

HYDROGEN SORPTION KINETICS OF NANOCRYSTALLINE MG-BASED COMPOSITES USING PROTON CONDUCTIVE CERAMIC CATALYSTS

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Metal hydrides offer a safe alternative medium for transmission and storage of hydrogen energy. A reversible hydrogen sorption capacity of 6.5 wt.% at 100°C and 0.1 MPa are targeted for automotive applications. Among these hydrides, Mg-based metal hydride is considered to be one of the most interesting alternatives for the reversible storage of hydrogen due to several unique advantages such as elemental abundance, economic production cost, easy handling as well as a high hydrogen storage capacity of 7.6 wt.%. However, the major problem of magnesium as a rechargeable hydrogen carrier system is its slow reaction rate.

The main challenges in the field of hydrogen storage are to devise new materials or combinations of materials to exhibit 1) high volumetric / gravimetric capacity, 2) fast sorption kinetics at near-ambient temperatures, and 3) high tolerance to recycling. Even though a breakthrough in hydrogen storage technology has been achieved by preparing nanocrystalline hydrides using high-energy ball milling, the desorption and absorption kinetics of magnesium hydrides at lower temperatures are still too slow, limiting technical applications. To overcome this problem, metallic catalysts and transition metal oxides have been added to nanocrystalline magnesium for a better H₂-dissociation at the surface and the enhanced sorption behavior of nanocrystalline Mg-based systems.

In this work, we have investigated the influence of proton conductive ceramic catalysts on the hydrogen sorption behaviors of nanocrystalline Mg-based systems for the first time. The hydrogen reaction kinetics of composites was significantly enhanced in comparison to nanocrystalline MgH₂, while the hydrogen capacity of the nanocrystalline MgH₂ composite decreased at 300°C. Proton conductive catalysts containing nanocrystalline composites increased the reactive sites on the surface of the Mg by forming the effective triple phase boundaries of the hydrogen gas, the proton conductive ceramic catalyst, and the Mg, which will enhance H₂ absorption, desorption, dissociation, surface diffusion, and bulk diffusion at lower temperatures.

The static pressure-composition isotherms for MgH₂ with ceramic catalysts obtained at 300°C using a volumetric sorption analyzer showed that the plateau pressures are nearly horizontal showing complete conversion from α to β phase and vice versa at 300°C. While the absorption pressure plateau of composites decreased significantly in comparison to pure MgH₂, there is a drastic increase of the desorption plateau pressure for composites, indicating the enhanced dehydriding kinetic rate.