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Ascending Diffusion Or Transmutation

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INTRODUCTION

In any field of investigations new ideas in combination with newly developed equipment can provide advance results. In view of arising interest to cold nuclear fusion (CNF) [1] and searches for consequences of its occurrence the study of the interaction of hydrogen with metals has coincided with the wide spread of the micro-probe X-ray spectrum analysis. This analysis is performed during measurements of alloying element concentration [1] with resolution of about 1x1 μm^2.

Savvotimova et al. [2] revealed the appearance of residual elements on the surface of a palladium cathode after electrolysis in the plasma of a glow discharge in deuterium medium and established that concentration of these elements increases by tens and thousands times. The authors ascribe the local concentration of elements (Ag, B, Ni, et al.) to transmutation resulted from nuclear reactions, though, according to the measurements made by the authors, the number of detected γ -quanta is 8-10 times less than it is required for the case of appearance of such amount of residual elements. The results of this paper in respect to accumulation of elements are confirmed in a number of publications relating to electrolysis on palladium cathodes [3,4] where the term “non-expected elements “ was introduced.

The present paper ascribes the appearance of these clusters in titanium alloy samples to ascending diffusion of impurities.

MATERIALS AND EXPERIMENTAL PROCEDURE

A sample of VT9 titanium alloy was saturated by hydrogen (^1H) from a gas phase at the temperature T= 850^0 C up to the concentration C_H= 0, 57 wt. % using a Siverts type device. The sample was subjected to multiple steps forging in the air at the temperature T≈ 600^0 C with changing the axis of deformation through 90^0 according to the technique described in [5].

The analysis of its composition was made using an electron microscope Jeol JXA-6400 with an X-ray-fluorescent adapter.

EXPERIMENTAL RESULTS

In recent years we studied the formation of ultra fine-grained structure in titanium alloys during severe plastic deformation using reversible hydrogen alloying [5]. Prior to mechanical testing the samples was subjected to degassing. The samples with a total weight of 30 g and a minimum thickness of 2mm were installed into a special device. In the process of dehydrogenation annealing of the samples at the temperature 600°C one observed a semi-transparent film of a metal with the dimensions ∅35x120 mm at the distance of 100 mm from the furnace. The metal observed was Zn, and its concentration was no less than 98 %. The spectrum analysis of the initial metal showed the presence of Zn with the concentration not exceeding 10^{-4} wt %. The rapid calculation showed that the available amount of Zn was sufficient for the formation of the film revealed.

DISCUSSION OF RESULTS

First of all it should be noted that the alloy was saturated by conventional hydrogen (^1H), and one cannot speak about any transmutation of elements.

One of the most advanced theories of solid-state physics is a notion of dislocations as microscopic defects of a crystal lattice. At present, on the basis of the theory of dislocations many experimental facts are explained including those connected with the interaction of hydrogen with metals. It is known that hydrogen interaction with dislocations creates atmospheres [6-8].

A number of studies devoted to the formation of dislocations and their interaction with interstitial and substitutional impurities during deformation of metals are known. For example, it was concluded [9] that substitution atoms with an ion radius larger than the ion radius of the basic metal (R_0) and all interstitial atoms are concentrated in the region of tension formed by the dislocation field, while atoms with the ion radius smaller than R_0 tend to the region of compression.

It is also known that hydrogen atmospheres move at rather low strain rates since with increasing strain rates to some critical values, dislocations lose contact with atmospheres [6]. That is why traditionally low strain rates are used for the formation of fine-grained structure [10]. The joint action of these processes is responsible for the formation of segregations of residual elements with hydrogen in the vicinity of the sample surface during multiple step forging. Further vacuum annealing of samples at the temperature $T \approx 600^0$ C leads to intense release of hydrogen that leaves the sample together with zinc impurity.

The elevated rate of diffusion in the presence of dislocation was noted in a number of studies devoted to self-diffusion [11, 12], and was explained as diffusion along *dislocation tubes* [13]. So, the extraction of zinc from samples can be explained by well known mechanisms of solid-state physics without applying additional ideas such as transmutation of elements.

The process of saturation of samples by hydrogen isotopes at room temperature also leads to the processes analogous to the ones described above. However, this occurs not due to external deformation. As the hydrogen concentration in the metallic matrix increases the constant lattice grows [7, 8] and at room temperature this results in initiation and growth of internal stresses. These stresses generate dislocations that have their own non-symmetric stress fields. The region of tension created by these stresses is inhabited by interstitial and substitutional atoms the sizes of which are larger than the sizes of atoms of the basic metal, while the region of compression is inherited by substitutional atoms with sizes less than those of the basic metal. As a result, Kottrel atmospheres are created [9].

It is rather easy to explain the formation of hydrogen atmospheres and segregation of metal ions in them during electrolysis in water solutions or saturation in the plasma of a glow discharge, the radius of metal ions being different from that of the titanium or palladium. Nobody doubts in the existence of atmospheres of hydrogen atoms at room temperature. That is why the creation of clusters of residual elements depends only on the duration time of hydrogen saturation that should be long because of the low rate of diffusion. Then, due to the movement of such clusters some impurity elements come to the surface.

From photos given in [3, 4] it is seen that segregations of unexpected elements have a local character. On the basis of general considerations it seems that exactly so must look the results of local diffusion along the *dislocation tubes*.

The influence of such atmospheres comprising deuterium and concentrated impurities on fusion of deuterium nuclei, i.e. cold nuclear fusion itself, is not yet clear. This issue requires additional studies.

The occurrence of such high concentrations of alloying elements in the vicinity of the surface of a metal can lead to the formation of new phases including the ordered ones. Due to their brittleness these phases can cause initiation of cracks and this might be one more reason for hydrogen brittleness.

Besides, this phenomenon has its own independent value, since after more thorough study it can be used for purification of hydrogen solvent metals from impurities. This can be implemented for processing articles out of pure and extremely pure metals such as palladium and titanium.

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