2008 Solar Annual Review Meeting

Session: Film Silicon
Company or Organization: United Solar Ovonic LLC
Funding Opportunity: SAI Technology Pathway Partnerships

Dr. Subhendu Guha

United Solar Ovonic
3800 Lapeer Road
Auburn Hills, MI 48326

Phase I Budget and Solar America Initiative Alignment

United Solar Ovonic LLC			
Project Beginning Date	**FY07 Budget**	**FY08 Budget**	**Total Budget**
4/30/2007	$ 1,121,938	$ 8,123,286	$ 9,245,224

- This cost-shared project supports the Solar America Initiative by:
  - Reducing costs in the following four key areas of Building-Integrated PV Systems to contribute to the goal of grid parity by 2015
    - Modules
    - Inverter and BOS
    - Systems Engineering and Integration
    - Deployment Facilitation

Project Overview

Objective:

To demonstrate LCOE of 12.8 c/kWh by year 2010 and 7.6 c/kWh by 2015 for BIPV systems on commercial buildings using lightweight, flexible, and aesthetically pleasing thin film PV arrays and installations.

Approach:

We have Identified specific cost centers to achieve the LCOE goals. We have assembled a great team drawing experts from industries, universities, and national laboratory to address the SAI goals. The program follows the stage gate approach with milestones and deliverables at the end of each phase.

Amorphous Silicon Alloy Solar Panels

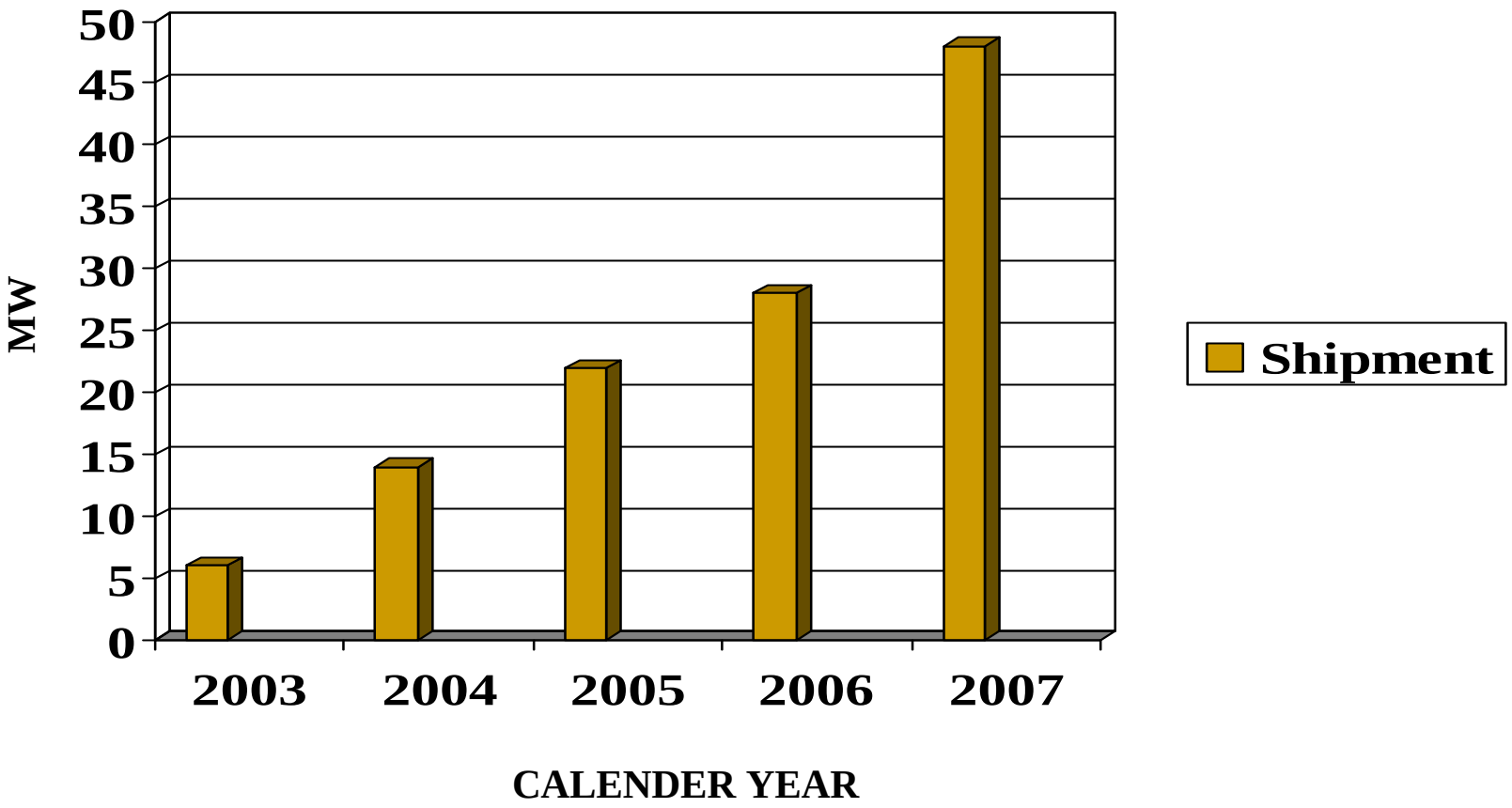
Advantages

- Low material cost
- Short energy pay back time
- More electricity per rated power
- Environmentally safe
- Rugged and flexible products
- Ideal for building integration

Challenges

- Light-to-electricity conversion efficiency
- Manufacturability at low cost and high yield

GROWTH IN UNI-SOLAR® ANNUAL SHIPMENT

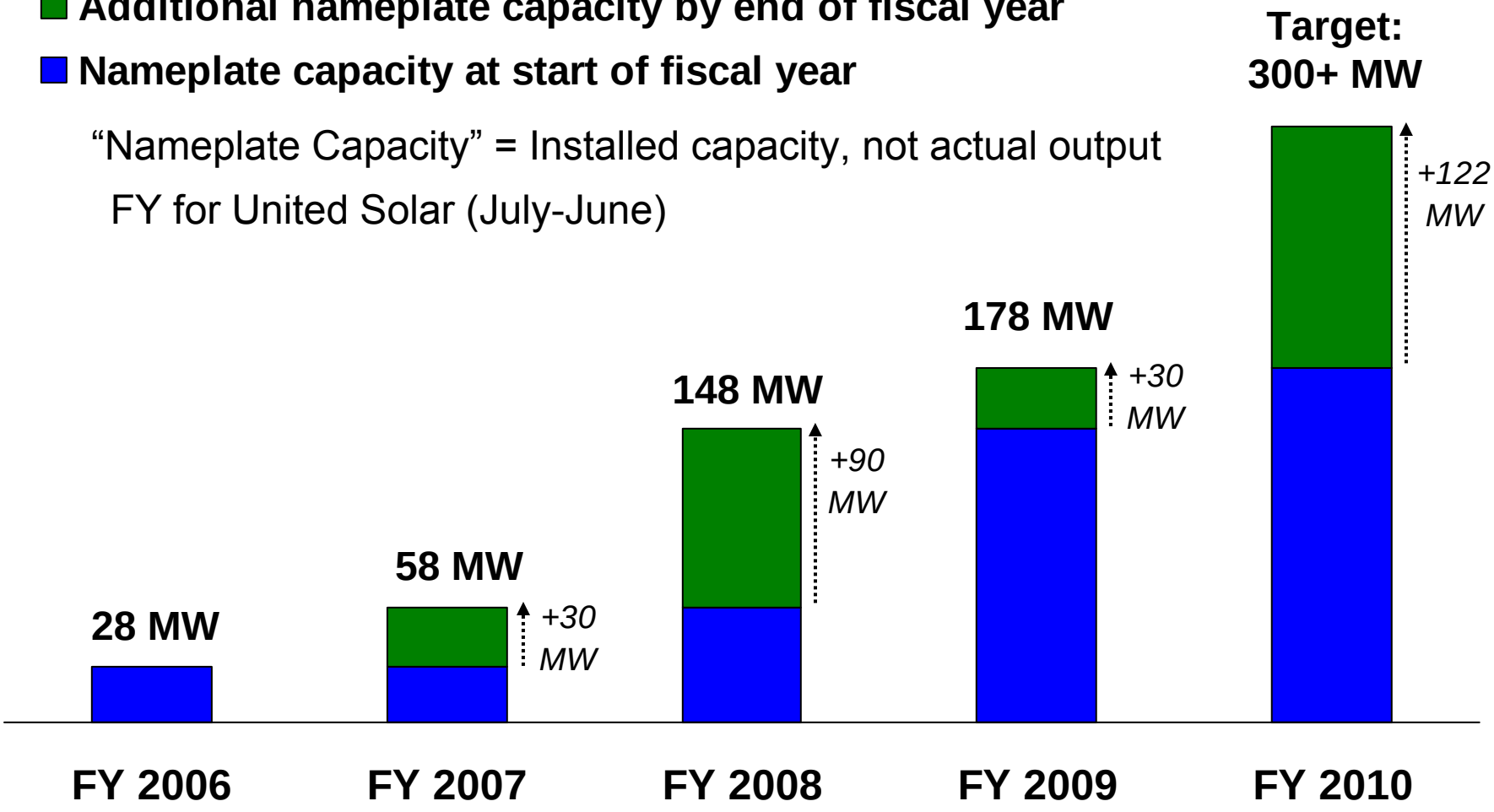


Nameplate Capacity Expansion

- **Additional nameplate capacity by end of fiscal year**
- **Nameplate capacity at start of fiscal year**

"Nameplate Capacity" = Installed capacity, not actual output

FY for United Solar (July-June)

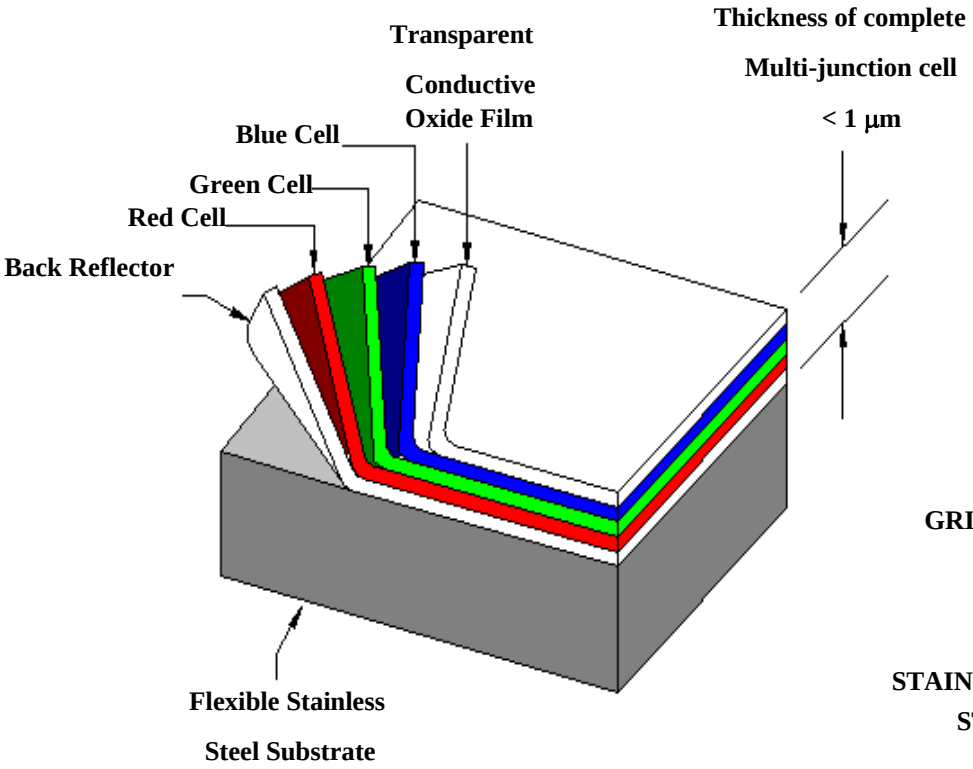


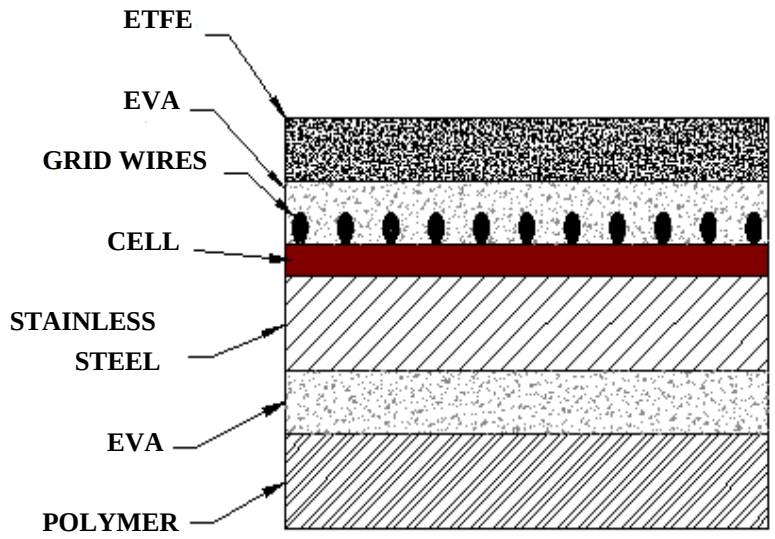
2006 Cost Structure for Large Commercial BIPV Installation

Modules:	59%
Inverter & BOS:	17%
Installation:	8%
Deployment/Indirect:	17%

Current LCOE in CA 16-20 c/kWh

Triple-Junction Solar Cells and Packaging





Project Update

Phase I key Stage Gate Milestone	**Current Status**
NREL confirmed ~9.2% stable total-area (0.268 cm^2) cell efficiency on multi-junction device incorporating nc-Si:H, using small-area MVHF batch reactor on Al/ZnO back reflector with production condition constraints.	We have achieved a stabilized total-area solar cell efficiency of **9.5%** using an a-Si:H/a-Si:H/nc-Si:H triple-junction structure after 100mW/cm^2 light-soaking for 1000 hours at 50°C. Samples will be sent to NREL for confirmation.

Project Update

Phase 1 Key Stage Gate Milestone	**Current Status**
Attain uniformity ≥90% for a-Si:H, a-SiGe:H, and nc-Si:H layers deposited over a large area (450 cm^2) using a MVHF batch machine. Thickness measurements to be made by an optical technique on various regions of the film.	We have achieved ≥81%, 85%, and 83% uniformity for a-Si:H, a-SiGe:H, and nc-Si:H layers over an area of 450 cm^2 using a large area MVHF batch machine.

Project Update

Phase 1 Key Stage Gate Milestone	**Current Status**
Deposition of nc-Si:H over 50” wide cathode at 0.6 nm/sec with uniformity better than 90% over 42”, with photoconductivity and morphology similar to small area VHF research samples. Thickness measurements to be made by an optical technique on various regions of the film.	We have achieved uniformity better than 90% over the entire 42” x 8” substrate area for a-Si:H depositions. The deposition rate is higher than 0.8 nm/sec. We are now working on nc-Si:H deposition.

Project Update

Phase 1 Key Stage Gate Milestone	**Current Status**
Build and install VHF cathode in large area MVHF batch reactor and deposit films with ≥ 90% thickness uniformity over an area of 450 cm^2. Thickness measurements to be made by an optical technique on various regions of the film.	We have designed and built a large area MVHF batch reactor and developed a high rate a-SiGe:H deposition process (8-11Å/sec). 85% thickness uniformity has been achieved for the high rate a-SiGe:H over an area of 450 cm^2.

Project Update

Phase 1 Milestone	**Current Status**
Attain ≥ 8.0% stable total-area (0.268 cm^2) efficiency on a-Si:H/a-SiGe:H/a-SiGe:H triple-junction device, using small-area MVHF batch reactor on Al/ZnO back reflector with a-Si:H and a-SiGe:H cells deposited at ≥ 0.6 nm/s, which is twice the rate of that in the roll-to-roll production machine.	We have achieved a stabilized total-area efficiency of **9.0%** using an a-Si:H/a-SiGe:H/a-SiGe:H triple-junction structure after 100mW/cm^2 light-soaking for 1000 hours at 50°C. Samples will be sent to NREL for confirmation.

Project Update

Phase 1 Milestone	Current Status
Achieve power rating of 140 W on the 22L product.	More than 70% of 22L laminates meets the 140 W Phase I milestone by optimizing the deposition parameters. We are also developing a cell blending process to further increase the proportion of high-power modules.

Key Metrics

Task	Goal	Current Status
Optimize multi-junction solar cells incorporating nc-Si under manufacturing constraints	Demonstrate total area stable cell efficiency >9.2%	Attained efficiency ~9.5% at United Solar, to be confirmed by NREL
Deposit a-Si, a-SiGe, and nc-Si films using MVHF	Demonstrate uniformity >90% over 450 cm^2	Achieved uniformity >81% for a-Si, >85% for a-SiGe, and >83% for nc-Si
Deposit nc-Si films at high rate using large area reactor	Demonstrate uniformity > 90% at 0.6 nm/s over ~2700 cm^2	Attained uniformity >90% for a-Si at 0.8 nm/s as baseline, started nc-Si work
Deposit a-SiGe films at high rate using VHF under manufacturing constraints	Demonstrate uniformity > 90% over 450 cm^2	Achieved uniformity >85% for a-SiGe at 0.8-1.1 nm/s over 450 cm^2

Summary

- The entire program is progressing very well. We have not encountered any major obstacles. We are on track with all Phase I Key Stage Gate Milestones.
- We are working closely with our subcontractors, University of Oregon, Syracuse University, Colorado School of Mines, and National Renewable Energy Laboratory, to improve our fundamental understanding of the thin film materials and solar cells.
- We are making good progress on (1) *in-situ* deposition monitoring, (2) cost reductions in module fabrication and encapsulation, and (3) system engineering and integration.