

Microsystems Enabled Photovoltaics (MEPV)

Gregory N. Nielson

Sandia National Laboratories

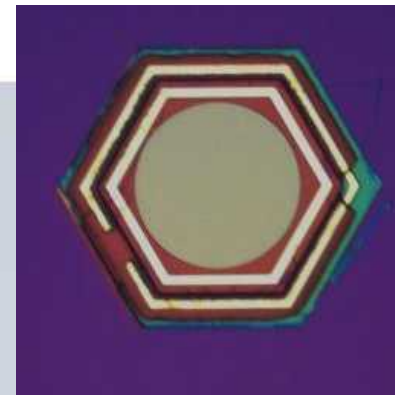
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND 2013 XXXX-P



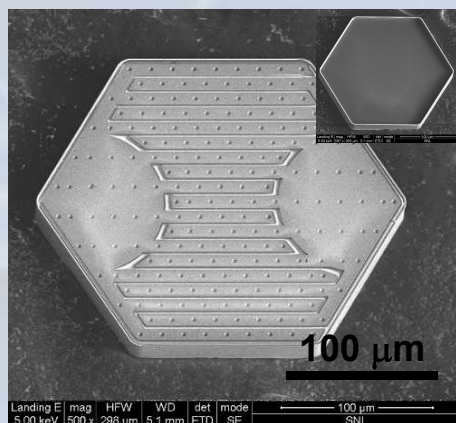
New PV Cell Architectures

Unique cell performance characteristics:

- 10X or more reduction in semiconductor material
- Backside contacted c-Si and III-V PV cells
- Removes constraints of lattice matching and current matching on multijunction PV cell design and performance
- Utilizes existing manufacturing infrastructure and supply chains from IC, MEMS, LCD, and LED industries

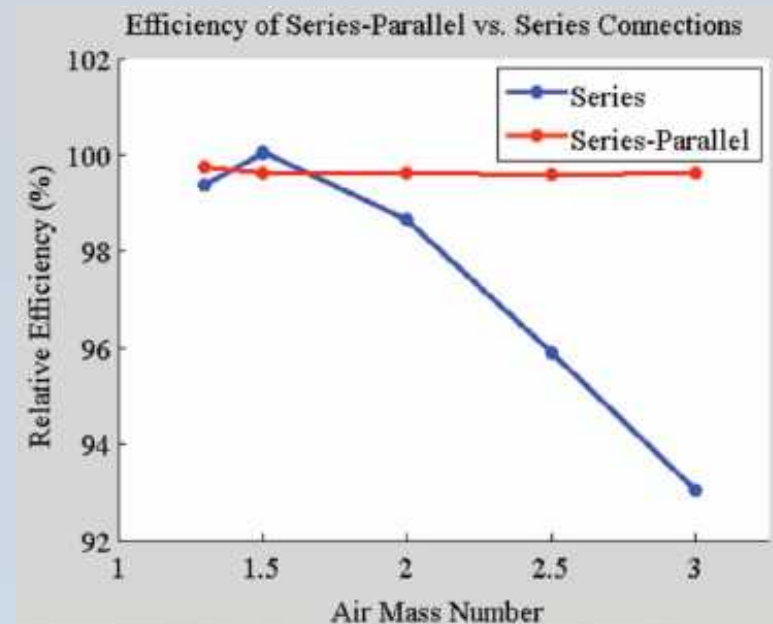


4 μm thick, 250 μm across GaAs cell transferred and directly integrated with a receiving substrate



Material	Bandgap
<i>InGaN</i>	2.5
<i>InGaP</i>	1.85
<i>GaAs</i>	1.4
<i>Si</i>	1.1
<i>InGaAsP</i>	0.9
<i>InGaAs</i>	0.6

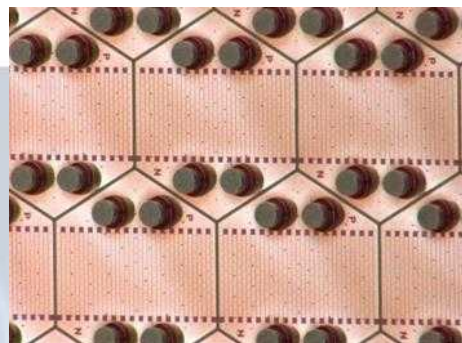
14 μm thick, 250 μm across crystalline silicon cell-



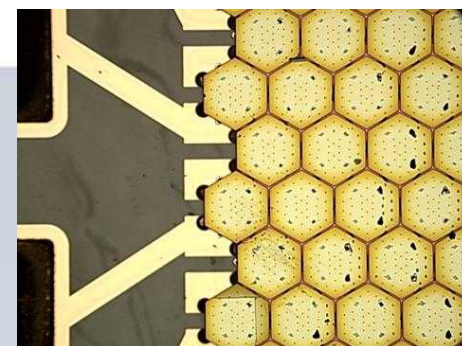
High-Efficiency, Highly Flexible PV

Key Performance Metrics:

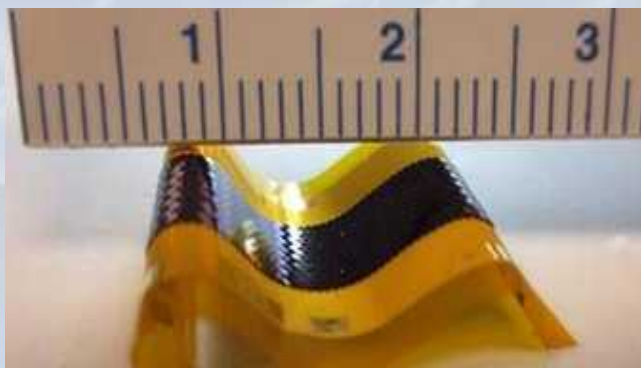
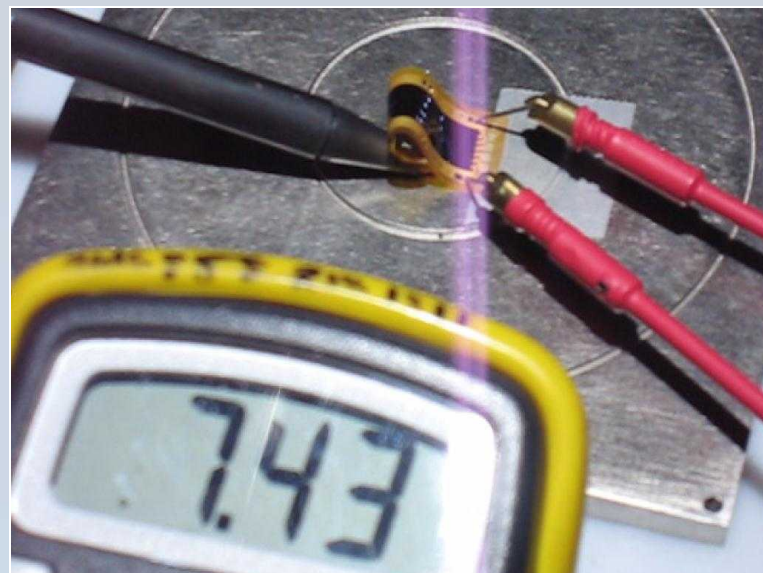
- Module flexibility down to 1 mm bend radius
- Demonstrated module performance of 14%, >20% possible with c-Si, >30% with multijunction cells
- 440 W/kg module specific power demonstrated, 1000 W/kg possible
- Significant improvement in shade and damage tolerance compared to traditional PV



Cells on wafer with solder bumps



Cells after solder reflow connection to receiving substrate



1mm bending radius!

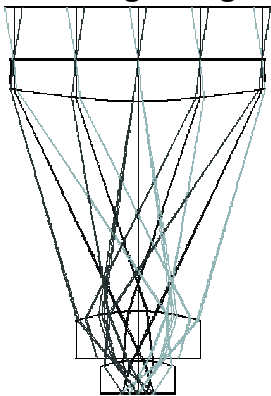
MEPV Micro-concentrator System

Key Performance Metrics:

- Concentrator thickness of ~1cm and concentration levels up to 400X
- Acceptance angles of $\pm 4^\circ$ or more
- Utilizes the low-cost balance-of-system components of current flat plate PV
- Allows economical use of high efficiency multi-junction PV cells
- Potential for LCOE less than \$0.10/kWh across most of USA (as low as \$0.6/kWh in some locations)



Incoming sunlight



PV cell

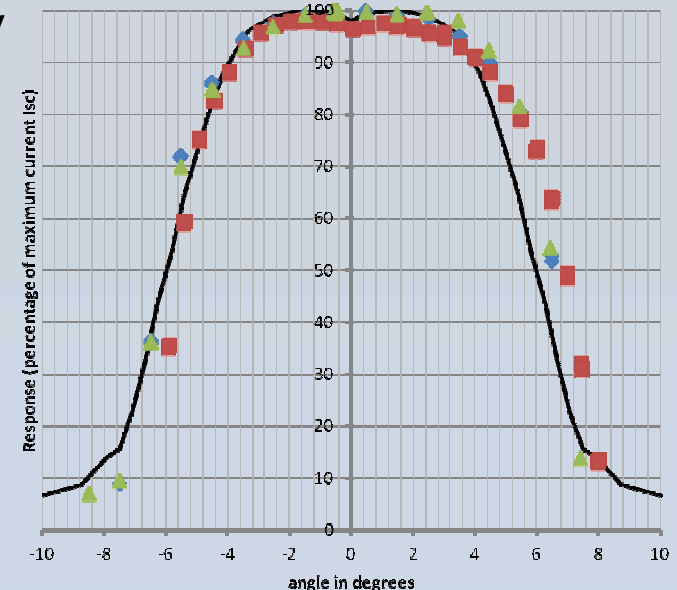
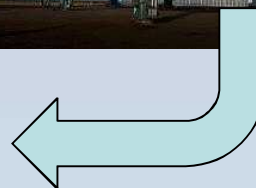
Optical ray trace model of optical concentrator made possible by microscale solar cells.



Low-cost, coarse 2-axis tracking

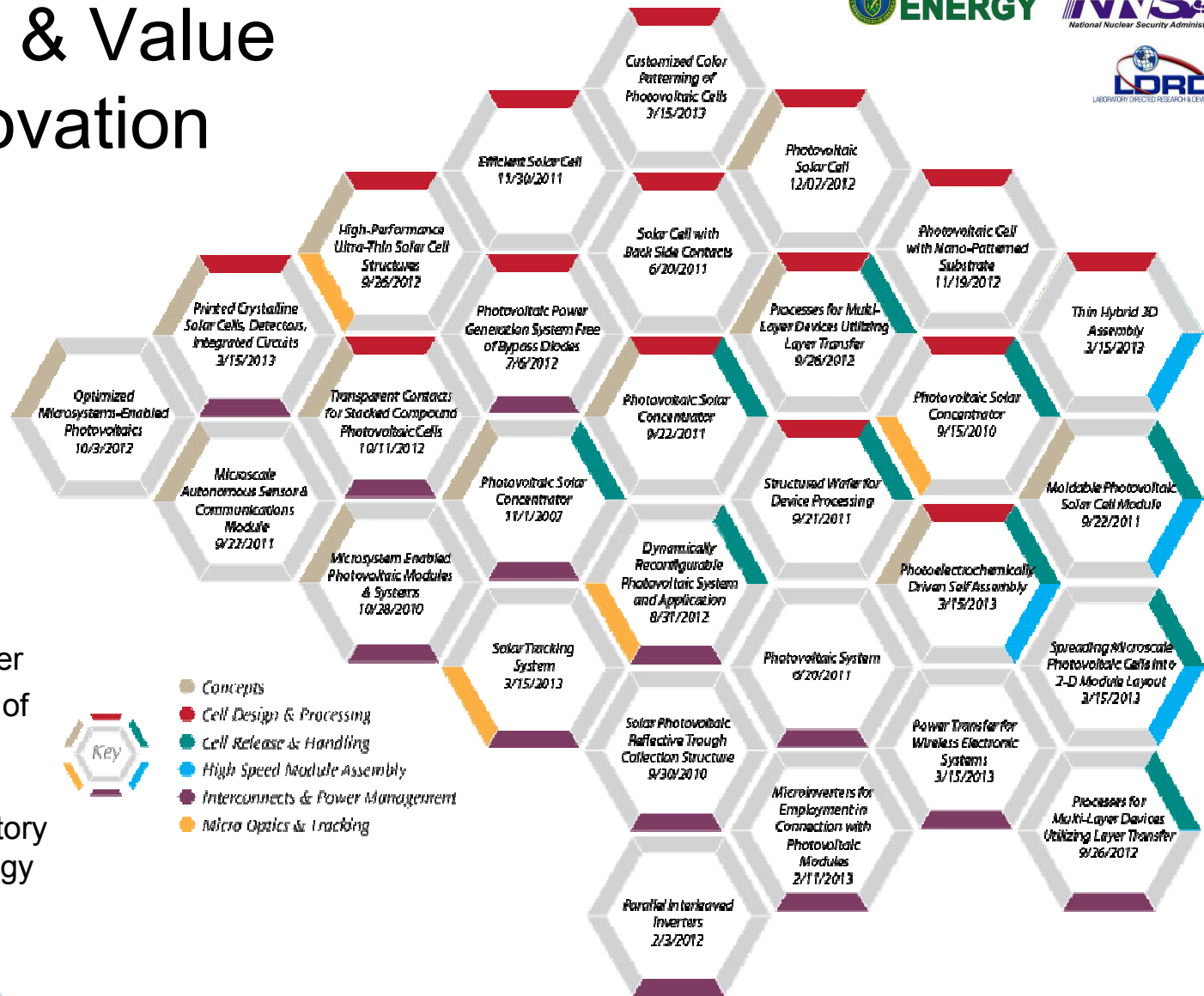


Expensive, high accuracy tracking



◆ Cross elevation ■ Elevation ▲ Diagonal — indoor testing

Protection & Value of the Innovation

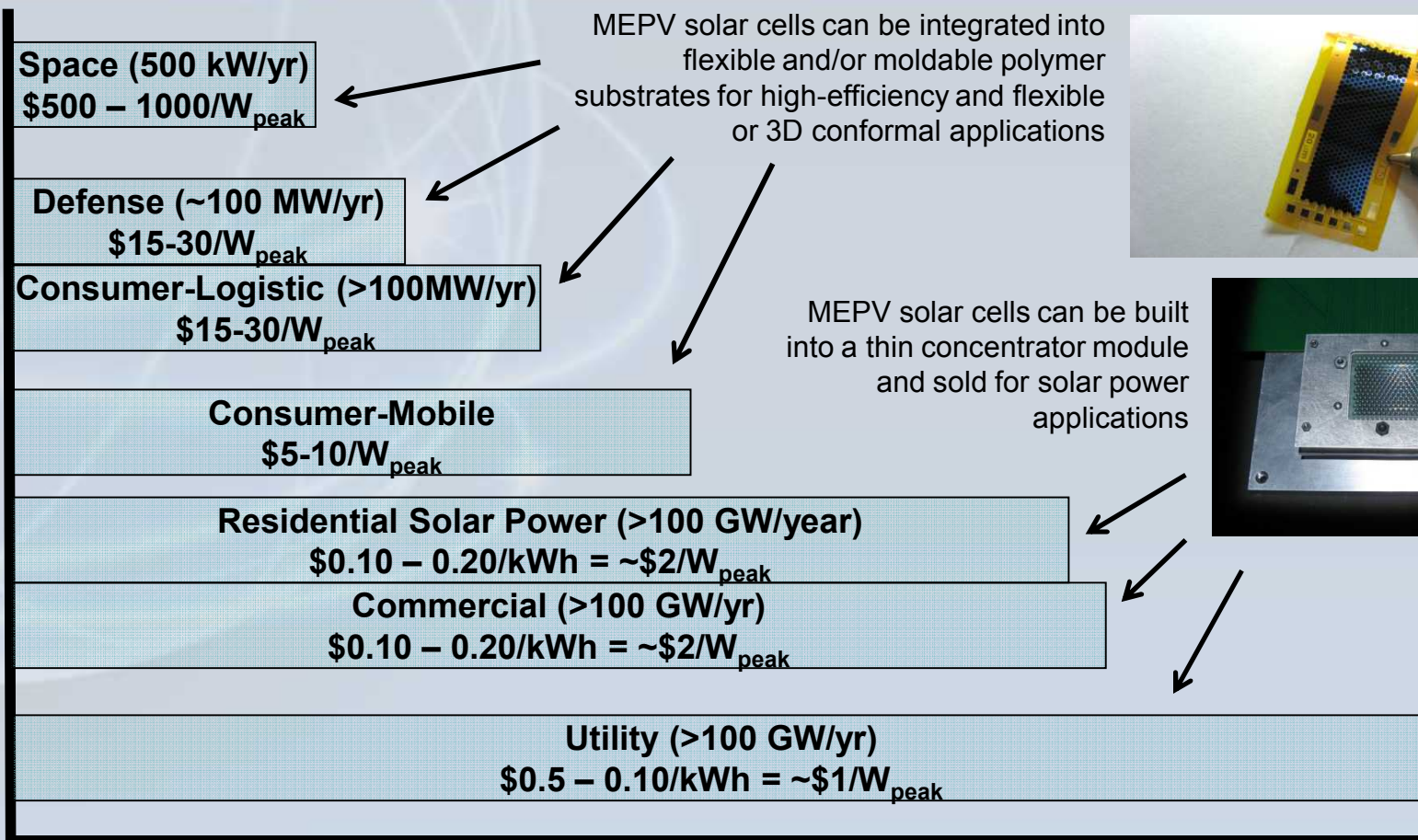


Awards:

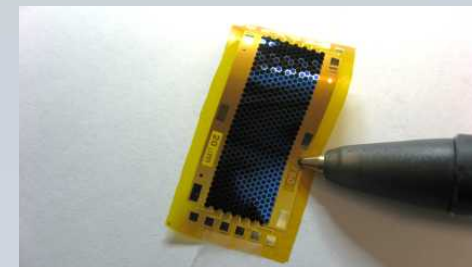
- 2012 R&D 100 Winner
- 2011 Optical Society of America Green Photonics Award
- 2011 Federal Laboratory Consortium Technology Transfer Award

Broad Application: Power Markets

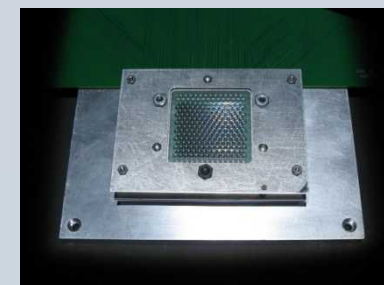
Value of Power



MEPV solar cells can be integrated into flexible and/or moldable polymer substrates for high-efficiency and flexible or 3D conformal applications



MEPV solar cells can be built into a thin concentrator module and sold for solar power applications



Market Size

Contact Information

- Gregory Nielson,
Sandia National Laboratories
 - IP@sandia.gov
 - energy.sandia.gov
- Please stop by Booth #1105 for more information on MEPV and other projects from Sandia National Laboratories.

