39th IEEE Photovoltaic Specialists Conference
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Tampa, Florida

On Wednesday, June 19th the fourth day of the PVSC, long before the rest of the conference attendees were awake, an astounding mass of runners joined Larry Kazmerski for his traditional Sun Run. While chasing Larry, this year's runners enjoyed a breathtaking view of Tampa Bay and a fairly temperate morning climate that every runner could enjoy.

Shortly after the run the main conference work began with three outstanding plenary lectures from Area's 5, 8, and 9 that were delivered by world leaders in crystalline wafer based silicon, III-V and concentrator technologies, and CIGS thin-film photovoltaics. Jianhua Zhao (photo below left) of Area 4 talked about the evolution of silicon cell technology with specifics on front and rear passivation and metallization approaches, which ultimately have led to the demonstration of > 20% efficiency PERC type cells. Harry Atwater (photo below right) provoked the audience to think about different approaches to achieving very high-efficiency and low-cost photovoltaics through his teams work on spectrum splitting, full spectrum photovoltaics in the Area 3 plenary. A 'full spectrum' photovoltaic module, which takes advantage of advances in low-cost III-V

compound cell fabrication and emerging optical and electronic fabrication/assembly methods, features 6-15 independently connected subcells in a spectrum splitting, concentrating photovoltaic receiver.

Bill Shafarman (photo below right) from IEC gave an excellent talk about the opportunities and challenges in CIGS solar cells. He talked about 2 step and 3 step metal precursor selenization processes with H_2S/H_2Se, demonstrated that grain size is not critical, and was able to reduce the CIGSS thickness down to 0.25 micron and yet generate a 9% efficient device. He also proposed a superstrate cell with a back wall light trapping structure.

Following the morning break Tim Boscke talked about fully ion implanted n-type silicon wafer solar cells with 20.7% efficiency. Of this, a 0.6% efficiency increase was obtained by optimizing P diffusion. Jimmy Quiroz discussed the critical topic of voltage regulation and time series simulation modeling of the various regulation devices. The complex methods and settings of voltage regulators were described as were the advantages and challenges of QSTS modeling platforms. Joseph Williams discussed a new clustering methodology for classifying distribution feeders. The 15% "Rule of Thumb" was discussed and the concept of determining new hosting capacities based on topology was presented. The k-means clustering algorithm was used to differentiate different distribution circuits with the intent of classifying each feeder in California. James Cale presented an

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evaluation of the Flagstaff feeder in the APS service territory of Arizona. CYMDIST was used to set up the intermediate model, and exported to OpenDSS. The main focus of the study outputs was voltage sensitivity analysis. The topic of model fidelity and potential errors were discussed and the need for accurately modeled controls was highlighted. It was shown that active volt/VAr inverters can dramatically improve the feeder voltage profile. Yusuke Miyamoto discussed improved generation efficiency of PV using heat pump load control. The heat pump water heaters (HPWH) cannot absorb all energy during the day, but can have significant impact. The HPWH are using to reduce PV output and utilize energy locally. The result was fewer efficiency losses and improved voltage levels. Lucio Ciabattoni presented on neural networks (NN) based home energy management systems. Linear and non-linear layers were described as inputs to the NN. A forecasting/load manager algorithm for the NN was described along with load forecasting methods. The approach was to look at single appliances with a "fuzzy inference engine".

Following lunch, Tim Anderson (photo to right) shared his extensive work on understanding the process kinetics, growth pathways and thermodynamics that govern the formation of selenized CIGS-based absorber layer materials. Kwang-Ming Li shared his team's progress and significant achievement of 15.7% efficiency on a square meter CIGSS module using CdS buffer layer. C. G. Bailey (photo below left) described the effect of incorporating InGaAs quantum well structures in an InP lattice-matched 1 eV InAlGaAs n-i-p solar cell.

In Area 5, Marinus Fischer, a best student award finalist, described low and fast degradation in a-Si. Robert Collins gave an excellent presentation about the influence of the crystalline volume fraction of the n-layer on the a-Si cell performance. This was studied using a unique in-situ ellipsometry diagnostic tool.

Halvard Haug, of Area 4, shared a unique new method of measuring recombination using PL. Wensheng Liang presented work on behalf of Hang C SiO that described an ingenious way to study the influence of crystal orientation on surface passivation in multicrystalline silicon.

In Area 9, Boudewijn Elsinga proposed using a variogram to characterize PV output variability, which is potentially the first time this approach has been used to evaluate variability of irradiance. Alex Cronin, a best student presentation award finalist, described how ramp rate limitations imposed in Puerto Rico are limiting PV variations to 10% of plant capacity per minute. There is great debate regarding this subject as many researchers and operators do not agree on exactly how to interpret this rule. Different definitions affect the strategies for mitigating this variability to meet this new rule.

In the Area 1 fundamentals and new concepts session two best student paper nominees presented. Kasidit Toprasertpong shared his work optimizing the barrier thickness to maximize tunneling transport in a QW superlattice solar cell. The other nominee, Michael Slocum, followed with his results on development of a n-i-p-i solar cell with excellent radiation tolerance. Masakazu Sugiyama presented modeling and experimental results for asymmetric quantum well structures that assist with carrier escape and cut the escape time from the QW in half. Joshua Samberg presented his work on the

mitigation of the deleterious effects of bleeding of phosphorous from GaAsP barrier layers into InGaAs QW layers. Kentaroh Watanabe used a nano-imprint technique to enhance light trapping in a single-junction quantum well solar cell. The absorption was enhanced by a factor of ~1.7 in the QWs for the nano-imprint pattern cells compared with flat QW control cells.

At the end of the day the late afternoon poster session was again well attended. Sarah Kurtz (photo above) was captured by the paparazzi while talking with a colleague at her poster.

That wraps up the fourth day of the 39th IEEE PVSC conference.