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Citation	Bulletin of the Graduate School of Integrated Arts and Sciences, Hiroshima University. II, Studies in environmental sciences , 14 : 107 - 108
Issue Date	2019-12-31
DOI	
Self DOI	
URL	https://ir.lib.hiroshima-u.ac.jp/00048897
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Relation	



Investigation of High Temperature Properties of BCC Hydrogen Storage Alloys

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The energy demands for the applications and the developing energy systems must be practical, cost-effective, sustainable, reliable and should have a very low impact on the environment. As of now, fossil fuels are being widely used for the energy systems and transportation all over the world. However, the burning of fossil fuel releases a high amount of CO₂ emission which is polluting the air and making global warming. As a solution to this problem, the hydrogen energy technology can be an efficient and suitable one for the on-board vehicular applications. The development of hydrogen storage material is very important for establishing hydrogen energy infrastructure all over the world in near future. Particularly, the hydrogen storage materials should possess high hydrogen capacity with moderate thermodynamic properties as well as optimum kinetics. Recently, the development of metal hydride compressor is a promising technology for hydrogen compression which has the capability of compressing hydrogen to a high pressure by only increasing heat without the need of any moving mechanical parts.

In this thesis, the hydrogen storage properties and the compressor cyclic performance of V-Ti-Cr BCC alloys were systematically investigated to understand the effect of high temperature and pressure conditions on their sorption performance.

V₂₀Ti₃₂Cr₄₈ and V₄₀Ti_{21.5}Cr_{38.5} two different composition alloys were selected for this study according to their effective hydrogen storage performance. The hydrogen sorption capacity of high vanadium content V₄₀Ti_{21.5}Cr_{38.5} alloy is stable after

10 cycles with their plateau pressures and hysteresis remain almost the same up to 100 cycles. Instead of, low vanadium content V₂₀Ti₃₂Cr₄₈ alloy continuously degraded in terms of their hydrogen storage capacity over a number of cycles. Structural and morphological investigations suggest that the low vanadium content alloy has two stable hydride phases i.e TiH_{0.66}, and VH_{0.81} after compressor cycling, which requires more than 400 °C to desorb hydrogen completely. This seems to be the responsible reason for the hydrogen storage capacity decrease in each successive cycle of the V₂₀Ti₃₂Cr₄₈ alloy.

In order to improve the cyclic and hydrogen storage properties of V₄₀Ti_{21.5}Cr_{38.5} alloy further, the fourth element has been substituted for Cr. Niobium, Iron, and Zirconium were selected to alter the thermal stability as well as the cyclic performance of V₄₀Ti_{21.5}Cr_{38.5} ternary alloy at moderate conditions. The V₄₀Ti_{21.5}Cr_{33.5}Nb₅ alloy was found stable after 50 cycles of compressor cyclic test with a higher hydrogen sorption capacity than that of parent and other two alloys. Structural and morphological investigations suggest the formation of VH_{0.81} phase responsible for initial capacity decay for Nb substituted alloy which could not desorb hydrogen at the studied temperature range. The Fe doped V₄₀Ti_{21.5}Cr_{33.5}Fe₅ alloy was found continuously degraded over a number of cycles with hydrogen storage capacity. However, structural and morphological investigations suggest no phase segregation during the cycling of V₄₀Ti_{21.5}Cr_{33.5}Fe₅ alloy in contrast to the other alloys, which suggests that phase segregation is not the only responsible

reason for the performance degradation of BCC alloys employed for compressor cycle. In some cases similar to $V_{40}Ti_{21.5}Cr_{33.5}Fe_5$, stress/strain formation in the lattice during cycling may also cause the degradation of the material. On the other hand, the hydrogen sorption

capacity of Zr doped $V_{40}Ti_{21.5}Cr_{33.5}Zr_5$ alloy was found stable after 25 cycles with its plateau pressures and hysteresis remain same up to 100 cycles. The initial degradation was suggested to be associated with the formation of stable hydride phases ZrV_2H_x .