Hydrogen storage properties of Mg-Ni-Al-V-Ti alloy prepared via ball milling

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The high-entropy alloys are of high research interest in materials science due to their potential as hydrogen storage materials and other promising properties. In their development, the classical alloys which are based on a base metal with added alloying elements, are replaced by a nearly equimolar multicomponent alloys. Mg-based high-entropy alloys with some other capable to store hydrogen alloys or metals with high catalytic activity or better corrosion resistance is a way to improve the performance of magnesium materials as hydrogen storage media and anodes in NiMH batteries. A review and summarized results of high entropy alloys with application as hydrogen storage materials were published recently [1]. Some results about the effect of high entropy alloys on the hydrogen sorption properties of MgH_2 are published also [2, 3]. The 90 wt% MgH_2-10 wt.% CrFeCoNi or CrMnFeCoNi and 95 wt% MgH_2- 5 wt% FeCoNiCrMn high entropy alloys exhibited good cycling performance of hydrogenation/dehydrogenation and enhanced hydrogen storage properties of MgH_2.

More investigations on hydrogen storage properties of high entropy alloys and nanostructured Mg-based alloys regarding synthesis methods, higher storage capacity, fast absorption/ desorption kinetics at lower pressure and temperatures are needed. Driven by these reasons, in the present work the corresponding mixture with composition $Mg_{50}Ni_{12.5}Al_{12.5}V_{12.5}Ti_{12.5}$ is synthesized by ball milling and its hydrogen storage properties are studied at different temperatures.

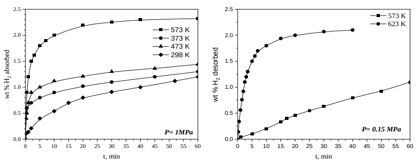

Figure 1. Hydrogen absorption and desorption curves at different temperatues.

The mixture of metals with composition $Mg_{50}Ni_{12.5}Al_{12.5}V_{12.5}Ti_{12.5}$ is milled under Ar in a planetary mill Pulverisette 6 Fritsch with rotation speed 300 rpm, stainless steel balls to powder weight ration 15:1 for duration of 100h. After milling of 10, 20, 40, 60, 80 and 100h some amount of the powder is taken for XRD analyses by using Powder X-ray Diffractometer Bruker D8 Advance with a LynxEye detector. The hydrogen sorption properties are studied at different temperatures 298, 373, 473 and 573 K and a pressure of 1 MPa for absorption and 0.15 MPa and 573 and 623 K for desorption using a Sieverts type apparatus. After 100 h of ball milling under Ar and hydrogenation at 473 K and 1 MPa, the samples are characterized by TEM HR STEM JEOL JEM 2100 with GATAN Orius 832 SC1000 CCD Camera.

The XRD patterns of ball milled for 100 hours under argon of $Mg_{50}Ni_{12.5}Al_{12.5}V_{12.5}Ti_{12.5}$ showed Mg, Al, Ni, V and Ti. TEM analyses confirmed the XRD results. In Fig. 1 hydrogen absorption and desorption curves at different temperatures are presented. Even at room temperatures the kinetics and capacity are good. Of cause at 573 K and 1 MPa the capacity is with highest value of 2.3 wt% and at 298 K is 1.2 wt%. The desorption reaction is not so fast and for 1h at 573 K the desorption capacity is 1.1 wt%, but at 623 K for the same time is 2.1 wt%.

The reversible hydrogen storage capacity of the $Mg_{50}Ni_{12.5}Al_{12.5}V_{12.5}Ti_{12.5}$ is due mainly to Mg and at 573 K is 2.3 wt%. This metallic powder showed fast absorption kinetics and resistance to oxidation. It appears that the effects of ball milling like decreasing particles size and introducing many defects also contributed to these good absorption kinetics properties.

References

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Acknowledgments: The authors would like to thank to the Bulgarian Academy of Sciences under project IC-TR/02/2022-2023.

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