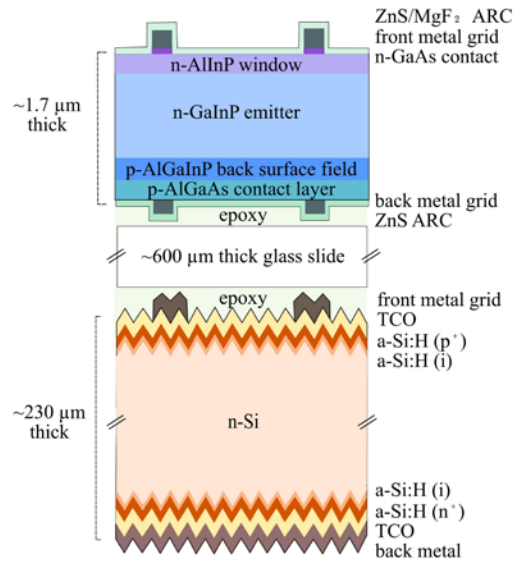
NATIONAL RENEWABLE ENERGY LABORATORY

# NREL, CSEM Jointly Set New Efficiency Record with Dual-Junction Solar Cell

*Highlights in Research & Development*

## Scientists set a new world record for converting non-concentrated sunlight into electricity using a dual-junction III-V/Si solar cell.

A joint effort between the National Renewable Energy Laboratory (NREL) and the Swiss Center for Electronics and Microtechnology (CSEM) has resulted in a novel tandem solar cell that operates at 29.8% conversion efficiency under 1-sun conditions. The new solar cell technology combines NREL's 1.8-eV gallium indium phosphide (GaInP) technology as a top cell and CSEM's crystalline silicon (Si) heterojunction technology as a bottom cell.




*Schematic cross-section showing NREL's GaInP top subcell and CSEM's Si bottom subcell epoxied onto an intervening glass slide to form the completed mechanically stacked dual-junction device.* Illustration by Stephanie Essig, NREL

As a single-junction device, the 1.8-eV GaInP cell achieved a 20.8% efficiency at 1-sun and has been considered the most qualified candidate as a top cell in an Si-based multijuntion device. Adding a higher-bandgap material to Si cells adds tremendous market value to the already dominant Si cell industry. But there is a problem: the GaInP cannot easily be deposited on the silicon because of differing coefficients of thermal expansion and mismatched lattice constants.

The NREL/CSEM solution to the problem was to grow the GaInP cell and the Si cell separately, rather than monolithically, and then mechanically stack the two cells. In practical terms, the GaInP top cell and the Si bottom cell are connected to one another with an adhesive, which allows considerable flexibility for surface irregularities and architecture of the two subcells.

In addition, the mechanically stacked, four-terminal dual-junction cell does not require a tunnel diode between subcells, making the top-cell growth requirements much less stringent compared to conventional two-terminal multijunction cells. And the subcells can operate electrically independent of each other at their own maximum power point. The result is that there is no need for current matching between cells, so the device is more tolerant to variations in the solar spectrum.

NREL and CSEM scientists are confident of continued advances in performance as this technology is further developed and optimized. NREL also has a program to drive down the cost of the III-V component to the cell. Ultimately, the hope is to feed a market hungry for low-concentration, silicon-based tandem solar cells that are economical and have high efficiency.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**Reference:** S. Essig; M.A. Steiner; C. Allebe; J.F. Geisz; B. Paviet-Salomon; S. Ward; A. Descoeudres; T. Moriarty; L. Barraud; V. LaSalvia; N. Badel; A. Faes; J. Levrat; M. Despeisse; C. Ballif; P. Stradins, D.L. Young. "Realization of GaInP/Si dual-junction solar cells with 29.8 percent one-sun efficiency," *IEEE J. Photovoltaics*, accepted (2016).


## Key Research Results

### Achievement

NREL and CSEM scientists created a four-terminal, dual-junction device with an efficiency of 29.8% at 1-sun.

### Key Result

This is a world-record efficiency (29.8%) for a mechanically stacked 1-sun tandem cell, and it surpasses the efficiency of the record gallium arsenide single-junction device (28.8%), the record silicon device (25.6%), and a theoretical 1-sun silicon cell (29.4%).

### Potential Impact

The four-terminal operation allows ease of construction and greater spectral tolerance. And this collaborative work could open the market for low-concentration, silicon-based tandem solar cells.


**NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.**

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