Tuesday, May 12

1:30 p.m. L-10 North America - The Next Solar Growth Market

E. Wegener and P. Thompson, AGC Flat Glass North America, Alpharetta, GA

Invited 40 min. Talk

Although the modern solar industry has its roots in North America, in recent years, the focus of market development efforts and capital investment has been in Asia and Europe. While these two markets are unquestionably the largest, the market growth rate in North America has accelerated in recent years. North America is a smaller but more attractive market because its forecasted growth shows no sign of abating. The prospective growth is not confined to any particular segment. C-Si, thin film and CSP (concentrating solar power) all have strong growth momentum and the ability to attract investment capital to fund the growth. The underlying technologies in each of these segments have different drivers that will influence adoption and commercialization rates. This presentation will examine each of these segments and discuss growth, challenges and opportunities going forward. As of this writing, it appears that an Energy Bill will be passed and signed into law; this too will play an important role in developing the market going forward.

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2:10 p.m. CT-1 Silicon Oxide Barrier Layers on Flexible Metal Substrates for Thin Film Photovoltaic Produced by High Rate EB-Deposition for Large Area Coatings

F. Haendel, H. Morgner, and C. Metzner, Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Dresden, Germany

For thin film photovoltaic applications, functional layers are inevitable in terms of electrical insulation and diffusion resistance. The change of substrate material from rigid glass to flexible metal foil for thin film solar cell production demands the prevention of diffusion into the absorber layer of impurity atoms out of the metal. Furthermore, modules with monolithic serial connection need an electrical separation of the cell back contact from the conducting metal substrate. SiO_x-based layers on steel strips were produced by electron beam (EB) technology, hollow cathode arc activated deposition (HAD-process), plasma polymerization and by combining these three processes. These methods are distinguished by their in-line capability enabling roll-to-roll processing with dynamic rates of up to 1 μm·m / s. Moreover, the possibility arises to produce coatings scaled up to common industrial width and larger dimensions. Electrical and dielectrical examinations of the layers were carried out to characterize the insulating abilities. Also microstructure and layer growth were analyzed. The efficiency of the barrier properties was determined by SIMS-measurements. The insulating properties are distinguished by the breakdown voltage of some hundred volts. The positive effect of the barrier layer is apparent from the strong reduction of Fe diffusion into the CIGS-layer.

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2:30 p.m. CT-2 PECVD Thin Films for Anti-Reflection and Passivation of Crystalline Silicon Solar Cells

M. George, H. Chandra, and J.E. Madocks, General Plasma, Inc., Tucson, AZ

Crystalline silicon solar cells owe their high efficiencies in part to advanced high throughput thin film technologies. These thin films serve both as optically matched anti-reflective layers and simultaneously render the surfaces of the underlying active semiconductor passive. Hydrogenated silicon nitride is of keen interest because it is a key thin film for commercial crystalline silicon n^+ emitter solar photovoltaic devices. A new Plasma Enhanced Chemical Vapor process has developed that deposits thin films for this demanding requirement: an advanced hydrogenated SiN:H process capable of depositing SiN:H films on n^-type FZ Si surfaces with minority carrier lifetimes exceeding 2 milliseconds, measured by photoconductivity decay. Deposition conditions include temperatures between 200˚C and 350 ˚C and pressures from 20 to 75 millitorr - yielding a SiH_4 utilization efficiency that exceeds 10% at deposition rates >60 nm-m/min. We discuss the thermal stability, thin film bonding and surface chemistry of the SiN:H films that account for this exceptional surface passivation. Future crystalline silicon cells will be manufactured with p^+ emitters, enabling efficiency improvements of 2-5% over 21% efficient n^+ emitter cell designs. This cell architecture requires films with altogether different properties from SiN:H to enable these dramatic efficiency gains. We include summary data on thin films deposited by our Dual PBS, PECVD source for this application that include index of refraction, minority carrier lifetime and deposition rates.

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2:50 p.m. CT-3 Stochastic Nanostructures on Polymers for Solar Applications

N. Kaiser, K. Fuechsel, U. Blumrueder, P. Munzert, and U. Schulz, Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Jena, Germany

A new technology based on plasma etching has been developed to produce antireflective nanostructures. By choosing thin initial layers and variable plasma conditions a broad range of differently shaped structures can be produced on various polymers. A broadband antireflective effect can be achieved that is less sensitive to the incident angle of light compared to multilayer interference coatings. In combination with metallic layers, some types of structured surfaces can be transformed to show high absorption. Such surfaces appear completely black in the visible spectral range. This paper presents structured polymer surfaces exhibiting broad band antireflective properties optimized for the solar wavelength range as well as absorbing surfaces produced by plasma etching.

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3:10 p.m. CT-4 Web and Inline System Optimization Utilizing Thermal Sources for Thin Film Solar

J. Patrin and R. Brasnahan, Veeco Instruments, St. Paul, MN; and D.L. Miller, Consultant, Valley Center, CA

Recently, there has been considerable activity scaling thin film photovoltaics from R&D to high volume manufacturing because of their low cost potential. For CIGS thin film solar, the manufacturing challenges focus on optimizing the deposition for high material utilization, low thickness variation and decreased system footprint. In this contribution we report on a deposition modeling and optimization method that evaluates parameters such as number of sources, individual flux rates, source-to-substrate distance, source angle, source separation and deposition area in order to quantify the impact of these variables and their dependency on one another. We have used this process for a variety of deposition configurations including thermal point sources for copper, indium, gallium and an array of nozzles for selenium linear sources integrated into web and inline glass systems. The modeling process provides a fast, cost effective and low risk means of determining the optimal system design given the process and hardware constraints. This method is applicable for substrate sizes beyond 1m and we will present system configuration results for substrate sizes ranging from 300mm to 1200mm for copper, indium, gallium and selenium sources illustrating that material utilizations up to 75% can be obtained with thickness variations +/- 5%.