ABSTRACT OF THE THESIS

Severe plastic deformation (SPD) techniques are increasingly applied for improving the hydrogen storage properties of various kinds of metal hydrides. The present dissertation work mainly focuses on the effects of severe plastic deformation through high-pressure torsion (HPT) of different nature of magnesium based powders on modifying the hydrogen sorption properties. A new powder metallurgy route has been adopted in the present study to produce a wide variety of materials combinations. This novel processing route consists of: (i) synthesis of a rather “clean” type of ultrafine Mg based powder particles by evaporation/condensation and (ii) HPT consolidation of the as-synthesized powder precursors into bulk materials for hydrogen storage applications. The different nature of powders was obtained by either a gas-atomization process or an arc-plasma evaporation/condensation method. After improving our understanding of the HPT processing technique on bulk sample with different crystal structures (FCC Al vs. HCP Mg), consolidated bulk products were fabricated by the HPT processing of: (i) two types of Mg powders, (ii) combination of Mg and Fe powders, and (iii) Mg/carbon based powders. These products were thoroughly assessed for their potential improvements in hydrogen storage properties of Mg in comparison with the starting powder precursors.

Among the studied powder composites, the Mg/graphene based powder demonstrated excellent hydrogen sorption properties representing faster activation kinetics. This superior storage property was mainly attributed to its unique morphological features consisting of a “core-shell” type powder morphology, in which the core of Mg powder particles was surrounded by a protective thin layer of graphene sheets. The severe plastic deformation through HPT has provided substantial differences, and even opposite trends, in the hydrogen sorption characteristics of Mg. A significant advantage of the HPT processing was to break the impervious MgO oxide layers usually formed around the Mg powder particles, and to disperse them uniformly along with catalytic additives within the Mg domains. Through the introduction of structural defects and microstructural refinement, the HPT processing has allowed significant improvements in the first hydrogenation kinetics for the consolidated Mg and Mg-Fe products compared to their initial powder precursors while it was reverse for the C-doped HPT products. Another significant impact of the HPT processing was to reduce the hysteresis between the

absorption and desorption plateau pressures during the pressure-composition-temperature (PCT) experiments. Moreover, it was revealed that the HPT processing has drastically reduced the hydrogen desorption temperatures for all the powder combinations while the rate of dehydrogenation was slightly diminished for their consolidated products. Nevertheless, the major drawback of the HPT processing, irrespective of the nature of studied composites, was that it always impaired the maximum hydrogen storage capacity of the starting powder precursors.