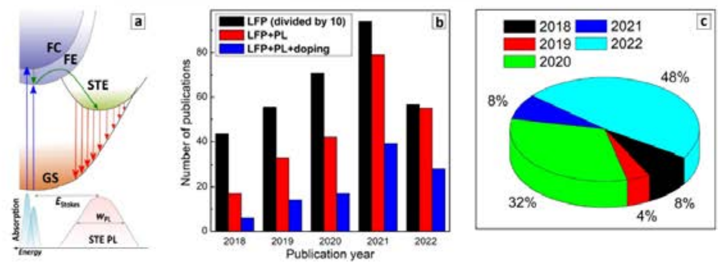


Figure 1. a) Scheme of the excitation and recombination processes in LFPs, GS –ground state, FC – free charge carriers, FE – free exciton, STE – self-trapped exciton, E_{Stokes} – Stokes shift, w_{PL} – spectral width of PL band. b) Statistics on publications related to LFPs collected for the last five years: total number of all publications on LFPs (black bars, divided by 10), papers on luminescent materials (LFP+PL, red bars), and papers on doped luminescent LFPs (LFP+PL+doping, blue bars). c) Yearly distribution of reports on doped LFP materials with PL QY higher than 50% for the last five years. Data collected by Web of Science service.

However, nanosized phosphors face multiple adverse implications regarding the efficiency and stability of the PL emission which we will analyze in the present Minireview. Finally, we provide a general outlook on the most promising strategies for the quest for new LFP host matrices and "magic key" dopants, the tailoring of the spectral properties and kinetics of STE PL emission via controlled distortion of the host matrix lattice, and special features revealed by nanocrystalline LFP phosphors.

We note a quite astonishing fact that ca. 50% of all reports on highly emissive doped LFPs with PL QYs larger than 50% have been published in 2022 (Figure 1c), indicat-

Oleksandr Stroyuk has been a Research Scientist at Helmholtz Institute Erlangen-Nuremberg for Renewable Energy, HI ERN (Forschungszentrum Jülich GmbH) since 2019. He received his Ph.D. in physical chemistry (2003) and a Doctor of Sciences degree (2011) from L.V. Pysarzhevsky Institute of Physical Chemistry, National Academy of Sciences of Ukraine. He was a Marie Skłodowska-Curie Fellow at the Technical University of Dresden (2016–2018) and a Research Scientist at the Technical University of Chemnitz (2018–2019).

Oleksandra Raievska has been a Research Scientist at HI ERN (Forschungszentrum Jülich GmbH) since 2021. She received her Ph.D. in physical chemistry (2004) from L.V. Pysarzhevsky Institute of Physical Chemistry, National Academy of Sciences of Ukraine. She was a visiting scientist at the Technical University of Dresden (2016–2019) and a Research Scientist at the Technical University of Chemnitz (2019–2020).

Jens A. Hauch is the head of the research unit for high-throughput methods in photovoltaics and leads the group on high-throughput materials and devices at HI ERN (Forschungszentrum Jülich GmbH). He received his Ph.D. in experimental physics from the University of Texas at Austin (USA) in 1999. He was Head of the Department of Renewable Energies at the Bavarian Centre for Applied Energy Research (ZAE Bayern, 2016–2018), Managing Director of the interdisciplinary Energy Campus Nuremberg Research Center (2012–2015), Managing Director of Konarka Technologies GmbH (2009–2011), and Senior Scientist at Siemens Corporate Technology (1999–2004).

Christoph J. Brabec received his Ph.D. (1995) from Linz University (Austria). After a postdoc period under Serdar Sariciftci and Alan Heeger, he joined the Siemens research labs (project leader) in 2001, Konarka in 2004 (CTO), Erlangen University (full professor) in 2009, ZAE Bayern e.V. (scientific director, board member) in 2010, Interdisciplinary Center for Nanostructured Films (spokesman) in 2013. He was named honorary professor at the University of Groningen (2018–2023) and director at HI ERN, Forschungszentrum Jülich GmbH (IEK-11) in 2018. His research interests include all aspects of solution processing organic, hybrid, and inorganic semiconductor devices with a focus on photovoltaics and renewable energy systems.

Congratulations to our colleagues with their PhD defenses

Many i-MEETers have passed their PhD examinations during the 2022 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 YousefiAmir, AminAbbas (*Printed Thin Film Photodetectors*), Tam, Kai Cheong (*Materials and architectures for fully solution-processed organic solar modules: material-specific requirements for lossminimized module interconnection*), Hübner, Tobias (*Tintenstrahldrucken von Indiumphosphid basierten Quantenpunkt-Leuchtdioden*)

YousefiAmir AminAbbas

Tobias Hübner

<u>Fahimeh</u> has finished her doctoral study with very good grades. The PhD defence took place digitally via zoom that allowed a larger audience to be present. During her PhD Fahimeh worked on the modification of low dimensional nanostructured TiO_2 for energy application. Nanostructured TiO_2 can provide unique advantages for photovoltaic and photocatalysis reactions. Fahimeh focused on synthesizing nanostructured TiO2 and employing novel approaches to modify its properties in order to use in photovoltaic solar cells and photocatalysis H_2 evolution. She says: “I believe the results of this thesis provide considerable insight into the importance of not only using TiO_2 in specific nanostructure forms but also appropriate modification approaches in order to obtain efficient solar energy conversion systems”

<u>Kai Cheong “Eric” Tam</u> finished his PhD thesis “Materials and architectures for fully solution-processed organic solar modules: material-specific requirements for loss-minimized module interconnection” in March 2022.

Organic photovoltaics is a promising technology thanks to many advantageous properties, such as printability, semitransparency and flexibility. Despite the recent breakthrough of power conversion efficiencies around 20% on small cell level, module efficiencies still lag behind by around 8%. A major challenge on the way to closing this lab-to-fab efficiency gap lies in establishing high quality monolithic interconnections between individual cells in a solar module. In his thesis, Eric analysed and minimized the electrical losses that are attributed to interconnections, focusing on those formed with silver.

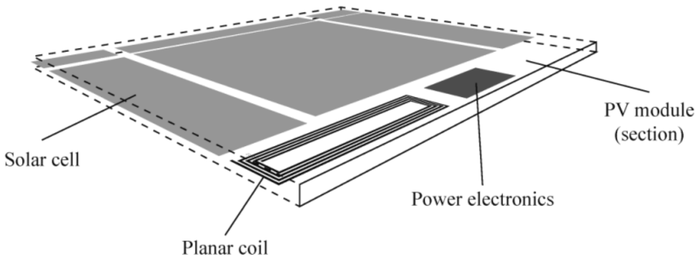
In the first part of the thesis, Eric replaced the conventional evaporated silver electrodes with printed ones, in order to enable fully printed organic modules. By developing appropriate silver nanoparticle inks and the corresponding printing processes he managed to reduce the performance difference between evaporated and printed silver electrodes to less than 4% in a 4 cm2 organic solar module.

In the second section Eric replaced the opaque silver nanoparticle top electrodes by transparent ones, consisting of silver nanowires (AgNW), which enables the fabrication of semi-transparent OPV modules. Employing the novel cross bridge Kelvin resistor structure (CBKR) as an accurate tool to measure interconnection resistances, he found that the resistance between silver nanowire (AgNW) top electrode and Indium tin oxide (ITO) bottom electrode is orders of magnitude higher than the interconnection resistance between printed silver and ITO observed in the first section. He managed to reduce this interconnect resistance by two orders of magnitude by choosing an alternative interconnection approach. Instead of making a direct contact between the two electrodes, he printed narrow lines of silver nanoparticles (AgNP) onto the ITO bottom electrode which connect the subsequently coated AgNW top electrode to the ITO.

In the last section Eric realized fully printed organic solar modules by replacing also the ITO bottom electrode by AgNWs. The challenges of this approch, apart from the surface roughness of AgNW bottom electrodes, lies in the small effective contact area between bottom and top AgNW electrodes, which causes not only a high interconnection resistance but results also in a low damage threshold of the AgNW/AgNW contact. On the basis of quantitative measurements of the interconnection resistance and its power rating, the interconnection between top and bottom AgNW electrodes was optimized step by step, until it reliably connected the individual cells of a fully printed 4 cm^2 organic solar module with minimal electrical and active area losses. Eric concludes the thesis with a short guide providing qualitative estimations on the efficiency losses caused by interconnections to facilitate future printed solar module design.

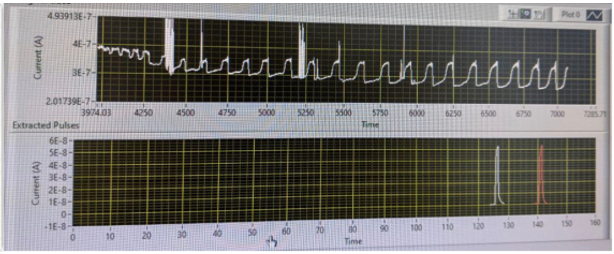
Chao passed her PhD examination with the great success and excellent grades! Her study focused on the development of advanced functional interface materials as required for the scalable production of highly efficient and stable organic solar cells with simple solution processing techniques. One major outcome of her thesis is the demonstration and application of a fully functional and robust tandem recombination layer that indeed inhibits solvent penetration and thus protects the bottom solar cells. A second major success was the clarification of the fundamental processes how SnO2-based nanoparticles do form interfaces to organic semiconductors.

Having resolved that challenge allowed Chao to demonstrate a significant reduction of the currently existing interface challenges of OSCs with PEDOT:PSS, which now no longer of that great concern to the photovoltaic community. Thank you Chao for the fantastic work you have done over the years and looking forward to another exciting year with you as Postdoc working on transparent solar cells for the project CitySolar!

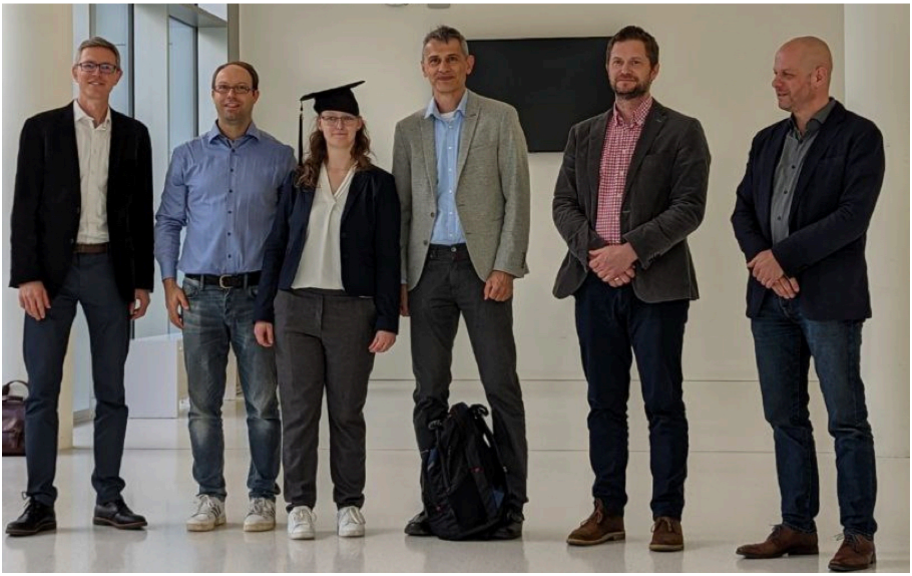


Fabian has finished his doctoral study on Friday with very good grades! In his work the inductive power transfer was applied in the field of PV in order to develop a completely new and innovative PV system, which does not require a large number of traditional electrical connectors. The direct current of the solar cells is converted into an alternating current using a resonant converter and fed through a primary coil placed inside the PV module, which then induces a voltage to the secondary coil placed outside the PV module. The measured power transmission efficiency over the coils was 97.9% ±0.83% (k=1) and the modelled European efficiency of the whole wireless PV module including power electronics was 94.3%.

During his doctoral research, **<u>Sasha</u>** worked at SOPSEM group (Prof Dr. Heiß) with pigments and their application in photocatalysis and in electrochromic smart devices. For the photocatalysis Sasha shaped quinacridone to the hedgehog-like nano-microstructures and covered them with platinum, as well as he used pigment-doped carbon nitride. Those systems were able to enhance H_2O_2 generation from water and showed good stability. Alongside with this Prussian blue and cerium oxide were modified for the smart windows applications. Prussian blue-based inks were optimized to achieve optical transparency without the formation of aggregates. While for the cerium oxide various methods of stripping oleylamine from the surface of nanocrystals were investigated. This improved the electrical conductivity and allowed to utilize it subsequently as an ion storage material. Fabricated electrochromic devices based on Prussian blue and cerium oxide showed improved performance and promising results. Sasha will continue working at HI ERN, investigating the correlation between external influences and the degradation of backside polymer films of PV modules.



<u>Sarah</u> has done her PhD with Siemens Healthineers and was supervised by W. Heiß at i-Meet. Her work was devoted to metal-organic perovskites for direct X-ray conversion. Especially she introduced a new strategy to integrate perovskite wafers with a read-out electronics, which allowed to demonstrate an X-ray imager with both, high sensitivity and high spatial resolution. Further, she demonstrated the scalability of this approach and studied the long-term stability of such X-ray detectors. While the majority of the work was focused on methyl-ammonium lead perovskite wafers, she expanded this approach also to lead-free perovskites.



Welcome to the family!

We are also happy to welcome Dr. Hannah Smith, and Dr. Masoudeh Maleki


Dr. Hannah Smith


Dr. Maleki Masoudeh


Dr. Oleksiy Balitskii

PhD students


Robin Basu


Andreas Bornschlegl

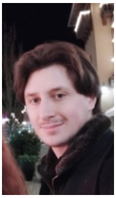

Inna Khyzhna


Chaohui Li

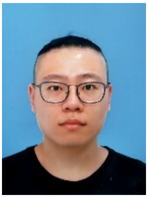

Ntumba Lobo


Jana Schultheiß


Sven Strüber


Ernst Wittmann


Zhenni Wu


Endong Zhang

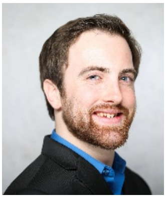
Difei left i-MEET after more than a year working in our group on novel Y6 derivatives and is continuing her career back at SCUT. Yakun is leaving i-MEET after 5 years PhD and ~ 1 year Postdoc working on double cable materials and will join KAUST as a Postdoc working on the photophysics of advanced semiconductors. Junsheng is also back to China and will work at the University of Electronic Science and Technology of China (UESTC)

Dr. Matthias Arzig

Dr. Fabian Carigiet

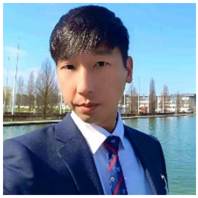
Dr. Sarah Deumel

Dr. Yakun He



Dr. Johannes Hepp

Dr. Tobias Hübner



Dr. Jihoon Lee

Ntumba Lobo

Dr. Junsheng Luo

Dr. Oleksandr Mashkov

Jerrit Wagner

Difei Zhang

Dr. Yicheng Zhao

4. Bachelor Theses

Daniel Künzl, (Brabec/Daum)
Optimierung der Prozessierung von Nanopartikeldispersionen für Organische Solarzellen

Mihai Gusetu, (Egelhaaf)
Surface Modification of Perovskites Using a Series of Different SAM Materials

Robert Kammel, (Heiss/Rehm)
Alkali-halide single-crystal-growth for solution-epitaxy of metal-halide-perovskites

Danica Kettner, (Brabec)
Methodenevaluation zur Untersuchung von Subsurface Damagelayern in CdTe-Wafern nach mechanischer Bearbeitung

Ole Schneider, (Brabec/Heumüller)
Messung und Aufbau zur Charakterisierung der temperaturabhängigen Leitfähigkeit dotierter organischer Halbleiter

Claudia Heinzl, (Hock/Batentschuk)
Investigation of the influence of surface roughness on the reflex positions in X-ray diffractometry under grazing incidence

5. Master Theses

Cosima Güttler, (Brabec/Stroyuk)
Spectroscopic characterization of the state of degradation of polymer encapsulations of silicon-based photovoltaic modules

Caroline Gräser, (Egelhaaf/Distler)
Investigation and Minimization of the Performance Gap between High-Efficiency Organic Solar Cells and Modules

Frederik Schmitt, (Brabec/Heumüller)
Using Machine Learning to optimize the Efficiency and Stability of Organic Solar Cells

Maximilian Diez, (Batentschuk)
Tailoring Electronic Properties of Zn-In-Cu-S Quantum Dots for Solar Applications

Maximilian Siegel, (Brabec)
Untersuchung der elektrochemischen und morphologischen Eigenschaften von thermisch abgeschiedenen Iridiumoxid-Beschichtungen

Maret Ickler, (Heiss)
Verbesserung von polykristallinen Methylammoniumbleiiodid - Perowskit Röntgendetektoren

Alexander Flohrer, (Batentschuk)
Material optimization of SiO_2 and TiO_2 by use of an ion-assisted e-beam evaporation process for the deposition of high reflectivity interference mirrors

Christopher Clauss, (Heiss),
Bleisulfid Quantum-Dots: Einfluss des Schwefel-Präkursors auf die Bauteileigenschaften

Rishabh Raval Nitin, (Egelhaaf)
Development of a process for printing Organic solar cells on 3D object using Inkjet Printing

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

Aydan Alkan, Ecem (Brabec/Hauch, i-MEET)
High-througput Synthesis of Conjugated Polymers for Development of Semitransparent Organic Photovoltaics

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

Basu, Robin (Brabec/Egelhaaf/Distler, i-MEET)
Fully solution-processed organic solar cells

Bornschlegl, Andreas (Brabec, i-MEET)
Radiation Hard OPV for Outer Space

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

Elshaimaa, Darwish (Batentschuk, i-MEET)
Fabrication of nanomaterials with enhanced stability for photovoltaics applications

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

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 dipole engineering in fully printed perovskite solar cells and module

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

Elsayed, Hany (Heiss, i-MEET)
Solution-Epitaxial Metal Halide Perovskite Microcrystal Lasers

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)
Predictive models for Photophysics at buried Interfaces

Hu, Huiying (Brabec/Osvet, i-MEET)
Enhanced stability of perovskite nanocrystals for display and lighting

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

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

Kong, Mengqin (Brabec/ Batentschuk, i-MEET)
Synthesis and application of AgInS/ZnS in QDs and double perovskite

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

Li, Chaohui (Brabec/Lüer, i-MEET)
Highly efficient and stable inverted perovskite solar cells

Lobo, Ntumba (Brabec, i-MEET)
Pigment Nanocrystals for Energy and Energy Saving Applications

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

Meng, Wei (Brabec/Li, i-MEET)
Defects associated physical mechanism and engineering for perovskite solar cells

Peng, Zijian (Brabec/Lüer, 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

Rocha Ortiz, Juan Sebastian (Brabec, i-MEET)
Synthesis of triphenylamine-based hole transporting and donor-acceptor molecules for photovoltaic applications

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

Saboor, Abdus (Brabec/Stroyuk, i-MEET)
High-Throughput "Green" Synthesis of Indium- and Tin-based Multinary Chalcogenide and Perovskite Nanocrystals for Light Conversion Applications

Schultheiß, Jana (Wellmann, i-MEET)
Defektcharacterisierung mittels Röntgenbeugung von 4H-SiC

Steinberger, Marc (Egelhaaf/Distler, ZAE)
Process-Structure-Performance Relationship of Organic Solar Cells

Steiner, Johannes (Wellmann, i-MEET)
Experimentelle und numerische Untersuchung von Stickstoffdotierung und Temperaturfeld auf Versetzungen in einkristallinem 100 mm 4H-SiC PVT-Wachstum

These, Albert (Brabec, i-MEET)
Defects in Perovskites

Tian, Jingjing (Brabec/Lüer, i-MEET)
Development of highly efficient and stable wide bandgap inorganic perovskite/organic tandem solar cells

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)
Wavelength dependent degradataion of Organic Solar Cells

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

Wu, Zhenni (Brabec/Peters, i-MEET)
Recycling of perovskite solar cells

Xie, Qian (Brabec/ Li, i-MEET)
Study on the stability of organic solar cells based on random polymer donor materials

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

Zhang, Heyi (Brabec/Li/Osvet, i-MEET)
The co-modification of dipole aligned and group passivation on MeOx HTL in p-i-n perovskite solar cells

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

Zhou, Shuyu (Heiss, i-MEET)
Two-dimensional nanomaterials for interface engineering

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

7. Doctoral Theses Completed

21.01.2022
Shahvaranfard, Fahimeh (Brabec, i-MEET)
Modification of low dimensional nanostructured TiO_2 for energy application

15.03.2022
YousefiAmir, AminAbbas (Heiss, i-MEET)
Printed Thin Film Photodetectors

16.03.2022
Tam, Kai Cheong (Brabec, ZAE)
Materials and architectures for fully solution-processed organic solar modules: material-specific requirements for lossminimized module interconnection.

10.06.2022
Hübner, Tobias (Brabec, i-MEET/OSRAM)
Tintenstrahldrucken von Indiumphosphid basierten Quantenpunkt-Leuchtdioden

22.06.2022
Liu, Chao (Brabec, i-MEET)
Design, Characterization and Application of Interfaces for Efficient Organic Solar Cells

01.10.2022
Carigiet, Fabian (Brabec, Zürcher Hochschule für Angewandte Wissenschaften)
Inductive Power Transfer for Photovoltaic Modules

14.10.2022
Mashkov, Oleksandr (Heiss, i-MEET)
Pigment Nanocrystals for Energy and Energy Saving Applications

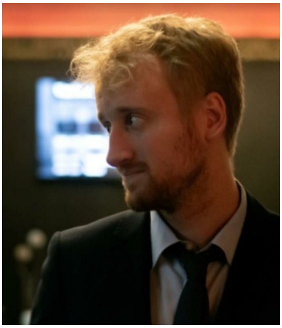
03.11.2022
Deumel, Sarah (Heiss, i-MEET)
Metall-organische Perowskite für direkt konvertierende Röntgendetektoren

8. Awards

We cordially congratulate Dr. Ning Li on his appointment as Professor at the South China University of Technology. He has been a valuable member of our family for over a decade, making significant contributions to teaching, research, and service. As a Professor, Dr. Li will start his own research group, which we believe will have a positive impact on the university's research landscape. We thank Dr. Li for his dedicated service and wish him continued success in his new role!

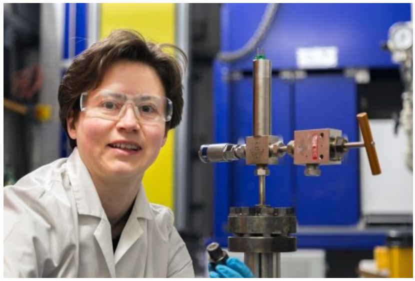
Our sincere congratulations go to Dr. Xiaoyan Du as well, who obtain her PhD in i-MEET and was working here as a postdoc, accelerating research with AMANDA. Dr. Du has received the position of Professor at Shandong University. Although we are sad to see her leave our department, we are excited for her new opportunity and congratulate her on this achievement. We wish Xiaoyan all the best in her future endeavors, and we are confident that she will continue to make important contributions to the field of organic photovoltaics!

We also want to extend our heartfelt congratulations to Dr. Zicheng Yhao on his recent appointment as junior professor in the School of Electronic Science and Engineering at the University of Electronic Science and Technology of China (UESTC). This is a well-deserved recognition of his outstanding contributions and his dedication to advancing knowledge in his field.



Vincent Le Corre for receiving Emerging Talents Initiative Grant, 15 000 euro. The Emerging Talents Initiative (ETI) is aimed at helping excellent young researchers apply for external funding within the funding period (12 months).

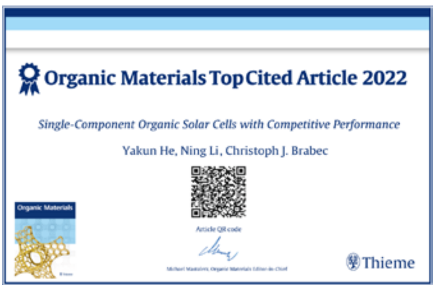
Saskia Schimmel with IUCr Young Scientist Award (International Union of Crystallography) and also Emerging Talents Initiative (ETI) (Friedrich-Alexander-Universität Erlangen-Nürnberg). The program aims to give outstanding researchers the opportunity to lead a junior research group and fulfill specific teaching tasks, thus meeting the requirements for being appointed as a university lecturer.



A total of 1,320,000 euros has been approved for the first three-year funding period, with a total of 550,000 euros plus project lump sums earmarked for the second funding period, also lasting three years. The research group's project will focus on developing innovative nitride semiconductors and gaining a deeper understanding of the manufacturing process using ammonothermal synthesis. The materials investigated within the project are potentially combinable, thereby creating new opportunities for creating devices. Dr. Schimmel's work aims to contribute to inventing innovative and more energy-efficient electronic devices and to drive forward fundamental research into the synthesis and properties of semiconducting nitrides.

Viktor Rehm with IRTG Young Researcher Award "Highest Impact"

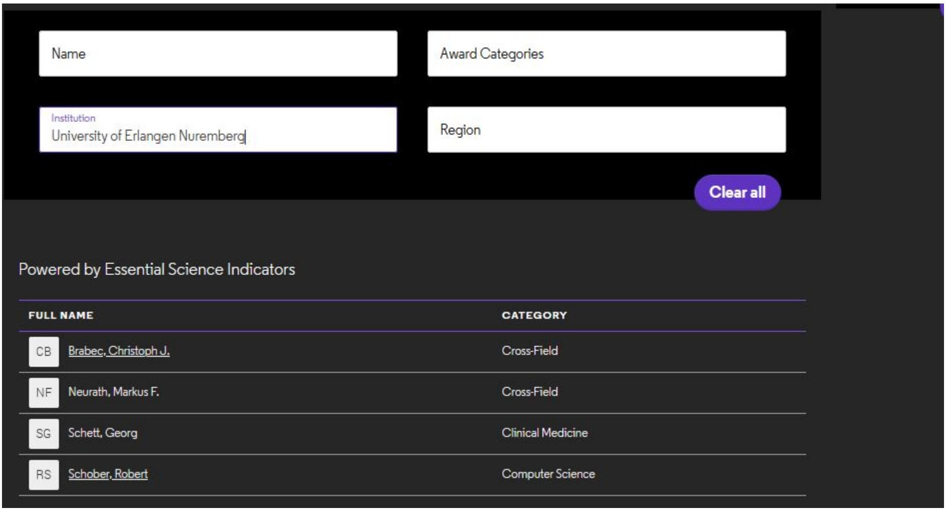
Yakun He won the best oral presentation prize at nanoGe Spring Meeting 2022. She took the prize for the best oral presentation at NanoGe spring meeting 2022! In her talk Yakun highlighted recent research published in Advanced Energy Materials. In the article the quality of charge generating interface was quantitatively assessed from purely optical measurements, and, without changing the density of interfaces, slowly convert the nature of the interface from geminately recombining to free carrier generating



Alonside **Yakun's paper** is the top cited article of Organic Materials in 2022!
Her review on single-component organic solar cells dedicated to the 65th birthday of Prof. Peter Bäuerle become a Thieme Chemistry Organic Materials Top Cited Article. Congratulations!

Christoph is highly cited researcher 2022!

For the tenth 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. This year is specifically great. Not only Christoph made it into the HCR list, but also Ning Li (SCUT and HIERN) as well as Yi Hou (NUS and FAU), two of our PhD students, Postdocs and now professors made it at an unusual young age on the Highly Cited Researcher List from Clarivate. 3 HCR from one institute is a very strong sign! The full list of highly cited researchers can be found on the Clarivate website.



9. Publications

(Full Papers and Conference Proceedings)

Osbel Almora, Derya Baran, Guillermo C. Bazan, Carlos I. Cabrera, Sule Erten-Ela, Karen Forberich, Fei Guo, Jens Hauch, Anita W. Y. Ho-Baillie, T. Jesper Jacobsson, Rene A. J. Janssen, Thomas Kirchartz, Nikos Kopidakis, 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, Barry P. Rand, Uwe Rau, Henry J. Snaith, Eva Unger, Lídice Vaillant-Roca, Chenchen Yang, Hin-Lap Yip, Christoph J. Brabec
Device Performance of Emerging Photovoltaic Materials (Version 3)
*Advanced Energy Materials, **13(1)**, Article number 2203313, 2022*
DOI: 10.1002/aenm.202203313

Zhang, Jiyun, Liu, Bowen, Liu, Ziyi, Wu, Jianchang, Arnold, Simon, Shi, Hongyang, Osterrieder, Tobias, Hauch, Jens, Wu, Zhenni, Luo, Junsheng, Wagner, Jerrit, Berger, Christian G., Stubhan, Tobias, Schmitt, Frederik, Zhang, Kaicheng, Sytnyk, Mykhailo, Heumueller, Thomas, Sutter-Fella, Carolin M., Peters, Ian Marius, Zhao, Yicheng, Brabec, Christoph J. Brabec
A Fully Robotic Platform for Optimizing the High-Dimensional Processing Parameter Space of Perovskite Thin-Films
*Joule, **in press**, 2022*
DOI: 10.2139/ssrn.4309089

Qian Xie, Yongjie Cui, Zeng Chen, Ming Zhang, Chao Liu, Haiming Zhu, Feng Liu, Christoph J. Brabec,Xunfan Liao and Yiwang Chen
Achieving Efficient and Stabilized Organic Solar Cells by Precisely Controlling the Proportion of Copolymerized Units in Electron-rich Polymers
*Nanoscale, **47**, 2022*
DOI: 10.1039/D2NR03992C

Youcai Liang, Difei Zhang, Zerun Wu, Tao Jia, Larry Lüer, Haoran Tang, Ling Hong, Jiabin Zhang, Kai Zhang, Christoph J. Brabec, Ning Li & Fei Huang
Organic solar cells using oligomer acceptors for improved stability and efficiency
*Nature Energy, **7**, pp. 1180-1190, 2022*
DOI: 10.1038/s41560-022-01155-x

Ntumba Lobo, Takuya Kawane, Gebhard J Matt, Andres Osvet, Shreetu Shrestha, Levchuk Ievgen, Christoph J Brabec, Andrii Kanak, Petro Fochuk and Masashi Kato
Trapping effects and surface/interface recombination of carrier recombination in single- or poly-crystalline metal halide perovskites
*Jpn. J. Appl. Phys., **61(12)**, Article number 125503, 2022*
DOI: 10.35848/1347-4065/aca05b

Yuanqing Bai, Zhisheng Zhou, Qifan Xue, Chunchen Liu, Ning Li, Haoran Tang, Jiabin Zhang, Xinxin Xia, Jie Zhang, Xinhui Lu, Christoph J. Brabec, Fei Huang
Dopant-Free Bithiophene-Imide-Based Polymeric Hole-Transporting Materials for Efficient and Stable Perovskite Solar Cells
*Advanced Materials, **34(49)**, Article number 2110587, 2022*
DOI: 10.1002/adma.202110587

Rui Sun, Tao Wang, Xinrong Yang, Yao Wu, Yang Wang, Qiang Wu, Maojie Zhang, Christoph J. Brabec, Yongfang Li & Jie Min
High-speed sequential deposition of photoactive layers for organic solar cell manufacturing
*Nat Energy, **7**, pp. 1087-1099, 2022*
DOI: 10.1038/s41560-022-01140-4

Shijing Sun, Ming Liu, Janak Thapa, Noor Titan Putri Hartono, Yicheng Zhao, Donglin He, Sarah Wieghold, Matthew Chua, Yue Wu, Vladimir Bulović, Sanliang Ling, Christoph J. Brabec, Andrew I. Cooper, and Tonio Buonassisi
Cage Molecules Stabilize Lead Halide Perovskite Thin Films
*Chem. Mater., **34(21)**, pp. 9384-9391, 2022*
DOI: 10.1021/acs.chemmater.2c01502

Jingjing Tian, Kaicheng Zhang, Zhiqiang Xie, Zijian Peng, Jiyun Zhang, Andres Osvet, Larry Lüer, Thomas Kirchartz, Uwe Rau, Ning Li, and Christoph J. Brabec
Quantifying the Energy Losses in $CsPbI_2Br$ Perovskite Solar Cells with an Open-Circuit Voltage of up to 1.45 V
*ACS Energy Lett., **7(11)**, pp. 4071-4080, 2022*
DOI: 10.1021/acsenergylett.2c01883

Vanessa M. Koch, Jaroslav Charvot, Yuanyuan Cao, Claudia Hartmann, Regan G. Wilks, Ivan Kundrata, Ignacio Mínguez-Bacho, Negar Gheshlaghi, Felix Hoga, Tobias Stubhan, Wiebke Alex, Daniel Pokorný, Ece Topraksal, Ana-Sunčana Smith, Christoph J. Brabec, Marcus Bär, Dirk M. Guldi, Maïssa K. S. Barr, Filip Bureš, and Julien Bachmann
Sb_2Se_3 Thin-Film Growth by Solution Atomic Layer Deposition
*Chem. Mater., **34(21)**, pp. 9392-9401, 2022*
DOI: 10.1021/acs.chemmater.2c01550

Oleksandr Stroyuk, Oleksandra Raievska, Jens Hauch, Christoph J. Brabec
Doping/Alloying Pathways to Lead-Free Halide Perovskites with Ultimate Photoluminescence Quantum Yields
*Angew. Chem. Int. Ed., **135(3)**, Article number e202212668, 2022*
DOI: 10.1002/ange.202212668

Balitskii, Olexiy, Oleksandr Mashkov, Anastasiia Barabash, Viktor Rehm, Hany A. Afify, Ning Li, Maria S. Hammer, Christoph J. Brabec, Andreas Eigen, Marcus Halik, Olesya Yarema, Maksym Yarema, Vanessa Wood, David Stifter, and Wolfgang Heiss
Ligand Tuning of Localized Surface Plasmon Resonances in Antimony-Doped Tin Oxide Nanocrystals
*Nanomaterials, **12(13)**, Article number 3469, 2022*
DOI: 10.3390/nano12193469

Kaicheng Zhang, Andreas Späth, Osbel Almora, Vincent M. Le Corre, Jonas Wortmann, Jiyun Zhang, Zhiqiang Xie, Anastasia Barabash, Maria S. Hammer, Thomas Heumüller, Jie Min, Rainer Fink, Larry Lüer, Ning Li, and Christoph J. Brabec
Suppressing Nonradiative Recombination in Lead–Tin Perovskite Solar Cells through Bulk and Surface Passivation to Reduce Open Circuit Voltage Losses
*ACS Energy Lett., **7**, pp. 3235-3243, 2022*
DOI: 10.1021/acsenergylett.2c01605

Hany A. Afify, Viktor Rehm, Anastasiia Barabash, Albert These, Jiyun Zhang, Andres Osvet, Christoph Schüßlbauer, Dominik Thiel, Tobias Ullrich, Martin Dierner, Thomas Przybilla, Johannes Will, Erdmann Spiecker, Dirk M. Guldi, Christoph J. Brabec, Wolfgang Heiss
Shape-Controlled Solution-Epitaxial Perovskite Micro-Crystal Lasers Rivaling Vapor Deposited Ones
*Advanced Functional Materials, **32(45)**, Article number 2206790, 2022*
DOI: 10.1002/adfm.202206790

Yuanqing Bai, Zhisheng Zhou, Qifan Xue, Chunchen Liu, Ning Li, Haoran Tang, Jiabin Zhang, Xinxin Xia, Jie Zhang, Xinhui Lu, Christoph J. Brabec, Fei Huang
Dopant-free Bithiophene Imide-based Polymeric Hole Transporting Materials for Efficient and Stable Perovskite Solar Cells
*Advanced Materials, **34(49)**, Article number 2110587, 2022*
DOI: 10.1002/adma.202110587

Ian Marius Peters, Jens A.Hauch, Christoph J.Brabec
The Role of Innovation for Economy and Sustainability of Photovoltaic Modules
*iScience, **25(10)**, Article number 105208, 2022*
DOI: 10.1016/j.isci.2022.105208

Jiyun Zhang, Jianchang Wu, Stefan Langner, Baolin Zhao, Zhiqiang Xie, Jens A. Hauch, Hany A. Afify, Anastasia Barabash, Junsheng Luo, Mykhailo Sytnyk, Wei Meng, Kaicheng Zhang, Chao Liu, Andres Osvet, Ning Li, Marcus Halik, Wolfgang Heiss, Yicheng Zhao, Christoph J. Brabec
Exploring the Steric Hindrance of Alkylammonium Cations in the Structural Reconfiguration of Quasi-2D Perovskite Materials Using a High-throughput Experimental Platform
*Advanced Functional Materials, **32(43)**, Article number 2207101, 2022*
DOI: 10.1002/adfm.202207101

Oleksandr Stroyuk, Oleksandra Raievska, Christoph J. Brabec, Volodymyr Dzhagan, Yevhenii Havryliuk and Dietrich R. T. Zahn
Self-Assembly of Colloidal Single-Layer Carbon Nitride
Nanoscale, 2022
DOI: 10.1039/D2NR03477H

Guichuan Zhang, Francis R. Lin, Feng Qi, Thomas Heumüller, Andreas Distler, Hans-Joachim Egelhaaf, Ning Li, Philip C. Y. Chow, Christoph J. Brabec, Alex K.-Y. Jen, and Hin-Lap Yip
Renewed Prospects for Organic Photovoltaics
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DOI: 10.1021/acs.chemrev.1c00955

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10. Books

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Rare-Earth Ion-Based Photon Up-Conversion for Transmission-Loss Reduction in Solar Cells
Book Chapter in Lissau, J.S., Madsen, M. (eds) Emerging Strategies to Reduce Transmission and Thermalization Losses in Solar Cells. Springer, Cham, pp 241–267, 2022

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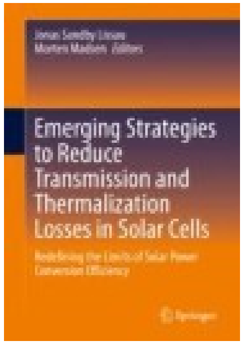


11. Presentations at Conferences, Workshops, Events

Brabec, Christoph J.

17.01.2022
The inauguration of the Perovskite Society of India, online symposium
Invited talk:

02.2022
Bitterfeld, Avancis
Invited talk:

01.03.2022
Farewell symposium for Ning, Erlangen, Germany
Opening talk: *OPV at i-MEET with Ning – a glimpse back and one into the future*

7-11.03.2022
NanoGE spring meeting, online
Invited Talk**:** *Bulk or Interface – what is limiting the operational lifetime of perovskite solar cells*
Invited Talk**:** *Long Lived OPV – what are the lifetime limitations of organic solar cells*

04.2022
CPE Symposium for Prof. Dr. Bradley, London, UK
Invited Talk:

09-10.05.2022
KAUST Research Conference: Accelerating Solar Energy Research towards meeting Vision 2030 Goals, Jeddah, Saudi Arabia
Invited Talk: *Long Lived "Solution Processed" Photovoltaics- a look into the Material Science behind Interfaces*

20.06.2022
DGM Regionalforum Erlangen, Germany
Invited Talk: *Accelerating Solar Energy Materials Discovery*

27-30.06.2022
XXXVIII biennial meeting of the Royal Spanish Chemical Society for Spain, Granada, Spain
Invited Talk*: Accelerating the development of solar materials with automated research lines*

04-06.07.2022
Next-Generation V+ PV Materials, Oosterpoort, Groningen, the Netherlands
Invited Talk: *Progress on tandem cell and module technology*

07.2022
Groningen, International Symposium on behalf of Prof. Kees Hummelen, Groningen, the Netherlands
Invited Talk:

30.08 -02.09.2022
Annual Accelerate Conference, Toronto, Canada
Plenary Talk:

05-07.09.2022
The 23rd Sede Boqer Symposium on Solar Electricity Production, Summit on Solar Electricity, Ben-Gurion University, Be'er Scheva, Israel
Plenary Talk: **Accelerating Lifetime Engineering of Emerging-PV Technologies**

19-21.09.2022
Singapore, MRS Singapore
Plenary talk:

27-30.09.2022
International Summit on Organic and Hybrid Photovoltaics Stability, ISOS-XIII Sonderborg, Denmark
Invited talk:

24-28.10.2022
nanoGe Fall Meeting Materials for Sustainable Development Conference (MAT-SUS) (NFM22) EN05, MRS Boston, USA (virtual conference)
Invited talk: *Spectrally induced degradation mechanisms in organic solar cells – the last hurdle on the road to longevity?*
Invited talk: *An Automated Platform to Screen Lead-Free Halide Double-Perovskites for Opto-Electronic Applications*

10.2022
Workshop between DOE and HGF, Washington, USA
Invited talk:

11.2022
NSA workshop on acceleration science, Washington, USA
Invited talk:

11.2022
Infineon Technologies, Regensburg, Germany
Invited talk:

12.2022
Department of physics, Linköping, Sweden
Invited talk:

12.2022
Green AI Seminar, (online)
Invited talk:

14-15.12.2022
Techblick PV conference, The Future of Photovoltaics: Organic, Perovskites, CIGS, Tandem, (online)
Invited talk:

18-20.12.2022
The 14th International Photonics and OptoElectronics Meetings (POEM), Wuhan, China
Invited talk: *Accelerating emerging PV technologies*

Distler, Andres

17.09.2022
Nacht der Wissenschaften 2022, Energie Campus Nürnberg
Talk: *Gedruckte Photovoltaik und deren Anwendungsfelder*

Dong, Lirong

04-06.07.2022
NEXT-GEN V+ PV materials, Groningen, Netherlands
Poster: *Minimalistic interface requirement for fully printable perovskite solar cells and modules enabled by a dipole layer*

Doll, Bernd

28.03. – 01.04.2022
12th International Conference on Crystalline Silicon Photovoltaics, Konstanz, Germany
Poster: *Photoluminescence setup for photovoltaic module characterisation in the field*

26-30.09.2022
8th World Conference on Photovoltaic Energy Conversion, Milan, Italy
Poster: *Artificially Induced Series and Parallel Resistance for Precise Determination of IV Curves from Luminescence Images of PV Modules*

Du, Tian

19-25.05.2022
HOPV 2022 (International Conference on Hybrid and Organic Photovoltaics), Valencia, Spain
Talk: Additive-free, Low-temperature Crystallization of Stable α-FAPbI3 Perovskite

Kalancha, Violetta

30.05-03.06.2022
Emerging Solar Energy Materials and Applications (ESEMA 2022), Porquerolles, France
Talk**:** *Overcoming Temperature-Induced Degradation of Silver Nanowire Electrodes by an Ag@SnOx Core-Shell Approach*

23 -24.06.2022
GRK final Symposium, Erlangen, Germany
Talk**:** *Highly Stable Solution-Processed Silver Nanowires SnOx Core-Shell Conductive Transparent Electrode*

Kollmuß, Manuel

11-16.09.2022
International Conference on Silicon Carbide and related Materials, Davos, Switzerland
Poster: *Transfer of heteroepitaxial grown 3C-SiC layers for application in optical frequency combs*

Le Corre, Vincent

05.2022
Perovskite house seminar of the Loi's Group, University of Groningen, online
Invited Talk: *Do's and Don'ts for SCLC analysis of perovskite materials*

30.05-03.06.2022
Emerging Solar Energy Materials and Applications (ESEMA 2022), Porquerolles, France
Contributed Talk**:** *Lessons learned from device modeling of solar cell current-voltage characteristics*

07-09.09.2022
International Conference on Simulation of Organic Electronics and Photovoltaics (SimOEP '22) – Fluxim, Winterthur, Switzerland
Invited Talk: *Smart-Automated Device Doctor for Solar Cells*

27.11-02.12.2022
MRS Fall Meeting Boston, USA
Contributed talk: *Do's and Don'ts for SCLC analysis of perovskite materials*

11.2022
Institut Photovoltaïque d'Ile-de-France (IPVF), Palaiseau, France
Invited Talk: *Smart-Automated Device Doctor for Solar Cells*

Lüer, Larry

22.06.2022
PVSPACE Online Conference on New Generation Photovoltaics for Space (PVSPACE), online
Contributed talk: *Fully solution-processed, light-weight, and ultraflexible organic solar cells*

24-27.10.2022
NanoGE Fall Meeting 2022, Barcelona, Spain
Invited talk: *Optimizing performance and stability of organic photovoltaics with small driving force for charge separation*
Invited talk: *Solution-Processed Light-Weight and Ultraflexible Organic Solar Cells (in replacement for Christoph J. Brabec)*

07.12.2022
Next Generation Solar Energy (NGSE7), online
Contributed talk: *Quantitative Structure-Property Relationships in organic photovoltaic devices from high throughput experimentation*

Peng, Zijian

04-06.07.2022
NEXT-GEN V+ PV materials, Groningen, Netherlands
Talk: *Minimizing interfacial losses for inverted CsPbI2Br inorganic solar cells*

Rocha Ortiz, Juan Sebastian

01-03.07.2022
DAAD Scholarship Holder Meeting, Munich, Germany
Talk: *BODIPY and Triarylamines as potential moieties for organic solar cells*

Schimmel, Saskia

29.05-02.06.2022
8th International Workshop on Crystal Growth Technology, Berlin, Germany
Poster: High Energy Computed Tomography as a Tool for Validation of Numerical Simulations of Ammonothermal Crystal Growth of GaN

25- 27.07.2022
7th European Conference on Crystal Growth, Paris, France
Poster: In Situ Monitoring Technologies as Prospective Validation Tools for Numerical Simulations of Ammonothermal Crystal Growth

Steinberger, Marc

28.08-01.09.2022
Advanced Materials Congress, Stockholm, Sweden
Talk: *All Inkjet-printed Organic Solar Cells on Curved Surfaces of 3D Objects*

Tian, Jingjing

04-06.07.2022
NEXT-GEN V+ PV materials, Groningen, Netherlands
Talk: *Quantifying the Energy Losses in $CsPbI_2Br$ Perovskite Solar Cells with an Open-Circuit Voltage of up to 1.45 V*

These, Albert

03.06.2022
Emerging Solar Energy Materials & Applications, IGeSA, Porquerolles Island, France
Talk: *Additive Manufacturing of Semiconducting Perovskites: the relevance of process induced defects*

Wang, Rong

04-06.07.2022
NEXT-GEN V+ PV materials, Groningen, Netherlands
Talk: *Tailoring the charge transfer states between polymer donor and nonfullerene acceptor in organic solar cells by interface engineering*

Wortmann, Jonas

30.05-03.06.2022
Emerging Solar Energy Materials and Applications (ESEMA 2022), Porquerolles, France

Talk**:** *Quick lifetime evaluation of OPV by separate degradation of incomplete layer stacks*

Wu, Jianchang

10-13.10.2022
11th Solar Technologies Go Hybrid (SolTech), Munich, 2022
Poster: *Semi-Automated Synthesis and Autonomous Optimization of Molecular Materials for Photovoltaic Applications*

Zhang, Jiyun

10-13.10.2022
11th Solar Technologies Go Hybrid (SolTech), Munich, 2022
Poster: *Exploring the Steric Hindrance of Alkylammonium Cations in the Structural Reconfiguration of Quasi-2D Perovskite Materials Using a High-throughput Experimental Platform*

Zhang, Kaicheng

30.05.-01.06.2022
TandemPV 2022 Workshop, Freiburg, Germany
Talk: *Reducing Energy Losses in Narrow-bandgap Solar Cells by Bulk and Surface Passivation*

Participation in the Summer/Winter schools, scientific courses:

These, Albert
PV School Les Houches, Quantsol Summer School

Wortmann, Jonas
GRK Summerschool

Hu, Huiying
SAOT Winter Academy 2022:“A brief introduction to photovoltaics”

Kalancha, Violetta
Event: Softskill seminar: “PhD Thesis Defence Training”
Date: 07-08.07 2022
Location: IZNF (01.160), Cauerstraße 3, 91058 Erlangen, by Anja Berninger

Event: Online-Webinar: Self-presentation and networking
Date: 18.07./20.07./22.07.2022
Location: online, by Karin Bodewits

Exkursionen: Fraunhofer-Institut für Keramische Technologien und Systeme (IKTS)
Date: 19.05.2022
Location: Äußere Nürnberger Strasse 62, 91301 Forchheim, Germany

Exkursionen: company Osram
Date: 30.06.2022
Location: Leibnizstraße 4, 93055 Regensburg, Germany

Exkursionen: Zeiss manufacturer
Date: 11.10.2022
Location: Carl-Zeiss-Straße 22, 73447 Oberkochen

12. Seminar Presentations

12.01.2022
Christopher Clauss
Ligandenaustausch an ATO Nanokristallen

26.01.2022
Benfang Niu, (guest talk, Zhejiang University, China)
On the lead leakage concern of perovskite solar cells

02.02.2022
Cosima Güttler, (Master Thesis, supervisors Prof. Dr. Christoph Brabec, Dr. Oleksandr Stroyuk)
Spectroscopic characterization of the state of degradation of polymer encapsulations of silicon-based photovoltaic modules
Christian Kupfer, (annual PhD report)

09.02.2022
Huiying Hu, (annual PhD report)
Enhanced photostability for perovskite with Mn^{3+} *introduction*
Wei Meng, (annual PhD report)
Interface engineering for perovskite solar cells

16.02.2022
Andreas Bornschlegl, (guest talk, LMU München)
Exciton Diffusion in Perovskite Nanocrystals

23.02.2022
Yicheng Zhao
The dance of cation and halide in hybrid perovskite materials

02.03.2022
Jiyun Zhang, (annual PhD report)
Intercalating-organic-cation-induced Stability Bowing in Quasi-2D Metal-halide Perovskites

09.03.2022
Caroline Gräser, (Master Thesis, supervisors PD Dr. Hans-Joachim Egelhaaf, Dr. Andreas Distler)
Investigation and Minimization of the Performance Gap between High-Efficiency Organic Solar Cells and Modules
Milap Mehta
MEG and Quantum Materials- Generate more excitons with one
Jingru Zhao
Concept to break the Detailed - Balance Limit
Shuyue Yao
Singlet Fission in photovoltaics

23.03.2022
Violetta Kalancha, (annual PhD report)
Detailed investigation of SnOx layer on silver nanowires using electrochemical and TEM techniques

06.04.2022
Frederik Schmitt, (Master Thesis, supervisors: Prof. Dr. Christoph Brabec, Dr. Thomas Heumüller)
Using Machine Learning to optimize the Efficiency and Stability of Organic Solar Cells
Bernd Doll, (annual PhD report)
Towards monitoring of large-scale photovoltaic installations with advanced high throughput luminescence imaging

20.04.2022
Daniel Künzl, (Bachelor Thesis, supervisors: Prof. Dr. Christoph Brabec, Manuel Daum)
Optimierung der Prozessierung von Nanopartikeldispersionen für Organische Solarzellen

18.05.2022
Maximilian Diez, (Master Thesis, supervisor: PD Dr. Miroslaw Batentschuk)
Tailoring Electronic Properties of Zn-In-Cu-S Quantum Dots for Solar Applications
Mihai Gusetu, (Bachelor Thesis, supervisor: PD Dr. Hans-Joachim Egelhaaf)
Surface Modification of Perovskites Using a Series of Different SAM Materials

25.05.2022
Safety instructions, Dr. Andres Osvet
Benny Febriansyah, (guest talk, Berkeley Education Alliance for Research in Singapore (BEARS), Campus for Research Excellence and Technological (CREATE))
Low dimensional organic metal-halide hybrids: molecular design & optoelectronic properties

01.06.2022
Laser and XRD safety instructions, Dr. Andres Osvet
Dr. Hannah Smith, (guest talk, Princeton University, USA)
Doping at the Limit: Improving Charge Transport in Organic Light-Emitting Diodes Using Molecular Dopants

08.06.2022
Maximilian Siegel, (Master Thesis, supervisor: Prof. Dr. Christoph Brabec)
Untersuchung der elektrochemischen und morphologischen Eigenschaften von thermisch abgeschiedenen Iridiumoxid-Beschichtungen
Julian Haffner-Schirmer
Free charge photogeneration in a single component high photovoltaic efficiency organic semiconductor

Michael A. Anderson, (guest talk, Materials Science and Engineering University of Arizona, USA)
A multi-modal approach to understanding degradation of organic photovoltaic materials

15.06.2022
Maret Ickler, (Master thesis, supervisor: Prof Dr. Wolfgang Heiss)
Verbesserung von polykristallinen Methylammoniumbleiiodid - Perowskit Röntgendetektoren

06.07.2022
Thomas Osterberg, (guest talk, Epishine)
Laminated Printed Photovoltaics for Indoor Applications

13.07.2022
Robert Kammel, (Bachelor thesis, supervisor: Prof. Dr. Wolfgang Heiss)
Alkali-halide single-crystal-growth for solution-epitaxy of metal-halide-perovskites

03.08.2022
Alexander Flohrer, (Master Thesis, supervisor: PD Dr. Miroslaw Batentschuk)
Material optimization of SiO_2 and TiO_2 by use of an ion-assisted e-beam evaporation process for the deposition of high reflectivity interference mirrors

24.08.2022
Dr. Loredana Protesescu, (guest talk, University of Groningen, Nanomaterials Chemistry Zernike Institute for Advanced Materials)
Chemical design for metal halide perovskites nanostructures

14.09.2022
Josua Wachsmuth, (annual PhD report)
Routes to highly efficient fully solution-processed printed Organic Solar Cells: Materials and Challenges
Danica Kettner, (Bachelor thesis, supervisors: Prof. Dr. Christoph Brabec)
Methodenevaluation zur Untersuchung von Subsurface Damagelayern in CdTe-Wafern nach mechanischer Bearbeitung

07.10.2022
Dr. Olga Wodo, (guest talk, Materials Design and Innovation Department (MDI) University of Buffalo, USA)
Microstructure informatics: bridging materials and data science for accelerated design

12.10.2022
Christopher Clauss, (Master thesis, supervisor: Prof Dr. Wolfgang Heiss),
Bleisulfid Quantum-Dots: Einfluss des Schwefel-Präkursors auf die Bauteileigenschaften

<u>19.10.2022</u>
Ahmed S. M. Ismail, (guest talk, Dunia Innovations)
A catalyst acceleration platform towards realizing the energy transition

<u>16.11.2022</u>
Huiying Hu, (annual PhD report)
Engineering of Perovskite Quantum Dot Enhanced Films (QDEF) for implementation in a tablet device with high color purity

<u>23.11.2022</u>
Andreas Bornschlegl, (annual PhD report)
OPV in Outer Space: Designing a high-throughput AI guided experiment
Prof. Dr. Alessio Gagliardi, (Guest talk, Technische Universität München, Munich Data Science Institute),
Machine Learning to Investigate Material Properties

<u>30.11.2022</u>
Lirong Dong, (annual PhD report)
Fullerene-enabled interface engineering in fully printed perovskite solar cells and modules

<u>07.12.2022</u>
Robin Basu, (annual PhD report),
Aerosol Jet Printed Barriers for Organic Photovoltaics

<u>21.12.2022</u>
Ole Schneider, (Bachelor thesis, supervisors: Prof. Dr. Christoph Brabec, Dr. Thomas Heumüller)
Messung und Aufbau zur Charakterisierung der temperaturabhängigen Leitfähigkeit dotierter organischer Halbleiter

Guest Talks 2022

<u>26.01.2022</u>
Benfang Niu, (Zhejiang University, China)
On the lead leakage concern of perovskite solar cells

<u>16.02.2022</u>
Andreas Bornschlegl, (LMU München)
Exciton Diffusion in Perovskite Nanocrystals

<u>25.05.2022</u>
Benny Febriansyah, (Berkeley Education Alliance for Research in Singapore (BEARS), Campus for Research Excellence and Technological (CREATE))
Low dimensional organic metal-halide hybrids: molecular design & optoelectronic properties

<u>01.06.2022</u>
Dr. Hannah Smith, (Princeton University, USA)
Doping at the Limit: Improving Charge Transport in Organic Light-Emitting Diodes Using Molecular Dopants

<u>08.06.2022</u>
Michael A. Anderson, (Materials Science and Engineering University of Arizona, USA)
A multi-modal approach to understanding degradation of organic photovoltaic materials

<u>06.07.2022</u>
Thomas Osterberg, (Epishine)
Laminated Printed Photovoltaics for Indoor Applications

<u>24.08.2022</u>
Dr. Loredana Protesescu, (University of Groningen, Nanomaterials Chemistry Zernike Institute for Advanced Materials)
Chemical design for metal halide perovskites nanostructures

<u>07.10.2022</u>
Dr. Olga Wodo, (Materials Design and Innovation Department (MDI) University of Buffalo, USA)
Microstructure informatics: bridging materials and data science for accelerated design

<u>19.10.2022</u>
Ahmed S. M. Ismail, (Dunia Innovations)
A catalyst acceleration platform towards realizing the energy transition

<u>23.11.2022</u>
Prof. Dr. Alessio Gagliardi, (Technische Universität München, Munich Data Science Institute),
Machine Learning to Investigate Material Properties

13. Conferences organized by Members of the Institute

Brabec, Christoph

<u>01.03.2022</u>

Conference (Full name): Farewell symposium for Ning

Location: Erlangen, online

<u>6-8.12.2022</u>

Conference (Full name): The 7th International Conference on Next Generation Solar Energy (NGSE7)

Location: Erlangen, online conference

Peters, Ian Marius

<u>05-10.06.2022</u>

Conference (Full name): 49. IEEE Photovoltaic Specialists Conference (PVSC), Area 10

Location: Philadelphia, USA

The 7th International Conference on Next Generation Solar Energy (NGSE7)

This year the conference (NGSE7) was held from 6th – 8th of December 2022 in hybrid format. For the 7th edition of the NGSE conference, 14 speakers were invited to give 30 min talk in the topic of 'Machine learning method and high-throughput experimentation for material research'.

The NGSE 7 was followed by two topic-specific workshops about 'Emerging PV database workshop' and 'Transparent photovoltaic workshop'.

Over 230 people registered for the conference and the average attendance for the talks was around 80-100.

NGSE 7 schedule:

NGSE 7 Tuesday Dec. 6th	**NGSE 7 Wednesday Dec. 7th**	**Emerging PV workshop Thursday Dec. 8th (morning)**	**Transparent PV workshop Thursday Dec. 8th (afternoon)**
15:45-15:55 Welcome NGSE Introduction			
15:55-16:30 Aram Amassian (North Carolina State University) Sustainable, Scalable and Collaborative High Throughput Experimentation for Energy Research	**15:30-16:05** **Yicheng Zhao** (University of Science and Technology of China) High-throughput intelligent photoluminescence analysis	**10:00-10:15** **Osbel Almora** (University Pablo de Olavide) 3 Years of Emerging PV initiative: Summary and Outlook	**14:00-14:30** **Roland Krippner** (Technische Hochschule Nürnberg) Building-integrated photovoltaics – On design and transparency in façade constructions
16:30-17:05 **Alexander Hammer** (Dunia Innovations) From high-throughput platforms to smart labs	**16:05-16:40** **Beat Ruhstaller** (Zurich University of Applied Sciences, Fluxim AG) Characterizing & optimizing next generation solar cells	**10:15-10:40** **Anita Ho-Baillie** (University of Sydney) Perovskite Tandem Solar Cells	**14:30-15:00** **Aldo di Carlo** (University of Rome) Semitransparent photovoltaics: from dye sensitised to perovskite solar cells
17:05-17:40 **Loïc Roch** (Atinary Technologies Inc.) Atinary SDLabs: ML-driven experiment	**16:40-17:15** **Tobias Stubhan** (SCIPRIOS GmbH) From Spincoating Robot to Materials Acceleration Platforms	**10:40-11:05** **Hin-Lap Yip** (City University of Hong Kong) Monolithic perovskite/organic tandem solar cells	**15:00-15:30** **Harald Ade** (North Carolina State University) Solar-Powered Integrated Greenhouse (SPRING) Systems Using

planning for accelerated material discovery.			Wavelength Selective Photovoltaics for Complete Solar Utilization
17:40-18:15 **Larry Lüer** (University of Erlangen-Nuremberg) High throughput experimentation for quantitative structure-property relationships	**17:15-17:50** **Thomas Kirchartz** (Forschungszentrum Jülich) Bayesian parameter estimation for halide perovskite solar cells	**11:05-11:30** **Mohammad Khaja Nazeeruddin** (EPFL) To be announced	**15:30-16:00** **Richard Lunt** (Michigan State University) Emergence and Commercialization of Highly Transparent PVs for Distributed Applications
18:15-18:25 Break	**17:50-18:00** Break	**11:30-11:55** **Fei Guo** (Jinan University) Suppressing Nonradiative Losses in Wide-Bandgap Perovskites for Printed Tandem Photovoltaic Devices	17:00-17:40 ePV meeting & website demonstration-(American and Europe times edition)
18:25-19:00 Pascal Friederich (Karlsruhe Institute of Technology) Machine learning methods for accelerated materials simulation and discovery	**18:00-18:35** **Evelyne Knapp** (Zurich University of Applied Sciences, Fluxim AG) Machine-Learning Assisted Parameter Extraction in Solar Cells	**11:55-12:20** **Eva Unger** (Helmholtz-Zentrum Berlin) The Perovskite Database: where we started from and where we need to go	

19:00-19:35 **Jens Hauch** (Helmholtz Institute Erlangen-Nürnberg for Renewable Energy) From automated materials research to autonomous materials discovery	**18:35-19:10** **Shijing Sun** (Toyota Research Institute) How machine learning can help with experimental energy materials innovation	12:20-13:00 ePV meeting & website demonstration- (Asia and Europe times edition)
19:35-20:10 **Jie Xu** (Argonne National Laboratory) Autonomous robotic platform (PolyBot) for electronic polymer discovery	**19:10-19:45** **Curtis P. Berlinguette** (University of British Columbia) Self-Driving Labs for the Optimization of Solar Cell Hole Transport Materials	13:00-14:00 Break

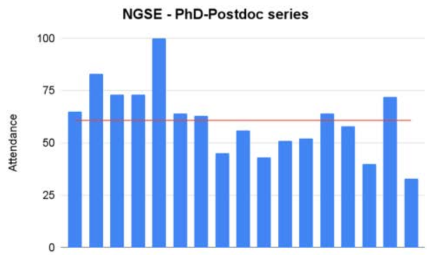
The Next Generation Solar Energy (NGSE) PhD-Postdoc series

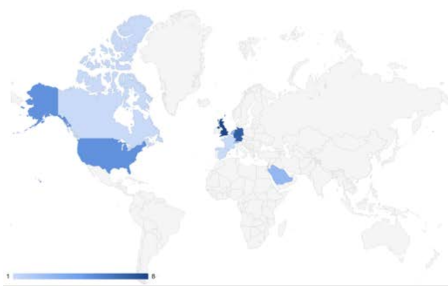
The Next Generation Solar Energy (NGSE) PhD-Postdoc series (https://www.ngse.info/phd-postdoc-series/) continued in 2022 to promote the work of Emerging Scientists (PhD students and Postdocs) in the field of solar energy. In this series, only early career researchers present in order to promote a new generation of promising scientists.
This year **17** talks were organized with researchers from 8 different countries and 18 different institutions.

Attendance:

Attendance throughout the series has been relatively stable with an average attendance of **60** people. In total over **600** people registered for at least one of the talk.

Statistics for the NGSE PhD-Postdoc series:





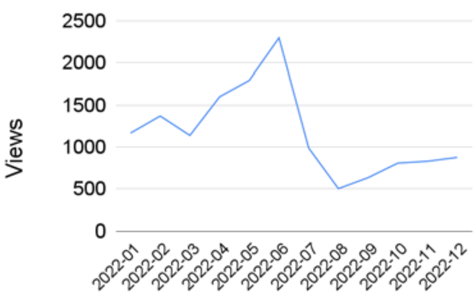
Social Media Presence:

Twitter:

Social media presence of the group has been increase in 2022.

The follower count nearly double for both the i-MEET (@iMEET_PV) and the NGSE conference (@NGSE_conf) accounts over the course of 2022. Going from 260 and 238 to 436 and 527 respectively.

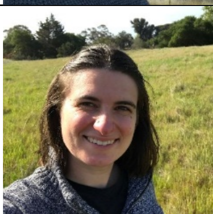
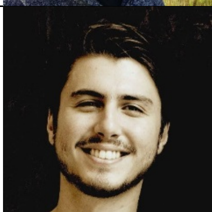
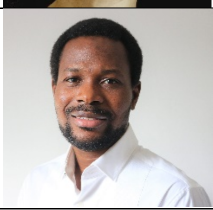
YouTube:



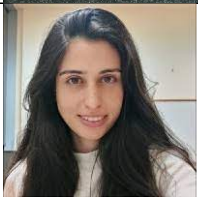
Following trends from last year, the monthly views on the YouTube channel now stabilized between 500 to 1000 views per month. Videos from the NGSE PhD-Postdoc series are released regularly.

The most viewed video of the channel is the video by Dr. Yicheng Zhao 'Perovskite solar cell with ultra-long durability' with over 5.5 k views. The channel now has over 23 k views and 376 subscribers.

Speakers list 2022:

26-Jan-2022		Simon Kahmann – University of Cambridge, UK	Taking a closer look: the power of optical microscopy to unravel the complex world of two-dimensional perovskites.
09-Feb-2022		Erkan Aydin – KAUST, KSA	Solution-processed perovskites on textured interfaces: A successful platform for efficient perovskite/silicon tandem solar cells.
23-Feb-2022		Mathias Uller Rothmann – University of Oxford, UK	Advanced Electron Microscopy of Metal Halide Perovskites.
09-Mar-2022		Rhiannon Kennard – UC Santa Barbara, US – University of Sheffield, UK	Using Grazing Incidence X-Rays to Understand Halide Perovskite Films.
23-Mar-2022		Pietro Caprioglio – University of Oxford, UK	Open-circuit and short-circuit loss management in inverted wide-gap perovskite pin solar cells.
13-Apr-2022		Nutifafa Doumon – INRS, Ca – NREL, US	Challenges Faced by Emerging (Organic) Photovoltaic Technologies.

27-Apr-2022		Loreta A. Muscarella – AMOLF, NL – Utrecht University, NL	Strain-induced stabilization of phase segregation in mixed-halide perovskites.
11-May-2022		Clément Maheu – TU Darmstadt, DE	Photoelectron Spectroscopies provide insights in solar energy materials and their interfaces.
25-May-2022		Safakath Karuthedath – KAUST, KSA	Role of Ionization Energy Offset in Binary and Ternary Organic Solar Cells.
08-Jun-2022		Mohammed Azzouzi Imperial College London, UK	Multiscale modelling of OPV devices: Reconciling models of interfacial state kinetics and device performance in organic solar cells.
22-Jun-2022		Basita Das – Forschungszentrum Jülich, DE	Parameter estimation in Perovskite solar cells using Bayesian Inference.

28-Sep-2022		Daniel A. Jacobs – EPFL, CH	Lateral Ion Migration Accelerates Degradation in Halide Perovskite Devices
12-Oct-2022		Carlo A.R. Perini – Georgia Institute of Technology, US	Halide perovskite photovoltaics: tailoring interfaces to maximize the energy yield
26-Oct-2022		Tobias Osterrieder – Alexander-Universität Erlangen-Nürnberg, DE	Autonomous Optimization of ternary OPV devices on automated research lines
09-Nov-2022		Sapir Bitton – Technion Israel Institute of Technology, IL	Iodine Reactions as Mobile Recombination Centers – a Drift-Diffusion Reaction Simulation of Perovskite Cells' Degradation
23-Nov-2022		Amran Al-Ashouri – Helmholtz-Zentrum Berlin, DE	Boosting Perovskite Tandem Solar Cells and Exploring Charge Carrier Dynamics with Self-Assembled Monolayers

14-Dec-2022		Arava Zohar – UC Santa Barbara, US	In Operando, Photovoltaic, and Microscopic Evaluation of Recombination Centers in Halide Perovskite-Based Solar Cells

14. Cooperation in Committees

<u>Batentschuk, Miroslaw</u>

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

<u>Brabec, Christoph J.</u>

<u>*Activities for the Friedrich-Alexander University Erlangen - Nürnberg (FAU):*</u>
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
Spokesmen of the Erlangen Research Cluster FAU Solar
<u>*National Activities:*</u>
Scientific Director Department Renewable Energies, ZAE Bayern, Erlangen
Member of the EnCN Science Board (Energy Campus Nürnberg)
<u>*International Activities:*</u>
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
Spokesman of the HGF Initiative “Solar TAP”
<u>*Services to the Community:*</u>
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

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: 7559825, (Germany)
01.08.2018 – 31.10.2022
Lead-free Perovskite Xray detectors

GRK 1896, DFG (Germany)
01.04.2018-30.09.2022
In situ microscopy with electrons, X-rays and scanning probes

Deutsche Forschungsgemeinschaft DFG: Teilprojekt (755890) (Germany)
01.01.2020-30.06.2024
IGK 2495: Energy conversion systems: From Materials to Devices, Teilprojekt I: Growth of Single Crystal Transition Metal Perovskite Chalcogenides

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

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), (PV-IL, ZF4506011DF9) (Germany)
01.04.2020 –30.09.2022
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 (EB1022), (Germany)
01.08.2018 –31.10.2022
Modulanalytik und Fehlerauswertung (optiCIGS_II)

Bayerisches Staatsministerium für Wissenschaft und Kunst (iPV4.0), (Germany)
08.2018 –31.01.2022
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)

Bundesministeriums für Wirtschaft (AiF), KK5094002LTO, (Germany)
01.01.2021-31.12.2023
ZnInCuAgS Herstellung Nanokristall-Partikel

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“

Deutsche Forschungsgemeinschaft DFG DU 2323/1-1 AOBJ: 688992 (Germany)
05.08.2022-04.05.2025
Experimentelle und theoretische Untersuchungen von Prozessparametern zur Herstellung dicker und defektfreier Perowskit-Schichten

Das Zentrale Innovationsprogramm Mittelstand (ZIM) des Bundesministeriums für Wirtschaft (AiF), KK5094004GM1
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, BR 4031/20-1 (Germany)
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 (AiF), 16KN098724
01.12.2021 – 30.11.2023
OPV4IoT

Das Zentrale Innovationsprogramm Mittelstand (ZIM) des Bundesministeriums für Wirtschaft
01.03.2020-30.09.2022
Photoinduzierte Ladungsträgerdynamik als Qualitätskriterium in der Halbleiterproduktion (PIASOL)

Strukturbildende Verbundprojekte am Energie Campus Nürnberg
01.01.2022 – 31.12.2022
EnCN-OPVplus

BMWK via AiF Berlin, ZIM project
01.01.21 – 31.12.23
Development of new ZnInCuAgS – photoluminescence nanocrystals for optical active layers in Si solar modules for enhancement of energy efficiency via alignment of the spectral distribution of incoming sunlight

VolkswagenStiftung, Stipendium for Mrs. M. Sc Inna Khyszna
01.09.2022 – 31.08.2022
Spectroscopy of defects in semiconductors for new generation of optoelectronics

Bayerische Forschungsstiftung (BFS), PhD-Stipendium
01.09.21 – 30.08.2024
High-throughput synthesis of conjugated polymers for the development of semi-transparent organic photovoltaics for greenhouse and window applications

Epishine
01.06.2022-31.05.2023

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

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-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)

China Scholarship Council (China)

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

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

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

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

16. Teaching

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*

Summer Term 2022

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, M. Batentschuk, A. Osvet, W. Heiss*

Halbleitercharakterisierung, *W. Heiss*

Kolloidale Nanokristalle [KNKr], *W. Heiss*

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 Wafer Characterization, *P. Wellmann*

Crystal Growth - Lab Work 1 InSb Czochralski [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 Manufacturing and Characterization of Phosphors and Storage Phosphors [LW-Phosphors], *A. Osvet, M. Batentschuk*

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

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, Th.Heumüller, H.-J. Egelhaaf, J. Hauch*
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, A. Osvet, Th.Heumüller, M. Batentschuk, K. Forberich*

Seminar über Bachelor- und Masterarbeiten _- Crystal Growth [BMD-CG-Sem], *P. Wellmann*

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 2022/23

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, A. Osvet*

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

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

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

Crystal Growth 1 - Fundamentals Wide Bandgap Semiconductors, *P. Wellmann*

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

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

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

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

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

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 Wafer Characterization, *P. Wellmann*

Crystal Growth - Lab Work 1 InSb Czochralski [WCrGr-Pra], *P. Wellmann*

Excercises Photovoltaic systems – Fundamentals (CEP) (Ex-PVS-F) [Ex-AST-PVS-Design(A)], *Ch. J. Brabec, K. Forberich, A. Osvet.*

Exercices Phosphors for Light Conversion in Photovoltaic Devices and LEDs (CEP) (Ex-PVS-LC), *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 Solution Processed Electronics [LW-SP-El], *A. Osvet, Th. Heumüller*

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

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

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

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

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 Solution Processed Semiconductors [SPS_AG-Sem], *W. Heiss*

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

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*

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

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

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

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

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*

17. Addresses and Maps

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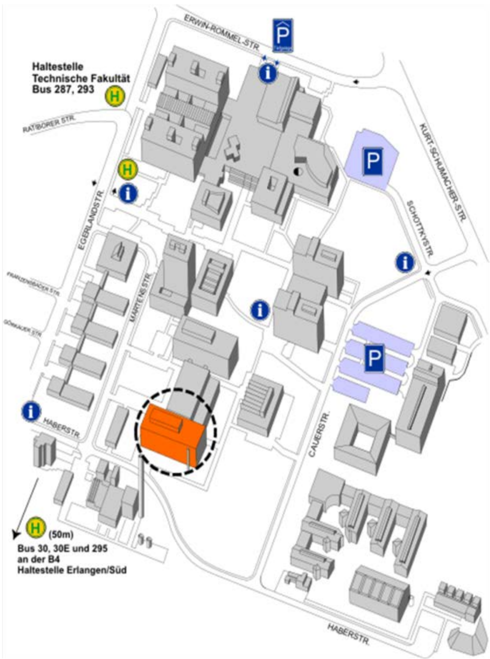

By car:
Highway A3 exit **Tennenlohe**; direction to Erlangen (B4). Follow the signs "**Universität Südgelände".** After junction **"Technische Fakultät"** please follow the map.

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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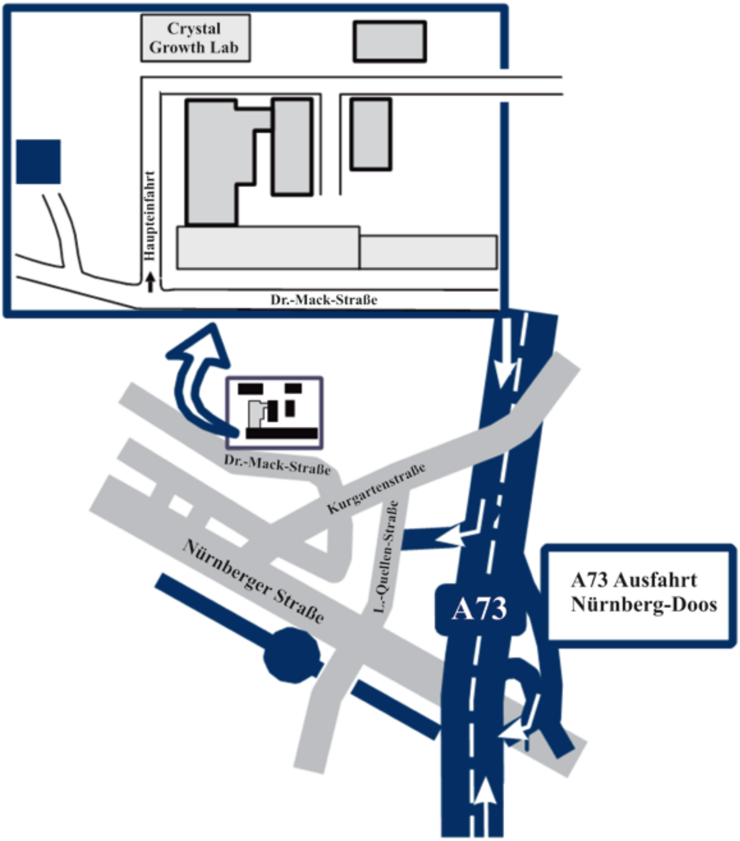

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