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Solar Junction

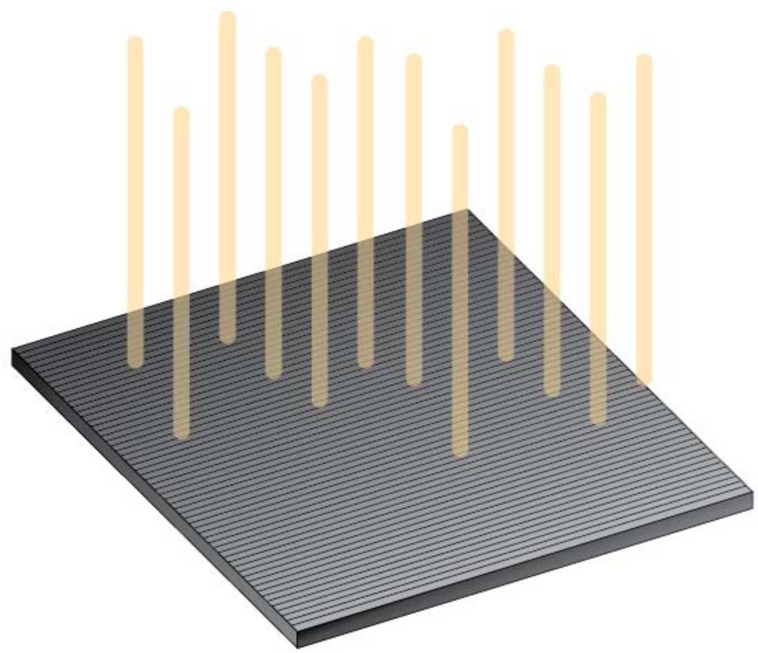
Series A Funding

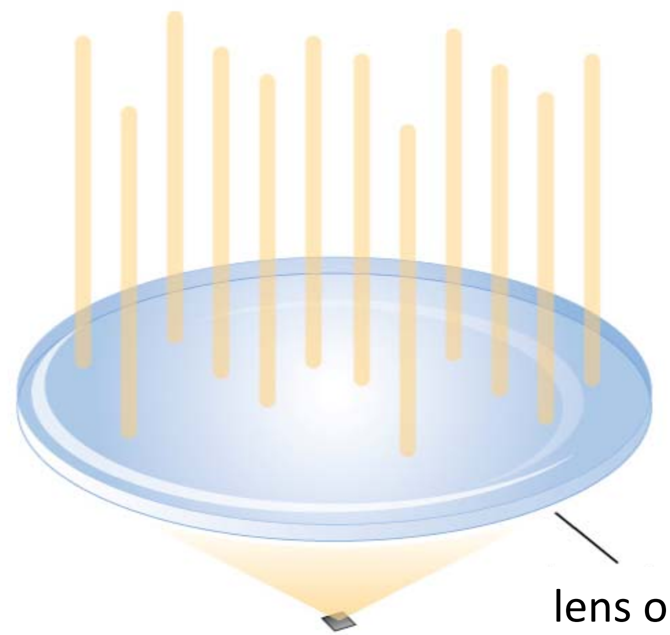
March 13th, 2008

Outline

- Solar Junction: What we do
- Who we are
- How concentrated PV (CPV) fits into the solar landscape
- The Solar Junction opportunity
  - The market opportunity
  - Our value to customers
- Introduction to our technology
- Cost modeling
- 6 quarter plan with milestones

Flat Panel vs. 500x Concentration





Flat Plate PV

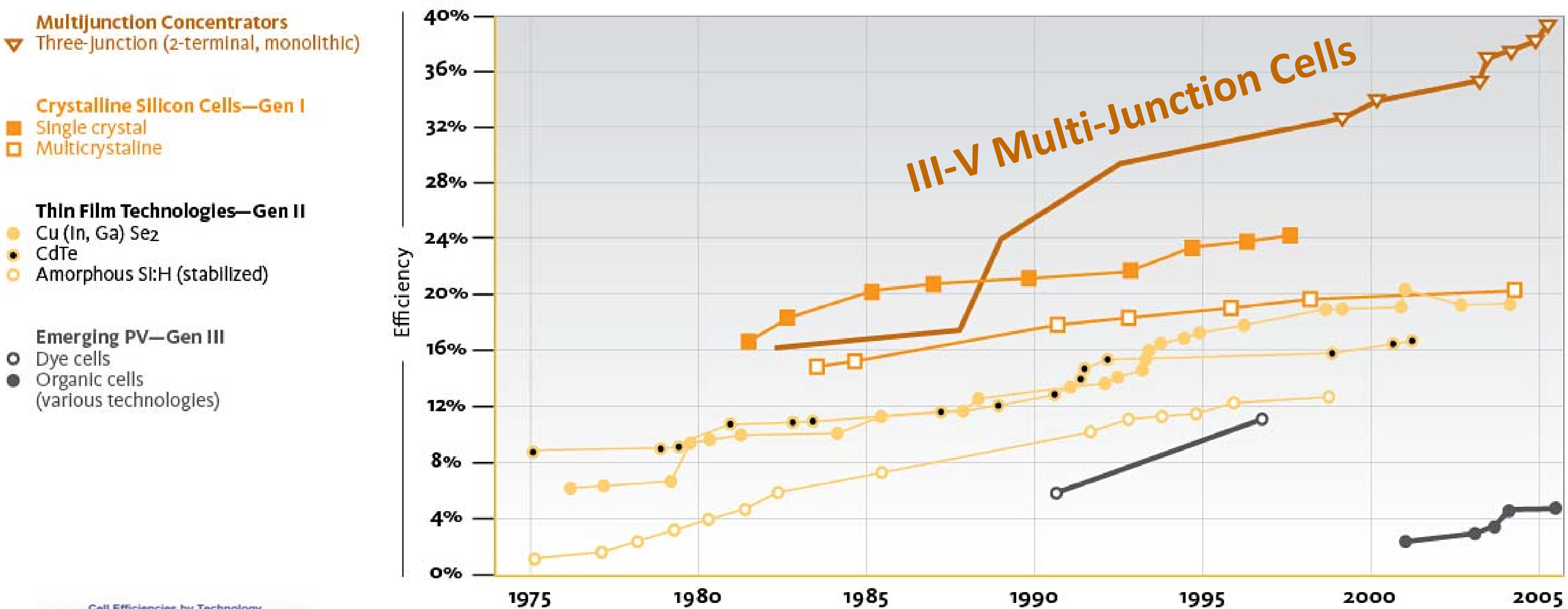
- Typical silicon cell is 5”x5”
- 16-22% efficient

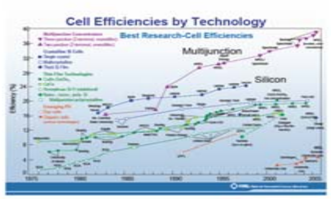
Concentrated PV (CPV):

- Equivalent cell is 0.2” x 0.2”
- 36-38% efficient today
- **40-45% efficient with Solar Junction technology**

Solar Cell Technologies:
Efficiencies vs. Time

Efficiency: Research Demonstrations





Source, National Renewable Energy Lab (NREL), Kazmerski and Zweibel

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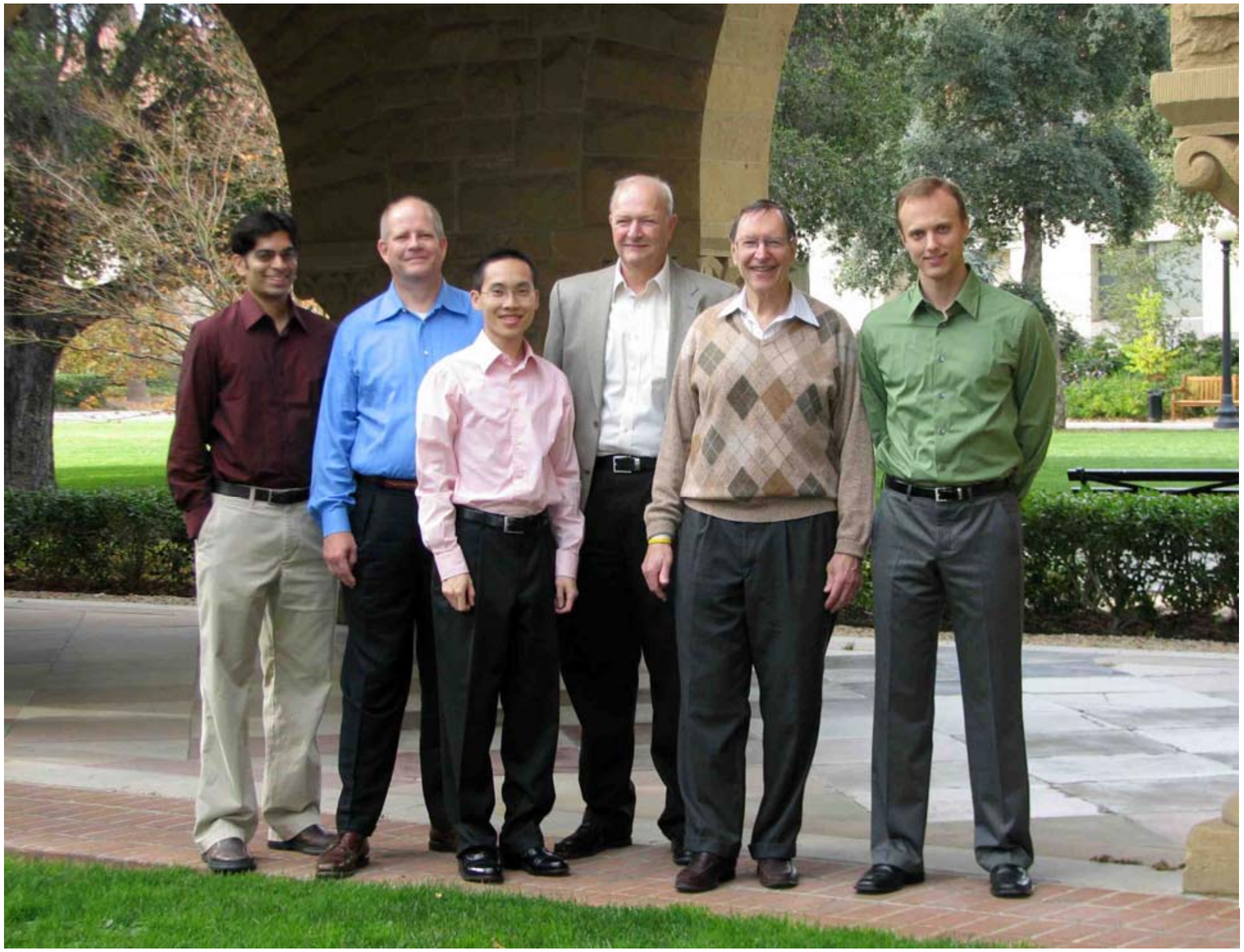

Dr. Vijit Sabnis, Jim Weldon, Dr. Homan Yuen, Craig Stauffer, Prof. James Harris, Dr. Mike Wiemer

Founding Team Bios

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- **Jim Weldon** — Over 25 years experience in Operations, Business Development, Corporate Development (M&A) with an extensive background in Technology and Materials Research. Has held executive level positions in Sales, Marketing, Business Development, Corporate Development and Operations.
- **Craig Stauffer** — Over 30 years experience in Operations, Business Development, Corporate Development (M&A) with an extensive background in IP valuation. Has held executive level positions in management, technology and Marketing. Provides expertise in business development.
- **Dr. Homan Yuen** — Ph.D. in Materials Science & Engineering in 2006 from Stanford University focused on materials development and characterization. Has over 7 years experience conducting semiconductor materials research towards device implementation. At Stanford, Dr. Yuen worked under the direction of Prof. James S. Harris, where he helped to successfully develop and utilize the (Ga,In)(N,As,Sb) materials alloy for long-wavelength lasers.
- **Dr. Vijit Sabnis** — Ph.D. in electrical engineering from Stanford University in 2003. Extensive experience in photonics focused on optoelectronic materials and device characterization. Diverse background in modeling and simulation. At Stanford, under the direction of Prof. James S. Harris and Prof. David A. B. Miller, he developed GaAs- and InP-based, ultra-fast optically-controlled optical switches.
- **Dr. Michael Wiemer** — Ph.D. in electrical engineering from Stanford University in 2007. Extensive experience in photonics focused on optoelectronic materials and device characterization. Diverse background in modeling and simulation. At Stanford, under the direction of Prof. David A. B. Miller and Prof. James S. Harris, he developed novel GaAs-based lasers.
- **Professor James Harris** — James and Ellenor Chesebrough Professor, Department of Electrical Engineering, Applied Physics, and Materials Science at Stanford University. Worldwide leading authority in epitaxy and heterojunction devices with the distinction of being in the top tier of Compound Semiconductor academia and industry. Over 35 years experience in Optoelectronics. Awarded the Alexander von Humboldt Senior Research Prize in 1998 for his contributions to GaAs devices and technology.

Where is CPV's Place in Solar?

The Importance of Efficiency

"All solar installations are area limited."

(The value of efficiency is) "…so incredible."

- Dick Swanson, CTO of SunPower
in a talk given at Stanford University, 11/29/07

Concentrated Photovoltaics (CPV)

Higher efficiency means …
more power to the user

Google Campus in Mountain View, CA

All rooftops & carports covered in c-Silicon fixed flat plate modules from Sharp.
Only meets ***30% of their power needs***.

CPV could meet **100%** of their needs using the **same area**.

Sol3g

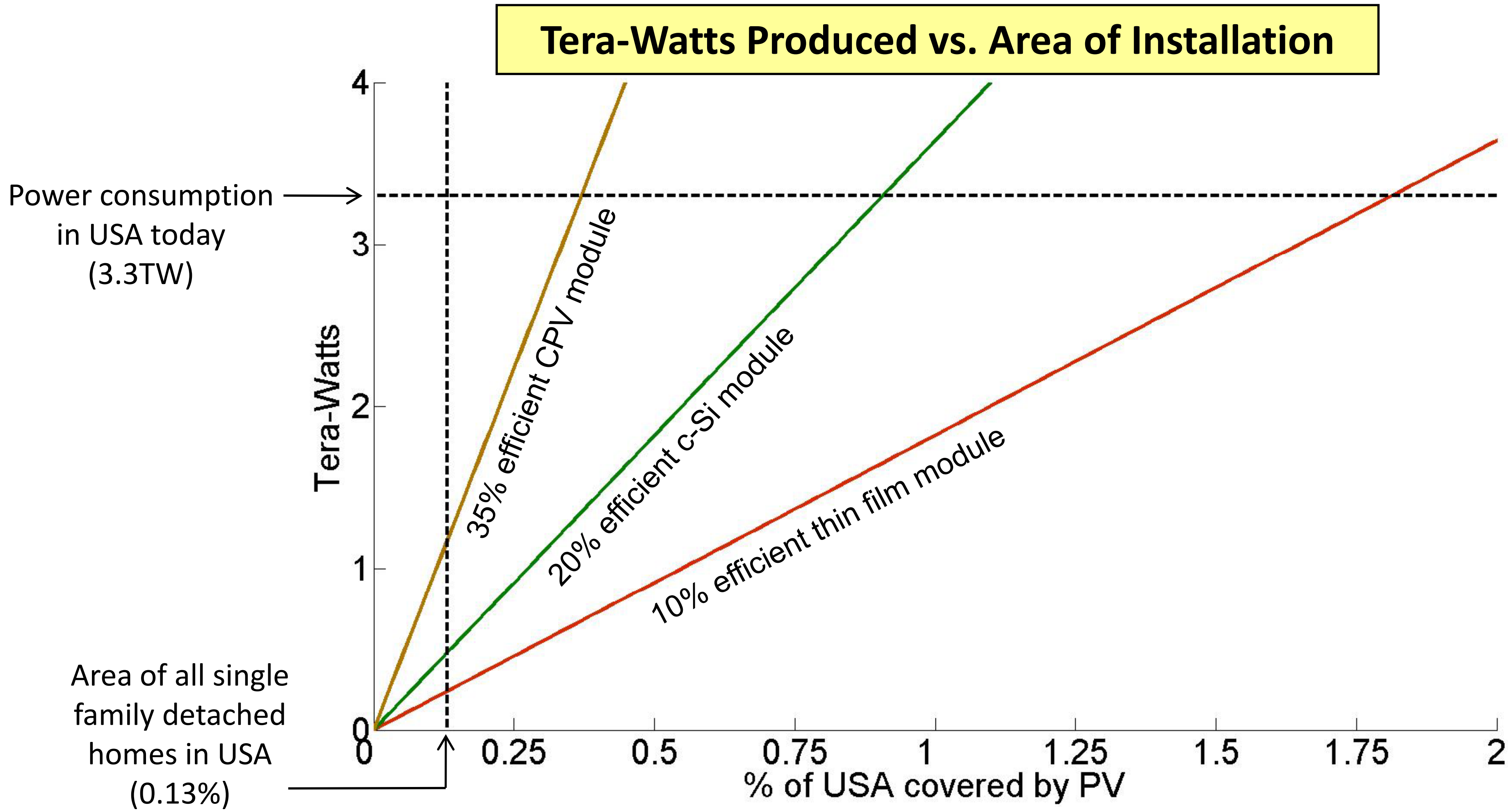
Soliant Energy

From Soliant Energy:

- High efficiency great for area constrained applications
- Optimized for the rooftop
- Same dimensions & weight as conventional solar panel
- Identical Installation
- Tracking makes peak power generation correspond to peak need

tracking

The Importance of Efficiency
The WORLD is area limited



Plot uses day & night average insolation for entire USA (200W/m2). American southwest insolation is more like 290W/m2. No tracking on c-Si or thin film

CPV has many market opportunities

Amonix

SolFocus

SolFocus

Sol3g

Soliant Energy

Greenvolts

Utility Scale — Small Installation — Large Rooftops

Simplicity & Modular nature enables:
- Future capacity increases & upgrades
- Lower initial CapEx
- Power generation closer to end users reducing transmission loss
- Installation on non-contiguous or oddly shaped plots of land
- Simpler to design & operate

Muni-water plants, Corporate campuses…
- Highest efficiency delivers more power
- Perfect for area constrained installations
- Close proximity to end user reduces transmission loss
- Modularity allows future capacity increases
- Peak power & demand overlap

From Soliant Energy:
- Optimized for the rooftop
- Same dimensions & weight as conventional solar panel
- Identical Installation
- High efficiency great for area constrained applications

Solar Junction supplies to all

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Amonix

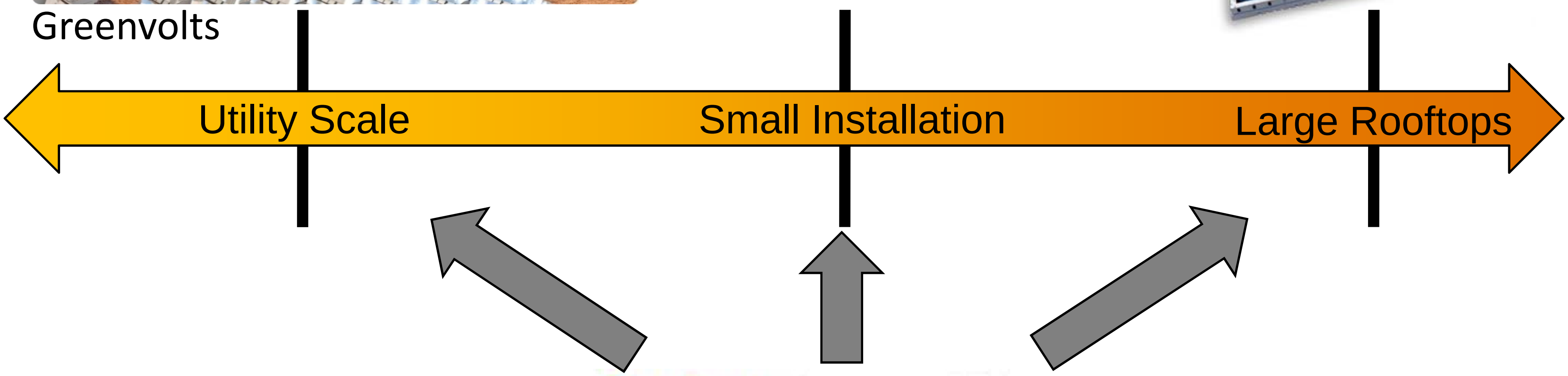
SolFocus

SolFocus

Sol3g

Soliant Energy

Greenvolts



Solar Junction

Solar Junction's Customers
Concentrator Systems Companies

Company	Optical System	Product	Concentration ratio	System Size [kW_p]	Cell Efficiency [%], η	Cell Type	Cell Size	Concentration Module Efficiency	System Efficiency {%]	Cooling Type	Tracking	Power Input [W] [1]
High Concentration Photovoltaics (HCPV)												
Amonix, Inc.	Fresnel Lens	Mega Module	500	25	27.6	Silicon		18	16	Passive	Hydraulic	1%
Concentrating Technologies, LLC	Dish Mirror	Micro Dish	300	3.0 - 50	35	GaInP/GaAs/Ge		25	23	Passive		7
Concentrix Solar GmbH	Fresnel Lens	CX 5000	385	5.75	>33	GaInP/GaInAs/Ge		>25	>23	Passive	2 axis	<10
Cool Earth Solar	Inflated Mirror	SA-10	220	10	22	Silicon		17	11	Active	Tensile truss	<500
Daido Steel Co., Ltd.	Fresnel Lens		550 - 1340	1.0 - 10	30 - 35	Triple Junction		28	20	Passive		
Emcore Corporation	Fresnel Lens		500	25	35	Multijunction				Passive		
Entech, Inc.	Point Focus Fresnel	Advanced SR	500	50	35	Multijunction		30	23.7	Act./Pass.	2 axis	200
Green & Gold Energy - SCIG	Fresnel Lens	Sun Cube	1000+	0.3	35	Triple Junction		35.4 [6]	35.4 [6]	Passive	2 axis	<1
Green Volts	Off-axis Dish	HCPV	625	3.5	37	Multijunction				Passive	2 axis	
Guascor Foton, S.L.	Fresnel Lens	SIFAC 25X	400	25	27.6	Silicon				Passive	el. Hydraul.	
Pyron Solar, Inc.	Proprietary	Pyron Triad	500	90	36	Multijunction		30	28	Passive	2 axis	5
Sharp Corporation	Fresnel Lens	Sharp CPV	700	2.9	37	GaInP/GaInAs/Ge				Passive		
Sol3g, S.L.	Fresnel + secondary	M40	476	1, 4 and >	30 - 32	GaInP/GaInAs/Ge		21 - 25	19 - 23	Passive	2 axis	Negligible
Solar Tec AG	Fresnel Lens	Sol Con	400	2.16	36	GaInAs/GaInP/Ge		28		Passive	2 axis	200
Solfocus, Inc. [4]	Reflective optics, Mirrors [3]	Gen 1	500		35	GaInP/GaInAs/Ge	1cm^2	17	14.5	Passive	2 axis	
Solfocus, Inc. [7]	Reflective optics, Mirrors [3]	Gen 2	500+		36 - 37	GaInP/GaInAs/Ge	1mm^2	est. 25	est. 22	Passive	2 axis	
Low Concentration Photovoltaics (LCPV)												
Day4Energy, Inc.	Fresnel Lens, Mirror	LCPV Receiver	<10		16.5	Silicon		16.5		Passive	1 or 2 axis	
Entech, Inc.	Linear Fresnel Lens	Solar Row (SR)	21	25	20	Silicon		16.6	13.5	Act./Pass.	2 axis	
JX Crystals, Inc.	Mirrors	3-sun Panel	3	1,2 ,25	20	Silicon		15	14	Passive	1 axis	
NuEdison [2]	Asymmetric Conc.	Next Module	2 - 4.5		16 -20	Silicon		16 - 20		Passive	None	
Pacific Solartech	Fresnel Lens	Micro PV	2 - 10.0	0.5 - 1000	15	Silicon		13		Passive	None	
Prism Solar Technologies, Inc.	Holographic Film	HPC	1.25 -2			any				None	None	
Silicon Valley Solar, Inc.	Total Internal Reflection	Sol-X	2.2	0.2 module	17	Silicon		15.3		Passive	None	
Stelaris Corporation	Non-Imaging Optics	Clear Power	3	1 - 100+		CIGS, Silicon				Passive	None	
Taihan Techren Co., Ltd.	Fresnel Lens	MS-900	9	5	16 - 20	Silicon		14 - 18	11.0 - 12.0	Passive	2 axis	
Whitfield Solar Ltd.	Fresnel Lens	Sun Light	40	0.3	19	Silicon		15	13	Passive	Tilt & Roll	

Notes: 1. Power Input - consumption for tracking, cooling and system management 2. NuEdison acquired by Silicon Valley Solar 3. Similar to Cassegrain telescope 4. SunPower pursued a similar approach in the 1990s with the RXI concentrator

4. SunPower pursued a similar approach in the 1990s with the RXI concentrator, SolFocus reflector panel 6. Solar Harvest Efficiency equates to ~ 10MW_p

7. Tile nested in mirrors, monolithic optical concentration for size reduction

Opportunity in the Marketplace

Customers are nervous about the cell supply chain

- **Emcore**
  - Rapidly growing terrestrial market. 2007 cell revenues (recognized) 90% space/10 % terrestrial. Expect 50/50 split in 2008 and 25/75 split in 2012.
  - > 1 GW of terrestrial CPV cells on order since 2007. Represents > $235M cell revenue.
  - Orders placed for installation in Spain, Ontario, S. Korea, Australia, US Southwest.
  - Considering PV spinoff and IPO.
- **Spectrolab**
  - Large number of orders (not public).
  - Multiple offers made on Spectrolab by variety of equity groups and at least one CPV company.
- **Problems:**
  - Both companies encumbered by space market/gov't constraints and priorities (NASA/DOD).
  - Large order backlog, capacity can't meet demand.
  - Poor customer service, lack of customization. Big disadvantage for CPV systems mfgs.
  - Vertically integrating, mfg'ing CPV systems
    - ➢ *now competing head-to-head with many customers*
  - Risky, unproven technology roadmap for achieving higher efficiencies.

Levelized Cost Of Energy (LCOE)

CPV is Competitive

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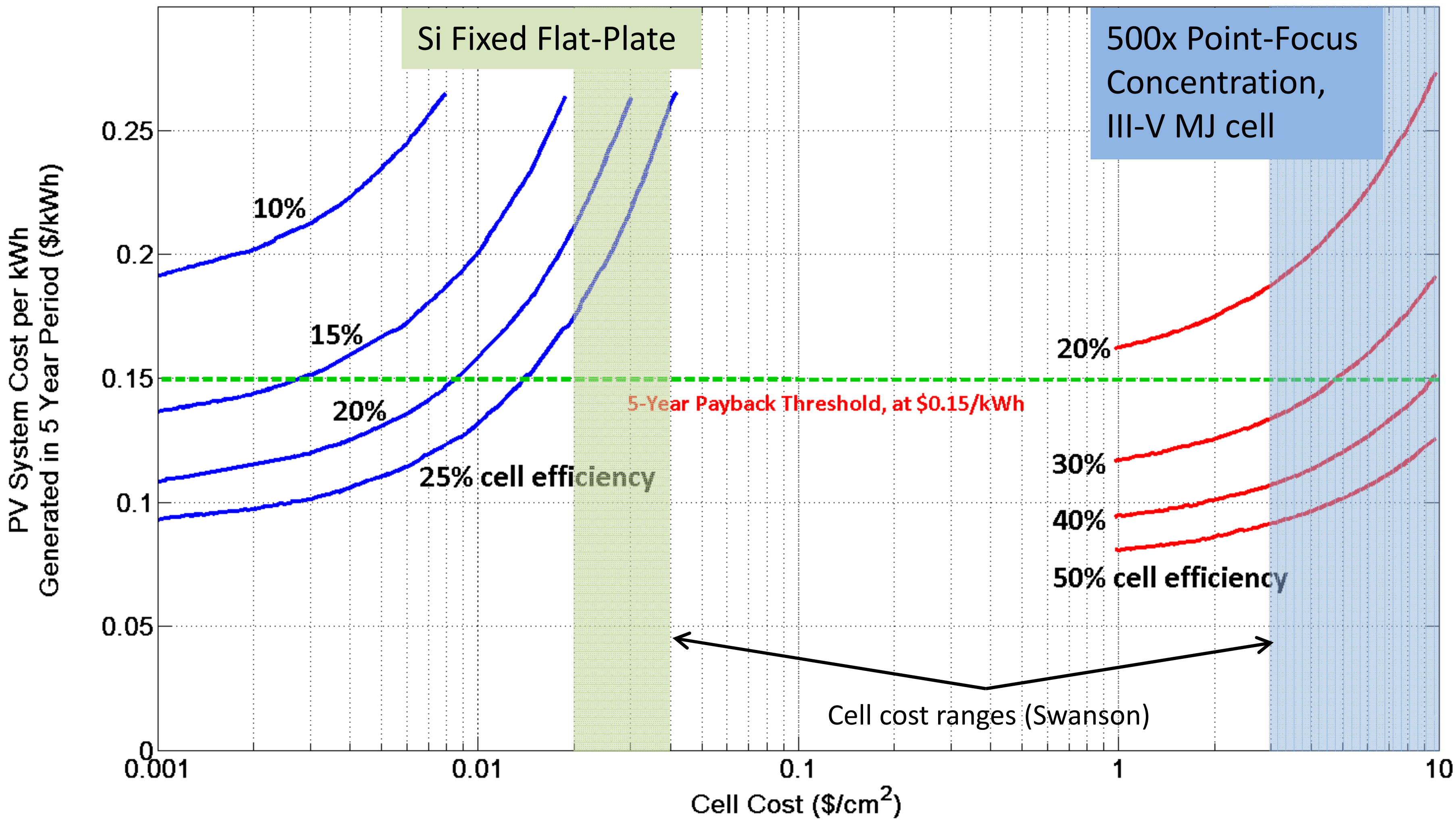

Data from R.R. King (Spectrolab), R. M. Swanson (SunPower)

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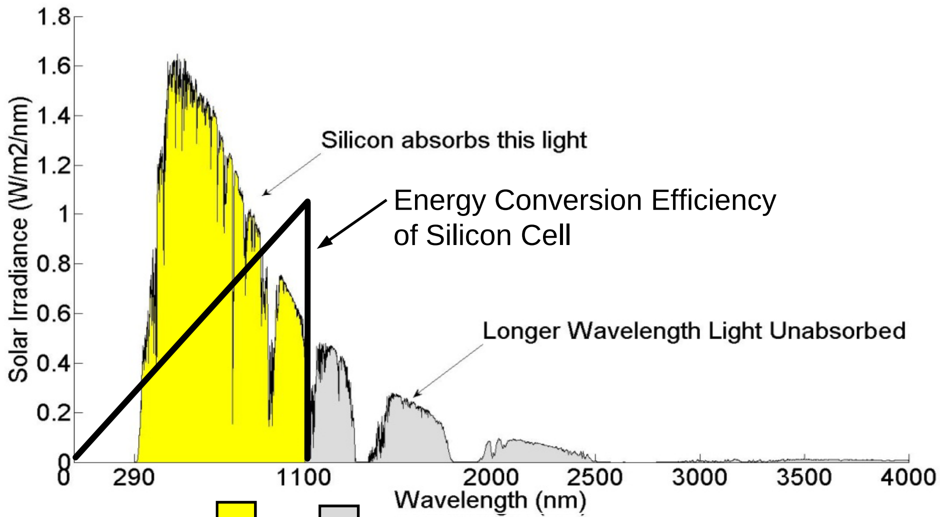
The Solar Junction Technical Advantage

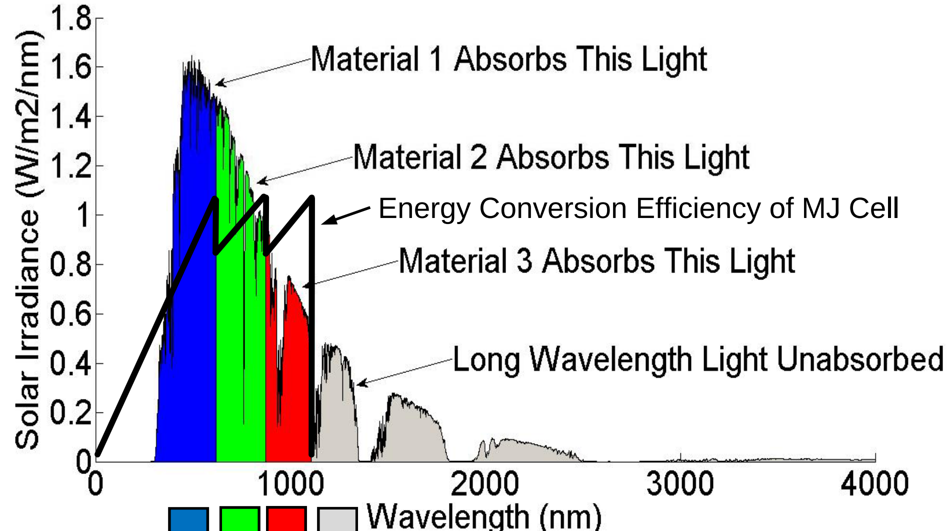
Current III-V Three Junction PV is Inherently Limited

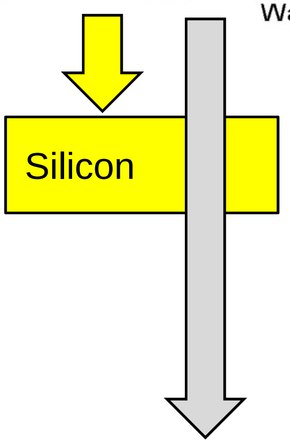
- Three junctions (3J) target optimal efficiency for 88% of the solar spectrum with 45% theoretical efficiency (silicon is 30% theoretical efficiency)
- III-V 3J efficiency has been limited because the smallest bandgap junction is not optimally efficient
- Solar Junction solves this by delivering an optimally efficient 1 eV junction through unique, innovative design and materials combined with superior technology and execution
- Solar Junction's breakthrough employed a "clean sheet of paper approach" that would require competitors to re-tool their process lines to compete (3-year+ lead to SJ), or to engineer and implement a complex four-junction device

How To Make a High Efficiency Solar Cell

$$\text{Energy Conversion Efficiency} = \frac{\text{Light Energy (Input)}}{\text{Power(Output)}}$$

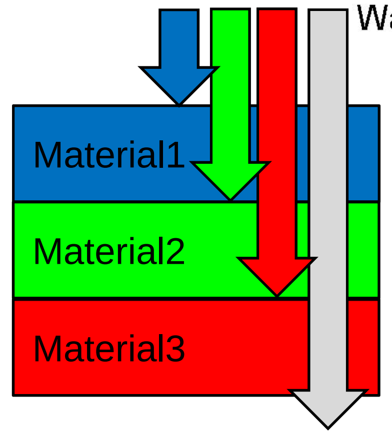






1 Junction Silicon Solar Cell

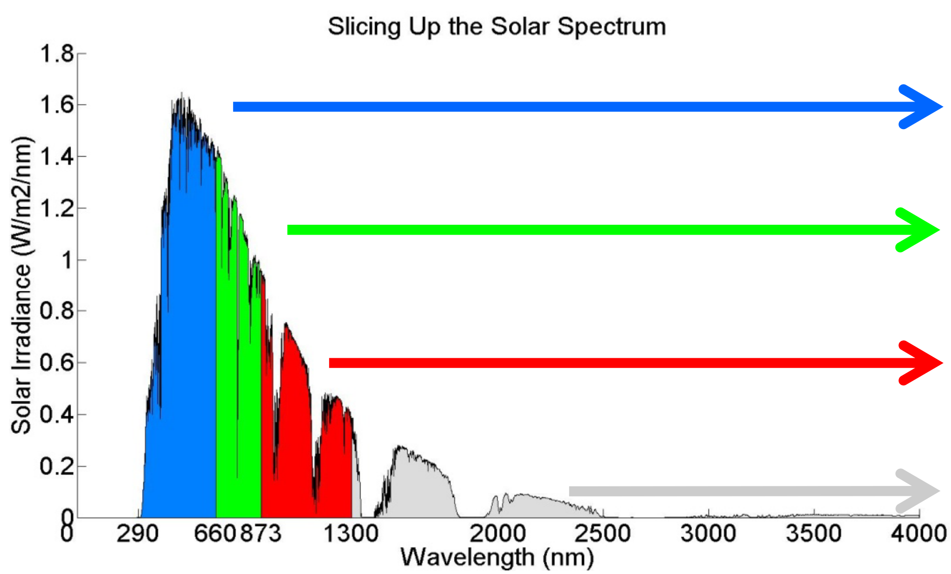
Max. Theoretical Efficiency ~30%



3 Junction Solar Cell Stack

Example Theoretical Efficiency 45%

Optimal Spectrum Slicing:
3 Layers



1.88eV InGaP Junction (42% of total sun power) √

1.42eV GaAs Junction (24% of total sun power) √

1eV Unknown Junction (22% of total sun power) ??

Uncollected Long Wavelength Light (11% of total sun power)

Current Solution: Germanium
- Germanium has a 0.7eV bandgap (not 1eV)
  - Compatible material with InGaP and GaAs
  - Germanium-based 3 junction cells now in space applications

BUT

Issues with Germanium Junction
- Germanium Bandgap is NOT optimal:
  - 0.7eV vs. optimal 1eV
- Max theoretical efficiency of 3 Junction cell with
  - Germanium Subcell: 39.9%
  - Unknown 1eV Material Subcell: 44.5%

Paths to a 1eV Junction

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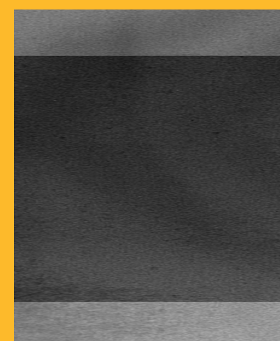
GaInNAs Material

- 1.0eV Bandgap Possible
- Widely recognized as the ideal approach for Multi-Junction Solar Cells

Tried by many and failed

GaInNAs(Sb) Success!!

- Homan Yuen, James Harris of Solar Junction (& Stanford Univ.)
- Necessary performance metrics for Multi-Junction cell integration demonstrated

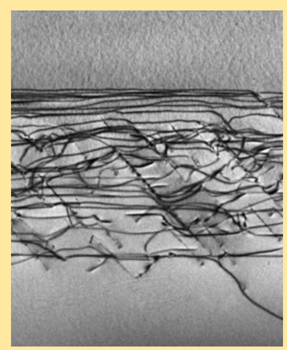


← Transmission Electron Microscope (TEM) image of lattice matched GaInNAs(Sb) material sandwiched between GaAs layers.

Notice: No defects!

2^{nd} Choice Approach: Metamorphic InGaAs

- Complicated growth process
- Less desirable
- Material quality not ideal



← Transmission Electron Microscope (TEM) image of Metamorphic InGaAs on GaAs.

Notice the high density of threading defects!

Roadmap

40%

3 Junctions

2 Junctions +
Germanium

45%

3 Junctions

2 Junctions +
1eV GaInNAs

50%

Improved Tunnel Junctions

4+ Junctions

Optimize
Bandgaps

**Utilize
GaInNAs:
0.9eV – 1.42eV**

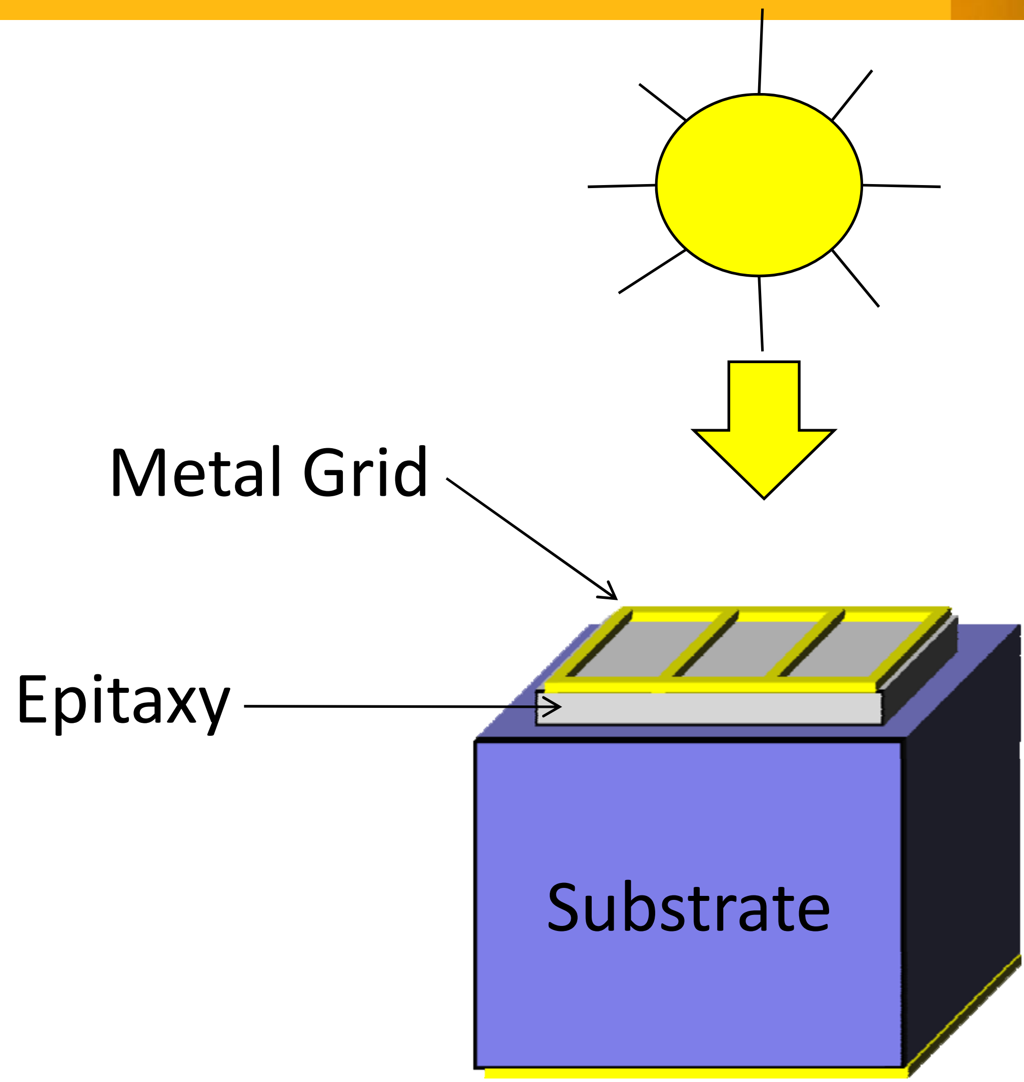
Current | Phase I | Phase II

Current Status Summary

- 1eV GaInNAs(Sb) single layer solar cell demonstrated with world record performance
- Ready for integration into 3 junction cell
  - Target: world record solar cell efficiency
- Further optimization of GaInNAs(Sb) possible
- Utilizing Stanford University facilities for growth / process / test
  - Now is time to obtain Solar Junction owned & operated equipment

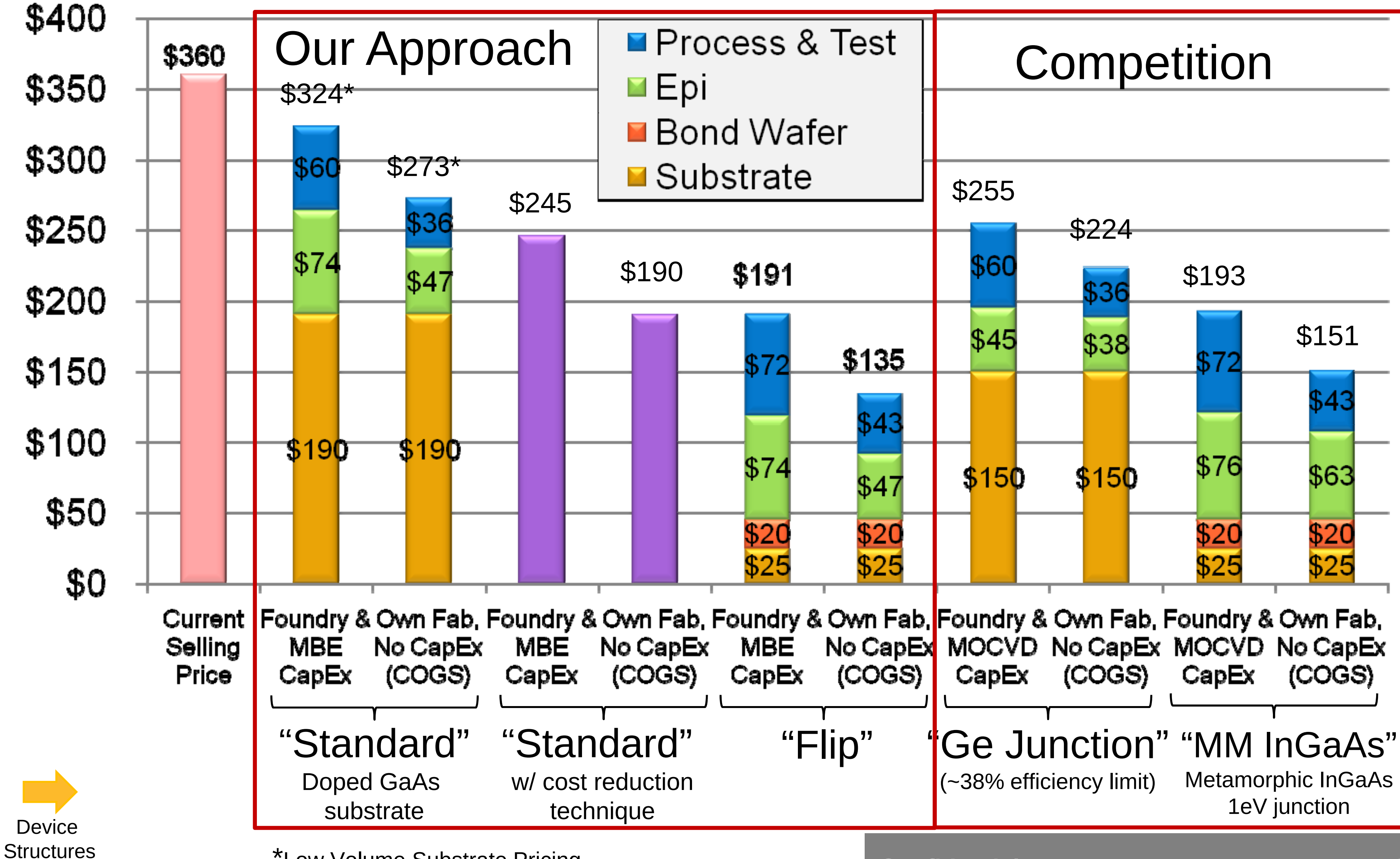
Cost Modeling

What a III-V Cell Looks Like



Single Cell
(wafers have arrays of these….)

Summary: $/product wafer



*Low Volume Substrate Pricing

The Plan

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Overview: The Plan

f o c u s o n u s

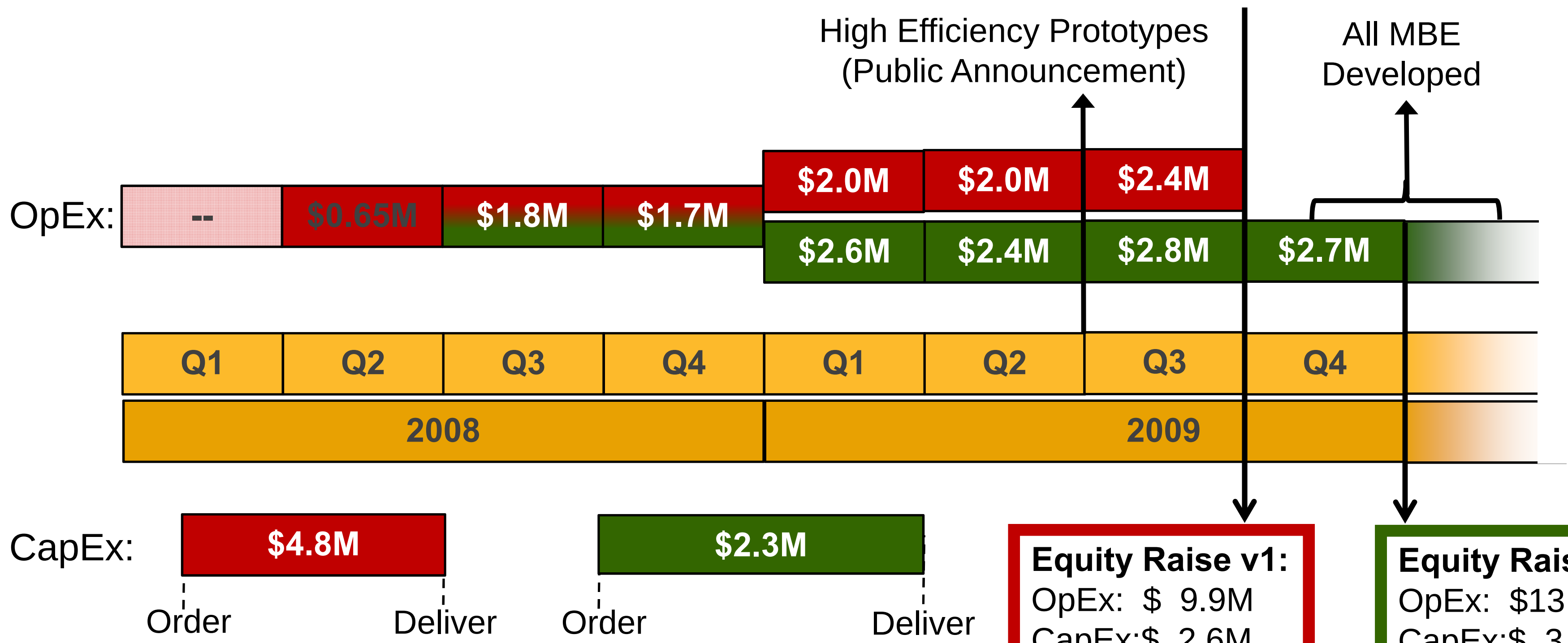
Development (Current Phase)

- Solar Junction acquired MBE epitaxy growth tool & support equipment
- Hire staff
- Develop key technology partners
  - Spire
  - NREL
  - Foundry
- Create world's highest efficiency cell using our proprietary 3rd junction
  - Outsource growth of the 2 "standard" junctions (GaAs / InGaP)
  - Growth of the 1eV junction in-house

Production (Next Phase)

- All epitaxial growth in-house
- Utilize existing foundries & outsourcing
  - Infrastructure already exists
  - Low CapEx
  - Fast production ramp-up
  - High quality & yield

Timeline



CapEx #1 (Raise v1 & v2)
Gen200 1st Chamber
Metrology Tools
Test Equipment
Cleanroom & Improvements

CapEx #2 (Raise v2)
Gen200 2st Chamber

Equity Raise v1:
OpEx: $ 9.9M
CapEx:$ 2.6M

Total: $12.5M

Debt: $5.2M → $2.6M
(50% debt)

Equity Raise v2:
OpEx: $13.9M
CapEx:$ 3.9M

Total: $17.7M

Debt: $7.7M → $3.9M
(50% debt)

CPV Levers for a Tera-Watt Solar Revolution

Levers

	Research (Phase I)	Pilot (Phase II)	Production (Phase 1)	Production (Phase 2)	Production (Phase 3)	Production (Future)
Wattage	NA	4MW – 40MW	200MW	1.6GW	6.4GW	150GW
Concentration	500	500	500	1000	2000	5000
Wafer Size	3inch	4inch	4inch	4inch / 6inch	4inch / 6inch	?
Efficiency	40%					50%
Fab Process Revision				X	X	X
MBE Tool Revision				X	X	X
Technology Innovations	GaInNAsSb / Improved Tunnel Junctions				Add Junction	TPV?

Conclusion

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- All solar technologies will co-exist in the future
- CPV can address utilities to rooftops
- CPV wins when:
  - Installation is area constrained
  - Trying to scaling to Tera-watt levels
  - Cost is an issue
- CPV module vendors feel their cell supply is in jeopardy
- Solar Junction's technology set will create the highest efficiency solar cells in the world
- Efficiency is very valuable to CPV module vendors

Solar Junction