Study of the Structural, Thermodynamic and Cyclic Effects of Vanadium and Titanium Substitution in Laves-Phase AB_2 Hydrogen Storage Alloys

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Abstract

The substitution of the high-purity and expensive raw materials vanadium (V) and titanium (Ti) by their low-cost, low-purity alternatives ferrovanadium (FeV) and Ti sponge in $Ti_{0.98}Zr_{0.02}V_{0.43}Fe_{0.09}Cr_{0.05}Mn_{1.5}$ was investigated and the microstructural, thermodynamic and cyclic properties were tested of these compounds. Four different samples were prepared and studied: one material

prepared with high-purity V and Ti, a second one prepared with FeV in substitution for V and Fe, a third prepared with Ti sponge in substitution for Ti, and a fourth prepared with FeV and Ti sponge in substitution for V, Fe and Ti. The substitution of Ti with Ti sponge and of V and Fe by FeV had negligible effects on the microstructural properties. 2.0 mass% H were absorbed in both the pristine (high-purity V and Ti) material and after replacing Ti by Ti sponge. Substitution of V by FeV reduced the initial hydrogen absorption capacity to approximately 1.7 mass%. All materials exhibited equilibrium hydrogen absorption and dissociation pressures of ca. 1.5 MPa. They reversibly stored 1.8 mass% H for both the pristine and Ti-substituted samples and 1.6 mass% H after substitution of V and Fe by FeV or after substitution of V, Fe and Ti by FeV and Ti sponge, respectively.

Long-term cyclic experiments over 1000 de-/hydrogenation pressure swing cycles were performed for the pristine material and after substitution of V, Fe and Ti by FeV and Ti sponge, respectively. Both materials exhibited similar activation and degradation behavior upon cycling. A reversible capacity of 1.5 mass% H was recorded for the pristine material after 1000 cycles, and 1.4 mass% H were reversibly stored in the material prepared with FeV and Ti sponge subjected to 1000 cycles. The raw material cost to store an equal amount of hydrogen can be reduced by 83 % when V and Ti are substituted by FeV and Ti sponge.