# NREL reports world record 31.1 percent efficiency for III-V solar cell

June 25 2013

(Phys.org) —The Energy Department's National Renewable Energy Lab has announced a world record of 31.1% conversion efficiency for a two-junction solar cell under one sun of illumination.

NREL Scientist Myles Steiner announced the new record June 19 at the 39th IEEE Photovoltaic Specialists Conference in Tampa, Fla. The previous record of 30.8% efficiency was held by Alta Devices.

The tandem cell was made of a gallium indium phosphide cell atop a gallium arsenide cell, has an area of about 0.25 square centimeters and was measured under the AM1.5 global spectrum at 1,000 W/m2. It was grown inverted, similar to the NREL-developed inverted metamorphic multi-junction (IMM) solar cell – and flipped during processing. The cell was covered on the front with a bilayer anti-reflection coating, and on the back with a highly reflective gold contact layer.

The work was done at NREL as part of DOE's Foundation Program to Advance Cell Efficiency (F-PACE), a project of the Department's SunShot Initiative that aims to lower the cost of solar energy to a point at which it is competitive with other sources including fossil fuels.

At the beginning of the F-PACE project, which aims to produce a 48%-efficient concentrator cell, NREL's best single-junction gallium-arsenide solar cell was 25.7% efficient. This efficiency has been improved upon by other labs over the years: Alta Devices set a series of records, increasing the gallium-arsenide record efficiency from 26.4% in

2010 to 28.8% in 2012. Alta's then-record two-junction 30.8% efficient cell was achieved just two months ago. The new record may not last long either, but "it brings us one step closer to the 48% milestone," said NREL Principal Scientist Sarah Kurtz, who leads the F-PACE project in NREL's National Center for Photovoltaics. "This joint project with the University of California, Berkeley and Spectrolab has provided us the opportunity to look at these near-perfect cells in different ways. Myles Steiner, John Geisz, Iván García and the III-V multijunction PV group have implemented new approaches providing a substantial improvement over NREL's previous results."

"Historically, scientists have bumped up the performance of multijunction cells by gradually improving the material quality and the internal electrical properties of the junctions—and by optimizing variables such as the bandgaps and the layer thicknesses," NREL Scientist Myles Steiner said. But internal optics plays an underappreciated role in high-quality cells that use materials from the third and fifth columns of the periodic tables – the III-V cells. "The scientific goal of this project is to understand and harness the internal optics," he said.

When an electron-hole pair recombines, a photon can be produced, and if that photon escapes the cell, luminescence is observed – that is the mechanism by which light-emitting diodes work. In traditional single-junction gallium-arsenide cells, however, most of the photons are simply absorbed in the cell's substrate and are lost. With a more optimal cell design, the photons can be re-absorbed within the solar cell to create new electron-hole pairs, leading to an increase in voltage and conversion efficiency. In a multijunction cell, the photons can also couple to a lower bandgap junction, generating additional current, a process known as luminescent coupling.

The NREL researchers improved the cell's efficiency by enhancing the photon recycling in the lower, gallium-arsenide junction by using a gold back contact to reflect photons back into the cell, and by allowing a significant fraction of the luminescence from the upper, GaInP junction to couple into the GaAs junction. Both the open-circuit voltage and the short-circuit current were increased.

Silicon solar cells now dominate the world PV market, but researchers see opportunities for new materials. High-efficiency concentrator cells bolstered by lenses that magnify the power of the sun are attracting interest from utilities because the modules have demonstrated efficiencies well over 30%. And there may be commercial opportunities for one-sun or low-concentration III-V cells if growth rates can be increased and costs reduced.

The same cell should work well when lenses are added to multiply the sun's power. "We expect to observe similar enhancements of the solar cell characteristics when measured under concentrated illumination," Steiner said.

Provided by National Renewable Energy Laboratory