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Concentrating PV Arrays Using High Efficiency III-V Cells

Presented at the DOE
Concentrating Solar Power (CSP) Peer Review Meeting
Albuquerque, NM
November 2001

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Why Concentrating PV?

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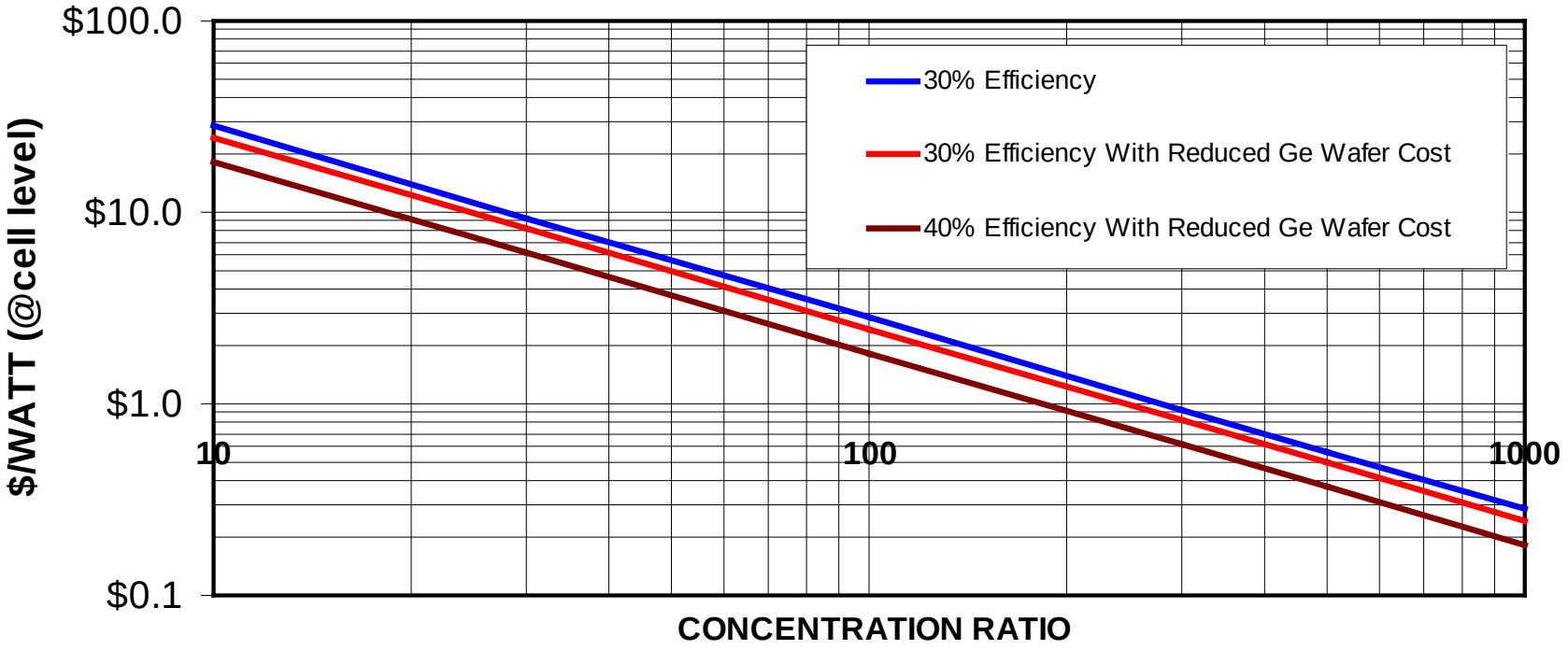
- A tremendous **increase in the PV cell efficiency happened over the last few years**, with the introduction of multijunction III-V cells.

- **CPV is the only opportunity to leverage high-efficiency III-V cells in the terrestrial market.**



Concentrator Cell Development

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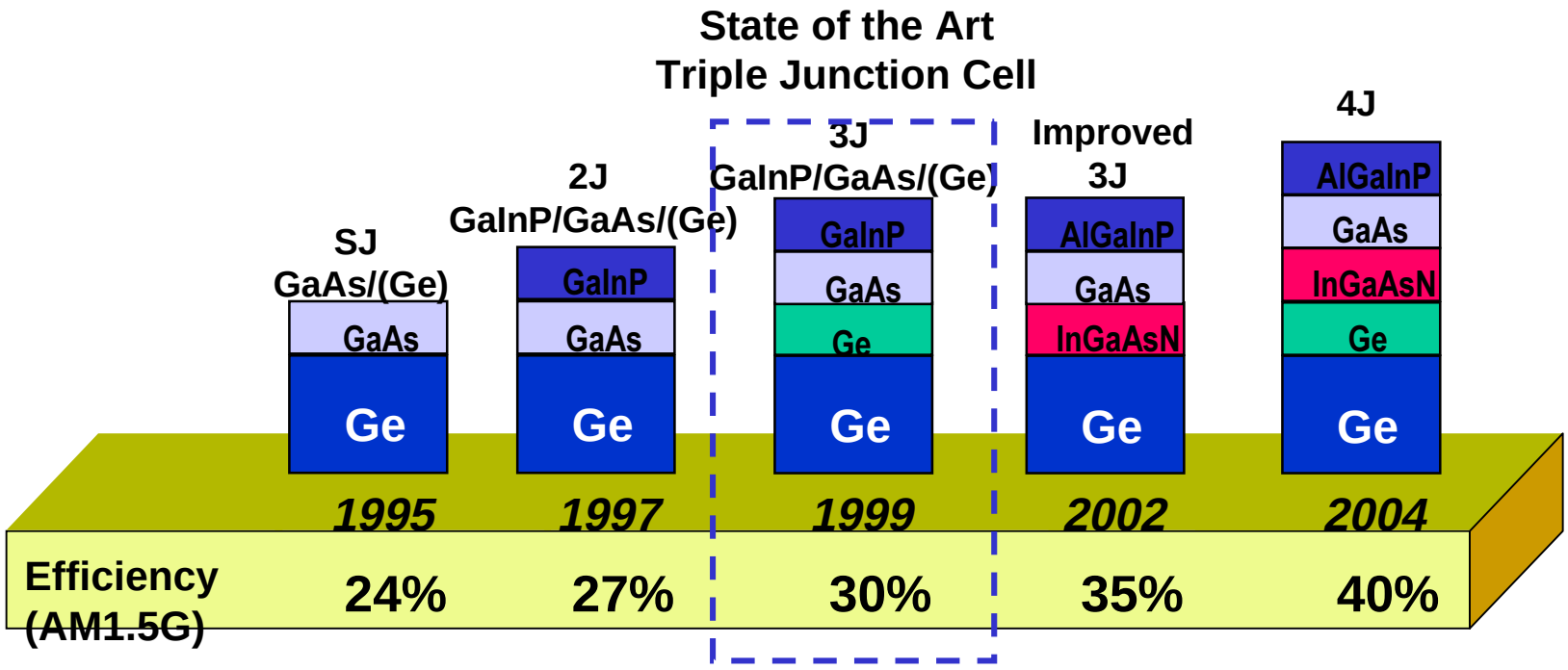
- Extensive research towards increasing the efficiency of solar cells is funded by PV manufacturers and the government, e.g. NREL's HiPer PV, the AFRL DUS&T.



Spectrolab Concentrator Cell Roadmap

World-Record Concentrator Cell

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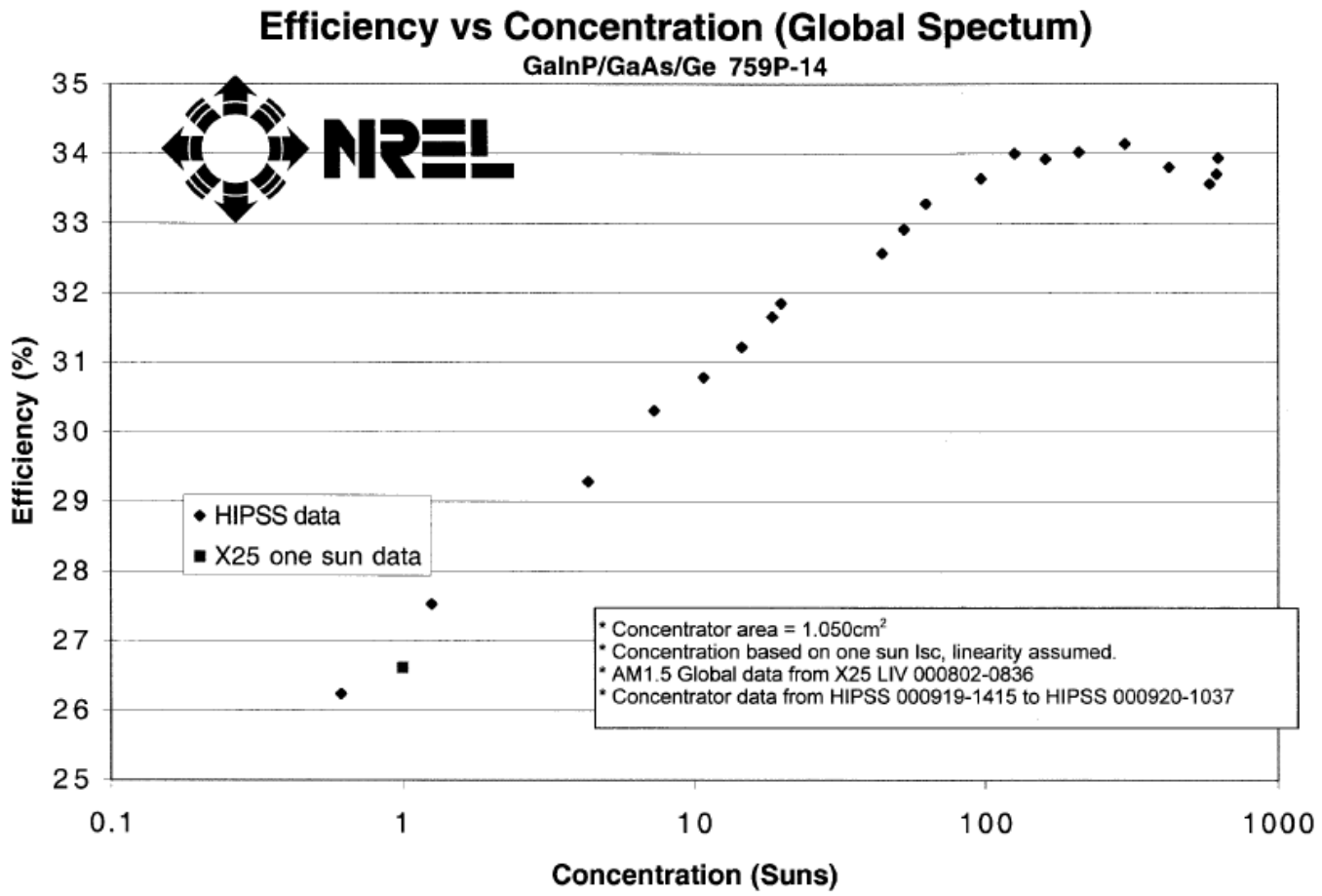

- Cell development efforts led to a world-record cell efficiency under concentration during pulse testing, recognized as one of R&D 100 most significant accomplishments in 2001.

Spectrolab CPV Capabilities

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Spectrolab wants to be a major player, not just as a cell manufacturer, but also as a provider for CPV arrays.

Spectrolab capabilities include:

- MOVPE and cell fabrication, enough to produce 50 MW of peak power at 300 suns, without adding any new facility.

- High concentration test capabilities
  - Pulse testing (up to 1500 suns) using the HIPSS.
  - Outdoor test station using fresnel lens (manual tracking)
  - Efforts to bring-up outdoor test station with automated tracking system.

- Packaging lab for PV receiver assembly.

CPV Array Development

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A parallel effort to cell development is needed for CPV array development work. Why?

Concentrator Cell & Module Challenges

- Cell shunting at high concentration levels during continuous illumination, especially when the solar flux is highly non-uniform.
- Efficient thermal management to enable going to higher levels of concentration.
- Increased design robustness (e.g. electrical isolation, material compatibility, minimal drop in output power if one or more cells are lost).
- Continuous illumination testing for individual cells and receivers.
- Cost reduction

Spectrolab & APS Dense PV Array

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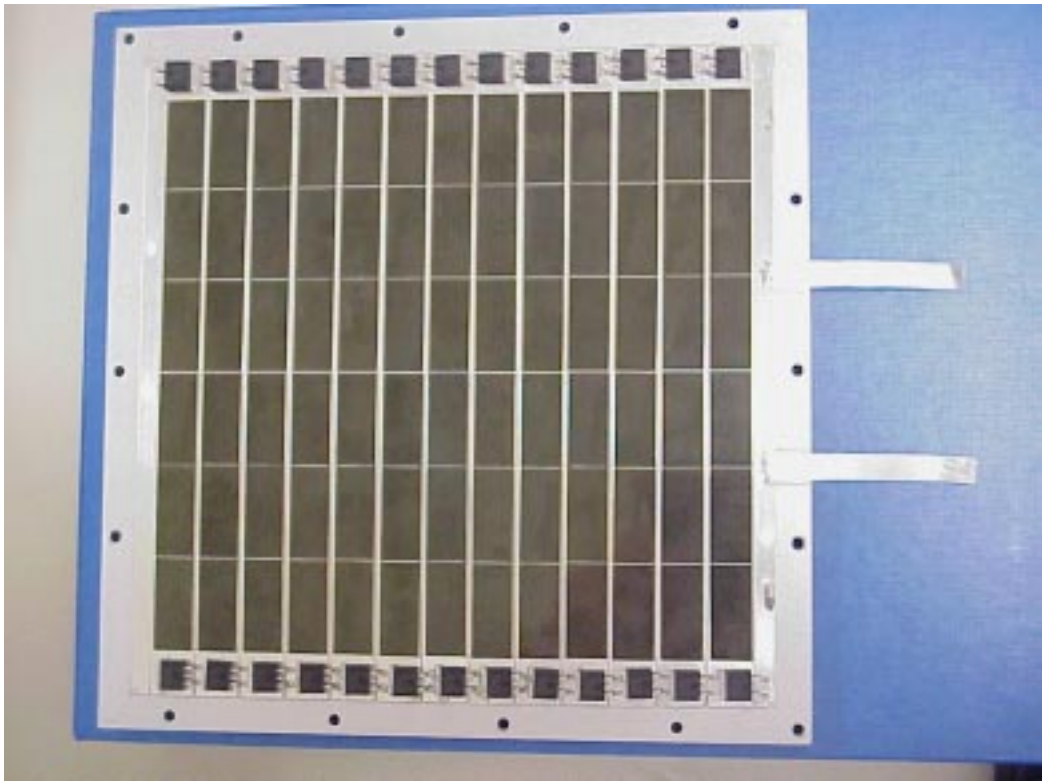
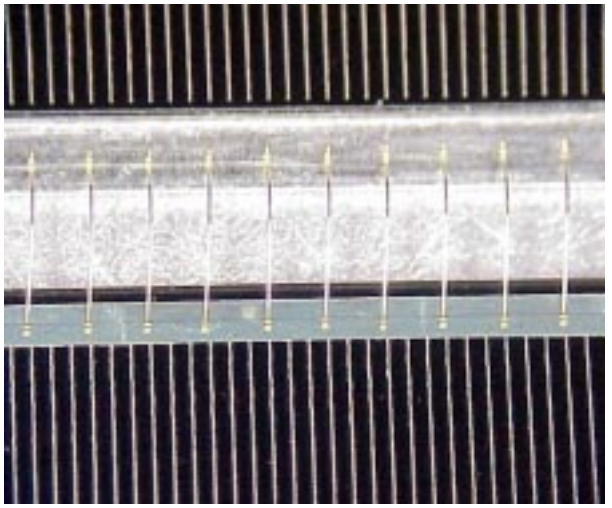
One subassembly (3-cells & 1 diode soldered to a kovar substrate)



Full assembly (26 subassemblies)



Electrical connections by wire bonding between subassemblies

Some Outdoor Test Results

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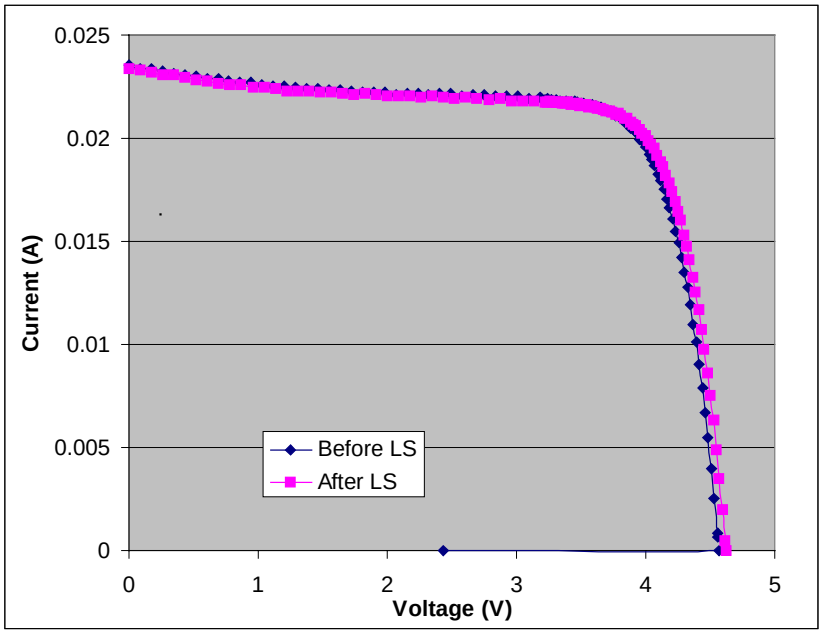

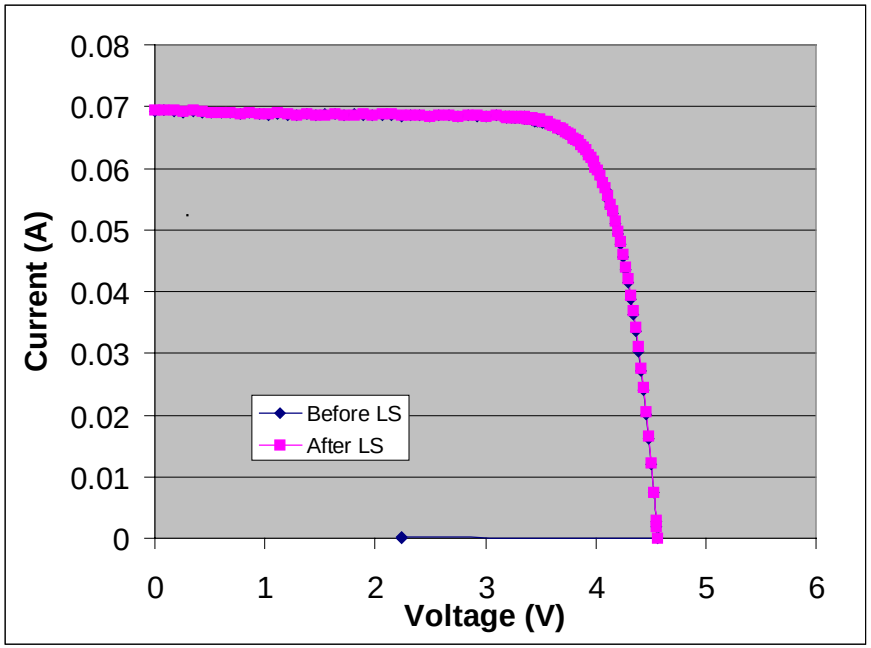

	Before	After
Voc	4.567	4.624
Isc	0.0235	0.0234
Eff	20.8	21.03
Pmax	0.0799	0.0808
FF	74.39	74.56
Vmp	3.854	3.907
Imp	0.0207	0.0207

2 small cells in series with a bypass diode post light soak at 550 suns

DC	Before	After
Voc	4.562	4.562
Isc	0.0695	0.0695
Eff	20.01	20.09
Pmax	0.246	0.247
FF	77.61	77.86
Vmp	3.814	3.832
Imp	0.0644	0.0644

2 big cells in series with a bypass diode post light soak at 295 suns

Collaboration Between Spectrolab and CSP

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1. Spectrolab as a prime for developing densely packaged array to be tested under the high flux solar furnace. ~ $93k from NREL with 30% cost share from Spectrolab.

Work Scope

- Design phase
- Fabricate and test concentrator cells
- Mount cells on subassemblies and then to a cooling plate. (A total of 6 subassemblies in series, each with 3 cells in parallel).
- Test the receiver at different levels of concentration and temperatures using the HFSF.

Benefits

- Test results will enable us to establish maximum concentration level for reliable operation at different temperatures.

Status

- Phase I- Design phase, completed.
- Phase II- Fabrication and Test, not funded yet.

Collaboration Between Spectrolab and CSP (Cont.)

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2. Spectrolab & APS as subcontractors to Concentrating Technologies to deliver 1 complete system (2 kW peak power) to be installed at NREL.

Work Scope

- CT, APS, and Spectrolab put a complete system at NREL for continuous testing at 300 sun concentration.

Benefits

- Test results will help establish some reliability field data for different system components

Status

- CT fabricated the reflective dish mirrors and installed it at NREL
- Spectrolab delivered 1 array to CT.
- CT is integrating the PV array with its secondary optics and cooling system
- System will be tested first at Alabama and then be given to NREL.

Future Collaboration Suggestions

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Continuous collaboration between CSP and PV and system manufacturers is needed.

1. Use the HFSF as a test bed for different concentrator cell designs.
   - Is there a maximum concentration level for MJ cells?
   - Is it related to the cell size?
   - How does the solar flux non-uniformity play in?

2. Use the HFSF as a test bed for different PV array designs.
   - Establish the relationship between receiver design and the maximum concentration level that can be sustained.
   - Obtain data on different receiver designs performance and reliability, irrespective of the optical system.

3. Generate performance and reliability data on concentrator systems.

Concluding Remarks

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1. CPV using high efficiency solar cells offer real opportunities for renewable energy generation at commercially feasible prices, using the latest developments in MJ cells.

2. Collaboration with CSP will offer tremendous help to PV manufactures, as it will enable them to test their concentrator cells and modules at different concentration levels and obtain reliability data on small-scale systems.