Friday at PVSC42 wrapped up an outstanding conference with attendees recuperating from the masquerade banquet. Many I'm sure awoke to some strange photos in the email inbox….

Friday was a shortened day but there was no shortage of outstanding work being reported on. There were two oral sessions today followed by the closing of the conference.

The 8:30 to 10:00 session got things underway with a number of excellent results reported. Highlights of the early morning session include:

Area 1 - Emerging Photovoltaic Technologies. Anna Trojnar from University of Ottowa presented modeling of GaAs nanowire cells showing potential for efficiencies of 24% given proper surface passivation and other device optimization. Nina Vaidya from Stanford presented on graded index optics for passive solar concentratorsChloe Fabien presented an double heterojunction InGaN solar cell. One device had 22% In content and exhibited a record Voc of 1.5V. Promising paths forward were also discussed to improve InGaN device efficiency.

Area 2 – Materials characterization and modeling. Dr Hiroi from Solar Frontier presented new results on pure sulfur CIGS solar cells, with voltage up to 960 mV. He demonstrated that FF and Jsc are at the same level as high efficiency CIGS, but that Voc is the bottleneck. He mentioned that the challenge is also to have a KCN-free and Cd-free process. Critical parameters were sulfurization temperature and gallium profile. They also modified the CdS thickness. Highest efficiency achieved was 14% and the highest voltage was 960mV. Finally, they achieved 15.5% cell with Cd-free buffer layer. Dr. Arehart from OSU presented results on nm-scale mapping of traps in CIGS solar cells. Specifically he presented work on nano-deep level transient spectroscopy. 2 trap levels were observed at 0.27eV and 0.47eV, both by DLTS and nano-LDTS, validating the technique. Mapping indicates that the 0.47eV traps are localized, and appears at some inter-grain boundaries but not all. Dr. Ana Kanavce from NREL presented an innovative approach to quantify grain boundary recombination in CdTe device using a combination of catholuminescence and 2D modeling. By examining the contrast between CL within the grains and GBs provide a unique measure of GB recombination. Dr. Ying-shen Kuo provided exciting results on single crystal ZnTe/CdTe solar cells based on a double heterostructure using MBE. This technology as produce material with minority carrier lifetimes greater than 1 microseconds. In this system simulations revealed that surface recombination at the pn junction controls performance in this system. Purvesh Soni presented an interesting examination of the defect distribution in the heterojunction region of CIGS solar cells using atom probe tomography.

Area 4 – Contact Formation and Module Integration. Joerg Horzel from RENA presented a cost effective and stable and robust method how to introduce Ni/Cu/Ag plating into mass production.

Area 6 - Organic Materials and Devices**.** Dr Forrest presented an overview of organic photovoltaics and the importance of nanostructure and interface control. High efficiencies are possible with OPV as was demonstrated with a 4 junction solar cells with an efficiency of 12.6% (a new record). Stability is still an issue but preliminary results suggest that small molecules device could last 10 yrs. Rob Walter showed new structure for organic polymer solar cells for underwater applications.

Area 8 – In-situ Characterization. This session highlighted how in situ ellipsometry can be used to monitor the degradation of thin-film solar cells.

Area 9 - Building Integrated PV and Novel Applications. Angele Reinders presented ray-tracing based animation of irradiation throughout a day, highly valuable for product integrated PV and PV in the built environment, as software (entitled "VR4PV") and enables fast and easy shadow analysis for BIPV and PIPV. Zeger Vroon showed a BIPV test installation in the Netherlands pinpointing the relevance of temperature increase in relation to ventilation. Ankush Halbe presented a prototype demonstration facility for BIPV performance testing of innovative lightweight mounting systems. Christopher Ballif presented on behalf of Laure-Emmanuelle Perret-Aebi, on "white solar module"; Actually, PV cost is not as relevant in light of other material costs: 150 euro/m2 for wood up to 1000 euro/m2 for marmor. The "white" PV modules show efficiency above 10%.

Lastly the 10:30 to 12:00 sessions there were the following highlights:

Joint Area 2 & 8 - Characterization of Chalcopyrite and Kesterite Photovoltaics. O. Awadallah: In situ Raman analysis of CZTS, where temperature dependent measurements were performed. T. Ishii: Detailed correlation between potential and capacitance signals in CIGS, where they resolve the signal dependence with the Ga content within the samples, and map Cd diffusion from the CdS layer.E. Pogue: Cryo-CL on CZTS solar cells, where a detailed analysis of the luminescence peaks is performed, and correlated with possible defects within the samples, including the diffusion of Cu, Zn, and Sn.M. Stuckelberger: X-Ray based characterization, simulations are shown to explain the advantages of XBIC compare to EBIC; in particular higher resolution can be achieved. Experiments are shown on several PV absorbers, evidence of depth profile analysis. M. Leite: High resolution techniques to map thin films EQE. NSNOM correlation between topography and current map at the nanoscale. Combining the study with wavelength tunnable laser excitation, low collection efficiency of grain boundaries are shown on CdTe and CIGS. Depth profile analysis is possible. C. Xiao: development of scanning capacitance spectroscopy applied to CIGS solar cell. SCM analysis are applied to look at the location of the junction and compare with AFM and SEM images. n-type signature of the surface is shown to evidence the homo-junction behavior.

Joint Area 1,3,4 & 7 - III-V on Si via Non-III-V Buffers and Bonding. Fitzgerald spoke about latest results from ongoing work on monolithic III-V/Si 3 junction for space applications. High Voc reported and some evidence of radiation hard SiGe layer. Essig showed encouraging results for mechanically stacked GaInP on Si with impressive EQE results. Milakovich reported some nice work on optimizing GaAsP top cells monolithic showing elimination of loops by careful growth initiation. Xiong presented an ELO wafer bonding approach to AlGaAs/Si tandem showing encouraging results. Wang presented results from monolithic GaAsP/SiGe showing a good result of 20.3% under indoor conditions by current matching optimization.

Area 4 - Silicon Material: Technology. Paul Basore (NREL) presented a very elaborate and analytical study of the investment dynamics across the PV value chain. The rate of Capital Investment appears to have dropped in 2011 to levels which do not seem to be sustainable today. Lowering the cost of manufacturing by a factor of two will have a similar effect to increasing the Capital Investment Rate by 10c$/W. The latter seems within reach and is the route encouraged by the author. Florian Schindler (Fraunhofer ISE) presented his work nominated for the Best Student Presentation Award. His team has grown a high purity low structural defect multi-crystalline n-type ingot. The material quality is analyzed and solar cell efficiencies are simulated for a variety of cell structures. The predictions are validated by the fabrication of a 2x2-cm2 cell reaching 19.6% efficiency. The device only fails to reproduce the predicted FF due to issues with the plating process used. Jeff Binns from SunEdison demonstrated In-doped Si grown by Continuous Cz method that minimizes segregation-induced doping non-uniformities in the axial direction. At high In concentrations, non-ionized In causes bulk lifetime decrease. However, at wafer resistivities above 2 Ohm-cm, relatively high lifetimes were observed, opening way to use In-doped wafers in LID-free high efficiency cells.

Area 9 - System Performance Rating and Monitoring. NREL reported a new method for measuring series resistance without the need for IV curves. The method requires measurements of Voc at low irradiance conditions. Anton Driesse demonstrated the significance of high frequency signals that can cause significant errors in standard monitoring data. One signal that is not usually known or considered is the anti-islanding signal that is injected by many inverters. Wilfried van Stark talked about a large scale study of system performance in Europe, comprising of 15,000 systems. He demonstrated techniques for scraping performance data from large online datasets, and identified the geographic distribution of site performance. Nils Reich demonstrated the importance of detailed assessment on decreasing the errors in determining the PR loss chain for a system. He demonstrated methods to validate loss factors for temperature loss, soiling, and shading losses. Jimmy Quiroz demonstrated a novel module level embedded I-V curve tracer, and demonstrated data and analysis from a sample system at Sandia.

Following these talks it was time for the closing session. All of the Poster session award winners received a warm round of applause and the Student best presentation awards were announced and the winners presented with a plaque and a check. The Paper Napkin Award was won by Sylvain Marsillac for PVSC42, for all of his efforts in making PVSC42 the successful conference it has been. Before wishing everyone bon voyage the next major PV conferences were advertised so that people can get their travel plans sorted early.

That rounds out the highlights for Friday, and for this year's PVSC. A big thank you to Alex Freundlich Robert Walters, and Steve Ringel for always helping me even when very busy with advice and resources. Thanks also to Angus Rockett and John Meakin for supplying such great photos that captured the spirit of PVSC42. Also a big thank you to all of the session chairs for providing summary highlights for these newsletters. Thank you also to Pam Angelos for getting me out of a number of binds with efficiency and patience. Last, but not least, thanks to Adam Kohm for making sure everything worked so seamlessly. Finally, thank you to everyone who attended the conference, for providing so many highlights!

See y'all in Portland for PVSC43!

Cheers
Stephen Bremner