

DOI: <https://doi.org/10.37434/tpwj2022.07.05>

CORROSION RESISTANCE OF PLASMA COATINGS PRODUCED FROM COMPOSITE TiAl-BASED POWDERS WITH THE ADDITION OF NON-METALLIC REFRACTORY COMPOUNDS

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ABSTRACT

The results of the study of the phase composition and corrosion resistance of plasma coatings from composite powders based on intermetallic in TiAl with the introduction of non-metallic refractory compounds (SiC or Si₃N₄) into its composition are presented. The plasma coatings were deposited on the specimens of St3, AMg3 and VT6 alloys. The coatings were studied by the methods of metallographic and X-ray structural phase analysis. The studies of electrochemical properties of the plasma coatings were carried out by the potentiostatic method in a 3 % NaCl solution. As initial materials for plasma spraying, the composite powders TiAl–SiC, TiAl–Si₃N₄, produced by the method of mechanochemical synthesis were used. Using the method of X-ray structural analysis, it was revealed that the phase composition of the plasma coatings for TiAl–SiC system consists of the following phases: TiAl, TiAl₃, TiC, Ti₅Si₃, Ti₃AlC, TiO₂, and for the coating TiAl–Si₃N₄ from the phases Ti₂Al, Ti₅Si₃, TiN, TiO. The average thickness of the coatings was 200 ± 50 μm and the porosity did not exceed 10 %. It was found that the introduction of SiC or Si₃N₄ into the composition of the composite coating leads to a decrease in the corrosion current in a 3 % NaCl solution by about an order of value, and the corrosion resistance of St3, AMg3 and VT6 alloys increases by 12–13, 8–9, and 1.8–2.0 times, respectively. The service life of the plasma coatings made of TiAl composite powders with the addition of SiC and Si₃N₄ was calculated. The studied coatings belong to the class of resistant and are capable to protect metals in a 3 % NaCl solution for a period from 6 to 10 years.

KEYWORDS: intermetallics, titanium, aluminium, non-metallic refractory compounds, composite powder, plasma coatings, corrosion resistance

INTRODUCTION

Intermetallics of Ti–Al system have a number of unique properties such as high melting point, low density, high modulus of elasticity, yield strength, which grows (for TiAl) at an increase in temperature, high values of heat and corrosion resistance. Titanium aluminides (TiAl, Ti₃Al) can be used as structural materials, such as protective coatings in gas and oil refining facilities of the chemical industry, nuclear engineering, where such characteristics as corrosion resistance and resistance to high-temperature oxidation are required [1–8].

Such methods of spraying coatings are used as ion-plasma [9], magnetron spraying [10], electrospark deposition [11]. The results of these works indicate that introducing such elements as carbon, nitrogen and silicon into the composition of the coatings allows improving their protective and also anticorrosion properties.

At the PWI, for thermal spraying of protective coatings based on intermetallics of Ti–Al system, composite powders (CP) with the introduction of non-metallic refractory compounds (NRC) were developed, namely B₄C, BN, SiC and Si₃N₄.

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In this work, to study the corrosion properties of the coatings with CP based on TiAl intermetallics, two compositions of TiAl + 12 wt.% SiC and TiAl + 14 wt.% Si₃N₄ with addition of NRC were selected. The choice of these compositions was made on the basis of comparison of corrosion resistance of SiC and Si₃N₄ with other compounds of this group (B₄C, BN).

According to literary sources [12, 13], the beginning of B₄C oxidation is a temperature of 500 °C, and at 800–1000 °C, oxidation transfers to the active phase; BN is actively oxidized at 700–800 °C with the formation of B₂O₃, N₂, while Si₃N₄ silicon nitride has a high chemical resistance: compact specimens are resistant to air for a long time at 1200 °C, and in an oxygen medium, oxidation begins at 1000 °C and only at 1400 °C it runs actively. Regarding silicon carbide, as is known, even in an oxygen medium at 1300 °C, the ratio of weight of the oxidized powder before the initial state is less than 5 %.

Comparing the corrosion resistance of products of interaction of CP components TiAl–NRC (for B₄C and BN they include carbides, nitrides, and for SiC and Si₃N₄ they are silicides, titanium and aluminium nitrides) according to the literary sources [14], silicides have a higher corrosion resistance as compared

to other refractory compounds. This was the reason for choosing CP types in this work.

The aim of this work is the studies of influence of NRC (SiC, Si₃N₄) on corrosion resistance of plasma coatings from TiAl intermetallics and evaluating their protective action on carbon steels and light alloys (aluminium AMg3 and titanium VT6 alloys).

RESEARCH OBJECTS AND EXPERIMENT PROCEDURE

The initial materials for plasma spraying were CP TiAl–SiC and TiAl–Si₃N₄, produced by the method of mechanochemical synthesis with a particles size of 40–63 μm. The coatings were deposited on the specimens of St3, AMg3 and VT6 alloys in the installation UPU-8M for plasma spraying using the following modes: $I = 600$ A, $U = 40$ V, $Q_{Ar+N_2} = 50$ l/min, spraying distance — 80 mm.

The coatings were examined by the methods of metallographic, microdurometric and X-ray structural phase (installation Dron-UM-1, monochromatized CuK_α radiation) analysis.

The electrochemical properties of the plasma coatings were studied by the potentiostatic method in the potentiostat P-5827M at a scanning rate of 0.2 mV/s and a temperature of 18–20 °C. Stationary potentials were measured relative to the silver chloride electrode.

For the studies, the medium of a 3 % NaCl solution was selected. The choice of this electrolyte is predetermined by the fact that the main use of titanium and aluminium based alloys is the protection of parts and units in the aircraft industry [15]. The limited serviceability of individual units is associated with the fact that in them during operation many factors interact, which determines the conditions of operation — high-temperature gas corrosion, corrosion under the influence of Cl⁻ ions. The source of corrosion-aggressive components can be water, containing chloride ions, which enters the engine during injections (up to 1000–1200 injections per year). The presence of Cl⁻ ions leads to local destructions, as well as inhibits the formation of passive films on the metal surface. That is why as an aggressive medium for electrochemical tests, a 3 % NaCl solution was selected. Based on the experimental data, cathode and anode polarization curves were built in the coordinates $E_c = f(\lg i_c)$ where E_c is the potential, V; i_c is the corrosion current, A/cm². According to polarization curves, using the graphic method, the rate of i_c and the potential E_c of the corrosion respective to the extrapolation of Tafel slopes on cathode and anode curves before their mutual intersection were determined. Using the values of corrosion currents, determined from the polarization

curves, the weight and depth index of corrosion of the coatings were calculated by the formulas

$$K_w = \frac{iA1000}{nF}, K_d = K_d \frac{8.76}{\rho},$$

where K_w is the weight index of corrosion, g/(m²·h); A is the atomic weight of metal, g/mol; n is the valence of a metal ion, that went into the solution; F is the Faraday number, 26.8 A·h/mol; K_d is the depth index of corrosion, mm/year; ρ is the methane density, g/cm³; 8.76 is the coefficient for the transition from the weight index of corrosion K_w to the calculation for 1 h to the depth index of corrosion K_d of about a year, calculated from the number of hours per year (24×365 = 8760 h) and divided by 1000.

RESULTS OF THE EXPERIMENT AND THEIR DISCUSSION

Examinations of the microstructure (Figure 1) and microhardness of the deposited plasma coatings indicate that the developed coatings have heterogeneous structure with uniform distribution of phases over depth, any defects and delaminations at the interface with the base are absent. The average thickness of the coatings is 200 ± 50 μm, the porosity is 8–10 %, the microhardness is 5500 ± 600 MPa for TiAl–Si₃N₄, and 6000 ± 100 MPa for the composite coating TiAl–SiC. Using the method of X-ray structural analysis, it was revealed that the phase composition of the plasma coatings for TiAl–SiC system consists of the following phases: TiAl, TiAl₃, TiC, Ti₅Si₃, Ti₃AlC, TiO₂, for the coatings of TiAl–Si₃N₄ system with Ti₂Al, Ti₅Si₃, TiN, TiO (Figure 2). At the same time, the phase composition of the coatings does not depend on the type of the base, on which they are deposited.

The studies of the kinetics of the electrode potentials of the developed plasma coatings made it possible to reveal that the values of the electrode potential are stabilized within 40–60 min during the immersion of the coated specimens into it. The stationary potentials E_{st} of the studied coatings in a 3 % NaCl solution were –0.2 – –0.7 V, depending on the base material. The highest positive potential is observed in the coatings deposited on VT6 alloy (–0.2 V), followed by the coatings deposited on St3 and AMg3 alloy being –0.58 and –0.7 V, respectively. The specified discrepancies in the values of the stationary electrode potential E_{st} can be explained, first of all, by the difference in the chemical composition of the base material. The plotted dependence curves in the coordinates $E_{st} - \tau$ have approximately the same form (Figure 3). Thus, the I region corresponds to a rapid change in E_{st} in the II region, a slow change in E_{st} occurs, and in the III region, the initial equilibrium value of the potential

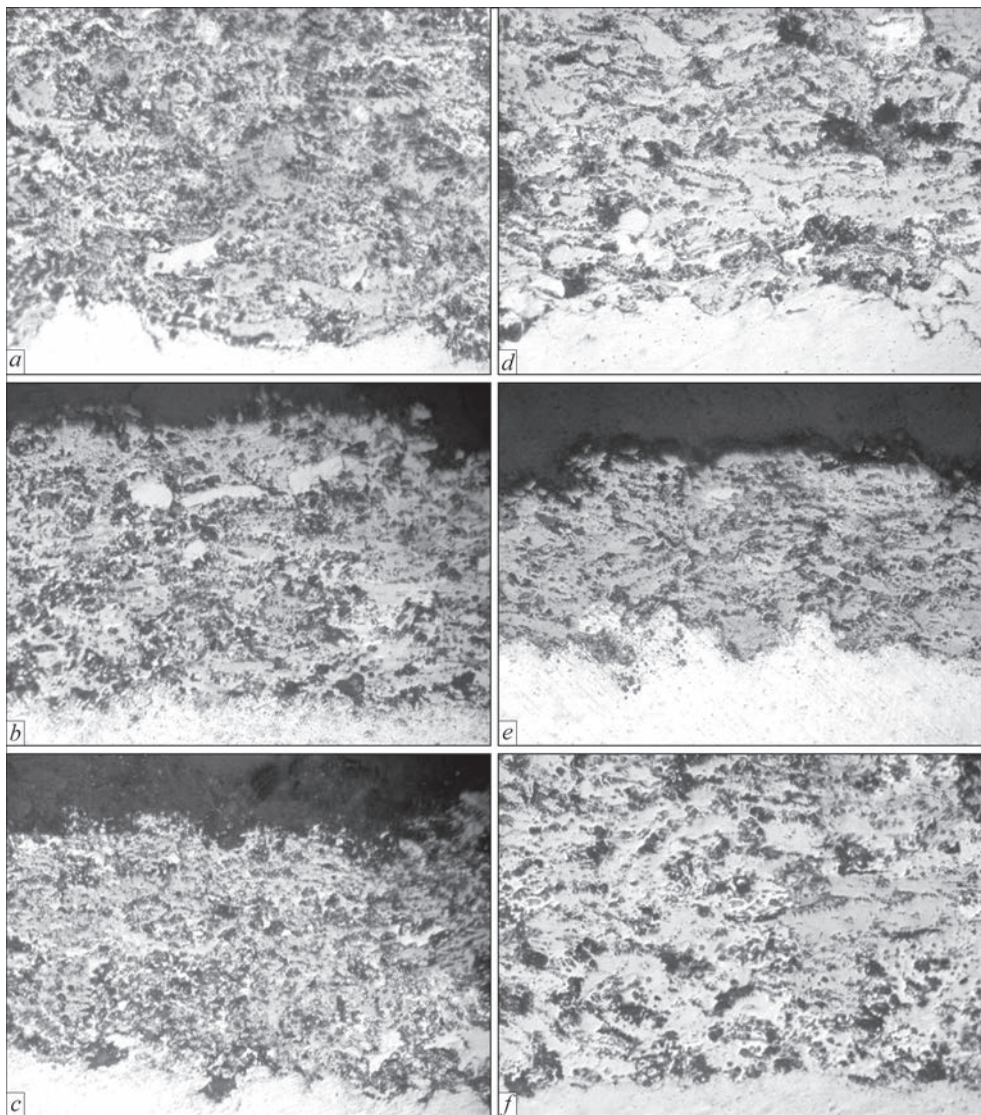


Figure 1. Microstructure ($\times 400$) of plasma coatings of TiAl–SiC system (*a–c*) and TiAl–Si₃N₄ (*d–f*), deposited on St3 (*a, d*), aluminium AMg3 (*b, e*) and titanium VT6 (*c, f*) alloys

is restored very slowly, at which the rate of running anode and cathode processes is equal.

The analysis of the obtained polarization curves (Figure 4) showed that the nature of the corrosion behaviour of the plasma coatings with CP TiAl–SiC, TiAl–Si₃N₄, deposited on different bases, is approximately the same. The comparison of corrosion cur-

rents (Table 1), determined by extrapolation of Tafel regions of the polarization curves, showed that the coatings deposited on titanium VT6 alloy are characterized by the minimum corrosion current i_c , respectively, and its corrosion resistance is the highest.

In the literature, the information about the electrochemical behaviour of the alloy based on intermetallic

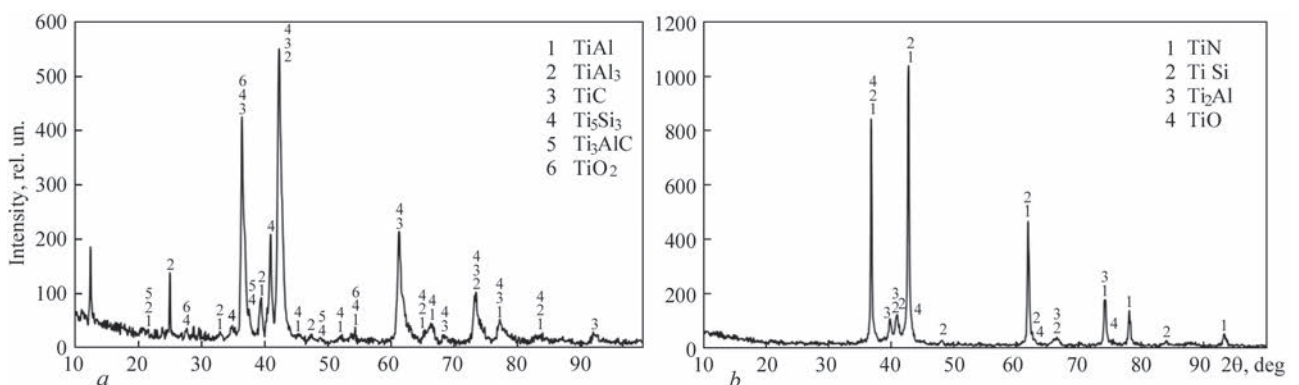


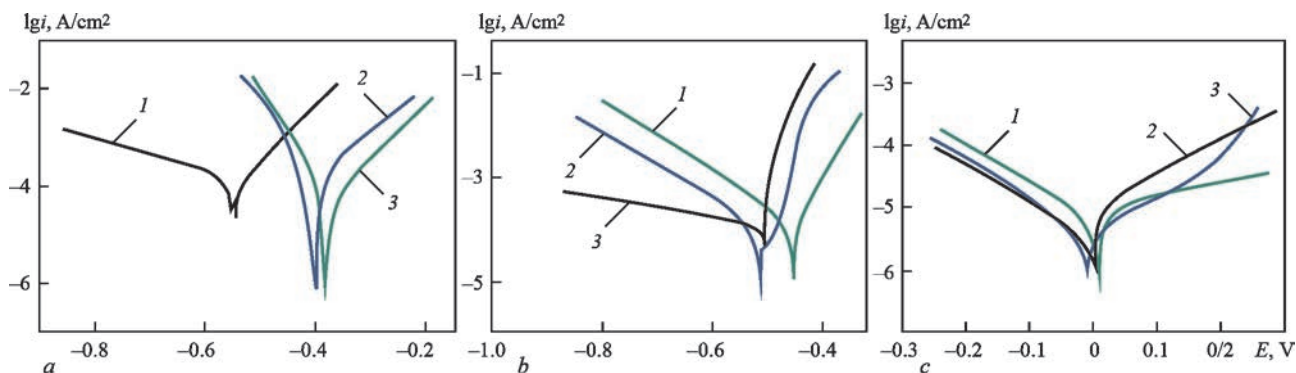
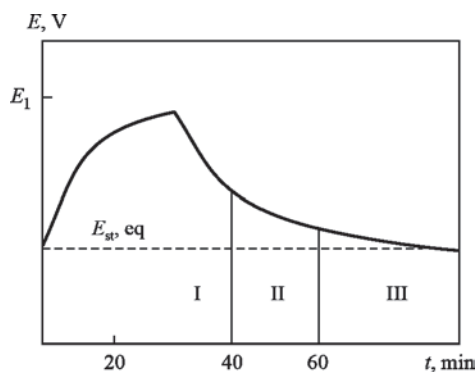
Figure 2. X-ray patterns of plasma coatings in the initial state: *a* — TiAl–SiC; *b* — TiAl–Si₃N₄

Table 1. Results of electrochemical studies of plasma coatings in a 3 % NaCl solution

Base	Coating	Electrochemical characteristics		
		E_{st} , V	E_c , V	i_c , A/cm ²
AMg3 alloy	–	–0.84	–0.5	$2.6 \cdot 10^{-5}$
	TiAl–Si ₃ N ₄	–0.64	–0.46	$4.1 \cdot 10^{-6}$
	TiAl–SiC	–0.7	–0.51	$5.2 \cdot 10^{-6}$
St3	–	–0.48	–0.5	$6.5 \cdot 10^{-5}$
	TiAl–Si ₃ N ₄	–0.58	–0.41	$5.4 \cdot 10^{-6}$
	TiAl–SiC	–0.58	–0.36	$4.4 \cdot 10^{-6}$
VT6 alloy	–	–0.04	0.04	$2.6 \cdot 10^{-6}$
	TiAl–Si ₃ N ₄	–0.2	–0.01	$3.5 \cdot 10^{-6}$
	TiAl–SiC	–0.2	–0.01	$3.2 \cdot 10^{-6}$

of TiAl titanium is available [15], according to which in a 3.5 % NaCl solution, the corrosion current i_c for it is about $5 \cdot 10^{-5}$ A/cm². Electrochemical studies of the plasma coatings (Table 1) showed that the introduction of carbide and nitride additives into TiAl alloy, which leads to the formation of new phases during plasma spraying of CP, produced by the method of mechanochemical synthesis, increases its corrosion resistance in the electrolyte by an order of value ($i_c = 10^{-6}$ A/cm²).

The corrosion potential of the plasma coatings on St3 shifts by 0.1–0.2 V in a more positive direction as compared to the stationary potential, on the polarization curves, inhibition of the cathode process of hydrogen release can be observed. The analysis of anode polarization curves (Figure 4, *a*) indicates that in the region of active dissolution (near the potential of –0.38 V), a linear relationship between the potential and the logarithm of the current density is observed. When the potential is further increased (≈ -0.3 V), the dissolution process is inhibited and the saturation current is achieved, after which the current density remains unchanged when the potential is increased.

**Figure 4.** Polarization curves of plasma coatings with CP TiAl–SiC and TiAl–Si₃N₄ in a 3 % NaCl solution, deposited on St3, AMg3 and VT6 alloys: *a* – 1 – St3; 2 – TiAl–SiC; 3 – TiAl–Si₃N₄; *b* – 1 – AMg3 alloy; 2 – TiAl–SiC; 3 – TiAl–Si₃N₄; *c* – 1 – VT6 alloy; 2 – TiAl–SiC; 3 – TiAl–Si₃N₄**Figure 3.** Change of stationary potential over time for plasma coatings

For the plasma coatings, deposited on AMg3, the corrosion potential is also shifted by 0.2–0.3 V in a more positive direction (–0.5 V), which indicates a uniform dissolution of the base through the pores of coatings of ions Al³⁺. Analysis of anode polarization curves allowed revealing that the electrochemical process occurs in the region of anode dissolution and at a potential close to zero, its inhibition occurs.

In spraying of plasma coatings on VT6 alloy, the corrosion potential enters the passive region in connection with the formation of the protective layer of titanium TiO₂ oxide on the surface.

The plasma coatings, deposited on St3 and AMg3, reduce corrosion currents in the studied electrolyte by one order and negligibly affect the corrosion resistance of VT6 alloy.

After corrosion experiments, an X-ray phase analysis of surface areas on the plasma coatings, exposed to the aggressive environment, was carried out. It was revealed that the phase composition of the coatings, deposited on different metal bases, is slightly different.

Thus, the coatings with CP TiAl–SiC between the main phases of TiC, Ti₃Si₃ and intermetallics of TiAl system on St3 contain iron FeO and Fe₃O₄ oxides, on AMg3 aluminium Al₂O₃ oxide, on VT6 titanium TiO₂ oxide (Figure 5, *a–c*).

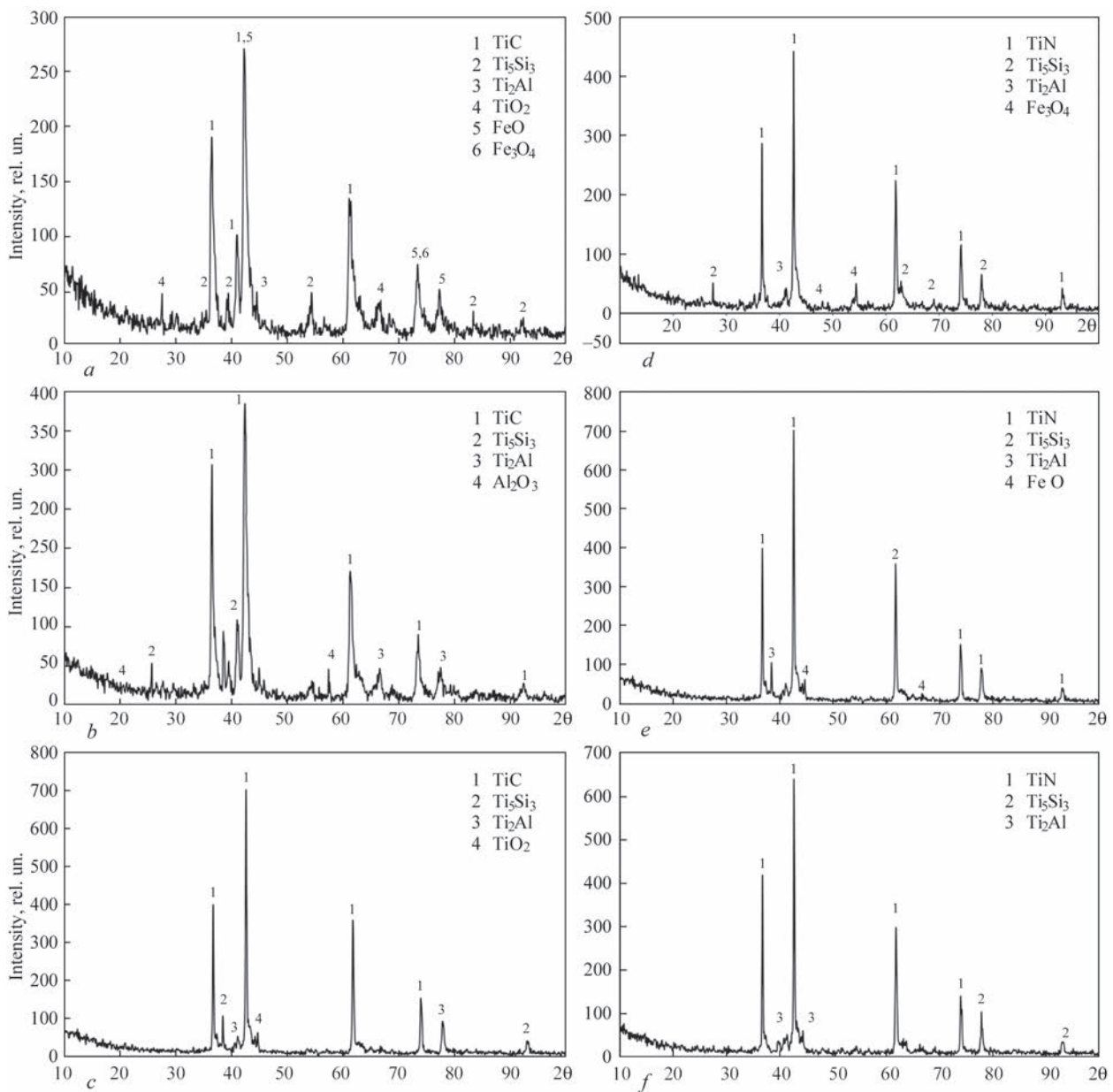


Figure 5. X-ray patterns of the surface of plasma coatings with CP TiAl–SiC (*a–c*), TiAl–Si₃N₄ (*d–e*), deposited on St3 (*a, d*), aluminium AMg3 (*b, e*) and titanium VT6 (*c, f*) alloys, after corrosion tests in a 3 % NaCl solution

For the coatings with CP TiAl–Si₃N₄ on St3, in addition to the main phase composition of TiN, Ti₅Si₃ and intermetallics of Ti–Al system, iron Fe₃O₄ oxide was detected. These results may indicate that the aggressive environment is penetrated into the interface of the coating with the base with the release of corrosion products on the surface of the electrode.

Analysis of corrosion test results showed that the plasma coatings with CP TiAl–SiC and TiAl–Si₃N₄ reduce the rate of corrosion of St3 by 10–16 times, AMg3 alloy by 8–9 times and VT6 alloy by 1.8–2.0 times. An increase in corrosion resistance can be explained by the formation of titanium silicide (Ti₅Si₃) in the plasma coatings. From literary sources it is known that silicides of metals significantly improve the corrosion resistance of coatings and alloys in vari-

ous aggressive environments, which is predetermined by the presence of strong covalent bonds metal-non-metal, and also Si–Si bonds [17, 18].

According to the polarization curves, the plasma coatings deposited on the surface of St3 and aluminium AMg3 alloy affect the rate of anode dissolution both in the active region, as well as in the region of their passive state, the anode process is inhibited (see Figure 4, *a, b*).

The process of anode dissolution of coatings on St3 proceeds mainly according to the reaction $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$, Fe²⁺ ions pass into the solution from the base material through the pores in the coating. This is confirmed by the data of XRD, where it was revealed that after corrosion tests, on the surface of the coatings deposited on St3, a layer of corrosion products

Table 2. Resistance and service life of plasma coatings in a 3 % NaCl solution

Coating (base)	Depth index of corrosion K_d , mm/year	Point on the resistance scale	Service life, years
TiAl–Si ₃ N ₄ (AMg3 alloy)	0.058	5	6
TiAl–Si ₃ N ₄ (St3)	0.045	4	7
TiAl–Si ₃ N ₄ (VT6 alloy)	0.042	4	8
TiAl–SiC (AMg3 alloy)	0.055	5	6
TiAl–SiC (St3)	0.049	4	7
TiAl–SiC (VT6 alloy)	0.036	4	10

Notes. 1. For St3 $K_d = 0.5935$; for AMg3 — 0.4925; for VT6 — 0.0667 mm/year. 2. All coatings belong to the group “resistant”.

consisting of iron oxides (FeO, Fe₃O₄) is formed. The process of anode dissolution of the coatings on AMg3 alloy proceeds according to the reaction $Al \rightarrow Al^{3+} + 3e$, on the surface of the coatings, a layer of Al₂O₃ oxide is formed.

The polarization curves for the coatings deposited on VT6 alloy are located quite close to each other, the corrosion potential indicates the passive state of the surface of the specimens as a result of the formation of a film of titanium TiO₂ oxide on them. The corrosion potential, which is close to zero, characterizes the completely passive corrosion resistance of the coating surface [19]. It should be noted that inhibition of anode dissolution occurs both for the alloy itself and for the plasma coating as well (see Figure 4, c).

The values of the corrosion currents, found from the polarization curves, made it possible to calculate the depth index of the coating corrosion. To characterize the corrosion resistance, a ten-point evaluation scale was used, according to which the plasma coatings can be attributed to the group “resistant”. The calculated service life of the plasma coatings indicates the possibilities of their operation in the environment of a 3 % NaCl solution for 6–10 years (Table 2).

In terms of corrosion resistance, the plasma coatings with CP TiAl–SiC are not inferior to the composite coatings produced by sintering of powders of Ti₃Al intermetallics with the addition of silicon carbide and deposited on a titanium alloy by the electrospark method ($i_c = 2.04 \cdot 10^{-6}$ A/cm²) [20].

CONCLUSIONS

1. It was found that the plasma coatings have heterogeneous structure with uniform distribution of phases over depth and the absence of defects and delaminations on the interface with the base. The phase composition of the plasma coatings for TiAl–SiC system consists of the following phases: TiAl, TiAl₃, TiC, Ti₅Si₃, Ti₃AlC, TiO₂, for TiAl–Si₃N₄ system with Ti₂Al, Ti₅Si₃, TiN, TiO. The thickness of the coatings was 200 ± 50 μm.

2. The introduction of non-metallic refractory compounds into the plasma coatings based on TiAl in spraying on the bases of St3 and AMg3 allows increasing their corrosion resistance in a 3 % NaCl solution by an order of value, in spraying on the base of VT6, the corrosion resistance does not increase significantly.

3. Corrosion resistance of the plasma coatings based on TiAl almost does not depend on the nature of a refractory additive (SiC and Si₃N₄), which is introduced, because for both coatings, the formation of Ti₅Si₃ occurs, as a result of which this characteristic increases.

4. The plasma coatings with CP TiAl–SiC, TiAl–Si₃N₄, which are deposited on the bases of St3, AMg3 and VT6, increase their corrosion resistance in a 3 % NaCl solution by 12–13 times, 8–9 times and 1.8–2.0 times, respectively.

5. The plasma coatings can be placed in the following line by increasing their corrosion properties: coatings on AMg3 → coatings on St3 → coatings on VT6.

6. According to the scale of corrosion resistance, the plasma coatings with CP TiAl–SiC and TiAl–Si₃N₄ belong to the “resistant” group. The calculated service life of the coatings indicates the possibility of their operation in the environment of a 3 % NaCl solution for a period from 6 to 10 years.

REFERENCES

1. Sinelnikova, V., Podergin, V., Rechkin, V. (1965) *Aluminides*. Kyiv, Naukova Dumka [in Russian].
2. Kablov, E.N., Lukin, V.I. (2008) Intermetallics based on titanium and nickel for advanced engineering products. *The Patent Welding J.*, **11**, 65–70.
3. Kurzina, I. A., Kozlov, E., Sharkeev, Yu. (2007) Influence of ion implantation on nanoscale intermetallic-phase formation in Ti–Al, Ni–Al and Ni–Ti systems. *Surf. Coat. Tech.*, **201**, 8463–8468.
4. Cinca, N., Guilemany, J. (2012) Thermal spraying of transition metal aluminides: An overview. *Intermetallics*, **24**, 60–72.
5. Yang, D., Tian, B., Cao, Y. (2011) Microstructures and properties of FeAl coatings prepared by LPPS, APS and HVOF. In: *Proc. of ITSC'2011*, 1229–1234.

6. Cinca, N., Guilemany, J. (2013) An overview of intermetallics research and application: Status of thermal spray coatings. *J. of Materials Research and Technology*, 2(1), 1–11.
7. Syrovatka, V.L., Oliker, V.E., Yakovleva, M.S. (2013) Intermetallics of Fe–Al system: Methods of producing, properties, coatings. *Materialovedenie*, 3, 46–53 [in Russian].
8. Grigorenko, S.G. Grigorenko, G.M., Zadorozhnyuk, O.M. (2017) Intermetallics of titanium. Peculiar features, properties, application (Review). *Sovrem. Elektrometal.*, 3, 51–58 [in Russian].
9. Blinkov, P.R., Volkhonsky, V.S., Sergevnnin, N.Yu. (2015) Structure- and phase formation in Ti–Al–Si–N system at forming of nanostructural ion-plasma coatings. *Neorganicheskie Materialy*, 51(11), 34–38 [in Russian].
10. Voronov, A.V., Sergeev, V.P., Sergeev, O.V. et al. (2009) Producing of nanocomposite coatings based on Ti–Al–Si–N system using two magnetrons. *Izv. TPU, Engineering Geosursov*, 315(2), 147–150 [in Russian].
11. Pyachin, S.A., Ershova, A.A., Vlasova, N.M. et al. (2019) Preparation and properties of electrospark coatings from Ti₃Al granules with silicon carbide and boron carbide additives. *Letter Materials*, 9(2), 191–196.
12. Vojtovich, R.F. (1981) *Oxidation of carbides and nitrides*. Kyiv, Naukova Dumka [in Russian].
13. Vojtovich, R.F., Golovko, E.I. (1978) *High-temperature oxidation of metals and alloys*. Kyiv, Naukova Dumka [in Russian].
14. Nikitin, V.I. (1987) *Corrosion and protection of gas turbine blades*. Moscow, Mashinostroenie [in Russian].
15. Zhuk, N.P. (2006) *Course in the theory of corrosion and protection of metals*. Moscow, Alliance [in Russian].
16. Seikh, A.H. (2015) Corrosion behavior in 3,5% NaCl solutions of γ -TiAl processed by electron beam melting process. *Metals*, 5, 2289–2302.
17. Shein, A.B. (2010) Corrosion-electrochemical behavior of metal silicides of iron triad in different electrolytes. *Fizikokhimiya Poverkhnosti i Zashchita Metallov*, 4(46), 403–413 [in Russian].
18. Knyazheva, V.M., Babich, S.G., Kolotykin, V.I., Kozhevnikov, V.B. (1991) Metal-like compounds of transition metals as the new class of corrosion-resistant materials and protective coatings. *Zashchita Metallov*, 4(27), 603–616 [in Russian].
19. Tomashov, N.D., Chernova, G.P. (1993) *Theory of corrosion and corrosion-resistant structural alloys*. Moscow, Metallurgiya [in Russian].
20. Burkov, A., Pyachin, S., Vlasova, N. et al. (2018) Improvement of anticorrosion and tribotechnical properties of Ti₆Al₄V alloy by deposition of electrospark Ti–Al–Si–C coatings. *Obrabotka Metallov*, 20(3), 85–96 [in Russian].

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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SUGGESTED CITATION

Yu.S. Borysov, A.L. Borysova, N.V. Vihilianska, O.P. Gryshchenko, Z.G. Ipatova, K.V. Yantsevych, M.A. Vasylykivska (2022) Corrosion resistance of plasma coatings produced from composite TiAl-based powders with the addition of non-metallic refractory compounds. *The Paton Welding J.*, 7, 28–34.

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Received: 09.06.2022

Accepted: 15.09.2022

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