

STRUCTURE-PHASE MECHANISM OF α_2 -Ti₃Al DESTRUCTIVE HYDROGENATION

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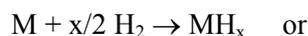
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Introduction

At the present-day stage of the technological expansion the alloys on the basis of the titanium aluminids and the ordered solid solution α_2 -Ti₃Al in particular are the perspective materials for application in the biomedicine, in the aircraft, aviation and motor-car industries. They are characterized by the favorable combination of the most important features for the construction materials as low density, high melting temperature, high heat - resistance and corrosion stability. At the same time the large titanium content in Ti₃Al (up to 88 mass. %) guarantees the high hydrogen capacity (about 3,32 mass. %). However high dehydrogenating temperature and extremely low rate of interaction with hydrogen confine the utilization of α_2 -Ti₃Al as hydrogen accumulator.

Ti₃Al interaction with hydrogen can be realized in accordance to reactions:



We shall call these reactions as direct and destructive hydrogenation of Ti₃Al accordingly.

Purpose of the present work is investigation of the structure-phase mechanism of α_2 -Ti₃Al destructive hydrogenation.

Results and discussion

The experimental objects are the semicircular plates of 3 mm in thickness and 12 mm in diameter. The microsections are made on the plane-parallel sides before the hydride experiments immediately with the aim of oxygen films elimination and easing the activation of Ti₃Al interaction with hydrogen.

The mechanism of Ti₃Al destructive hydrogenation is investigated by the way of long-term consistent small - stepping hydrogenation of the initial samples at the constant temperatures of 293, 373, 473, 573, 873 and 973 K. In each new experiment the new initial Ti₃Al plates were used for the making of the samples with the increasing hydrogenation ranges. The samples after hydrogenation were put to the structure - phase investigation.

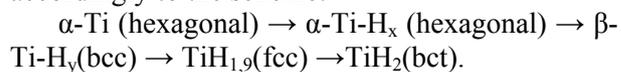
The diffractograms of the products of α_2 -Ti₃Al destructive hydrogenation at the temperatures of

293, 373, 473, 573, 873 and 973 K during 130 hours are obtained. It is shown that only titanium hydrides with cubic face centered (TiH_{1,9}) and/or TiH₂ tetragonal (TiH₂) structures, which are different by the hydrogen concentration, are the products of DH at 293, 373, 473 K. Aluminum consisting phases are not registered. One can suppose that aluminum is part of disordered X-ray-amorphous structure of nonstoichiometric Ti_{3-x}Al composition.

On diffractogram of α_2 -Ti₃Al after destructive hydrogenation at 573 K the peaks of titanium hydrides and halo with the evidence of the forming TiAl₂ and TiAl₃ phases on the places of their main Bragg peaks are revealed. The structures of TiAl₂ and TiAl₃ phases are formed better after the DH at 873 and 973 K, about which the intensity increase and X-ray peak narrowing are evidence.

It is significant the registered after 96 h of DH at the temperature of 293 K fact of formation of the β -titanium stabilized by hydrogen. This phase was the fine lamellate and was contained in the mixture with the powders of the cubic and tetragonal titanium hydrides as well as the disordered Ti_{3-x}Al-H. In accordance to titanium - hydrogen equilibrium diagram the hydrogen solution in α -titanium becomes the thermodynamically unstable at 593 K and its hexagonal lattice rebuilds in the face centered cubic lattice of β -titanium stabilized by hydrogen. Obviously the decrease of the temperature of $\alpha \rightarrow \beta$ transition in titanium from 593 to 293 K during Ti₃Al destructive hydrogenation is caused by the effect of aluminum consisting phase Ti_{3-x}Al-H on the thermodynamic equilibrium in Ti-H system.

The mechanism of α_2 -Ti₃Al destructive hydrogenation is determined. It consists in the next. When the concentration of the soluted hydrogen enhances to 0,44 % mass., the crystalline structure of Ti₃Al is disordered. Then hydrogen interacts not with disordered alloy, but with titanium, which is went out from Ti₃Al, accordingly to the scheme:



The intermetallic compounds TiAl, TiAl₂, TiAl₃ with the enhanced aluminum content are

arised, when the suitable stoichiometric concentrations are formed.

For the obtaining of the monolithic nonporous composite the initial Ti_3Al alloy was destructive hydrogenated at 973 K under hydrogen pressure 1,0 MPa during 4 hours. Its phase compositions was $(Ti_3Al-TiAl-TiAl_2) - ((\alpha-Ti-H_x) - (\beta-Ti-H_y)-TiH_2)$. The microstructure of the obtained composite was investigated by the procedure of the diffraction electronic microscopy with the use of microscope of JEM 100 CX1 type.

The volume-modulated structure of the composite is registered. The composite consists of the continuous matrix and inclusions situated in it. The matrix is composite and consists of Ti_3Al , $TiAl$ and $TiAl_2$ phases. It has the lamellar structure with the layer width from 70 up to 170 nm. The minimum dimensions of the intermetallic components are near unities of nanometers. The inclusions are composite too, consist of $(\alpha-Ti-H_x)$ (hexagonal), $(\beta-Ti-H_y)$ (bcc), $TiH_{1,9}$ (fcc), TiH_2 (bct) phases, which are situated in

the twin orientation. The twin width is from a few nanometers.

Conclusions

Interaction between α_2-Ti_3Al alloy and hydrogen in temperature diapason from 298 K up to Ti_3Al melting temperature is performed in accordance to the reaction of the destructive hydrogenation. The structure-phase mechanism of Ti_3Al destructive hydrogenation has been investigated. Titanium hydride and Ti-Al intermetallic compounds with the enhanced aluminum content in comparison with Ti_3Al are formed. Such hetero-phase composites have nanosize structure components and are characterized by the increased hardness. The obtained results are important in the view of the development of the new hydrogen-thermal technology for the treatment of the titanium intermetallic compounds directed to forming *in situ* the nanostructure conditions with new useful properties.