SAND2011-4510P

THE 2011 FLC MID-CONTINENT REGION ANNUAL AWARDS

Nomination Form

Please note the specific criteria for the nominated award.

I nominate the following individual, technology, or organization for the following award (please √):

- ❑ Regional Laboratory Award
- ❑ Regional Partnership Award
- ❑ Representative of the Year Award
- ❑ STEM Mentorship Award
- **X Notable Technology Development Award**
- ❑ Excellence in Technology Transfer
  Criteria is similar to FLC national award – see page 2

Nomination submitted by: Jackie Kerby Moore, Manager, Dept. of Technology and Economic Development
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Nominee's Names: Gregory N. Nielson, Sandia Lead Investigator; Murat Okandan, Jose Luis Cruz-Campa, Vipin P. Gupta, Paul J. Resnick, Carlos A. Sanchez, Anton Filatov, Peggy J. Clews, William C. Sweatt, Anthony L. Lentine, Tammy Pluym, Jeffrey S. Nelson
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Microsystems-Enabled Photovoltaics—Solar Glitter
Basis for Nomination—Notable Technology Development

Overview

A team of Sandia National Laboratories (SNL) researchers has developed glitter-sized photovoltaic cells that could revolutionize the way solar power is collected and used. Microsystems-Enabled Photovoltaics (MEPV) are fabricated using microelectronic and microelectromechanical systems (MEMS) techniques. They are expected to be less expensive and more capable than current photovoltaic collectors. Moving to micro-scale PV cell sizes results in many benefits at the cell, module, and system level. By making the technology efficient, versatile, and inexpensive, it can serve power utilities, building owners, and individuals. Partnerships with companies, labs and universities are moving the technology forward, and patents have been filed. MEPV components have a real chance at achieving the elusive cost breakthrough that is needed to make solar a mainstream energy source.

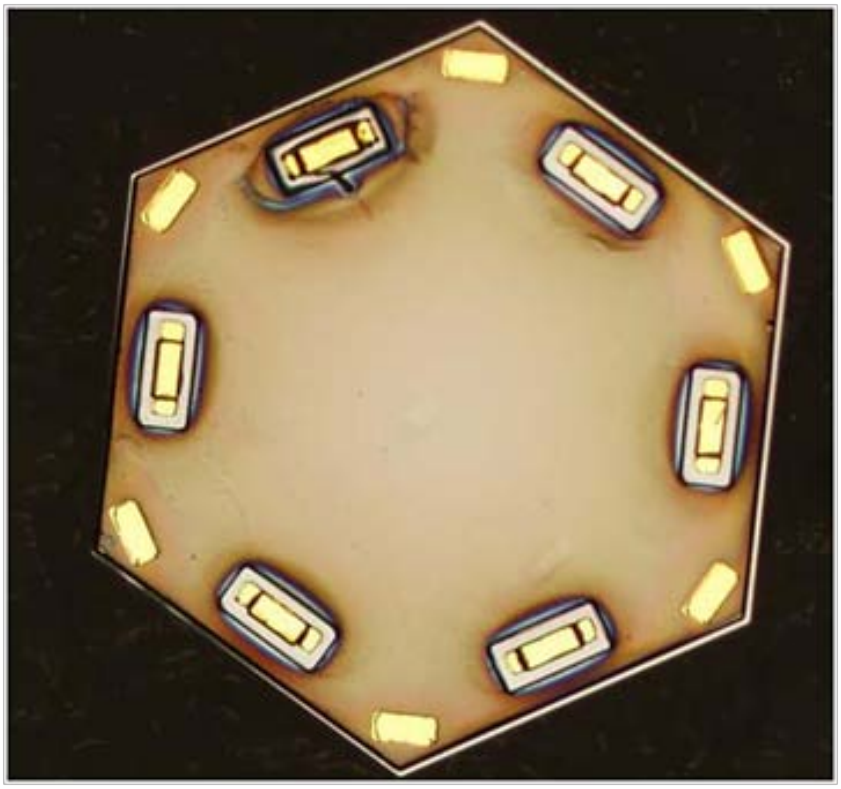

Figure 1 Double junction InGaP GaAs solar PV cell with back contacts at the same level

MEPV Technology

SNL's MEPV technology uses microdesign and microfabrication techniques common to semiconductor, LCD, and microsystem industries to produce miniaturized solar cells as small as 3-20 microns thick and 100-250 microns wide. These PV cells are then placed or "printed" onto a low-cost substrate with embedded contacts and microlenses for focusing sunlight onto the cells.

Moving to micro-scale PV cell sizes results in over two dozen distinct benefits at the cell, module, and system level,[1] including:

- A factor of >30 improvement in conversion efficiency per gram of utilized PV material
- Use and reuse of any wafer size, enabling utilization of dormant or underutilized IC fabs
- Improved carrier collection
- Rapid pick-and-place or directed self-assembly
- High-temperature processing done on wafer, enabling use of low-temperature, lower cost materials in the module
- Production of flexible PV modules operating at >20% conversion efficiencies (Commercial flexible PV products available today operate at ~5% conversion efficiency)

[1] G.N.Nielson, M. Okandan, P. Resnick, J.L. Cruz-Campa, P. Clews, M. Wanlass, W. Sweatt, E. Steenbergen, V. Gupta, "Microscale PV cells for concentrated PV applications," Conference Record of the 24th EU PVSEC (2009) 170-173.

• Operating temperatures at up to 500X concentration that equal operating temps of commercial one-sun modules

• High voltage, low current output that improves overall module reliability and reduces system wiring costs

• Simpler, flat panel sun tracking configurations, reducing both the cost and complexity of concentrating optics and sun tracking structures

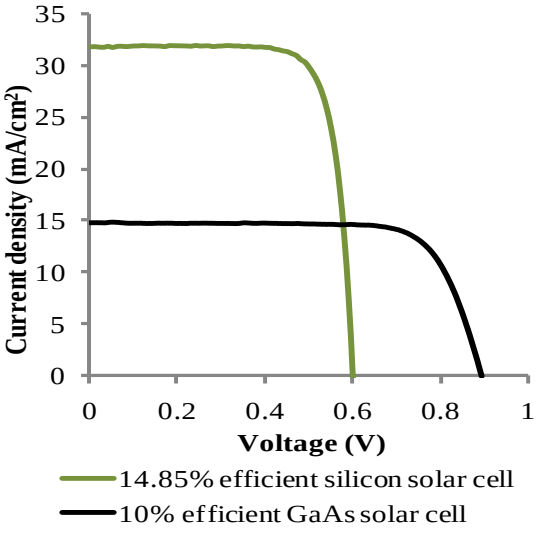

Figure 2 Experimental J-V measurement curves for SNL's micro-PV cells

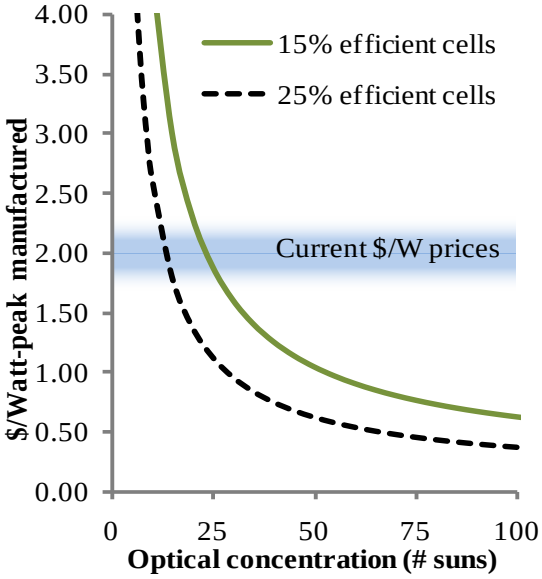

Figure 3 MEPV can lead to much lower prices for solar PV.

Problem it solves and benefits

With growing concerns about atmospheric emissions from fossil fuel use and ever increasing demand for electricity, there is an insatiable need for point-of-use technologies that generate electricity in a clean way. While solar energy is the one resource that can meet national and global energy consumption with orders of magnitude to spare, the collection and conversion of sunlight to electricity remains 2-3 times more expensive than fossil fuel electricity generation.

The SNL MEPV team has conceived a solar photovoltaic design based on microsystems-enabled components that reduce overall system cost by a factor of 2-3. These components, combined with our new manufacturing and installation concepts, have a real chance at achieving the elusive solar cost breakthrough that is needed to make solar a mainstream energy source.

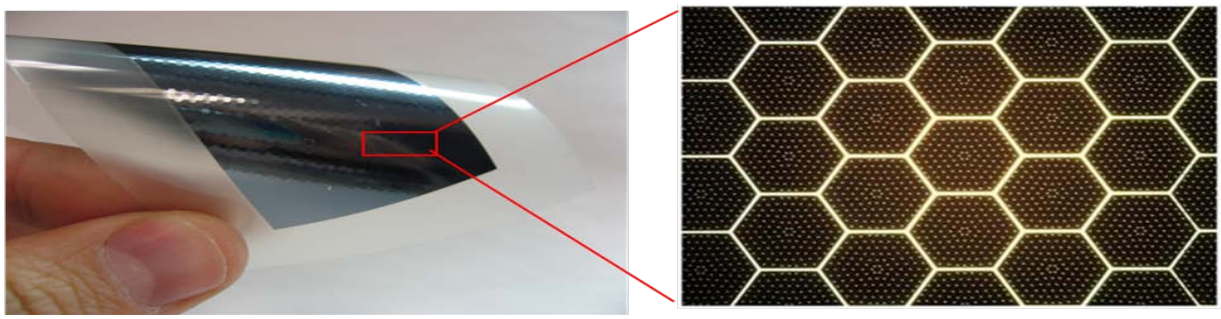

Figure 4 Prototype of flexible PV solar panel consisting of 20 micron thick segmented crystalline silicon cells without passivation.

Markets and Consumers

MEPV development is focused on making this technology the most efficient, versatile, and inexpensive way to produce electricity to serve three distinct markets:

• **Power Utilities:** At 75-125X concentration on single-axis sun trackers, utilities could acquire MEPV modules at prices competitive with grid power, install the hardware rapidly, and operate the system reliably. This would give utilities the ability to produce solar electricity at the lowest wholesale prices on the market by a factor of two.

• **Building Owners:** At 2-10X concentration, facility managers could install low-concentration, flat-plate MEPV modules on horizontal rooftops. This would provide building owners cost-competitive retail electricity as well as price stability over the 20-30 year lifetime of the system.

• **Individuals:** At one sun, individuals could purchase homes, vehicles, gadgets, and clothing powered with built-in, flexible MEPV devices. Designed to fit within various shapes and contours, these products would provide light, temperature control, digital communications, propulsion charging, and/or computational power to the individual using ambient light or sunlight energy harnessed by the MEPV device.

Figure 5 Flexible mechanical model with embedded MEPV cells and micro optics

Partnerships formed

As part of MEPV technology development, a variety of mutually beneficial partnerships have been formed, some with small businesses. The SNL team's role in all of these partnerships is to design, fabricate, and/or test MEPV cells, modules, systems, and/or devices.

- Lockheed-Martin: Integrate MEPV devices into military systems
- Universal Instruments: Adapt UI pick-and-place tools & techniques to produce MEPV modules
- Endicott Interconnect: Produce flex circuit substrates for MEPV cells
- EMCORE: Produce high-efficiency MEPV cells from Emcore III-V wafers
- Nat'l Renewable Energy Lab: Produce high-efficiency MEPV III-V cells from NREL wafers
- Univ. of Central Florida: Prototype small-scale MEPV module using MEPV cells
- Univ. of Southern Florida: Conduct experiments in directed, self assembly using MEPV cells

Patents filed or awarded

Five patents have been filed in the past nine months for various aspects of the technology with Gregory Nielson and a number of team members listed as inventors.

- Photovoltaic Solar Concentrator Serial# 12/882,976
- Solar Photovoltaic Reflective Trough Collection Structure Serial# 12/894,772
- Microsystem Enabled Photovoltaic Modules and Systems Serial# 12/914,441
- Photovoltaic Solar Concentrator Serial# 12/957,082
- Backside Contacted Thin Compound Semiconductor Solar Cells Serial# 13/164,017

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