Polycrystalline Thin-Film Research: Cadmium Telluride

Cadmium telluride (CdTe) photovoltaic (PV) research has enabled costs to decline significantly, making this technology one of the most economical approaches to adding new electricity generation to the grid. In fact, CdTe photovoltaics supplied ~40% of the 2019 U.S. utility market, and the levelized cost of electricity is generally less than traditional power sources like nuclear, coal, and natural gas.

The semiconductor layers in CdTe solar cells are just a few microns thick, less than one-tenth the diameter of a human hair. This enables implementing durable and inexpensive substrates such as ultrathin glass, metal, and plastic for diverse lightweight and flexible applications. Typically, glass enters a factory and exits as a completed panel in just a few hours. Fundamental material issues abound, and there is substantive room for continued improvement. NREL's CdTe photovoltaics research strives to increase performance and stability while continuing to lower costs to make clean, dispatchable energy ubiquitous.

NREL works on a range of technology readiness levels to advance fundamental understanding, overcome materials science roadblocks, explore new paths, and enhance performance. For example, NREL research has replaced copper with novel Group V dopants to overcome 30-year voltage and stability limits, thereby increasing energy yield. We have also pioneered methods to reveal the p-n junction interface after fabrication with atomic smoothness and without exposure to air to enable state-of-the-art characterization and interfacial engineering. Other work is examining novel methods to achieve colossal grain growth and ultrafast single-crystal or large-grain epitaxial deposition with low-cost thin-film equipment. New processes include thermal evaporation on coated glass followed by wet processing for high-efficiency cells with extraordinary simplicity.

Coupling novel materials synthesis with state-of-the-art characterization as well as ab-initio theoretical calculations allows for pioneering scientific understanding. This is an integral part of advancing state-of-the-art technology to its theoretical limits. Integrating low-cost solar electricity with advances in storage can ultimately provide clean energy anytime, anywhere.

Core Competencies and Capabilities

Our capabilities—supported by state-of-the-art equipment, leading-edge techniques, and expert staff—have breadth and depth. And they're all located under one roof at NREL.

- **Synthesis:** We work across a wide range of materials and processes, including single crystals, molecular beam epitaxy, close-spaced sublimation, thermal evaporation, vapor transport deposition, ultrafast epitaxy, large-grain growth, sputtering, atomic layer deposition, and novel Group V doping. We also fabricate diverse contact, buffer, and transparent conducting oxide layers. More than 100 recent journal articles demonstrate creativity and innovation.
- **Characterization:** We perform microscopy and imaging on scales ranging from atoms to modules, laser spectroscopy, and advanced measurements to determine electro-optical properties. We also perform advanced surface and interface characterization.
- **Analysis, computation, and theory:** We perform state-of-the-art device simulations, ab-initio calculations, new materials discovery, and unique simulations of diverse characterization experiments to advance scientific understanding.
- **Collaboration:** NREL has collaborated throughout the years with nearly every university and company working in this area, and we are interested in working with you.

Partner With Us

We have multiple paths for partnering, including licensing NREL intellectual property, testing and characterization, analysis, and generating new technology solutions through cooperative R&D agreements.

CdTe PV roof tiles installed on a home (top). Office building containing semitransparent CdTe PV windows (middle). First Solar panels installed at NREL for systems integration testing (bottom). *Top photos from Advanced Solar Power. Bottom photo by Dennis Schroeder, NREL 55200*

Contact Us

Technical
Matt Reese
Matthew.Reese@nrel.gov
303-384-7613

Partnerships
Laura Schelhas
laura.schelhas@nrel.gov
303-275-3722

Web

Learn More About Cadmium Telluride Solar Cells
https://www.nrel.gov/pv/cadmium-telluride-solar-cells.html

Cover image: Desert Sunlight cadmium telluride (CdTe) solar plant.
Photo from First Solar

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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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