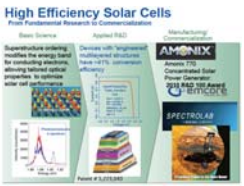
Solar Technologies

Photovoltaics

The National Laboratories are aligned with the U.S. Department of Energy's SunShot Initiative to make solar cost competitive by the end of the decade. The National Laboratories have a broad R&D portfolio in solar conversion ranging from fundamental research to applied R&D:

- Discovery of new concepts and materials
- Fundamental studies of materials, processes and interfaces
- Materials and device performance
- Advanced manufacturing concepts
- Reliability testing and prediction

SunShot U.S. Department of Energy



The development of high-efficiency solar cells benefitted significantly from fundamental theory and experiment through applied industry research and support.

Standard Device Performance Characterization and Reliability

World-leading Standard Cell and Module Measurements
- ISO 17025-accredited for PV secondary cell, secondary module, and primary reference cell calibration
- The U.S. primary Lab for device efficiency validation
- Standards development and leadership

NREL

PV Reliability Testing and Analysis
- Real-time and long-term outdoor testing
- Accelerated testing and methodology development
- Measurement and characterization diagnostics

Photovoltaics System Evaluation (PVSEL)

- Conducts research in PV cells and modules
- Performs detailed analysis in PV systems design and characterization
- Provides highly accurate, comprehensive characterization of cells, modules, arrays, and system components in real world scenarios, including irradiance calibrations, spectral characterization, and reference cell calibration

Sandia National Laboratories

Process Development and Integration Laboratory (PDIL)

The CIGS cluster tool, designed by the National Center for Photovoltaics to accelerate the development of thin-film PV to commercial readiness.

The PDIL is a unique collaborative facility where industry and universities can work closely with NREL scientists on integrated equipment to answer pressing questions related to photovoltaics (PV) development.

The PDIL consists of unique cluster tools for each of the PVtechnologies:
- Silicon ((crystalline & film)
- Thin-film CIGS
- Thin-film CdTe
- Silicon wafer replacement
- Atmospheric processing
- Integrated measurements
- Stand-alone measurements

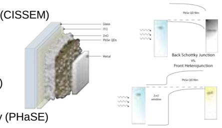
NREL

Multi-lab effort in developing next-generation PV

DOE Office of Science Energy Frontiers Research Centers (EFRC)

The National Labs lead or participate in 11 Energy Frontier Research Centers focusing on solar energy R&D (www.energyfrontiers.us)

- Center for Interface Science: Solar Electric Materials (CISSEM)
- Center for Energy Efficient Materials (CEEM)
- Molecularly Engineered Energy Materials (MEEM)
- Center for Inverse Design (CID)
- Argonne-Northwestern Solar Energy Center (ANSER)
- Center for Excitonics (CE)
- Polymer-Based Materials for Harvesting Solar Energy (PHaSE)
- Photosynthetic Antenna Research Center (PARC)
- Center for Advanced Solar Photophysics (CASP)
- Redefining Photovoltaic Efficiency through Molecular-Scale Control (RPEMSC)
- Understanding Charge Separation and Transfer at Interfaces in Energy Materials (CST)

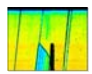


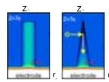
CASP EFRC has developed a quantum dot solar cell based on colloidal PbSe with a peak external photocurrent quantum efficiency exceeding 100% resulting from multiple-exciton generation in a quantum dot solar cell—Semonin et al. Science 334, 1530 (2011).

Applied Research
- Reducing levelized cost of energy (LCOE)
- High-volume roll-to-roll manufacturing
- Non-vacuum deposition techniques

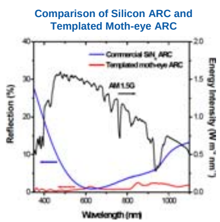
Fundamental Research
- Role of defects in polycrystalline material
- How does CdTe PV work? Vapor CdCl treatment?
- Large-area compositional control of CIGS

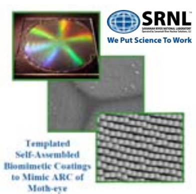
Next-Generation PV
- New material development (non-toxic, Earth-abundant)
- Increased efficiency using unique nanostructures
- Long-term stability of organic PV

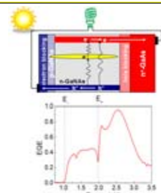




Oak Ridge National Laboratory







BERKELEY LAB

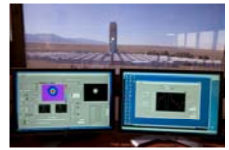
A schematic of the IBSC structure with its simplified band diagram (upper panel) and the measured external quantum efficiency (lower panel) demonstrating the basic operation principle of the solar cell.

- Intermediate-band solar cells (IBSCs) have the potential for very high theoretical power conversion efficiency exceeding 60%.
- Recently we have designed, fabricated, and tested the first IBSC.
- This work made use of the highly mismatched GaNAs alloy that has a well-defined intermediate band as the absorber.
- The key to the successful device performance was a design of proper layers blocking charge transport in the intermediate band.
- The successful realization of this first IBSC opens a new research field focused on potential applications of a large variety of highly mismatched alloys for solar power conversion technologies.

Concentrating Solar Power

Distributed Energy Technology Laboratory

DETL uses a reconfigurable infrastructure comprising distributed generation sources, storage, and programmable loads to simulate electric grid and microgrid scenarios. DETL engineers are skilled in high-penetration renewable integration, component and system performance testing, modeling, cyber-security integration, microgrid communications, enhanced efficiency, and load be integrated into a controlled system for testing and evaluation.



National Solar Thermal Test Facility

The NSTTF's primary goal is to provide experimental engineering data for the design, construction, and operation of unique components and systems in proposed solar thermal electrical plants planned for large-scale power generation. The NSTTF offers a complete testing environment for solar array and solar applications testing.

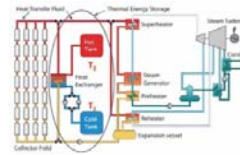
Sandia National Laboratories

SolarTAC Technology Acceleration Center

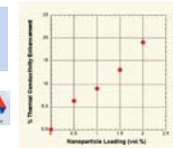
SolarTAC in Aurora, CO is a partnership of private industry, the research community and government for researching, testing and validating near-market technologies, components, and grid integration for solar energy (www.solartac.org)

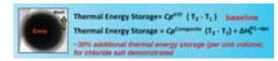
SolarTAC

Multi-lab effort in developing next-generation thermal fluids

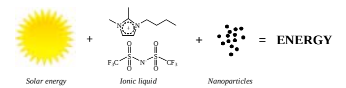


Argonne National Laboratory

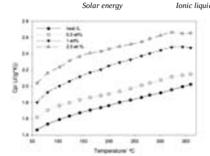


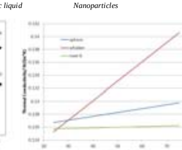


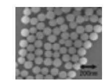
Adding nanoparticles to a fluid offers many advantages such as an increase in the density, thermal conductivitiy, and heat-transfer coefficient of the fluid. Further, a dramatic increase in the thermal storage of CSP plants can be achieved by adding multifunctional, core-shell phase-change nanoparticles to the HTFs. These nanoparticles contribute additional thermal storage in the form of latent heat of fusion of the phase-change material.



SRNL We Put Science To Work







Adding nanoparticles can greatly impact the heat capacity of the neat HTF. In addition, the morphology and composition of the nanoparticle have a large effect on the properties of the composition fluid.

Brayton Energy LLC

Prototype SolarCAT (Solar Compressed Air Turbine) 200-kWe system in 2011 field test

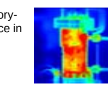
Solar receiver

Oak Ridge National Laboratory

ORNL furnace cycle test to simulate duty cycle

Investigating Thermal and Fluidic Properties of Substituted Naphthalenes as Heat-Transfer Fluids

- Small-scale, high- temperature static and ramping tests with detailed chemical analysis.
- High-temperature laboratory-scale testing of performance in repeated and continuous cycling in ORNL high-temperature test loop.
- LCOE calculations on potential efficiency gains from use of high-temperature HTF.
- Testing at temperatures up to 325°C in loop coupled with Stirling engine power conversion.



Cool Energy

U.S. Department of Energy