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Study of the Influence of Refractory Nitride Additives on Hydrogen Storage Properties of Ti6Al4V-Based Materials Produced by Spark Plasma Sintering

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Abstract : Hydrogen is an appealing alternative to fossil fuels because of its abundance, low weight, high energy density, and relative lack of contaminants. However, its low density presents a number of storage challenges. Therefore, this work studies the influence of refractory nitride additives consisting of 5 wt. % each of hexagonal boron nitride (h-BN), titanium nitride (TiN), and aluminum nitride (AlN) on hydrogen storage and electrochemical characteristics of Ti6Al4V-based materials produced by spark plasma sintering. The microstructure and phase constituents of the sintered materials were characterized using scanning electron microscopy (in conjunction with energy-dispersive spectroscopy) and X-ray diffraction, respectively. Pressure-composition-temperature (PCT) measurements were used to assess the hydrogen absorption/desorption behavior, kinetics, and storage capacities of the sintered materials, respectively. The pure Ti6Al4V alloy displayed a two-phase (α+β) microstructure, while the modified composites exhibited apparent microstructural modifications with the appearance of nitride-rich secondary phases. It is found that the diffusion process controls the kinetics of the hydrogen absorption. Thus, a faster rate of hydrogen absorption at elevated temperatures ensued. The additives acted as catalysts, lowered the activation energy and accelerated the rate of hydrogen sorption in the composites relative to the monolithic alloy. Ti6Al4V-5 wt. % h-BN appears to be the most promising candidate for hydrogen storage (2.28 wt. %), followed by Ti6Al4V-5 wt. % TiN (2.09 wt. %), whereas Ti6Al4V-5 wt. % AlN shows the least hydrogen storage performance (1.35 wt. %). Accordingly, the developed hydride system (Ti6Al4V-5h-BN) may be competitive for use in applications involving short-range continuous vehicles (~50-100km) as well as stationary applications such as electrochemical devices, large-scale storage cylinders in hydrogen production locations, and hydrogen filling stations.

Keywords : hydrogen storage, Ti6Al4V hydride system, pressure-composition-temperature measurements, refractory nitride additives, spark plasma sintering, Ti6Al4V-based materials
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