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Evolution of Phase Composition of Composite Materials at Contact of Titanium-Aluminium Obtained by Welding Explosion

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In this work, welding explosion of multiple sample with its further annealing to 300 degrees is used as the method of receiving layered materials. Using this technology allows heating in the air; herewith possibility of oxygen penetration into internal material layers is eliminated. Using this technology allows heating in the air. Furthermore, pressures developed in the process of welding exposure ensure quality contact between the surfaces of plates [1].

Keywords: titanium-aluminium, composite materials, phase transformation, welding explosion, intermetallides.

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Эволюция фазового состава композиционного материала в зоне контакта алюминий-титан, полученного сваркой взрывом

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В данной работе в качестве метода получения слоистых материалов использована сварка взрывом многослойного пакета с последующим его отжигом до 300 градусов. Использование данной технологии позволяет проводить нагрев на воздухе, при этом устраняется возможность попадания кислорода во внутренние слои материала. Кроме того, давления, развиваемые в

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процессе сварки взрывом, обеспечивают качественный контакт между поверхностями соединяемых пластин [1].

Ключевые слова: титан-алюминий, композиционные материалы, фазовые превращения, сварка взрывом, интерметаллиды.

Introduction

At the moment, one of the most important tasks of machinery manufacturing development is improvement of quality, reliability and lifetime of the components of various machines and mechanisms. For solving this problem complex approach, including creation of new materials, development and learning to use new technologies is needed. The work [2] represents the method of obtaining composite materials on the basis of Ti-Al.

Many papers are concerned with structural transformation in the alloys on the basis of aluminum and titanium. Titanium alloys are characterized by sufficient specific strength, high anticorrosion properties and considerable heat resistance. The advantage of heat-resistant Titanium alloys is small specific weight and small specific stress during operation of the components in centrifugal conditions. These are disks, blades and other components of gas turbines [3]. The studies undertaken earlier showed possible simplifying the technical process of creation of layered intermetallide Ti-Al composite materials in consequence of Ti and Al melt interaction [4].

Introduction of aluminum into technical titanium even in small quantities (up to 13%) allows sharp increasing alloy heat resistance when decreasing its density and cost. This alloy is a perfect construction material. Adding 3-8% of Al increases temperature of α-Ti transformation into β-Ti. Aluminum is basically the only alloying stabilizer of α-Al increasing its strength at stability of properties of plasticity and viscosity of titanium alloy and increasing its heat resistance, creeping strength and elastic modulus. The only disadvantage of titanium is eliminated this way [5].

However, during further annealing this material might have undesirable properties, such as fragility, small strength and plasticity, in consequence of which absolutely major defect – cracks occurs [6, 7].

Purpose of work

Researching of structure and phase composition at contact of AL-Ti material, obtained by welding explosion and further annealing at 300 °C.

Samples and methods of samples obtaining

Studying material was obtained by welding explosion. 12 plates of aluminium and 11 of titanium with thickness 0.5 mm and 1 mm were used for welding explosion. Explosive material is ammonite 6LS. Welding process was made in accordance with method, which described in work [1]. Phase composition of obtained composite (point TiAl3001 in Fig. 1) was studied by X-Ray diffractometer “Bruker”. After that sample was heated in high temperature X-ray diffractometer attachment to 300 °C (point TiAl3001 in Fig. 1). After that sample was annealed for 1 hour (point TiAl3002 in Fig. 1). Results of X-ray diffraction analysis at these points are shown in Fig. 1 and Fig. 2, respectively.

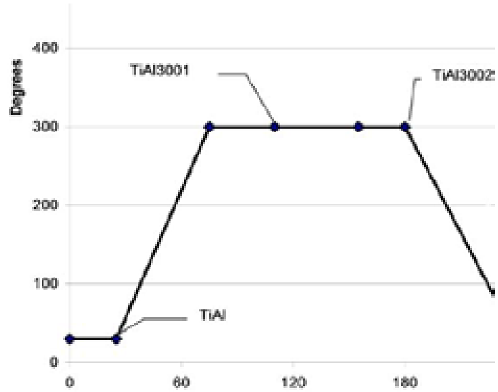


Fig. 1. Annealing scheme in X-ray diffractometer of the AL-Ti composite at 300 °C

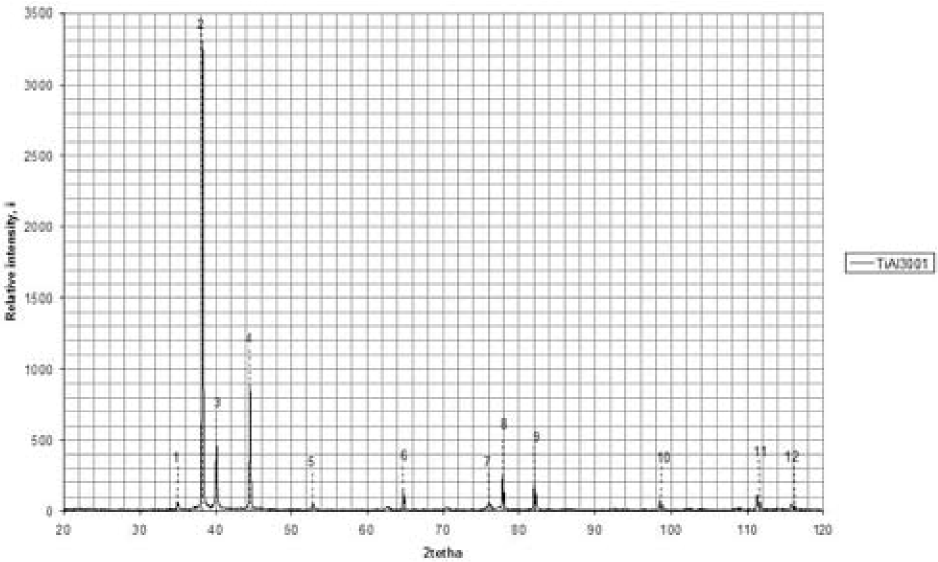


Fig 2. Diffractogram of sample of Ti-Al after heating for 1 hour to 300 °C

Results and discussion

Fig. 2 shows the X-ray diffraction pattern of Ti-Al obtained by diffraction analysis method.

As shown in Table 1, phase of solid solution of aluminum with titanium exists. According to work [8] phase reflexes of Al_3Ti are displaced phase reflexes of Al_2Ti are closer to the values obtained by us.

As shown in Table 2, phase TiO_2 appeared. And also a phase based on the fcc lattice of Al, which is equivalent of solid solution of aluminum with titanium, as mentioned earlier.

Welding explosion process is nonequilibrium process, as result of this process atomic displacement occurred. Such displacements were a reason of several phases' formation i.e. nonequilibrium structure, the positions of the atoms in this structure do not exactly correspond to the interatomic distances of equilibrium structures. The estimation of such displacements is given in the modifications column in Table 1.

Table 1. Explanation of the X-ray diffraction pattern shown in Fig. 2

№	Ti cph		Al face-centered		Θ	d (hkl)	2 Θ	Al_3Ti Pm3m	Al_2Ti ГПУ	Modifications
	hkl	d(hkl)	hkl	d(hkl)						
1	100	2.56437			17.6	2.5477	35.2	3.80	3.94	+1.3923
2			111	2.34925	19.15	2.3485	38.3	2.196	2.277	-0.0715
3	101	2.24902			20.05	2.2468	40.1	2.714	2.814	+0.5672
4			200	2.03495	22.25	2.0343	44.5	1.9	1.97	-0.0643
5	102	1.73022			26.45	1.7293	52.9	1.696	1.758	+0.0287
6		1.47892	220	1.43858	32.35	1.4395	64.7	1.342	1.392	-0.0475
7	112	1.25098			38.1	1.2484	76.2	1.551	1.608	+0.3596
8			311	1.22657	38.9	1.2267	77.8	1.145	1.187	-0.0397
9			222	1.17432	41	1.1741	82	1.098	1.138	-0.0361
10			400	1.01681	49.25	1.0168	98.5	0.95	0.985	-0.0318
11			331	0.93297	55.65	0.9330	11.3	0.871	0.903	-0.03
12			420	0.90946	58	0.9083	116	0.850	0.881	-0.0273

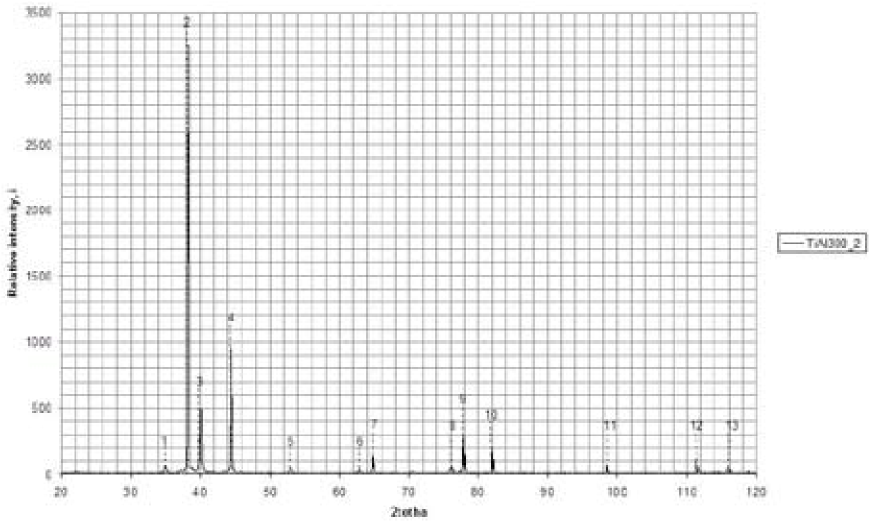


Fig. 3. Diffractogram of sample of Ti-Al after curing for 1 hour at temperature of 300 °C

As shown in Table 3, new lines № 6, № 8, № 9 appeared, explanations of these lines determined the Al_2Ti phase with a hcp lattice at 300 °C.

The explanations showed that Al_3Ti coincides within the error limits with the results of work [7, 8]. The detection of the Al_2Ti phase coincides with the results presented in works [7] and [9].

Fig. 4 shows transformation way from the bcc lattice to the hcp lattice with insignificant atomic displacements through the fcc phase.

Conclusions

1) Annealing at 300 °C temperature were a reason of titanium oxides elimination from the structure Ti-Al.

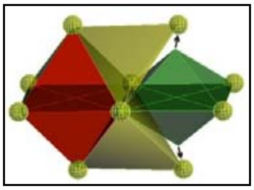
Table 2. Explanation of the X-ray diffraction pattern shown in Fig. 3

№	Ti		Al		Θ	d (hkl)	2 Θ	Al_3Ti	Al_2Ti
	hkl	d(hkl)	hkl	d(hkl)					
1	100*	2.56295			11.55	3.8476	35.1	3.80	3.94
2	002	2.35004			19.15	2.3485	38.3	1.9	1.97
3	101	2.24952			20	2.2523	40	2.714	2.814
4			200	2.03508	22.3	2.03004	44.6	1.9	1.97
5	102	1.73046			26.45	1.7295	52.9	1.696	1.758
6	110	1.47797			31.55	1.4721	63.1	2.714	2.814
7			220	1.43874	32.4	1.4375	64.8	1.342	1.392
8	112	1.25124			38.1	1.2484	76.2	1.551	1.608
9	201	1.22665			38.9	1.2267	77.8	1.696	1.758
10		1.17427	222		41	1.1662	82	1.098	1.138
11		0.99014	400	1.01675	49.25	1.0168	98.5	0.95	0.985
12			331	0.93301	56.5	0.9241	111.3	0.871	0.903
13			420	0.90941	58.15	0.9069	116.3	0.850	0.881

Table 3. Comparison of Al_2Ti phases, based on data of Tables 1 and 2

Al_2Ti				
№	hkl	Table 1	hkl	Table 2
1	100	3.94	100*	3.94
2	111	2.277	002	1.97
3	101	2.814	101	2.814
4	200	1.97	200	1.97
5	102	1.758	102	1.758
6	220	1.392	110	2.814
7	112	1.608	220	1.392
8	311	1.187	112	1.608
9	222	1.138	201	1.758
10	400	0.985	222	1.138
11	331	0.903	400	0.985
12	420	0.881	331	0.903
13			420	0.881

2) Shear deformation mechanism of the atomic groups displacement in mesoscopic spaces were suggested.



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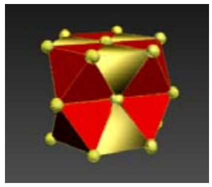

b

Fig. 4. Cluster model of the transition from the structure with the bcc lattice to the hcp lattice through the fcc phase

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