DS 2: Thin Film Chalcogenide Photovoltaics I (Focused Session – Organiser: Ronning)

Time: Monday 11:00–13:00 Location: GER 37

Topical Talk DS 2.1 Mon 11:00 GER 37

$Cu(In,Ga)Se_2$ solar cells: the importance of lateral variations of the absorber quality — •Susanne Siebentritt — University of Luxembourg, Laboratory for Photovoltaics, Belvaux, Luxembourg

Thin film solar cells are considered the second generation of photovoltaic technologies, because of their considerable cost reduction based on the small amounts of material and energy used in production. Among these technologies solar cells based on $Cu(In,Ga)Se_2$ show the highest efficiencies in the lab as well as in industry. Record efficiencies above 20 % have been reached with these polycrystalline solar cells.

It becomes more and more evident that lateral inhomogeneities, most prominently grain boundaries, limit the efficiency. Electrostatic band bending at grain boundaries appear a major obstacle for higher open circuit voltages. Fluctuations of the band gap and the quasi-Fermi level splitting have been determined by laterally resolved photoluminescence. Some of these variations can be related to lateral changes of the Cu supply during growth - with far reaching consequences for the design of preparation processes.

Topical Talk DS 2.2 Mon 11:30 GER 37

Efficient Photovoltaic Devices using Multinary Chalcogenide Semiconductors — •Hans-Werner Schock and Thomas Unold — Helmholtz Zentrum Berlin für Materialien und Energie, Hahn-Meitner Platz 1, 14109 Berlin, Germany

Multinary compounds like $Cu(In,Ga)S,Se_2$ are very promising materials for thin film solar cells currently reaching photoconversion efficiencies beyond 20 % for small device areas. The tolerance of chalcopyrite semiconductors regarding grain structure and defects allows to fabricate $Cu(In,Ga)Se_2$ thin films with a variety of deposition technologies and significant differences in the growth parameters and composition. In the long term, modifications of materials and devices are needed in order to overcome limitations by the use of rare elements e.g replacing indium by the combination of a group II and a group IV element to form the kesterite compound Cu_2ZnSnS_4. Advanced methods for film characterisation facilitate the analysis of such new materials, also in-situ during film growth. The combination of analytical methods based on x-ray methods, electron beams and optical and electrical spectroscopy give insights in the microstructure and related electronic properties of the absorber films. Due to the large degrees of freedom in multinary materials, analysis and control of structural and electronic inhomogeneities is essential to reach efficient photoconversion.

Topical Talk DS 2.3 Mon 12:00 GER 37

From Micro Meter to Mega Watt: Pentanary Chalcopyrite Thin film Solar Cells — Joerg Palm, Alejandro Avellan, •Thomas Dalibor, Stefan Jost, Helmut Vogt, Thomas Niesen, Paul Mogensen, and Franz Karg — AVANCIS GmbH & Co KG, Otto-Hahn Ring 6, 81739 München

CIS based thin film solar cells and modules are currently entering the phase of mass production with hundreds of megawatts capacity per year. This presentation illustrates how materials and device research in cooperation between industrial R&D and university groups significantly support the development of highly efficient solar cells. The pentanary chalcopyrite absorber film based on Cu, In, Ga, Se and S is preferably formed in a two stage process by chalcogenization of metal precursor films. The understanding of the reaction paths from metals via binaries to the pentanary phase has been deepened by X-ray diffraction studies. The chalcopyrite/II-VI hetero-junction is a complex interface between absorber surface region, buffer layers and the transparent conducting oxide. Several heterojunction partners are being investigated in terms of device efficiency, band alignment and interface structure. The physical processes involved in layer removal for monolithic interconnection completely change while going from mechanical patterning via nanosecond pulsed laser to ultrashort laser pulses. Device simulation helps identifying loss mechanisms in the solar cell structure. In the AVANCIS pilotline modules of size 30cm x30cm are processed with a record efficiency well above 15%. We finally present the realization of a mass production process at AVANCIS.

Topical Talk DS 2.4 Mon 12:30 GER 37

Electrical Characterization of $Cu(In,Ga)(Se,S)_2$ -Based Solar Cells at Low Temperatures — •Udo Reislöhner — Friedrich-Schiller-Universität Jena, Physikalisch-Astronomische Fakultät, Institut für Festkörperphysik, Max-Wien-Platz 1, D-07743 Jena, Germany

Thin-film solar cells based on $Cu(In,Ga)(Se,S)_2$-absorbers are industrially produced as mass product on a high level of quality. Due to rising production capacities and promising non-vacuum processes like chemical deposition or printing techniques a further cost reduction is expected. But contrary to the great success in production is the peculiar lack of comprehension concerning basic electrical spectroscopy of band-gap levels in this material system. A prominent example is the so called N1-defect observed by capacitance based methods like thermal admittance spectroscopy (TAS) and DLTS. It has unusual properties, e.g. a continuous shift of its band-gap level after moderate annealing, and has been controversially discussed for longer than a decade. However, these measurements extend to temperatures well below 200K and thereby overlap with the temperature domain where charge carrier transport by hopping is expected in the absorber. By consequently considering the impact of hopping transport on the capacitance measurement a hitherto undiscovered reason for a TAS-signal is found and the N1-signal is shown not to be correlated with a defect. Instead, this signal is generated by the freezing-out of carrier mobility with decreasing temperature when hopping conduction prevails. The consequence of this finding on electrical measurements and defect spectroscopy at $Cu(In,Ga)(Se,S)_2$-based solar cells will be discussed.