

# INVESTIGATION OF $Ti_{1.5}Al-NH_3$ AND $Ti_2Al-NH_3$ SYSTEMS

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## Introduction

Now in a number of the scientific works in chemistry and materials technology of alloys and compounds of the titanium it is communicated about perspective of alloys of Ti-Al system as the constructional materials possessing rather small relative density and significant stability to oxidation [1, 2]. But the alloys with the high content of the titanium possess significant plasticity that is by the reason of occurrence of cold-hardening, amorphous phases and oxidation of a surface of particles at mechanical crushing a cast material. Therefore it is necessary to find and develop other ways for crushing, in particular for these purposes the ammoniac dispergation method can be used [3].

The present work continues the investigation of Ti-Al-NH<sub>3</sub> system and contains data about transformations and properties of alloys Ti<sub>1.5</sub>Al and Ti<sub>2</sub>Al, consisting of intermetallic compounds TiAl and Ti<sub>3</sub>Al, in the ammonia medium in an interval of the temperatures 100-500°C in the presence of ammonium chloride as promoter of hydronitriding process.

## Results and discussion

The composition of initial alloys established by the X-ray phase analysis, according to which the melted alloys are biphasic and consist from the intermetallic compounds Ti<sub>3</sub>Al ( $a = 5.792 \text{ \AA}$ ,  $c = 4.660 \text{ \AA}$ ) and TiAl ( $a = 3.976 \text{ \AA}$ ,  $c = 4.100 \text{ \AA}$ ). The specific surface area of 100-micron fraction of powders of alloys makes 0.05 m<sup>2</sup>/g.

The treatment products of powders of alloys by ammonia at temperatures up to 400°C are a mixture of not shared hydride and hydridonitride phases of intermetallic compounds making alloys. Therefore it is not obviously possible to determine a concrete chemical composition for each phase. Besides to rise in temperature of heating from 100 up to 400°C the formation of amorphous intermetallide TiAl occurs.

The treatment of alloys by ammonia at 100 and 150°C is accompanied by formation of hydride phases of intermetallic compounds without essential change of parameters of a crystal lattice, but with increase in the size of a specific surface area of a product at the order of size (from 0.05 up to 0.2 m<sup>2</sup>/g). Such gain of size of a surface is caused

by the further crushing of particles during hydronitriding a powder of an alloy. The content of the absorbed hydrogen is kept at a level of 0.5 wt. % and after removal of pressure that testifies to hydrogenation of a mixture of intermetallides at the indicated temperatures and formation of steady hydride phases with rather developed surface, but with the small contents of the absorbed hydrogen, that is the treatment of alloys by ammonia at 100 and 150°C is process of hydride dispergation [3].

With the further rise in interaction temperature (from 200 up to 400°C) of powders of alloys with ammonia in products of reactions the content of the absorbed hydrogen increases (up to 0.8-1.0 wt. % at temperature of hydronitriding 400°C) and simultaneously there is an introduction of nitrogen deal in a crystal matrix of intermetallides. At that at increase in temperature in the specified interval the nitrogen content raises up to 2.3-2.7 wt. %. Accumulation of hydrogen and nitrogen occurs still without destruction of an initial crystal lattice to what data of the X-ray phase analysis of products of reactions testify. The maximal compositions on hydrogen are noted for the samples received at 400°C (for example Ti<sub>1.5</sub>AlH<sub>0.8</sub>N<sub>0.2</sub> and Ti<sub>2</sub>AlH<sub>1.3</sub>N<sub>0.2</sub> after pressure chop). The parameters of a crystal lattice of hydridonitride phases received on the basis of the intermetallide Ti<sub>3</sub>Al, a part of alloys Ti<sub>1.5</sub>Al and Ti<sub>2</sub>Al, vary within the limits of  $a = 5.7251-5.7910 \text{ \AA}$ ,  $c = 4.6075-4.6321 \text{ \AA}$  for phases of a number of Ti<sub>1.5</sub>Al and  $a = 5.7550-5.7990 \text{ \AA}$ ,  $c = 4.6322-4.6501 \text{ \AA}$  – for of a number of Ti<sub>2</sub>Al. The specific surface area of products of ammoniac treatment at 350-400°C gradually increases and reaches 1.2 and 3.3 m<sup>2</sup>/g.

The treatment of investigated alloys by ammonia at 450-500°C causes destruction of a crystal lattice of the intermetallides, making alloys, and hence processes, characteristic for products of decomposition of compounds in an ammonia atmosphere. However the destruction of alloys is not the finished process at the given temperatures to what testify characteristic for initial intermetallic compounds strips of reflections on X-ray spectrum of hydronitriding products. The titanium formed at specified temperatures enters into interaction reaction with hydrogen, which source is ammonia,

with formation of the titanium dihydride. The quantity of the last increases with rise in reaction temperature from 450 to 500°C. Simultaneously the titanium dihydride, cooperating with nitrogen, which source also is ammonia, turns to the titanium nitride, that already it was marked earlier [3]. This transformation is accompanied by formation of intermediate hydridonitride phases of variable composition. Besides among products of reaction the intermetallic compounds TiAl<sub>3</sub> and TiAl<sub>2</sub> not interacting with hydrogen are present as destruction products of a metal lattice of intermetallides making initial alloys. The aforesaid explains the complex composition of products of interaction of alloys with ammonia at the temperatures 450-500°C. It is necessary to note, that according to data of the chemical analysis products of the hydronitriding lead at 450-500°C contain a significant amount of nitrogen – up to 8.6 and 3.9 wt. % for of Ti<sub>1.5</sub>Al–NH<sub>3</sub> and Ti<sub>2</sub>Al–NH<sub>3</sub> systems accordingly. These data confirm the results of the X-ray phase analysis about formation and accumulation of nitride phases in products of reactions.

In the table 1 the values of a specific surface area of hydronitriding products of the investigated alloys and, for comparison, the intermetallic compounds Ti<sub>3</sub>Al and TiAl at the temperatures 100-500°C are resulted. The presented data testify to growth of a specific surface area of products with increase in temperature of hydronitriding of all investigated alloys. It is possible to see also, that at heating up to 250°C the hydronitriding products have rather not developed specific surface testifying to an existent only embrittlement of a surface of particles.

Table 1. Specific surface area (m<sup>2</sup>/g) products of hydronitriding of alloys at various temperatures

T, °C	The initial alloy			
	Ti <sub>3</sub> Al	Ti <sub>2</sub> Al	Ti <sub>1.5</sub> Al	TiAl
100	0.1	0.1	0.4	0.5
150	0.1	0.2	0.2	0.4
200	0.2	0.2	0.2	0.4
250	0.5	0.5	0.6	0.5
300	0.8	0.7	0.9	5.7
350	1.8	1.2	1.4	3.1
400	3.6	3.3	1.3	2.8
450	5.7	5.4	3.9	3.7
500	8.8	7.3	17.8	1.5

For reception of superfine or nanopowder from alloys Ti<sub>1.5</sub>Al and Ti<sub>2</sub>Al it is necessary to use additional high-energy treatment, for example in conditions of planetary spherical mills. The powders which are obtained at hydronitriding temperature of 350-400°C and being on the size of particles (0.3-0.6 nm) superfine are more perspective in this respect. The powders received at temperature of 500°C are characterized, especially in case of Ti<sub>1.5</sub>Al, by the developed specific surface area, on two-three orders exceeding a surface size of initial alloys, but represent a mixture of various substances.

### Conclusions

The treatment of Ti<sub>1.5</sub>Al and Ti<sub>2</sub>Al alloys by ammonia at 400°C leads to formation of hydridonitride phases of intermetallides TiAl and Ti<sub>3</sub>Al with the size of particles of <1 micron.

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