innovation

The Spectrum of Clean Energy Innovation

Fundamental Science

Market-Relevant Research

Systems Integration

Testing and Validation

Commercialization

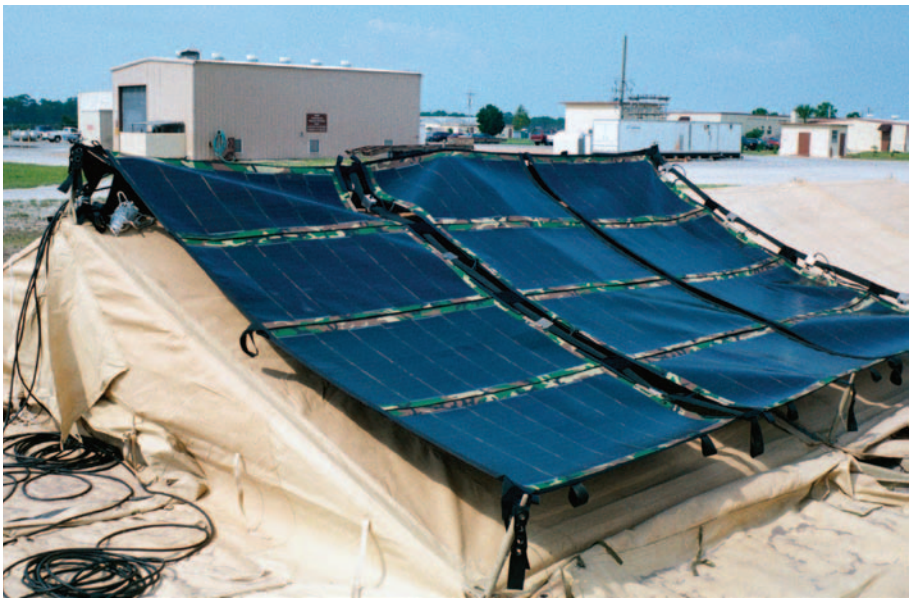
Deployment

Encapsulation Advancements Extend Life of Thin-Film PV

Thin-film photovoltaic technology is proof positive that great things can come in lightweight, flexible packages. This technology, pioneered by NREL in 1978, has changed the way the world uses energy from the sun. And now, thin-film photovoltaic (PV) devices are even better, since NREL scientists created a low-cost way to encapsulate them that provides greater resistance to heat and moisture—and longer lifetimes.

Thin-film solar cells made from semiconductors such as copper, indium, gallium, and selenium (known as "CIGS") have several advantages over traditional crystalline silicon solar cells. One big advantage is that they can be made into flexible products that can be used in aerospace applications, integrated into buildings (for example, on rooftops and walls), and much more. However, flexible CIGS thin films also have one big disadvantage. They're susceptible to failure under long-term exposure to heat and humidity.

This vulnerability is apparent in the breakdown of the "window" layer caused by moisture entering through the device's flexible encapsulation and degrading its transparent conductive material, typically zinc oxide. The zinc oxide serves to collect the current from the device and deliver the current to the module's electrical terminals.



Thin-film CIGS PV makes it possible to create a lightweight power supply that can travel easily to the most remote locations and provide the energy needed to power a rapidly deployed, temporary military command center like the one pictured here. Credit: Global Solar Energy. PIX 13413

Through deep technical expertise and an unmatched breadth of capabilities, NREL leads an integrated approach across the spectrum of renewable energy innovation. From scientific discovery to accelerating market deployment, NREL works in partnership with private industry to drive the transformation of our nation's energy systems.

This case study illustrates NREL's innovations and contributions in Fundamental Science through Deployment.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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.

Solving the Degradation Problem Stabilizes Performance

To solve that problem, NREL scientists created an improved window layer using a sputter-deposited coating of protective transparent metal oxide (PTMO). This PTMO glaze helps prevent moisture from degrading the zinc oxide while permitting light to be transmitted, like glass does.

"The PTMO coating technology invented by NREL is an extremely important step toward developing a flexible, transparent package for CIGS PV technology that can withstand a lifetime of outdoor use," said Bolko von Roedern, senior project leader in the NREL National Center for Photovoltaics.

In addition to improved performance and reliability, this PTMO technology could make flexible thin-film modules highly competitive in the marketplace.

"NREL is always interested in finding pathways to make PV devices more environmentally stable," said NREL principal scientist Tim Gessert. "For this PTMO coating, CIGS thin film is the main benefactor. Our continued research of this technology could benefit other thin films as well."

Advancing CIGS Thin-Film Technology Is Part of NREL's History

The importance of NREL's research and support of the PV industry cannot be underestimated, especially in regard to thin-film technology. In addition to developing the PTMO coating technology, NREL also holds the world record—20%—for the efficiency of a CIGS solar cell, as verified in the laboratory.

Beyond its achievements in the fundamental science of CIGS technology, NREL helps the PV industry accelerate manufacturing capacity and commercialization of various PV technologies, including CIGS.

For example, the Thin-Film PV Partnership project that ran between 1992 and 1994 was an expansion of previous thin-film PV work conducted by NREL's predecessor, the Solar Energy Research Institute, since 1978. The goal of this project was to facilitate the widespread market penetration of a range of thin-film technologies, including CIGS.

The Photovoltaic Manufacturing Technology project, which was eventually transformed into the PV Manufacturing R&D project, played an important role in helping U.S. PV manufacturers reduce costs, expand production, and remain competitive in a rapidly growing global PV market during the 1990s and into the new century.

Today, the NREL Photovoltaic Technology Incubator program focuses on enabling small U.S. businesses to accelerate prototype and precommercial technologies toward pilot and full-scale production. The companies partner with experts at NREL, which reduces the risk of project implementation, quickly overcomes R&D hurdles, and increases the likelihood that performance and reliability objectives can be achieved.

Helping to Build the CIGS Thin-Film PV Industry

Through its collaborations with industry, NREL has helped deliver thin-film CIGS PV technology to market. These are two companies that can map their successes back to NREL:

Global Solar Energy—A leading manufacturer of thin-film CIGS on a flexible substrate, Global Solar Energy began working with NREL in 1996. NREL developed a laboratory procedure to produce CIGS solar cells with 20% conversion efficiencies using glass as a substrate. Global Solar licensed the technology from NREL and is using the same procedure, but instead deposits the coating on flexible stainless steel in a roll-to-roll production process. The company has achieved a 10% average solar cell efficiency—the first CIGS company to reach this milestone in a production environment. Global Solar has manufacturing plants in Arizona and Germany. Together, these plants set industry records for CIGS production capacity.

Ascent Solar Technologies Inc.—This manufacturer of thin-film CIGS PV on a flexible plastic substrate was selected as an NREL Photovoltaic Technology Incubator program partner and a recipient of Colorado Renewable Energy Collaboratory research funds. Ascent Solar's extremely lightweight and flexible technology produces the highest efficiency levels currently available on plastic. This thin-film PV easily integrates into a wide range of product applications, including roofing surfaces for buildings, portable electronic products, defense applications, space solutions, vehicles, and more.

National Renewable Energy Laboratory

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