2008 Solar Annual Review Meeting

Session: CPV
Company or Organization: NREL
Funding Opportunity: SETP CPV Technology

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NREL/PR-520-43168
Presented at the Solar Energy Technologies Program (SETP) Annual Program Review Meeting held
April 22-24, 2008 in Austin, Texas

Budget and Solar America Initiative Alignment

National Renewable Energy Laboratory			
Project Beginning Date	**FY07 Budget**	**FY08 Budget**	**Total Budget**
9/1/2006	$2.8M	$2.15M	$4.95M

This project supports the Solar America Initiative by:

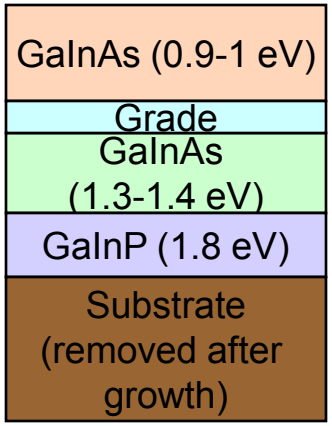
- Reducing LCOE through
  - Increased power output from cell
  - Avenues for lowering of cell cost - substrate recycling
- Establishing reliability by
  - Determination of cell degradation mechanisms
  - Integration of design for reliability into future cell development

Project Overview

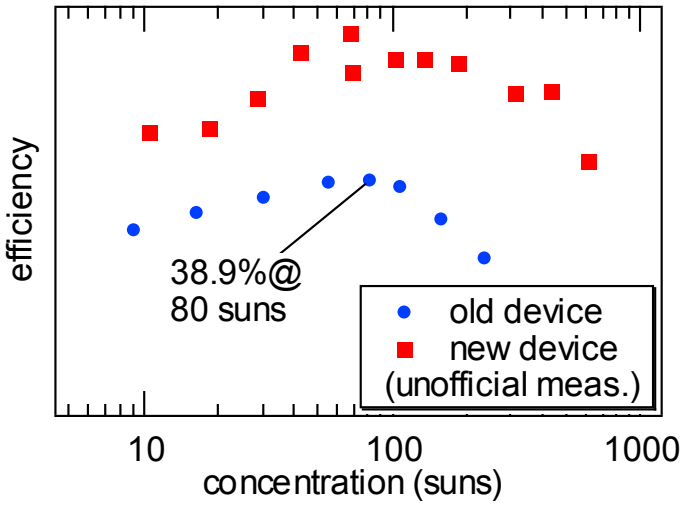
- future-generation cell development
- cell reliability
- advanced modeling for cell-system integration
- basic science supporting cell development
- industry study

Next-generation cell development

Near-term

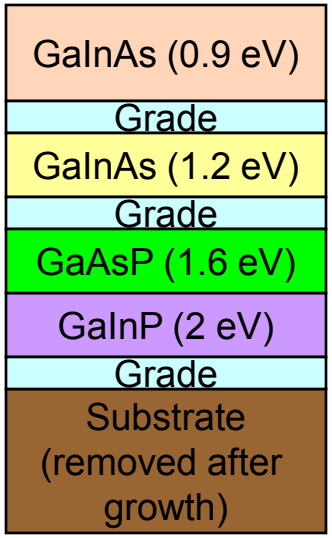


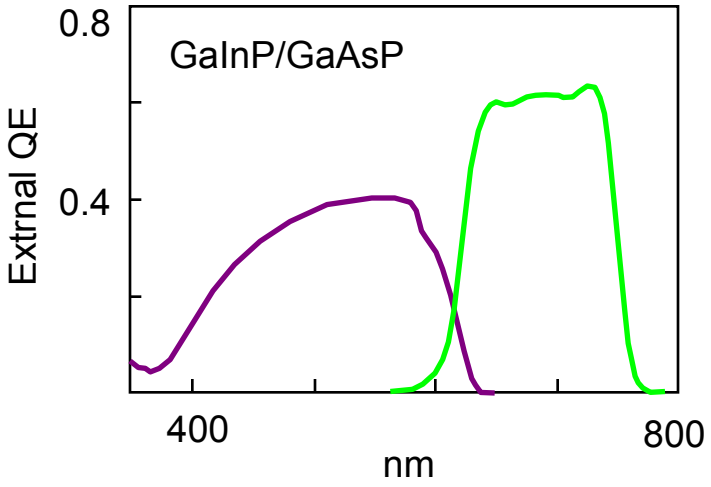
- Demonstrated ~40% eff.
- High-conc operation
- Potential for 45% eff.
- Much industry interest, including SAI partners and others



Next-generation cell development - cont'd

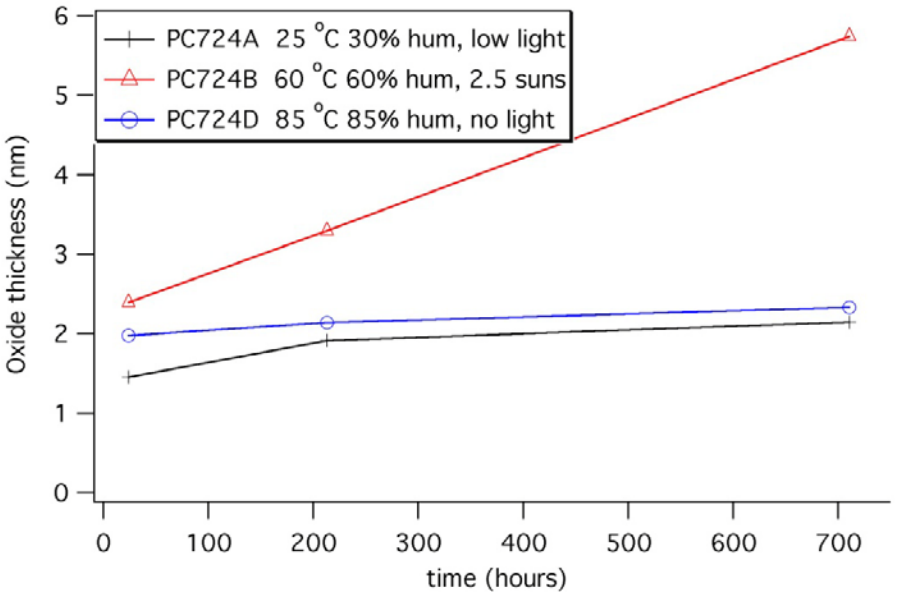
Longer term



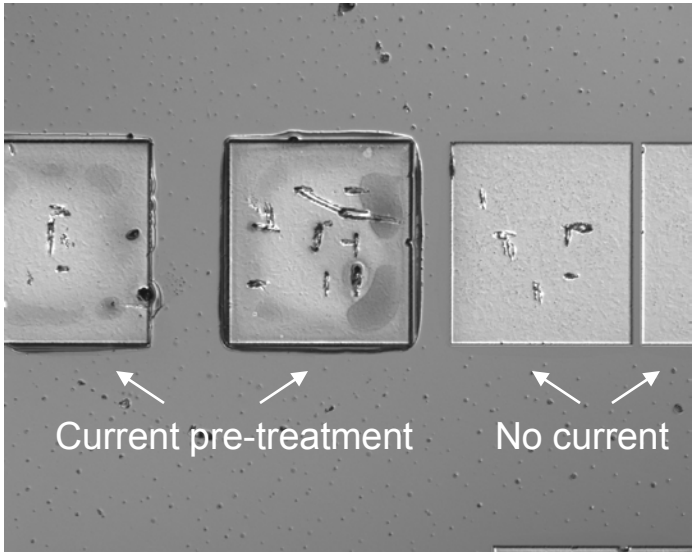


- Top two cells demonstrated
- Potential for 50% eff.

Cell Reliability



AlInP oxidation in various weathering conditions



contact layer and metalization after 100 hrs at 85/85/0

- Potential degradation area identified in initial studies
- Oxidation rates of Al-containg layers quantified

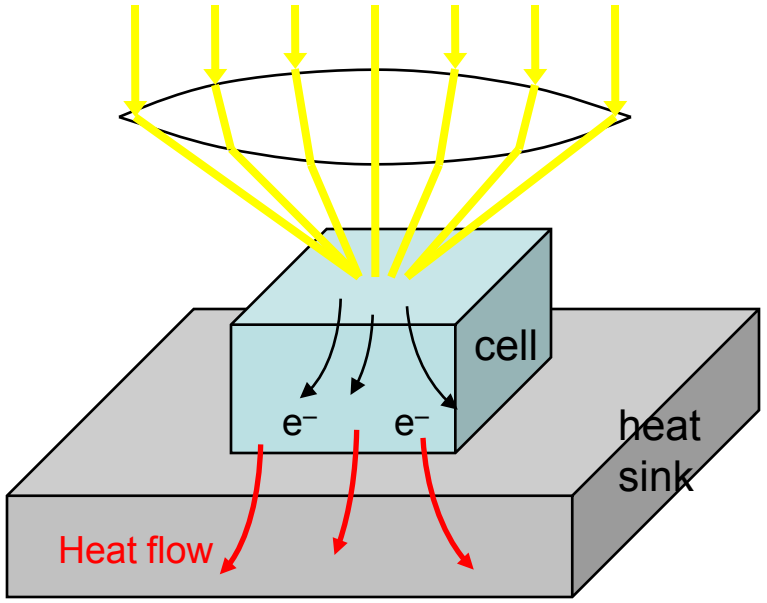
Advanced Modeling

Develop capability to model coupled

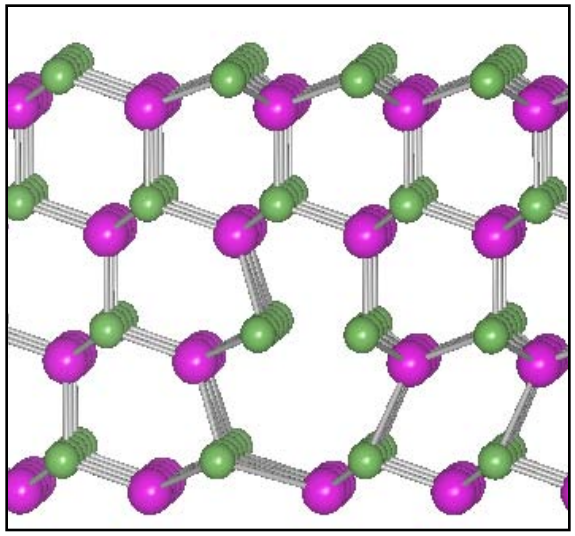
- Inhomogeneous illumination
- 2D and 3D current flow
- 2D and 3D heat flow

Will aid in

- Cell design for real-world systems
- Solution of industry problems -- industry has expressed interest



Basic science supporting cell development



- Preliminary results give improved understanding of modeling of dangling bonds along dislocation core

CPV Industry Study

Study is in progress - areas of study include:

- Current status of CPV systems industry
  - More than 25 CPV systems companies identified worldwide
- Performance rating questions
- Cell supply and reliability issues

Project Alignment with Technology Roadmap

Task addressing the need

Roadmap Need

	Future-gen cells	Cell reliability	Advanced modeling	Epitaxy science
1. Establish reliability of prototypes		✓	✓	
2. Optimize overall system design			✓	
3. Reduce system cost			✓	
4. Increase system efficiency	✓		✓	✓
6. Develop next-gen high-efficiency cells	✓			✓
7. Establish science underpinnings of semiconductor growth and properties				✓

Project Update: Past

Planned work since last Program Review	Status
Demonstrate 300 suns high efficiency inverted triple junction cell	Apr. 2008
Establish optical stress sensor as an in situ probe of relaxation of lattice-mismatched solar cells	Aug. 2007
Transfer the recipe for the inverted triple junction cell to the low-pressure reactor to identify differences in growth of this structure at low pressure	Oct. 2007
Assess potential for further efficiency improvements in inverted three-junction solar cell	Sep. 2007
Grow ~1 eV GaInNAs with Bi surfactant toward achieving >2 μm depletion width in GaInNAs	May 2007; Redirected effort
Advanced modeling: make final selection of software platform, and start to implement	Apr. 08

Project Update: Ongoing / Future

Planned work since last Program Review	Status
Develop iLMM cell with optimized second- and third-junction band gaps	Sep. 2008
Develop first two junctions of advanced iLMM cell	Sep. 2008
Identify critical cell degradation mechanisms, and initiate studies of causes and mitigation	Sep. 2008
Investigate the atomic structures and electronic states of III-V misfit dislocations	Sep. 2008 & ongoing

Multiyear Objectives 2008-2012

Objective	Timeframe
Develop capability to model and optimize performance of cells under real-world conditions in a concentrator system, including effects of inhomogeneous nonnormal illumination; thermal hotspots; and mechanical stress	2008 – 2010
Develop a comprehensive catalog of MJ cell degradation mechanisms; establish the science underpinnings of their root causes; and identify mitigation paths	2008-2011
Develop next-generation broadband antireflection coating optimized for operation under concentrator optics, and suitable for production cells	2009 – 2011
Develop predictive understanding of LMM epitaxy and effects on cell performance	2008 – 2012
Demonstrate 48%-efficient concentrator cell hardened against degradation	2012

Obstacle Discussion

- Key Challenges of CPV in general:
  - More complex than flat plate
  - Much smaller market presence than flat plate
  - Less heritage of reliability/field test data than flat plate
  - Finding space in market between flat plate and solar thermal — continued improvement of system performance will be critical
- iLMM cells:
  - Inherent reliability
  - Cost of processing
- Programmatic:
  - Capital equipment needs