2008 Solar Annual Review Meeting

Session: CIGS
Company or Organization: Nanosolar
Funding Opportunity: Technology Pathway Partnership

Brian Sager
Nanosolar, Inc.
5521 Hellyer Avenue
San Jose, CA 95138
bsager@nanosolar.com

nanosolar

Budget and Solar America Initiative Alignment

Nanosolar			
Project Start	**Phase I**	**Phase II**	**Total Budget**
Sep-07	$19.6MM	$21.7MM	$42.6MM

This project supports the Solar America Initiative by:

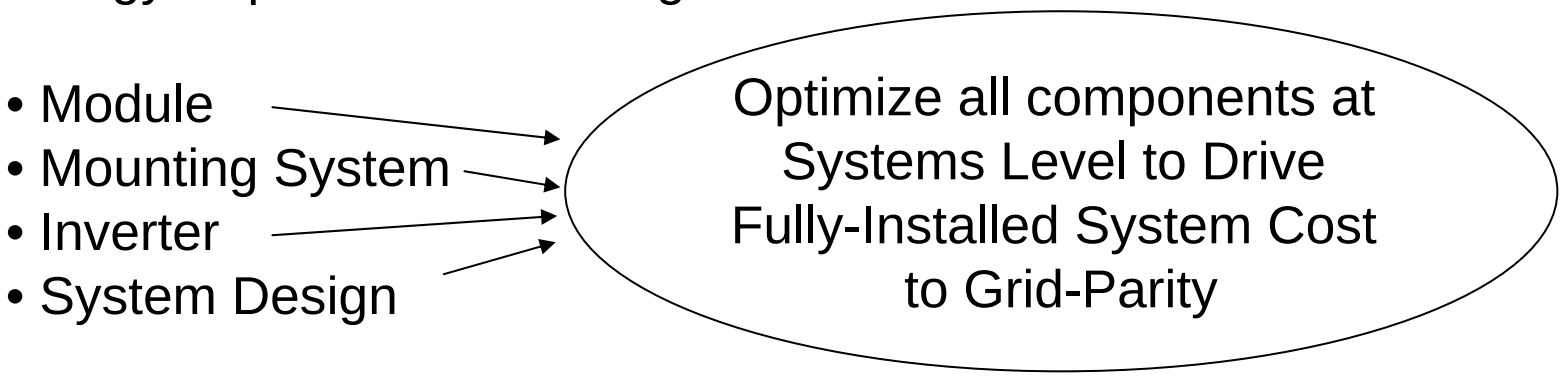
- *Optimization of module production processes which*
  - enable grid parity PV economics
  - enable high production volume
- *Top-down Integration of System Components to minimize fully installed system cost*
  - PV Module
  - Mounting
  - Cabling
  - Inverter
  - System Deployment Practices
- *Focusing on large-area system deployments (>MW)*

Project Overview

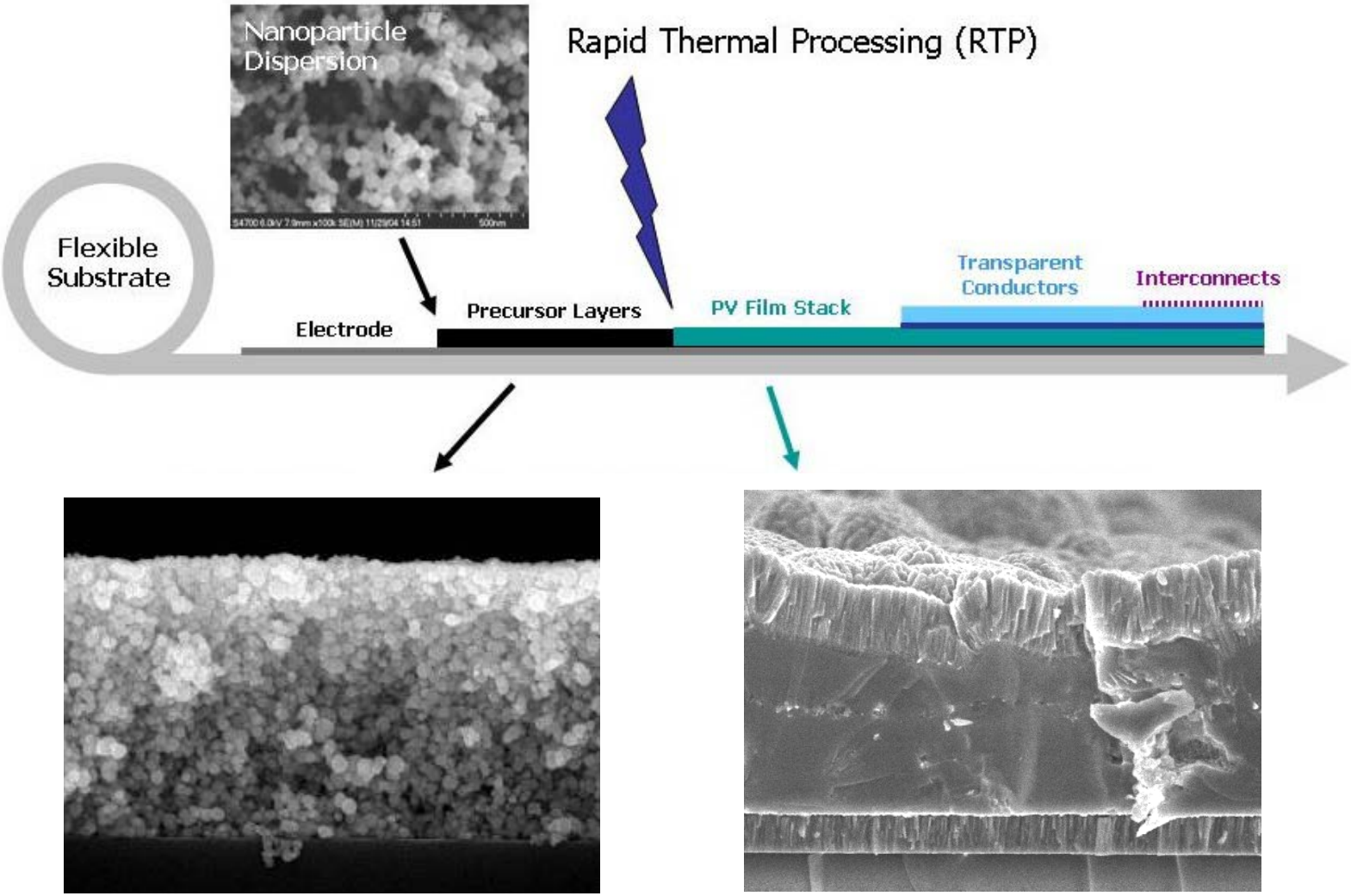
• Nanosolar has developed a nanoparticulate printing process that permits the rapid and high-throughput production of solar modules. The economics of the Nanosolar printing process substantially reduce cell cost

• Nanosolar has developed low-cost module packaging tuned for minimized system installation costs

• Achieving grid-parity PV system economics using Nanosolar technology requires further design innovations:

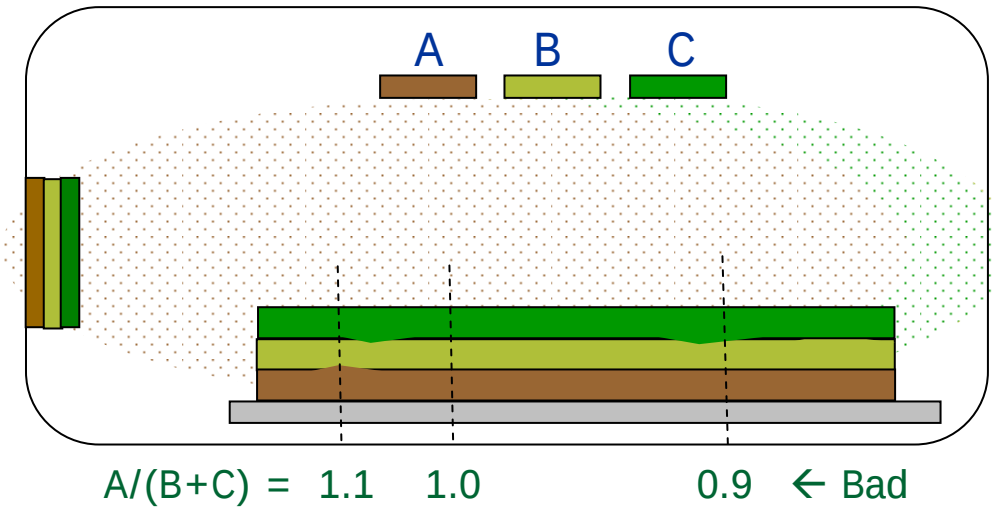


Roll-to-Roll Printing of CIGS onto Flexible Foil

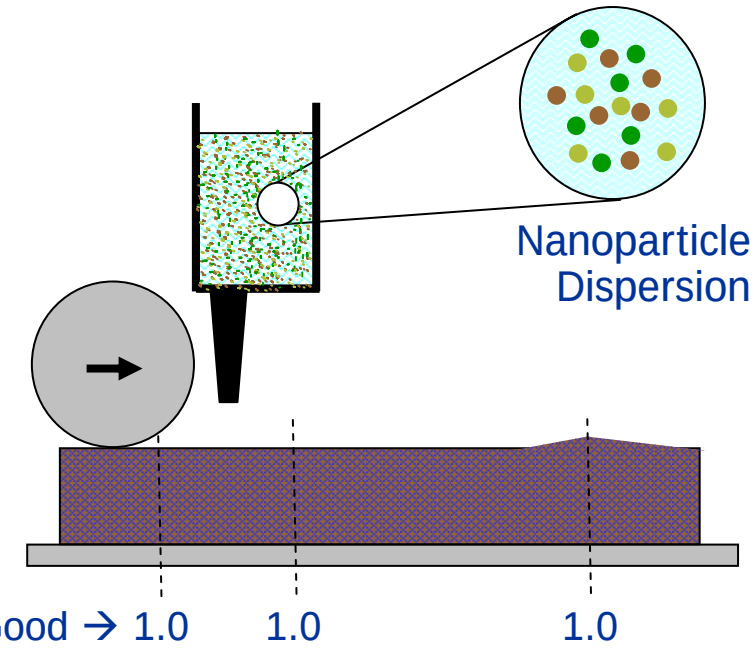


Advantages of Printed CIGS

Multi-Source Vacuum Deposition

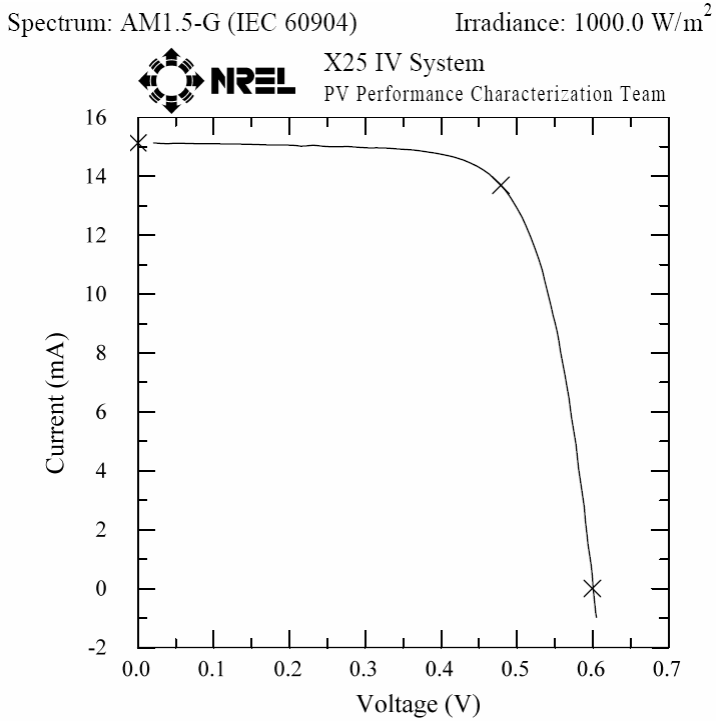


Nanosolar: Printing



	Synchronization Challenge	**Built-in Reproducibility**
Materials Utilization	30-60%	Near 100%
Throughput/CapEx	1x	10…100x

Performance of CIGS Solar Cells



V_{oc} = 0.5993 V
I_{sc} = 15.131 mA
J_{sc} = 32.193 mA/cm^2
Fill Factor = 72.31 %

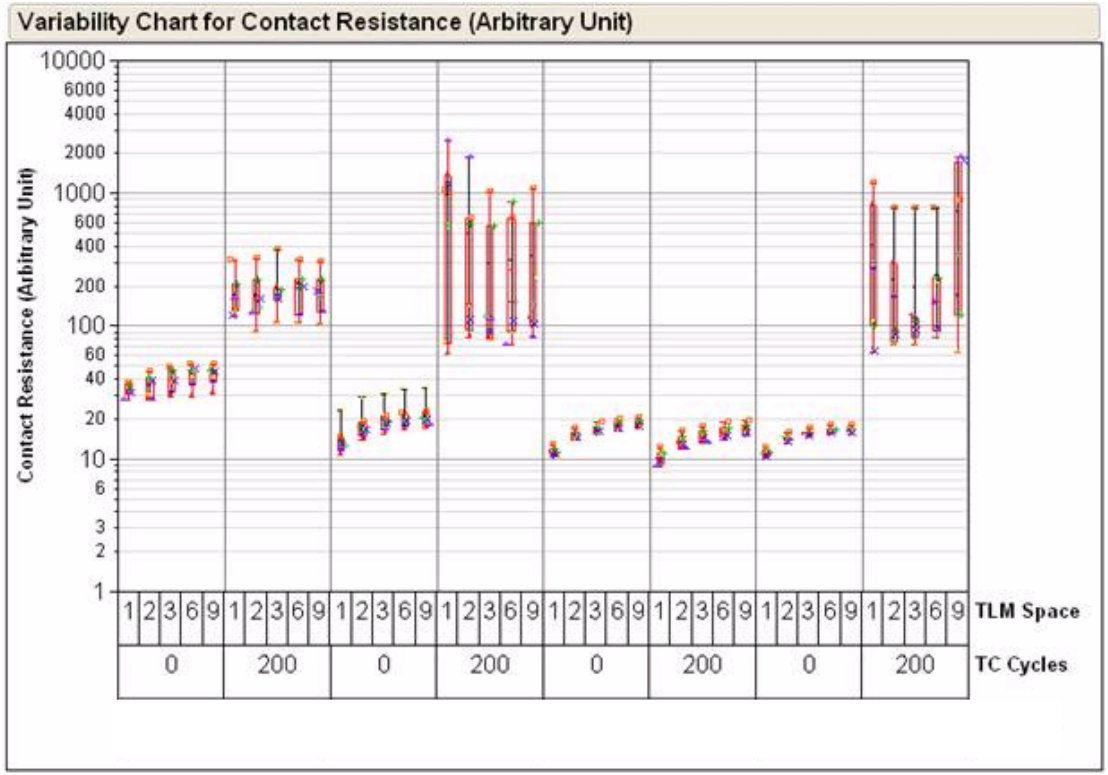
I_{max} = 13.693 mA
V_{max} = 0.4788 V
P_{max} = 6.5566 mW

- 14% total-area efficiency (no AR coating) measured by NREL
- Translates to ~14.5% active-area efficiency
- Highest reported efficiency fabricated using a particle-derived CIGS film

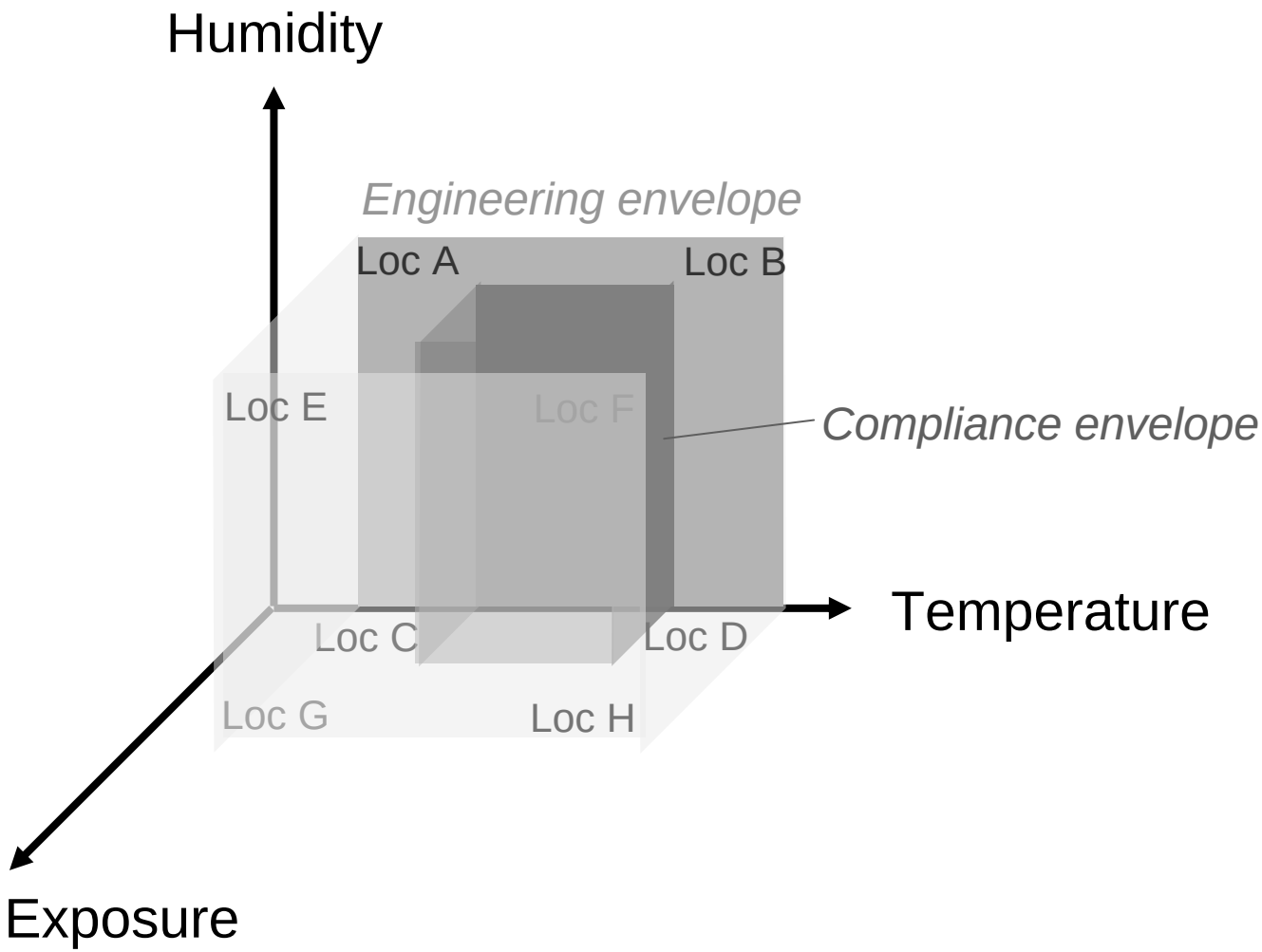
Indoor Aging of Nanosolar Module Components

Example: Grid Optimization

- Multiple Grid materials were tested for contact resistance loses during thermo-cycling.
- Stable and unstable responses were found that aided in the down-selection



Outdoor Testing Regime for Nanosolar Modules



Project Alignment with Technology Roadmap

What needs in the Technology Roadmap are your project responding to?

What approaches are you using to address those needs?

Need	Significance	Approach
• Develop alternative fabrication processes	• Reduce manufacturing cost by using lower-cost processing	• Printing of CIGS with high compositional and dimensional uniformity
• Higher throughput deposition	• Effective equipment depreciation	• High-speed roll-to-roll printing and processing on flexible foil substrates
• Improve schemes outside CIGS layer	• Improved reliability durability of thin-film PV	• Development of back-contacted cells on foil substrates
• Develop protocols to assess CIGS module reliability	• Enhance quality of durability testing	• Outdoor exposure testing for determination of failure modes and comparison with accelerated aging tests

Project Update – Planned Work Since Last Program Update

- All first set of tasks completed on or ahead of schedule
- All first tasks completed on or under budget
- Milestones met substantially ahead of schedule
- Currently in second project phase

Obstacle Discussion

- Technical Challenges for CIGS
  - Lack of predictive models that quantitatively describe the 3-D formation of CIGS films under different processing conditions
  - Lack of accelerated aging tests with predictive power to 25 years

- Challenges for U.S. Solar Market
  - Lack of Feed-In Tariff Framework in U.S.
  - Volatility of Federal policies (e.g. ITC)
  - Non-harmonization of state and local incentives
  - Insufficient system integration capacity for large-scale deployments