

## **CdTe Device Workshop Santa Clara, California November 2/3, 2017**

First Solar, Inc. and Colorado State University jointly hosted a two-day workshop on CdTe photovoltaic devices and were joined by colleagues from the National Renewable Energy Laboratory, Arizona State University, the University of Toledo, the National Institute of Standards and Technology, the University of Delaware, the University of Illinois at Chicago, the University of South Florida, the University of Utah, and Swansea University.



The purpose of the workshop was to bring together a broad spectrum on those engaged in CdTe research at the device level, to review recent progress, to share ideas on what should come next, and to make specific plans for mutual support. The agenda for the workshop is attached.

The first day was devoted to recent progress. It had 15 presentations on topics that included CdTe efficiency increases from higher currents and fill-factors, as well as narrowing of the voltage deficit, progress with doping epitaxial and poly-crystalline CdTe, reductions in interfacial recombination, new device structures, particularly those that alloyed Se with CdTe, and applications of advanced characterization techniques to CdTe devices. It concluded with a tour of the nearby First Solar facilities.

Each of the 16 presenters on the second day was asked to propose ideas on what his or her program and the broader community should do next. An assignment for each of the presenters was to ask at least one person from a different organization for specific assistance on a research project. The result was considerable discussion of projects and collaborations. Overall, there was consensus that the workshop was successful and provided the participants with substantial technical and networking value.

Agenda 2/3 November, 2017

Participant Name	Abstract Title		Session Day
Markus/Jim	Welcome	8:30 AM	
Wyatt Metzger	The evolution of understanding and changing stubborn material properties for CdTe photovoltaics	8:45 AM	sx-px
Teresa Barnes	Lessons Learned from FPACE 2: MBE CdTe	9:05 AM	sx-px
Yong-Hang Zhang	Crystalline CdTe/MgCdTe and Mg <sub>0.13</sub> Cd <sub>0.77</sub> Te/Mg <sub>x</sub> Cd <sub>1-x</sub> Te double heterostructures and solar	9:25 AM	sx-px
Zachary Holman	II-VI/silicon tandems: Prospects and present status	9:45 AM	sx-px
Admin	Break	10:05 AM	Break
Darius Kuciauskas	Electro-Optical Defect Spectroscopy and Microscopy - Current Results	10:20 AM	Chaz
Robert Klie	Structural characterization of poly-crystalline CdTe device	10:40 AM	Chaz
Paul Haney	Modeling tools for polycrystalline PV	11:00 AM	Chaz
Brian McCandless	Controlling CdTe Properties in Vapor Transport Deposited Polycrystalline Thin Films	11:20 AM	Process
W. S. Sampath	Advancers in Processing CdTe Devices	11:40 AM	Process
Admin	Lunch	12:00 PM	Lunch
Jim Sites	Back-Contact Combination of Te and Cu	1:00 PM	Back-Contact
Randy Ellingson	Exploration of low-barrier CdTe back contacts	1:20 PM	Back-Contact
Chungho Lee	Back-contact alternatives to ZnTe:Cu	1:40 PM	Back-Contact
Mike Scarpulla	Nanochemistry at the back contact of grain boundaries in CdTe and device implications	2:00 PM	Back-Contact
Dingyuan Lee	Arsenic Doping in Polycrystalline CdTe at First Solar	2:20 PM	Doping
Stuart Irvine	What can we learn from flying CdTe solar cells in space?	2:40 PM	Process
Admin	Transportation	3:00 PM	TRANSFER
Admin	Arrive at FSLR Office - Social/Coffee	4:00 PM	Coffee
Admin	Tour of CTC facilities (2 Groups)	4:00 PM	Tour
Admin	End Of Day	5:00 PM	Break
Admin	Purpose/Rules of the day	8:30 AM	Welcome
Wyatt Metzger	Realizing the future of CdTe solar energy	8:45 AM	Entitlement
Gang Xiong	Toward 25% CdTe cell efficiency	9:00 AM	Entitlement
Teresa Barnes	Foundational Materials Science for Higher Radiative Efficiency	9:15 AM	Entitlement
Zachary Holman	Technology hurdles to an 18%-efficient II-VI top cell suitable for tandems	9:30 AM	sx-px
Yong-Hang Zhang	How can research on monocrystalline structures help understand many important issues for polycrystalline?	9:45 AM	sx-px
Admin	Break/Discussion Buffer	10:00 AM	Break
Brian McCandless	Overcoming p-type Doping Obstacles to Enable Voc > 1V in Polycrystalline Thin Film CdTe Solar	10:30 AM	Doping
Chris Ferekides	In-situ Group V Doping and Defect Studies	10:45 AM	Doping
Stuart Irvine	The path to higher activation ratio Group V doping in CdTe solar cells	11:00 AM	Doping
Yanfa Yan	Revisiting density functional theory calculation of defect and doping properties in CdTe	11:15 AM	Fundamentals
Igor Sankin	Defects in CdTe, from theory to prediction	11:30 AM	Fundamentals
Admin	Break/Discussion Buffer	11:45 AM	Break
Admin		12:00 PM	Lunch
Robert Klie	How do we deal with grain boundaries in CdTe: Model systems for passivating grain boundary	1:00 PM	Characterization
Paul Haney	Revisiting EBIC experiments in polycrystalline CdTe	1:15 PM	Characterization
Darius Kuciauskas	Electro-Optical Defect Spectroscopy and Microscopy - Open Questions	1:30 PM	Characterization
Admin	Can we wrestle defects into submission?	1:45 PM	Discussion
Randy Ellingson	Materials and interfaces for high efficiency, transparent, bifacial, and tandem CdTe PV	2:30 PM	Back-Contact
Jim Sites	What Next for Electron Reflection?	2:45 PM	Back-Contact
W. S. Sampath	CdSeTe Absorber Grading and Doping, CdTe vs c-Si	3:00 PM	Other
Mike Scarpulla	Engineering grain boundaries	3:15 PM	Other
Admin	Open Floor on priorities for CdTe research	3:30 PM	Discussion
Admin	How to enable/improve collaborations?	4:10 PM	Discussion
Admin		4:30 PM	Depart