HL 55: Photovoltaics: Silicon-based Systems II

Time: Wednesday 11:15–12:45 Location: ER 270

HL 55.1 Wed 11:15 ER 270

Photo-induced tunneling current microscopy on amorphous silicon films covered by metal islands — •Andreas Englisch, Uwe Schmitt, and Uwe Hartmann — Institute of Experimental Physics, Universität des Saarlandes, P.O. Box 15 11 50, D-66041 Saarbrücken

The efficiency of thin film solar cells consisting of amorphous silicon is strongly reduced in the wavelength regime beyond 800 nm. In order to overcome this disadvantage, silver nano-particles were placed at close vicinity to the intrinsic photoactive layer. The regime of the optical resonances overlaps with the regime of low intrinsic absorbance of the amorphous silicon. The subsequent increase of the efficiency cannot be explained by optical field enhancement effects only. To understand the mechanism of charge carrier generation in the vicinity of the silver islands STM und STS-measurements were performed across an illuminated scanning area. The samples were composed of 20 nm amorphous silicon films on a 1000 nm thick ITO layer deposited onto a glass substrate. A 4 nm thick silver layer below the percolation threshold was located either between silicon and ITO or on top of the silicon film. First measurements with the silver island film at the silicon-ITO- interface show local variations of the change of the tunneling current on top of the silicon layer if the intensity of the light (820 nm wavelength) is varied. The contrast is influenced by the topography but not consistently, which is a hint to the influence of the hidden metal island film. Intensity-dependent U-I-characteristics were analyzed in order to deconvalve the serial tunneling and photo resistances of the sample.

HL 55.2 Wed 11:30 ER 270

Plasmonic enhanced NIR response in thin film a-Si:H solar cells — •Florian Lükermann[1], Ulrich Heinzmann[1], and Helmut Stiebig[2,1] — [1]Molecular and Surface Physics, Bielefeld University, 33615 Bielefeld, Germany — [2]Malibu GmbH & Co. KG, 33609 Bielefeld, Germany

Metal nanoparticles (NPs) exhibit Localized Surface Plasmon (LSP) resonances upon interaction with electromagnetic radiation. These LSP resonances accompany strong field enhancements in the close surroundings of the NPs.

In previous work [1] it has been shown that incorporating silver NPs in hydrogenated amorphous silicon (a-Si:H) photosensitive devices in the n-layer/i-layer configuration can yield a photocurrent for photons with energies below the a-Si:H bandgap. This photocurrent is attributed to excitation of charge carriers originating from states inside the a-Si:H bandgap which are mediated by the LSP resonances.

A distinct design of solar cell structures or photosensitive devices is necessary in order to observe this sub bandgap absorption in external quantum efficiency measurements. The talk will deal with recent results on this topic.

[1] F. Lükermann, F. Hamelmann, U. Heinzmann, H. Stiebig, 2011. Silver nanoparticles for enhanced light absorption in thin film amorphous silicon solar cells. Science Direct, Energy Procedia (in press)

HL 55.3 Wed 11:45 ER 270

Paramagnetic defects at the interface of silicon heterojunction solar cells detected by Electrically Detected Magnetic Resonance — •Benjamin Muguluvila George[1], Jan Behrends[2], Tim Ferdinand Schulze[1], Matthias Fehr[1], Lars Korte[1], Manfred Schmidt[1], Alexander Schnegg[1], Klaus Lips[1], and Bernd Rech[1] — [1]Helmholtz Zentrum Berlin für Materialien und Energie — [2]Freie Universität Berlin

Amorphous silicon (a-Si:H)/crystalline silicon (c-Si) heterojunction solar cells reach the highest efficiency of mass produced silicon solar cells. Due to the high quality of the silicon wafer material and low thickness of a-Si:H used, the passivation quality of interface defects ultimately determines device efficiency. Additionally this heterojunction is an instructive model system for state-of-the-art microcrystalline silicon (mu-cSi:H) solar cells as they intrinsically possess a high number of a-Si:H/c-Si interfaces at grain boundaries. In this study the spectroscopic properties of paramagnetic defects at the a-Si:H/c-Si interface are investigated by low temperature electrically detected magnetic resonance (EDMR) due to its high sensitivity and the ability to study fully processed solar cells. Spin-dependent recombination between conduction band tail states in the a-Si:H bulk and a-Si:H/c-Si interface dangling bonds is detected. By taking a rotation pattern this signal has been assigned to the a-Si:H/c-Si interface. The g-tensor of this site on the [111] oriented silicon wafer resembles the values of the well-known Pb center at the SiO2/Si interface. By way of sample preparation it can be excluded that natural SiO2 is present at the interface.

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Photovoltaic potential of femtosecond laser hyperdoped silicon — •Augustinas Ruibys[1], Kay-Michael Günther[2], Stefan Kontermann[1], and Wolfgang Schade[1,2] — [1]Fraunhofer Heinrich Hertz Institute, EnergieCampus, Am Stollen 19B, 38640 Goslar — [2]Clausthal University of Technology, EFZN, EnergieCampus, Am Stollen 19B, 38640 Goslar

Hyperdoping silicon with a femtosecond laser in a sulfur rich environment extends its absorption capacity far into the infrared. It is believed that high concentrations of sulfur create sub-bands rather than recombination centers within silicon. We present first deep-level transient spectroscopy (DLTS) measurement results that display the existence of a sub-band gap energy structure, although energy level degeneration could not yet be concluded. We then calculate the detailed balance limit of conversion efficiency for the hyperdoped silicon with an arbitrary positioned sub-band. Strategies to exploit the photovoltaic potential of this new material are discussed.

HL 55.5 Wed 12:15 ER 270

Classification of different types of precipitates grown in block-cast multicrystalline solar silicon — •Susanne Richter[1], Martina Werner[1], Sina Swatek[1], Benjamin März[2], and Christian Hagendorf[1] — [1]Fraunhofer-Center für Silizium-Photovoltaik CSP, Walter-Hülse-Str. 1, 06120 Halle (Saale) — [2]Fraunhofer-Intstitut für Werkstoffmechanik IWM, Walter-Hülse-Str. 1, 06120 Halle (Saale)

Precipitates in multicrystalline silicon (mc-Si) for wafer-based solar cell production are of great importance for the efficiency and production yield in the photovoltaic industry. In particular, it has been shown that during the crystallization of mc-Si ingots the accumulation of C and N in the Si melt results in the development of precipitates like SiC and Si3N4 in various morphologies. We present here a study on the morphological structure and the elemental composition of different types of precipitates. In particular, intermixture types occasionally occurring during the growth of mc-Si ingots in VGF crystallizers were investigated. Results from different methods for microstructural, morphologic and chemical analyses including IR microscopy, ToF-SIMS, FIB target preparation for TEM combined with nanospot-EDS and SAED are shown. A more detailed classification with the help of the investigated material properties is proposed.

HL 55.6 Wed 12:30 ER 270

Determination of quasi-Fermi level separations and characteristic tail-state energies of microcrystalline silicon by photoluminescence — •Sven Burdorf, Rudolf Brüggemann, and Gottfried Heinrich Bauer — Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg, Germany

Hydrogenated microcrystalline silicon (μc-Si:H) is used as the bottom cell of amorphous silicon/microcrystalline silicon tandem cells. The density of band-tail states is one of the factors limiting the performance of the microcrystalline absorber layer; in particular tails limit the splitting of the quasi-Fermi levels and thus the open-circuit voltage. The band-tail profile can be measured by electronic methods like modulated photocurrent (MPC), thermally stimulated currents (TSC) etc; the straightforward interpretation of the results however, requires samples on insulating substrates with coplanar contacts, which are in contradiction to solar cell architectures. Thus, a contactless method, like photoluminescence, for the analysis of the absorber properties in diode structures is much more appropriate. In this contribution, we present a luminescence approach based on Kirchhoff's generalized law to evaluate photoluminescence (PL) spectra of μc-Si:H in terms of the separation of quasi-Fermi levels and the characteristic tail state energies by assuming an exponential band-tail distribution and PL originating from tail-tail transitions. We extract from the PL-spectra of HWCVD-prepared μc-Si:H layers characteristic tail-state energies of about 50 meV and an energetic splitting of quasi-Fermi level at 20 K of about 1 eV.