DS 6: Thin film photovoltaics: CIGSe + processing

Time: Monday 11:15–12:45 Location: H 2032

DS 6.1 Mon 11:15 H 2032

Properties of dislocations in Cu(In,Ga)Se2 film and their formation during growth — •Jens Dietrich[1], Daniel Abou-Ras[2], Thorsten Rissom[2], Thomas Unold[2], Tore Niermann[3], Michael Lehmann[3], Hans-Werner Schock[2], and Christian Boit[1] — [1]Technische Universität Berlin, Department of Semiconductor Devices, Einsteinufer 19, 10587 Berlin — [2]Helmholtz Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin — [3]Technische Universität Berlin, Institute of Optics and Atomic Physics, Hardenbergstrasse 36, 10623 Berlin

Transmission electron microscopy (TEM) studies were performed on Cu(In,Ga)Se2 (CIGSe) thin films for solar cells with a special focus on dislocations. A sample series of glass/Mo/CIGSe stacks with varying [Cu]/([Ga]+[In]) ratio were prepared by interrupting the growth processes at several stages. TEM imaging and elemental distribution maps by energy-dispersive X-ray spectroscopy gave structural and compositional information at certain film growth states. Furthermore, high resolution TEM imaging was used to confirm a structural model of dislocations in complete CIGSe solar cells and by means of in-line electron holography we examined changes in the mean inner potential. A decrease of the mean inner potential at the position of the dislocations was observed. This might be attributed to a change of the atomic density due to the dislocation, a local segregation or a charge at the dislocation core.

DS 6.2 Mon 11:30 H 2032

Novel Laser Structuring Method for Chalkopyrite Solar Cells — •Manuel Schüle[1], Christof Schultz[1], Heinrich Endert[2], Björn Rau[3], Rutger Schlatmann[3], Volker Quaschning[1], Bert Stegemann[1], and Frank Fink[1] — [1]University of Applied Sciences (HTW) Berlin, Wilhelminenhofstr. 75a, 12459 Berlin, Germany — [2]Newport Spectra-Physics GmbH, Ruhlsdorfer Strasse 95, 14532 Stahnsdorf, Germany — [3]PVcomB - Competence Centre Thin-Film- and Nanotechnology for Photovoltaics Berlin, Schwarzschildstr. 3, 12489 Berlin, Germany

In thin-film photovoltaics laser structuring is aimed to achieve appropriate monolithic serial interconnection. Generally, three structuring steps P1, P2, and P3 are necessary to separate the solar cells and to perform monolithic interconnection. However, manufacturing of chalcopyrite (CIGSe) thin film solar cells involves typically only one laser structuring step (P1), whereas two mechanical structuring steps (P2 and P3) are carried out.

In our approach, complete laser structuring of CIGSe solar cells is successfully demonstrated by application of short nanosecond laser pulses (<10 ns) with a single wavelength of 532 nm. The P1 and the P3 trenches are scribed by induced direct and induced indirect ablation respectively. For the P2 scribe, the thermal input of the ns laser pulses is used to transform the CIGSe absorber layer locally into a highly conductive compound that provides proper electrical interconnection between the front and back contact. These findings promise further simplification and flexibility to thin film solar cell production.

DS 6.3 Mon 11:45 H 2032

Investigation of CIGSe Solar Cell Performance Deviations in Nominally Equal Absorbers — •Robin Knecht[1], Jürgen Parisi[1], Ingo Riedel[1], Raymund Schäffler[2], and Bernhard Dimmler[2] — [1]Energy and Semiconductor Research Laboratory, University of Oldenburg, Germany — [2]Würth Solar GmbH & Co. KG, Schwäbisch-Hall, Germany

$Cu(In,Ga)Se_2$ (CIGSe) solar cells were fabricated independently by industrial scale co-evaporation in two separate production lines with the same nominal composition and thickness of the absorber film. Although the device properties were believed to be the same we observed substantial deviations of the respective values of the open circuit voltage ($\triangle V_{OC} = 40mV$) and of the fill factor ($\triangle FF = 4\%$), whereas the short circuit current was essentially the same. We performed fundamental device analysis, space charge and defect spectroscopy, transient photoluminescence as well as in-depth profiling of the chemical gradients of the absorber films. Using the results from the experiments we set up a simulation baseline which allowed us to conclude that the apparent deviations can be related to the presence of deep recombination centers with different concentration within the CIGSe absorber as well as to variations of the band gap grading.

DS 6.4 Mon 12:00 H 2032

Influence of the mechanical properties of sputtered Mo solar cell back contacts on laser scribing — Christof Schultz[1], Manuel Schüle[1], Heinrich Endert[2], •Jörn Bonse[4], Björn Rau[3], Rutger Schlatmann[3], Volker Quaschning[1], Bert Stegemann[1], and Frank Fink[1] — [1]University of Applied Science (HTW) Berlin, Wilhelminenhofstr. 75A, 12459 Berlin, Deutschland — [2]Newport Spectra-Physics GmbH, Ruhlsdorfer Strasse 95, 14532 Stahnsdorf, Deutschland — [3]PVcomB - Competence Centre Thin-Film and Nanotechnology for Photovoltaics Berlin, Schwarzschildstr. 3, 12489 Berlin, Deutschland — [4]BAM Bundesanstalt für Materialforschung und -prüfung Unter den Eichen 87 12205 Berlin, Deutschland

In thin-film photovoltaics complete laser structuring of the solar modules is aimed to perform appropriate monolithic serial interconnection. We have studied the laser ablation behavior of sputtered molybdenum back contacts for chalcopyrite solar cells. The properties of these Mo layer are sensitive to the sputter conditions. The process pressure influences the mechanical layer properties and, thus, contributes directly to the quality of the laser scribes. Precise, reliable and reproducible laser scribing requires the proper adaptation of the laser parameters to the material properties. In our study it was achieved by comprehensive analysis of the laser matter interaction and by detailed determination of the ablation thresholds as a function of the Mo layer thickness and ductility for different laser wavelengths and pulse durations, accompanied by thermal modeling.

DS 6.5 Mon 12:15 H 2032

Untersuchung der Selenisierung von Cu2ZnSnS4 mit energiedispersiver Röntgenbeugung — •Ole Zander, Roland Mainz, Alfons Weber, Justus Just, Thomas Unold und Hans-Werner Schock — Hahn-Meitner-Platz 1, 14109 Berlin

Die Selenisierung von sulfidischem Cu2ZnSnS4 (CZTS) durch schnelle thermische Prozessierung wurde mit Hilfe energiedispersiver Röntgenbeugung (EDXRD) in-situ untersucht. Dazu wurden verschiedene Präkursoren bestehend aus Binär- und Ternär- und Quarternärverbindungen des Cu-Zn-Sn-S Materialsystems durch Koverdampfung bei verschiedenen Substrattemperaturen hergestellt. Die Selenisierung der Präkursoren erfolgte durch schnelle Erhitzung unter Zugabe von elementarem Selen in einer Reaktionskammer am Bessy II Synchrotron. Durch die Beobachtung der Fluoreszenz- und Beugungssignale während der Selenisierung konnte die Bildung von CZTSe und Sekundärphasen, die Rekristallisation der Schichten, und der Verlust von Sn bei hohen Temperaturen beobachtet werden. Ein Modell welches die Kinetik der stattfindenden Teilprozesse und Substitutionsreaktionen beschreibt wird diskutiert.

DS 6.6 Mon 12:30 H 2032

Spectral variations in thin film PV module performance under real conditions — •Yvonne Boose[1], Martin Bucher[2], Christian Heller[2], Mark Lynass[2], and Peter Müller-Buschbaum[1] — [1]TU München, Physik Department, LS Funktionelle Materie, James-Franck-Str.1, 85748 Garching, Germany — [2]General Electric Global Research, Freisinger Landstraße 50, 85748 Garching, Germany

For planning and monitoring of large scale solar parks an exact as possible prediction of the energy yield is essential. In this work we investigate the solar spectrum for one location (48°15'N, 11°39'E). Spectral data of the incoming global irradiance from 300 to 1680 nm, the electrical parameters of a commercial CdTe and a CIGS solar module and weather data such as global, direct and diffuse irradiation, ambient temperature and humidity are recorded with a high temporal resolution of less than 10 seconds which allows also the investigation of short term meteorological effect such as cloud enhancement and fast moving cumulus clouds. Furthermore photographic weather records support the evaluation. Aerosol, ozone and water vapor data from the AERONET database are consulted to evaluate spectral variations. Experimental results are compared with simulations from the SMARTS2 and the SANDIA model.