Dissociation of singlet excitons in PPV derivatives with varying dielectric constant

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In bulk heterojunction solar cells, the low relative permittivity of conjugated polymers such as poly-(p-phenylene vinylene) (PPV) is considered to be a limiting factor of the charge separation process. The lower the dielectric constant, the stronger the bond of the primary photoexcitations, i.e., singlet excitons. Here, we investigate the influence of the relative permittivity on the exciton binding energy. For this purpose, three PPV derivatives exhibiting similar charge carrier mobilities but different relative permittivities of 3.0, 4.0 and 5.5, respectively, are characterized by means of external quantum efficiency and field dependent photoluminescence measurements. We discuss our
experimental results in terms of the two-step dissociation process from exciton via polaron pair to polarons as well as the impact on solar cell performance.

**HL 62.8** Thu 18:00 Poster D2

**Influence And Optimization Of The Exciton Blocking Layer In Diindenoperylene Based Photovoltaic Cells** — E. Runge, A.K. Topczak, M. Mester, T. Rolleri, and J. Pfalau

The power conversion efficiency of small molecule Organic Photovoltaic Cells (OPVCs) depends on the exciton diffusion length as well as on the respective energy level positions at the donor acceptor and the metal-organic interface. We discuss two major aspects determining the OPVC performance: the exciton blocking and the exciton diffusion. As bilayer systems, OPVCs based on Diindenoperylene (DIP) as donor and C$_{60}$ as acceptor material were employed. We analyse the influence of different exciton blocking layers (EBL) like Batho-Phenanthonilin (BPPhen) or 1,4,5,8-Naphthalene-Tetracarboxylic Acid Dihydrazide (NTCDA). Beside the position of the electronic levels the nucleation behavior of the metal contact on the EBL is a critical factor. The second part addresses the comparatively large exciton diffusion lengths of DIP of about 1000 nm [1]. We performed complementary studies on OPVCs photocurrent as well as on photoluminescence (PL) quenching on layered stacks of similar composition. A strong correlation between the exciton transport characteristics and the crystalline morphology of the DIP layer is demonstrated. Financial support by DFG (project PF385/4) is gratefully acknowledged.


**HL 62.9** Thu 18:00 Poster D2

** Femtosecond Transient Absorption Spectroscopy of Organic Semiconductors** — Börn Gieseking, Daniel Kreier, Moritz Liedtke, Carsten Deibel, and Vladimir Dyakonov

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Organic solar cells based on conjugated polymers exhibit great potential for photovoltaic applications due to their low fabrication costs. Bulk heterojunction devices comprised of regioregular poly(3-hexylthiophene) and the [6,6]-phenyl-C$_{61}$ butyric acid methyl ester fullerene derivative have approached efficiencies of more than 5%. A further optimization requires a deeper insight into the elementary processes following the photoexcitation of these blends. For such studies a very high time resolution is crucial.

We present investigations applying a transient absorption spectroscopy setup based on two optical parametric amplifiers which are tunable from the visible to the infrared spectral range and provide a sub picosecond time resolution. By probing the different transient species we are able to get a better understanding of photogeneration of free charge carriers and their loss mechanisms in order to improve the performance of organic solar cells.

**HL 62.10** Thu 18:00 Poster D2

**Recombination kinetics of charge carriers and trap states in P3HT:PCBM blends studied by transient Electron Spin Resonance** — Magdalena Zawadzki, Andreas Sperlich, Hannes Kraus, Carsten Deibel, and Vladimir Dyakonov

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The combination of poly(3-hexylthiophene) (P3HT) and [6,6]-phenyl-C$_{61}$-butyric acid methyl ester (PCBM) has shown promising performance in organic solar cells. In order to understand the fate of photoexcited charge carriers in P3HT:PCBM blends, cw- and transient electron spin resonance (ESR) were used to investigate the recombination kinetics of the light induced charges. Using cw-ESR the negative and positive polarons and trap states related to impurities and oxygen contamination can be detected as separate signals, while transient ESR allows access to the life and recombination times of the different species, which are in a time scale from $\mu$s to minutes. We recorded the kinetics of the photoinduced decay of the photoluminescence after excitation by a pulsed LED. With the transient ESR technique, in addition to the cw-ESR, more detailed information about the P3HT:PCBM blends could be gained.

**HL 62.11** Thu 18:00 Poster D2

**Decay of excited species in P3HT:PCBM blends studied by transient absorption** — Matthias Guse, Julien Gorenplot, Carsten Deibel, and Vladimir Dyakonov

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One important parameter for improving the efficiency of organic solar cells is to understand the involved processes of charge generation and recombination, as well as their time dependence. Transient absorption spectroscopy enables us to observe the dynamics of photoexcited species. The investigations are carried out on blends of P3HT:PCBM on a timescale from nanoseconds to milliseconds. Pump intensity and temperature dependencies are studied, as well as the influence of different acceptor materials. The experimental results are compared to the charge carrier continuity equation, accounting for monomolecular and bimolecular recombination.

**HL 62.12** Thu 18:00 Poster D2

**Charge Transfer States in Polymer:Fullerene Solar Cells** — Michael Binder, Daniel Rauch, Carsten Deibel, and Vladimir Dyakonov

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In the field of organic photovoltaic power conversion efficiencies as high as 6% have been achieved. One of the key factors is a high exciton dissociation yield. It is crucial to understand the processes involved in charge carrier separation such as the relaxation of the exciton to the so called charge transfer state (CTS). A possibility to investigate those states is to measure the external quantum efficiency (EQE) of solar cells in the near-infrared region as shown by Vandewal et al [1]. With additional EQE measurement of diodes consisting only of the pure acceptor or donor we confirm that the CTS are solely found in donor/acceptor blend systems. The energies we determined from the charge transfer-tails can be directly linked to the open circuit voltage of the solar cell. We investigated the CTS for polythiophene-fullerene blends with varying electron acceptor strength. Furthermore we discuss their energy and magnitude in view of solar cell preparation conditions and the impact on the device performance.


**HL 62.13** Thu 18:00 Poster D2

**Nanotomography of organic heterojunction solar cells** — Mario Zerson, Andreas Sperlich, Hannes Kraus, Carsten Deibel, Vladimir Dyakonov, and Robert Mageble

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The morphology of organic heterojunction solar cells based on blends of P3HT:PCBM is an important factor determining the power conversion efficiency. For a good charge carrier generation the interface between the two components should be as large as possible. Furthermore, bicontinuous networks of both components are required for an efficient charge carrier extraction. We investigate the three-dimensional structure of P3HT and blends of P3HT and PCBM with Nanotomography based on scanning force microscopy (SFM). The specimen is ablated layer by layer using plasma etching and imaged with tapping mode SFM after each etching step. From the resulting series of images the three-dimensional structure is reconstructed. We will present first volume images of P3HT:PCBM blends and discuss the structure of the interface between donor and acceptor components in view of the charge generation efficiency. Furthermore we investigate the morphology of P3HT and P3HT:PCBM blends using SFM with super-sharp tips and the electro-optical properties at the same samples. We aim at comparing the microstructure of the polymer with the photoluminescence-detected magnetic resonance (PLDMR) which provides information on the recombination kinetics of photoinduced charges.

**HL 62.14** Thu 18:00 Poster D2

**The effect of a cathode interlayer on the performance of polymer-fullerene bulk heterojunction solar cells** — Antonietta De Sio, Elizabeth von Hauff, and Jürgen Parisi

Energy and Semiconductor Research Laboratory, Institute of Physics, Carl von Ossietzky Universität Oldenburg, D-26111 Oldenburg, Germany

We report on the impact of different cathode configurations on the per-
forms of polymer-fullerene photovoltaic devices. The operation of the standard bulk heterojunction solar cell structure, in which the active layer consists of a blend of poly-3-hexylthiophene (P3HT) and [6,6]-phenyl-C61-butyric acid methyl ester (PCBM) 1:1 in weight ratio and the metal cathode is a 150nm thick Al layer, was first recorded as the reference. The electrical behavior of the devices upon inserting an interlayer between the organic active layer and the metal cathode was investigated. We also explored the effect of different kinds of interlayers on device performance, i.e. conductive materials like Ca and Mg, as well as insulating materials such as LiF. The effect of the interlayer is reflected in the solar cell parameters, in particular on the open-circuit voltage.

Charge Transport Investigations of P3HT:PCBM Bulk Heterojunction Solar Cells using the CELIV Method — Ralph Huber, Antonietta De Sio, Elizabeth von Hauff, and Jürgen Parisi — Energy and Semiconductor Research Laboratory, Institute of Physics, University of Oldenburg, 26129 Oldenburg, Germany

Impedance spectroscopy is a widely used and powerful tool for investigating electrical characteristics on the frequency scale of batteries, fuel cells and solar cells. For new materials and novel devices, impedance spectroscopy can be used to gain information about material parameters and to characterize specific regions of the device. In this study, we investigate polaronic behavior in fullerene bulk heterojunction solar cells using the CELIV method. Here we present results from impedance spectroscopy measurements on the single carrier devices.

Recombination in P3HT based solar cells with different acceptor materials — Sebastian Hafner1, Andreas Baumann1, Carsten Deibel1, and Vladimir Dyakonov1,2 — 1Experimental Physics VI, Julius-Maximilians-University of Würzburg, D-97074 Würzburg, Germany — 2Functional Materials for Energy Technology, Bavarian Centre for Applied Energy Research (ZAE Bayern), D-97074 Würzburg

In order to improve the performance of organic solar cells, it is indispensable to understand the recombination mechanisms in those devices. In previous investigations, a reduced Langevin polaron recombination could be observed [1]. We apply the experimental technique of Photo-CELIV (Charge Carrier Extraction by Linearly Increasing Voltage) to study the recombination dynamics in organic bulk heterojunction solar cells. With this technique, the charge carrier concentration and the mobility of the carriers can be determined simultaneously. The recombination processes in the material system of P3HT with different fullerene acceptors [PC61]BM, bis-[PC61]BM, PC71BM was investigated in dependence on the temperature and laser intensity. We relate our experimental findings concerning recombination to the performance of polymer-fullerene solar cells.


Limits for the efficiency improvement of hybrid dye- microcrystalline silicon solar cells — Svend Burdorf1, Max Messner1, Rudolf Brüggemann1, Andreas Decker2, Thomas Mayer2, Wolfram Jägermann2, and Gottfried H. Bauer1 — 1Institut für Physik, Carl von Ossietzky Universität, 26111 Oldenburg — 2Fachbereich Materialwissenschaften, Technische Universität Darmstadt, 64287 Darmstadt

Recently hybrid solar cells consisting of dye sensitizers embedded in a microcrystalline silicon thin film matrix have been proposed and even recently processed [1]. The dye sensitizers are introduced to the matrix due to their high absorption coefficients and therefore enhance the absorption of the dye-sensitized cell. A microcrystalline silicon matrix is chosen because it is far more TOO forgiving" to distortions introduced by the dye molecules and transport properties of charge carriers are still acceptable. In this contribution we present calculations for the efficiency improvement of hybrid microcrystalline silicon solar cells compared to pure microcrystalline solar cells. The calculations were performed for varying thickness of the microcrystalline silicon layer, dye concentrations and wavelength of maximum absorption of the dye.

Transmission electron microscopy analyses of binary and ternary iron silicides in the system Al:Fe-Si — Patrick Schwager, Doaa Abdelbary, and Michael Seibt — Georg-August-Universität Göttingen, IV. Physikalisches Institut, Friedrich-Hund-Platz 1, 37077 Göttingen

In order to use low-cost polycrystalline silicon for photovoltaic applications it is essential to eliminate metal impurities. One technique to remove device-degrading impurities is aluminum gettering which exploits segregation of metal impurities into the forming Al:Si liquid for annealing above the eutectic temperature of 577°C. The segregation coefficient can be estimated by consulting the binary Al:M and Si:M phase diagrams where M is the metal impurity, here Fe. Experimental data yield instead values which are lower by two orders of magnitude. It has been proposed that this discrepancy stems from a higher solubility of Fe in Si in equilibrium with the ternary Al:Fe-Si melts compared to iron in silicon in equilibrium with the binary Fe-Si phases. To test this concept, we performed transmission electron microscopy techniques to analyze the structure and chemistry of ternary Al:Fe-Si surface layers after high temperature formation as well as extended defects formed in the bulk of the wafers.

HL 62.22 Thu 18:00 Poster D2
Charge transport in thin layers of nanocrystalline mesoporous Titania — Steve Albrecht, Sylvia Paul, and Dieter Neher — Universität Potsdam, D-14476 Potsdam, Germany

Nanocrystalline mesoporous Titania (nc-TiO2) has been shown to function as a very good electron acceptor in combination with common electron-donating polymers like poly(phenylene vinylene) or poly(3-hexylthiophene). However, charge transport in nc-TiO2 layers is not well understood, though it might severely affect the energy conversion efficiency of these hybrid cells. Here, we present measurements of the electron mobility using the technique of charge extraction by linearly increasing voltage (CELIV). Layers of ca. 100 nm in thickness were prepared via dip-coating from a dispersion of 5 nm sized Titania particles. These layers were then annealed at different temperatures to remove the organic compounds. Unexpectedly, a pre-bias needed to be applied to CELIV curves in order to obtain a measurable extraction peak. Apparently, these layers possess a high density of traps, which requires a certain number of electrons to be accumulated within the layer prior to the injection of mobile carriers. This interpretation was nicely confirmed by results from dark-injection measurements. We observed a significant increase of free carrier mobility with annealing temperature, reaching ca. 10−7 cm2/Vs for a layer annealed at 600°C, while the trap density decreased with temperature. In accordance to these results, the performance of hybrid solar cells improved largely when the nanocrystalline Titania layer was annealed at higher temperatures prior to the deposition of the polymers.

HL 62.23 Thu 18:00 Poster D2
Influence of pyridine treatment on the ligand shell of OA-capped CdSe nanoparticles and the impact on polymer/CdSe hybrid solar cells — Irina Lokteva, Nikolay Radychev, Helger Borchert, Jürgen Parisi, and Joanna Kolyv-Olesiak — University of Oldenburg, Oldenburg, Germany

This study describes the surface modification of the original oleic acid (OA) capped CdSe colloidal quantum dots (QDs) with pyridine molecules and application of the pyridine coated CdSe QDs for the preparation of polymer/CdSe hybrid solar cells.

The composition of the ligand shell was investigated by means of nuclear magnetic resonance (NMR) spectroscopy and thermal gravimetric analysis (TGA). It was shown that after one-fold pyridine treatment some amount of OA was still present in the sample, which motivated us to fulfill repeated steps of the ligand exchange. The absorption spectra after repeated pyridine treatment revealed that no aggregation or oxidation of the nanoparticles in solution occurred. TEM images were used as well to characterize the successive steps of the ligand exchange.

The hybrid CdSe:pyridine solar cells were fabricated using the pyridine capped CdSe QDs and ELV characteristics of these cells were collected to characterize the sequential steps of the pyridine treatment. Although repeated ligand exchange was found to have a beneficial effect in the sense that they led to more complete ligand exchange which in turn enabled more efficient charge transfer, the main characteristics of the solar cells were found to deteriorate. Correlations of this behavior with the morphology of the hybrid blends were analyzed.

HL 62.24 Thu 18:00 Poster D2
Photovoltaic Devices with Varying Ga-Content — Julia Riediger, Jan Kellen1, Jörg Ohland1, Martin Knipper3, Ingo Riedel1, Jürgen Parisi1, and Roland Mainz2 — Universität Oldenburg, Oldenburg, Germany

We investigated Cu(In,Ga)S2 (CIGS) solar cells on flexible substrates open up new applications for photovoltaics. Technologies like integrating photovoltaics, lightweight construction photovoltaics or integrated modules in clothes or pockets for charging iPods, mobile phones or laptops. Depending on their application these solar cells operate at different irradiances and types of illumination. Therefore real working conditions have to be considered and model calculations for different irradiances. Additionally, the effects of various production parameters in the manufacturing of solar cells from the Solaron AG were investigated and analyzed. We show correlation between Cu/III ratio of CIGS, i-ZrO layer thickness and metalic grid design with low light intensity performance.

Using these results optimized solar cells and modules can be manufactured for the mentioned applications and illumination conditions.

HL 62.25 Thu 18:00 Poster D2
Optimization of Cu(In,Ga)Se2 solar cells under different irradiance — Sebastian Jander1,2, Stefan Puttnies1,2, Andreas Rahm1, and Marius Grundmann2 — Solarion AG, Ostende 5, 04288 Leipzig, Germany — 1Institut für Experimentelle Physik II, Universität Leipzig, Linnéstraße 5, 04103 Leipzig, Germany

Cu(In,Ga)Se2 (CIGS) solar cells on flexible substrates open up new applications for photovoltaics. Technologies like integrating photovoltaics, lightweight construction photovoltaics or integrated modules in clothes or pockets for charging iPods, mobile phones or laptops.

Depending on their application these solar cells operate at different irradiances and types of illumination. Therefore real working conditions have to be considered and model calculations for different irradiances. Additionally, the effects of various production parameters in the manufacturing of solar cells from the Solaron AG were investigated and analyzed. A show correlation between Cu/III ratio of CIGS, i-ZrO layer thickness and metalic grid design with low light intensity performance.

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HL 62.26 Thu 18:00 Poster D2
Transmission electron microscopy analyses of binary and ternary iron silicides in the system Al:Fe-Si — Patrick Schwager, Doaa Abdelbary, and Michael Seibt — Georg-August-Universität Göttingen, IV. Physikalisches Institut, Friedrich-Hund-Platz 1, 37077 Göttingen

In order to use low-cost polycrystalline silicon for photovoltaic applications it is essential to eliminate metal impurities. One technique to remove device-degrading impurities is aluminum gettering which exploits segregation of metal impurities into the forming Al:Si liquid for annealing above the eutectic temperature of 577°C. The segregation coefficient can be estimated by consulting the binary Al:M and Si:M phase diagrams where M is the metal impurity, here Fe. Experimental data yield instead values which are lower by two orders of magnitude. It has been proposed that this discrepancy stems from a higher solubility of Fe in Si in equilibrium with the ternary Al:Fe-Si melts compared to iron in silicon in equilibrium with the binary Fe-Si phases. To test this concept, we performed transmission electron microscopy techniques to analyze the structure and chemistry of ternary Al:Fe-Si surface layers after high temperature formation as well as extended defects formed in the bulk of the wafers.
Surface roughness, optical and spectroscopic properties of thin film systems based on Cu(In,Ga)Se
surface roughness, optical and spectral properties of TEM-investigations. Single precipitates were extracted by focused-ion-beam technique for — conditions we established quite small concentrations of precipitates investigate the recombination properties of these defects by LBIC—defects after indiffusion of nickel and iron into float-zone silicon. We existing nucleation sites. Recent studies deal with the simultaneous or copper, iron precipitation generally requires the presence of pre-existing transition metal impurities such as iron, nickel and copper. The electrical properties of silicon are strongly influenced by fast diffusion processes as well as for that of lateral inhomogeneities.

HL 62.28 Thu 18:00 Poster D2
Maximum voltage determined by appropriate superposition of photothermal induced current from polycrystalline Cu(In,Ga)Se
layer — Floran Heidemann1, Rudolf Bruegmann1, Saoussen Medres2, Alexander Meden3, and Gottfried H. Bauer1 — 1Institute of Physics, CVo University Oldenburg, Germany — 2SE2, Helmholz-Zentrum Berlin, Germany — 3SULFURCELL Solarotechnik GmbH, Berlin, Germany
Thin film solar cells based on the chalcopyrite Cu(In,Ga)Se
of Cu(In,Ga)Se
2 offer an alternative to the predominant Cu(In,Ga)Se
2 with the benefit of higher band-gap and thus of nominal higher open circuit voltage. We have performed calibrated photoluminescence (PL) studies on absorbers to characterize their optoelectronic quality. To record spectrally resolved PL with sufficient photon fluxes we collect PL signals from a homogeneously illuminated area of 1 mm². Due to absorber polycrystallinity the collected PL-signal is composed of contributions of individual sites in the µm-scale varying in intensity and spectral shape. Since the splitting of quasi-Fermi levels (E_F — E_P) according to Planck's generalized law is derived from the logarithm of the spectral PL yield, measuring without sufficient local resolution leads to an overestimation of E_F — E_P. With a second confocal setup we analyze spectrally resolved PL with a lateral resolution of less than 1 µm. For detection limitations we need excitation fluxes in the order of 10¹⁸ AM1.5 to extrapolate from distribution functions of PL signals recorded at 300 K and high excitation towards AM1.5. We correct E_F — E_P from the calibrated setup, which corresponds to the maximum achievable Voc.

HL 62.29 Thu 18:00 Poster D2
Investigations of defects after indiffusion of iron and nickel into float-zone silicon — Philipp Sarig, Nils Hildebrand, Marie Aylin Falkenberg, and Michael Sticht — IV-Physikalisches Institut der Georg-August-Universität, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany
The electrical properties of silicon are strongly influenced by fast diffusion processes as well as for that of lateral inhomogeneities. In this work we focus on the distribution of the electrically active defects after indiffusion of nickel and iron into float zone silicon. We investigate the recombination properties of these defects by LBIC- and EBIC-measurements as well as their concentration and majority charge carrier kinetics by DLTS experiments. By suitable annealing conditions we established defect sites and concentrations of precipitations (< 10¹⁷ cm⁻³) and metal doped zones below the sample surfaces. Single precipitates were extracted by Focused-Ion-Beam technique for TEM-investigations.

HL 62.30 Thu 18:00 Poster D2
Defect characterisation of thin a-Si:H and μc-Si:H-films with FTPS (“Fourier Transform Photocurrent Spectroscopy”) — Dominik Schaep1, Armin Brechling1, Ulrich Heizmann2, Thomas Westervalbesloh2, and Helmut Stiebig2 — 1Molecular and Surface Physics, Bielefeld University, Germany — 2Malibu GmbH & Co. KG, Bielefeld, Germany
An important characteristic of silicon semiconductors is the defect concentration. Acting as recombination centers, defects lead to a reduced carrier lifetime, which strongly influences the performance of a solar cell. One way to get information about the defect concentration is the determination of the optical absorption coefficient α(E) in the sub-band range. Obtaining α(E) of thin a-Si:H- and μc-Si:H-layers is a challenge since α(E) varies over several orders of magnitude. A very sensitive method to determine the absorption coefficient is the Fourier Transform Photocurrent Spectroscopy. Here, the a-Si:H—μc-Si:H sample acts as an external detector in a FTIR setup, which enables very fast measurements. By calibrating the FTPS-signal with reflectance and transmittance data, absolute values for α(E) are obtained. Depending on the characteristics of α(E), a defect concentration can be calculated.

We will present the measurement setup and will discuss the sub-band gap distribution of different Si based (a-Si:H, μc-Si:H and c-Si) samples.

HL 62.32 Thu 18:00 Poster D2
Estimation of excess carrier depth profile from spectral photoluminescence yield in c-Si absorbers — Sebastian Knabe and Gottfried H. Bauer — Institute of Physics, University Oldenburg, Germany
The photoluminescence (PL) emitted from excited semiconductors provides access to parameters like the splitting of quasi-Fermi-levels, optical absorption, etc and is based on the recombination of excess carriers. Focusing on the crystalline fraction and especially its lateral homogeneity over the 1, 4 m² area we analyzed the intrinsic layer by Raman spectroscopy on different positions. Two excitation wavelength (473 nm and 633 nm) are used in order to get depth dependent information of the crystallinity. TEM observations of cross-section of chosen samples confirmed the spectroscopy given results. Based on the lateral information achieved the process was optimized and a correlation between crystalline volume fraction and local cell efficiency will be discussed.

HL 62.33 Thu 18:00 Poster D2
Verbesserung der Materialqualität von Galliumindiumdi-
triselenid (GaInNAs) durch Ausheizen zur Optimierung von hocheffizienten III-V-Mehrfachsolarzellen — Rönsch, Elke Welser, Tobias Roessner, Frank Dimroth and Alan W. Bett — Fraunhofer Institut für Solare Energiesysteme (ISE), Freiburg
Hocheffiziente Mehrfachsolarzellen aus III-V-Verbindungshalbleitern werden bereits für die Weltraumanswendung und für die Verwen-
dung in terrestrischen Konzentrationsystemen industriell gefertigt. Der theoretische Wirkungsgrad der etablierten, gitterangepassten Gao.50Ino.50/Fao.99Ino.01 As-Ge-Dreifachsolarzelle wird durch Erweiterung mit einer Gao.92Ino.08Aso.97Te-Teilzelle unter extraterrestrischen AM0 Standardbedingungen und einfacher Sonnen-
Die lichtkonzentration von 40,6 % auf 52,3 % deutlich gesteigert. Die-
se vielversprechende Viervachsolarzelle wird derzeit durch die geringe Materialqualität des GaInNAs stark limitiert. Zur Verbesserung der Materialqualität wurde das thermische Ausheilen wachstumsbedingter Defekte mittels Photolumineszenzmessungen (PL), elektronenstrahlinduzierten Strommessungen (EBIC) und kapazitiver Transientenspektroskopie (DLTS) untersucht. Mit EBIC konnten im GaInNAs ausgeprägte, punktförmige Defektstrukturen im Mikrometerbereich beobachtet werden. Ein Hochtemperaturschritt löst die Defektstrukturen auf. Gleichzeitig nimmt der EBIC-Strom zu, die PL-Intensität steigt und der mit DLTS bestimmte Einfangquerschnitt der Defekte nimmt um mehrere Größenordnungen ab.

Es wurden verschiedene Prozesskanten zur Minimierung dieser Verluste untersucht. Neben einer optimierten herkömmlichen Technologie, mit nasschemischem Ätzen und photostrukturiertem Polyimid als Dielektrikum zur Isolation der pn-Übergänge, wurde ein alternativer Trockenätzprozess mittels RIE-ICP sowie ein Prozess zur Strukturierung von Siliziumnitrid als Dielektrikum entwickelt. Damit wurden die Grabenbreiten von über 100 μm auf 57 μm reduziert. Dies entspricht nahezu einer Halbierung der Flächenverluste von 11% auf unter 6%. Der höchste erzielte Wirkungsgrad beträgt für eine Tandemstruktur η=24,7% bei einer Einstrahlung von 1037 MW/m². Dabei wurden folgende Kenngrößen gemessen: Voc=53,7 V, Isc=2,60 A, FF=80,1%.

Monolithisch integriert serienverschalteter Module (MIMs) sind großflächige Solarzellebauelemente für den Einsatz unter hohen Lichtintensitäten in konzentrierenden Photovoltaiksystemen. MIMs bestehen aus mehreren III-V basierten Solarzellsegmenten, die während der Prozessierung durch Verschaltungsgruben in Serie verschaltet werden. Die Breite dieser Gräben, sowie der damit verbundene Verlust an aktiver Solarzellefläche sind durch die verwendete Herstellungstechnologie limitiert.

Entwicklung alternativer Prozesstechnologien zur Herstellung monolithisch integrierter serienverschalteter Konzentratorsolarzellen (MIMs) — •Henning Helmers¹, Eduard Oliva¹, Wolfgang Bronner², Frank Dimoth¹ und Andreas W. Bett¹ — ¹Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg — ²Fraunhofer-Institut für Angewandte Festkörperphysik IAF, Freiburg