Measurement of interstitial iron content in multicrystalline silicon by microwave detected photoconductance decay — • KEVIN LAURIE, ABDULLAZEI LAADSE1, ALEXANDER LAERECKE1, HARTMUT UHRENSK1, and HEINRICH MEITZNER1 — 1CIS Institut für Mikrosensorik GmbH, SolarZentrum Erfurt, Konrad-Zuse-Str. 14, 99099 Erfurt, Germany — 2Institut für Physik, TU Ilmenau, Weimarer Str. 32, 98693 Ilmenau

A new approach to evaluate the photoconductance decay measured by microwave reflection in thin multicrystalline silicon wafers is presented. The minority carrier lifetime as a function of the excess carrier density is extracted from the photoconductance decay signal. We use this new approach to detect the interstitial iron content with a high spatial resolution. This is done by measurements in the two different states of the meta-stable iron-boron pairs. The limits of this method are discussed and it is shown to be applicable to thin and surface passivated multicrystalline silicon wafers with low minority carrier lifetime. A quantitative comparison to results obtained by means of a steady-state photoconductance measurements (QSSPC) is presented.

Monolithic III-V tandem solar cell lattice matched to InP(100) with a GaInAs/GaAsSb tunnel junction — • NADINE SZABÓ, ULF SEDELL, EROL SAGOL, KLAUS SCHWARZBURG, and THOMAS HANNAFEL — Hahn-Meitner-Institut, Glienicker Str. 100, Berlin

At present, III-V triple junction (3J) solar cells are achieving the highest conversion efficiencies ($\eta$ = 40.7%) worldwide. These cells are grown slightly lattice mismatched to Ge(100) and are containing three absorber layers: Ge, GaInAs and GaNP. Even higher efficiencies are possible if more than 3 subcells were used. To obtain this, one can replace the Ge bottom cell by a GaNP/GaAs tandem cell grown lattice matched to InP. The combination of these low band gap subcells with an established GaAs/GaNP tandem solar cell can be realised by mechanical stacking. The GaAs/GaNP//GaAsP/GaInAs 3J tandem solar cell has a theoretical conversion efficiency limit of 61% (500 suns), which is clearly higher than the limit of the current world record 3J solar cell (40%). The serial connection of the two subcells of our tandem cell was realised by a tunnel junction. This tunnel junction was composed of a n-GaInAs and a p-GaAsSb layer. Depending on the preparation of the n-GaInAs layer, the p-GaAsSb layer was grown either on III-rich or on V-rich surfaces. Whereas the growth of the GaAsP layer on a III-rich surface led to a sharper interface. Sun simulation with structural data, energy dispersive X-ray analysis, X-ray diffraction, and scanning electron microscopy have been applied.

Photonic intermediate layer for silicon tandem solar cells — • ANDREAS BELAVNY1, PAUL-TIEMO MIGLIA1, HALF WERNERFLOY1, SEUNG-MO LEE2, MATO KNEZ2, REINHARD CARUS3, MARIAN LISCA3, CARSTEN ROCKSTUHL3, and Falk Lederer1 — 1Martin-Luther Universität Halle-Wittenberg, Inst. für Physik, Mikro-MD, D-06120 Halle — 2Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle, — 3Forschungszentrum Jülich, Inst. für Photovoltaik (IFP)-5, D-52428 Jülich — 1Universität Jena, Dept. Physik, D-07743 Jena

The concept of incorporating a 3D photonic crystal as diffractive mirror into a solar cell has been investigated as a promising application. Our intermediate reflective filter enhances the pathway of spectrally selected light within an amorphous silicon top cell in its spectral region of low absorption. From our previous work, we expect a significant improvement of the tandem’s efficiency of about 1.2% (absolute). This increases efficiency for a typical silicon tandem cell from 11.2% to 12.4%, as a result of the optical current-matching of the two solar cells. Our wavelength-selective optical element is a 3D-structured optical thin-film - prepared by self-organized artificial opal templates and finalized with atomic layer deposition techniques. The resulting samples are highly periodic thin-film inverted opals made of zinc-oxide. We compare recent experimental data on the optical properties with our simulations and photonic bandstructure calculations.

Deposition and characterization of (Zn,Mg)O buffer layers on CIGSSe thin film solar cells — • BENJAMIN HUSSMANN1, FELIX ERFURTH1, THOMAS NIESEN2, JÖRG PALM2, ALEXANDER GRIMM3, ACHIM SCHOLTZ4, and EBERHARD UMBRACH4 — 1Universität Würzburg, Experimentelle Physik II — 2Avancis GmbH, München — 3Hahn-Meitner-Institut, Berlin — 4Forschungszentrum Karlsruhe (Zn,Mg)O buffer layers on Cu(In,Ga)(S,Se)$_2$ (CIGSSe) thin film solar cells are promising alternatives to CdS buffer layers by featuring comparable efficiencies, better environmental compatibility and the possibility to implement the deposition process into a vacuum processing line. The (Zn,Mg)O buffer layers are deposited by radio frequency sputtering onto separate multi-crystalline silicon wafers. Ceramic sputter targets to control the Mg-content and therefore the band gap of the buffer layer. In our experimental setup the sputter preparation chamber is connected with a UHV analysis system which allows in-situ characterization with X-ray photoelectron spectroscopy (XPS). The interface between the absorber and the buffer layer is believed to have a major influence on the cell efficiency and is thus of particular interest in this work. This interface has been investigated during layer deposition by sequentially interrupting the sputter process and performing XPS scans. We observed island growth of (Zn,Mg)O on CIGSSe and a strong oxidation of the absorber surface induced by the deposit. In order to complement the chemical and electronic information with structural data, energy dispersive X-ray analysis, X-ray diffraction, and scanning electron microscopy have been applied.

Influence of gap state defect passivation on transport properties in SiO$_2$/Si/SiO$_2$ quantum layers — • DANIEL SITZENFELD, MARTIN GRIMM1, and REINHARD CARIUS2 — 1Institut für Mikrostrukturphysik, D-06120 Halle, — 2Avancis GmbH, München

The maximum efficiency of standard silicon single bandgap photovoltaic devices is given by the Shockley-Queisser limit of 32.7%. A major loss resource is thermalization of hot photogenerated charge carriers. Novel methods utilizing quantum confinement effects have recently been proposed to circumvent this limit. Si/SiO$_2$ quantum well structures, utilizing stacked absorbers with different bandgaps, can better be adjusted to the solar spectrum and thus, avoid thermalization losses. However, the interface-to-volume ratio increases tremendously in such structures. Therefore, due to strong interface recombination and Coulomb scattering from charged interface states, the Si/SiO$_2$ interfaces are a major factor limiting carrier transport. In the present work, the impact of defect passivation by hydrogen treatment on interface gap state defect densities at structurally and chemically well-defined Si/SiO$_2$ interfaces has been analyzed using surface photovoltage (SPV) measurements and constant final state photoelectron spectroscopy. Moreover, transport properties in single SiO$_2$/Si/SiO$_2$ quantum well structures are analyzed and related to interface quality by means of highly sensitive photovoltage measurements.
Locally resolved characterization of CuInS2 thin film solar cells — Markus Wendt, Jo Klaer, Thomas Unold, and Hans Werner Schock — Hahn-Meitner-Institut Berlin Glienicker Str. 100 14109 Berlin

CuInS2 thin film solar cells were produced by sulfurization of metallic precursor layers using a rapid thermal anneal process. Depending on the processing conditions variations of the total photocurrent were found. At the same time, scanning electron microscopy revealed an inhomogeneous morphology for many of the solar cells processed. To investigate the influence of processing conditions on the photocurrent collection in more detail, laser beam induced current (LBIC) measurements were applied to selected solar cells. The excitation wavelength was 525 nm and the local resolution was 1-3 μm. The typical scanning range of the experiments was 1 sq.mm. LBIC-maps collected at low light-intensities of approximately 1 sun showed variations of 5% in the local photocurrent collection. However, LBIC maps at high intensities of approximately 1000 suns showed very large variations in the local photocurrent collection of nearly a factor of 2-3. We conclude that the local variation of current collection under high illumination is due to current crowding effects caused by inhomogeneities in the morphology of the solar cells.

Investigation of the Silicon-Oxide-Platinum interface for photoelectrochemical solar cells — Thomas Stempel Pereira1, Aggour Mohammed2, Katarzyna Skorupska1, Michael Lublow1, Andres Munoz1, and Hans-Joachim Lewerenz2 — 1Hahn-Meitner-Institut, Division of Solar Energy, Glienicker Str. 100, 14109 Berlin, Germany — 2Ibn Tofail University, Rabat, Morocco

Photoelectrochemical solar cells on the basis of Si can be fabricated with standard electrochemical methods. However, corrosion of the semiconductor surface leads to a degeneration of such cells. Attempts have been made to passivate the Si surface with an oxide while allowing charge transfer through metal deposits on the surface. Thus efficiencies of more than 10% can be achieved. We present experimental results of various preparation methods of anodic oxides on Si. The deposition of Pt nanoemitters on the electrode through pores in the oxide layer is investigated. The interface density of states was examined by capacitance measurements. Low interface density states can be achieved by anodic oxidation in phthalate solutions. Model experiments of electrochemically deposited Pt with synchrotron radiation photoelectron spectroscopy show that Si is oxidized during Pt-deposition, thus reducing the influence of metal induced gap states at the interface.