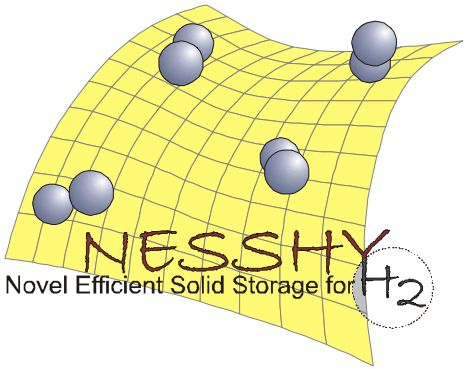
NESSHY

“Novel Efficient Solid Storage for Hydrogen”

Integrated Project SES6-CT-2006-518271



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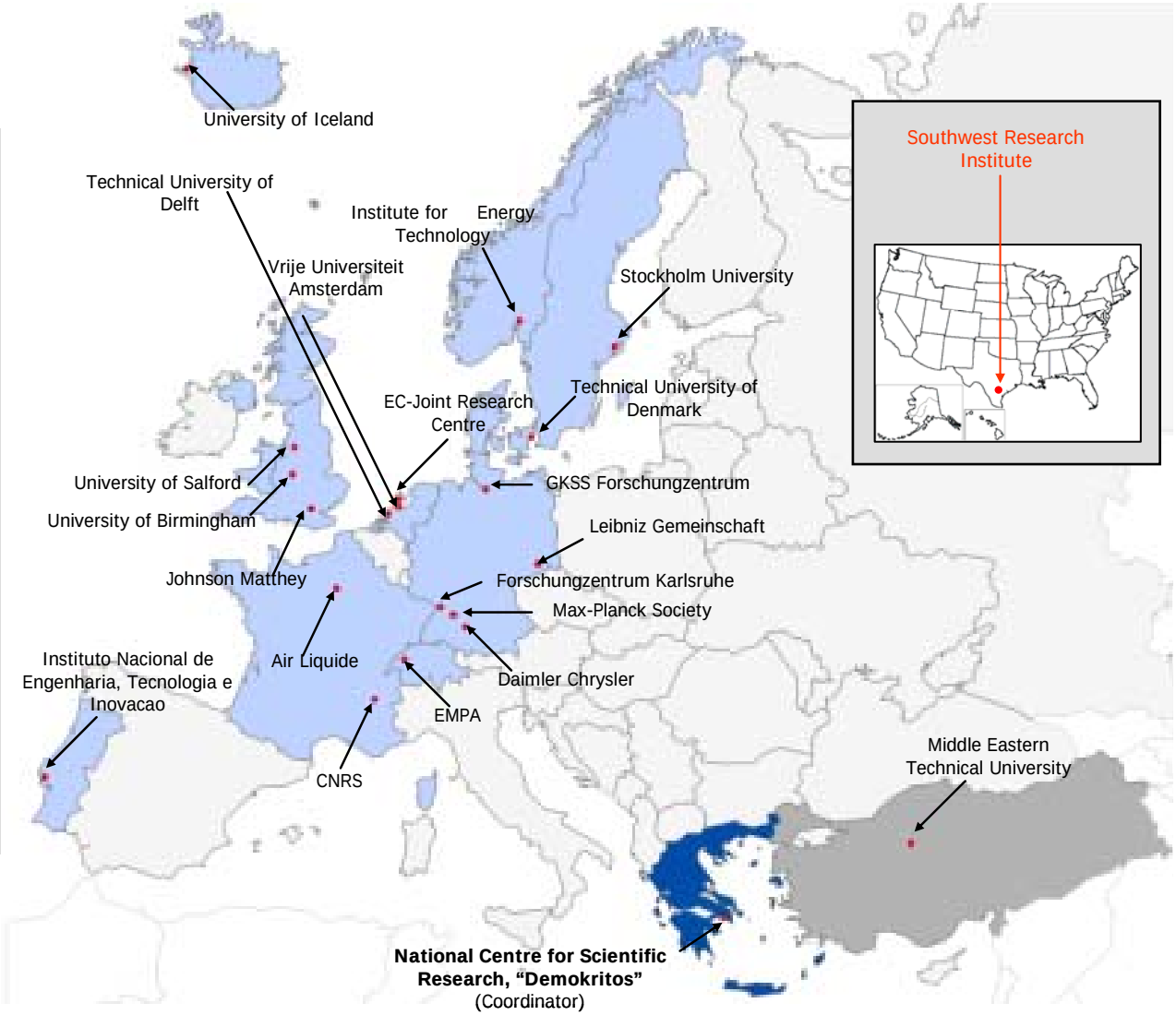
General facts

- **Co-ordinator: NCSR Demokritos (EL)**
- **Duration:1.1.2006 – 31.12.2010 (5 years)**
- **Budget: M€ 11.3**
- **EC contr.: M€ 7.5**
- **22 partners from 12 European countries and USA (1 OEM, 19 research institutes, 2 industrial companies)**

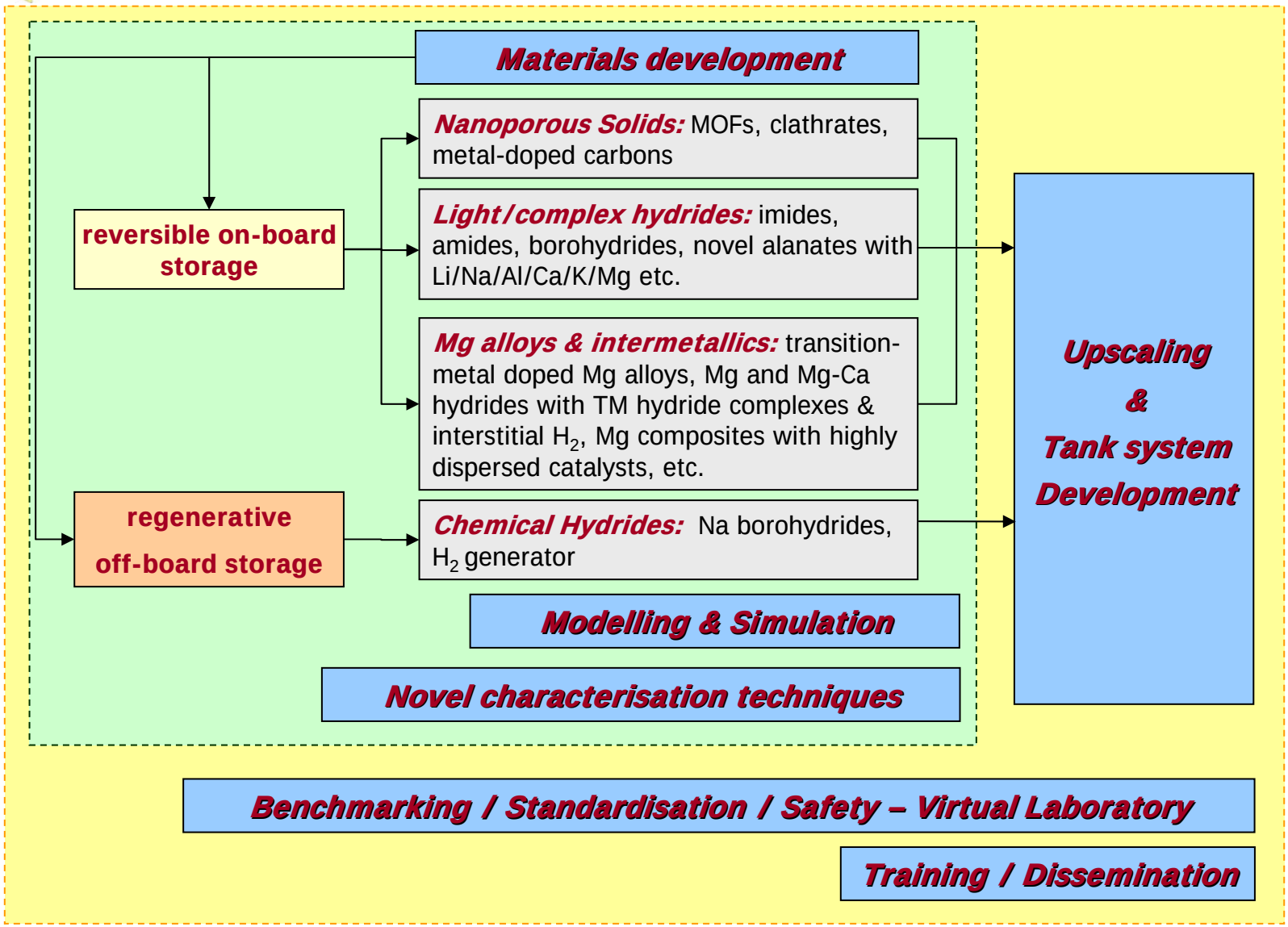


NESSHY vision

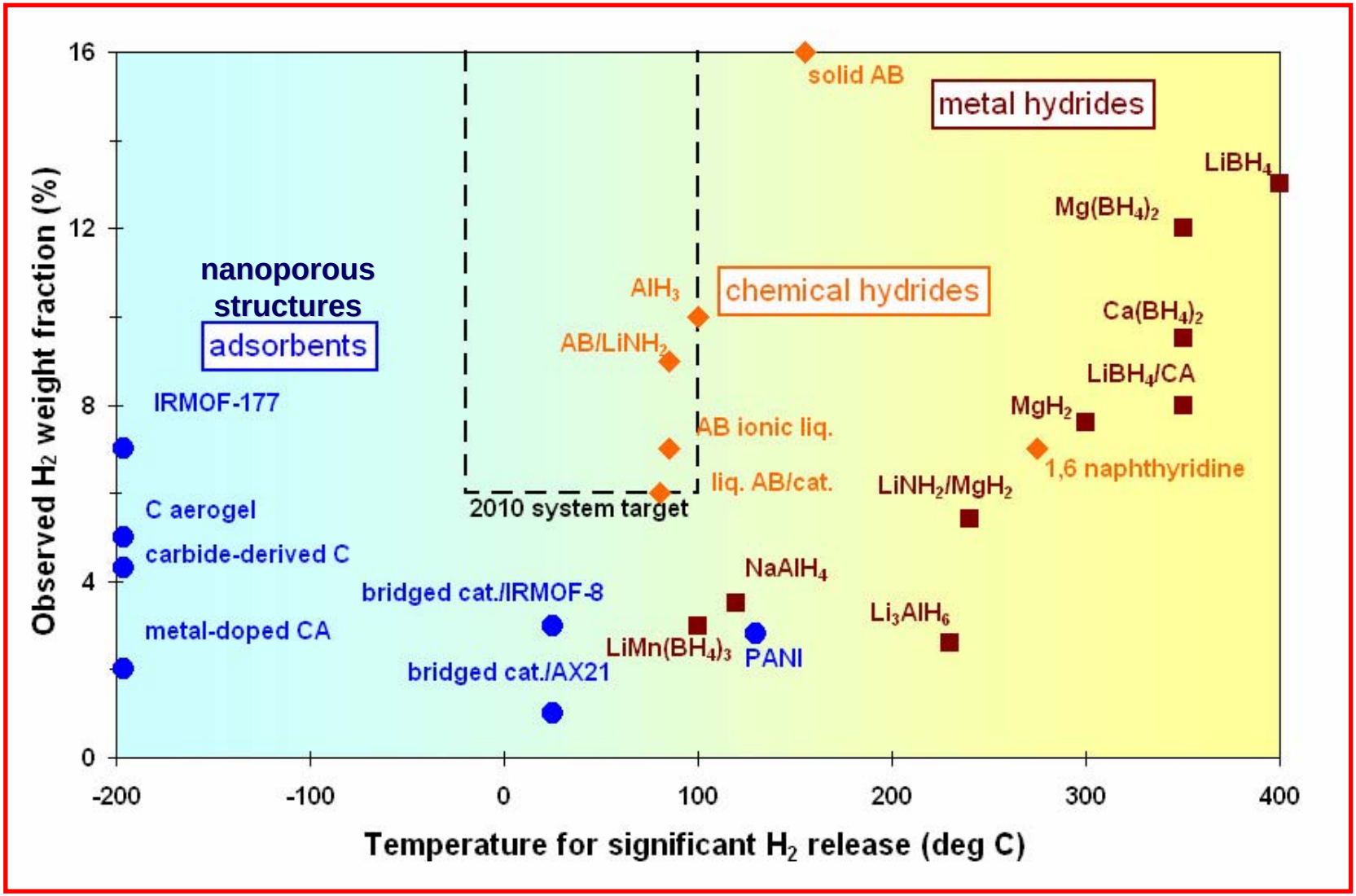
NESSHY aims at advancing the current state of hydrogen storage in solid materials, with respect to

- ✓ **novel materials**
- ✓ **enhanced understanding of the physical mechanisms involved**
- ✓ **novel analytical and characterisation tools and measurement techniques**
- ✓ **standardisation, testing protocols (virtual laboratory)**
- ✓ **advanced numerical methods for optimal material & storage design**
- ✓ **upscaling the production processes of promising materials**
- ✓ **design and testing of storage tank systems**

NESSHY workplan

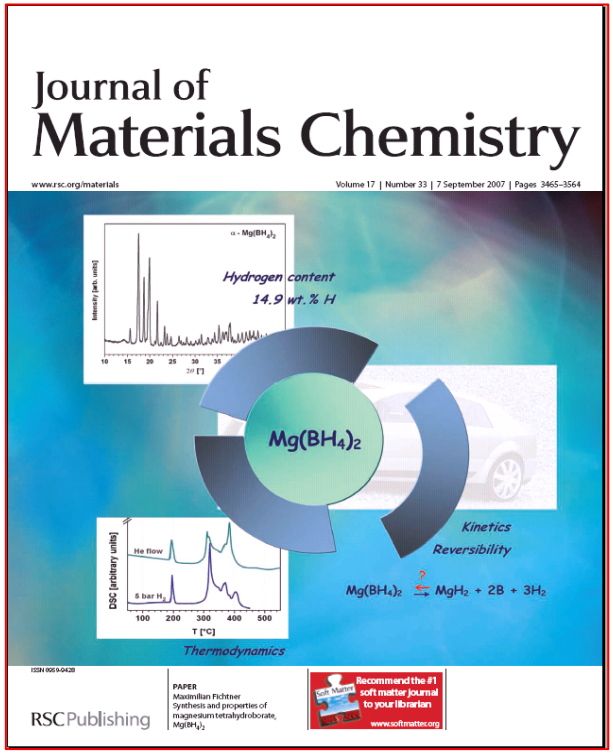


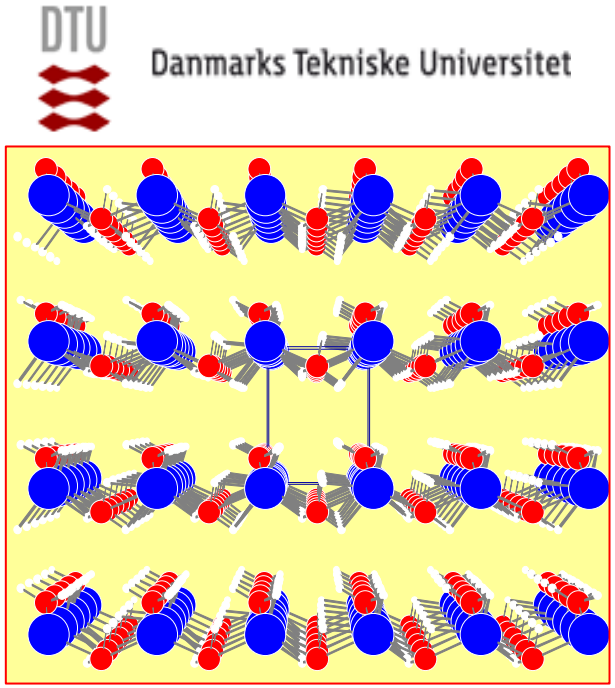
Materials State of the art



G. Thomas, et al., DOE (April 2007)

✓ **Novel synthesis of magnesium tetrahydroborate, $Mg(BH_4)_2$ → potential for H_2 storage (14.9 mass % H & suitable thermodynamic properties)**

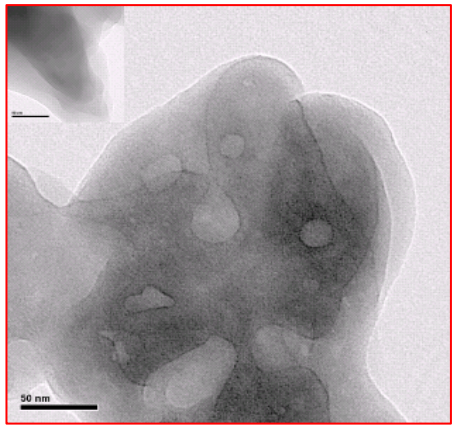


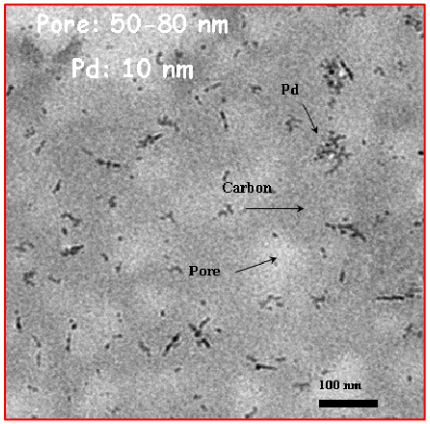


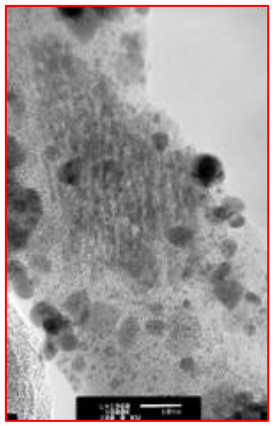
J. Mater. Chem., **17** (2007) 3496–3503

✓Metal-doped carbons:

- Synthesis of novel carbogenic foam with high surface spin concentration
- Synthesis of Pd/C foam nanocomposites to exploit the “spillover effect” → H_2 uptake: >2 wt % at 298 K
- Synthesis of Pd-alloy/C foam nanocomposites → Enhanced H_2 uptake at 298 K (verified also by JRC and SwRI)



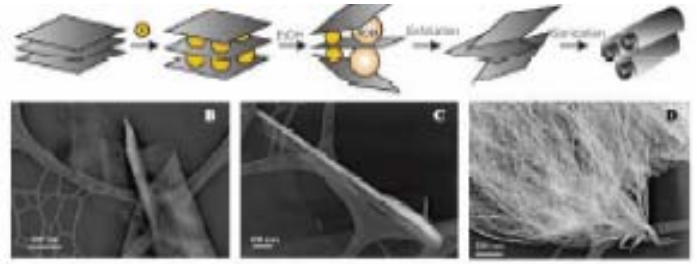




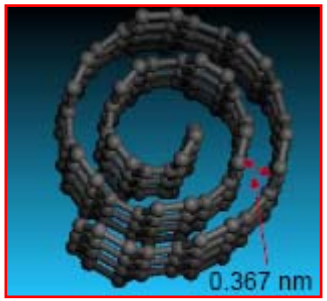
Carbon, **45** (2007) 852-857

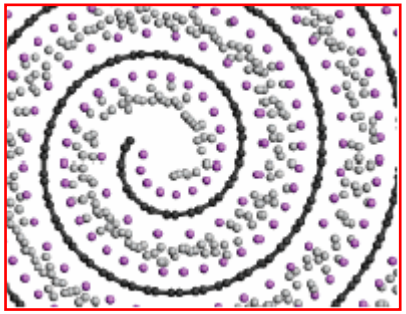
✓Metal-doped carbons (simulation):

- theoretical studies of Li-intercalated nanoscrolls → GCMC calculations predict H_2 uptake ~ 4 wt % at 293 K



Viculis et al., Science, 299 (2003), 1361





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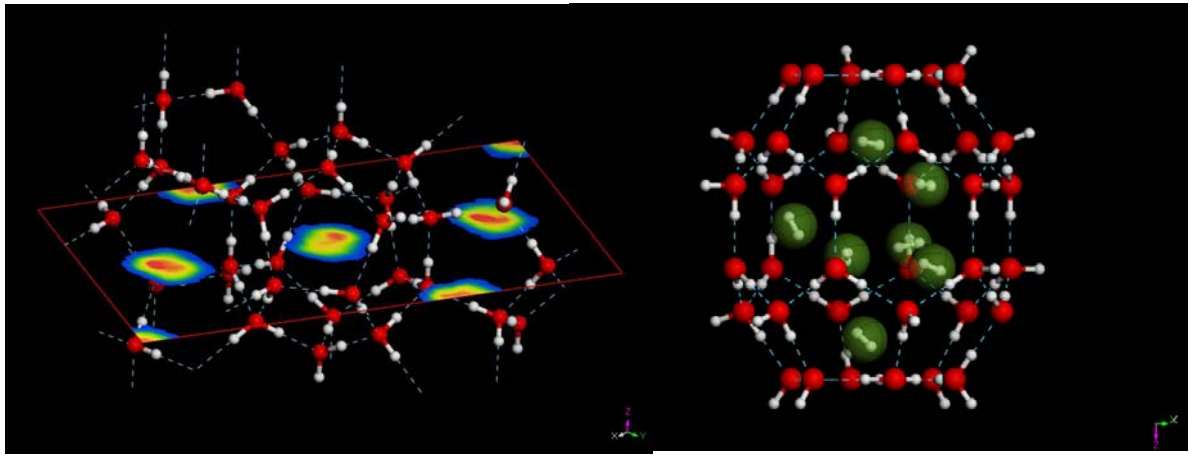
Nano Letters, **7** (2007) 1893-1897

✓Hydrogen clathrates:

- Simulations suggest that H_2-THF sII clathrates cannot store more than 1.1 wt% H_2 at pressures up to 1200 bar and close-to-ambient temperatures
- For the first time, H_2 hydrates with the sH structure have been synthesized (TUD). Estimated H_2 storage capacity → 1.4%
- Simulations (NCSRD), suggest that if a promoter can stabilize the “medium” cavity, up to 7 H_2 molecules can be stored in the “large” cavity → H_2 content up to 4 wt%

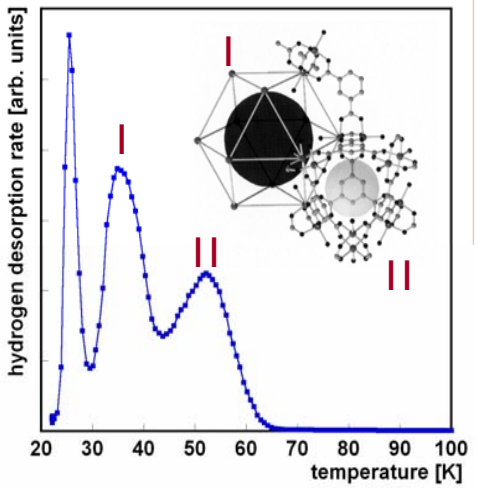


J. Phys. Chem. B, 112 (2008), 1888 -1889

✓MOFs:

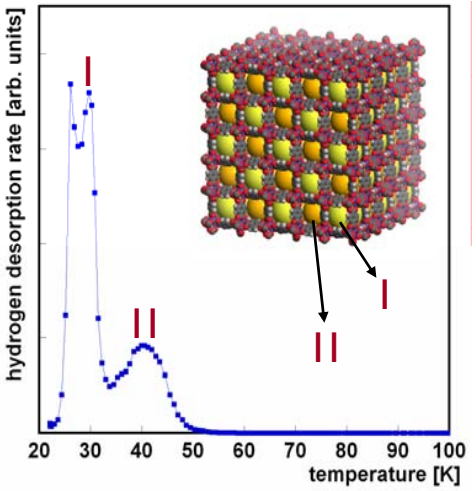
- Low temperature (from 20 K) thermal desorption spectroscopy measurements revealed adsorption sites → strongest adsorption in small pores

Cu-BTC



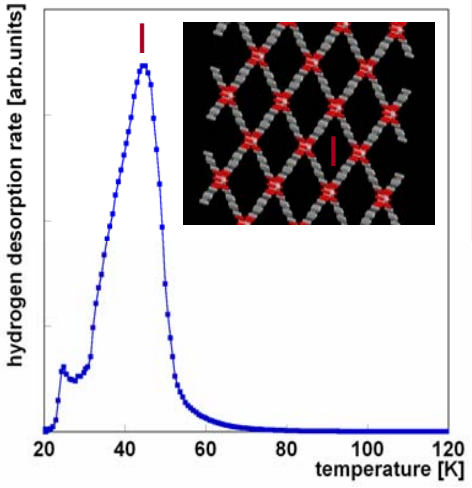
Picture from Krawiec et al. *Adv. Eng. Mater*. **8** (2006) 293

MOF-5



Picture kindly provided by J. Rowsell

MIL-53



Angew. Chem. Int. Ed., **47 (**2008), 2138-2142

✓Tanks:

- Large scale production of Mg based hydrides and development of storage tanks (2 kg of material available)
- 10 kg tank under development

Equal-channel angular processing (ECAP)

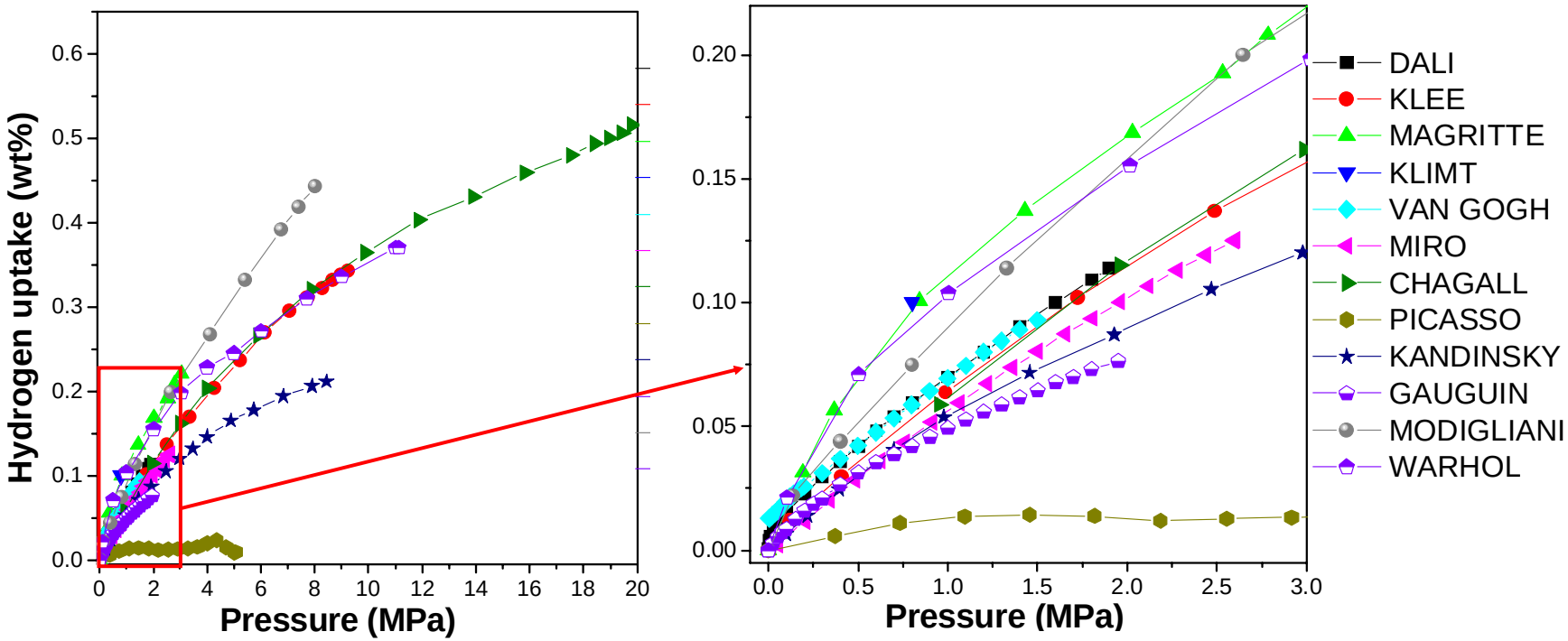
Industrial scale Milling

Helmet torch powered by Mg tank

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

✓Organisation of the first Round Robin Test in Europe:

- Physisorption @ 77K (commercial Carbon Molecular Sieve) - Completed
- Complex hydride (already started) & Mg-based materials (starting soon)
- In collaboration with SwRI/DoE and external (EU & non EU) organisations
- Analysis in progress



EUROPEAN COMMISSION JRC ie Institute for Energy

NESSHY Training & Dissemination activities

- **www.nesshy.net**
- IPHE recognition (September 2006)
- Interaction with other hydrogen related projects (HYTRAIN, COSY, HYDROGEN RTNs, SURMOF, MOFCAT, HYCONES)
- Two training and dissemination events with wide multi-national participation have been supported up to now by NESSHY
  - Hydrogen Summer School, University of Iceland - Reykjavik (June 2006)
  - One day Magnesium Titanium Hydride workshop, Vrije Universiteit - Amsterdam (August 2006)
- NESSHY Newsletter
- Establishment of collaboration with Chinese and Russian organisations → Specific Support Action HYSIC
- More than 50 papers in journals/conferences in the 1st year of the project

Enhancing Cooperation

Collaboration with other FP6 projects

	Project Acronym	Coordinator	Topic
Energy Priority	**STORHY** www.storhy.net 2004 – 2008	Magna Steyr *Austria*	Next generation H_2 storage technologies (compressed gas, cryogenic liquid and solid materials*) with a focus on automotive applications *Na-alanate, mixed alanates, alane
NMP Priority	**HYCONES** www.hycones.eu 2006 – 2009	NCSR Demokritos *Greece*	Hydrogen storage in Carbon cones
	SURMOF www.ruhr-uni-bochum.de/pc1/SURMOF 2006 – 2009	Rhur University *Germany*	Anchoring of MOFs to surfaces
	MOFCAT www.sintef.no 2006 - 2011	SINTEF *Norway*	Functional MOFs as heterogeneous catalysts and adsorbents
Marie Curie Research Training Networks (RTN)	**HYTRAIN** www.hytrain.net 2005 - 2008	University of Salford *UK*	Mg-based hydrides, complex hydrides (e.g. alanates, borohydrides), novel light hydrides (e.g. Li nitrides, amides)
	COSY www.cosy-net.eu 2006 - 2009	GKSS *Germany*	Fundamental understanding of the sorption kinetics in reactive hydride composites
	HYDROGEN www.theorchem.leidenuniv.nl 2006 - 2009	Leiden University *The Netherlands*	Hydrogen storage in alanates, borohydrides, and new class of materials to store it in form of ammonia

Enhancing Cooperation
International Collaborations

➔ **IPHE** label (September 2006)

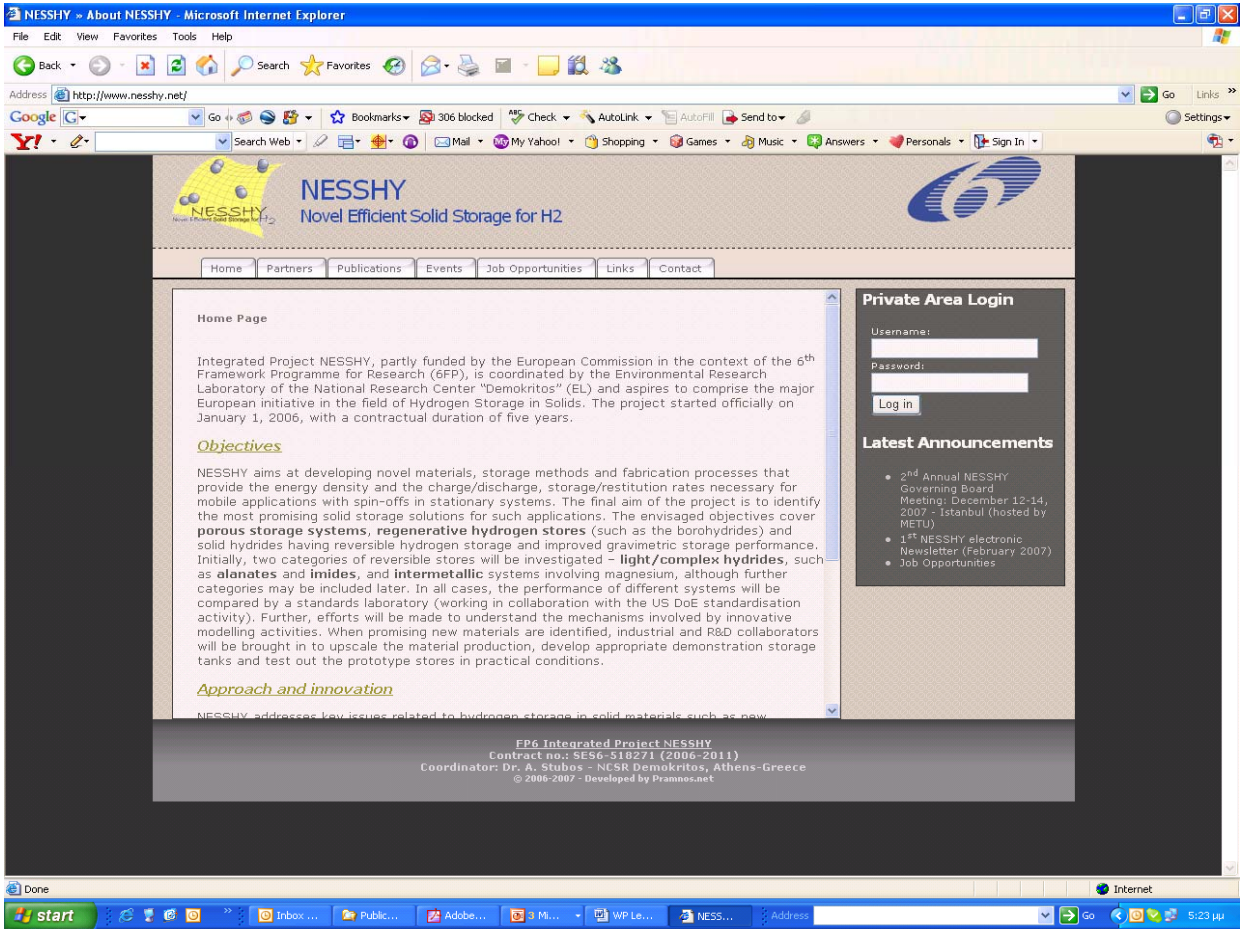
➔ Participation of **SwRI**, the American institute officially appointed by DoE for standardisation in H_2 solid storage measurements

➔ **HySIC**: "Enhancing International Cooperation in running FP6 Hydrogen Solid Storage Activities" Special Scientific Action linked to NESSHy (2007-2008)

- 8 partners from EU, Russian Federation,P. R. China and Lithuania
- Objectives:
  - *Performance of studies enhancing international cooperation (benchmarking, round-robin testing, testing protocol standardization)*
  - *Joint dissemination actions (workshops and integration activities)*

more information at

www.nesshy.net



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The NESSHY Team