PURPOSE

Task 32 addresses hydrogen-based energy storage by developing reversible or regenerative hydrogen storage materials. The goals and objectives in Task 32 are:

1. Develop reversible or regenerative hydrogen storage materials fulfilling the technical targets for mobile and stationary applications.
2. Develop the fundamental and engineering understanding of hydrogen storage materials and systems that have the capacity to fulfill target 1.
3. Develop materials and systems for hydrogen-based energy storage, including hydrogen storage for use in stationary, mobile and portable applications, and electrochemical storage.

STATUS OF THE TECHNOLOGY

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During the last 10-15 years hydrogen has gained importance as an energy carrier. Hydrogen storage is a crucial step for providing supply of hydrogen fuel for end uses such as vehicles and portable devices as well as energy storage in general for stationary applications. Without effective storage systems, a hydrogen economy will be difficult to achieve. At present the compressed hydrogen with pressure up to 700 bar seems to be the choice by car manufacturers, but there are still concerns related to both safety and cost. Hydrogen storage as liquid hydrogen at 20 K also involves a number of challenges, and has not been considered for most applications. Hydrogen storage in solid materials or as liquid hydrogen carriers constitute alternatives that possess the potential to surpass the storage densities of compressed hydrogen. In particularly high volumetric density, storage at low pressures that can be close to ambient conditions and significantly improve safety is the important driving force for further research activities on hydrogen storage in solid compounds. Beside possible applications in vehicles, worldwide activities increased significantly on hydrogen usage as energy storage, leading to the change from fossil to “green” energy sources as wind and solar power. For these stationary applications hydrogen storage in solid compounds is a very attractive concept. Furthermore, metal hydrides are important constituents in metal hydride batteries and also possible as electrolytes in Li-ion batteries.

TECHNOLOGY READINESS LEVEL

The projects in Task 32 cover TRL 1 to TRL 4: basic research, applied research, critical function, i.e. Proof of Concept Established and Laboratory Testing/Validation of Alpha Prototype Component/Process, respectively. The majority of the activities may be classified as TRL 2 and TRL 3.
HYDROGEN IMPLEMENTING AGREEMENT

FRAMEWORK SUMMARY

Task 32 started for a three year term in January 2013. The task is open to project types involving experimental, engineering and modeling (both scientific and engineering) activities and is focusing on the following classes of materials:

- Reversible metal hydrides, including borohydrides, alanates, amides/imides-systems, magnesium-based compounds, reactive hydride composites
- Regenerative hydrogen storage materials (chemical hydrides)
- Nanoporous materials, including coordination polymer framework compounds (MOFs, ZIFs, COFs, etc.), carbon-based compounds
- Rechargeable liquids hydrogen carriers
- Hydrogen-based compounds for electrochemical storage, e.g. MH-batteries, ion-conduction

During the kick-off and the second meeting six working groups have been formed:

- Porous materials (coordination polymer framework compounds, MOFs, ZIFs, COFs, and carbon-based compounds) (M. Hirscher, Germany)
- Magnesium-based hydrogen and energy storage materials (V. Yartis, Norway)
- Complex and liquid hydrides (borohydrides, alanates, amides/imides-systems, magnesium-based compounds, reactive hydride composites and rechargeable liquid hydrogen carriers) (A. Züttel, Switzerland)
- Electrochemical storage of energy (MH-batteries, ion-conduction) (M. Latroche, France)
- Heat storage – concentrated solar thermal using metal hydrides (C. Buckley, Australia)
- Hydrogen storage systems for mobile applications (B. van Hassel, USA)

MEMBERS

Fifty-two (52) experts from 17 countries are participating in Task 32 for a total level of effort at 55 person years in 2013. A similar participation is expected for the upcoming two years.

ACTIVITIES AND RESULTS IN 2011

Progress and accomplishments (by subtask or other order previously set forth)

Two Task 32 expert meetings were held in 2013:

- The kick-off meeting for Task 32 in Heraklion, Greece, April 21-25, had 37 participants from 17 countries (Figure 1)
- The second Task 32 meeting in Key Largo, USA, December 8-12, had 37 participants from 17 countries (Figure 2)

During the kick-off meeting each expert presented his/her project, discussing materials, approaches, and techniques available. Based on these topics, six working groups were formed. The groups were listed in the Framework Summary above and also appear below:

- Porous materials (coordination polymer framework compounds, MOFs, ZIFs, COFs, and carbon-based compounds) (M. Hirscher, Germany)
- Magnesium-based hydrogen and energy storage materials
- Complex and liquid hydrides
- Electrochemical storage of energy
- Heat storage – concentrated solar thermal using metal hydrides
- Hydrogen storage systems for mobile applications
After discussions in the working groups, the results were presented to all experts for a joint discussion. The second meeting was held in a similar fashion and the progress was discussed with emphasis on new and unpublished results. Task 32 is the major forum for international activities in this field, and a lot of international collaborative efforts have been established via active participation in the meetings.

OUTREACH AND COMMUNICATION

During the first year of Task 32, over 150 articles have been published in international peer-review journals. The experts presented results on numerous national and international meetings/conferences. Task 32 was presented in a plenary lecture at the EHEC 2014 in Seville, Spain in March 2014.

FUTURE WORK

ACTIVITIES AND/OR TARGETS FOR 2014

In 2014 there will be only one meeting and it will be held in Manchester, United Kingdom in July directly after the MH2014. The meeting in Manchester will be two days in duration and consist of reports from the working group leaders, short presentations of new developments and broader discussion related to challenges and general progress in the field.

ACTIVITIES AND/OR TARGETS BEYOND 2014

Two task meetings are planned for 2015, the first in Chamonix, France in January 2015 and the second one in Massachusetts, USA in July 2015 in connection with the GRC on Hydrogen-Metal Systems.

R&D CHALLENGES

Energy storage will be key to the change from a fossil-based to a renewable energy economy. Storage of hydrogen remains one of the major challenges for both mobile and stationary applications. At present, for mobile applications in particular, solid materials do not fulfill all requirements with respect to weight and volume of storage system, conditions (temperature and pressure) for hydrogen storage, and kinetics of the hydrogen uptake and release. Use of solid storage for stationary storage appears to be more feasible in the short term, but materials still need optimization. Fundamental understanding of hydrogen storage mechanisms is the key to a breakthrough in the development of materials with improved properties. For technical applications, a combined understanding of both fundamental and engineering aspects will be important. Additionally, improved hydrogen-based energy storage for either heat or electro-chemical storage will be a future target.
Figure 1: Participants at the Task 32 kick-off meeting in Heraklion, Greece, 21-25 April 2013.

Figure 2: Participants at the Task 32 meeting in Key Largo, USA, 8-12 December 2013.