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Solar Technologies and Their Role in Transforming the US Energy Enterprise

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NMSEA Solar Fiesta
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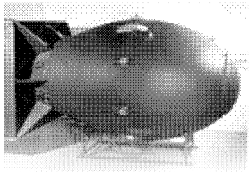
Sandia National Laboratories is a multi program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration, under contract DE-AC04-94AL85000.

History of Sandia Energy Programs



as a nuclear
ring
laboratory with deep science and engineering competencies

Energy crisis of the 1970s spawned the beginning of significant energy work

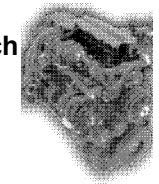
Strategic Petroleum Reserve – geological characterization of salt domes to host oil storage caverns

DOE's Tech Transfer Initiative was established by Congress in 1991

Advent Solar

Energy Policy Act of 2005

Combustions Research Facility (CRF) & Cummins partner on their newest diesel engine



Joint BioEnergy Institute

1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2007 | 2010

Our core NW competencies enabled us to take on additional large national security challenges

Vertical axis wind turbine

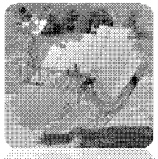
NRC cask certification studies & core melt studies

Solar Tower opens

CRF opens to researchers

Power grid reliability study

SunCatcher™ partnership with Stirling Energy Systems



Distributed Energy Technology Laboratory (DETL) to integrate emerging energy technologies into new and existing electricity infrastructures

Sunshine to Petrol Pilot Test

Large-scale pool fire tests of liquefied natural gas (LNG) on water

Consortium for Advanced Simulation of Light Water Reactors (CASL)

Climate stu
uncertainties to economies

Combustion Research Computation and Visualization (CRCV)

Our Vision

Enhance the nation's security and prosperity through sustainable, transformative approaches to our most challenging energy, climate, and infrastructure problems.

National Challenge Focus Areas

Energy Security

- *Reduce our dependence on foreign oil*
- *Increase deployment of low carbon stationary power generation*

Climate Security

- *Understand risks and enable mitigation of climate change impacts*
- *Provide the foundation for a future global climate treaty*

Infrastructure Security

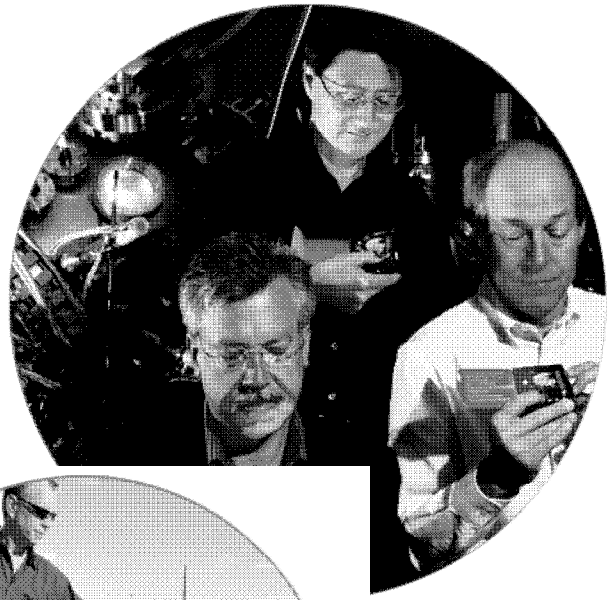
- *Increase security and resiliency of the electrical grid and energy infrastructure*
- *Assure energy security for critical installations*

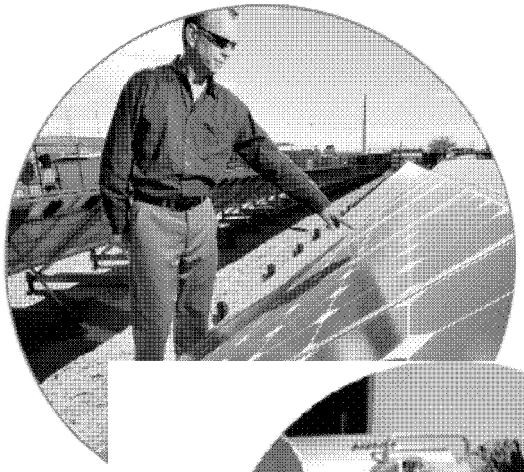
Enabling Capabilities

- *Strengthen the nation's S&T base in energy, climate, and infrastructure*

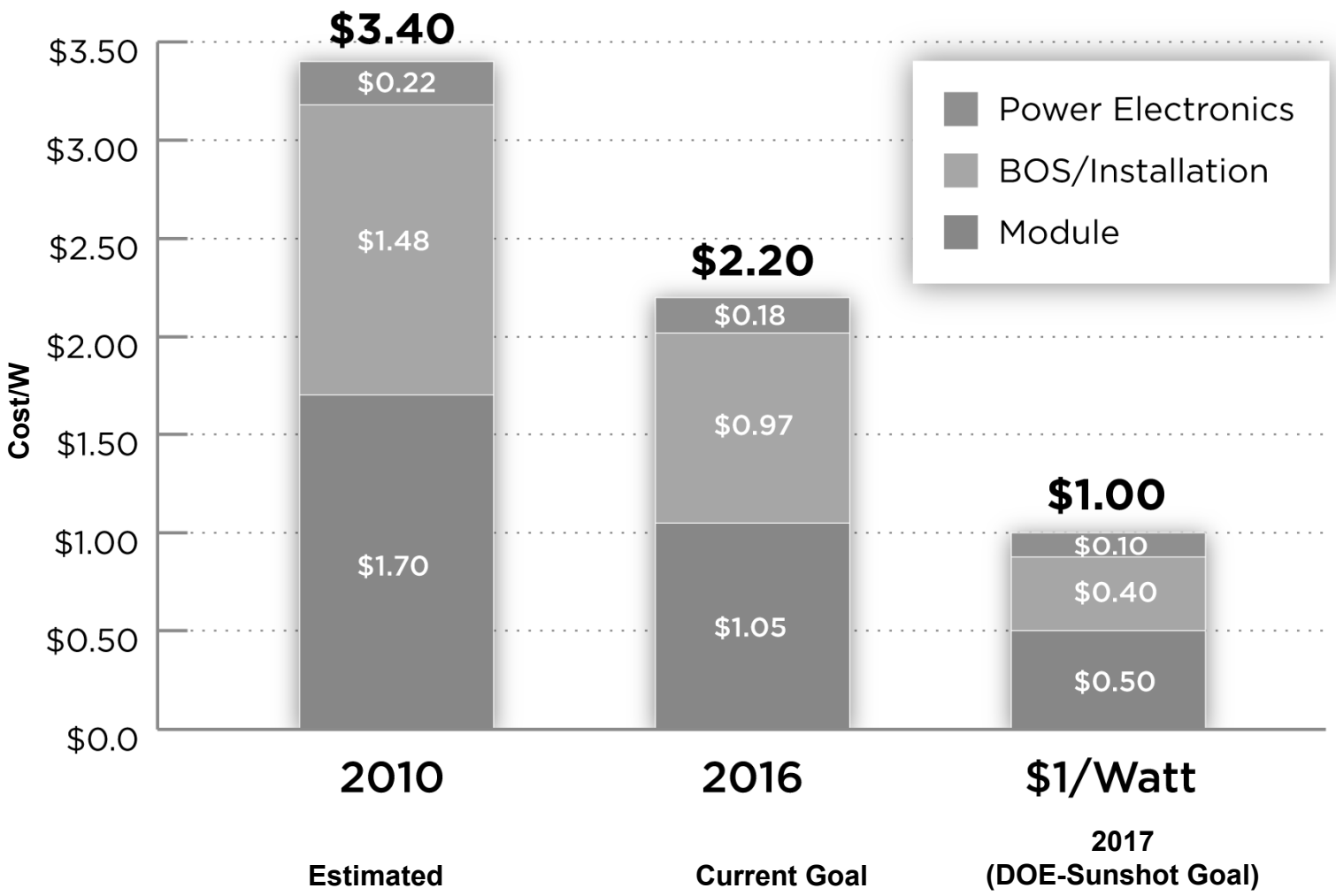
Two of Our Major Goals – Solar Energy Innovations

- Develop advanced solar technologies to allow a domestic solar industry to deliver at less than 10 cents per KW/hr.
- Demonstrate 12.5% sunlight to syngas that will enable greater than 10% lifecycle sunlight to fuel.





The Solar PV Challenge



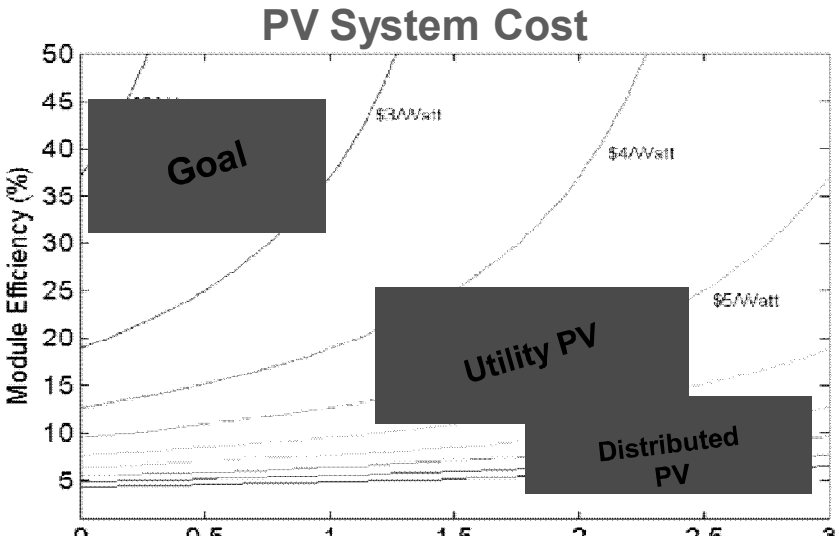
Solar Glitter is a Microsystem-Enabled PV Concept

Thin PV Cells

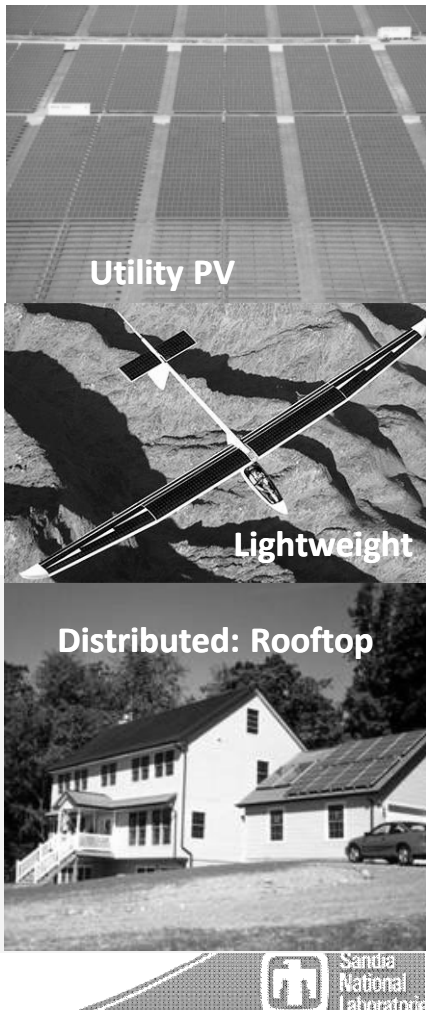
Goal: Develop advanced solar technologies and systems that will provide the US industry with a competitive advantage worldwide in delivering solar electricity at less than 10 cents per kWhr.

Motivation:

- **Double the efficiency and half the cost of conventional PV systems**
  - **high efficiency *(cell level >50%, system level >40%)***
  - **reduced cost (module cost of ~$0.5/Watt$_{peak}$, system cost of 2-3/Watt$_{peak}$).**



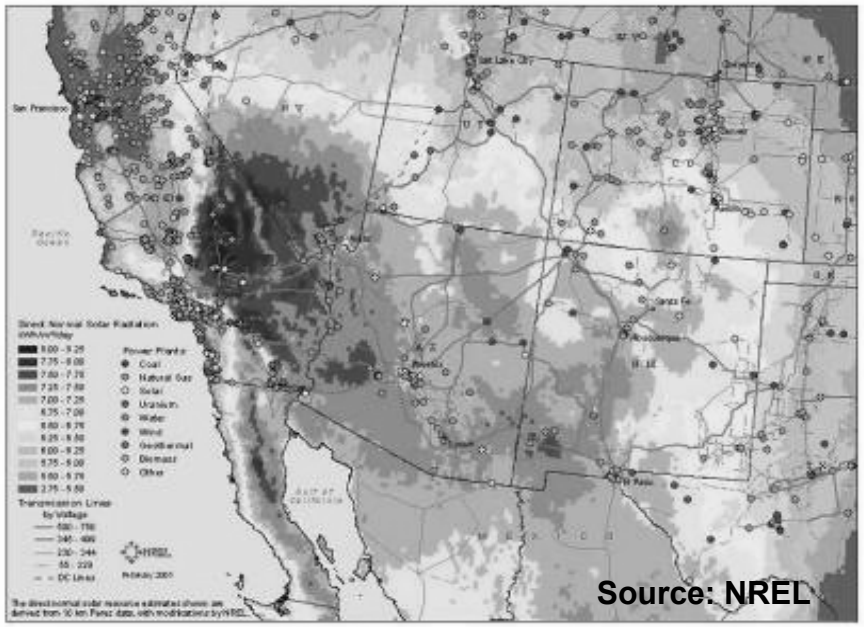
Possible Application



Micro-PV Benefits

- Improved performance
- Reduced costs
- Higher efficiencies
- New applications:
  - Units could wrap around unusual shapes for solar power integrated into buildings, tents, and maybe even clothing.
  - Rooftop micro-PV modules could have intelligent controls, inverters, and even storage built into the chip—simplifying the grid-integration process.
  - The tiny cells could turn a person into a solar battery charger—military personnel in the field or backcountry hikers could recharge batteries for phones, cameras, and other electronics as they walk or rest.

Solar Resources Analysis Shows the Promise of Scale with High Efficiency Target



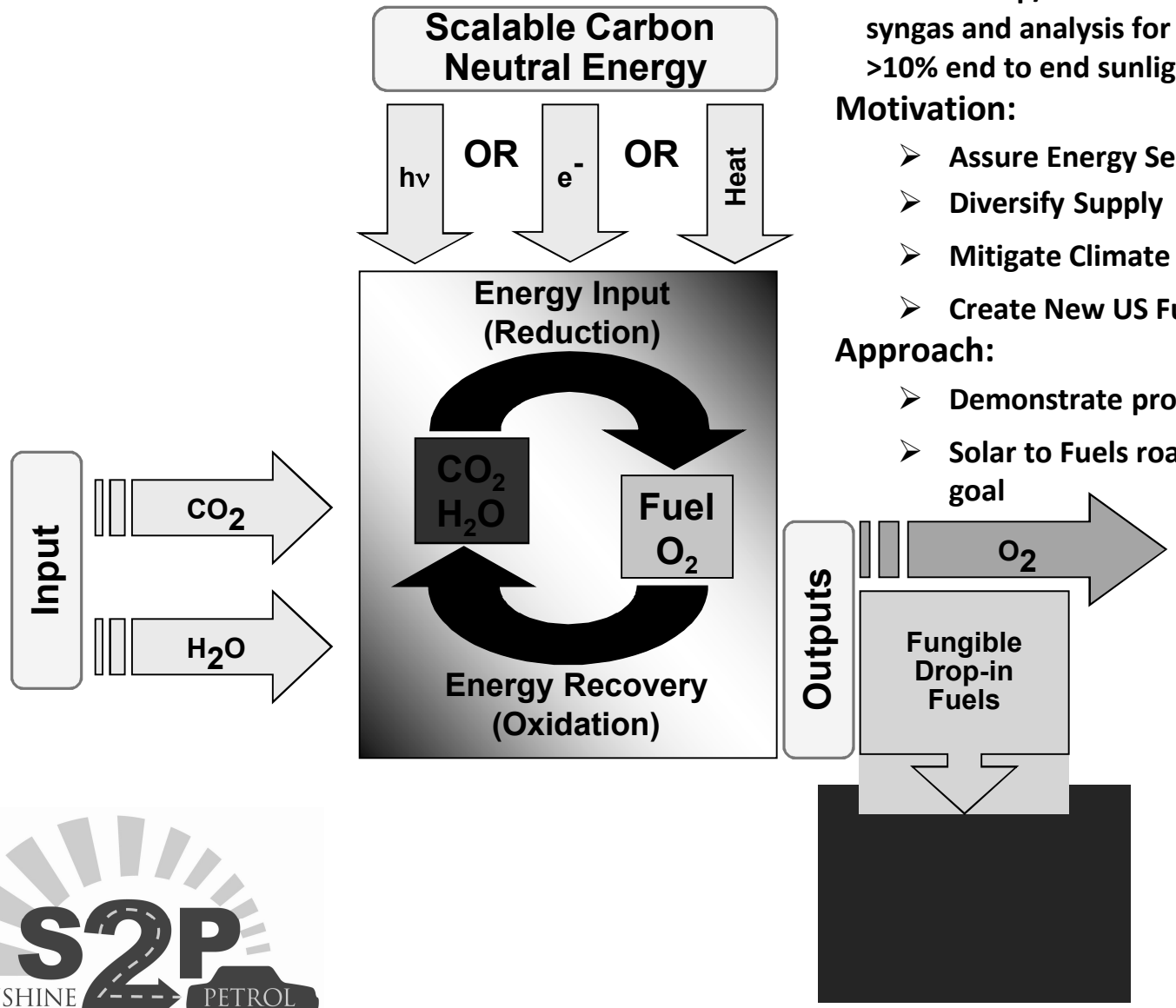
- U.S. petroleum demand is 20.7 million barrels per day (mb/d, 2007)
- 12.5% lifecycle efficiency could produce 16.6 mb/d (80% of total U.S. demand)
- NM alone could produce 23% of U.S. demand

"Filtered" Land Area Analysis

State	Land Area (10^9 m^2)	Solar Capacity (TW)	Fuel Capacity (GW)	Fuel Capacity (mb/d)
AZ	49.9	3.37	421	5.9
CA	17.7	1.20	150	2.1
CO	5.5	0.37	46	0.7
NV	14.5	0.98	122	1.7
NM	39.3	2.65	331	4.7
TX	3.0	0.20	25	0.4
UT	9.2	0.62	78	1.1
Total	139.2	9.39	1,174	16.6

139 billion m^2 is 1.5% of total U.S. land

Solar-driven Carbon Capture and Recycle to Fuels



Goal: Develop/Demonstrate 12.5% sunlight to syngas and analysis for a system design to achieve >10% end to end sunlight to fuel.

Motivation:

- Assure Energy Security
- Diversify Supply
- Mitigate Climate Change Risk
- Create New US Fuel Supply Industry

Approach:

- Demonstrate prototype heat engine (CR5)
- Solar to Fuels roadmap for 10% efficiency goal

SUNSHINE S2P PETROL

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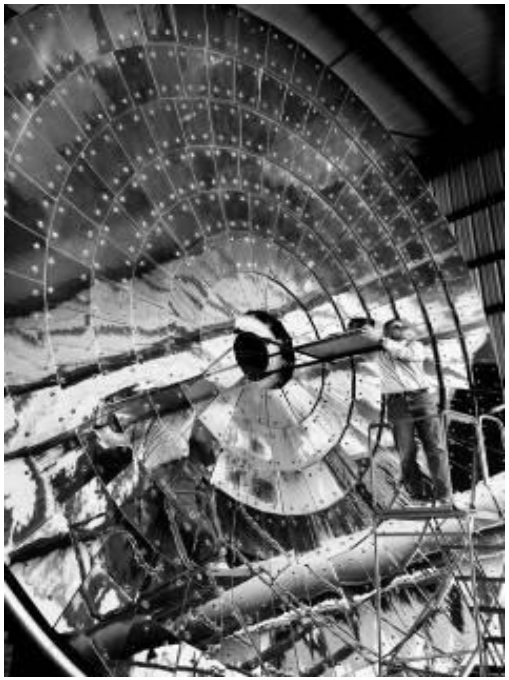
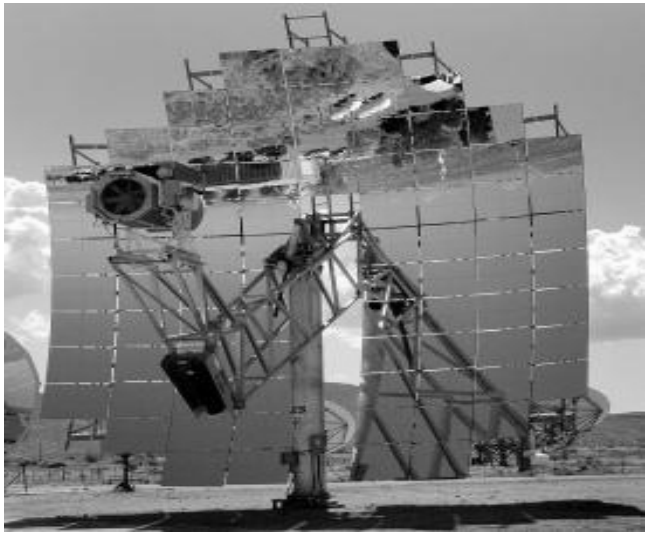
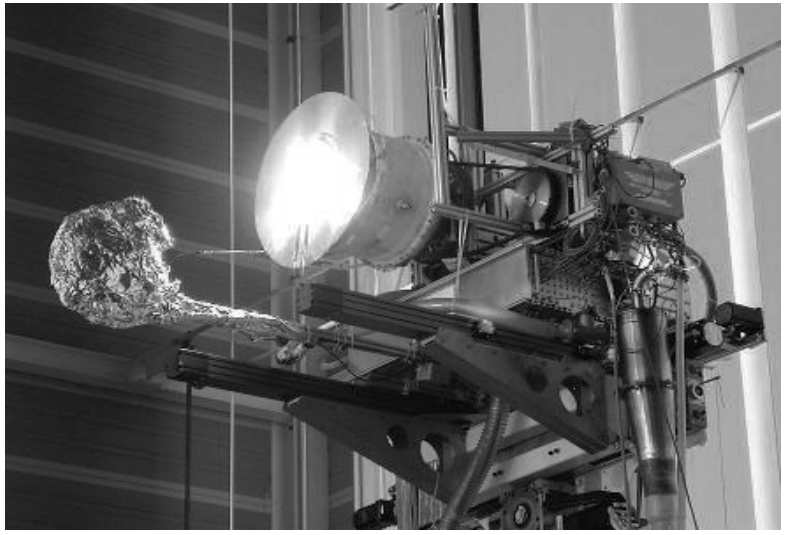
Sunshine to Petrol™ uses the Sun to Break Apart CO_2 and Store Energy in Hydrocarbons





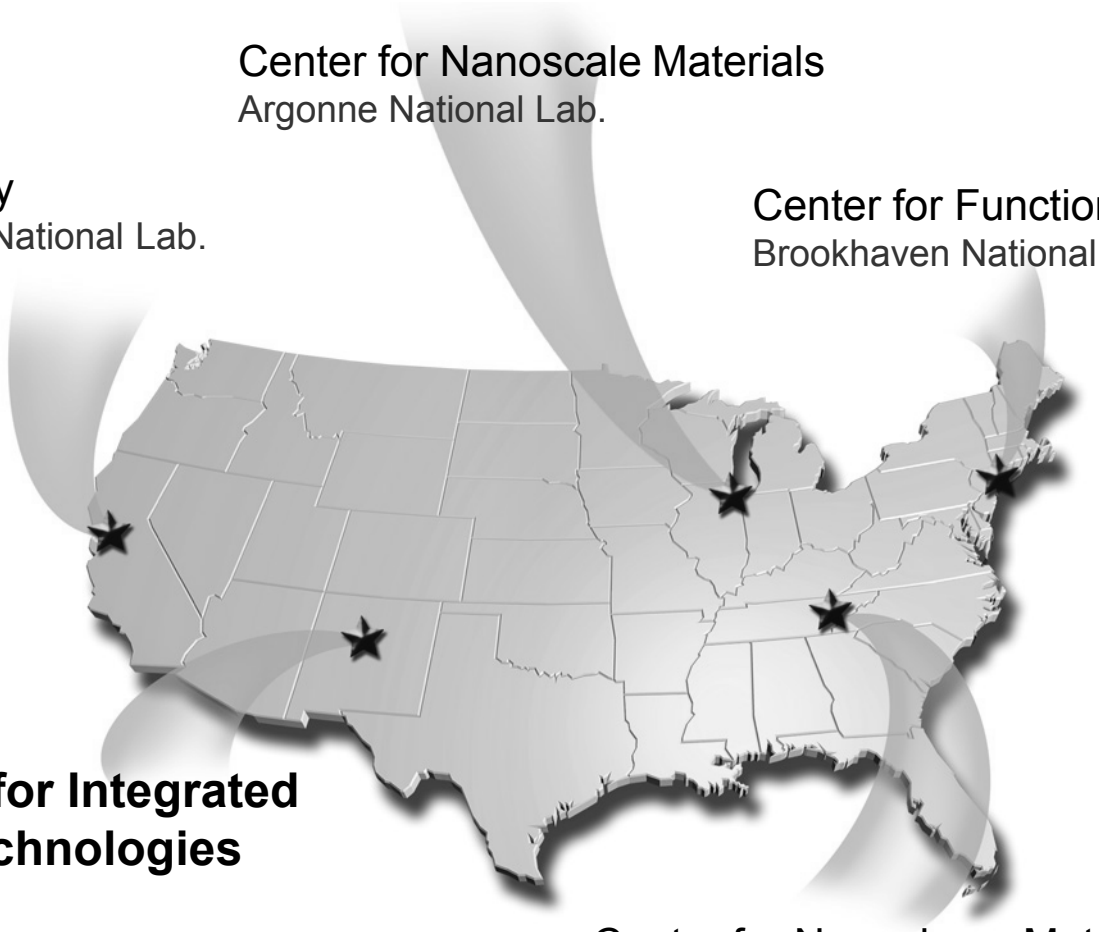


CINT is one of five U.S. Dept. of Energy Nanoscience Centers

Center for Nanoscale Materials
Argonne National Lab.

Molecular Foundry
Lawrence Berkeley National Lab.

Center for Functional Nanomaterials
Brookhaven National Lab.



Center for Integrated Nanotechnologies (CINT)
Sandia National Labs.
Los Alamos National Lab.

Center for Nanophase Materials Sciences
Oak Ridge National Lab.

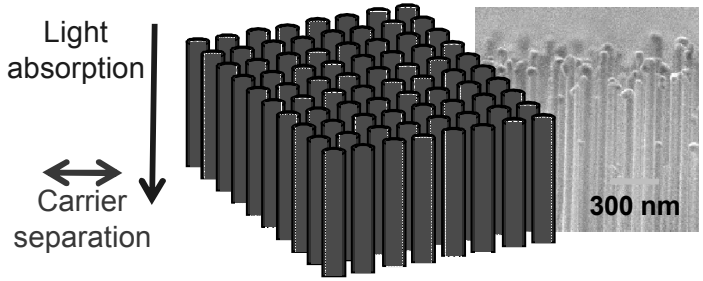
Los Alamos

Sandia National Laboratories

Nanowires for New Energy Concepts

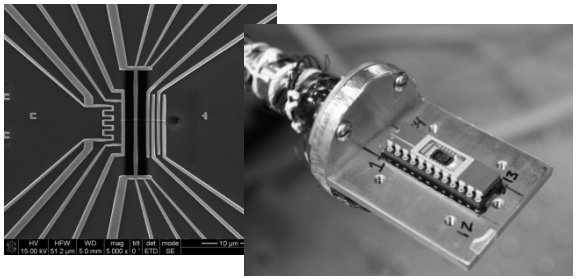
Heterogeneous nanowires provide new approaches to energy harvesting and storage.

Goal: Discovery new ways to decouple and enhance light absorption and carrier collection.



Goal: Discover new ways to enhance energy and power density.

Exploit surface & interface scattering



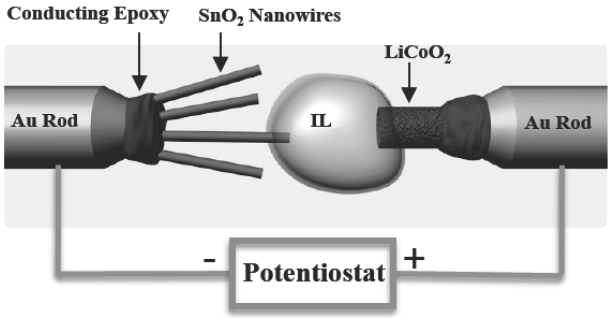
Integration Science Issues:

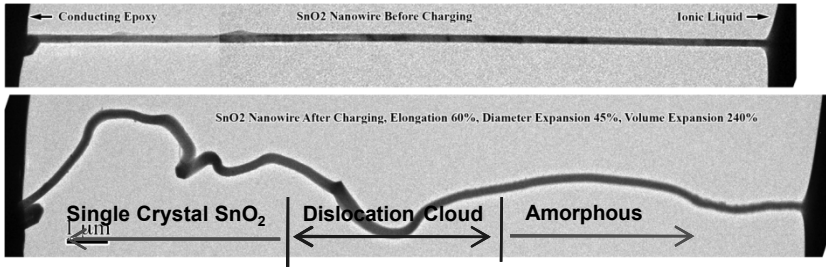
- **Electrical transport in wires and at interfaces**
- **Optical & optoelectronic excitation of nanowires**
- **Thermal transport in wires and at interfaces**

nsight from a Single Nanowire Battery Electrode

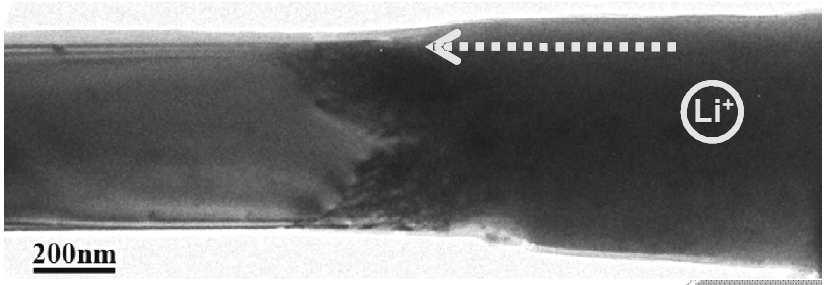
Improvements in Li-ion battery technologies require breakthroughs in materials and electrochemistry

World's smallest battery inside a transmission electron microscope, enabling real time observations of electrochemistry process at atomistic length scales





Jian Yu Huang, et al., *Science, Dec. 2010*



U.S. DEPARTMENT OF ENERGY | Office of Science

Sandia National Laboratories

Solar Technologies are Exciting Opportunities for the US

Microsystems based Photovoltaics

Solar Fuels

Nanotechnology inspired Photovoltaics and Batteries

… are just a few!