Mg-Ni alloys processed by fast forging for hydrogen storage

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Abstract

Reversible hydrogen storage in metal hydrides is crucial to the development of hydrogen as an energy carrier that will be part of the energy transition. Within this framework, magnesium-based alloys are widely studied because of their high gravimetric density (up to 7.6 wt. %) and reasonable cost. It is known that sorption properties of Mg-based alloys can be tuned by adding additives to form an intergranular phase, and/or by refining the microstructure using various processes such as high-energy ball milling, hot spinning or severe plastic deformation [1].

We have investigated the drop-forging of Mg-Ni alloys and demonstrated that the forging of Mg-Ni composite significantly improves hydrogen sorption properties compared to the untreated powder sample, while offering a safe and efficient route to produce bulk hydrogen storage materials compatible with large-scale manufacturing [2].

Hydrogen sorption kinetics differed greatly depending on the forging protocol. A fiber texture with (0002)-basal plane lying parallel to the forging direction is well developed upon cold fast forging, which is found to readily facilitate the activation (first absorption) of hydrogen sorption. However, the kinetics of hydrogen desorption remain rather slow for the cold forged sample owing to the extremely high stability of the hydride phase MgH_2. To promote hydrogen desorption, forging applied at elevated temperature was performed to form the intermetallic compound Mg_2Ni via fast alloying. Interestingly, a fast desorption but slow absorption kinetics was recorded for the hot forged sample. To combine the advantages of cold forging and hot forging, annealing followed by cold forging was carried out to produce a specific microstructure characterized by Mg_2Ni lamellae embedded in a textured Mg-matrix. Eventually, both hydrogen absorption and desorption kinetics were markedly improved due to the co-existence of the basal texture, the cracks and the fragmented Mg_2Ni lamellae. In situ neutron diffraction experiments under deuterium pressure were applied to identify the

sorption mechanism of these materials. In addition, microstructure analysis showed that twins formed in the MgD_2 grain. The mechanism of twin formation was also examined from these aspects.

References

[1] K. Edalati, E. Akiba, W. Botta, Y. Estrin, R. Floriano, D. fruchart, T. Grosdidier, Z. Horita, J. Huot, H.-W. Li, H.-J. Lin, A. Révész, M. Zehetbauer, Impact of severe plastic deformation on kinetics and thermodynamics of hydrogen storage in magnesium and its alloys, Journal of Materials Science and technologies, 146 (2023) 221.

[2] J. Wen, P. de Rango, N. Allain, L. Laversenne, T. Grosdidier, Improving hydrogen storage performance of Mg-based alloy through microstructure optimization, Journal of Power Sources 480 (2020) 228823.