
Pacific Northwest
NATIONAL LABORATORY
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# Fuel Cell Technologies Available at the Pacific Northwest National Laboratory

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Fuel Cell Seminar
Nov 10-12, 2014

# PNNL Overview

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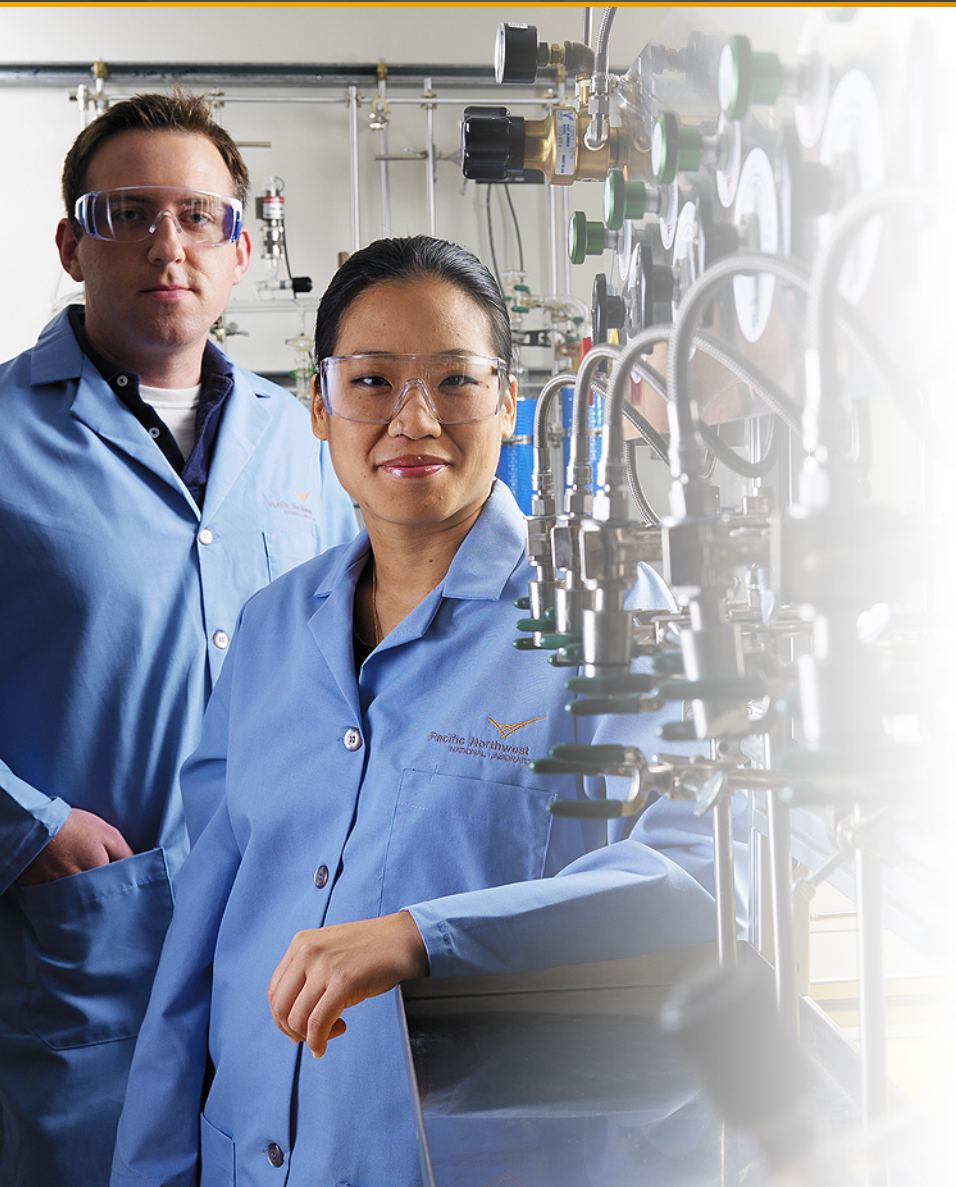

- Location: Richland, WA
- 4,300 scientists, engineers and non-technical staff
- 98 Awards for Technology Transfer to market, 93 R&D 100 awards
- Core Capabilities
  - Solid Oxide Fuel Cells
  - Institute for Integrated Catalysis
  - Applied Materials Science & Engineering
  - Systems Engineering & Integration
  - Energy storage and conversion
  - Supercomputing
  - Environmental Molecular Sciences Laboratory User Facility
  - Safety Codes and Standards / First Responder Training

# Microchannel Technology

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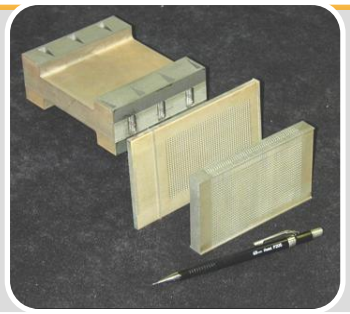
## PNNL's microchannel technology enables exceptionally fast heat and mass transfer



PNNL discovers microchannels increase heat and mass transfer resulting in high performance reactors and heat exchangers

Advanced integrated, heat exchangers, fuel processor and fuel cell systems for compact mobile applications

## Impact:

Microchannel technology results in up to 10x decrease in device size.

- ✓ Ideal for highly efficient heat exchangers
- ✓ Improved performance of heat or mass transfer limited reactions (i.e. endothermic)
- ✓ Perfect where size matters
- ✓ R&D 100 Awards in 1999, 2007, 2014

**Technical Point of Contact: Kriston Brooks – Kriston.Brooks@PNNL.gov**

http://availabletechnologies.pnnl.gov/

# Material Based Hydrogen Storage

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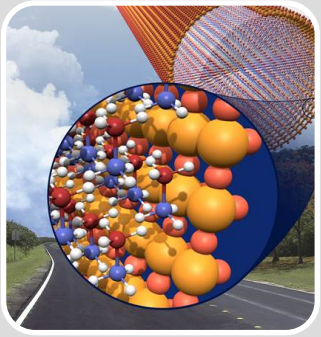
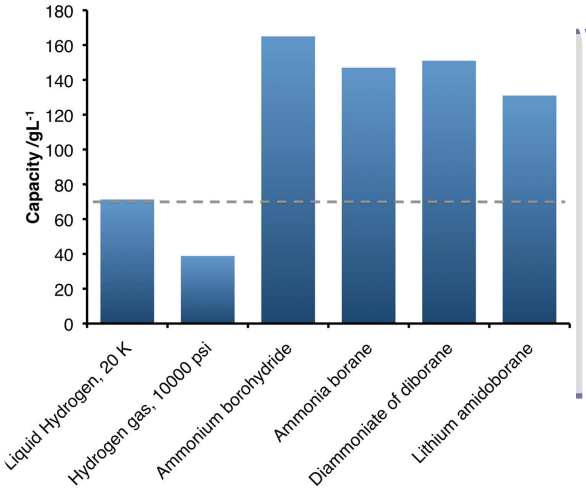
## PNNL developed new materials for safe, high density hydrogen storage



PNNL chemists developed new synthesis methods for ammonia borane and its derivatives - lithium amido-borane, EDAB




New materials have higher volumetric and gravimetric capacity than physical storage

# Impact:

Material based $H_2$ is ideal for many fuel cell applications. It is:

- ✓ Low pressure
- ✓ High capacity (>80 g $H_2$/L)
- ✓ Safe, air and thermally stable
- ✓ PNNL developed new lower cost ammonia borane synthesis technology

**Technical Point of Contact: Tom Autrey- Tom.Autrey@PNNL.gov**

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# Advanced High Performance Catalysts

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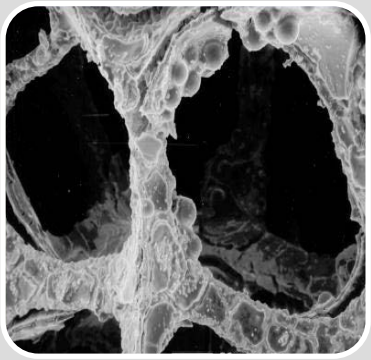
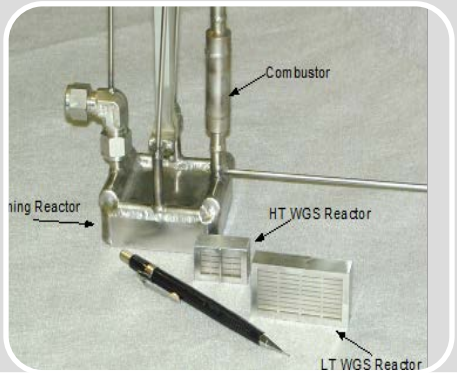
## PNNL's Institute for Integrated Catalysis (IIC)



PNNL catalysis capabilities provide foundational knowledge for the development of highly active and durable catalysts




Highly active catalysts are integrated into compact systems for hydrogen production technologies

## Impact:

PNNL's highly active steam reforming catalysts for paraffinic hydrocarbons and catalysts for methanol:

- ✓ 10x increase in activity (paraffinic hydrocarbon reforming)
- ✓ Methanol reforming catalyst is non-pyrophoric
- ✓ Engineered forms developed for easy reactor integration

**Technical Point of Contact: Yong Wang- Yong.Wang@PNNL.gov**

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# Low Cost Pressure Vessels

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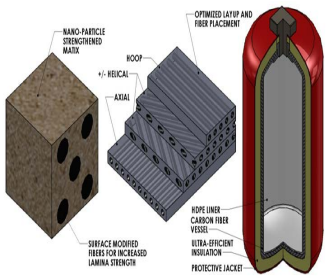
## PNNL developed technology for pressure vessel cost reduction




PNNL's unique combination of materials, engineering, and manufacturing enable low cost pressure vessel solutions

PNNL is partnering with carbon and glass fiber suppliers and vehicle and tank OEMs to design improved cryogenic $H_2$ and high pressure tanks

## Impact:

Our materials, engineering and design:

- ✓ Low cost glass and carbon fiber hybrid tanks
- ✓ Innovative designs to eliminate hydrogen waste and enable five minute fills
- ✓ >85% Conformability
- ✓ Design for low cost manufacturing

**Technical Point of Contacts: Dave Gotthold and Ken Johnson-Dave.Gotthold@PNNL.gov and KI.Johnson@PNNL.gov**

# Solid Oxide Fuel Cell

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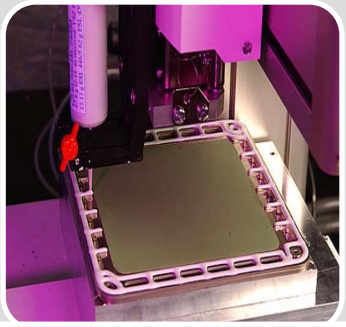
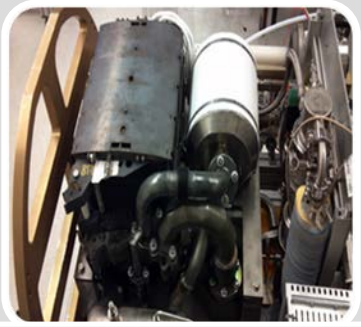
## PNNL leads in the development of Solid Oxide Fuel Cell development



PNNL developed materials, catalysts, seals, and manufacturing methods for SOFC



The SOFC technologies have been integrated with microchannel based reformers for complete systems

## Impact:

- ✓ Oxide based anodes that are $O_2$ tolerant, less susceptible to sulfur, high activity, low cost
- ✓ Glass-ceramic seals for planar technology
- ✓ Reactive air brazing for joining ceramics to metals
- ✓ Gas-tight sealing methods

**Technical Point of Contact: Jeffry Stevenson – Jeff.Stevenson@PNNL.gov**

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# Recent Collaborations in Fuel Cell Technologies

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- Tank Manufacturers
  - Hexagon Lincoln
  - PPG
- Fuel Cell Companies
  - Protonex
  - Nuvera
  - Plug Power
  - FuelCell Energy
  - Delphi
- Hydrogen Storage Materials
  - Cella Energy
- OEMs
  - Ford
  - GM
  - Boeing
- Institutions
  - California Fuel Cell Partnership
  - $H_2$ USA
- Other Companies
  - Echogen
  - Infinia Technology Corporation
  - AOC Resins
  - Crosslink Technologies
  - Cormtech
  - TianChen
  - Emerald Energy NW
  - Virent
  - Air Products
  - Velocys
  - Dow
- Universities and Institutions
  - Boston College / Boston University
  - University of Alabama
  - University of Quebec
  - Michigan State University
  - Oregon State University
  - University of Connecticut
  - Washington State University


Mission
We transform the world through courageous discovery and innovation.
Vision
PNNL science and technology inspires and enables the world to live prosperously, safely and securely.
DISCOVERY in Action
CREATIVITY
integrity
courage
Values
Impact
COLLABORATION
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# PNNL is mission-driven

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We **TRANSFORM THE WORLD** through courageous **DISCOVERY** and **INNOVATION**.

- Operated by Battelle since 1965
- Unique S&T capabilities
- Mission-driven collaborations with government, industry and academia


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# Thank you

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