2008 Solar Annual Review Meeting

Session: Organic Photovoltaics, Sensitized Cells, and Seed Funds
Company or Organization: SNL/NREL
Funding Opportunity: DOE Seed Funds

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Budget and Solar America Initiative Alignment

SNL/NREL				
Project	**Project Beginning Date**	**FY07 Budget**	**FY08 Budget**	**Total Budget**
Thin c-Si	1/15/2008	$0k	$359k	$1,077k (3 yr)
Thin III-V	1/15/2008	$0k	$223k	$669k (3 yr)

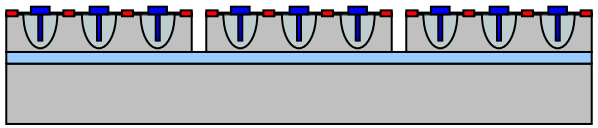
- **This project supports the Solar America Initiative by:**
  - C-Si material used significantly more efficiently (20 micron thick cells with a few microns of “kerf” loss).
  - III-V material used significantly more efficiently through epitaxial lift-off and/or other release methods. Substrate reused for subsequent cell growth.
  - Reduced material costs leads directly to lower cost per watt for solar power.
  - Small dimensioned cells lend themselves to high-volume, parallel self-assembly in roll-to-roll fashion. (Assembly R&D is not in the scope of this project.)
  - Small dimensioned cells provide system level benefits to concentrated PV systems.

Project Overview: Thin c-Si cells

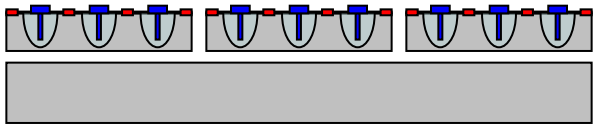
Thin c-Si PV cells are approximately 20 microns thick with back contacts.

SOI wafer

Create micro-PV cell then anisotropically etch between cells to buried oxide layer.



Release from handle wafer using an HF based release etch.



After release, the handle wafer can be reused to create a new SOI wafer.

Similar process possible with KOH and (111) oriented wafers. We are also considering other approaches.

Demonstrated to date

- Demonstrated lift-off of 20 micron thick c-Si chips.
- Demonstrated fabrication and lift-off of 20 micron thick c-Si cells (i.e. with a junction).

Released 20 micron thick c-Si chips with lateral dimensions from 0.25 mm to 10 mm.

Project Overview: Thin III-V cells

Grown release layer (epitaxial lift-off)

Grow release layer (AlAs) followed by the PV cell layers then anisotropically etch between cells to release layer.

Release from substrate with selective etch chemistry.

After chip release, substrate can be reused.

Implanted release layer

Implant oxygen into germanium substrate and anneal to create buried germanium oxide layer. Grow PV cell then anisotropically etch between cells to buried germanium oxide layer.

Release from substrate using water as a release etchant.

After release, the remaining wafer can be reused.

Ability to self-assemble small lateral dimensioned and thin cells may mitigate interlayer fracturing seen in large area ELO and decrease etch time.

Project Alignment with Technology Roadmap

Technology Roadmap Needs

Film-Silicon PV

- Develop inexpensive large-grain or single-crystal, high-quality c-Si film growth processes or materials for use with low-cost substrates.
- Develop inexpensive, reduced temperature processing for c-Si films

Wafer-Silicon PV

- Thinner wafers and processing
- Reduced Si waste

Concentrator PV

- Reduce system cost
- Increase system efficiency

Approaches Used to Address Needs

- Ultimate goal of project is to manufacture very thin c-Si and III-V PV cells that can be assembled onto an inexpensive substrate. This assembly can provide densely packed arrays of small cells for one-sun modules or sparsely packed for concentrator modules.

- All film depositions and dopant diffusions are done prior to assembling the PV cells on the low-cost substrates. This means that low-temperature substrates are compatible with the process flow.

- Silicon and III-V material waste is significantly reduced due to the reuse of substrates after lift-off of PV cells.

- Concentrator systems with smaller dimensioned cells allow more efficient optical systems, significantly simpler/more efficient heat dissipation, and simpler tracking.

Project Update

	Planned work since last Program Review	Status
Past	Lift-off c-Si chips using SOI/HF approach	Feb-08
	Lift-off c-Si PV cells using SOI/HF approach	Apr-08
	Perform high quality epitaxy of c-Si on SOI seed layer	Apr-08
Future	Lift-off c-Si chips using (111) Si/KOH approach	Anticipated May-08
	Lift-off c-Si PV cells using (111) Si/KOH approach	Anticipated June-08
	Characterize SOI c-Si PV cell performance	Anticipated Aug-08
	Characterize (111) c-Si PV cell performance	Anticipated Aug-08
	Lift-off III-V PV cells using ELO approach	Anticipated Aug-08
	Characterize III-V ELO PV cell performance	Anticipated Dec-08

Obstacle Discussion

- Anticipated Challenges
  - Ultimate success of this project depends on ability to handle and assemble small and thin PV cells in large numbers at low cost (self-assembly).
  - Surface passivation of lift-off surface may need to be done post lift-off.
  - Porting process flow to very low-cost tools that would be used in commercial production.
  - Making electrical contact to each cell.