3-D Solar Cell that Uses "Towers" to Boost Efficiency Wins Patents

Georgia Institute of Technology

A three dimensional solar cell design that uses micron-scale “towers” to capture nearly three times as much light as flat solar cells made from the same materials has been awarded broad patent protection in both China and Australia. Modeling suggests that the 3-D cell could boost power production by as much as 300 percent compared to conventional solar cells.

Because it can capture more power from a given area, the 3-D design could be useful for powering satellites, cell phones, military equipment and other applications that have a limited surface area. Developed at the Georgia Tech Research Institute (GTRI), the “three dimensional multi-junction photovoltaic device” uses its 3-D surface structure to increase the likelihood that every photon striking it will produce energy.

“One problem with conventional flat solar cells is that the sunlight hits a flat surface and can bounce off, so the light only has one chance to be absorbed and turned into electricity,” explained John Bacon, president of IP2Biz®, an Atlanta company that has licensed the technology from GTRI. “In the GTRI 3-D solar cell, we build a nanometer-scale version of Manhattan, with streets and avenues of tiny light-capturing structures similar to tall buildings. The sunlight bounces from building to building and produces more electricity.”

The arrays of towers on the 3-D solar cell can increase the surface area by several thousand percent, depending on the size and density of the structures.

“Conventional cells have to be very large to make adequate amounts of electricity, and that limits their applications,” Bacon explained. “The large surface area of our 3-D cell means that applications from satellites to cell phones will be more practical since we can pack so much light gathering power into a small footprint.”

The three dimensional structure also means that the cells don’t have to be aimed directly at the sun to capture sunlight efficiently, Bacon added. Conventional solar cells work best when the sunlight hits them at a narrow range of angles, but the new 3-D system remains efficient regardless of the angle at which the light hits.

The tower structures on the GTRI solar cells are about 100 microns tall, 40 microns by 40 microns square, 50 microns apart – and grown from arrays containing millions of vertically aligned carbon nanotubes. The nanotubes primarily serve as the structure on which current-generating photovoltaic p/n coatings are applied.

“The carbon nanotubes are like the framing inside of buildings, and the photovoltaic materials are like the outer skin of the buildings,” said Tom Smith, president of 3-D

Solar LLC, a company formed to commercialize the cells. “Within the three-dimensional structures, multiple materials could be used to create the physical framing. Carbon nanotubes were used in the original solar cells, but they are not required for the technology to work.”

The 3-D solar cells were developed in the laboratory of Jud Ready, a GTRI senior research engineer. Tests comparing the 3-D solar cells produced in Ready’s lab with traditional planar cells produced from the same materials showed an increase in power generation, Smith said.

The researchers chose to make their prototype cells from cadmium materials because they were familiar with them from other research. However, a broad range of photovoltaic materials could also be used, and selecting the best material for specific applications will be the goal of future research.

Fabrication of the cells begins with a silicon wafer, which also serves as the solar cell’s bottom junction. The researchers first coat the wafer with a thin layer of iron using a photolithography process that can create a wide variety of patterns. The patterned wafer is then placed into a furnace heated to approximately 700 degrees Celsius.

Hydrocarbon gases are then flowed into the furnace, where the carbon and hydrogen separate. In a process known as chemical vapor deposition, the carbon grows arrays of multi-walled carbon nanotubes atop the patterns created by the iron particles.

Once the carbon nanotube towers have been grown, the researchers use a process known as molecular beam epitaxy to coat the nanotube arrays with cadmium telluride (CdTe) and cadmium sulfide (CdS), which serve as the p-type and n-type photovoltaic layers. Atop that, a thin coating of indium tin oxide, a clear conducting material, is added to serve as the cell’s top electrode.

In the finished solar cells, the carbon nanotube arrays serve both as support for the 3-D arrays and as a conductor connecting the photovoltaic materials to the silicon wafer.

The 3-D solar cells were described in the March 2007 issue of the journal JOM, published by the Minerals, Metals and Materials Society, and in the Journal of Applied Physics in 2008. The research leading to their development was supported by the Air Force Office of Scientific Research and the Air Force Research Laboratory.

Beyond the patents in China and Australia, IP2Biz has applied for protection in the United States, Canada, Europe, Korea and India, Smith noted. The patents granted so far apply to any photovoltaic application in which three dimensional structures are used to capture light bouncing off them, he added.

“The 3-D photovoltaic cell could be of great value in satellite, cell phone and defense applications given its order of magnitude reduction in footprint, coupled with the potential for increased power production compared to planar cells,” Smith added. “We are very pleased with the level of interest in licensing or acquiring this innovation as means of addressing the world’s growing need for energy.”

Research News & Publications Office
Georgia Institute of Technology
75 Fifth Street, N.W., Suite 314
Atlanta, Georgia 30308 USA

Media Relations Contacts: John Toon (404-894-6986); E-mail: (jtoon@gatech.edu) or Kirk Englehardt (404-407-7280); E-mail: (kirk.englehardt@gtri.gatech.edu).

Writer: John Toon

Related Links

- Georgia Tech Research Institute [1]

SOURCE [2]

Source URL (retrieved on *12/26/2014 - 2:44pm*): http://www.ecnmag.com/news/2009/12/3-d-solar-cell-uses-towers-boost-efficiency-wins-patents

Links:
[1] http://www.gtri.gatech.edu/
[2] http://www.gatech.edu/newsroom/release.html?nid=48082