

# BROOKHAVEN NATIONAL LABORATORY

## **Accelerating Innovation**

Alane for Hydrogen Storage and Delivery

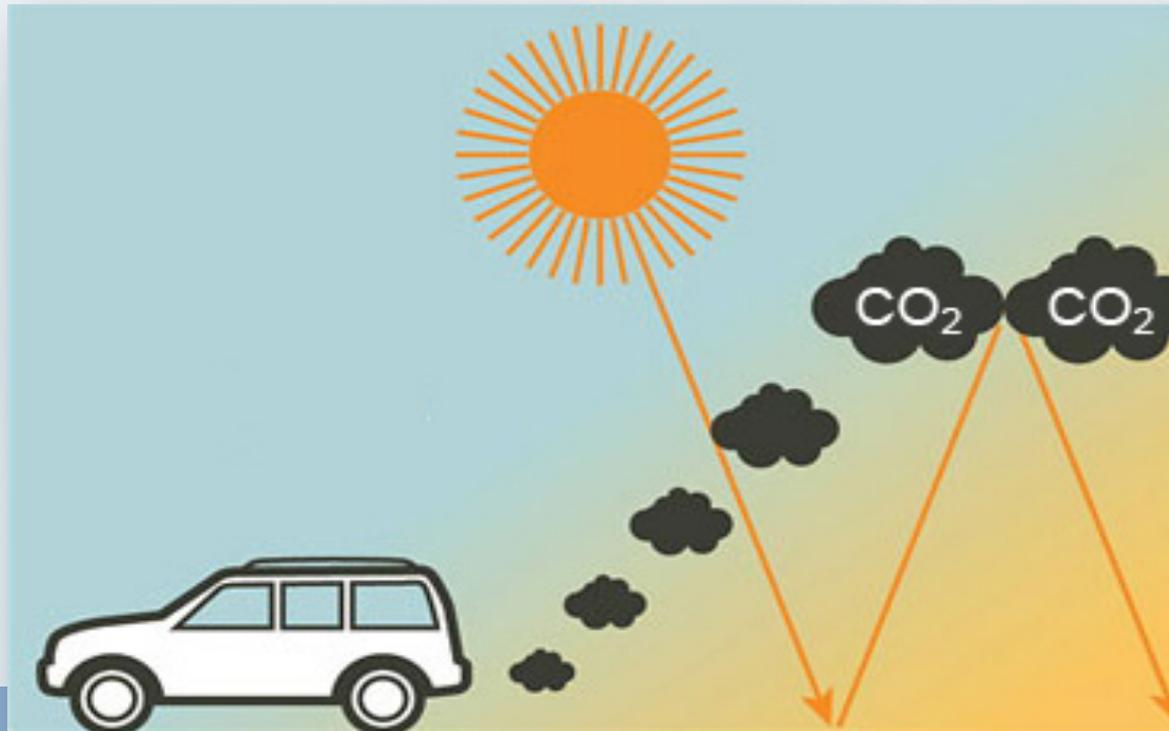
June 2012

# Why Hydrogen?

- Oil is a limited resource, generates green house gas and much of the worlds supply lies outside the U.S.
- 1 lb of hydrogen has the same energy as 3 lbs of gasoline

**Hydrogen is a clean fuel and produces no CO<sub>2</sub>**

**...only emission is water (H<sub>2</sub>O)**



# Hydrogen-powered fuel cells can supply energy to power anything from automobiles to homes to computers.



**WHAT'S NEW RECREATION**

**TRICKLE-DOWN TECH**

**WARM AND WIRED**

**BATTLE GEAR INSPIRES A BETTER BATTERY-POWERED JACKET**

**Battlers sometimes log** more than 30 pounds of batteries to run GPS units and other critical gear, so San Francisco company Andica set out to give them a lighter power pack. Now a civilian version lets the rest of us charge our phones—and stay warm. Andica's Meads Power System is the first to charge your heated winter clothes, like this jacket from Mountain Hardware, and your gear, too.

Andica's military pack, now in testing, tucks hydrogen fuel cells and lithium-ion batteries into a flexible case. The Meads uses only batteries, since fuel cells aren't widely available. But the layout is similar: Seven 2.75-inch batteries are linked inside a frame frame at the joints. It dips into the jacket's back and holds enough power to simultaneously (1) re-heat a conductive yarn and send current to a USB cord in a pocket. You get about nine hours of heat or 11 iPhone charges before you have to plug it in. Sturdy plastic connectors hook the Meads to a jacket's wiring. Detach them, and it becomes a portable charger that you can transfer to several compatible units or tuck on its own on your next mission. —MARK ANDROSS

**IN RELATED NEWS: SKINNY SUN POWER**

Another way to take gadgets on the go: a solar charger that looks like a power bank. It's new 20 by 14 inch model will let you get more power in your pocket, but it's more expensive. It absorbs light from nearby windows, not just sunlight, so it works in cloudy weather and at the desk, too. The charger bank system is due to hit stores and online this week. —LAWRENCE STROGAN [www.popsci.com](http://www.popsci.com)

**SET IT:** Andica Power System Meads. [www.andica.com](http://www.andica.com). Mountain Hardware. [www.mountainhardware.com](http://www.mountainhardware.com). [www.andica.com](http://www.andica.com). [www.mountainhardware.com](http://www.mountainhardware.com)

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# The Hydrogen Storage Problem

**Hydrogen is a gas at room temperature and a small amount of hydrogen takes up a lot of space...**



Hydrogen can be stored as a gas...



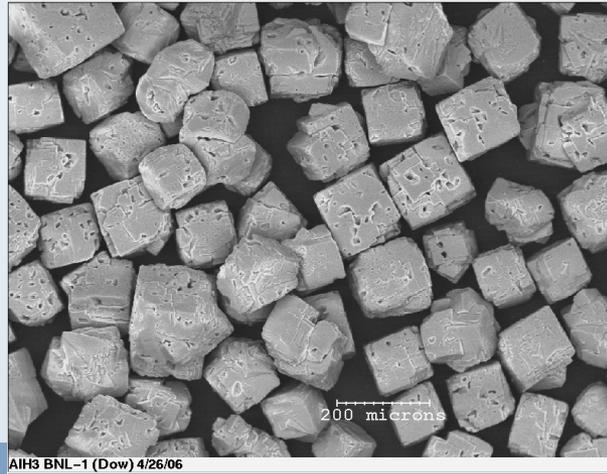
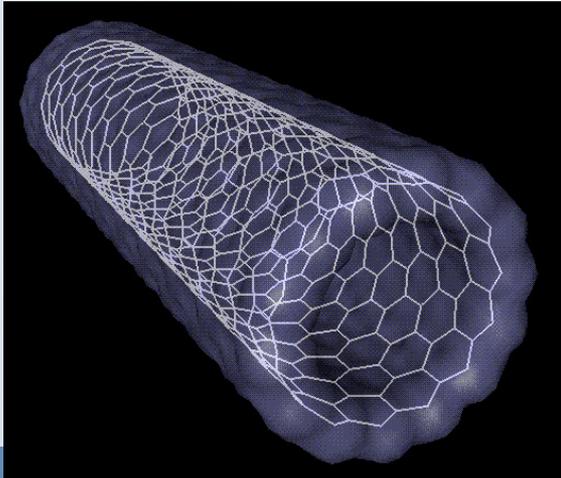
compressed hydrogen gas tank

a very cold liquid (-423°F)...

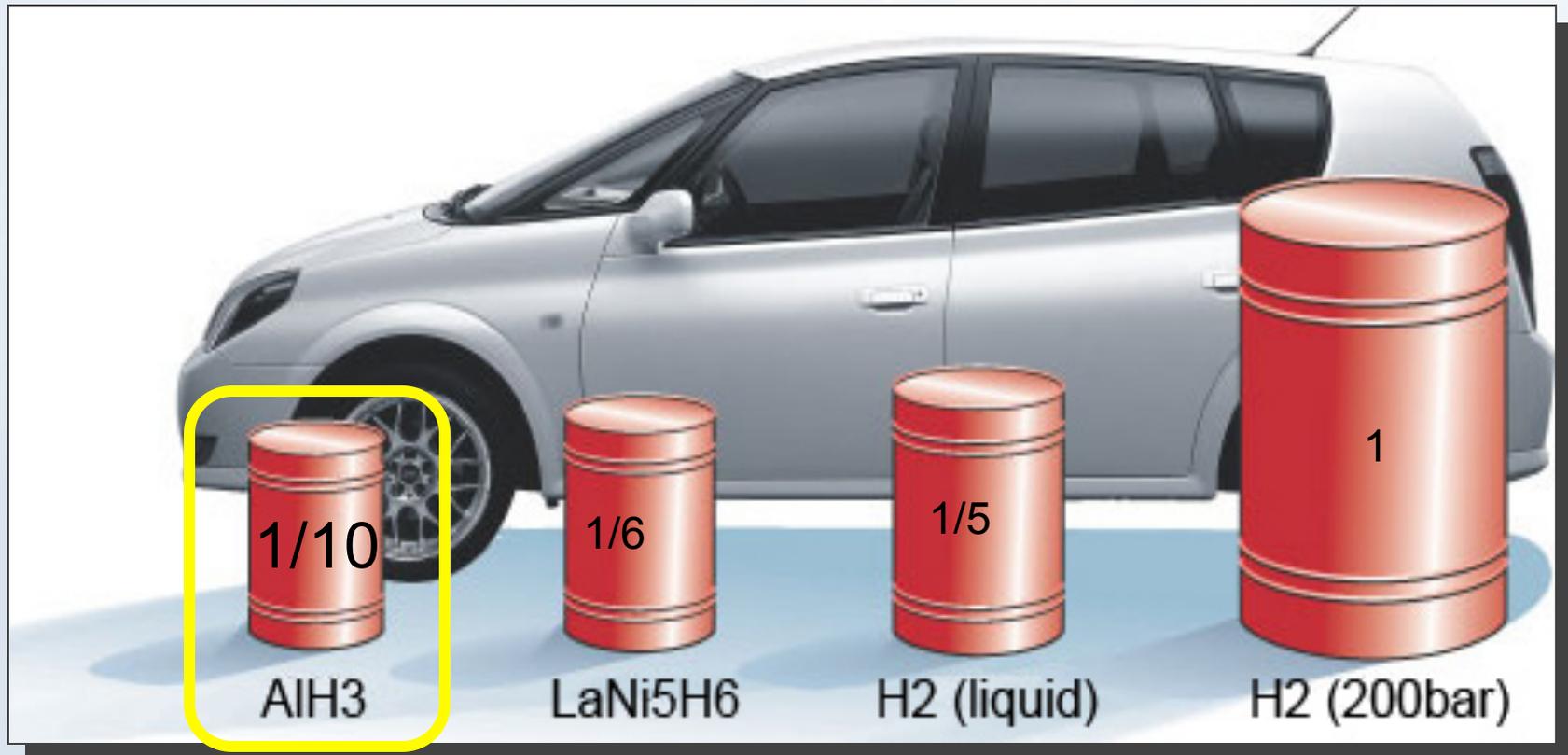


liquid hydrogen tank

and even in a chemical compound...



# What is the most compact way to store hydrogen?



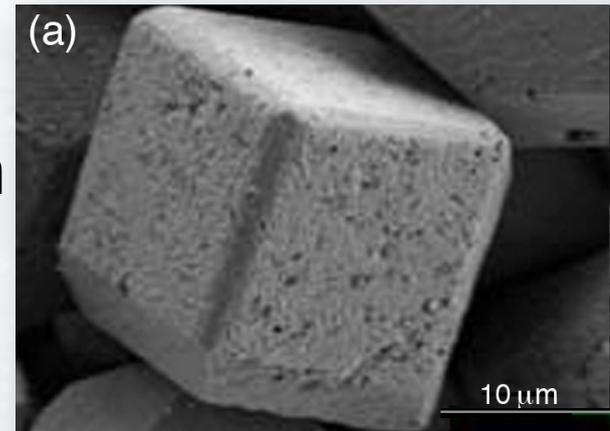
Volume of 4 kg of hydrogen (~200 mile driving range) in different storage media

**Solid-state hydrogen storage provides a much greater volumetric capacity than gaseous or liquid  $\text{H}_2$**

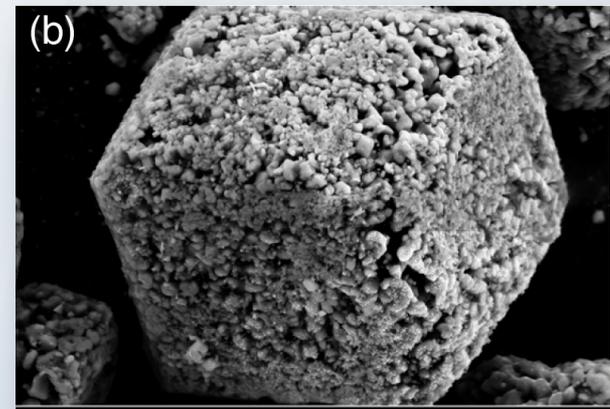
## The Solution: $\text{AlH}_3$

0.5 mL of  $\text{AlH}_3$  ( $\sim 0.75\text{g}$ ) contains the equivalent 1000 mL of  $\text{H}_2$  at room temperature

**Almost 2000 times more hydrogen  
in the same space**



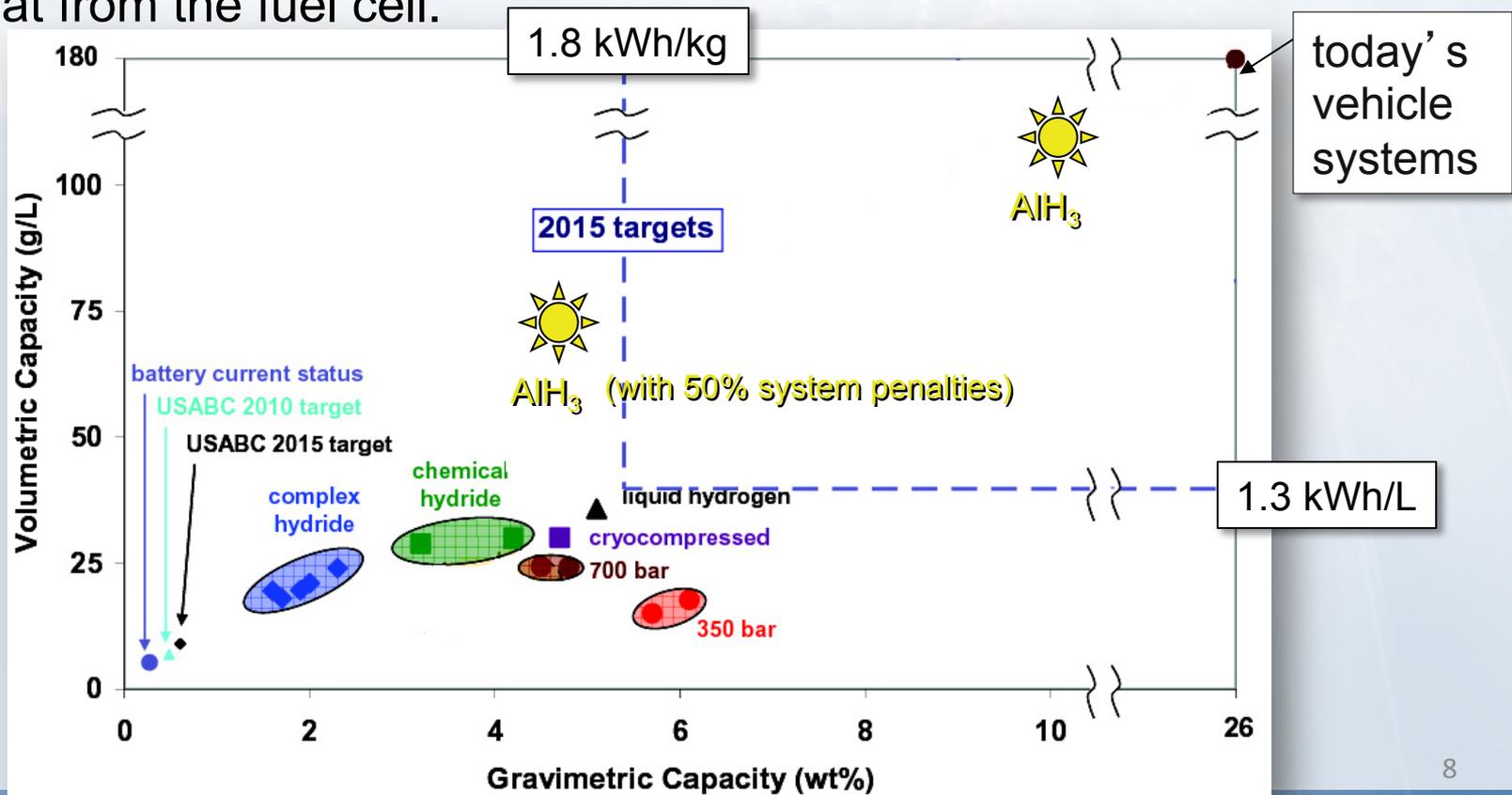
**Before hydrogen release**



**After hydrogen release**

# $\text{AlH}_3$ has a high hydrogen content.

- $\text{AlH}_3$  is prepared by a low pressure chemical process
- High capacity: **10.1 wt% hydrogen** (DOE 2015 system target 5.5 wt%)  
**149 gH/L** (DOE 2015 system target 40 gH/L)
- Hydrogen is easily released by heating the material to 80-120°C using waste heat from the fuel cell.



# Market Opportunity—Applications & Value Proposition

- Hydrogen can be used as a fuel in internal combustion engines and fuel cells.
- Once hydrogen is provided, fuel cells offer emissions-free energy.

***Activated  $\text{AlH}_3$  offers rapid low-temperature kinetics and high energy density as a source of hydrogen.***

- Further doping with titanium improves room-temperature desorption rates.

# Who could benefit from this technology?

- Hydrogen Suppliers
- Fuel Cell Companies
- Major Corporations



# Development Pathway—Lab to Market

- We can use aluminum hydride to power fuel cells by tuning the desorption rate.
- Power sources for portable electronics will probably be the first commercial application of the technology.
- Other applications include back pack fuel cells, especially for military use.
- Automotive applications will likely follow these.

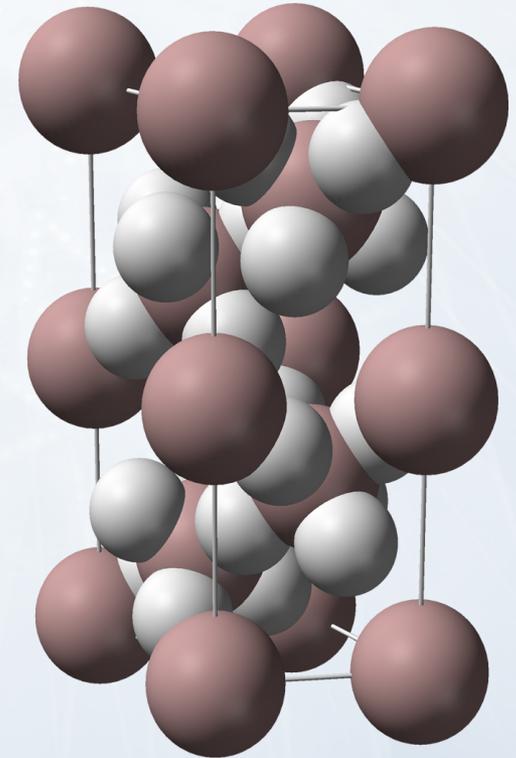


# Intellectual Property Landscape

- Our patent covers aluminum hydride hydrogen storage compositions and methods of producing hydrogen gas from them.
- We also have a patent that covers the preparation of aluminum hydride from the spent material: “Regeneration of Aluminum Hydride”

# Conclusion

- BNL's activated aluminum hydride offers a source of pure hydrogen for use as a fuel.
  - Hydrogen can be stored in the material virtually indefinitely.
  - The material is light, and has ten times the storage capacity of compressed gas.
  - The temperature and rate of hydrogen desorption can be controlled.



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