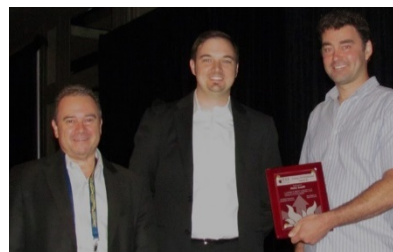
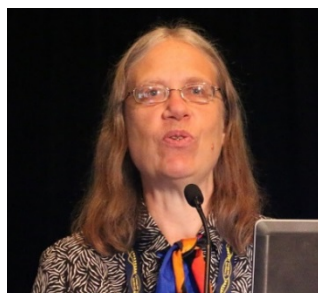




Thursday at PVSC42 began on a high note with the Young Professional Award being presented Prof Henry Snaith of the University of Oxford, beating out some strong competition Prof Snaith was awarded this great honor for his ground breaking work in perovskite materials for PV, with stunning success in the last few years.



Following the presentation of this award, Prof Snaith was the first plenary speaker in **Area 6**. He showed the latest progress in perovskite thin-film PV technology with an emphasis of the intriguing properties of perovskite and stability issues. He showed the latest result of stability of perovskite materials, exhibiting the stability over 2000 hr without any significant degradation. The most interesting result is high efficiency perovskite/Si monolithic tandem solar cells, demonstrating ~21% efficiency with the open-circuit voltage of ~1.8V under simulated one sun condition.



In **Area 11**, Sarah Kurtz reported on the ongoing work of the International PV Quality Assurance Task Force (PVQAT). She stressed the importance of having standards across the industry in order to ensure system problems are minimized and to enhance confidence in PV for large scale investors. This will also be critical to ensure costs are further reduced and to quantify the added value of panels. Sarah provided a great snapshot of the tough tasks that need to be tackled, but also the importance of these tasks and the good progress that has been made in this important area.

In a Special plenary talk, Becca Jones-Albertus of the US Department of Energy showed how the lowering of cost in the PV industry has led to sharp falls in the price of solar electricity, but for the Sunshot target of 6c per kWhr by 2020 to be reached the balance of systems costs must be brought down. She outlined how Sunshot funding will evolve to drive innovations in module design and packaging as well as manufacturing costs. The reliability of modules and systems was also stressed as an area of increasing importance to keep driving down the price of solar electricity.



From 10.30 it was on to a poster session with Areas 1, 2, 3, 4, 6, 11 being represented. The high quality of posters again led to vigorous discussion and the beignets helped to charge everybody's batteries! The following posters received awards in their respective areas:



## Poster Award Winners

**Area 1:** Physical and Optoelectronic Properties of  $V_x\text{In}_y\text{S}_z$  Intermediate Band Semiconductors Deposited by Atomic Layer, R. F. McCarthy, R. D. Schaller, A. B. F. Martinson, Paper 741

**Area 2:** On the temperature behavior of shunt-leakage currents in  $\text{Cu}(\text{In,Ga})\text{Se}_2$  solar cells: the role of grain boundaries and rear Schottky contact, G Sozzi et al., Paper 772

**Area 3:** PVMirror: A Tandem Solar Cell that Collects Diffuse Light, Z. J. Yu, K. C. Fisher, Z. C. Holman, Paper 794

**Area 4:** Investigating the Benefits of Multi Bus-bars for Industrial Al-BSF Silicon Solar Cells, N. Chen & A. Ebong, Paper 801

**Area 6:** Imaging surface potential and internal electric fields across heterojunction solar cells using scanning Kelvin probe microscopy, R. Ihly, J. M. Luther, S. U. Nanayakkara, Paper 826

**Area 11:** Cu Migration and its Impact on the Metastable Behavior of CdTe Solar Cells, D. Guo et al., Paper 859

Over lunch there was the annual Women in PV (WiPV) event for PVSC. This year's speaker was Dr. Atiye Bayman, Chief Technology Officer of MiaSole gave an inspiring talk about her career and experiences as a woman in the field of PV. One hundred and fifty attendees enjoyed the talk and conversation with the speaker and mentors in the field.

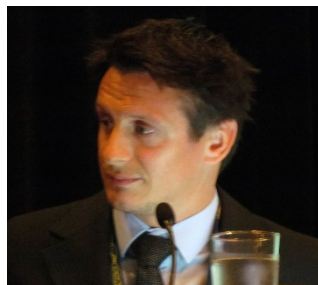


In the early afternoon oral sessions there were the following highlights from the oral sessions:

**Area 1 – Novel Materials and Concepts.** Joel Ager - transparent interconnects for non-epitaxial tandem solar cells with p-type TCO (or TCMs). PLD of  $\text{CuZnS}$  at room temperature show average transmittance ~84% for Zn-rich alloys, but falling off with increasing Cu. They show high p-type conductivity with temperature independence. This is much better than comparable TCMs. Deposition by CBD also yields high hole conductivity 500 S/cm with 75% transparency, but not quite as good as PLD. Bremner showed detailed balance based band gap engineering in multi-junction solar cells. The impact of radiative coupling between cells was investigated. Also silicon based MJ's looked at. Smith -  $\text{InAlAs}$  top cells for a triple junction. managing thermal defects is challenging. 16-17% efficiencies with different pathways. absorption peaks of three junctions are not well separated. Also measured diffusion lengths and saw high

mobilities. TTBAL and TMAI was used to increase  $J_{sc}$  and  $V_{oc}$ . Aaron Martinez - ZnSiP<sub>2</sub> for top active subcell material on Si subcell. Uses Photoelectrochemistry (PEC) for PV characterization of ZnSiP<sub>2</sub> bulk crystals. Crystals do show photoresponse, showing high voltage but low current due to narrow range of light being absorbed. PL studies indicate donor-to-acceptor transitions at 1.8eV, which shallow donor level at  $E_d=58\text{meV}$ . 2.17eV bandgap indicated. Angela Fioretti - ZnSnN<sub>2</sub> earth abundant semiconductor synthesized by combinatorial approach for high throughput and characterization. More desirable properties observed in Zn-rich compositions. No evidence of secondary phases in wurtzite structure. Reported lowest carrier density in films ever (n-type  $\sim 2 \times 10^{18}/\text{cm}^3$ ). Degeneracy in stoichiometric films indicated as due to oxygen on nitrogen sites ( $\sim 4\%$  oxygen).

**Area 2 – Devices Characterization and modeling.** Christopher Thompson gave a nice overview of the performance of (Ag,Cu)(In,Ga)Se<sub>2</sub> and devices made therefrom. He highlighted the change in composition gradients when one switches from Cu to Ag compounds. The front Ga gradient was found to be critical to the device and the optimal gradient was different in materials with Ag. Oki Gunawan presented results from IBM on CZTS solar cells characterized by a low light suns- $V_{oc}$  measurement. The instrument used a light filter that provided an exponentially changing light intensity. This could be combined with filtered light measurements. The measurements reveal several results including shunt and series resistances, voltage dependent collection, and  $V_{oc}$  pinning. Tao Song presented an analysis of the benefits and expected issues with CdTe epitaxial layers on CdTe, GaAs, Si, and InSb substrates. The latter is very attractive due to the lattice match and high conductivity of the InSb. However, some buffer layers are needed on the substrate prior to CdTe epitaxial growth. The suggested approach is a CdZnTe buffer layer combined with a tunnel diode in the InSb.



**Area 4 – Silicon Material: Analysis.** Brett Hallam UNSW (pictured left): Demonstrated rapid formation and mitigation of LID on finished solar cell by high intensity illumination. Further understanding of intrinsic defect in Cz silicon by F Rougieux ANU. Indium doped mono crystalline solar cells demonstrated with higher efficiency in comparison of B doped solar cells after LID shown by E. Cho, Georgia Tech.

**Area 5 - Light Management in Thin-Film Silicon Solar Cells.** H. Sai from AIST reported a new world record efficiency for a n a-Si:H / nc-Si:H / nc-Si:H triple junction device with 13.6% stabilized efficiency

**Area 7 – The space cells session** started with an exciting 36% efficiency for a 5J SBT cell from Philip Chiu at Spectrolab. A promising path for a record efficiency 6J was presented. In view of future deep space missions, Raymond Hoheisel from the George Washington University, discussed the possible degradation mechanisms for cells operating under low intensity and low temperature conditions.

**Area 11 – Module Reliability.** T. Silverman presented modelling results for thermal effects observed for thin-film modules under shading. V. Gade presented experimental results for formation of cell cracks in dependence of the type of backsheet. A. Morlier presented crack statistics for 572 modules from the field and demonstrated that the crack pattern depends on the location of the cell in the PV module. Crack resistance between cell parts was introduced to better simulate power loss of PV modules and PV arrays.

O. Abudayyeh presented results on development of a silver electrochemical deposition of cell contact for space cells. In an experimental study crack tolerant metal lines have been observed for up to 42 micrometer crack width. G. Zhou presented results of an experimental study for different combinations of cells and EVA encapsulants to understand the formation of snail trails in PV modules. The proposed model underlines the role of Ag oxidation. C. Flueckiger explained the fire classification of a PV module which is based on spread of flame and burning brand test. For PV systems differences between UL 2703 and new UL/ANSI 2703 were explained.



From 3:30 to 5:00 the International Cooperation Keynote session took place. Some of the experiences of international cooperation efforts in India and Japan were highlighted. The benefits of international cooperation in research efforts, particularly long term efforts were emphasized. The problem of securing funding for such long term efforts was acknowledged, with it noted there are a number of schemes available to researchers. In panel discussions ways in which to engage junior researchers in international cooperation efforts were explored. Prof Yamaguchi proposed a coordinated timetable for the major PV conferences with a world conference every four years, with all other conferences being merged in the world conference for that year.

The Banquet rounded out a busy Thursday for all with a masquerade ball inspired event. Held at the nearby Generations Hall an enjoyable evening was had by all, with great live music in an authentic New Orleans backdrop. The photo booth proved particularly popular with some intriguing ensembles captured for posterity. There was even time for boogey as everyone relaxed after a busy conference full of great results and new insights. There even seemed to be a late night mini-conference centered around a certain speckled feline....

That rounds out the highlights for Thursday, there will be many more to come in the days ahead!

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## **IEEE ELECTRON DEVICES SOCIETY - MEMBERSHIP PROMOTIONS FOR 42<sup>nd</sup> PVSC ATTENDEES**

Be sure to stop by the EDS membership booth, located in the registration area, to learn about the EDS membership promotion deals available to PVSC attendees.

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