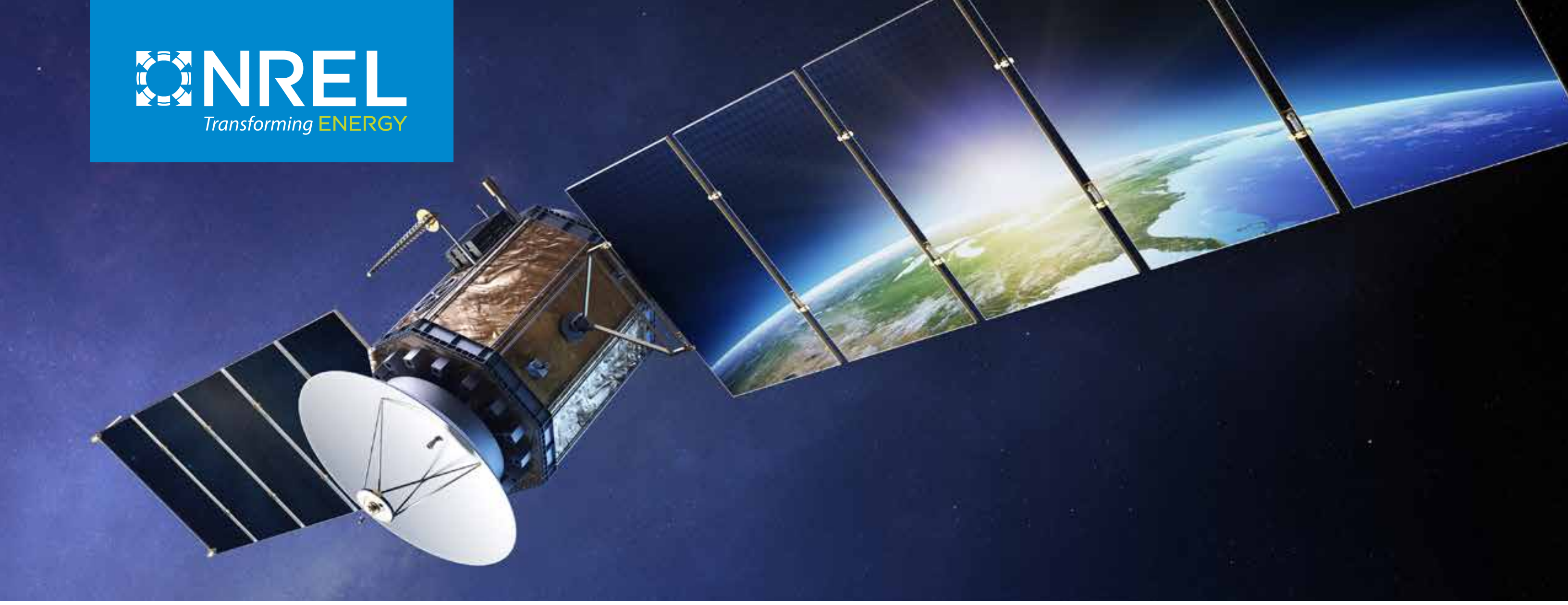


Photo from iStock 477750197

Space-Based Photovoltaics

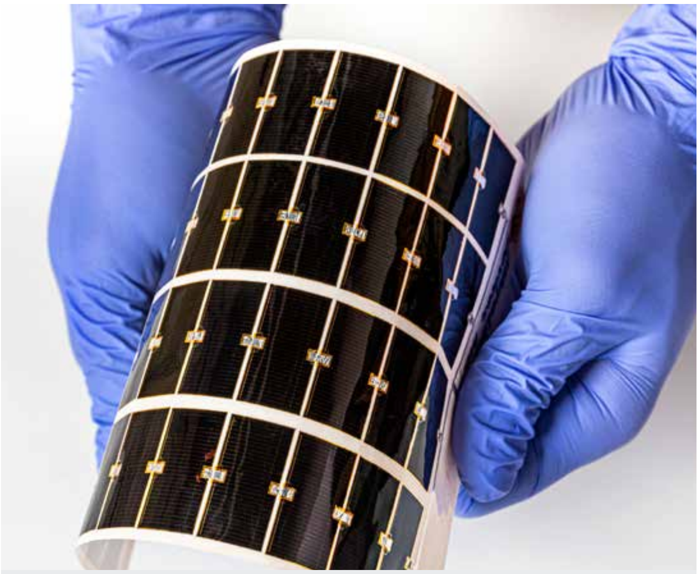
For almost 50 years, the National Renewable Energy Laboratory (NREL) has developed solar cells to power satellites and spacecraft. Today, we are working to improve the durability, performance, and affordability of several photovoltaic (PV) materials for space and power beaming applications. We work closely with partners to ensure our research can be quickly and widely adopted.

III-Vs

The long-established performance of III-V solar cells makes them the standard in space-based PV. They hold energy conversion efficiency records and demonstrate world-class stability in high-radiation and thermally extreme environments. All space-based III-V solar cells derived from cell architectures developed at NREL.

NREL is still pushing the frontiers of III-V solar cell technology. By exploring new deposition techniques and cell architectures, we have been setting the standard for III-V solar cells for decades. For example, NREL has created three of the last five world-record-efficiency III-V solar cells.

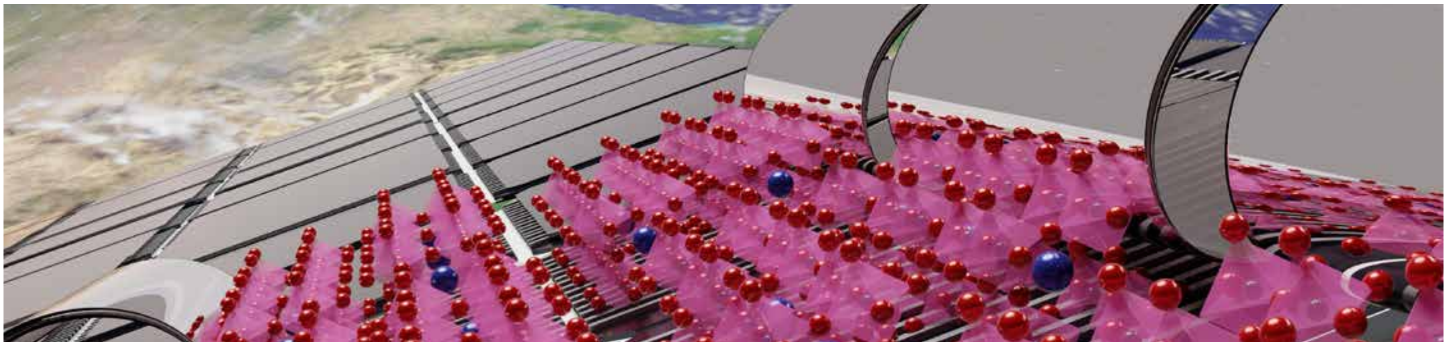
We are also developing low-cost, highly scalable manufacturing approaches for III-V solar cells. The dynamic hydride vapor-phase epitaxy (D-HVPE) process could ultimately reduce costs by an order of magnitude compared to the incumbent technology, and move III-V semiconductor growth from batch to in-line production. NREL is also working on substrate reuse and metallization approaches that would further lower the costs of these best-in-class solar cells, opening new markets.



One additional benefit of NREL's work on spalling III-V solar cells from their substrates for reuse is the ability to easily construct lightweight and flexible very high-efficiency solar modules, as shown here. *Photo by Werner Slocum, NREL 68556*

Perovskites

Perovskite photovoltaics are a potentially transformational next-generation energy technology. They could offer performance approaching that of III-V solar cells, but at much lower costs. Perovskite materials are solution-processable and use only Earth-abundant materials, promising low-cost, high-volume manufacturing.



NREL researchers discovered that a micron-thick layer of silicon oxide—100 times thinner than a human hair—could protect perovskite solar cells from the low-energy proton radiation in space that poses the greatest risk to the cells. *Image by Ahmad Kirmani, NREL*

Perovskites are potentially more tolerant to radiation than other solar cells. NREL recently developed an ultrathin, lightweight coating that hardens perovskites further against radiation while being much lighter than the conventional radiation barriers used for other solar cells. The next steps to widespread adoption of perovskite solar cells are improving their operational stability, scalability, and manufacturability. NREL is working to overcome these issues for terrestrial and space-based applications.

Silicon

Traditionally, silicon has degraded quickly in space, making it appropriate for only a few applications. However, as launch costs fall and mission lifetimes shorten, we anticipate that silicon PV will expand to space applications in the coming years.

NREL is working to reduce the degradation of silicon in high-radiation and extreme thermal environments. Though silicon is the most-studied photovoltaic material, there is more to learn about bulk defects in silicon—the primary cause of silicon's degradation in space. Our researchers are studying how to better mitigate these defects through improved characterization and by using hydrogen atoms to passivate (or fix) the defects. We are also studying methods to fabricate thinner, less dense silicon PV modules.

Optical Power Beaming

Another application of PV cells is beaming power by laser to unmanned aerial vehicles, remote installations, or between satellites. Because these receiver cells would collect concentrated beams of light in specific wavelengths, cost per area is less important than overall performance, making III-V materials the most promising option.

NREL has a long history of developing III-V cells for receiving concentrated high-intensity light. Specifically, we can develop, fabricate, and characterize PV receiver cells designed to function at very high irradiances (up to 100 watts/cm^2) that are capable of receiving light in a wide range of wavelengths (from 600 to 2000 nanometers).

Characterization, Reliability, and Techno-Economic Analysis

Designing an excellent solar cell is just the beginning. Ensuring it is reliable, durable, affordable, and manufacturable is also key to success.

NREL has deep expertise in characterizing all PV materials. This informs our efforts to build longer-lasting, higher-performing solar cells. We also study the manufacturing processes and supply chains that underpin the PV industry in an effort to ensure that new advancements will ultimately be adopted widely.

Read our factsheet about **PV characterization**

Partner with Us

We have a long history of working with partners to launch our research into application, including:

- Generating new technology solutions through cooperative R&D agreements
- Testing and characterization
- Licensing NREL intellectual property
- Techno-economic analysis.

Contact Us

Partnerships
Steve Gorin
stephen.gorin@nrel.gov
303-384-6216

Perovskites
Joey Luther
joey.luther@nrel.gov
303-384-6497

III-Vs, Silicon, and Power Beaming
Daniel Friedman
daniel.friedman@nrel.gov
303-384-6472

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National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

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