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Hydrogen Sorption Properties, Thermal Stability and Kinetics of Hydrogen Desorption From the Hydride Phase of The MgH_2 of a Mechanical Alloys of Magnesium with Ti, Ni and Y

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The mechanical alloys-composite MAs (Mg +10 % wt.Ti + 5 % wt.Y and Mg +10 % wt.Ni + 5 % wt.Y) were synthesized. The phase content, microstructure, the thermal stability, kinetics of hydrogen desorption from the MgH_2 hydride phase of the obtained MAs were studiedby using XRD, SEM, TDS methods. It has been established that the addition of Ti + Y and Ni + Y to magnesium leads to significant improvement in the kinetics of hydrogen desorption from the MgH_2 hydride phase, which is evidenced by a significant reduction (in 6 and 15 times)in the time of release of all hydrogen from MA1 and MA2, respectively. Due to, Ti, Ni,Y alloying, the decrease in the thermodynamic stability of MgH_2 is not found.

Keywords: mechanical alloy; hydride MgH_2; thermodesorption spectroscopy; hydrogen-sorption properties; thermal stability; kinetics of hydrogen desorption.

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Introduction

The development of molecular hydrogen storage systems and technologies requires the creation of new hydrogen absorption materials. Safe and compact storage of hydrogen in the solid state is the most acceptable from the point of view of the needs of the hydrogen economy in relation to mobile and stationary applications. The properties of a large number of metal-hydrogen systems are well known. However, the widespread use of metal hydrides and alloys for the storage of hydrogen is constrained by the fact that most of them do not fully or partially satisfy the requirements that practice has for hydrogen sorbent materials. It is known that to use the material in hydrogen storage systems on board an automobile, a hydrogen capacity of 5 – 6 % wt. is required, and the temperature of decomposition of the hydride phase is not higher than 150 – 200 °C. Some magnesium alloys, composites based on it turned out to be the most promising from the point of view of the optimal combination of such properties as high hydrogen capacity, high kinetic characteristics, reasonable cost. Despite the great attention of scientists, which in recent years has been given to magnesium dihydride, methods for its preparation and research of properties, it still does not find wide practical application as a hydrogen storage material due to difficulties in eliminating two significant drawbacks: high temperature ($\geq 300\ ^0C$ at 1 bar H_2) and slow dissociation kinetics. The main difficulty lies in the fact that, together with a decrease in the decomposition temperature, it is necessary to increase the decomposition rate while maintaining a high hydrogen capacity and the cyclic stability of the hydride phase MgH_2 of the obtained mechanical alloys-composites. That is, it is necessary to provide a whole range of characteristics that today constitute the problem. Most often, they most often try to solve this difficult task of forming several characteristics in MgH_2 by mechanically dispersing commercial MgH_2 in the presence of various kinds of catalytic additives (transition 3d, 4d metals, their oxides, fluorides, intermetallic compounds, additives of transition metals Al, Cu, Zn , In, Sn, graphite, etc.) or by grinding a metal Mg powder with the indicated additives in a hydrogen atmosphere (that is, reactive grinding) or in an inert gas atmosphere followed by its direct hydrogenation from the gas phase [1-31]. One of the ways to reduce the thermodynamic stability of MgH_2 is to use mechanical alloys, which are solid solutions in magnesium of one or several metals, which can reduce the enthalpy of formation / decomposition of Mg (Me) H_2 [32-42]. According to the theoretical forecast [4], the hydride of a solid solution of Al, Ti, Fe, Ni, Cu, Nb in Mg should have a lower enthalpy of formation and decompose at a lower temperature compared to pure MgH_2. Experimental studies show that the thermodynamic stability of such a solid solution hydride depends on the method and conditions for its preparation [32-36]. In [35], the decomposition of the hydride phase Mg (In) H_2 of a mechanical alloy obtained by high-energy grinding of MgH_2 powder with 10 % at. In at a hydrogen pressure of 150 bar, starts at 262.3 ^{0}C and a hydrogen pressure in the reactor of 1 bar. At the same time, as follows from the analysis of the P – C – T curves [35], the hydride of a solid solution of aluminum in magnesium obtained by grinding a mixture of 90 % at. MgH_2 + 10 % at. Al in a hydrogen atmosphere at a pressure of 150 bar, the effect of destabilization of the hydride phase of Mg (Al) H_2 was not found. The authors of [19, 20] report observing the effect of lowering the decomposition temperature of MgH_2 from 288 to 210 °C due to the complex doping of magnesium Al, Ni, Ti (Mn) during the synthesis.

In [43-46], Y was used to reduce thermal stability and improve the hydrogenation kinetics of Mg-based binary alloys. The authors of [43, 44] established the formation of one-dimensional MgH_2 nanostructures (whiskers) as a result of the disproportionation of $Mg_{24}Y_5$ intermetallic compounds during its hydrogenation. This nanostructured MgH_2, when heated in a vacuum, decomposes at a lower temperature and at a faster rate than commercial MgH_2. The effect of cyclic hydrogenation / dehydrogenation on the hydrogen capacity of the material has also been investigated. It was established [43] that the presence of yttrium improves the diffusion of hydrogen. As studies of binary $Mg_{24}Y_X$ alloys (x = 1 - 5) have shown [45], an increase in the yttrium content, which acts as a modifier, leads to a significant difference in the microstructures of the studied alloys and, as a result, to an increase in the kinetics of hydrogen absorption due to the formation of YH_2 nanoparticles that are dispersed throughout the MgH_2 matrix. However, as noted by the authors of [45], an increase in the yttrium content inevitably leads to a decrease in the ability to absorb hydrogen back. A study of the hydrogenation of Mg-13Y alloy by the authors of [46] showed that the experimentally determined enthalpy of hydride formation of this alloy (42 kJ/mol H_2) is significantly lower than the enthalpy of hydride formation of pure Mg (74.7 kJ/mol H_2). This difference in thermodynamic data indicates that the hydrogenation process of the Mg-13Y alloy is very different from the hydrogenation of pure Mg. The dehydrogenation enthalpy of Mg-13Y powder is quite close to that for MgH_2, which indirectly indicates the decomposition of only the hydride phase of MgH_2 during the dehydrogenation process (and the decomposition of the YH_2 phase does not occur).

The catalytic effect of titanium and yttrium on the hydrogen absorption properties of Mg + 14.5 % at. Ti + 0.5 % at. Y was studied in [47]. XRD analysis showed that the alloy consists of the main phase of $Mg_{24}Y_5$, a small amount of solid solution of Y in Mg and Ti clusters randomly dispersed in the sample. It was found that $Mg_{24}Y_5$ irreversibly reacts with hydrogen in two stages. In the first stage (at a hydrogen pressure of 50 kPa), YH_2 and Mg are formed. The second stage (at higher hydrogen pressures) ends with the formation of YH_3 and MgH_2. So, hydrogen desorption consists of two desorption reactions: the transition of MgH_2 to Mg and the transition of YH_3 to YH_2. It was found that the presence of both Y and Ti in this Mg-based alloy did not lead to any significant thermodynamic or kinetic improvement with respect to the sorption properties of pure magnesium hydride.

The influence of Y and Ni on the hydrogen absorption kinetics during the hydrogenation of Mg-20 % wt. Ni-Y alloy, $Mg_{90}Ni_5Y_5$ and $Mg_{80}Ni_{10}Y_{10}$ alloys, and $Mg_{11}Y_2Ni_2$ alloy were studied in [48–50]. It has been established that both the catalytic effect of the Mg_2Ni and YH_3 phases and the crystal lattice defects formed during mechanical activation are responsible for improving the hydrogen sorption kinetics in all of the above alloys during their hydrogenation. It was shown that ultrafine particles of yttrium hydride, which are formed during the hydrogenation of these alloys, contribute to the stabilization of the nanostructure during cycling and improve the kinetics of hydrogen sorption of magnesium.

Earlier, we investigated the role of each of the alloying elements Al, Ti, Mn, Fe, Ni separately in lowering the decomposition temperature of stoichiometric MgH_2 hydride obtained by reactive mechanical alloying (RMA) [25, 27, 29, 31], as well as the role of the pair doping with Al + Ti, Al + Fe, Al + Ni [51-54]. This study, namely: the study of the possibility of complex doping of magnesium hydride MgH_2 with both Ti and Y in order to lower the temperature and improve the kinetics of its dissociation, is a logical continuation of our previous studies, as well as [40, 41]. In this paper, the task was to obtain a mechanical alloys (MAs) of the composition Mg + 10 % wt. Ti + 5 % wt. Y and Mg + 10 % wt. Ni + 5 % wt. Y by RMA. To study the processes of hydrogen desorption from the MgH_2 hydride phase at a hydrogen pressure of 0.1 MPa, to determine hydrogen sorption properties, thermal stability of the obtained MAs using thermal desorption spectroscopy (TDS). The task was also set to establish whether, due to the selected composition of alloying elements and the method of obtaining MA, the enthalpy of formation of the hydride phase of MgH_2 decreases and, as a consequence, the equilibrium temperature of its decomposition. On the MAs samples, after their cyclic hydrogenation / dehydrogenation, trace how the microstructure and phase composition of the MAs change; how the effect of the addition of Ti, Ni and Y on the thermal stability and decomposition temperature of the MgH_2 hydride phase as a result of cyclic hydrogenation changes. It was expected that the results of these studies will help determine the composition of alloying elements and the conditions for obtaining a mechanical alloy, which can provide the lowest possible thermal stability and decomposition temperature of the

MgH_2 hydride phase with a simultaneous improvement in the kinetics of hydrogen sorption / desorption from it.

I. Materials and methods

The mechanical alloys-composites has been synthesized by reactive grinding in hydrogen of powders: Mg + 10 % wt. Ti + 5 % wt. Y (MA1) and Mg+ 10 % wt. Ni + 5 % wt. Y (MA2). For comparison, we synthesized an additional composite alloy Mg without any additives (MA3) and alloys-composites Mg + 10 % wt. Ti (MA4), Mg + 10 % wt. Ni (MA5). The commercial powders of Mg, Ti, Ni, Y with a purity of 99.98 % and particles sizes of 100; 6,7; 3; 200 μm, respectively, have been used as raw materials. The mechanical fusion by reactive grinding of the mixture of powders of MA1-MA5 composition, was realized in a RETCH100 ball mill with steel balls in a hydrogen atmosphere (under a hydrogen pressure of 1 MPa, for a velocity of rotation of 450 rot/min and a duration of grinding of 20 h). The ratio of the metallic balls mass and the treated mixture of powders was 20:1. Milling was interrupted every 60 min to allowthe vial to cool down to room temperaturef ollowed by the monitoring of the current state of hydrogen absorption. We use one and the same conditions of synthesis for all MAs under consideration that allows making a proper comparison of different alloying elements effect on temperature and the kinetics of MgH_2 hydride phase decomposition of synthesized MAs. Conditions of synthesis of all MAs derived by direct hydrogenation from the gas phase were also the same. After the MA synthesis and obtaining the first hydrogen desorption curve, the sample was not removed from the reactor. At temperature of 400 ^{0}C the reactor was filled with hydrogen until hydrogen pressure was 3 MPa and during the sample cooling together with the furnace its first (and subsequent) hydrogenation from the gas phase took place.

For the X-ray phase diffraction analysis of specimens, we used a DRON-3M diffractometer. The X-Ray patterns were obtained employing CuKα -radiation with a graphite monochromator. The profiles of diffraction lines were plotted with scanning steps of 0.1^0 and with exposure at each point of the spectrum over 15 sec. The diffraction patterns were analyzed using fullprof software Powder Cell 2.4 (https://powdercell-for-windows. software. informer. com /2.4/). The size changes of the powder particles upon mechanical milling were studied by a Super-Probe 733 scanning electron microscopy.

By the method of thermal desorption spectroscopy with a computerized automatic installation, we studied the influence of alloying elements on the hydrogen sorption properties, thermal resistance, the kinetics of hydrogen desorption from the MgH_2 hydride phase. This installation allows to plot the isobars of desorption-resorption of hydrogen under various pressures (from 0.1 to 1.0 MPa) in the reactor and to perform the hydrogenation/dehydrogenation of specimens under pressures up to 10 MPa and temperatures being in the range from room temperature to 1200 ^{0}C [29].

II. Results and Discussion

2.1 X-ray phase and microstructural analyzes of the samples.

Fig. 1 shows XRD pattern of the MA1, MA2 samples derived by reactive mechanical alloying (RMA) and Fig. 2 - after the gas phase hydrogenation (GPH) mechanical alloys. The information on the phase composition of the MAs specimens obtained by RMA and after GPH is presented in Table 1. Table 1 also shows the average particle size of mechanical alloys powders (after RMA). The lattice parameters and volume of unit cells for β-MgH_2 hydride phase of MA1-MA3 (Table 2) have been determined by the full-profile Rietveld method using Powder Cell2.4 program.

As Table 1 shows, both MAs (MA1,MA2) are composites, as aresult of reactive mechanical alloying. In addition to MgH_2 with tetragonal structure, theycontains a small amount of other hydride phases: γ-MgH_2,TiH_2, YH_3, YH_2 when MA1 and γ- MgH_2, YH_3, Mg_2NiH_4 when MA2. After the first hydrogenation / dehydrogenation cycles from the gas phase, all MAs shown the absence of changes in their phase composition. Based on our experimental data, the average particle size (which in turn consists of nanograin) in MA1, MA2, MA3 is 0.25, 0.2, 0.7 μm respectivelly. After repeated hydrogenation / dehydrogenation of powders from the gas phase, as shown by the study of their microstructure, the average particle size decreases and the average grain size increases due to cyclic heating / cooling.

2.2 Thermal behavior of the mechanical alloys-composites.

To evaluate the influence of complex alloying by Ti + Y and Ni + Y on decomposition temperature and thermal stability of MgH_2 phase hydrogen desorption from MA1-MA3 have been studied. All isobars were obtained at constant pressure of hydrogen in the reactor 0.1 MPa and sample heating rate of 3 °C/min. Hydrogen desorption isobars obtained at the first heating after RMA synthesis of MA1-MA3 samples are shown in Fig. 3, and after the first hydrogenation from the gas phase of MA1, MA2 are in Fig. 4. The isobars shown in Figs. 3 and 4 were used to determine both the hydrogen capasities and the hydrogen desorption beginning temperature ($T_{beg.}$) from hydride phase MgH_2 of MA1-MA3 in the course of its first heating after mechanochemical synthesis and of its gas phase hydrogenation (GPH). The obtained data are shown in Table 3. From Figs. 3 and 4, Table 3, it is obvious that the temperature of the beginning of hydrogen release from the MgH_2 hydride phase of MA1, MA2, MA3 composites after RMA was 295, 295, 288 ^{0}C, respectively. After their first hydrogenation from the gas phase, the temperature was 288, 288, 320 ^{0}C, respectively. If one compares T_{beg} of the release of hydrogen from the unalloyed MgH_2 phase of MA3 (288 ^{0}C) with the same temperature for MA1, MA2, one can states that the addition of Ti+Y and Ni+Y to magnesium practically does not reduce the thermodynamic stability of hydride phase $MgH_2$of MA1,MA2 and, consequently, does not reduce the

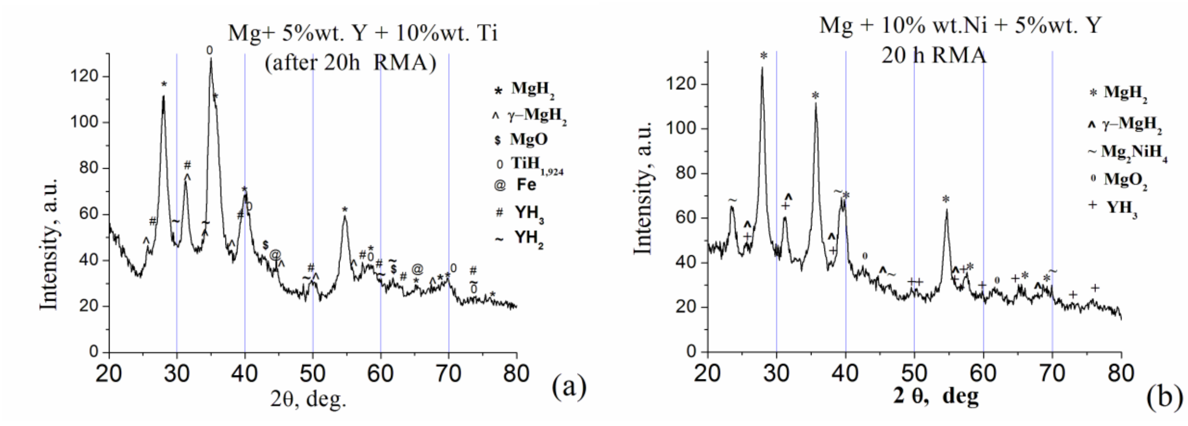

Fig. 1.X-ray diffraction pattern of specimens of the mechanical alloys: a - MA1, b - MA2, obtained by reactive mechanical alloying (20 h).

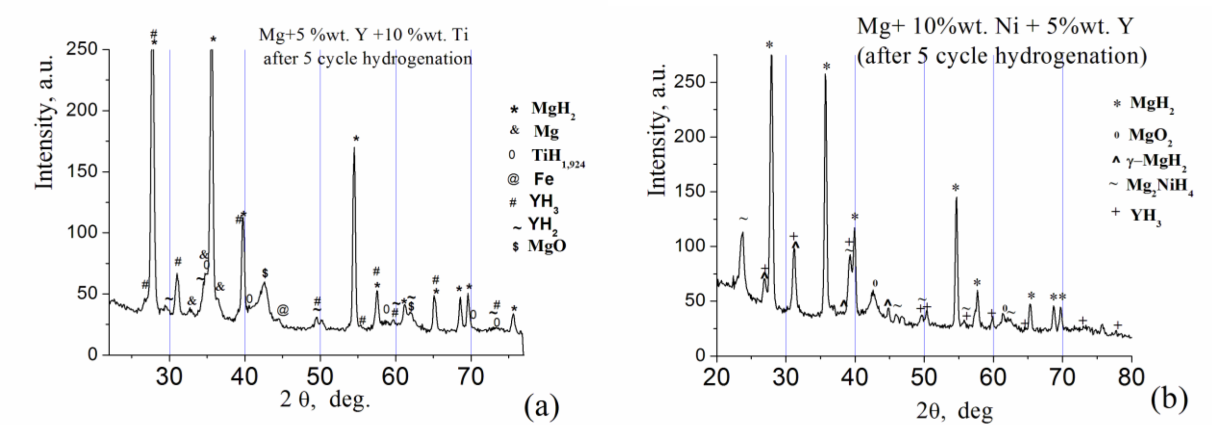

Fig. 2. X-ray diffraction pattern of specimens of the mechanical alloys: a - MA1, b - MA2, after hydrogenationfrom the gaseous phase.

Table 1

Phase's compositions of MA$_S$ after reactive mechanical alloying (RMA) and gasphase hydrogenation (GPH)

Mechanical alloy	Phase compositions		$D_{part.}$, µm
	RMA	GPH	RMA
MC1 (Mg+10wt.% Ti + 5wt.%Y)	MgH_2, γ-MgH_2,TiH_2, YH_3, YH_2, Fe,MgO	MgH_2, Mg, TiH2, YH_3,YH_2,Fe,MgO,	0.25
MC2 (Mg+10wt.% Ni +5wt.%Y)	MgH_2, γ-MgH_2, YH_3, Mg_2NiH_4, MgO_2	MgH_2, γ-MgH_2, YH_3, Mg_2NiH_4, MgO_2	0.2
MC3 (MgwithoutTi, Ni i Y)	Mg, MgH_2, $MgO_{0,91}FeO_{0,09}$	Mg, MgH_2, $MgO_{0,91}FeO_{0,09}$	0.7

temperature of the beginning of hydrogen desorption. In our opinion, the explanation of this can be the fact that in the conditions of our method of obtaining of MAs does not form a solid solution in magnesium Ti, Ni, Y, whose hydride is Mg(Ti,Y)H_2 or Mg(Ni, Y)H_2, according to [4], should have a lower formation enthalpy and a lower thermodynamic stability and decomposition temperature of MgH_2. The evidence of the fact that Mg(Ti, Y)H_2 or Mg(Ni, Y)H_2 hydride was not derived (or its quantity is rather minor) can be, in accordance with the XRD data (Table 1), the presence in the composite MA1 of TiH_2, YH_3, YH_2 phases and in the composite MA2 of Mg_2NiH_4, YH_3 phases (the latter phases are formed due to substantial amounts of the alloying elements Ti, Ni and Y). As can be seen from Table 2, the absence of the expected decrease in volume of the unit cell of MgH_2 hydride phase of the composites MA1, MA2 compared with that of the same hydride phase of the composite MA3 can also be an indication of the absence of formation in our synthesis conditions of Mg(Ti, Y)H_2 or Mg(Ni,Y)H_2 hydride. From data listed in Table 3, it is worth noting a decrease of hydrogen capacity and $T_{beg.}$ of hydrogen desorption from 295 ^{0}C to 288 ^{0}C in the case of the composites MA1 and MA2 after their hydrogenation from the gas phase. In our opinion, the main role in this decrease in $T_{beg.}$ was played by Y. As is known [48-50],

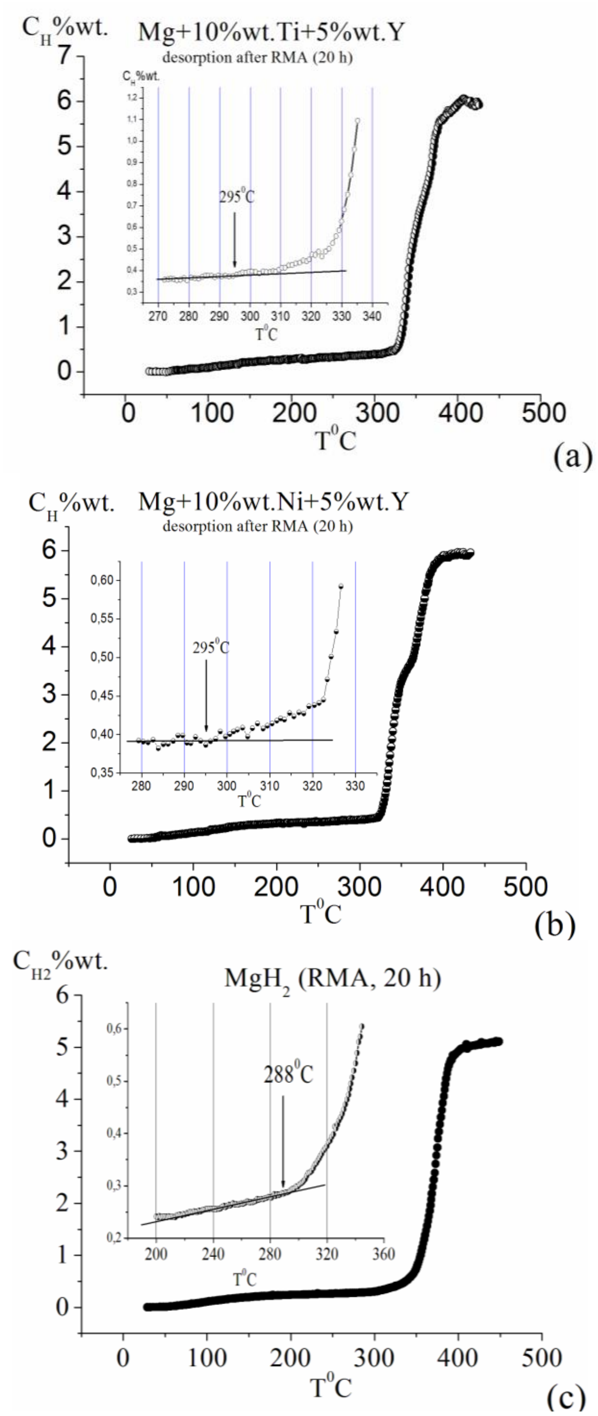

Fig. 3. Isobars of hydrogen desorption from the MgH_2 hydride phase of the mechanical alloys: (a)-MA1, (b) - MA2, (c) - MA3, derived after synthesis RMA.

it is able to inhibit the growth of grain size (crystallites) of mechanical alloys during their cyclic hydrogenation/dehydrogenation at elevated temperatures. It should be noted that as a result of 4-10 cycles of hydrogenation /dehydrogenation of the composites MA1, MA2 from the gas phase, we did not observe significant changes in the nature of the desorption curves and their position in the temperature scale. This may indicate reversibility of the process of cyclic hydrogenation / dehydrogenation of the obtained MAs and the absence of significant degradation of their hydrogen adsorption

Table 2

Crystal structure data (unit cell parameters: a, Å; c, Å; V, $Å^3$) for MgH_2hydride phase of composites

Mechanical alloy	Unit cell parameters: a,c - Å; V-$Å^3$	
	after RMA	afterGPH
MA1	a = 4.5077 c = 3.0320 V = 61.608	a = 4.5189 c = 3.0226 V = 61.723
MA2	a = 4.5174 c = 3.0225 V = 61.674	a = 4.5141 c = 3.0185 V = 61.508
MA3	a = 4.5223 c = 3.0157 V=61.671	

Table 3

The hydrogen desorption beginning temperature (Tbeg.) from MgH_2 hydride phase of MA1-MA3 and hydrogen capasity.

Mechanical alloy	after RMA		after GPH	
	$T_{beg.}$, ^0C	C_{H2}, %wt.	$T_{beg.}$, ^0C	C_H, %wt.
MA1	295	6.0	288	5.7
MA2	295	5.9	288	5.5
MA 3	288	5.1	320	6.3

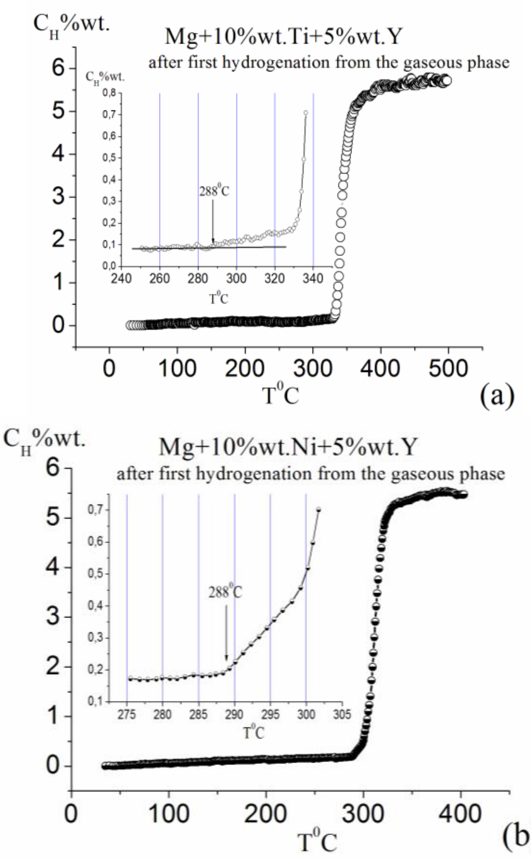

Fig. 4. Isobars of hydrogen desorption from the MgH2 hydride phase of the mechanical alloys: (a) MA1, (b) - MA2, derived after its first hydrogenation from the gaseous phase.

properties.

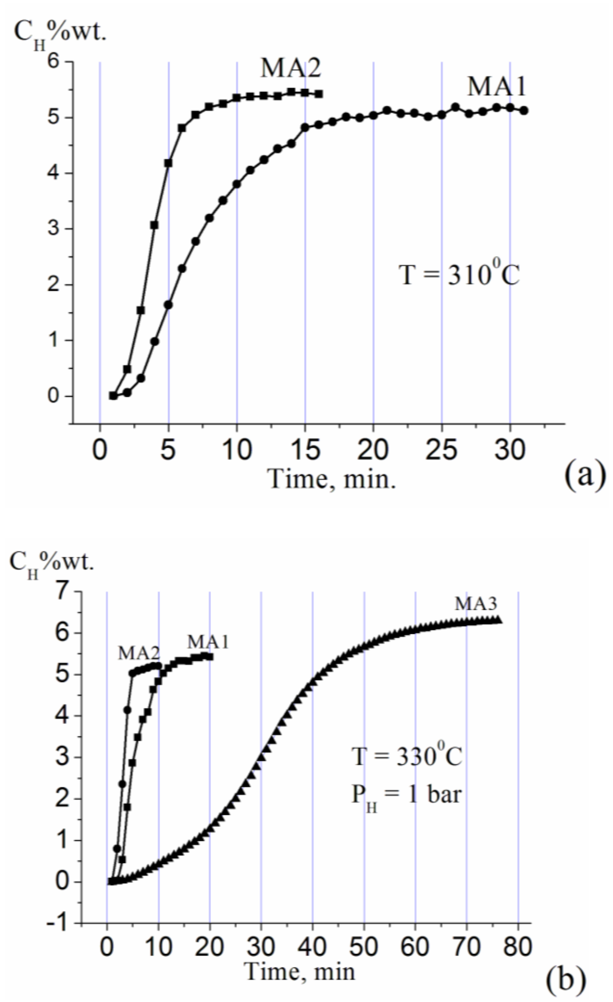

Fig. 5. Kinetic curves of isothermal hydrogen desorption from the MgH_2 hydride phase of the mechanical alloys MA1, MA2, derived at constant hydrogen pressure of 0.1 MPa in the reactor and temperatures: a – 310^0C, b –330°C.

2.3 Mechanical alloys hydrogen desorption kinetics process.

Hydrogen desorption kinetics from the MgH_2 hydride phase of all MAs synthesized by us after their hydrogenation from the gas phase under the same conditions has been investigated at the temperatures 310, 330 °C and at a constant hydrogen pressure of 0.1 MPa in the reactor. Hydrogen desorption kinetic curves for MA1, MA2, MA3 are presented in Fig. 5 and for MA4, MA5 - in Fig. 6. The data of hydrogen time release of half of hydrogen quantity ($\tau_{1/2}$) and total hydrogen quantity release (τ_f) for all MAs are shown in Table 4. The analysis of the experimental data given in Table 4 allows us to conclude that the addition of magnesium at the same time Ti + Y and Ni + Y leads in both cases to a significant improvement in the kinetics of hydrogen desorption from the MgH_2 hydride phase obtained by MA1 and MA2. This is evidenced by the experimentally recorded reduction by 6 and 15 times of the time it takes to release half and all the desorbed hydrogen in the case of MA1 and MA2, respectively, compared to MA3. In our opinion, Ti and Ni play the main role in improving the kinetics of hydrogen desorption in the composites MA1 and MA2. They possess high catalytic properties and favor recombination of hydrogen on the particle surface of the hydride phase, and, consequently, reduce its thermal stability. It can be seen from table 4, that a greater improvement in the kinetics of hydrogen desorption from the hydride phase of MgH_2 is observed in the case of its doping with Ni, and less in the case of doping of Ti. A reasonable explanation can be given to this observation if we use the results of a study [56] on the effect of these transition metals as alloying elements on the physicochemical state of the surface of metal

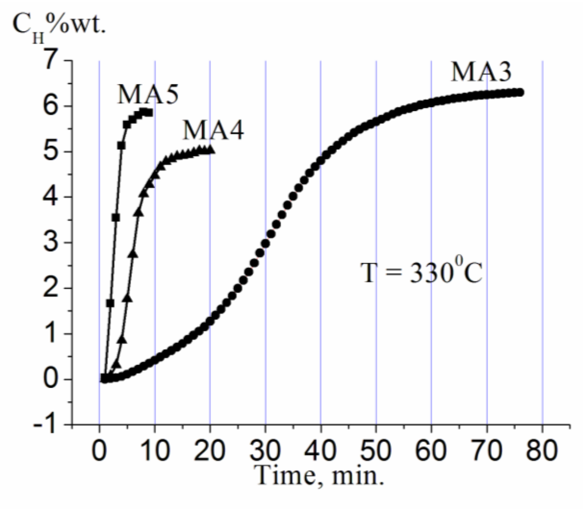

Fig. 6. Kinetic curves of isothermal hydrogen desorption from the MgH_2 hydride phase of the mechanical alloys MA3, MA4, MA5, derived at constant hydrogen pressure of 0.1 MPa in the reactor and temperature 330 °C.

Table 4

Time (min.) of desorption half ($\tau_{1/2}$) and full (τ_f) hydrogen amount from MgH_2hydride phaseMas at 310 ^{0}C, 330^0C

Mechanical alloy	310 ^{0}C		330 ^{0}C	
	$\tau_{1/2}$	$\tau_{\text{п}}$	$\tau_{1/2}$	$\tau_{\text{п}}$
MA1 (Mg+ 10wt.% Ti +5%wt.Y)	6,5	18	5	14
MA2 (Mg+ 10wt.% Ni +5%wt.Y)	2,73	9	2,1	5
MA3(Mg without Ti, N, Y)	88	130	30	80
MA4 (Mg + 10 wt.% Ti)	8,5	25	5,5	14
MA5 (Mg + 10 wt.% Ni)	2,2	7	1,6	5

hydrides or intermetallic hydrides ($TiFeH_2$), and therefore on the kinetics of their decomposition. As shown by XPS analysis [56], among such transition metals as Ti, Mn, Fe, nickel turned out to be the metal whose presence on the surface of the hydride-forming alloy more prevents its contamination with catalytic poisons and, as a result, maximizes its reactivity.

Conclusion

The new alloys-composites with reduced thermal stability and improved kinetics of the decomposition of their hydride phase MgH_2 were synthesized by the reactive grinding in the hydrogen atmosphere of a mixture of Mg powder with different content of additives Ti, Ni and Y. The influence of alloying elements Ti, Ni, Y on the hydrogen sorption properties, thermal stability and kinetics of the hydrogen desorption process from the hydride phase MgH_2 of the obtained MAs has been studied. It was established that the addition of Ti + Y and Ni + Y to magnesium leads to a significant improvement in the kinetics of hydrogen desorption from the MgH_2 hydride phase of the obtained MAs, as evidenced by the experimentally recorded significant reduction in time of the half and total quantity of desorbed hydrogen. The reduction of the thermodynamic stability of MgH_2 hydride due to its doping by Ti, Ni, Y was not detected. Results of the present study can be used in the development of new hydrogen sorbent materials for hydrogen energy.

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Воденьсорбційні властивості, термостабільність та кінетика десорбції водню з гідридної фази MgH_2 механічних сплавів на основі Mg з Ti, Ni та Y

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Були синтезовані механічні сплави - композити (МС) Mg +10 % ваг.Ti + 5 % ваг.Y та Mg +10 % ваг. Ni + 5 % ваг.Y). Фазовий склад, мікроструктура, термічна стабільність, кінетика десорбції водню з гідридної фази MgH_2 з отриманих МС були вивчені з використанням XRD, SEM, термодесорбційної спектроскопії (ТДС). Встановлено, що додавання Ti + Y та Ni + Y до магнію призводить до значного поліпшення кінетики десорбції водню з гідридної фази MgH_2, про що свідчить скорочення в 6 і 15 разів часу виділення всього водню з МС1 і МС2, відповідно при його тиску в реакторі 0.1МПа. Внаслідок цього легування зниження термодинамічної стабільності MgH_2 не встановлено.

Ключові слова: механічний сплав, гідрид MgH_2,воденьсорбційні властивості, термічна стійкість, кінетика десорбції водню.