BOR4STORE: Fast, Reliable and Cost effective Boron Hydride based high capacity Solid state Hydrogen Storage Materials

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General

- **Project funded by the European "Fuel Cells and Hydrogen Joint Undertaking"**

→Total Budget 4.07 Mio.€, total funding 2.3 Mio. €.

→Runtime April 2012 to March 2015

→3 Industry partners, 6 Research Institutes

→ Integrated approach for development and testing of novel, optimised and cost-efficient boron hydride based hydrogen storage materials with superior performance (materials capacity more than 8 wt.% and 80 kg H_2/m^3) for specific fuel cell applications.

Approach

BOR4STORE aspires to tackle the S&T challenges that still hinder the practical use of the extremely attractive boron hydrides. The technical objectives of the project reflect an innovative and carefully designed strategy involving

(a) new methods for the synthesis and modification of stable and unstable boron hydrides, as well as their combinations resulting in Reactive Hydride Composites and eutectic mixtures,

(b) systematic and rationalised investigation of the effect of special catalysts and additives, and

(c) adaptation of scaffolding concepts.

Selected results after 1st year

Eutectically Melting Composites: effect of scaffolding on Li- and Ca-Borohydride mixture

Aarhus University

EMC melts around 200 °C

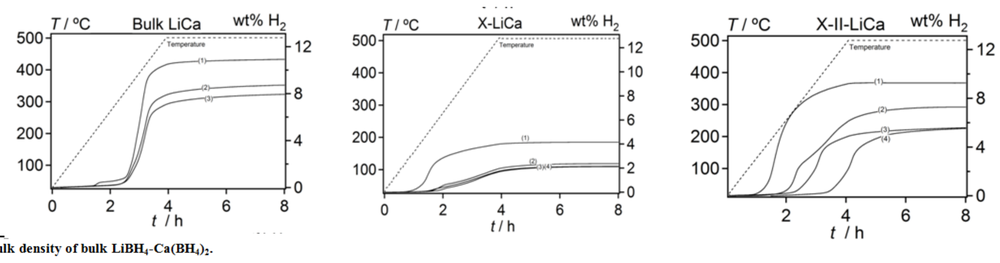
Melt infiltration RT-210 °C, $p(H_2)$ = 110-150 bar

Dehydrogenation: RT - 500 °C, $p(H_2) = 10^{-2}$ bar

Rehydrogenation: RT – 400 °C, 10 h, $p(H_2)$ = 180 bar

Sample	LiCa (wt %)	LiCa (Vol %
X-LiCa	67.0	70.0
X-I-LiCa	52.7	59.9
X-II-LiCa	63.6	60.0

*Calculated using V_{tot} and the bulk density of bulk $LiBH_4$-$Ca(BH_4)_2$.



more: 1.18 Payam Javadian, „Scandium Functionalized Carbon Aerogels for Hydrogen Storage"

Decrease of materials cost ⇒ Recycling of waste materials

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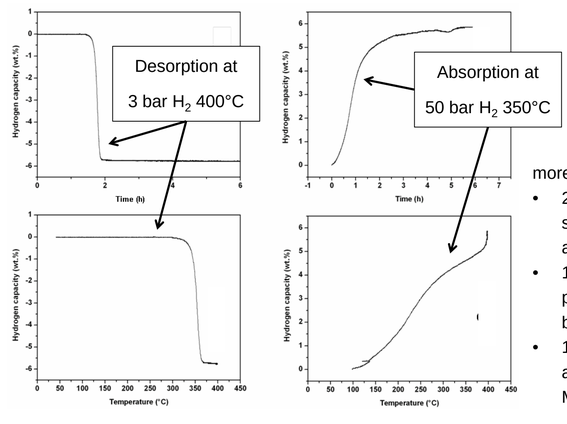
A) As received from turning
B) Milled
C) H_2 charged

Mg + 10 wt.% Gd ⇒ MgH_2 + GdH_2 mixture



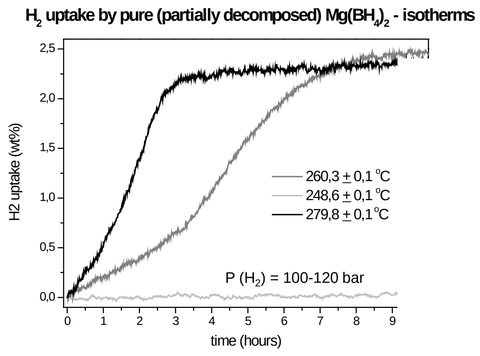
more:

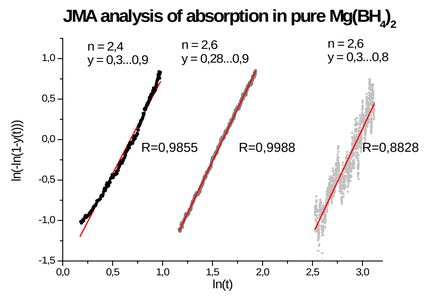
- 2.38 C. Pistidda, „Production of H_2 storage materials from waste Mg alloys"
- 1.46 N. Bergemann, „$NaAlH_4$ production from waste aluminum by reactive ball milling"
- 1.32 M. Dornheim, "Development and Characterization of Novel Materials for Hydrogen Storage"

$Mg(BH_4)_2$: rate limiting steps in reabsorption

IFE

H_2 absorption in partially decomposed $Mg(BH_4)_2$





Nucleation at a constant rate and diffusion-controlled growth (n = 5/2)

more: 2.21 Olena Zavorotynska, "Effect of additives on hydrogen sorption in $Mg(BH_4)_2$"

Simulation of combined SOFC – solid state hydrogen storage (SSHS) system

including thermo-chemical model of the MgH_2 storage material. External heating by exhaust gases, internal resistive heating plus interior fins

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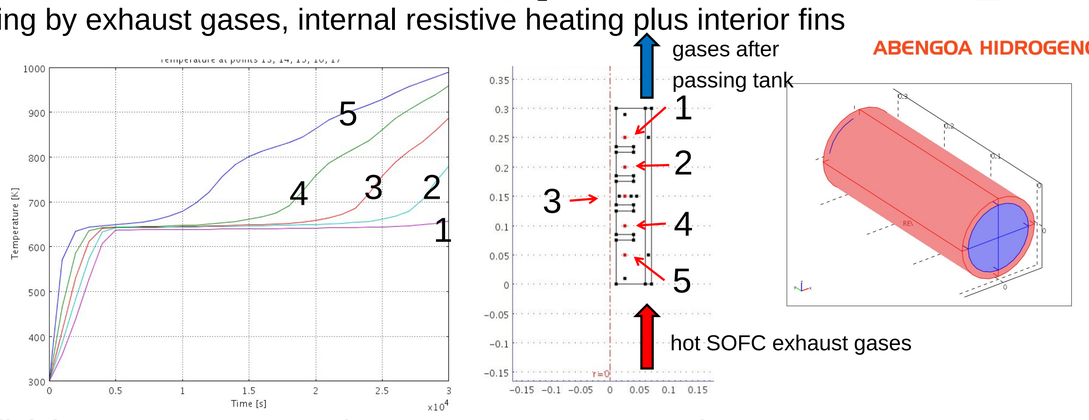


parallel flow of exhaust gases leads to inhomogenous unloading

internal heating necessary to achieve requested hydrogen flow

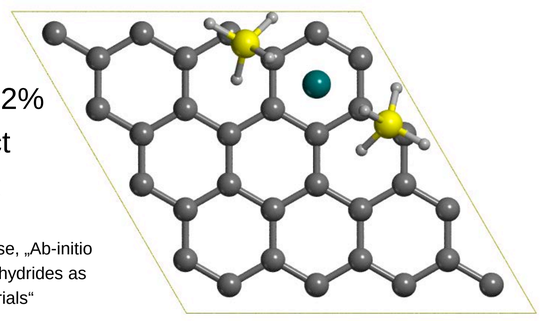
Modelling

Confinement

nanoconfinement of $Ca(BH_4)_2$ in carbon scaffold

⇒ simple model system containing a graphite monolayer and the smallest cluster of $Ca(BH_4)_2$

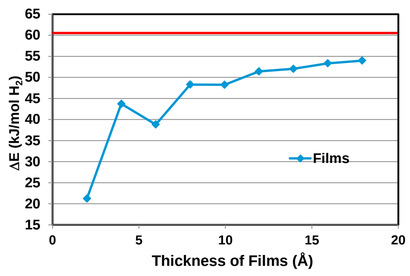
$B—H_{slab}$ + 1.2% with respect to the bulk



more: 2.1. Elisa Albanese, „Ab-initio modelling of metal borohydrides as hydrogen storage materials"

Nanostructure

$Ca(BH_4)_2 \longrightarrow CaH_2 + 2B + 3H_2$



The nano-structuring of $Ca(BH_4)_2$ in thin films decreases the decomposition enthalpy

First design draft of integrated SOFC – tank system

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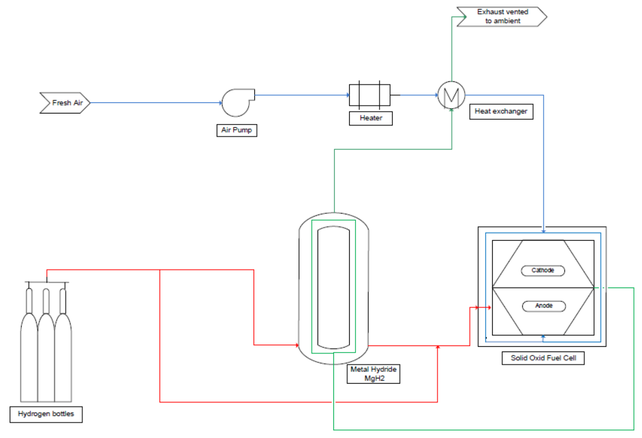

more:

- 1.7. J. M. Bellosta von Colbe, „Scale-up of Solid-State Hydrogen Storage Tanks"
- 1.35 J. Jepsen, „"Design and evaluation of a $LiBH_4$ - MgH_2 storage system"

Summary and further targets

Novel solid state hydrogen storage prototype system based on boron hydrides

→ System capacity > 40 kg H_2/m^3 , > 4 wt.% with priority on volumetric cap.
⇒ > 80 kg H_2/m^3, > 8 wt.% on materials level

→ Materials reaction enthalpies and kinetics of hydrogen loading and discharge suitable for typical load cycles of SOFC in net independent power supply

→ Cycling stability >98% of retained capacity over at least 500 loading-unloading cycles

Cost effective production route of the hydrogen storage material

→ Use of low purity raw materials

→ Demonstration of potential for scale-up of production and system cost of 500 €/kg of stored H_2

Laboratory prototype of SOFC integrated with hydrogen storage system

→ Model for a continuous power supply

→ Power in the range 0.1 – 1 kW ⇒ tank system ca. 100 - 1000 Nl

Compared to compressed gas storage and other fuel cell technologies, respectively

→Improved storage capacity

→Improved overall energy efficiency

→Decreased total cost of ownership

→ Indicator of allowable hydrogen purity for stable storage properties

Demonstration of

Techno-economical readiness of solid state hydrogen storage technology

http://www.bor4store.eu • Coordinator contact: klaus.taube@hzg.de

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