Space Power

For almost 50 years, the National Laboratory of the Rockies (NLR) has developed solar cells to power satellites and spacecraft.

Today, NLR is working to improve the durability, performance, and affordability of several photovoltaic (PV) materials for space and power beaming applications. The lab works closely with partners to ensure this research can be quickly and widely adopted.

III-V Solar Cells

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

The lab is exploring new deposition techniques and cell architectures to develop low-cost, highly scalable manufacturing approaches for III-V solar cells. The dynamic halide vapor-phase epitaxy (D-HVPE) process could reduce costs by an order of magnitude compared to the incumbent technology, and move III-V semiconductor growth from batch to in-line production.

The lab's researchers are also working on substrate reuse and metallization approaches that could further lower the costs of these solar cells and open new markets.

Perovskites

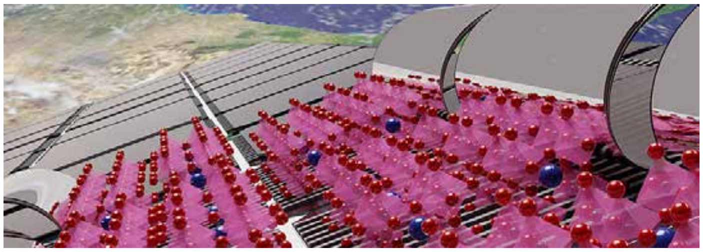
Perovskite photovoltaics are a promising next-generation energy technology. They could offer performance close to that of III-V solar cells, but at much lower costs. Perovskite materials are solution-processable and are made up of Earth-abundant materials, which can lead to low-cost, high-volume manufacturing.

Perovskites are potentially more tolerant to radiation than other solar cells. Researchers developed an ultrathin, lightweight coating that further hardens perovskites against radiation; the coating is much lighter than conventional radiation barriers used for other solar cells. The next steps to widespread adoption of perovskite solar cells are improving their reliability, scalability, and manufacturability. The lab's researchers are working to overcome these issues for both terrestrial and space-based applications.

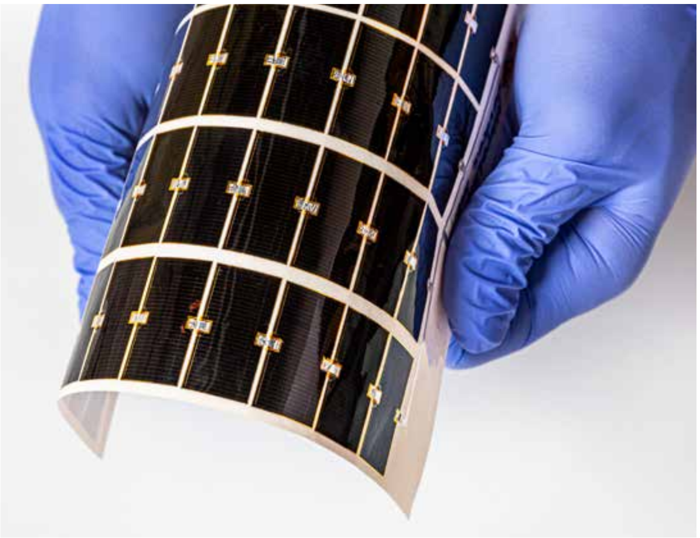
Silicon

Silicon was traditionally used as the PV material for space applications until it was supplanted by more radiation-tolerant III-V cells. However, as launch costs decrease and mission lifetimes shorten for large satellite constellations, silicon has regained interest for space applications because of its lower cost, higher manufacturability, and improved efficiency coupled with radiation hardness.

The lab 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 radiation-induced defects in silicon infused with gallium and antimony and their ability to self-heal under certain conditions. NLR scientists are using an in-house proton beam accelerator and silicon processing tools to study the role of hydrogen in the healing process. The team is also developing methods to fabricate thin (30-micrometer) silicon PV cells at scale.



Researchers at the National Laboratory of the Rockies (NLR) 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, National Laboratory of the Rockies (NLR)*



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

Optical Power Beaming

PV cells can also act to receive optically beamed laser power in unmanned aerial vehicles, remote installations, or between satellites. The receiver cells collect concentrated beams of light in specific wavelengths, making III-V materials the most promising for optical power beaming applications.

With a long history of developing III-V cells for receiving concentrated high-intensity light, the lab can develop, fabricate, and characterize PV receiver cells designed to function at very high irradiances (up to 100 watts per square centimeter) that can receive light in a wide range of wavelengths (from 600 to 2,000 nanometers).

Characterization, Reliability, and Techno-Economic Analysis

Designing and developing new technologies is just the beginning. Ensuring they are reliable, durable, affordable, and manufacturable is also important for success. With deep expertise in characterizing space power materials, researchers can help build longer-lasting, higher-performing devices. They also study the manufacturing processes and supply chains that underpin the space power industry to ensure that new advancements can be widely adopted.

Cover image: *Photo from Getty 477750197*

Partner With Us

NLR has 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 NLR intellectual property
- Conducting techno-economic analysis.

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