2008 Solar Annual Review Meeting

Session: Film Silicon
Institute of Energy Conversion
University of Delaware
Funding Opportunity: **TPP (Dow Chemical, GE, Konarka)**
Incubator (SoloPower)
Future Generation
University (two programs)

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Budget and Solar America Initiative Alignment

Organization	Start Date	FY07 Budget	FY08 Budget	Total Budget
DOW CHEMICAL				472,875
GE	09/01/07	14,000	94,684	451,232
KONARKA	07/01/07	38,745	156,712	486,049
SOLOPOWER*	01/01/08		75,000	150,000
FUTURE GENERAT	02/01/08		120,000	1,163,315
UNIVERSITY SAI	06/01/08			1,870,903
UNIVERSITY SAI	06/01/08			1,848,024

* 18 month program

- These projects support the SAI in near and long term:
  - Fundamental materials engineering and new device structures
  - Scale up of existing technologies
  - Lessons learnt in one program feed into the others

Projects cover Film and Silicon

TPP & Incubator Participant

- ***Fully Integrated Building Science Solutions for Residential & Commercial Photovoltaic Energy Generation*** **- Dow Chemical Company**
- ***A Value Chain Partnership to Accelerate US PV Growth*** **- GE Energy LLC**
- ***BIPV Dye Cell/Organics PV -*** **KonarkaTechnologies, Inc.**
- ***CIGS Technology Based on Electroplating*** **- SoloPower**

IEC/UD Programs

- ***Novel Approaches to Wide Bandgap CuInSe2 -Based Solar Cells***
- ***Development of a Low-Cost Insulated Foil Substrate for CIGS Photovoltaics***
- ***High-Efficiency Back Contact Silicon Heterojunction Solar Cells***

University of Delaware

Novel Approaches to Wide Bandgap $CuInSe_2$-based Solar Cells

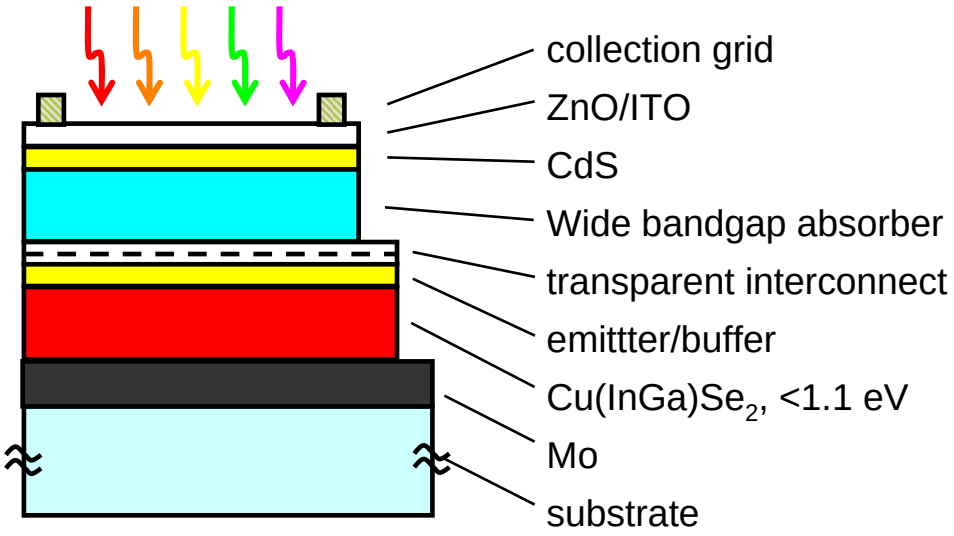
Technologies Addressed

Thin Films

Description

Development of a highly efficient, wide bandgap, CuInSe2 chalcopyrite-based solar cell, which is necessary for polycrystalline tandem devices. Laser processing will be used to control defects, which will improve the performance of the cell.

Target Efficiency	15% (single jcn) 2010



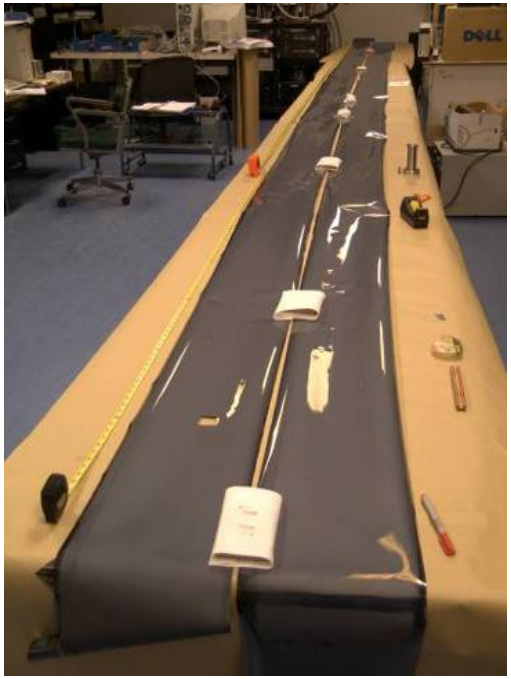
Resources ($)

Total Project	DOE Funds	Cost Share
$1,163,315	**$900,000**	**$263,315**

University of Delaware with Dow Corning

Institute of Energy Conversion

Development of a Low Cost Insulated Foil Substrate for CIGS Photovoltaics



Technologies Addressed

Insulating substrate for high temperature CIGS deposition.

Description

Develop a low-cost stainless steel flexible substrate coated with silicone-based resin dielectric and monolithic integration technology applicable across a variety of roll-to-roll (R2R) CIGS manufacturing techniques.

Target Efficiency	R2R devices ≥ 12%

Resources ($)

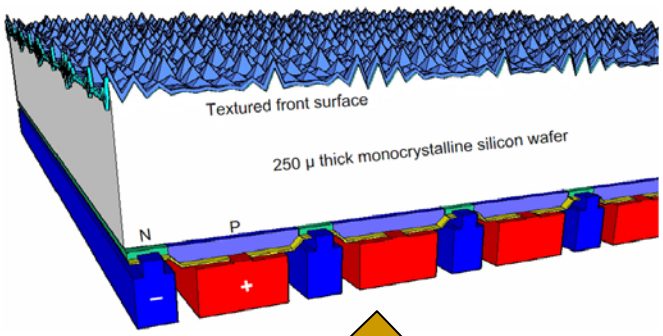
Total Project	DOE Funds	Cost Share
$1,848,024	**$1,478,331**	**$369,693**

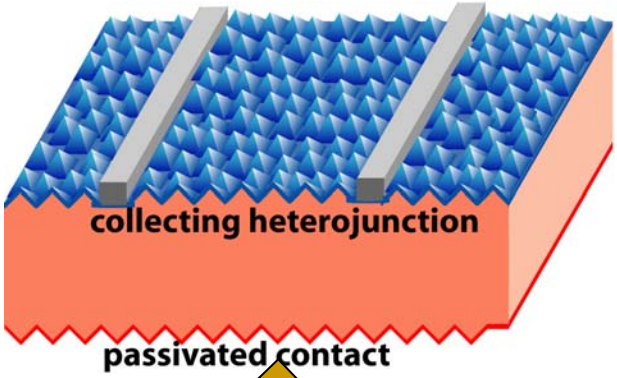
Overview

High-Efficiency Back Contact Silicon Heterojunction Solar Cells

- Project brings the amorphous/crystalline silicon heterojunctions (SHJ) to Sunpower's back contact cells.
- Low cost of a-Si deposition technology.
- A way to approach the efficiency limit of Si solar cells at 29% in a manufacturable way.
- Sunpower has a proven track record in high volume, high efficiency technologies.

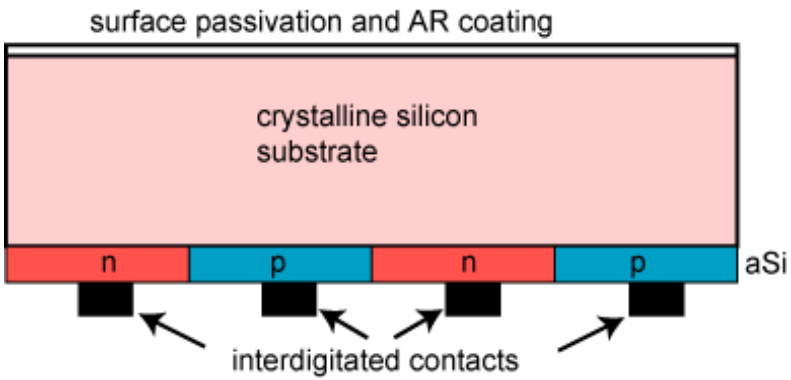
Interdigitated back contact silicon heterojunction (IBC-SHJ)





- High Jsc and FF of IBC

- High Voc of SHJ



- New solar cell structure implements an interdigitated back contact solar cell using silicon heterojunctions (IBC-SHJ)

Project Alignment with Technology Roadmap (High efficiency single crystal Si Cells)

Roadmap Need	Approach
1.Thinner wafers	IBCs improve with thinner wafers
2. Surface passvation	SHJ have shown the lowest surface recombinaton and highest Voc
3. Light management	IBC eliminates front shadowing
4. Low recombination contacts	SHJ show highest Voc without selective emitters
5. Feedstock cost	Use of defect tolerant *n-type* material

Addresses reduced module fabrication costs through IBC, Excellent watts/gm of Si.

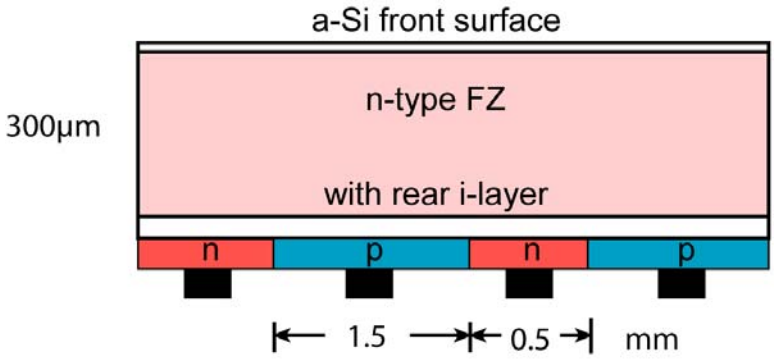
Project Timeline

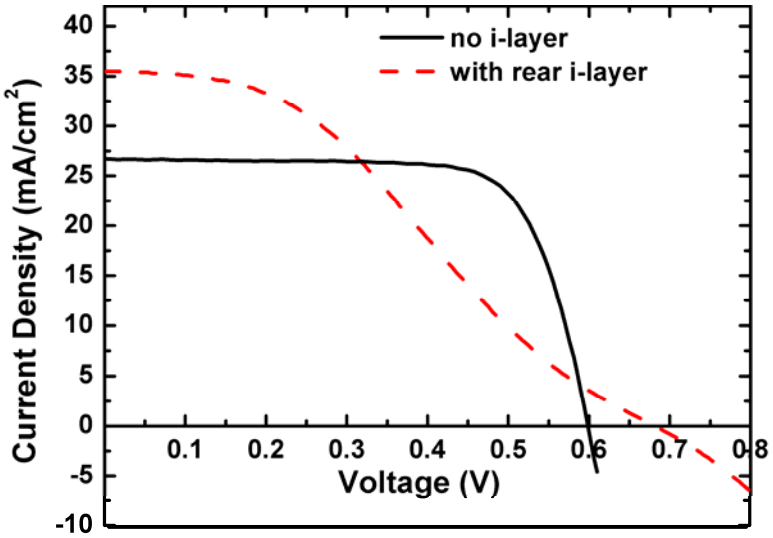
Task	Focus year
Task 1. Low temperature, high transparency passivation layers and methods including organic and inorganic materials	Y1
Task 2. Develop wide bandgap heterojunction emitters and base contacts for c-Si including modeling, UPS and XPS characterization	Y1 & Y2
Task 3: Fabricate all back contact solar cells with a heterojunction contact and emitter	Y3

Device Fabrication

Effect of adding rear i-layer

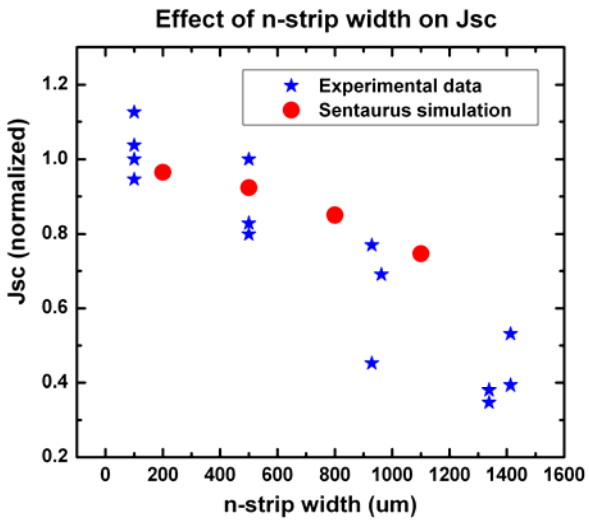
- Improves surface passivation
  - Increases the Voc to 691 mV
  - Increases Jsc
- IV curves has S-shape
  - Large decrease in the fill factor
  - Previously a problem with front junction devices, but solved with optimization

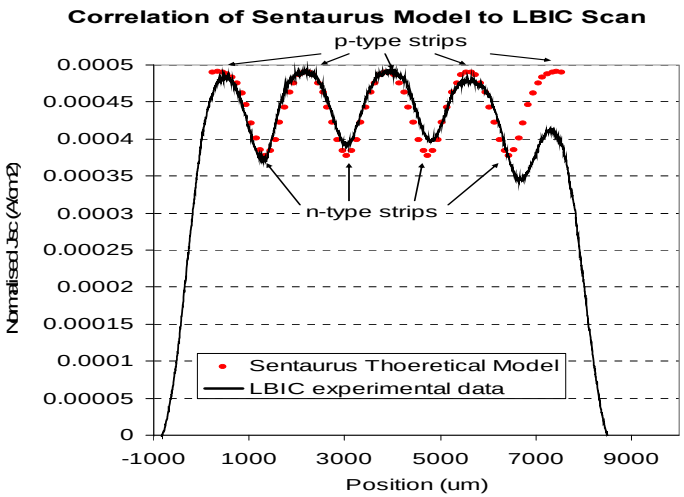




Sentaurus Modeling

- Sentaurus (incorporating DESSIS) models 2D and HJ
- a-Si properties matched to measured material properties
- Predictive 2D model for silicon heterojunctions





Efficiency Modeling

- Using existing device structure, Sentaurus modeling shows efficiencies of 22.7%
- Full device optimization shows a capability of 26% for future devices
  - Improved light trapping
  - Better front surface passivation
  - Conduction across heterojunction
- Substantial design flexibility: E.g. can use other heterojunction materials - since no light shines through the HJ it can even be opaque.