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# 2008 Solar Annual Review Meeting

**Session: Film Silicon**

**Company: Blue Square Energy**

**Funding Opportunity: PV Incubator**



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# Budget and Solar America Initiative Alignment



<b><i>Blue Square Energy</i></b>			
<b>Project Beginning Date</b>	<b>Phase I</b>	<b>Phase II</b>	<b>Total Budget</b>
11/9/2007	\$2,168,847	\$2,236,380	\$4,405,227

## **Incubator Subcontract addresses Film-Silicon PV, c-Si Film Roadmap components:**

- Develop inexpensive large-grain, high-quality c-Si film growth processes and materials for low-cost substrates: developing proprietary deposition process
- Develop inexpensive, high temperature (>600 C) substrates for c-Si films: developing low-cost substrate materials and processes with industry partners
- Develop, automate, and scale up deposition equipment for c-Si film fabrication: BSE cost-share component -- production proto system
- Develop improved characterization of c-Si films and establish key measures of quality (needed for volume production control)
- Develop light-management strategies for weakly-absorbing c-Si films

# Blue Square Energy Company Overview



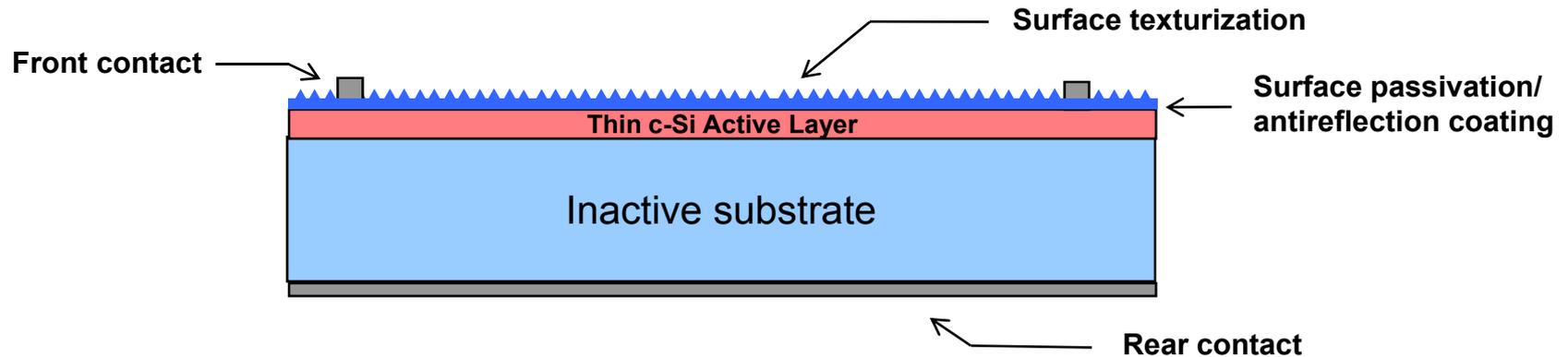
## Large-area (300 mm) Low-cost Solar Cell Manufacturing

- Formed technical team with extensive expertise (>60 man-years) in low-cost solar cell manufacturing in 2004
- Built 9 MWa of “recycled wafer” solar cell capacity in six months
- 25,000 SF factory located in North East, MD
- Profitable in 12 months; number of employees: 34

## High Performance Thin Crystalline Silicon Solar Cells

- Initial R&D on Bright Point technology began in 2004
- DOE SAI Incubator -- Subcontract start in November '07
- Number of R&D engineers and techs: 11

# Bright Point Solar Cell Technology



- Baseline architecture efficiency -- 14%; 20+% potential
- Low-cost, high-temperature, inactive substrate
- High-performance, thin crystalline silicon active layer
- Proprietary silicon solar cell manufacturing processes
- Two patents pending

# Active Layer Reaction Chamber



- Proprietary 5 MWa active layer c-Si growth system developed
- High purity, thin silicon layer (~10 microns) @ < \$0.10/Watt
- Pilot production deposition system at qualification testing
- Scalable machine design; capital cost less than \$500k/MW
- Replication and capacity build out scheduled for Q4/2008



## Project Alignment with Technology Roadmap

Need	Significance	BSE Approach
Develop inexpensive large-grain or single-crystal, high-quality c-Si film growth processes for use with low-cost substrates	Higher efficiency than amorphous, but lower cost than wafer-based silicon	<b>Develop unique design and process to form high-quality c-Si films on low-cost substrates</b>
Develop light-management strategies for weakly absorbing c-Si films	Increased efficiency	<b>Incorporate surface texturing and other light steering mechanisms to enhance light absorption</b>
Develop inexpensive, high-temperature (>600°C) substrates for c-Si films	Reduced cost	<b>Utilize both proprietary and available materials and common wafer processes to produce proprietary low-cost substrates</b>
Develop, automate, and scale up deposition equipment for c-Si film fabrication	Reduced cost and increased yield	<b>Develop proprietary equipment and processes to deposit c-Si films uniformly across areas of 1 sq-meter</b>

# Blue Square Energy -- Project Update



<b>Project Focus Area -- Incubator Phase 1</b>	<b>Status</b>
Develop low-loss metallization process	Complete
Investigate light-trapping structures	Complete
Demonstrate high quality c-Si process	Voc = 616 mV
Develop low-cost substrates	11.86% device
Develop AR and Surface Passivation Processes	May-08
Demonstrate 12% efficiency	Jul-08

# Blue Square Energy -- Results

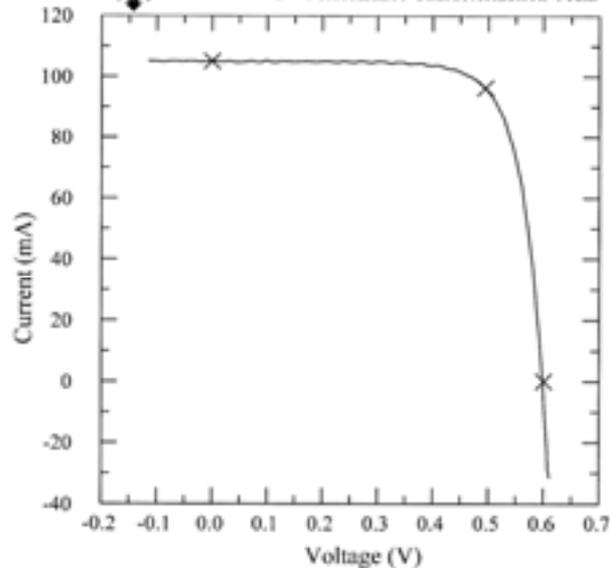


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## Blue Square Energy mono-Si Cell

Device ID: BSE-556B      Device Temperature:  $25.0 \pm 1.0$  °C  
Mar 05, 2008 12:49      Device Area:  $4.015 \text{ cm}^2$   
Spectrum: AM1.5-G (IEC 60904)      Irradiance:  $1000.0 \text{ W/m}^2$

 NREL X25 IV System CONFIDENTIAL  
PV Performance Characterization Team



$V_{oc} = 0.6008 \text{ V}$	$I_{max} = 96.201 \text{ mA}$
$I_{sc} = 0.1050 \text{ A}$	$V_{max} = 0.4949 \text{ V}$
$J_{sc} = 26.145 \text{ mA/cm}^2$	$P_{max} = 47.609 \text{ mW}$
Fill Factor = 75.49 %	Efficiency = 11.86 %

## c-Si on low-cost substrate:

- Thin (20 micron) active layer
- No surface texture
- Simple surface passivation
- Screenprint metallization
- No defect passivation

# Blue Square Energy -- Obstacle Discussion



Barriers encountered or anticipated that may the inhibit success of this program:

- Impact of areal uniformity on solar cell performance – model and modify deposition system
- Light “trapping” approach(es) – coatings vs. etching
- Material quality measurement for production volume – address with NREL assistance