Wednesday, May 13

8:30 a.m. CT-5 Basic Economics of Photovoltaics for Vacuum Coaters

G. Smestad, Sol Ideas Technology Development, San Jose, CA

Invited 40 min. Talk

With widespread deployment of Photovoltaic (PV) power imminent, it is useful for researchers in the coatings sector to have at least a basic knowledge of the economic principles that govern PV modules and systems. Several simplified and illustrative equations are presented, along with a technical overview of the field. For the past several years, PV modules prices have deviated from 80% progress ratios exhibited since 1980. These ratios are obtained from experience or learning curves. Deviation is due, in part, to strong demand and a Si supply shortage that is expected to end within the next two years. Thin film PV modules are believed to allow for a rapid return to prior trends. If Balance of Systems (BOS) costs are considered for existing technologies, the near term (2015) cost of PV power could be 0.08-0.13 $/kWh, assuming a module of 15% efficiency that lasts at least 15 years under the irradiance levels found in the sunnier regions of the world. Although solar cells of 15% efficiency that last for 15 years can be competitive with fossil fuels, those of less than 8% efficiency with lifetimes < 15 years will likely not lead to competitive products at MW scales.

Wednesday, May 13

9:10 a.m. CT-6 A Turnkey Approach for CIGS Thin Film Photovoltaic Production

D. Schmid, I. Koetschau, A. Kampmann, and T. Hahn, centrotherm photovoltaics AG, Blaubeuren, Germany

Invited 40 min. Talk

centrotherm photovoltaics AG has chosen Cu(In,Ga)Se_2 (CIGS) as material system for turnkey thin-film photovoltaic production lines because of its large potential concerning conversion efficiencies and economical production techniques. Several approaches are reported in literature for the deposition of CIGS thin-film solar cells, with two-stage processes being favoured by the industry. Here, a metallic Cu(In,Ga)-precursor is deposited, preferably by sputtering, while the crystallization of the CIGS-compound is completed by an annealing step under the presence of selenium. Within CIGS thin-film technology, centrotherm photovoltaics AG is introducing a completely new approach for the production of CIGS-layers, which has not been reported in literature so far. This centhrotherm-unique new technology allows for both, an easy scaling of the preparation techniques involved as well as unrivaled short process intervalls for CIGS formation. Hence, the new technology developed by centhrotherm photovoltaics AG is especially designed for the realization of economically operated in-line plants, since the fast processing of CIGS-modules is not restricted by module size. Thus, keeping the high efficiencies associated with the CIGS system, a considerable economical impact on thin-film solar cells due to this new technology is expected.

Wednesday, May 13

9:50 a.m. CT-7 TiO_2-Ge Nanocomposites for Solar Cells Applications

S.I. Shah and B. Ali, University of Delaware, Newark, DE; and M. Abbas, COMSATS Institute of Technology, Islamabad, Pakistan

Several new photovoltaic semiconductor materials and synthesis techniques have been developed as a result of the increasing need for renewable energy sources. Quantum dot (QD) based solar cell is potentially one of the best contenders. We have developed a thermodynamically stable nanocomposite (stable up to 900 °C) titania-germanium (TiO_2-Ge) which shows promise as the active layer for QD nanocomposite solar cells. In TiO_2-Ge nanocomposites Ge nanodots are distributed in a TiO_2 matrix. Due to the 3-D quantum confinement effect, tailoring of the optoelectronic properties is relatively easily done by simply varying the Ge nanodots size. Ge is particularly advantageous since the Bohr radius of Ge is relatively large, 25 nm. In addition to the specific results of the variation of the optoelectronic properties of TiO_2-Ge nanocomposites, some results on device fabrication and characterization will also be presented.

Wednesday, May 13

10:30 a.m. CT-26 Survey of Thin Film Solar Cell Technology in Germany

V. Sittinger, W. Diehl and B. Szyszka, Fraunhofer Institute for Surface Engineering and Thin Films IST, Braunschweig, Germany

Invited 40 min. Talk

Within the scope of limited non-renewable energy sources and the restricted capacity of the ecosystem for greenhouse gases and nuclear waste, sustainability is one important target in the future. Different energy scenarios showed the huge potential of photovoltaic to solve this energy problem. Nevertheless, in the last decade PV had an average growth rate of 44% per year. In 2007, the worldwide production of solar cells has grown to 4 GW. More than 90% of the recent production involves crystalline silicon technologies. These technologies have still a high cost reduction potential. On the other hand, the so-called second generation thin film solar cells based on a-Si/μc-Si, Cu (In,Ga)$(Se,S)_2$ or CdTe have material thicknesses of a few microns as a result of their direct band gap. Also the possibility of circuit integration offers an additional cost reduction potential. Nowadays, roughly 150 companies are engaged in this field worldwide. Especially in Germany, there are many companies focusing on thin film solar cells. Some of them have already started mass production. Schott Solar GmbH and Ersol Thin Film GmbH (takeover by Bosch GmbH) with the a-Si technology are collaborating in the development of a-Si/μ-Si tandem technology. The U. S. company, First Solar, produces in Germany using the CdTe technology. Würth Solar GmbH is also in production using the Cu(In,Ga)Se_2 technology. There are further different production lines under construction by companies for example by Avancis, Sulfurcell, Johanna Solar, and Solarion GmbH. Furthermore, the biggest company in the worldwide solar market so far is QCells Company, which has started up different subsidiary companies with all these technologies (Sontor, Calyxo, Solibro). Nevertheless, there are still many companies who have just started to build up their production lines. An overview of the research activity in different companies and with different thin film technologies will be given as well as different manufacturing and production processes.

Wednesday, May 13

11:10 a.m. CT-9 A Novel Approach for Thin-Film Crystalline Silicon on Glass

K. Sharma, A. Illiberi, A. Branca, M. Creatore, and M.C.M. van de Sanden, Eindhoven University of Technology, Eindhoven, The Netherlands

Thin film technology is emerging as a new and promising approach for industrial production of PV modules: polycrystalline silicon (Poly-Si) films are fabricated by crystallization of amorphous silicon layers, grown on low-cost supporting materials (glass substrate). In this framework, we are developing a new approach for the production of Poly-Si thin films: the amorphous layers are deposited by using the expanding chemical vapor deposition (ETP-CVD) technique, which has previously demonstrated device grade a-Si:H at high deposition rate (7-11 nm/s). The crystallization process has been induced by means of Solid Phase Crystallization. Fourier Transform Infrared and Spectroscopic Ellipsometry (SE) diagnostics have been used to characterize both the as deposited and annealed a-Si:H layers, by measuring the thickness, hydrogen content, bonding configuration and optical constants of the films. The imaginary part of the pseudo-dielectric function has been measured by means of SE to give insight into the crystallization degree of the annealed a-Si:H films. The results have been confirmed by Raman diagnostics. The structural material quality of the Poly-Si films has been investigated by means of cross-section Transmission Electron Microscopy: crystal grains (1 um lateral dimension) extending over the entire thickness (1um) of the annealed a-Si:H films on glass have been observed.

Wednesday, May 13

11:30 a.m. CT-10 Progressive DC Power for TCO Deposition

D. Ochs, HUETTINGER Elektronik GmbH + Co. KG, Freiburg, Germany; and P. Rozanski and P. Ozimek, HUETTINGER Electronic Sp. z O.O., Zielonka, Poland

Transparent conductive oxides (TCO) as ZnO:Al (AZO) are of great importance as transparent electrical contact layer for thin film solar cell application. As this material has a very high arcing rate pulsed DC power processes have been needed in the past. A new DC power supply family has been developed with the goal to replace these expensive pulsed DC processes by standard DC processes. The most important feature of this power supply is a very fast and advanced arc management. After detecting an arc a positive voltage is applied to the cable between power supply and cathode. This compensates the stored energy of the cable and reduces the energy supplied into the arc after power switch off. Measurements using a 60kW DC power supply have shown very stable process conditions over a long time for planar and tube AZO targets. Residual arc energies significantly less than 1 mJ/kW could be calculated from oscilloscope measurements of the voltage and current behavior during the arc event. Because of the very short process interruption stable processes with the in production typical arcing rates of several thousand arcs per second become possible. Transmission and resistivity of layers deposited with DC have been measured and compared with pulsed DC deposited layers. Pure DC deposited layers show similar or even better results in respect of transmission and resistivity compared to the pulsed deposited layers. It could be demonstrated that pulsed power can be replaced without any disadvantage.

11:50 a.m. CT-24 Mechanical Behaviour Study on Conductive Polymer and TCO Thin Films on PET for Smart Flexible Devices

V. Teixeira, J.O. Carneiro, P. Carvalho, and S. Lanceros, University of Minho, Guimarães, Portugal; and A. Cochet, U. Posset, and G. Schottner, Fraunhofer Institut für Silicatforschung ISC, Würzburg, Germany

In flexible organic electronic devices, the high brittleness and limited mechanical ruggedness of requisite inorganic thin films are a likely source of failure. It is, therefore, important to understand and improve the mechanical limits of these functional layers. In the present study, a multiple film cracking in thin film/substrate composite systems was analysed. Specifically, the experimental measurement of multiple cracking of indium tin oxide films (ITO) deposited by reactive magnetron sputtering on polyethylene terephthalate (PET) substrates was investigated. In addition, thin homogeneous and highly transparent films of the conductive polymer poly(3,4-ethylene dioxythiophene) (PEDOT) were prepared by means of spin coating via moderator controlled *in situ* chemical oxidative polymerization of EDOT on the ITO coated PET sheets. Such multilayered films may be used as cathodically colouring electrochemical half cells for the assembly of flexible electrochromic devices. The system was subjected to an unidirectional tensile loading. A shear lag model was used to derive the stress distribution in the system, and the film cracking problem was analysed using the strength criteria. In addition, a numerical computer simulation was performed to simulate the number of cracks, the crack distribution and the film fracture strength using a Weibull statistical analysis. The simulation predicted successfully the crack density and the distribution of fragment lengths during the progress of multiple cracking. The influence of the polymeric top layer on the mechanical properties of the composite systems is discussed.