

Flat plate concentrators with large acceptance angle enabled by micro cells and mini lenses: performance evaluation

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Introduction

Current commercial CPV limitations:

- High Balance of System costs
- Heavy
- Tight field of view
- Bulky modules

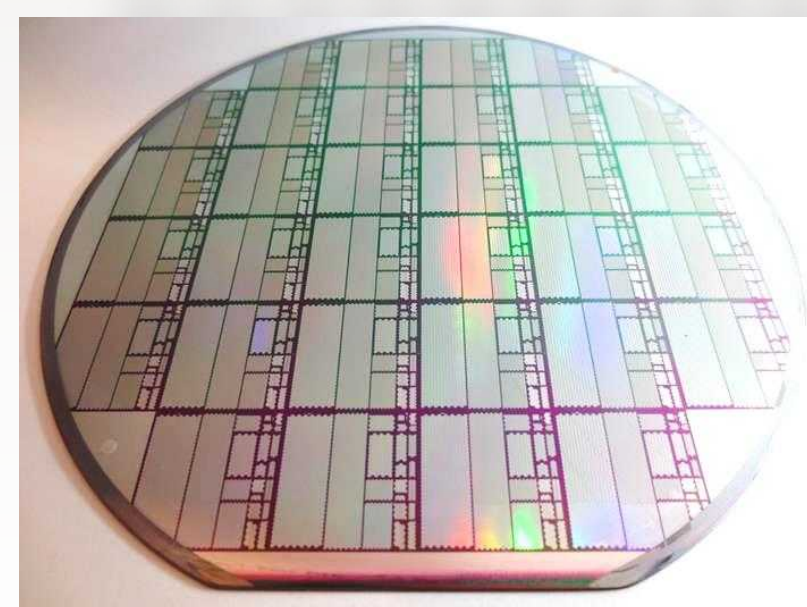
Proposed Flat plate concentrators:

- Low balance of system costs
- Concentrator thickness is less than 15 mm
- Field of view of +/- 4°
- Lightweight

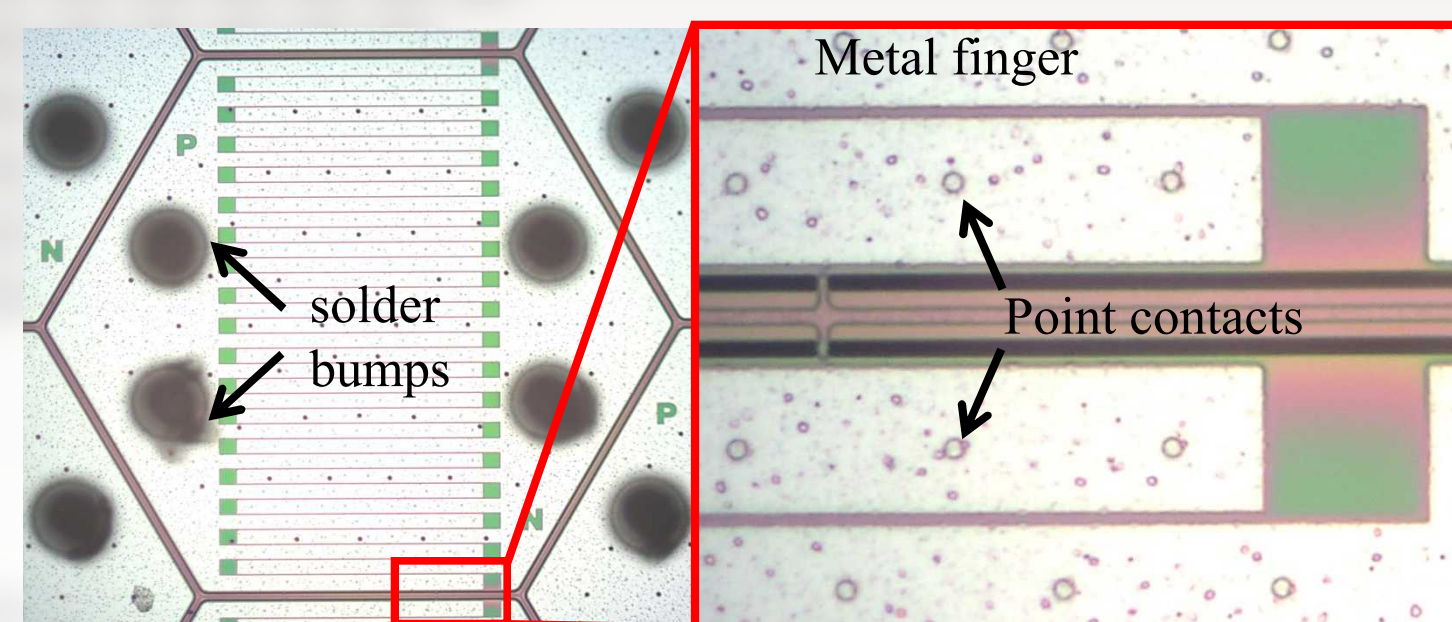


Conceptual vision of the system of flat concentrators mounted on inexpensive trackers.

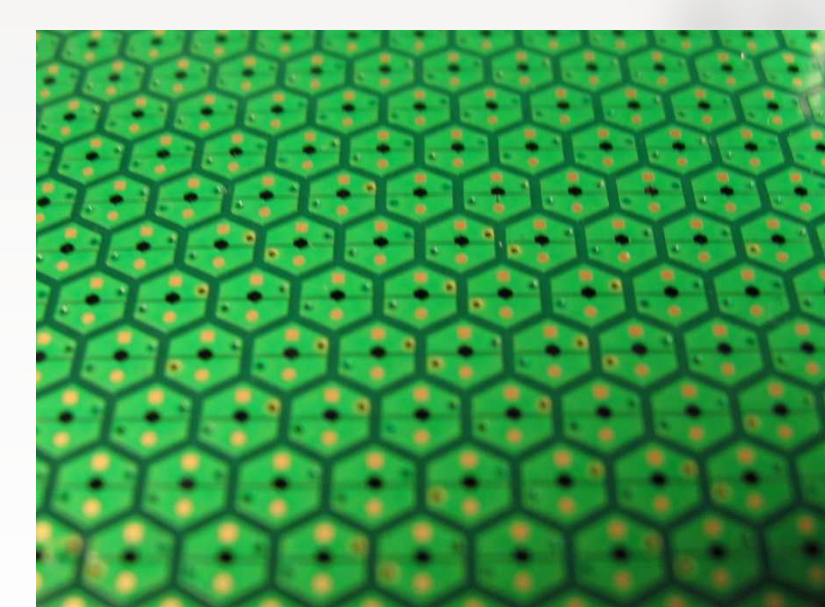
Fabrication



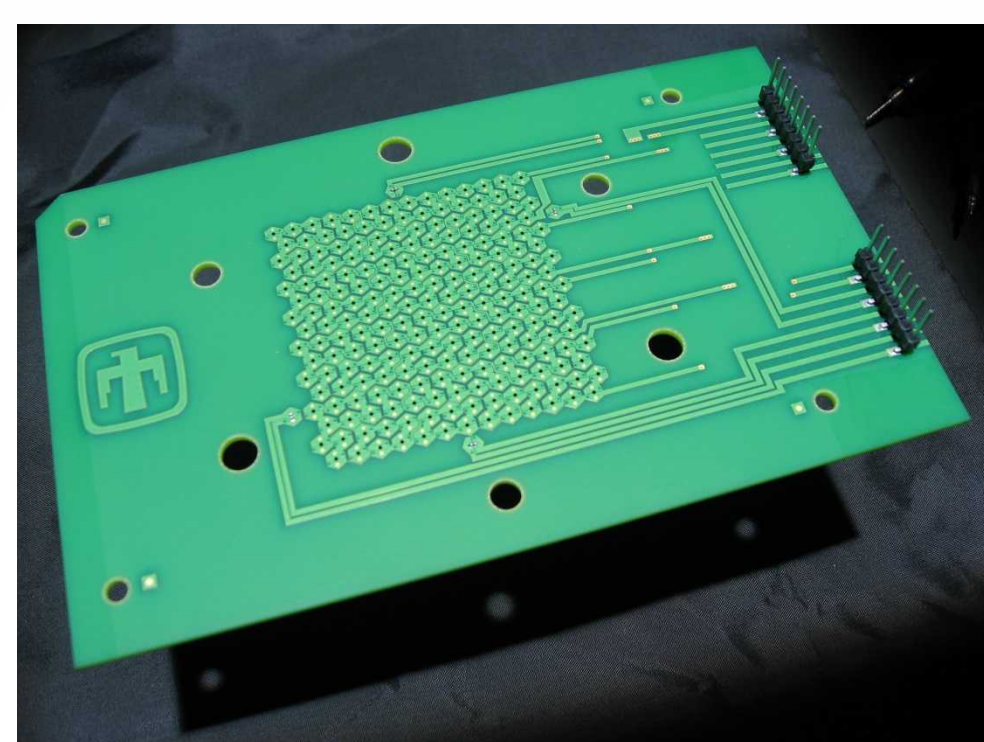
The cells are created in regular thickness wafers using standard processing tools.



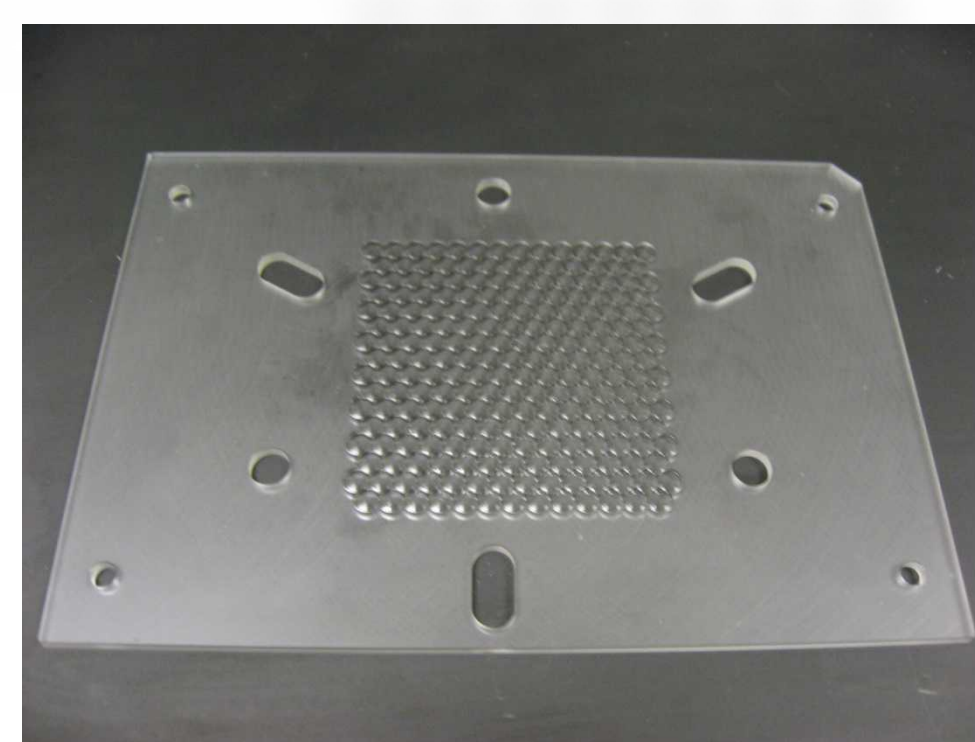
The fabricated cells have interdigitated back point contacts.



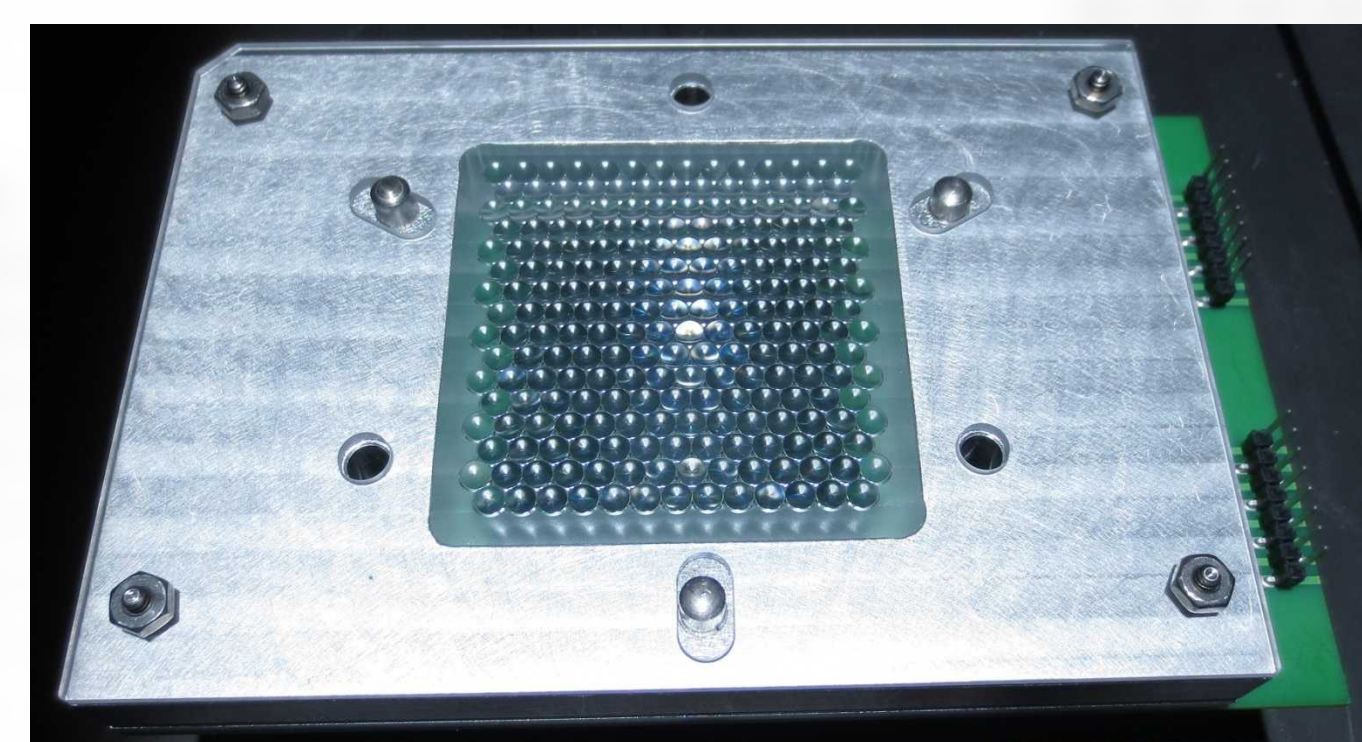
The cells were assembled onto a PCB board by pick and place techniques



The PCB board included internal routing of cables to establish series/parallel connections

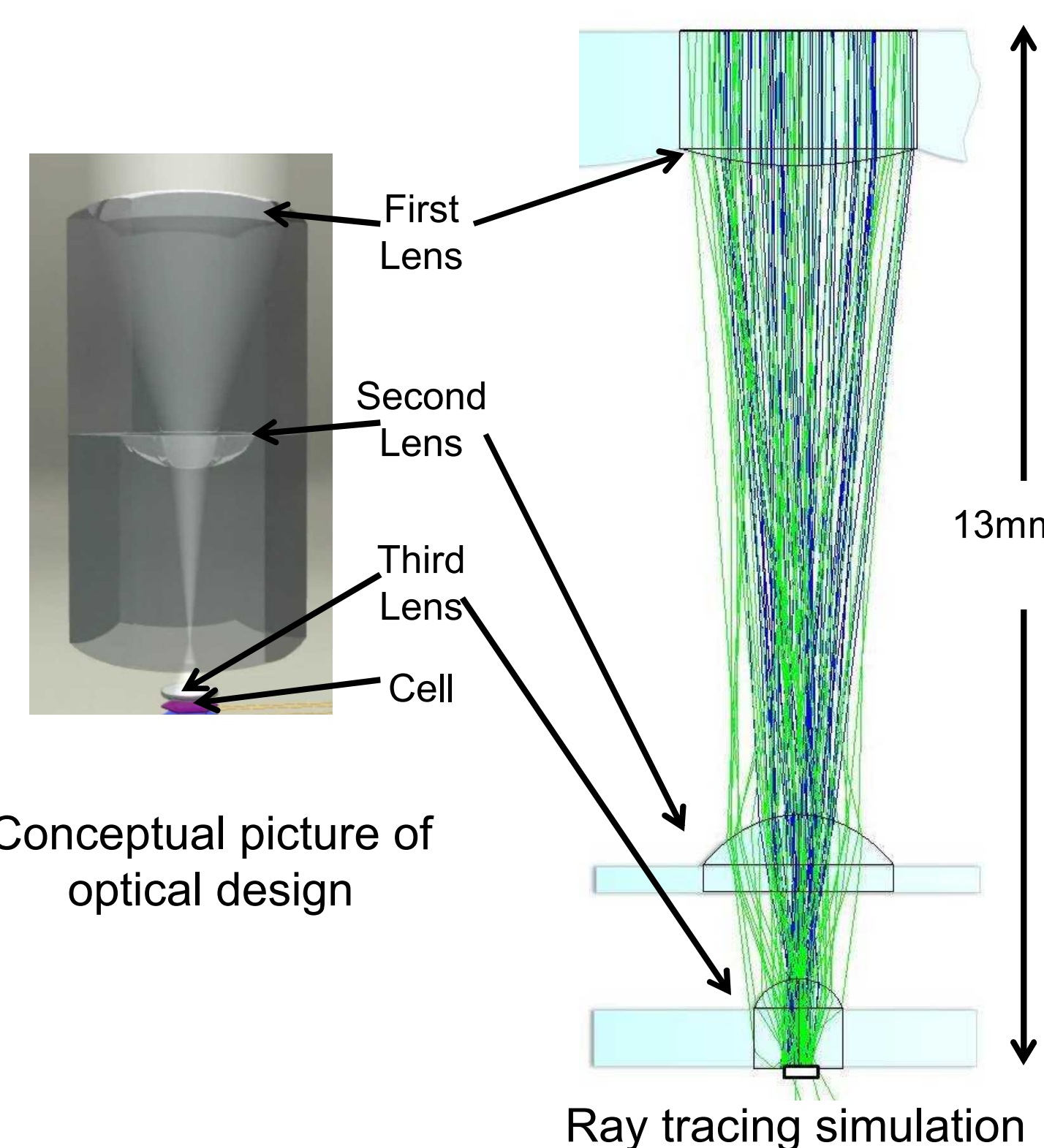


Three set of lenses were designed and fabricated in polycarbonate.



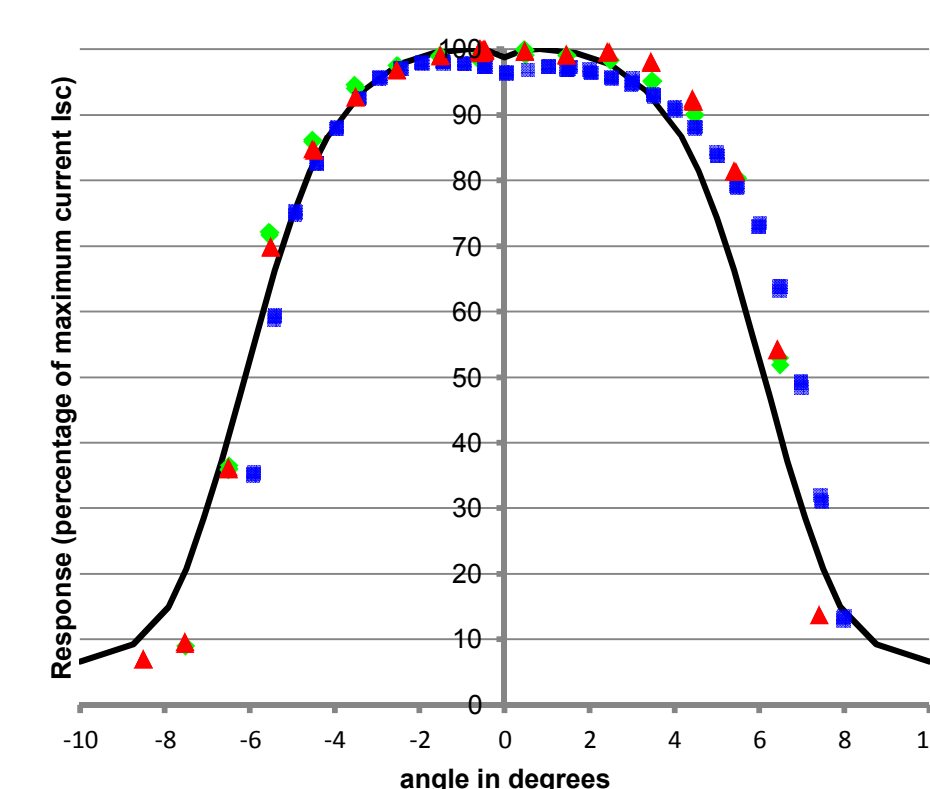
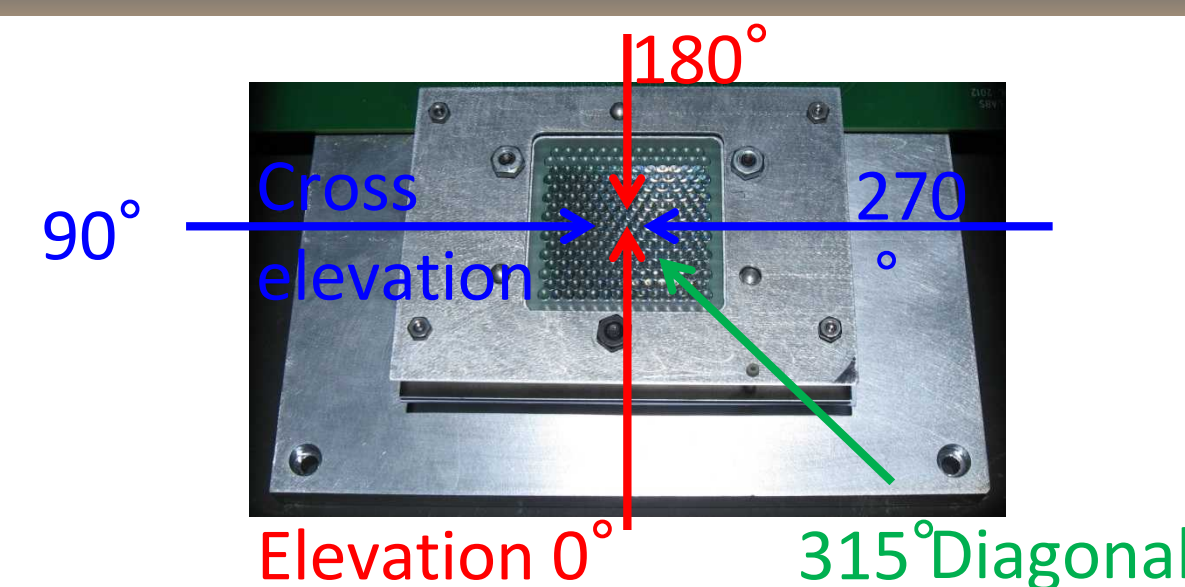
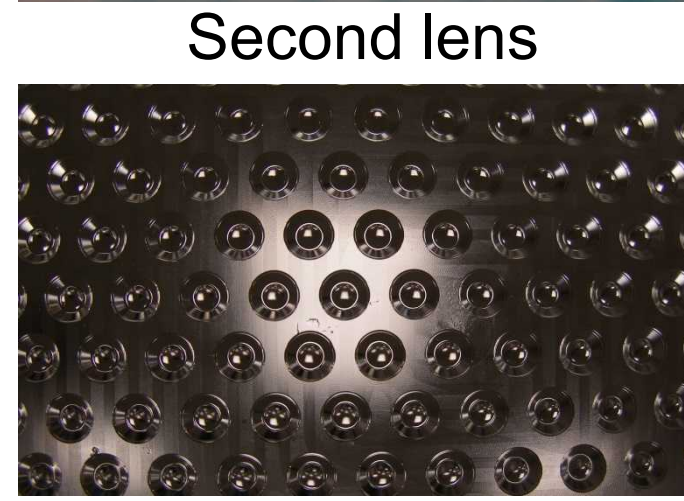
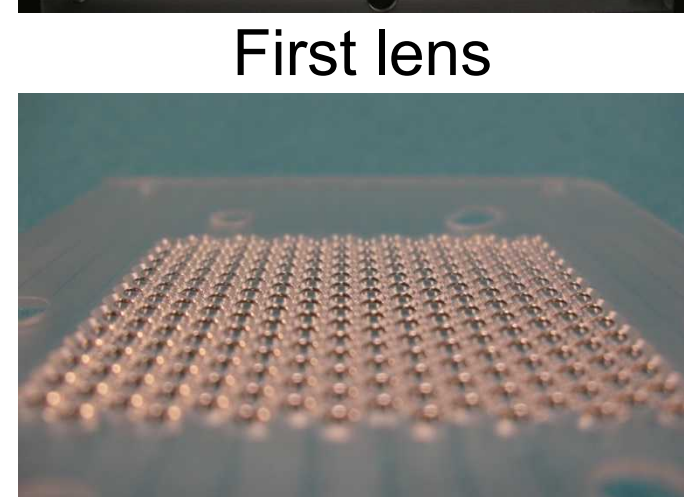
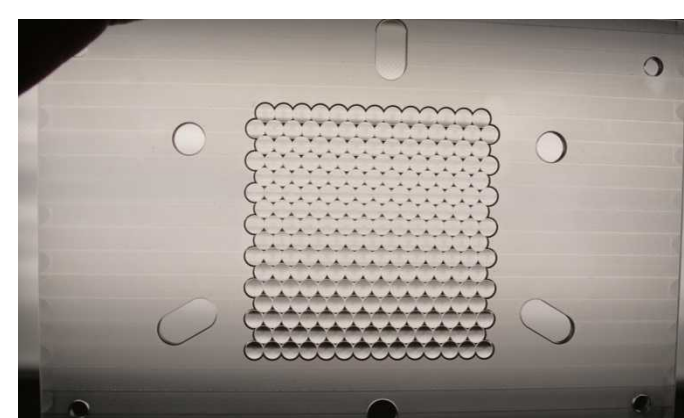
The module was assembled including the three set of lenses, spacers, and the PCB board including 216 micro cells.

Optics design and results



Conceptual picture of optical design

Fabricated lenses



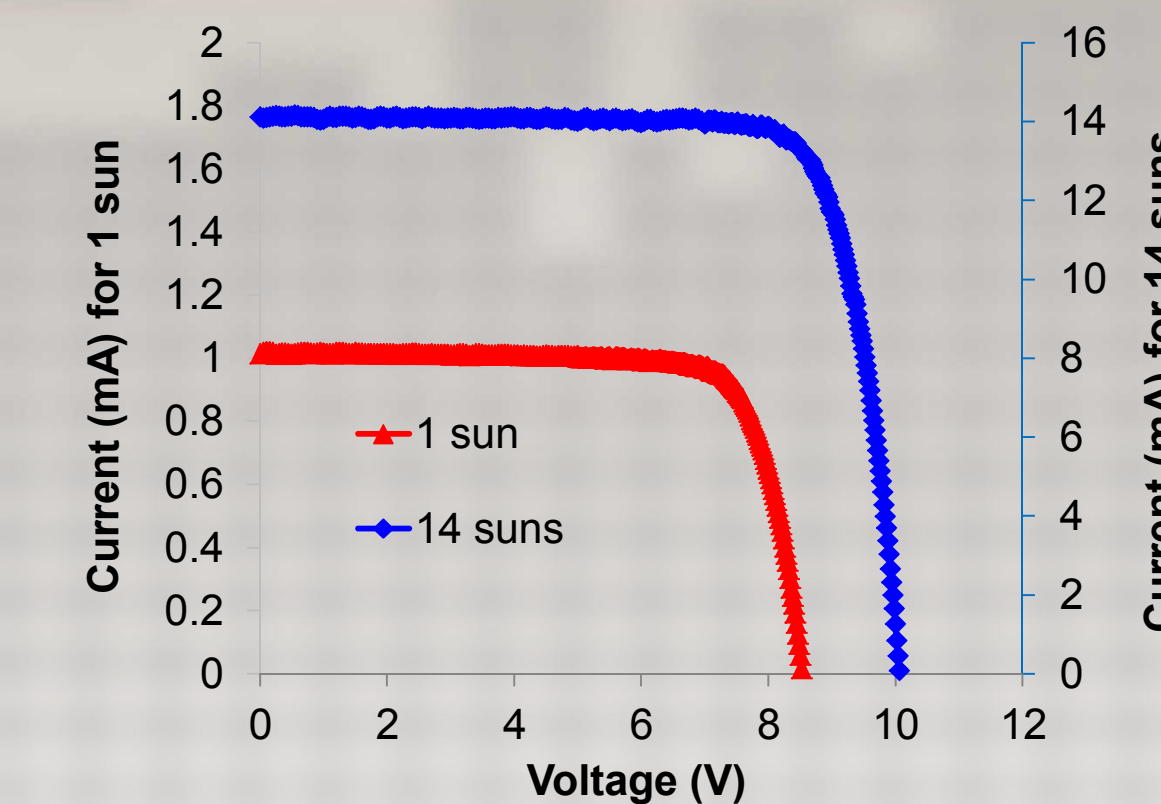
Directions tested on tracker and results for acceptance angle

Electrical Characterization

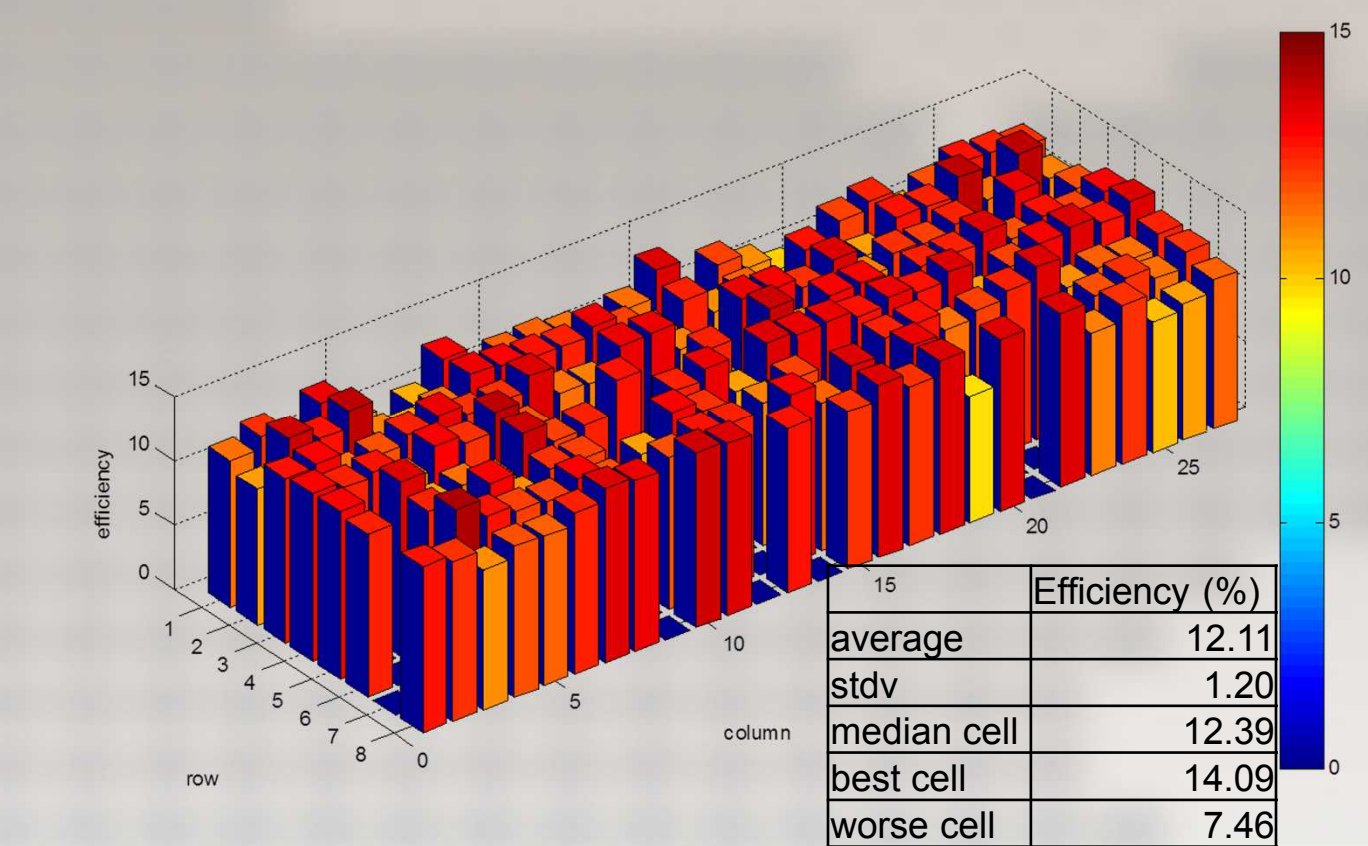
INDOOR TESTING



OAI Class AAA solar simulator and Agilent B1500 used for indoor testing



Performance of all the cells interconnected



Performance of individually connected cells

OUTDOOR TESTING



Sandia's dual axis tracker in Albuquerque, NM

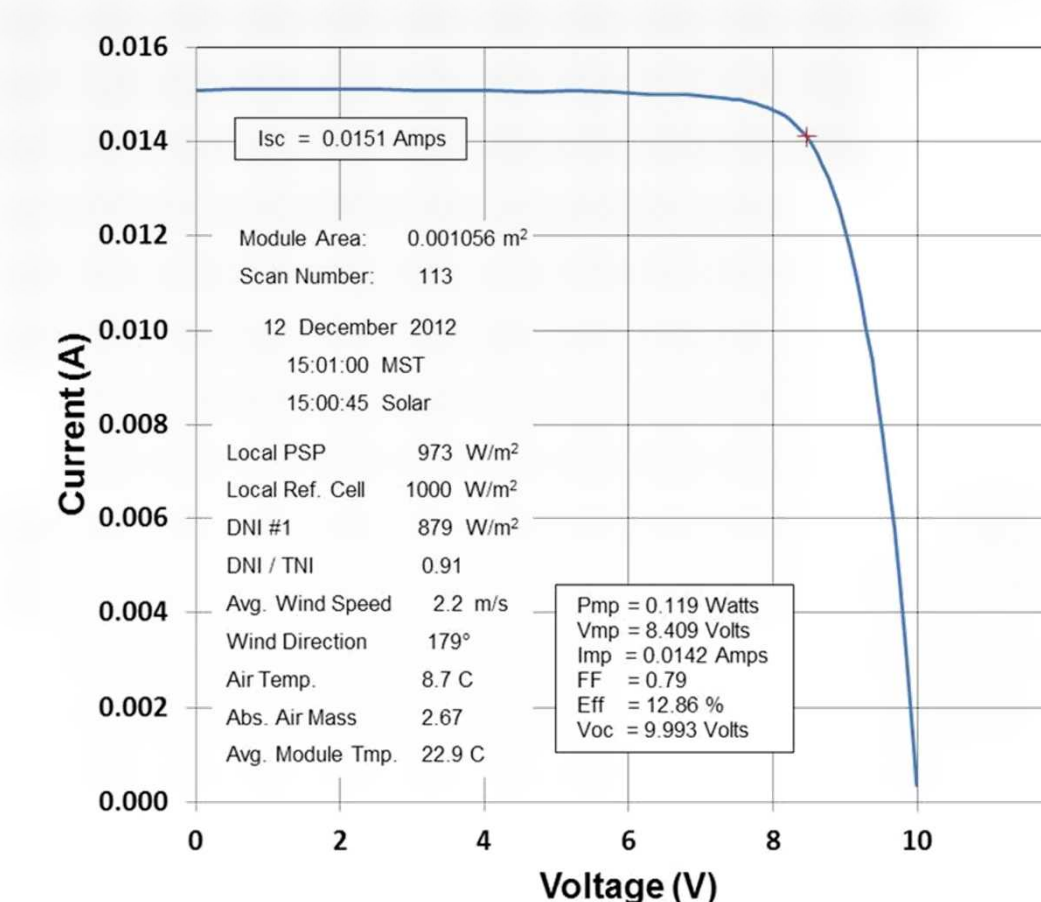


Instrumentation used for generation of IV's

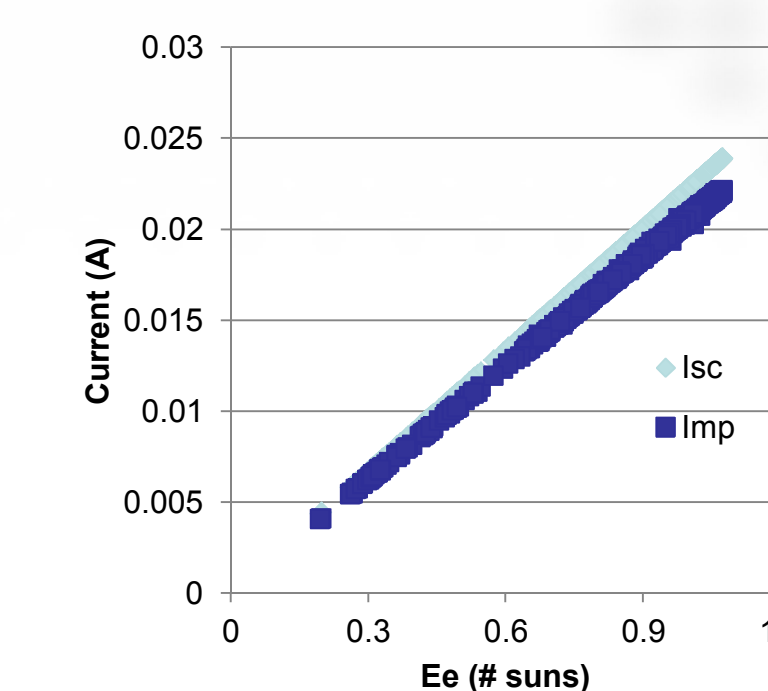


Attachment and connection of module to tracker

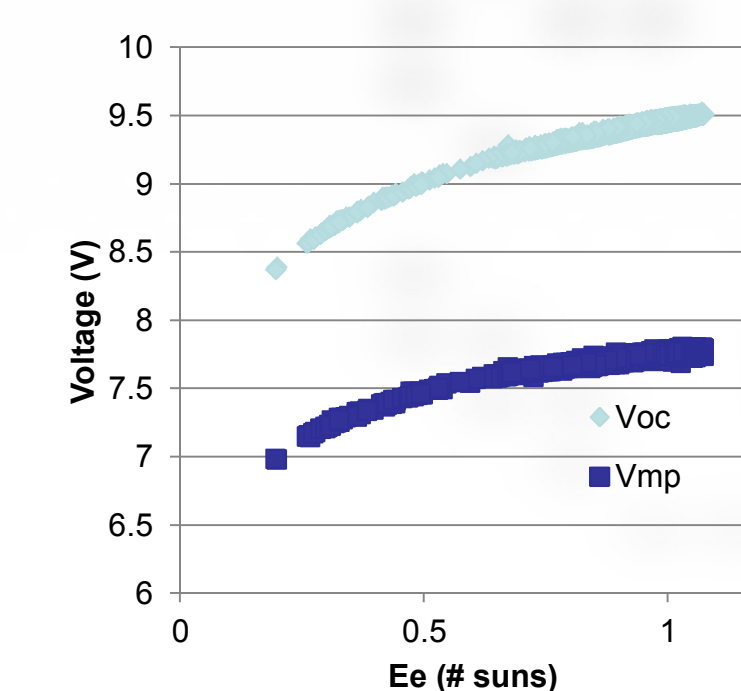
The module was analyzed for two half days including sunny and cloudy data. IV's were taken every minute. Analysis using Sandia's model was implemented to extract the parameters



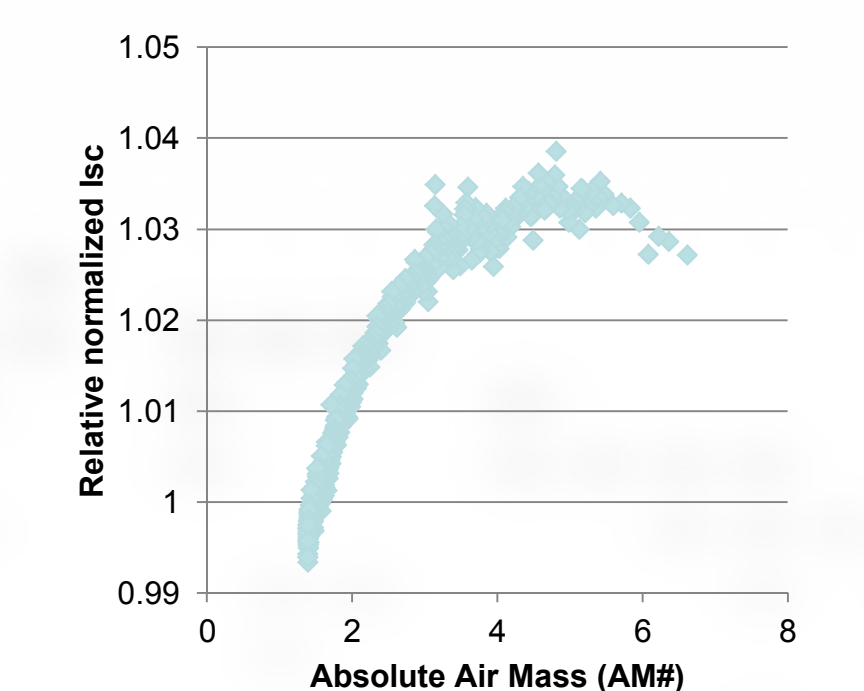
IV curve obtained outside with ideal conditions for the mini-module



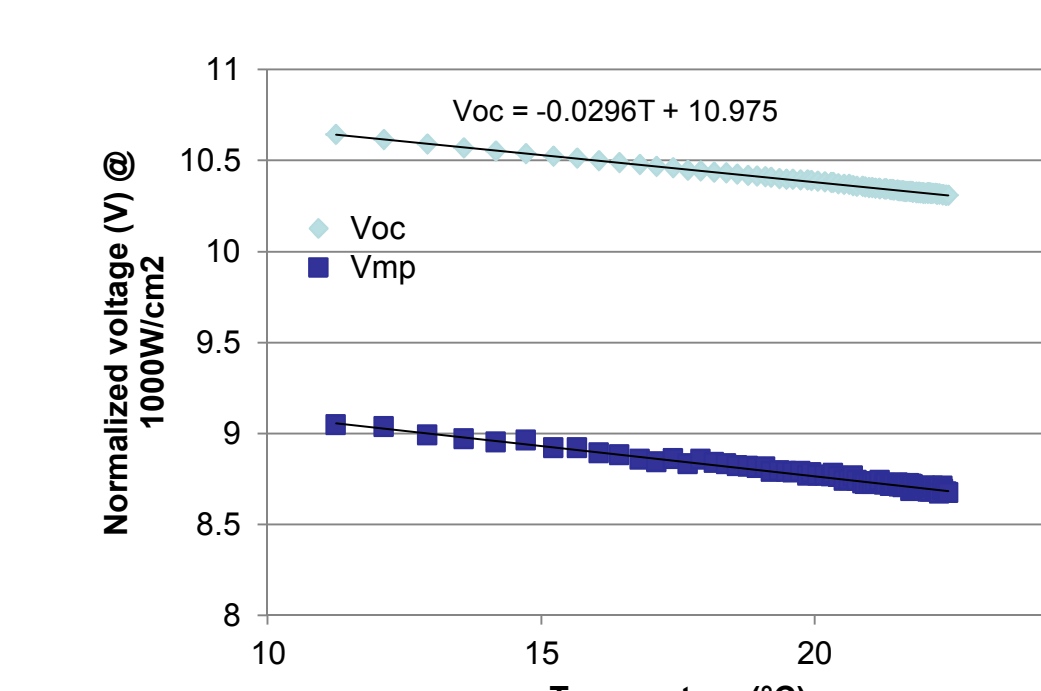
Current vs. # of suns



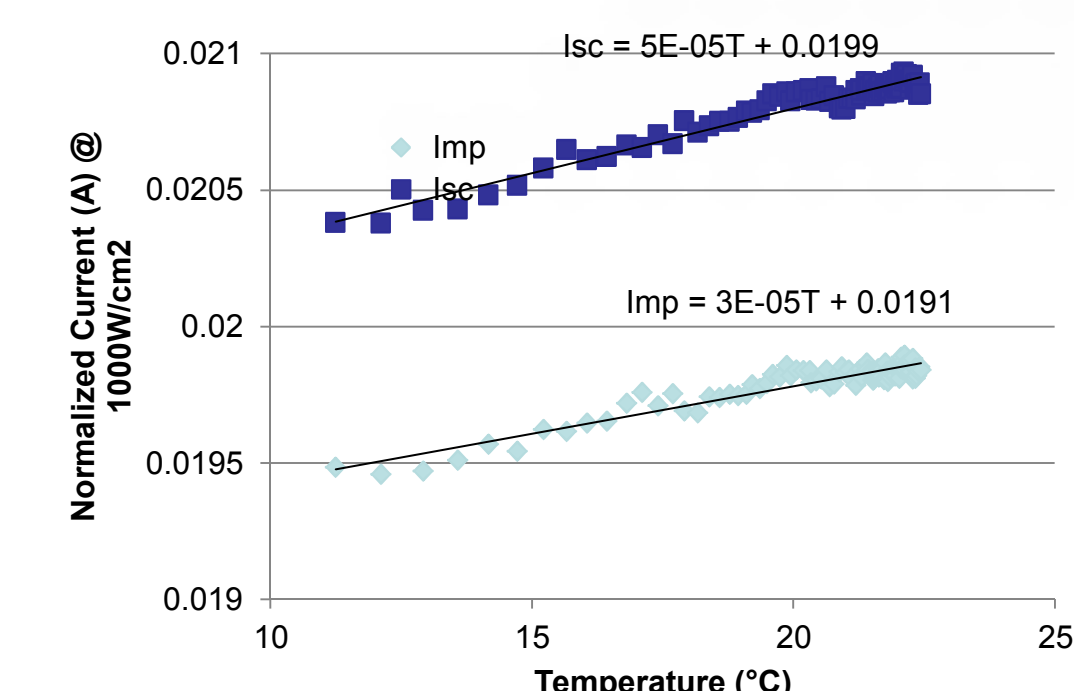
Voltage vs. # of suns



Normalized current vs. AM #



Volatges vs. temperature



Currents vs. temperature

Conclusion

In conclusion we demonstrated the concept of a flat plate micro-concentrator with encouraging early results. We achieved this by using ultrathin and micro sized single crystal silicon solar cells coupled with a mini-lens array. The 20 cm² array has a focal length of only 13 mm with a field of view of +/-4 degrees. 216 micro-cells were connected in series and parallel through a printed circuit board. Each cell is 720 μm in diameter and 20 μm in thickness. The open circuit voltage of the array was 10.3 V; the short circuit current was 21.8 mA; and the fill factor 80%. Cells under concentration behaved very similar to flat plate 1 sun modules.

References

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