Measurement and Standards: The Role of NIST

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Department of Commerce

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U.S. Department of Commerce

NIST Mission

To promote U.S. innovation and industrial competitiveness by advancing

- measurement science,
- standards, and
- technology

in ways that enhance economic security and improve our quality of life.

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NIST was founded in 1901 as the National Bureau of Standards and became the National Institute of Standards and Technology to recognize NIST's broader mission.

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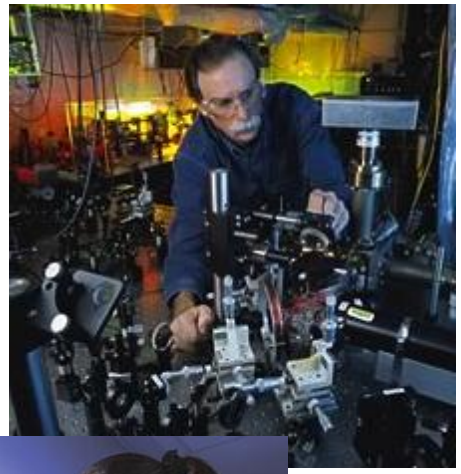
NIST at a Glance

Major Assets

- ~ 2,800 employees
- ~ 2600 associates and facilities users
- ~ 1,600 field staff in partner organizations
- ~ 400 NIST staff serving on 1,000 national and international standards committees

Major Programs

- NIST Laboratories
- Baldrige National Quality Program
- Manufacturing Extension Partnership
- Technology Innovation Program



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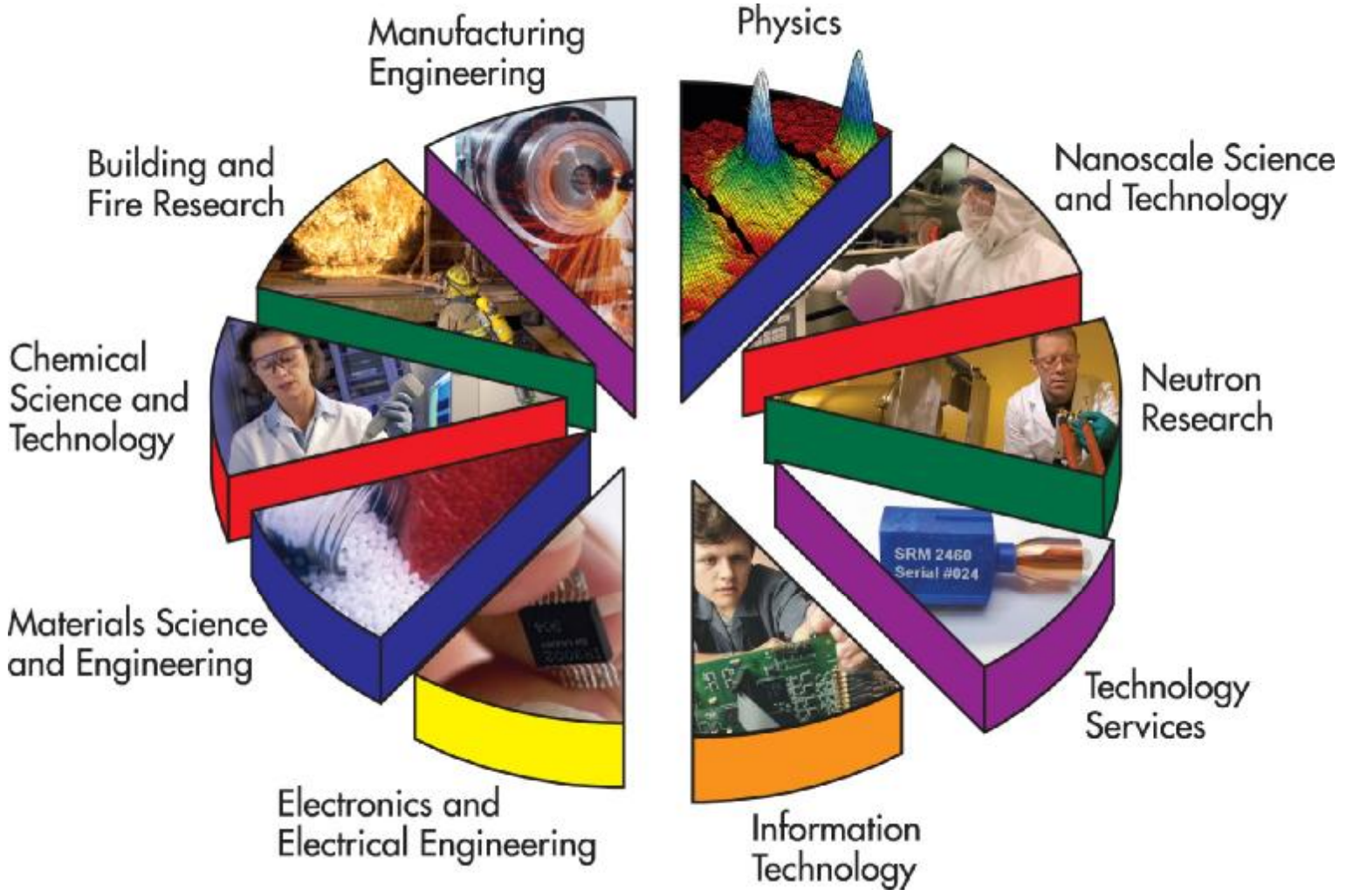
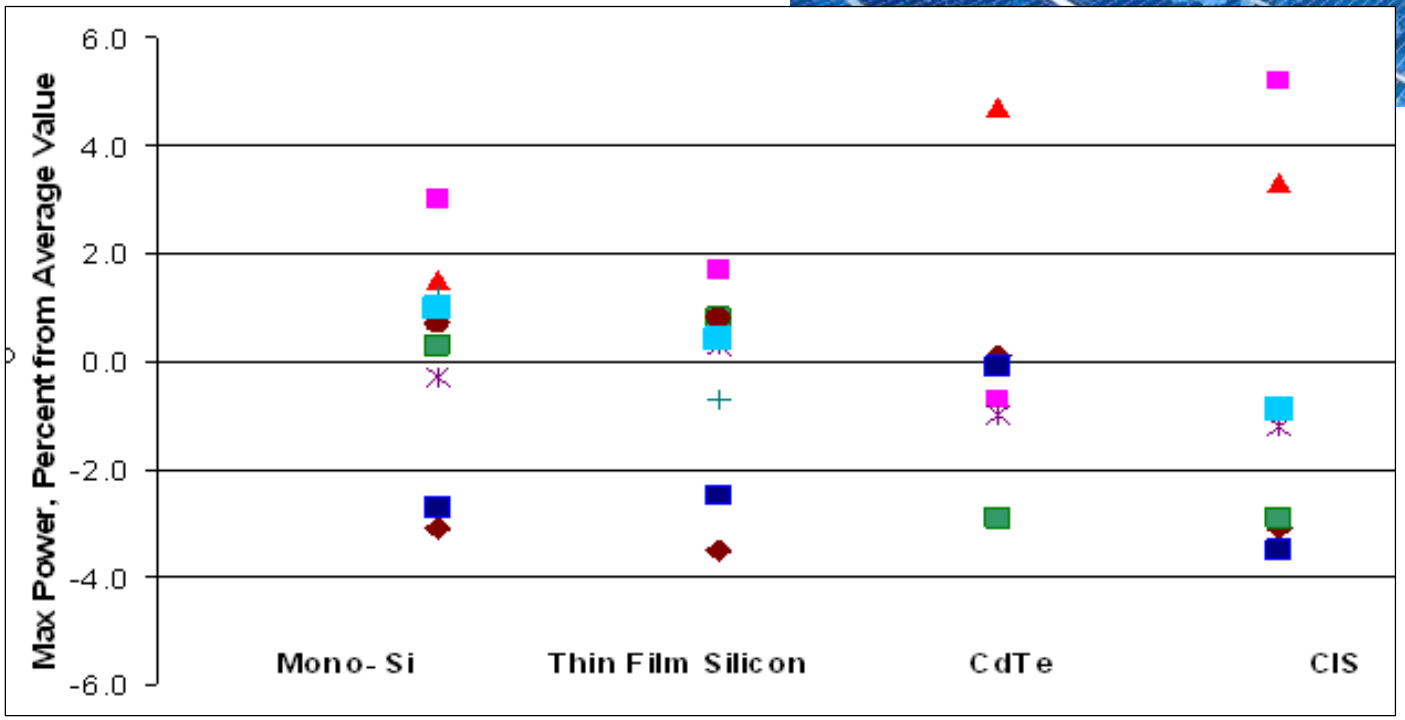
NIST Laboratories



Why Do Measurements Matter?

Consider Solar Module Ratings

Issue: International round robin showed significant variation in basic measurements such as peak power



"Results from the Second International Module Inter-Comparison", Rummel S., Emey K,King, D.,et al., 2006

NIST Activities:

Measurement Traceability

As the National Metrology Institute, NIST is charged with providing measurement traceability to the SI

- provide the traceability that underpins comparison across companies, labs, and nations

- provide measurement services for optical quantities (power, spectral responsivity, optical thermometry, etc.) and electrical quantities (power, voltage, current, waveform, etc.)

- provide international coordination of units

  CIPM Consultative Committee for Thermometry (Radiation Thermometry)

  CIPM Consultative Committee for Photometry and Radiometry

Primary Optical Watt Radiometer

Trap transfer detectors

NIST Activities:

Solar Module Ratings

NIST's Outdoor Solar Test Facility

NIST is improving measurement techniques to reduce overall uncertainty by

- developing high-speed radiometry to eliminate need for reference modules
- developing rating methods directly traceable to SI units
- developing energy production rating methodologies in lieu of power under ideal conditions

NIST's Indoor Solar Simulator

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NIST Activities:

Simulation Tools and Validation Data

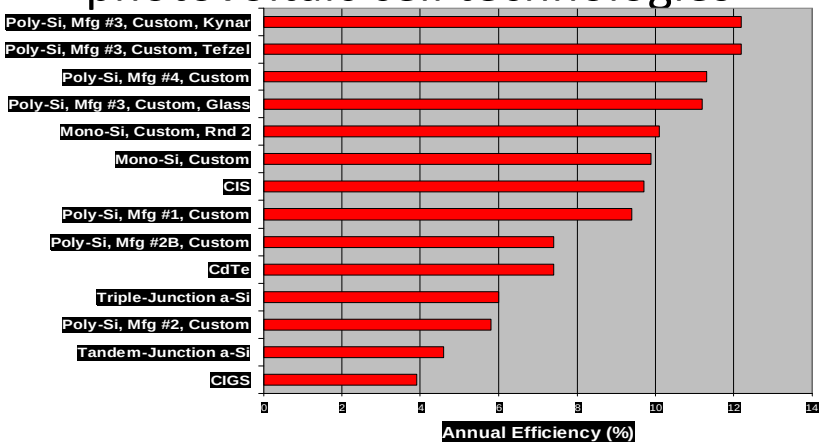
Residential Building Photovoltaic Panel

Issue: PV simulations do not accurately predict energy production under various field conditions.

Solution: NIST collected performance data for PV model validation under a wide-range of conditions:

- various geographical locations
- building orientations
- mounting techniques
- photovoltaic cell technologies

The test facility enables a side-by-side comparison of various mounting techniques as well as provide data on performance of various photovoltaic cell technologies.



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NIST Activities:

Power Conditioning Systems

Issue: DC solar energy requires integration with household AC systems & utility DER (Distributed Energy Resource) programs

Solution: NIST measurements to support development of power conditioning electronics that convert the unregulated DC power to (and from) 60 Hz AC power

- Perform measurements & develops test methods for high power PCSs
- Created "de facto standard" model used to enable development of IGBT power devices and systems used in PV systems
- NIST leads the interagency group that coordinates federal programs and information exchange for power conditioning devices

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NIST Activities:

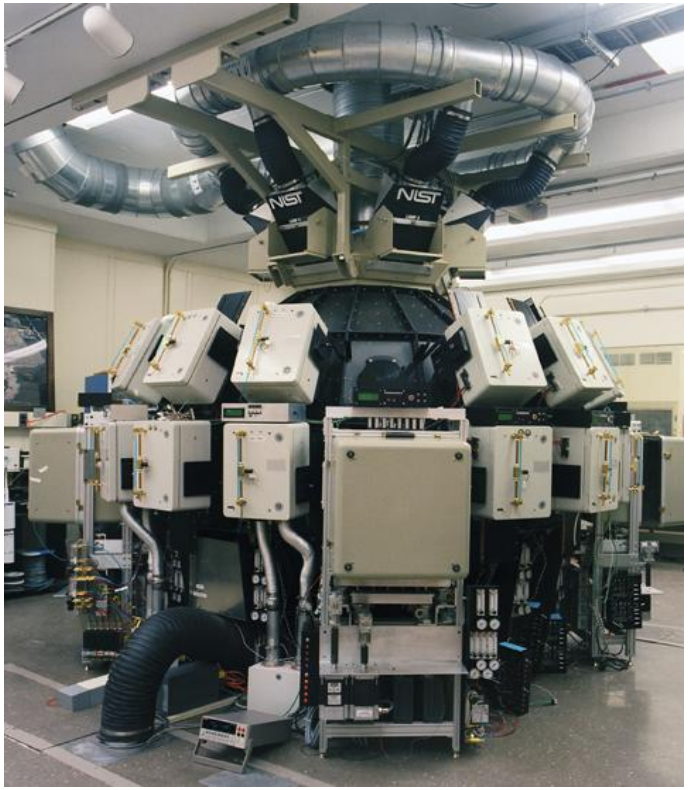
Photovoltaic service life

Issue: How can we estimate service lifetime, and is there a way to simulate aging for rapid testing?

Solution: Methodologies and metrologies are needed to rapidly assess PV long-term performance/reliability and characterize aging mechanisms in PV systems and component materials.

NIST Accelerated Weathering Device

- **Simulated Photodegradation via High Energy Radiant Exposure (SPHERE)**
- **8400 W UV à 22 "SUNS"**
- **95% exposure uniformity**
- **Precise control of temperature and relative humidity around specimens**



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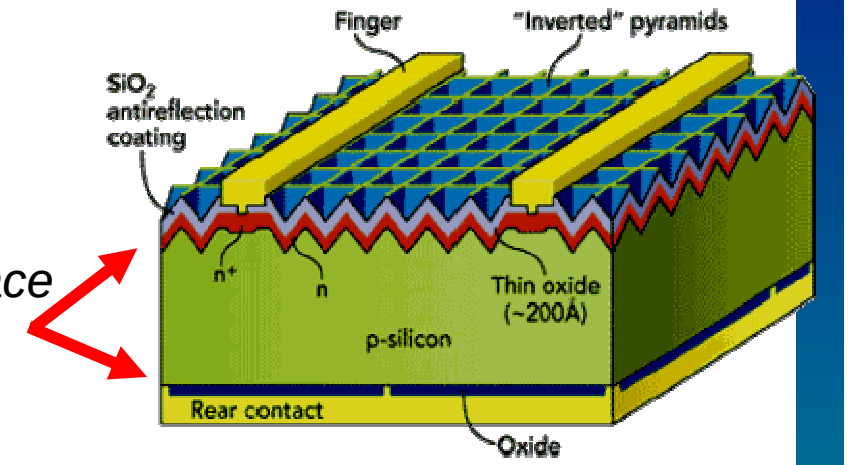
NIST Activities:

Semiconductor Device Metrology

Issue: interface defect generation decreases PV efficiency and causes degradation

Generated defects at the SiO2/Si interface increase carrier recombination



Solution: Research in CMOS device reliability is identifying key issues and promising directions:

- NIST research revealed that mechanism for interface defect generation by above bandgap photons in PVs solar is similar to electrical stress as well as Negative-Bias-Temperature-Instability in MOSFET.

…what about lifetime of supporting electronics in PV systems?

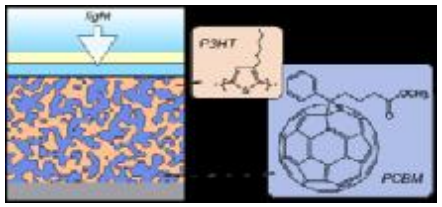
Future NIST Activities:

Measurements to Enable Next-Generation Photovoltaics

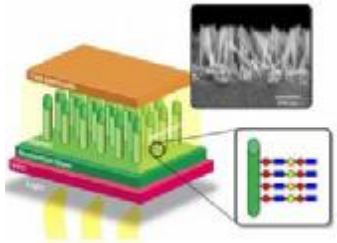
Issue: New measurement tools are critical to the development of the next generation of photovoltaic materials.

Solution: NIST is working to develop necessary measurement science by developing techniques to measure:

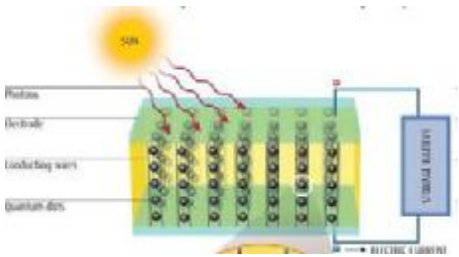
- carrier generation at wavelength (and subwavelength) scales
- carrier transport (mobility, recombination, lifetime) with at microscale (and nanoscale) resolution
- electron and hole concentration in individual 3D nanoscale structures and in nanostructured arrays



Organic PVs



Multi-junction PVs



Multi-exciton PVs

NIST Standards Activities:

Solar-Related Documentary Standards

Issue: Gaps exist in the portfolio of PV-related measurement and documentary standards.

Solution:

NIST researchers participate on various standards committees related to solar energy:

- ASTM E44 - Committee on Solar, Geothermal and other Alternative Energy Sources
- ASTM E44.09 - Committee on Photovoltaic Electric Power Conversion

NIST is planning to conduct a documentary standards gap analysis for the PV/solar energy technology sector.

NIST Standards Activities:

Smart Grid Documentary Standards and Solar

Issue: Renewable energy sources need to be integrated into the proposed Smart Grid.

Solution: NIST Smart Grid Interoperability Standards efforts supports increased use of renewable energy sources.

- NIST Roadmap effort is identifying additional work for standards to support integration of PV (solar) and other renewable energy sources
- Relevant standards:
  - IEEE 1547-3,4,6
  - IEC 61850-7-420 (for PV Inverters)
  - Zigbee Smart Energy Profile (Home Area Network)
  - PV Inverter Communication Project

Collaborations

DOE

- *Energy Efficiency and Renewable Energy (EERE Solar Energy Technologies Program*)
- *Office of Electricity*
- *National Renewable Energy Laboratory (NREL)*

Federal Energy Regulatory Commission (FERC)

IEEE, ASTM & various standards groups

BIPM/CIPM

Inter-agency Advanced Power Group, Electrical Systems Working Group (ESWG) chair