Quick Facts

Although a number of research entities were once investigating dual-junction solar cells, NREL researchers found the path to the first practical version. Their innovative choice for the top active layer of the solar cell remains the choice for all multijunction solar cells produced today.

Multijunction solar cells are the choice for most solar-powered space applications, such as satellites. In 2010, Boeing Spectrolab, a major supplier of space-based solar cells, announced that it had provided three million solar cells for 225 spacecraft. Multijunction solar cells also powered the first two Mars rovers, Spirit and Opportunity, and their durability helped to extend the rovers' lifetimes beyond predictions.

R&D Magazine has selected a number of multijunction solar cells for its R&D 100 Award over the years, including the dual-junction solar cell in 1991 and a variety of triple-junction solar cells in 2001, 2007, 2008, and 2012—all inventions to which NREL contributed. The award proclaims the inventions to be among the top 100 technological innovations of the year.

In October 2012, Solar Junction, of San José, California—a company that works closely with NREL—achieved a new solar cell conversion efficiency record with a cell that converts 44% of the sunlight hitting it into electricity. The record was achieved under sunlight concentrated to 947 times its normal strength, conditions the cell could experience when used in a concentrating photovoltaic system.

NREL Spurred the Success of Multijunction Solar Cells

Many scientists once believed that high-quality gallium indium phosphide (GaInP) alloys could not be grown for use as semiconductors because the alloys would separate. However, researchers at the National Renewable Energy Laboratory (NREL) thought differently, and they employed GaInP in a material combination that allowed the multijunction cell to flourish. The multijunction cell is now the workhorse that powers satellites and the catalyst for renewed interest in concentrator photovoltaic products.

A multijunction cell is like a semi-transparent layer cake: the top cell produces electricity from the higher-energy portion of the solar spectrum, and the lower-energy sunlight passes through to the lower cells to be converted into electricity, resulting in a highly efficient production of power. To make it work, the stacked cells need to absorb complementary wavelengths of sunlight, and those absorption wavelengths are determined by the material's bandgaps. A bandgap is the energy difference between certain energy bands that the material's electrons can occupy.

While many researchers were focused on materials with ideal combinations of bandgaps, NREL researchers thought the focus should change to finding materials with chemical and structural compatibility—materials that had a bandgap combination that would give a high, but not necessarily the highest, theoretical efficiency. With that in mind, NREL researchers focused their efforts on GaInP and gallium arsenide (GaAs), which are well-matched chemically and have the same lattice constant, an indicator of how their crystals fit together at the atomic and molecular levels.

NREL applied for a patent for this "dual-junction" solar cell, and although the first cells were less than 10% efficient, NREL researchers thought the efficiency could be improved by purifying the indium. They eventually showed that a top cell of GaInP and a bottom cell of GaAs could capture and convert photons into electricity more efficiently than other materials.

Subsequently, all major research entities working on similar multijunction solar cells adopted some version of the GaInP/GaAs cell. True to the predictions of NREL researchers, as knowledge and processes advanced, efficiency surged. After a decade of research, NREL's dual-junction solar cell surpassed 30% efficiency, and afterward, the NREL team and scientists worldwide started adding more semiconductor junctions, and the record steadily increased. More than a dozen companies are now capable of producing multijunction solar cells.

This archive photo shows NREL scientists Jerry Olson and Sarah Kurtz testing the voltage of their award-winning gallium indium phosphide/gallium arsenide solar cell, which had achieved record efficiencies, converting more than 30% of incident sunlight into electricity.

Photo by Warren Gretz, NREL 02002

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NREL/FS-6A42-59142 • August 2013

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