



Hydrogen Storage

Alex Bevan

Hydrogen materials Group

www.hydrogen.bham.ac.uk
www.hydrogen-wm-scratch.info

16th September 2009

Metallurgy and Materials, University of Birmingham

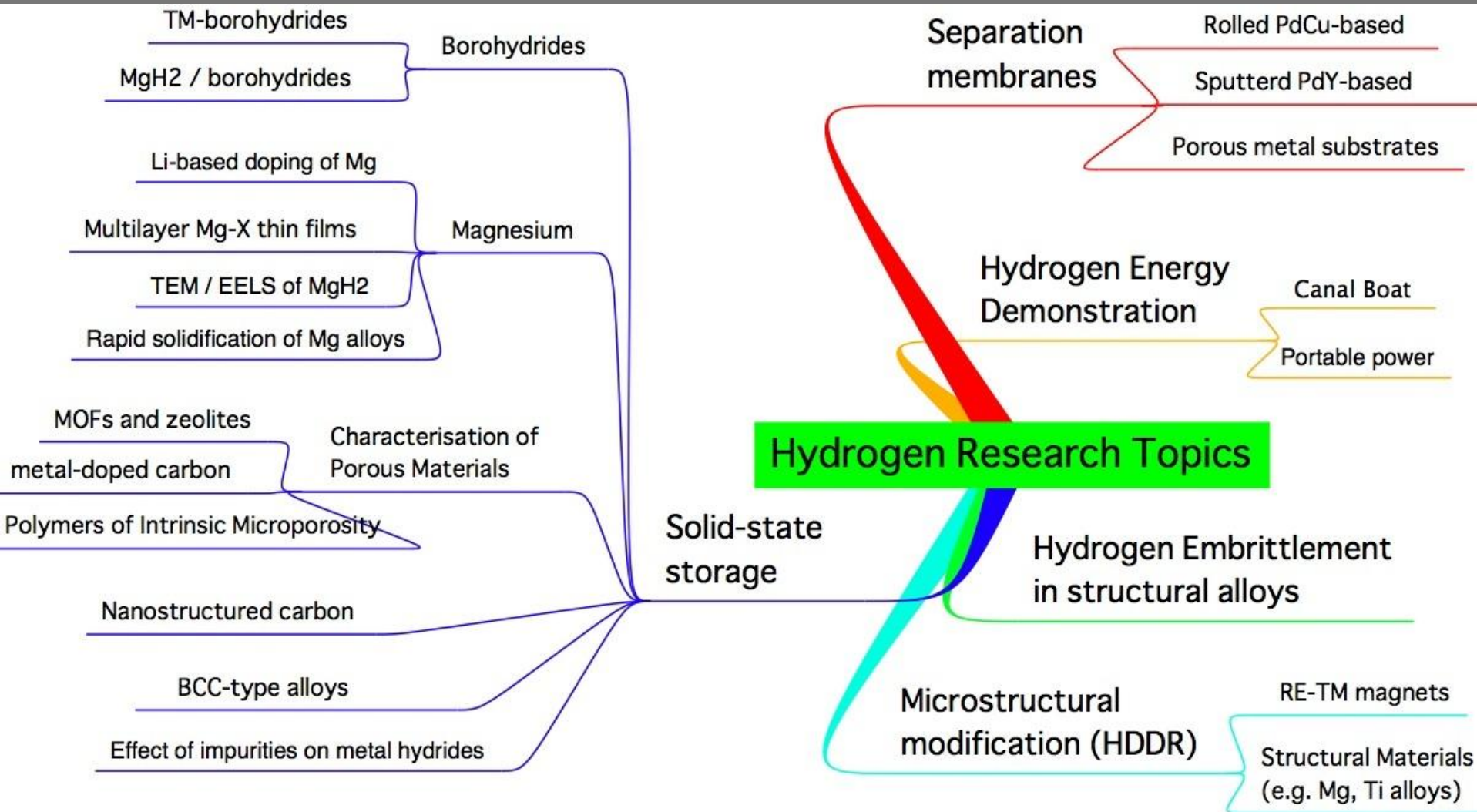
Hydrogen Materials Group

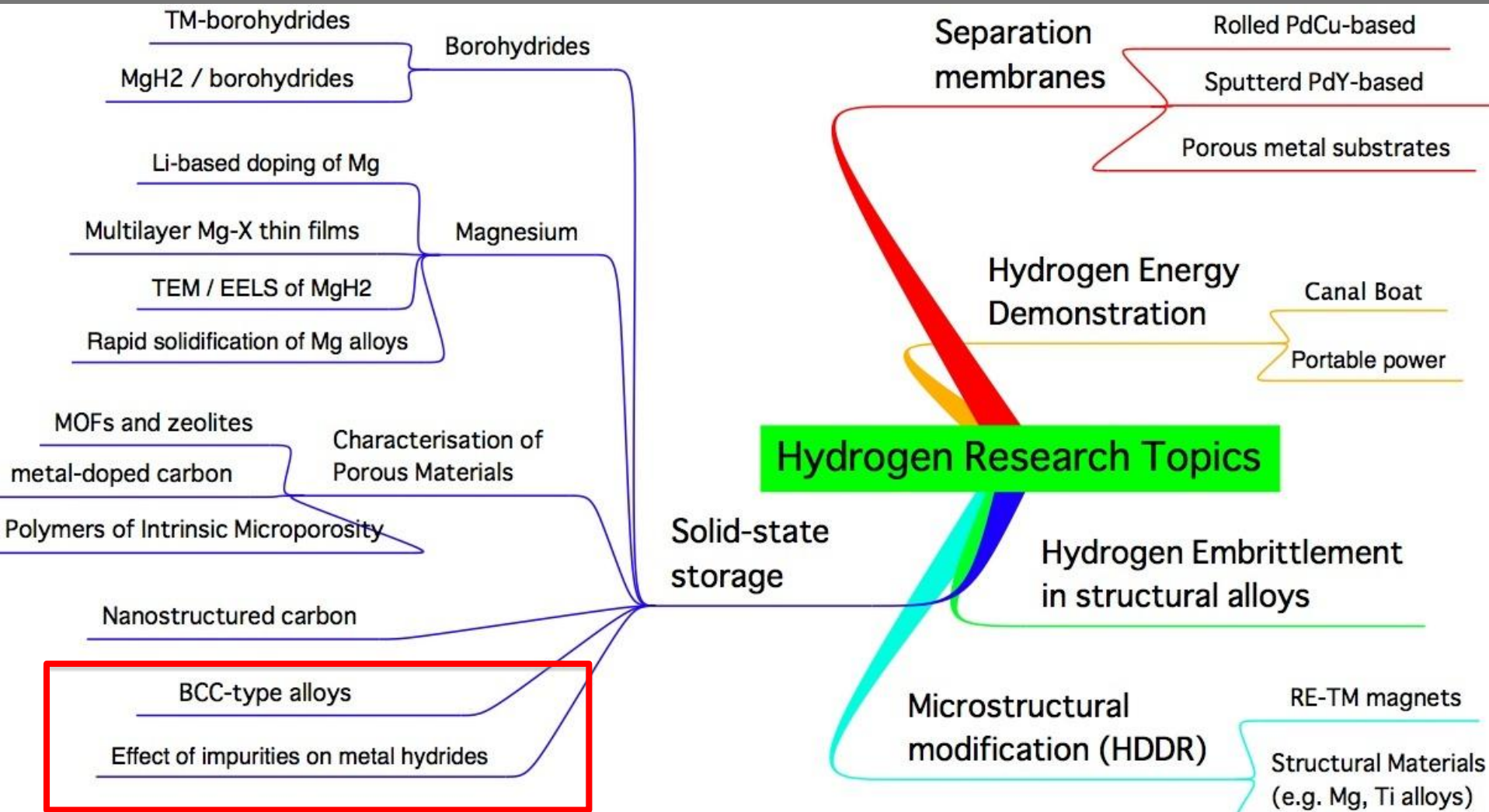
Dr David Book, Professor Rex Harris, Dr John Speight, Dr Allan Walton,
Dr Vicky Mann, Dr Alex Bevan, Dan Reed, Sean Fletcher

PhD/EngD: Rob Bell, Steven Tedds, Yinghe Zhang, David Brampton,
Dr Ruixi Liu, Xiaodong Yi

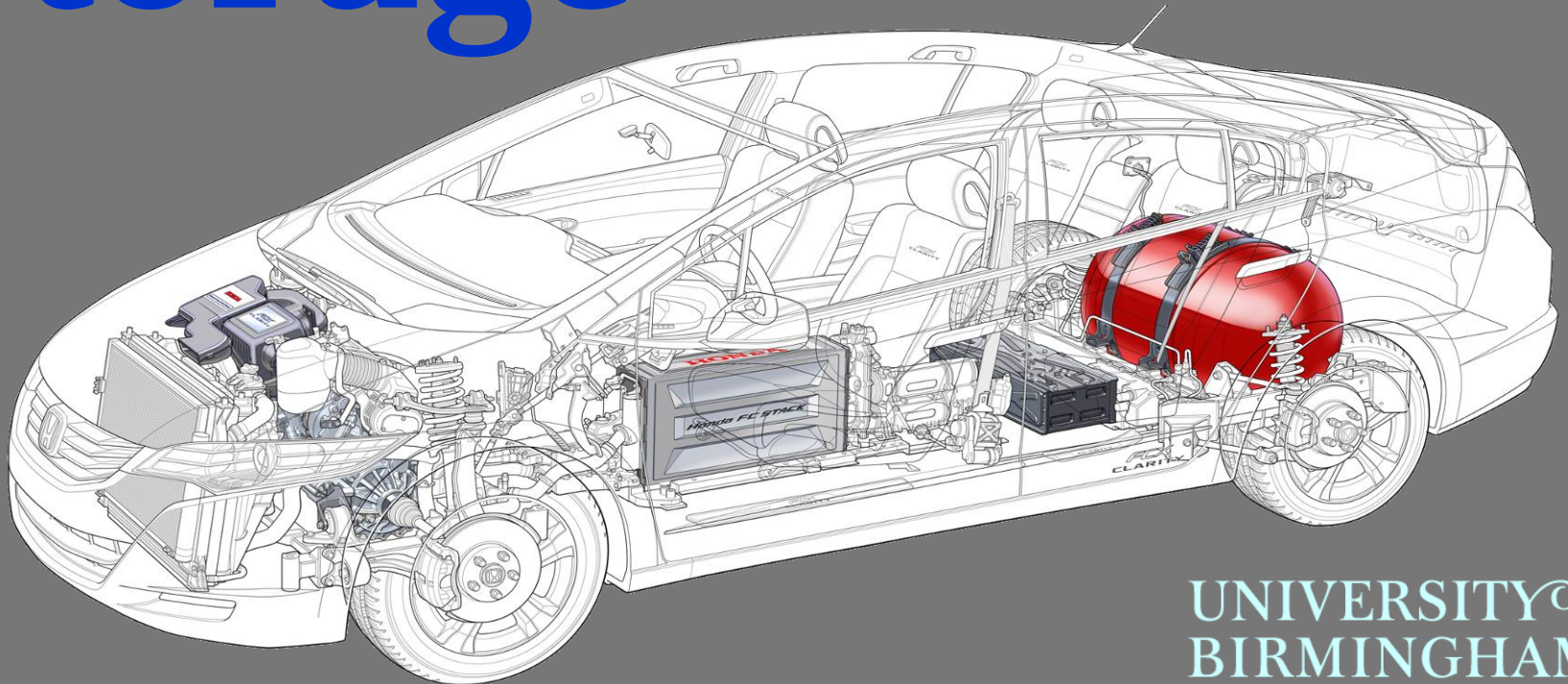
MRes: Dan Amos, Lydia Pickering, James Warren, George Simpson,
Peter Abell, Zhuo Wang

Technician: Simon Cannon





Hydrogen Storage

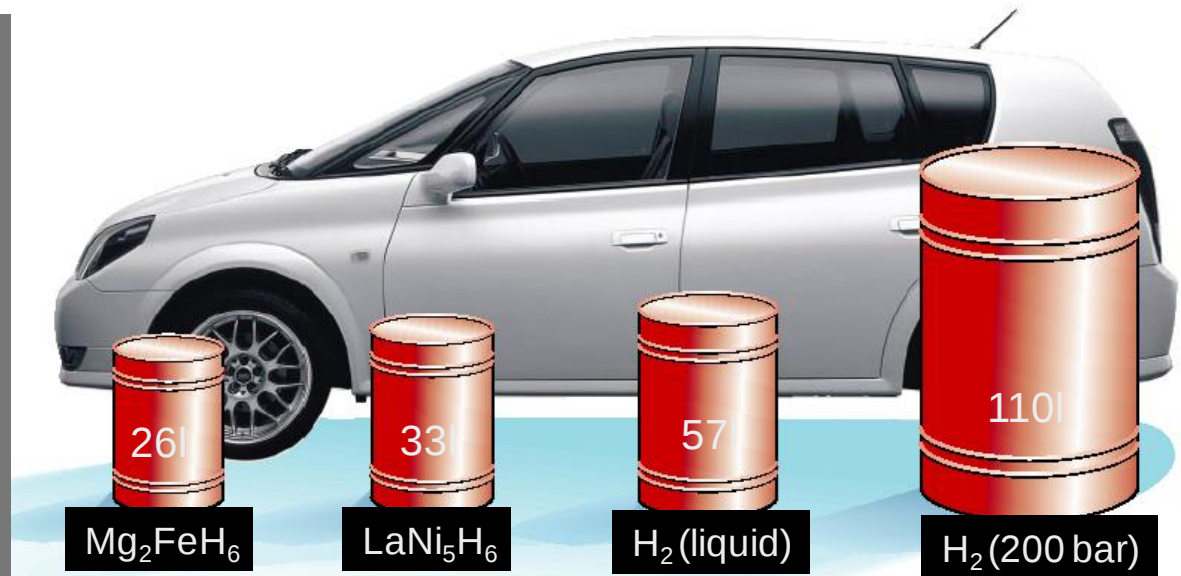


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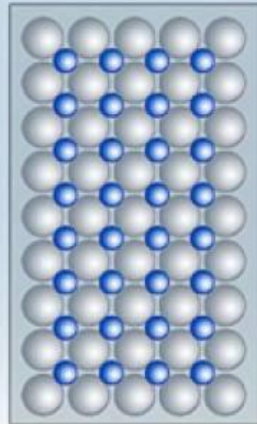
Solid-state Hydrogen Storage

4 kg hydrogen

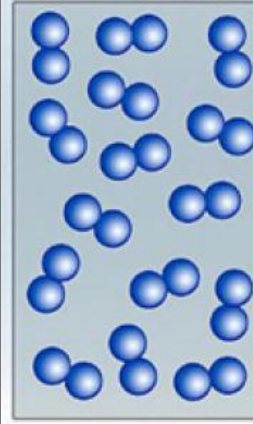
Louis Schlapbach &
Andreas Züttel,
NATURE, 414, p.353,
(2001)



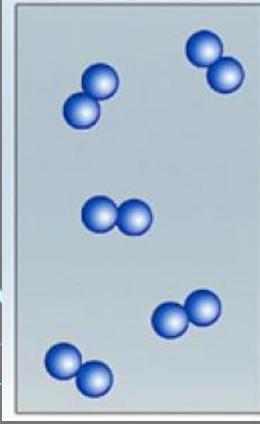
0.21 nm Westla
 10.7×10^{22}
atoms cm^{-3}



0.36 nm
 4.2×10^{22}
atoms cm^{-3}



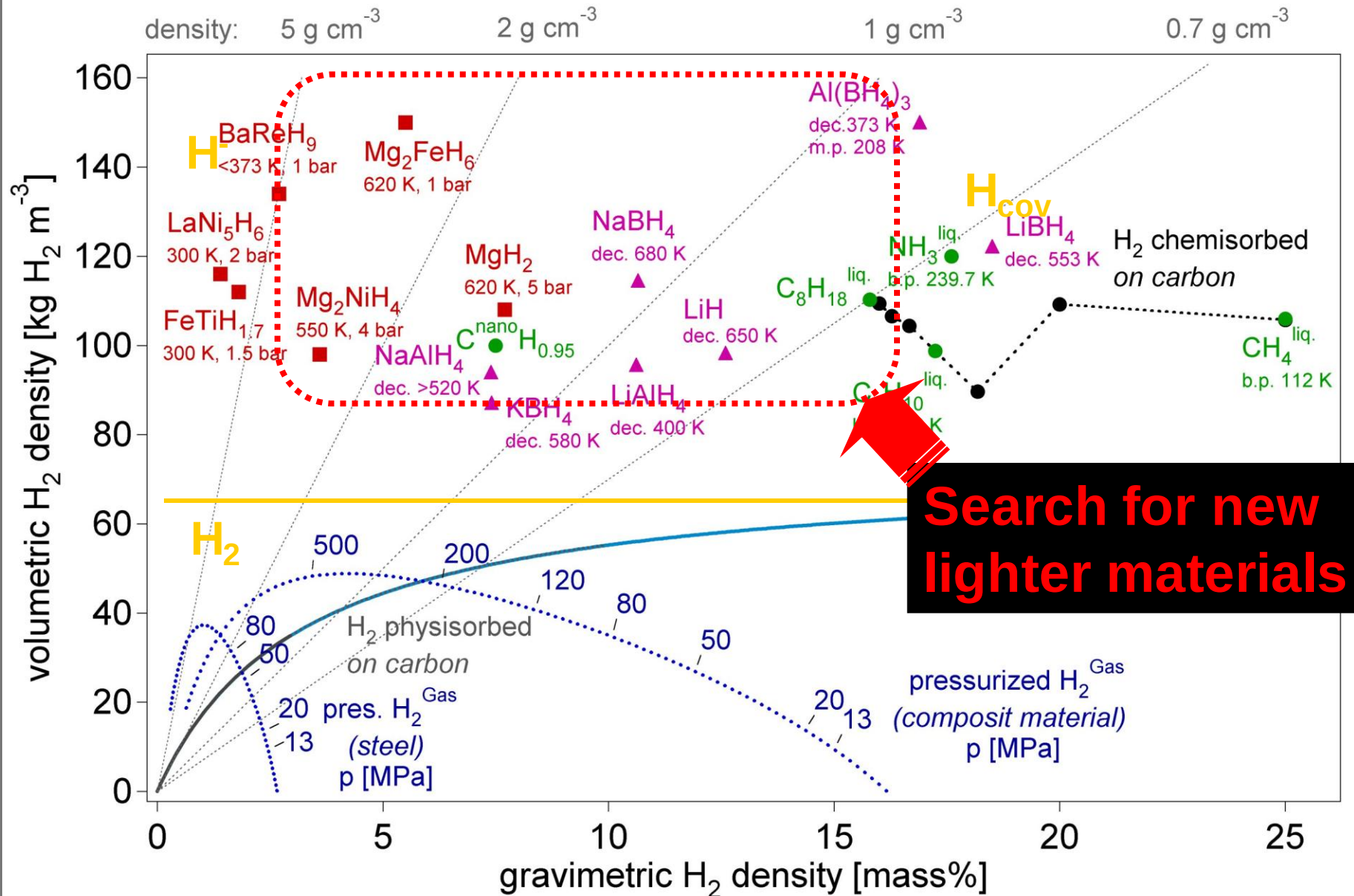
0.54 nm
 1.3×10^{22}
atoms cm^{-3}



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Hydrogen Storage Densities



The Protium Project

PEM Fuel Cell

Batteries & Motor

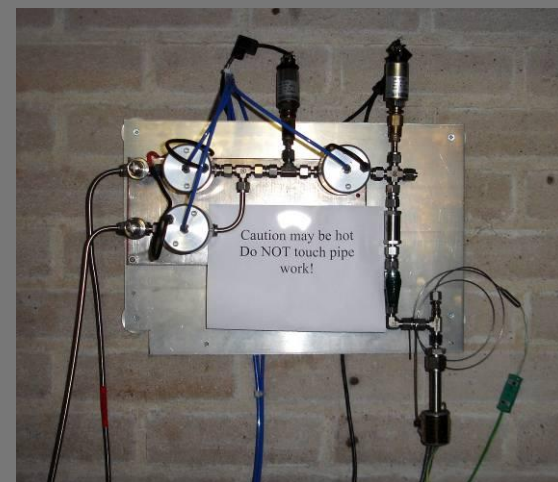
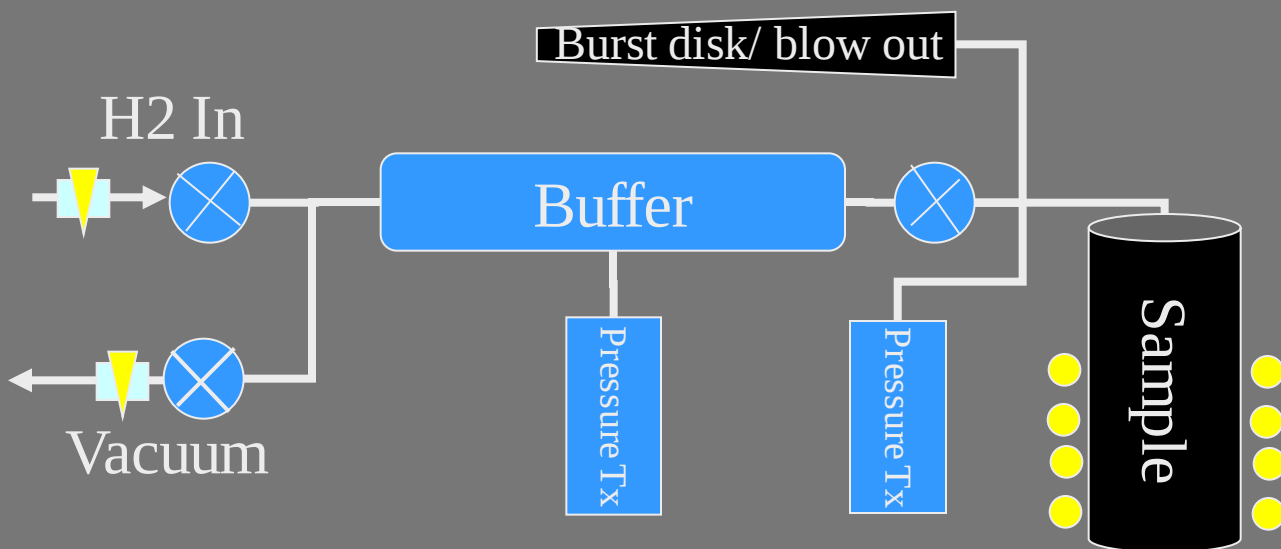
- 5 large cylinders, each containing 30 kg of metal hydride power.
- Gives about 2.5 kg of hydrogen.
- Operating pressure is < 10 bar





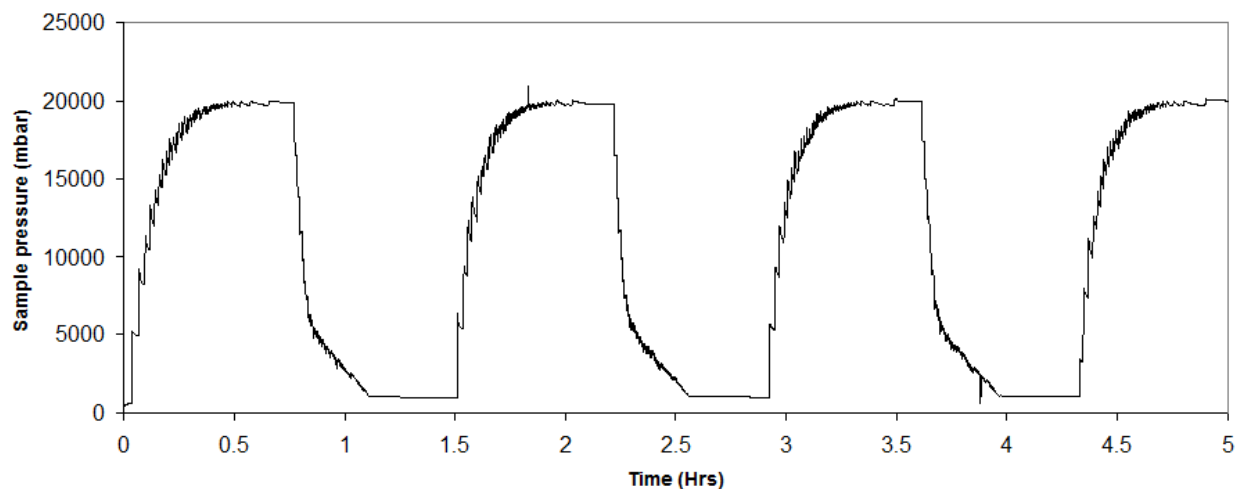
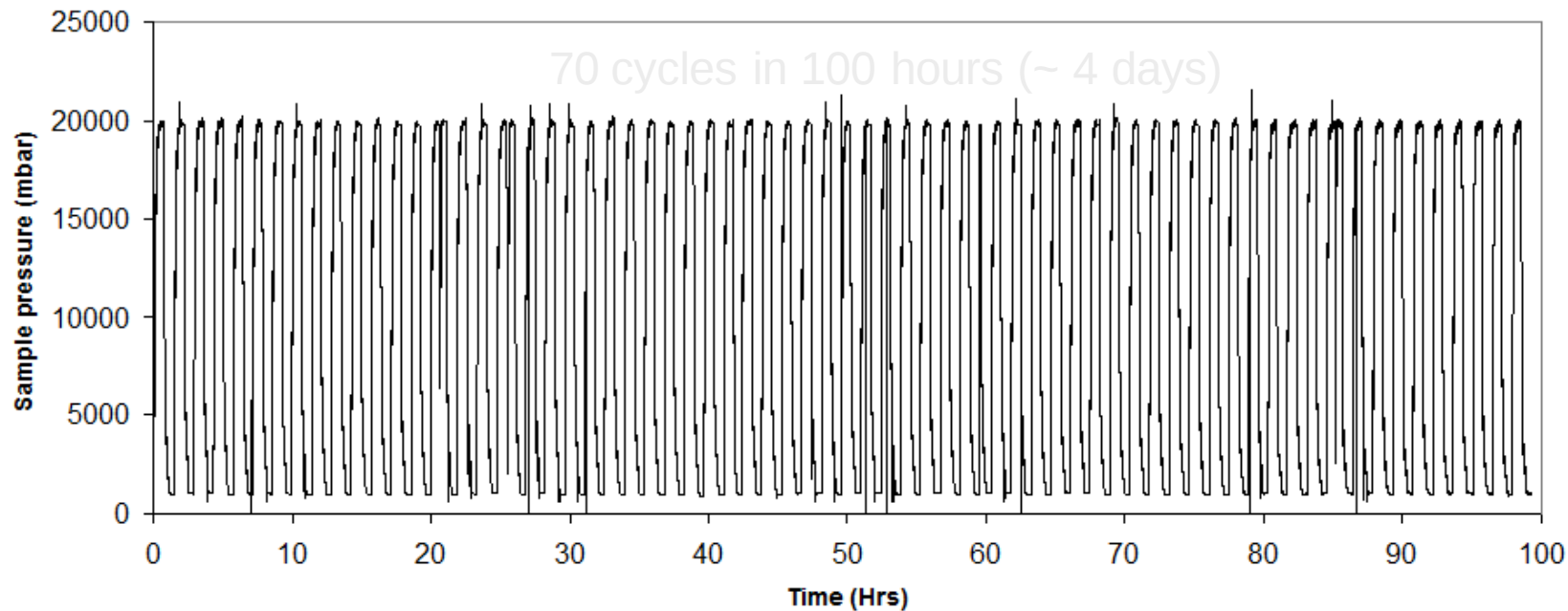
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Effect(s) of cycling and presence of impurity gases (EPSRC SCRATCH project)



Metal hydride store cycling system

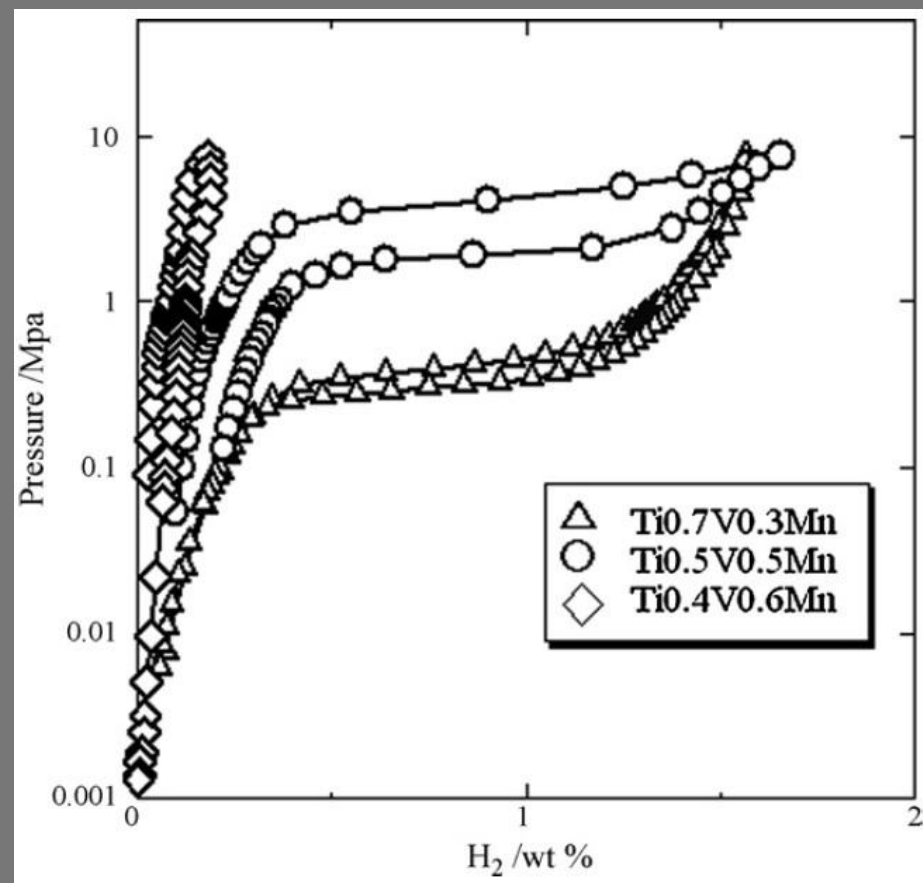
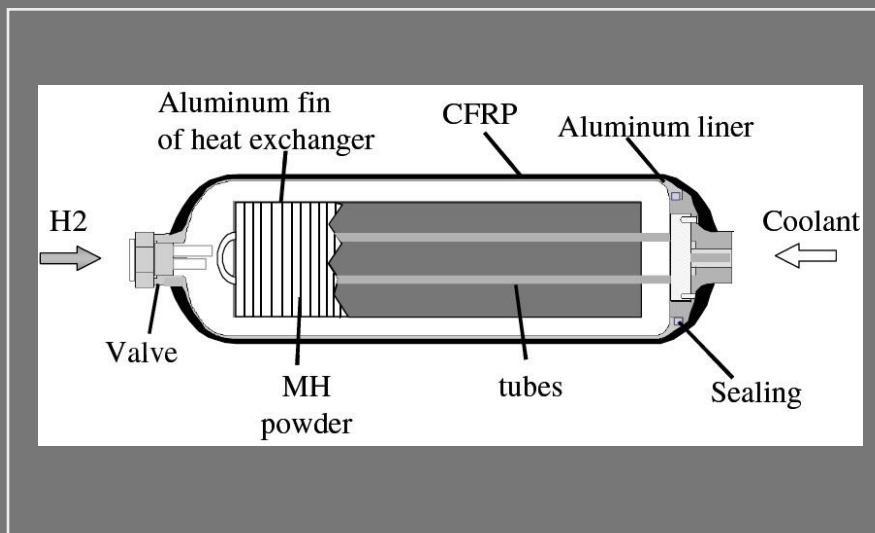
Cycling of $\text{Ti}_{0.93}\text{Zr}_{0.05}(\text{Mn}_{0.73}\text{V}_{0.22}\text{Fe}_{0.04})_2$



1000 cycles
would take
~60 days
(for this
alloy)

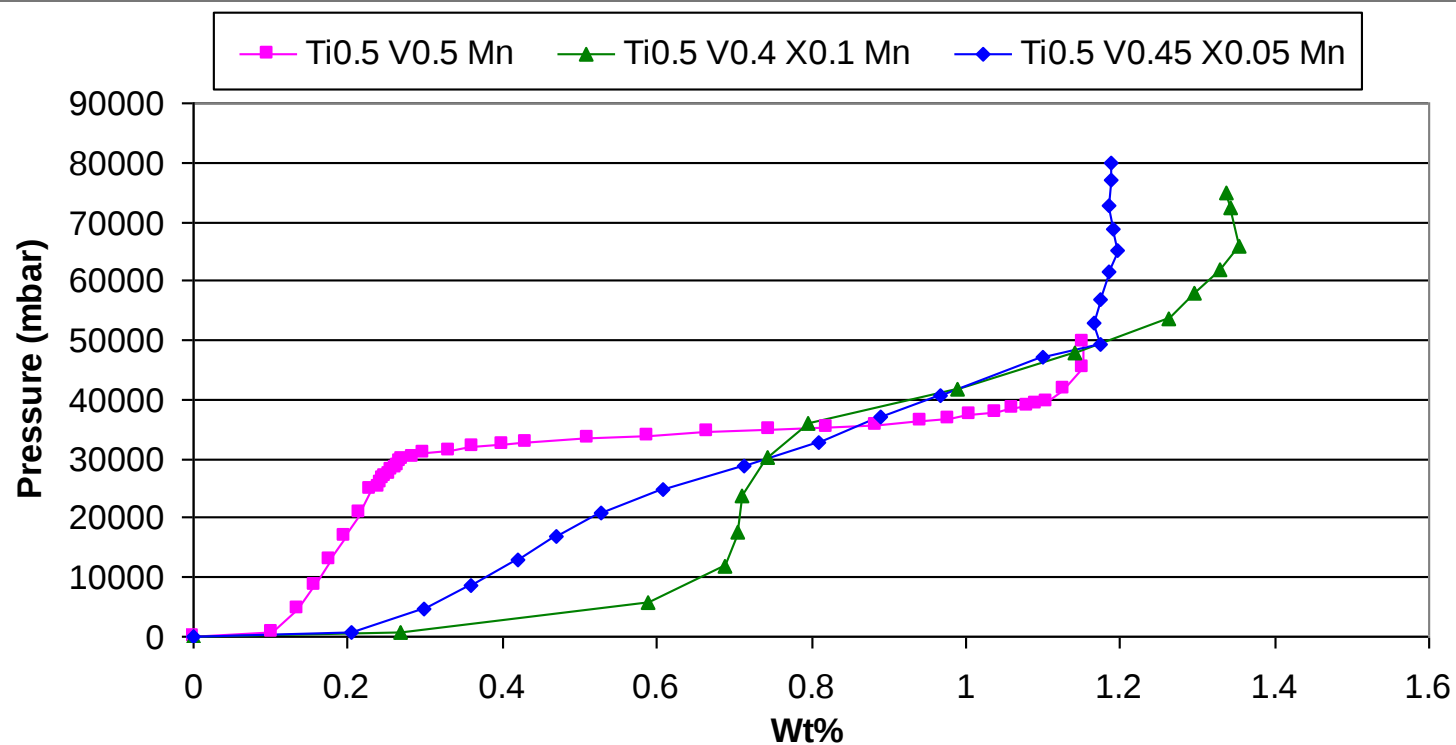
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New Metal Hydrides for Hybrid “High-Pressure / Hydride” Stores

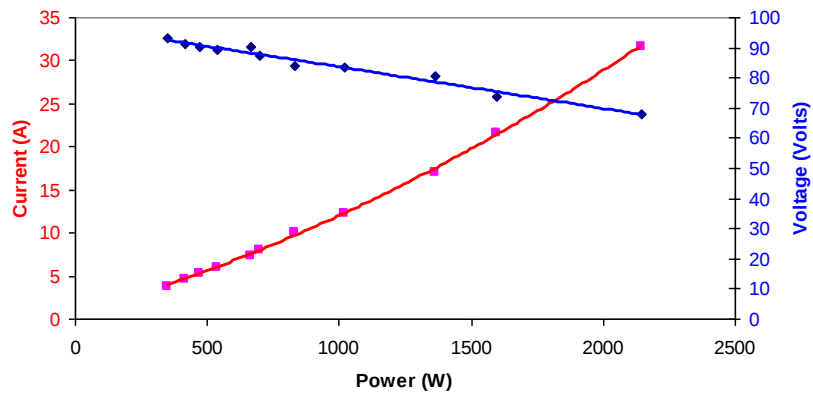
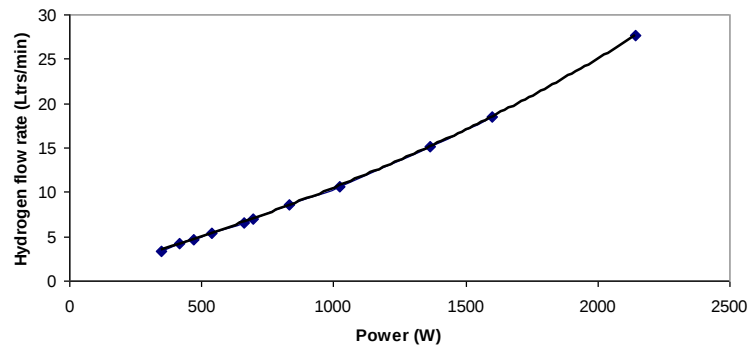


PCT curves of the Ti(1-x)V_xMn alloys at 293 K.

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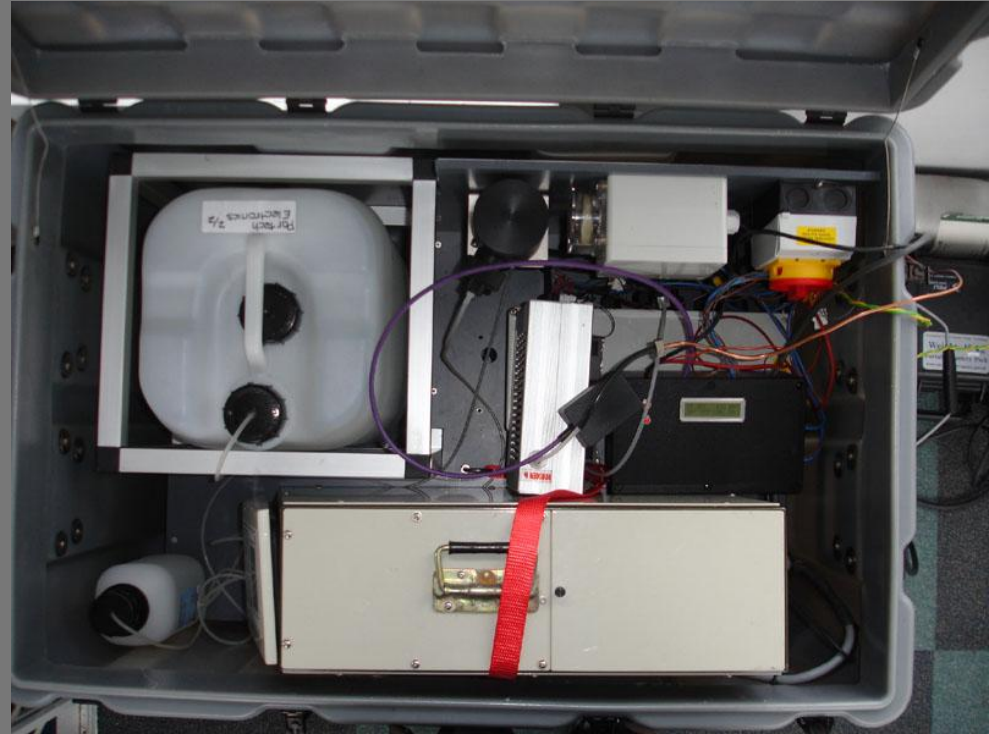


Other activities



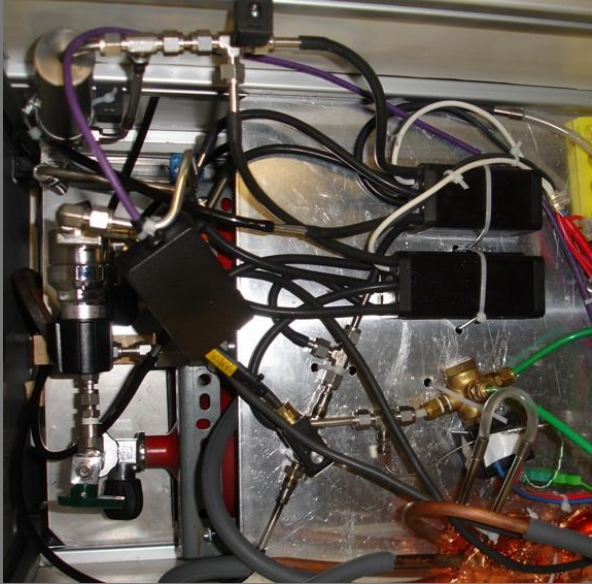
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Uninterruptible/ Power Supplies



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Hydrogen reggae



26th February 2009

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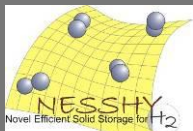
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Thank you for your attention

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Research Projects & Networks



EC FP6 “*Novel Efficient Solid Storage for Hydrogen*” (Jan 06 - Dec 10)
(inc. Daimler, JM, Air Liquide, Max Planck, CNRS, NCSR, EMPA, Delft,...)



EPSRC SUPERGEN “*UK Sustainable Hydrogen Energy Consortium*” (Apr 03 - Apr 11)
(inc. Bham-Chem, Nott-Mat, Nott-Chem, UCL, Oxford, STFC, Bath, Glasgow, Salford)



EPSRC SUPERGEN “*Delivery of Sustainable Hydrogen*” (Oct 08 - Oct 12)
(inc. St Andrews, Leeds, Warwick, Imperial, Cambridge, Manchester, Cardiff Uni's)



“*Polymer-based Hydrogen Storage Materials*” (July 06 - July 10)
with Cardiff Uni (Neil McKeown), Manchester Uni (Peter Budd)



“Supply Chain Research Applied To Clean Hydrogen (SCRATCH)” (Apr 07 - Apr 10)
ChemEng (Kevin Kendall), Biosci (Lynne Macaskie), ECON (Richard Green), Met&Mat (David Book)



Department for Business, Enterprise and Regulatory Reform / TSB (Dec 06 - May 09)
“*Hydrogen Permeable Novel Membranes*” (HYPNOMEM)



AWM Science City “Hydrogen Energy Project” (April 07 - March 09)
£6.3M for equipment for Birmingham and Warwick Universities



International Energy Agency Task 22 (2002-06, 2006-10, ...)
“*Fundamental and applied hydrogen storage materials development*”



“*UK-Japan Hydrogen Storage Research Network*” (Apr 07 - May 09)
Workshops for Universities / National Labs in the UK & Japan



DIUS / FCO “*UK/KOREA Focal Point Programme for H2 Storage*” (Apr 07 - Apr 09)
Workshops for Universities in the UK & Korea

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