PROCEEDINGS OF THE INTERNATIONAL CONFERENCE NANOMATERIALS: APPLICATIONS AND PROPERTIES
Vol. **2** No 1, 01NTF37(3pp) (2013)

Effects of Deuterium Concentration on Deuterium Desorption Temperature Range from Ni - In Composites

A.V. Zvyginceva[1,*], O.M. Morozov[2,†], V.I. Zhurba[2], V.O. Progolaieva[2]

[1] *Voronezh State Technical University, Faculty of Physics and Engineering, Voronezh, Russia*
[2] *National Science Center "Kharkov Institute of Physics & Technology",1 Akademicheskaya Str., Kharkov, Ukraine*

(Received 15 June 2013; published online 01 September 2013)

Spectra thermal desorption deuterium from the samples of system Ni-In preliminary implanted by various doses of deuterium ions at T~100 K. On the basis of these spectra are studied dependences of change are constructed.

It is shown that the structure of spectrum, thermal desorption_deuterium is function doses. On saturation of composite $Ni_{70}In_{30}$ with deuterium through ion implantation at T ~100 K the ultimate attainable concentration of deuterium makes ~2 at.D/at.Met.The increase in deuterium concentration brings about in composite $Ni_{70}In_{30}$, in addition to the solid state solution deuterium (decomposition at temperature ~530 K), the formation of the hydride, whose temperature of decomposition in vacuum is ~350 K.

Change of the component content in system Ni-In leads to essential change of a kind of a spectrum thermal desorption deuterium, shown in occurrence of additional temperature areas desorption (peaks) that testifies to formation of additional structural formations.

Keywords: Ni–In composites, Deuterium, Thermal desorption, Implantation

PACS numbers: 61.82.Rx, 64.75.St, 65.90. + I

1. INTRODUCTION

Studying mechanism of development hydrogen interaction with metals and alloys in a wide range of temperatures and pressure is an important problem in physical materials technology both with scientific, and from the applied point of view.

One of the most informative methods of hydrogen behavior in materials investigation is the method thermal desorption spectroscopy (TDS). Along with definition of temperature ranges of capture and allocation of the introduced hydrogen, definition thermal activation parameters, the method has shown good correlation of spectra hydrogen thermal desorption with phase diagrams of state systems metal-hydrogen, as has been successfully realized in studying kinetics formation and disintegration hydride phases of systems Pd-D [1], Ti-D [2], Zr-D [3].

In the given work as a method electrolytic sedimentation composite materials of system In-Ni are make and temperature ranges desorption ion-implanted deuterium depending on a parity a component and doses implanted deuterium are investigation.

2. MATERIALS AND METHODS

An irradiation of samples and measurement of thermal desorption spectra have been executed on the experimental installation "SKIF" in details described in work [4]. Deuterium introduction into the samples was performed by the ion implantation method (12 кэВ doses in range 3×10^{17}-3×10^{18} at.D/sm^2).

Ni-In composites received electrolytic sedimentation, with electrolyte compound: $NiSO_4 \times 7H_2O$ = 140 g/l; $Na_2SO_4 \times 10H_2O$ = 20 g/l; $In_2(SO_4)_3$ = 2 g/l; 4 g/l; 12 g/l [5]. Electrolysis it was spent by the platinum anode and the copper cathode. At increase in concentration $In_2(SO_4)_3$ from 1 to 12 g/l maintenance In in system increases in electrolyte to 47,5 wt.%, and Ni, accordingly, there is 52,5 wt.% that in recalculation for nuclear percent corresponds stoichiometry $Ni_{68}In_{32}$. At use of concentration $In_2(SO_4)_3$ in electrolyte 4 g/l samples with stoichiometry $Ni_{70}In_{30}$ have turned out. The maintenance of components in system Ni-In was defined by a X-Ray-fluorescent method.

3. RESULTS AND DISCUSSION

On fig. 1 characteristic thermal desorption spectra, the composite of stoichiometry $Ni_{70}In_{30}$ deuterium implanted in samples are resulted. Apparently from drawing, the structure of thermal desorption spectra is function deuterium doses. At low doses deuterium at a spectrum there is one peak with temperature of a maximum ~ 530 K. Such kind of a spectrum remains up to a dose 3×10^{17} at.D/sm^2. Dose increase leads to occurrence new low temperature peak with temperature of a maximum ~ 420 K.

The further increase in a dose temperature of a maximum of this peak of gas evolution gradually is displaced in area of lower temperatures. Thus the high-temperature site lower temperatures peak is stretched in area of high temperatures up to temperatures 600-700 K.

Presence of unique peak at low doses is caused by formation of a phase condition of a firm solution deuterium in composite Ni70In30, which temperature of disintegration ~ 530 K. This conclusion is made on the basis of the data received at studying kinetics of formation and disintegration hydride phases of systems

* zvyagincevaav@mail.ru
† morozov@kipt.kharkov.ua

Pd-D, Ti-D, Zr-D [1-3].

The low temperature area desorption apparently testifies to the hydride formation which disintegration begins at room temperature (the beginning deuterium desorption).

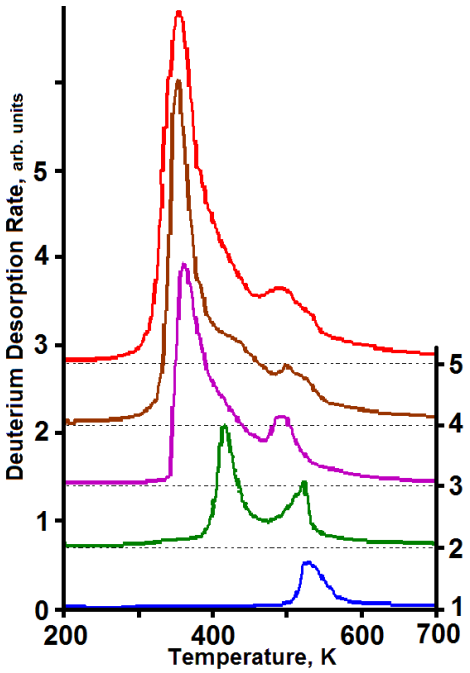

Fig. 1 – Thermal desorption spectra of deuterium released from composite $Ni_{70}In_{30}$ implanted in samples: (1) – 3×10^{17} D/cm^2; (2) – 7.5×10^{17} D/cm^2; (3) – 1.3×10^{18} D/cm^2; (4) – 2×10^{18} D/cm^2; (5) – 3×10^{18} D/cm^2

The analysis of the behavior of the curves in fig. 2, illustrating the quantity change deuterium released, shows that up to dose achievement 2×10^{18} D/cm^2 linear dependence of quantity introduced deuterium from an irradiation dose is traced. Then the sharp deviation from linearity and a tendency to an exit on saturation is observed at a dose ~ 3×10^{18} D/cm^2. Such course of dependence testifies that at temperature of implantation (~ 100 K) introduced deuterium has low diffusion mobility and is in limits implantation a layer. In view of that at irradiation temperature implanted deuterium at doses $\le 2\times10^{18}$ D/cm^2 is almost motionless and remains in limits implantation a profile, and also, considering size of average projective run of ions D^+ with energy 12 keV in a composite and the profile form bedding deuterium, it is easy to show that at aforementioned value of a dose of introduction the maximum concentration deuterium in implantation a profile makes ~ 2 at.D/at.Met, i.e. the concentration corresponding to value stoichiometric of a parity in hydride MeD_2 is reached.

According to the diagram of a phase state of system In-Ni (see fig. 3 [4]) for $Ni_{70}In_{30}$ composites presence of relatives on structure of chemical compounds Ni_3In and Ni_2In is characteristic. Nevertheless in our case, judging by thermal desorption spectra of deuterium (fig. 1 see), the single-phase condition with presence of considerable deformation pressure to what high-temperature site of a spectrum slowly falling down on temperature thermal desorption spectra of deuterium testifies is characteristic. It is promoted by essential distinction in the sizes of atoms a component in samples $R_{In}/R_{Ni} \cong 1.3$ ($R_{Ni} \cong 0.125$ nm; $R_{In} \cong 0.163$ nm).

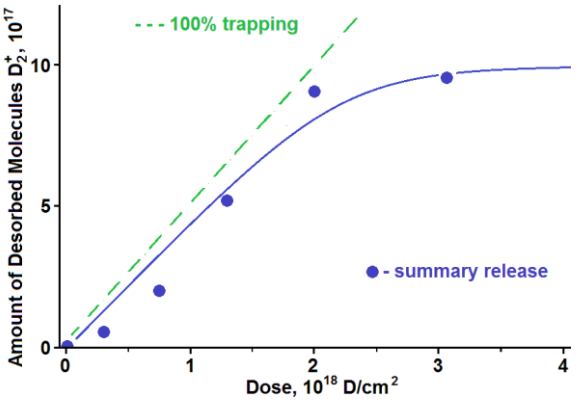

Fig. 2 – Integral quantity of desorbed deuterium as functions of implantation dose for a composite $Ni_{70}In_{30}$

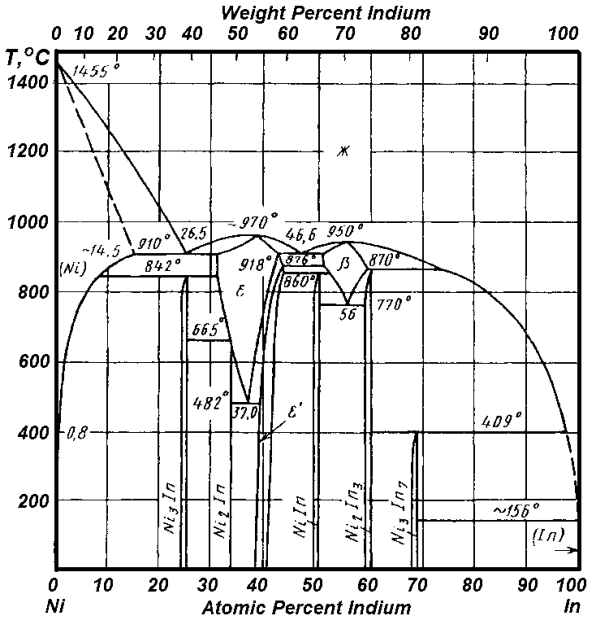

Fig. 3 – In-Ni. Phase diagram [6]

Change of the component content in samples system Ni-In has led to essential change of a kind of a thermal desorption spectra of deuterium, call forth in occurrence of additional temperature areas desorption (peaks) that testifies to formation of additional structural formations (see fig. 4).

Annealing composites leads to changes in thermal desorption spectra structure and testifies to essential structural changes in composites. The data about structural changes in the composites which have passed annealing we will present in the following publication.

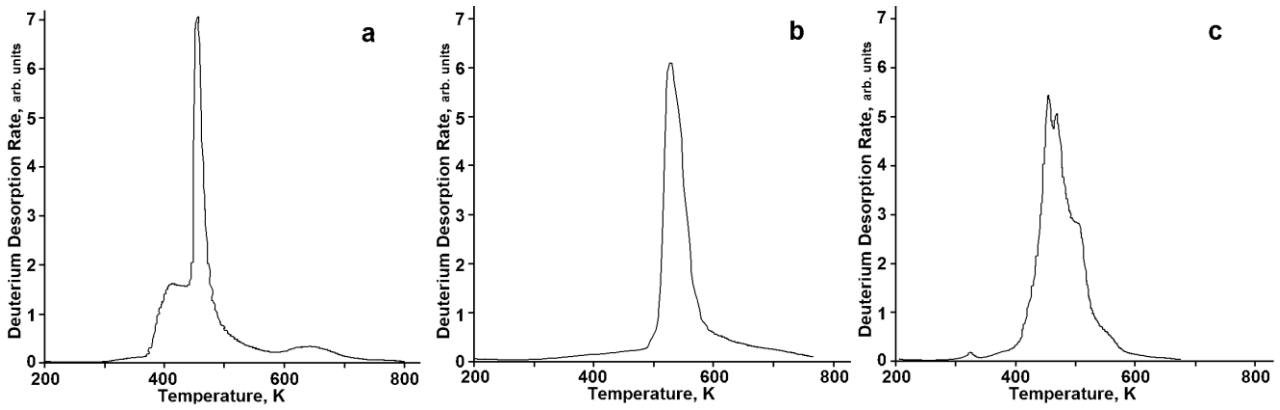

Fig. 4 – Thermal desorption spectra of deuterium to implanted in composite systems Ni–In (dose 3×10^{17} D/cm^2) depending on content composite: (a) - $Ni_{70+x}In_{30-x}$; (b) - $Ni_{70}In_{30}$; (c) - $Ni_{68}In_{32}$

4. CONCLUSIONS

The structure of thermal desorption spectra is deuterium doses function.

On saturation of composite $Ni_{70}In_{30}$ with deuterium through ion implantation at T ~100 K the ultimate attainable concentration of deuterium makes ~2 at.D/at.Me.

The increase in deuterium concentration brings about in composite $Ni_{70}In_{30}$, in addition to the solid state solution deuterium (decomposition at temperature ~530 K), the formation of the hydride, whose temperature of decomposition in vacuum is ~ 350 K.

Change of the component content in system Ni-In leads to essential change of a kind of a spectrum thermal desorption deuterium, shown in occurrence of additional temperature areas desorption (peaks) that testifies to formation of additional structural formations.

REFERENCES

1. V.F. Rybalko, A.N. Morozov, I.M. Neklyudov, V.G. Kulish, *Phys. Lett.* **287A**, 175 (2001).
2. I.M. Neklyudov, V.F. Rybalko, A.N. Morozov, V.G. Kulish, *Materealovedinie* **№11**, 45 (2005) [in Russian].
3. I.M. Neklyudov, V.F. Rybalko, A.N. Morozov, V.G. Kulish, B.V. Borts, T.P. Cherniaeva, *Materealovedinie* **№10**, 51 (2002) [in Russian].
4. V.V. Ruzhitsky, Yu.A. Gribanov, V.F. Rybalko, S.M. Khazan, I.S. Martynov, A.N. Morozov, *Vopr. At. Nauki Tekhn. Ser.: Phys. Radiation Eff. Rad Mat. Sci.* **51**, 84 (1989).
5. A.V. Zviagintseva, *Galvanotehnika i obrabotka poverhnosti* **3** №5-6, 47 (1994).
6. *State diagrams of double metal systems* vol 3-1 (ed. N.P. Lyakishev) (Moscow: Mashinostroyenie, 2001) [in Russian].