
2008 Solar Annual Review Meeting

Session: CdTe - Progress and Roadmap Alignment

Company or Organization: National Center for Photovoltaics

Funding Opportunity: EE&RE



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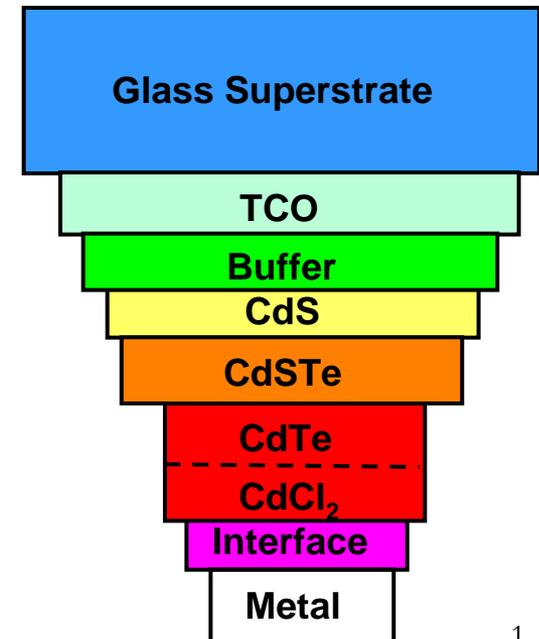
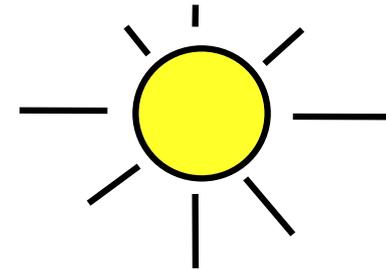
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Budget and Solar America Initiative Alignment



<i>Company or Organization</i>			
Project Beginning Date	FY07 Budget	FY08 Budget	Total Budget
Continuing	\$2.298M	0.88M	3.178

- This project supports the Solar America Initiative by:
 - Assistance to SAI Incubators (Primestar Solar, AVA Solar)
 - Providing industry with baseline understanding of CdS/CdTe device formation and reliability
 - Incorporation of low-cost, high-quality TCOs
 - Functionality and options for buffer layers
 - Effect of various CdS options
 - Effect of and importance CdSTe alloy formation
 - Effect and control of defect formation in CdTe
 - Effect and options for CdCl₂ treatment
 - Effect and options for back contact
 - Effect of residual impurities during all stages of device formation
 - Understanding modes and mechanisms of cell-level stability
 - Establishment of CdTe PDIL Tool for rapid material and process screening
 - NREL Developed
 - Industry Developed

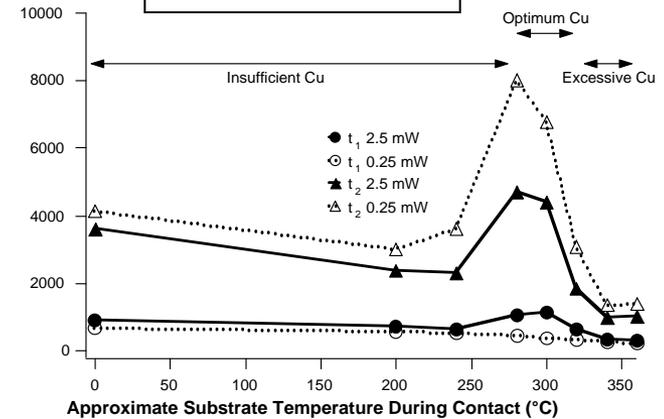


Project Overview (CdTe, Spring 07 - Spring 08)

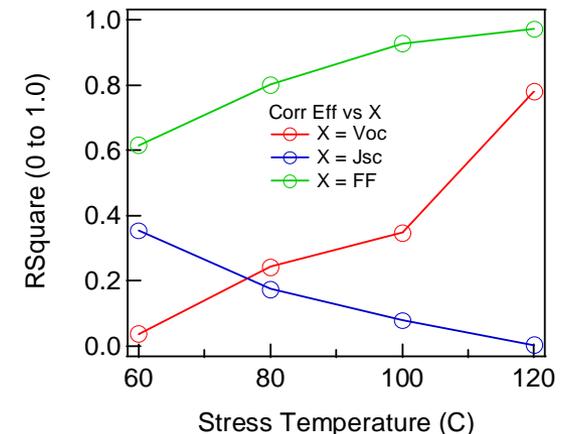


- Relocate Laboratories from SERF to STF**
 - Physical Move-ins/Move-outs: Fall 2006 - Fall 2007
 - Re-Establish Functionality: Fall 2006 - Ongoing
 - 1st STF Devices - 2/08 (~6-10%, FF ~50% range)
 - 2nd STF Devices - 3/08 (~8-13%, FF ~65% range)
- Advance critical understanding of how CdS/CdTe junctions form**
 - ZnTe:Cu/Ti contacts on CdS/CdTe device material from various sources
 - Cu diffusion during contact can increase lifetime
 - Re-establish high-bandgap device studies
- Advance critical understanding of cell-level degradation mechanisms**
 - Fill Factor reduction appears to be primary mode
 - Cu diffusion correlates to both lifetime increase and decreases

Some Key Results



Cu diffusion can increase minority-carrier lifetime

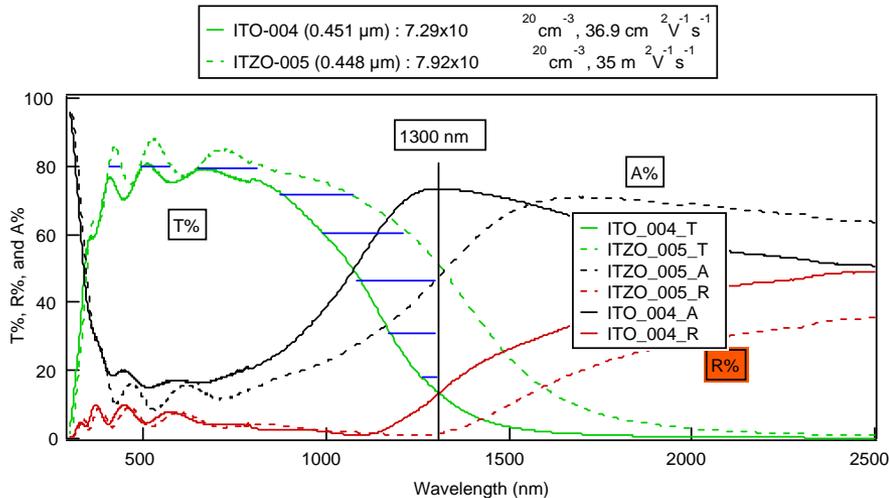
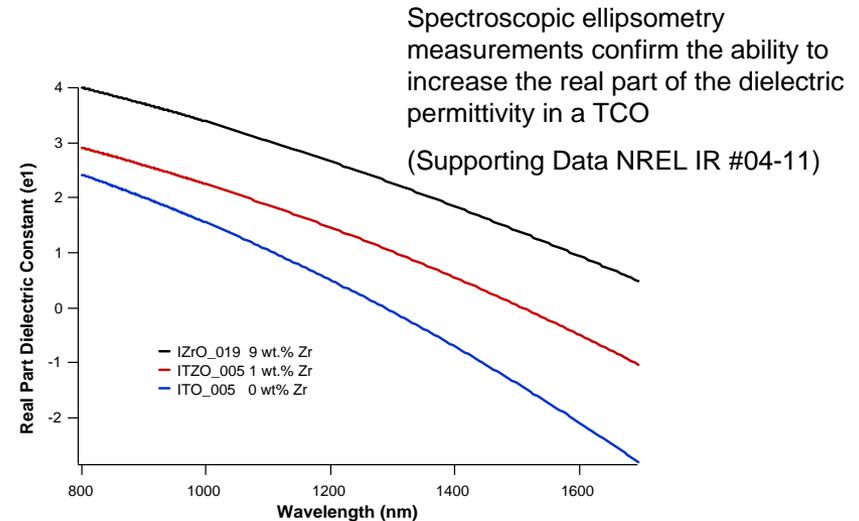


Fill factor strongly correlated with device stability

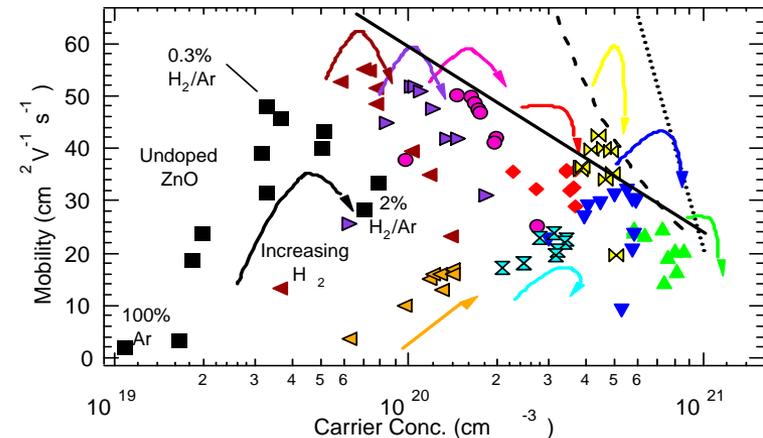
Project Overview (CdTe, Spring 07 - Spring 08)



- **Advancements in Low-Cost Glass/TCO**
 - Completed patent filing necessary to initiate funds-in CRADAs
 - NREL IR #04-11 (High Permittivity TCOs)
 - NREL IR #07-42 (ZnO:V)
 - NREL ROI #08-28 (ROI, Not Filed yet)



R-T-A analysis confirms Drude-Theory prediction that variation of permittivity improves TCO transmission (From NREL IR #04-11)



Data confirms prediction that use of hydrogen and V doping can increase mobility-carrier concentration product beyond that expected from ZnO:Al films (NREL IR #08-28)

Project Alignment with Technology Roadmap



Roadmap Needs	Approaches (FY07 and/or FY08)	FY08
Improve Device Efficiency <ul style="list-style-type: none"> Understand and demonstrate control over key parameters that limit device effic. and reliability. Address fundamental understanding of defects, grain-boundaries, and new materials. Develop methods and metrics to address process potential. 	<ul style="list-style-type: none"> Activity 4.1, Junction Formation Activity 5.3, ZnTe:Cu Contacts Activity 4.2 & 4.4, Defects, Acceptors, and Grain Boundaries Activity 5.3, Modeling Cu Diffusion <p style="text-align: center;">(Subtotal)</p>	<p>\$160K</p> <p>\$45K</p> <p style="color: red;">\$0K</p> <p style="color: red;">\$0K</p> <p style="color: blue;">(\$205K)</p>
Reduce Module/Device Efficiency Gap <ul style="list-style-type: none"> Develop and Test production consistent processes and materials to improve module efficiency 	<p>Activity 3.1, Low-Cost Glass/TCO</p> <p>Activity 3.2, Industry CTO</p> <p>Activity 3.3, Industry ZTO</p> <p>Activity 5.2, Cu_xTe Contacts (inc. Theory)</p> <p style="text-align: center;">(Subtotal)</p>	<p>\$140K</p> <p style="color: red;">\$0K</p> <p>\$55K</p> <p>\$145K</p> <p style="color: blue;">(\$340K)</p>

Project Alignment with Technology Roadmap



Roadmap Needs	Approaches (FY07 and/or FY08)	FY08
Reduce Module Cost Develop and test production-consistent processes and materials to reduce module cost	<ul style="list-style-type: none"> • Activity 2.1, 2.2, 2.3. 2.4 (PDIL Design) • Activity 2.5 (PDIL Tool/Software Integr.) <p style="text-align: center;">(Subtotal)</p>	\$125 \$0K (\$125K)
Improve Reliability Test completed devices to identify degradation mechanisms and establish specific ALT's	<ul style="list-style-type: none"> • Activities 1.1, 1.2, 1.3 (Cell-level Reliability activities) moved to Module Reliability Area in FY08 <p style="text-align: center;">(Subtotal)</p>	\$0K (\$0K)
Alternative processes Develop and test promising materials, devices designs, and process steps that are not a part of present module production	Activity 5.4, ZnCuO for Contacts (Ginley) Activity 7, Evident CRADA (Ginley) <p style="text-align: center;">(Subtotal)</p>	\$110K \$100K (\$210 K)
	FY08 Total	(\$880 K)

Project Update



Past
Future

Planned Work Since Last Program Review	Status
Filing of NREL IR #04-11 (High Permittivity TCOs)	Completed 5/07
Relocate CdTe Research Equipment from SERF to STF	Completed 7/07
Re-Establish CdTe Device Production in STF	Ongoing
Identify CRADA Partners for Low-Cost Glass/TCO Project(s)	Ongoing
Primestar CRADA	Ongoing
Processing for CTO, ZTO, CdS, CdTe, CdCl ₂ , and Contact - in STF	Completed 1/08
Filing of NREL IR #07-42 (ZnO:V)	March 08
Initiate Research on Tandem-junction Thin Films	Ongoing
Report on Fundamental Junction Evolution (Lifetime) with Process	May 2008
Perform CVD Processing for SnO ₂ -based TCO in STF	June 2008
Complete Design Development for CdTe PDIL Platform	June 2008
RFQ for Non-CSS Components of CdTe PDIL Platform	July 2008
CRADA for Low-Cost Glass/TCO with Industrial Partner	August 2008
Filing NREL IR # 08-28	August 2008
RFQ for CSS Components of CdTe PDIL Platform	October 2008

Obstacle Discussion



- Barriers encountered or anticipated that may inhibit success of programs
 - **Reduction of CdTe funding in FY08** has significantly slowed progress on all technical goals
 - FY07 = \$2.3M, FY08 = \$0.88M
 - Limited ability to replace staff (e.g., Wu, Zhou, 'Noufi')
 - Final Specifications for CdTe PDIL Platform RFQ
 - Critical NREL activities now linked to CRADA
 - Production of CdTe devices
 - CdTe cell-level reliability
 - **Significant increase in high-level requests** for industry advice, assistance, and collaboration
 - Has limited time for “science”
 - New and existing device producers
 - Related product producers (Glass, TCOs, Chemical Sources, etc.)
 - All want access and assistance to NREL IP or technology
 - Securing new IP requires significant time of high-level staff