Science and Technology City Hall
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Correlation of the structure of nickel-based electrochemical systems with hydrogen accumulation

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Problem statement

The work is devoted to the study of composite alloys Nix-By-Dz (Hz), obtained by the method of electrochemistry, with the aim of using it as an element of a metal hydride hydrogen storage device intended for use in the field of hydrogen fuel cells.

It is shown that the process of increasing the boron content in a nickel alloy is accompanied by an increase in the accumulated hydrogen in it. In other words, the boron impurity is a trap for hydrogen atoms in electrolytic nickel - boron composites.

This is the basis for the inclusion of the investigated alloy in a series of solid-state hydrogen storage devices.

Solution methods

Various methods of hydrogen storage are clearly demonstrated in the article. Analyzing various widespread methods of hydrogen storage, it is easy to conclude: the solid-state method of hydrogen storage has advantages over other methods.

The advantages include optimal volumetric and gravimetric density, safety and ease of storage without the use of bulky and expensive cryostat systems, as well as the extraction of hydrogen for consumption without the use of high temperatures and pressures, i.e. under normal thermodynamic conditions.

Hydrogen is a highly efficient energy carrier, and is widely used in industry, in particular, in the transport sector of the economy, therefore it is considered as a promising environmentally friendly renewable energy source, designed to replace existing energy sources . The process of formation of electrolytic metals (for example, nickel) occurs according to the scheme followed by the formation of a hydride phase (when interacting with atomic hydrogen):

$Me^{n+} + ne \rightarrow Me^0$; $H^+ + e \rightarrow H^0$; $H^0 + H^0 \rightarrow H_2$; $Me^0 + H^0 = MeH$.

The aim of this work is to optimize the parameters of nickel-based alloys to ensure increased susceptibility to hydrogen as a result of structure transformation (joint formation of structural defects in the alloy and hydrogen traps located in the vicinity of embedded boron atoms).

Solution methods

In this work, the hydrogen sorption properties of both pure nickel and boron-containing alloys based on it were estimated. The study was carried out on electrochemical samples of Ni-B alloys, by the method and differing from Ni by an increased defectiveness of the structure. The study of the dependence of the hydrogen sorption properties of nickel boron crystals on the boron content in them was determined using the "vacuum extraction" method.

Dependence of the hydrogen content on boron in the electrochemical complex Ni-B-H in the electrolysis mode: current density 2 A/dm^2; electrolyte temperature 40 ºC; electrolyte acidity 4.0; a sample thickness of 4 μm on a copper substrate, grade M-1

The hydrogen content in the sample, $cm^3/100$ g.	Boron content in the nickel-boron composite, wt. % Determination method - spectrophotometric.	Boron content in the nickel-boron composite, atom. % Method - mathematical recalculation.
104	0	0
85	0.18	0.94
69	0.35	1.87
75	0.45	2.40
80	0.62	3.28
113	0.97	5.05
200	1.33	6.82
348	1.65	8.35
591	1.91	9.56

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Conclusions

Results, implementation

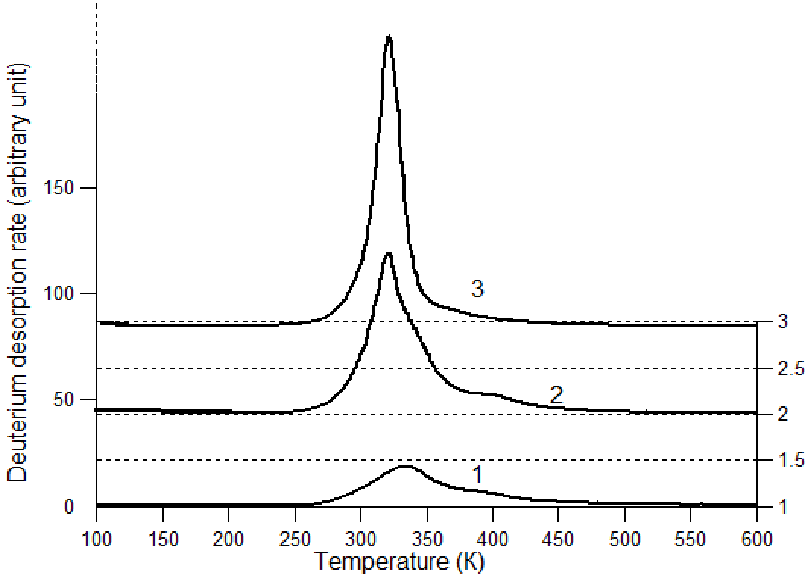

Figure 1. Deuterium thermal desorption spectra, implanted in pure nickel at a temperature of 100 K, obtained for different doses of implantation:1 – 2×10^{17}; 2 – 4×10^{17}; 3 – 1×10^{18} D/cm^2

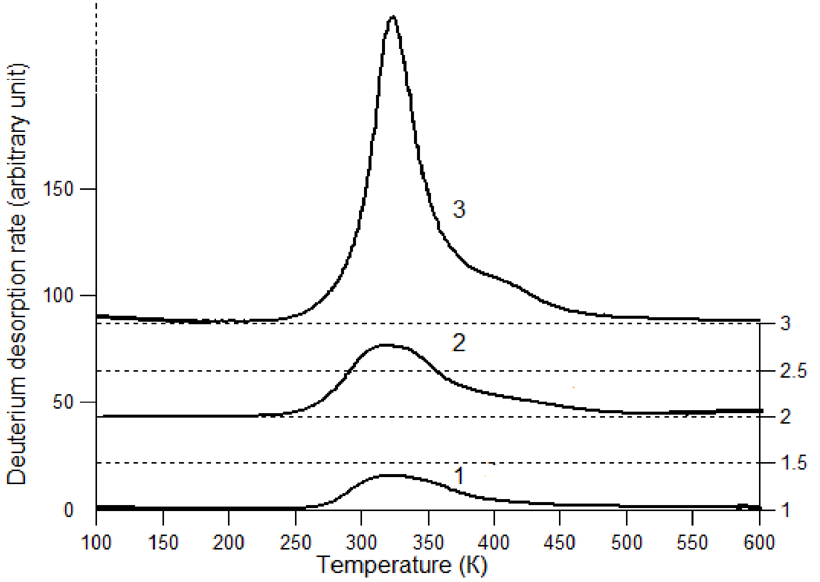

Figure 2. Deuterium thermal desorption spectra, implanted in a Ni-B alloy with a boron content of 1 wt.% B at a temperature of 100 K, obtained for different doses of implantation: 1 – 2×10^{17}; 2 – 4×10^{17}; 3 – 1×10^{18} D/cm^2

The results of measurements of samples of pure Ni and Ni–B alloy are shown in figure 1, 2. The most typical spectra of thermal desorption of deuterium from samples of the Ni–B composite for various doses of implanted deuterium are shown in figure 2.

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