

# Hydrogen Research at Lawrence Livermore National Laboratory

*Advanced Science and Technology  
for Carbonless transportation*

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# LLNL Overview

- Founded: 1952 as a Defense Technologies Laboratory
- Location: Livermore, CA
- Core capabilities
  - Cryogenic pressurized storage and delivery
  - Hydrogen safety sensors
  - High-performance computing
  - Computational spectroscopy
  - Synthesis and characterization of materials
  - Multiscale theoretical modeling
  - Hydrogen safety training
- 5 Principal Investigators and co-PIs in hydrogen storage; production; delivery; technology validation; and safety, codes, and standards

# Cryo-compressed hydrogen storage, delivery, and dispensing

- The only cryogenic pressurized hydrogen fueling station in the U.S., 100 kg/hr, 80 g/L refueling



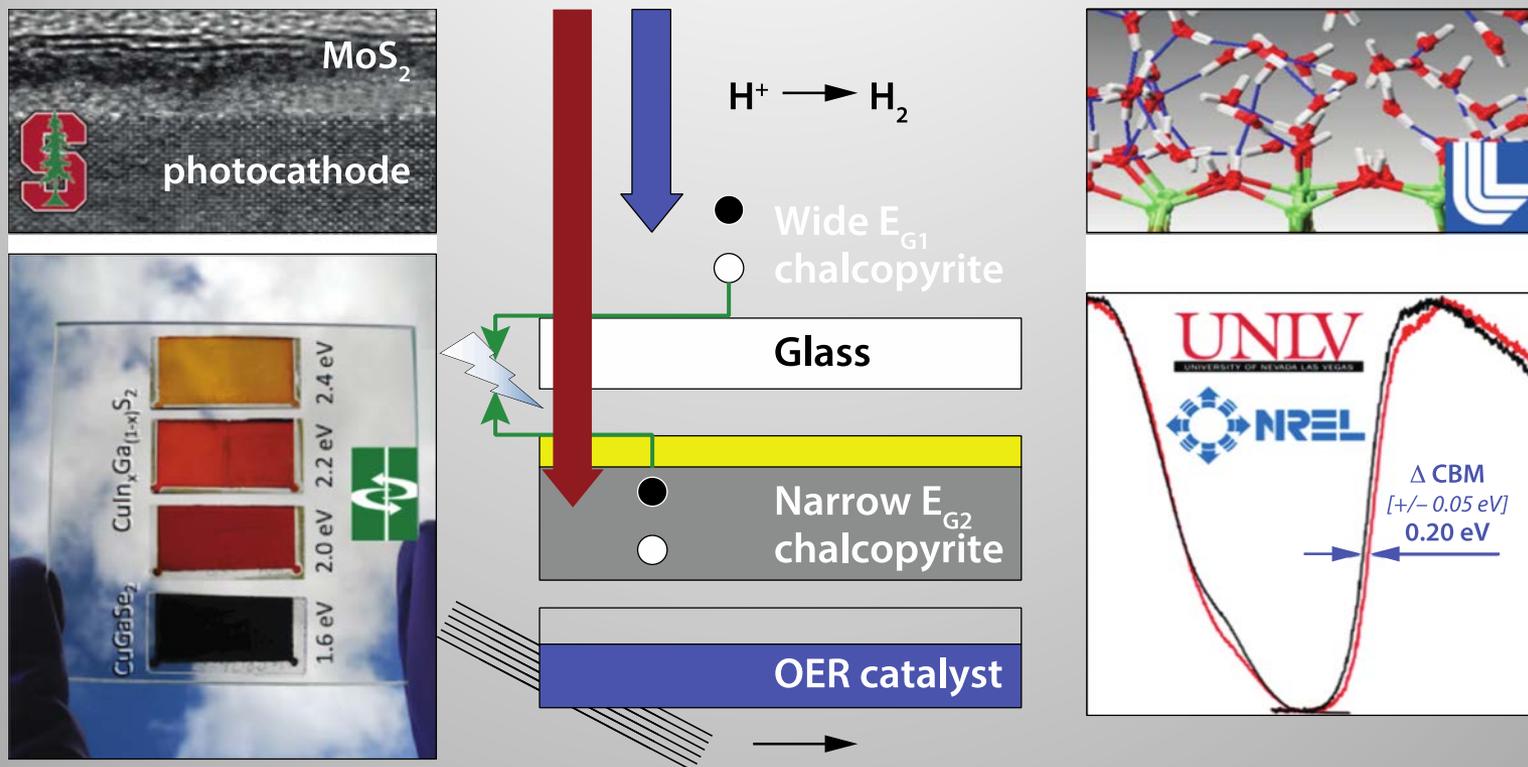
Cryogenic pressurized hydrogen promises to deliver safety, capacity, cost, and refuelability advantages for long-range (300+ miles) vehicle propulsion

# High Performance Computing Innovation Center

- New 150 teraflop/s *Catalyst* supercomputer available for solving practical problems of interest to industry

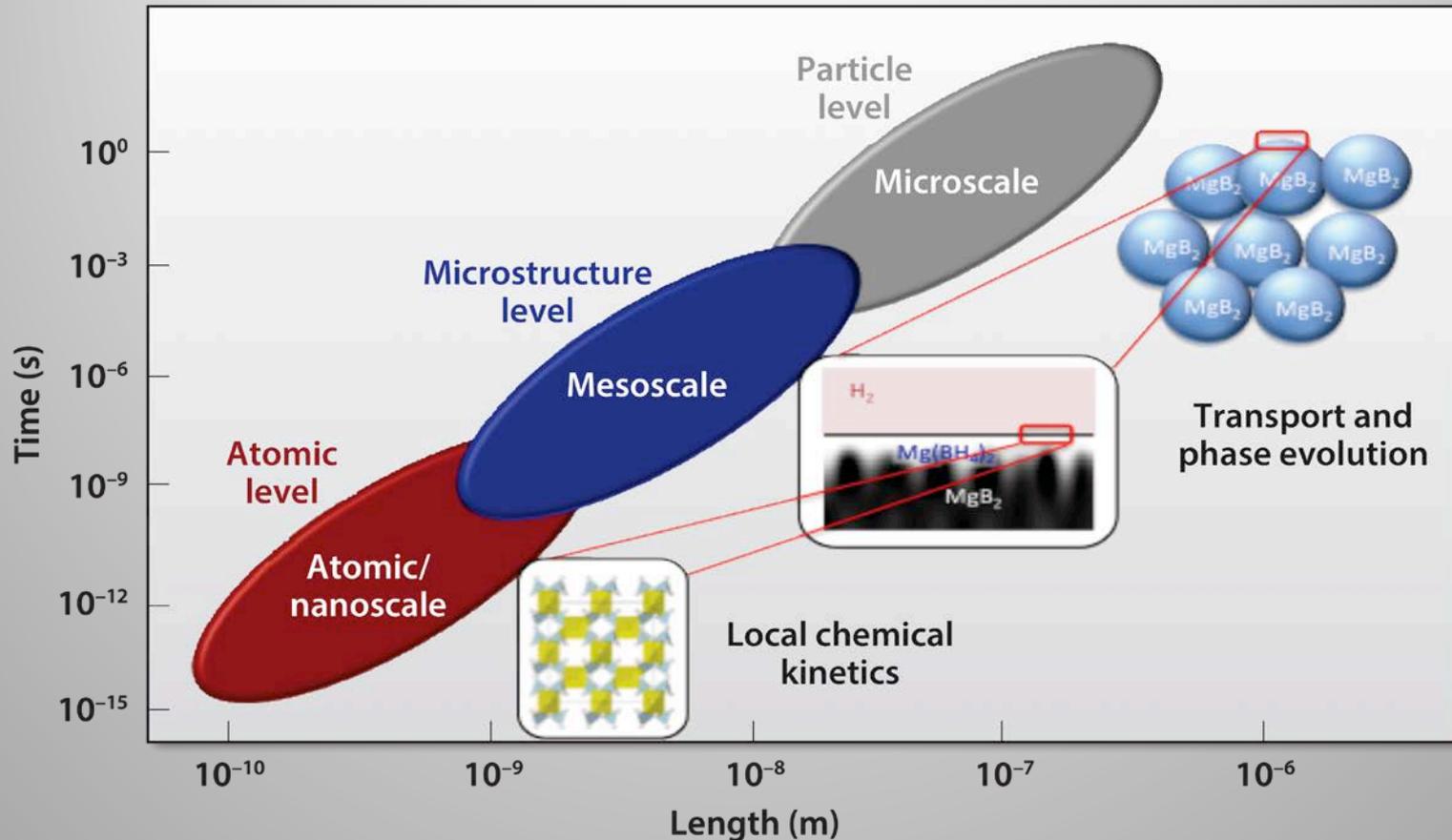
LLNL's High Performance Computing Innovation Center makes computing power and expert software assistance available to an industry in need of detailed modeling

# Photoelectrochemical H<sub>2</sub> production



Accelerated materials development by highly integrated theory/characterization/synthesis efforts for efficient photoelectrochemical H<sub>2</sub> production

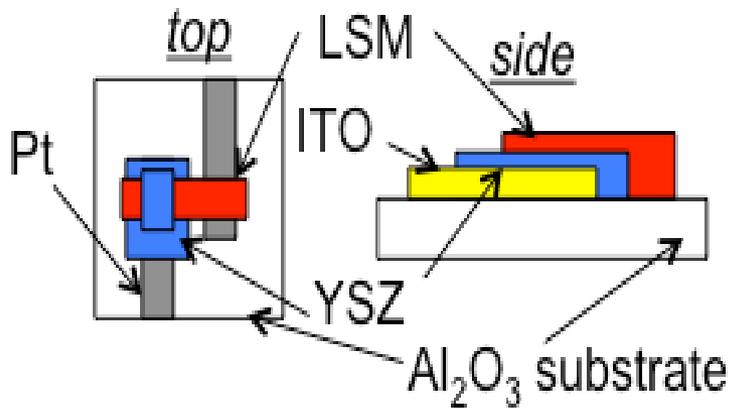
# Modeling of metal hydride absorption/desorption kinetics



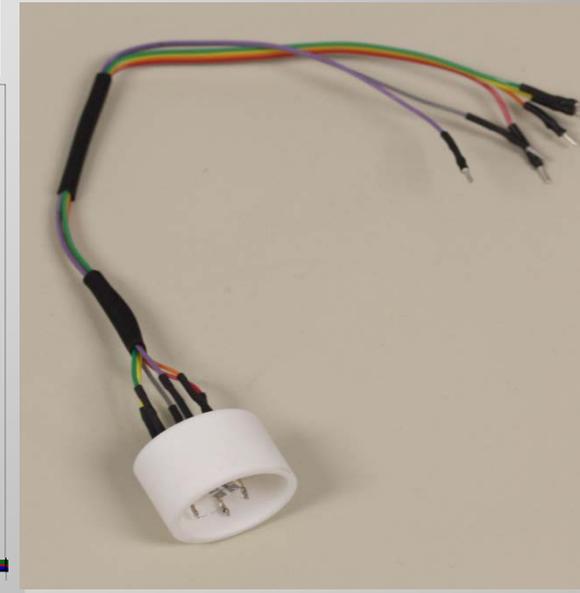
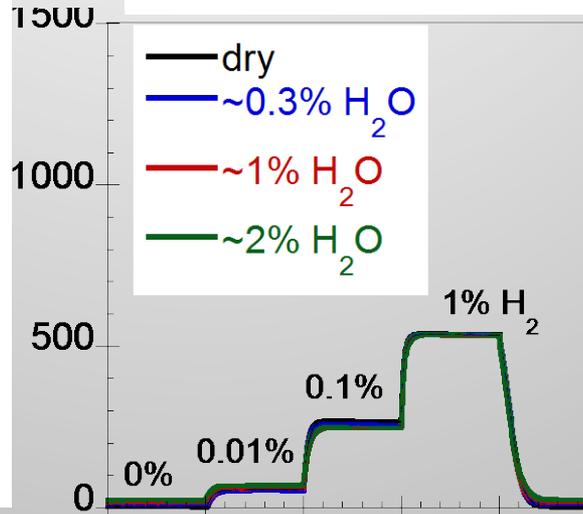
We are developing kinetic models of hydrogen storage in chemical hydride materials that address chemical, transport, and phase behavior across broad length and time scales

# Solid-state electrochemical sensors

ITO/YSZ/LSM prototype



Curves virtually overlap at various water concentration levels



Solid-state electrochemical sensors have good sensitivity to hydrogen in the 0.3–5.5% H<sub>2</sub> concentration range, less than 1-s response time, relative immunity to interference, and potential for mass manufacturing

# Technologies Coming to Market

## *Cryogenic Pressure Vessels*

- **Target industry**
  - Automotive
- **Partners**
  - Automotive companies and pressure vessel manufacturers
- **Benefits**
  - Safe, long range (300+ miles), inexpensive, rapidly refuelable, and zero emission transportation
- **IP, Patents**
  - 6 patents and 2 records of invention
- **Next Steps**
  - Demonstrate the potential for high volumetric and gravimetric performance in reduced scale (4.5 kg H<sub>2</sub>)

# Contacts

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## High performance Computing Innovation Center

<http://hpcinnovationcenter.llnl.gov>

## Industrial Partnerships Office

<https://ipo.llnl.gov>

