Hydride – Graphite – Composites for Hydrogen Storage

Carsten Pohlmann

The storage of hydrogen plays an important role for the realization of a hydrogen-based energy cycle. For portable and mobile applications, in particular, there is a dire need for safe, volume and weight efficient hydrogen storage technologies. The rapid loading and unloading of the hydrogen storage system is a further prerequisite. Metal hydrides – in contrast to high pressure and cryogenic storage – are a promising option to store hydrogen in a very compact and safe way.

Fig. 1 Pellets of MgH_2 with ENG

Common disadvantages of metal hydrides, however, are their low thermal conductivities (about 1 W/mK and less) in view of the supply and removal of reaction enthalpies that occur during hydrogenation and dehydrogenation (some ten kJ/mol). For the usage of such materials as reversible hydrogen storage materials in real storage tanks, the heat conduction properties have to be improved towards the range of 10 to 20 W/mK without deteriorating the other storage properties (storage density, kinetics). In order to cover a broad range of possible applications and temperature regimes, two complex hydrides (sodium alanate, lithium amide), a light weight metal hydride (magnesium based) as well as a conventional hydride (Ti-Mn alloy) are of particular interest.

The goal of this Ph.D. project is the development of multicomponent materials that combine the above stated hydrides (catalytically activated by e.g. transition metal catalysts, dispersed and nanostructured) with carbon materials (e.g. expanded natural graphite) in order to increase the effective heat conductivity of the composite hydrogen storage material. The targets are a carbon content of < 25 wt.% with an effective heat conductivity of the hydride-carbon composite of > 10 W/mK.

The experimental tasks are the synthesis of different hydride-composites with the carbon-based material, followed by processing of pellets via suitable compaction technologies. Analysis equipment provided in the ECEMP consortium is being advanced to meet the requirements of the materials, e.g. novel measuring cell for thermal diffusivity in order to assure an inert handling of the sample. Special attention is given to the anisotropy of the microstructure, thermal conductivity and gas permeability parallel and perpendicular to the direction of compression, which is of importance for the use of the pellets in pipe bundle storage systems for a tailored radial heat transfer. The results will be compared and evaluated on the basis of existing models to the effective heat conductivity of multicomponent systems known from the literature. Furthermore, the effect of reversible hydrogenation-dehydrogenation cycles, which cause volume changes in the storage material due to lattice dilatation, on the dimensional stability of hydride-carbon pellets is in investigation. Mass spectroscopy shall be used to find out whether undesired C-H compounds are formed during hydrogen sorption. Moreover, the produced hydride-carbon pellets shall be examined concerning degradation during extensive hydrogenation-dehydrogenation cycling.