The synthesis of Ni_3Al intermetallic compound on titanium alloy VT-6

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Intermetallic

Intermetallics are a unique class of materials that retain an ordered structure up to the melting point

Intermetallides have properties such as high strength, which does not degrade with increasing temperature, an anomalous dependence of the yield strength (in particular for Ni_3Al)

The purpose of this work is the synthesis of Ni_3Al intermetallic compound on the surface of VT-6 titanium alloy using an electron beam

Electron beam unit

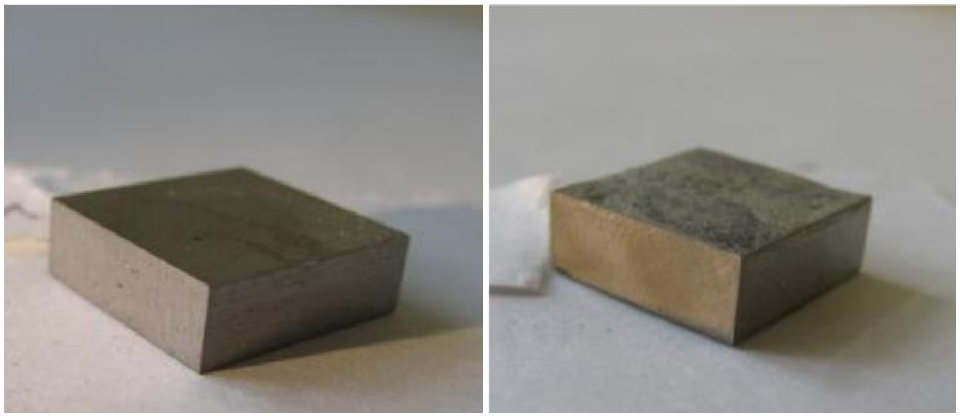
In this work was used to conduct experiments an electron beam unit with an axial gun on continuous cathode cathodes

Technical characteristics of high-voltage rectifier

Parameter	Quantity
Accelerating voltage, kV	30
Current direct incandescence, A	100
Current electron incandescence, A	4
Current electron beam, A	2
Voltage direct incandescence, V	10
Voltage electron incandescence, kV	2
Power, kW	60

Materials and experimental technique

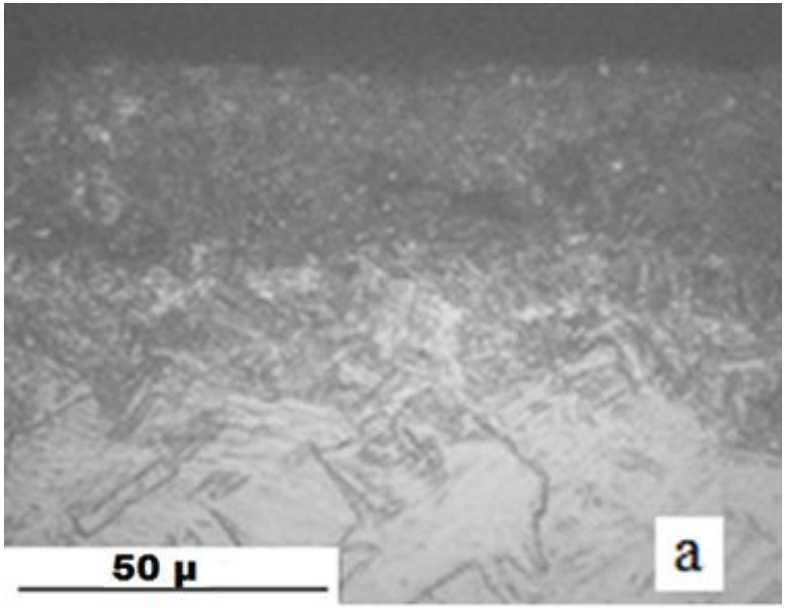
The samples of the titanium alloy for the study had the shape of a rectangle 1×1 cm in size and 0.5 cm thick. The stoichiometric reaction coatings of $NiO-Al_2O_3-C$ and Ni-Al were applied to the surface of the titanium alloy VT-6.

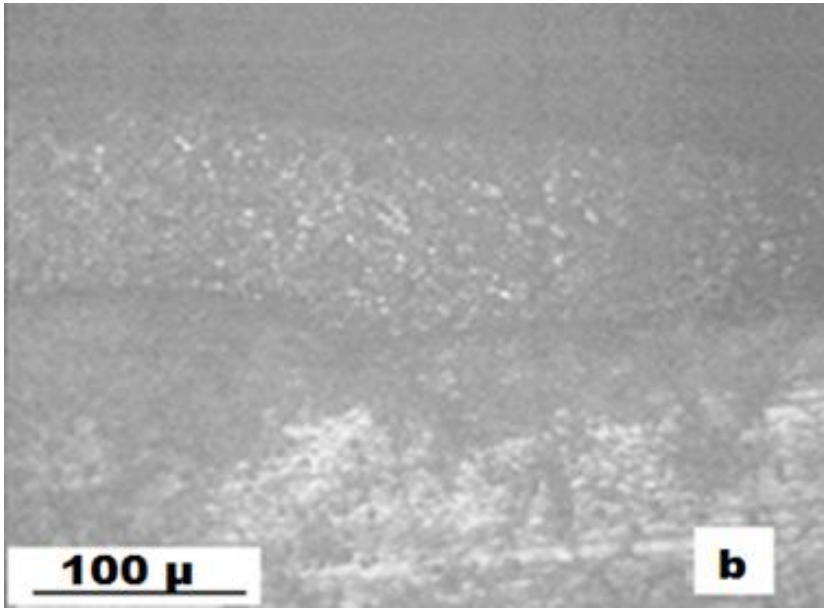


The specific power of the electron beam is $W = 5.7 \times 10^2$ W/mm^2, the diameter of the electron beam is d = 1 mm, the processing time is 1-2 min. The experiments were carried out at a pressure of 10^{-3} Pa

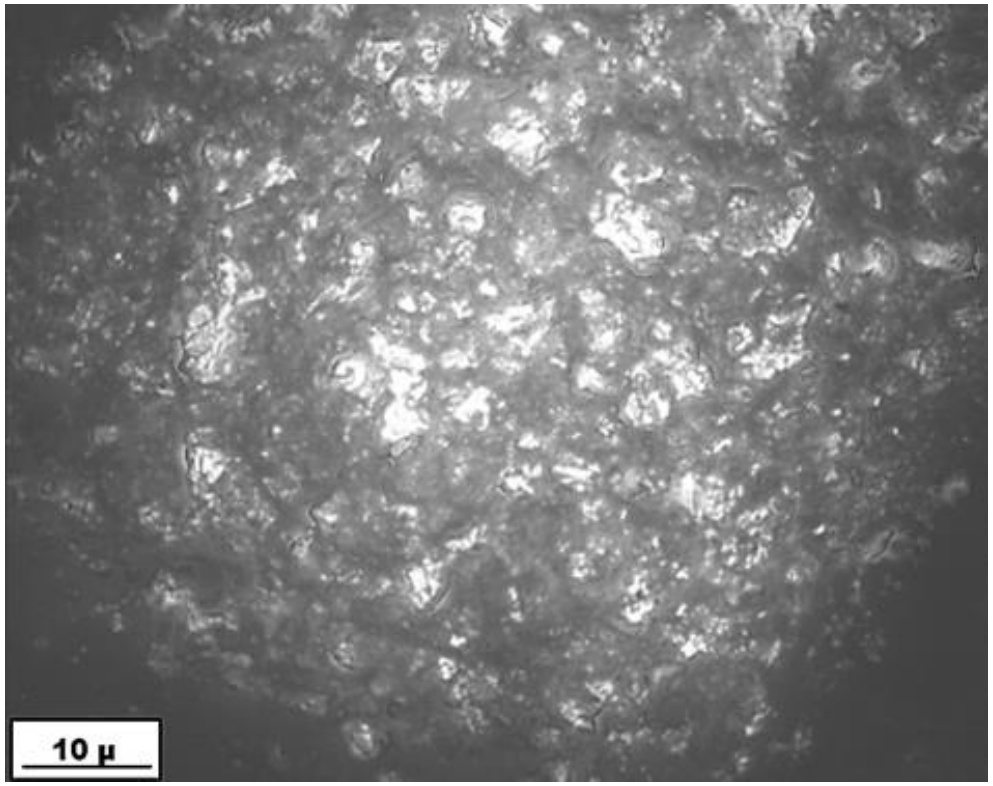
Results

After electron-beam treatment of samples of titanium alloy VT-6 with reaction coatings applied to them, heterogeneous layers of intermetallides are formed on the surface. The layers have good adhesion and are firmly held on a titanium base. The layer thickness is 50-100 μm.





Microstructure of the Ni-Al intermetallic layer on titanium alloy VT-6:
a – from powder Ni-Al; b – NiO-Al_2O_3-C

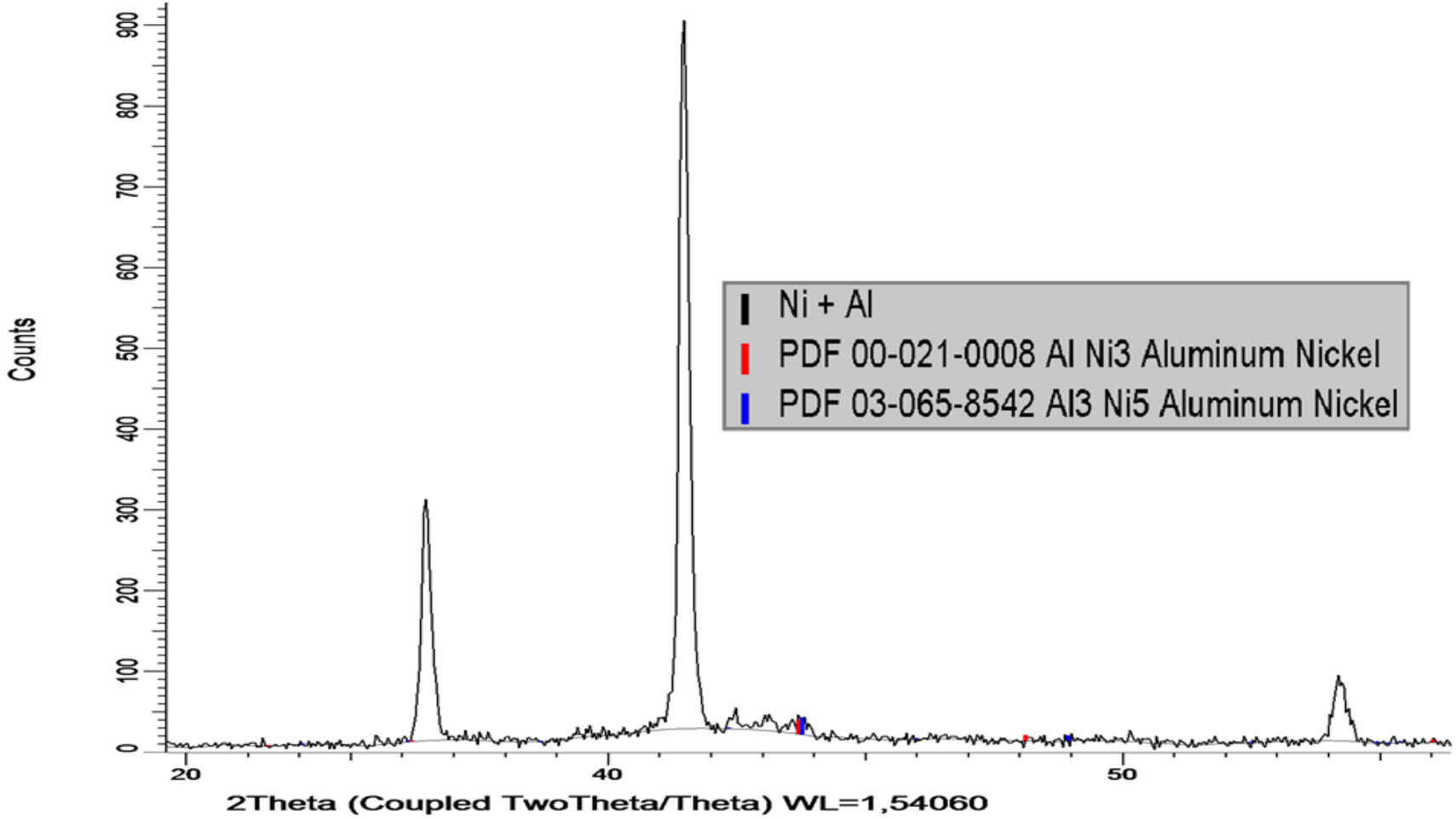


The microstructure of the synthesized layer, complex structure, the basis of which is a solid solution based on Ni_3Al.

The microhardness in the intermetallic layer is 3000-3500 MPa

Results of XRD

The synthesized Ni_3Al intermetallic compounds consist of two polymorphic modifications (PDF 00-050-1265 and PDF 00-021-0008), also Ni_5Al_3 (PDF 00-040-1157) intermetallic compound is present. All studied samples contained crystalline and amorphous phases in an amount of 68.4 to 82.1%

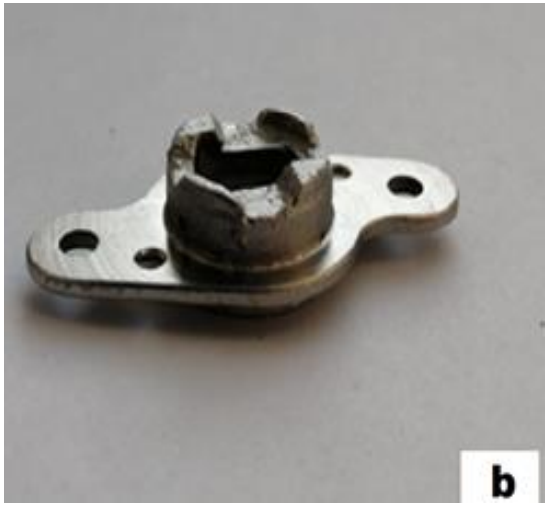


RESULTS OF XRD COATINGS BASED ON INTERMETALLIDES

Synthesized phases	Al + Ni	Al_2O_3 + NiO + C
$AlNi_3$ PDF 00-021-0008 P4/mmm a= 0,378 нм c= 0,328нм z=1	56,6%	19,4%
$AlNi_3$ PDF 00-050-1265 I4/mmm a=0,356 нм c=0,719нм z= 2	32,7%	12,2%
Ni_5Al_3 PDF 00-040-1157 Cmmm a=0,7475 нм, b=0,6727 нм c=0,3732 нм z= 2	10,7%	37,3%
Al0.5 C Ni3 Ti0.5 PDF 00-019-0035 Pm-3m a= 0,3589 нм, z=1	-	31,1%

Application

As part of the work, a series of experiments on the synthesis of Ni_3Al intermetallide on real parts was carried out. Ulan-Ude aircraft factory provided parts for applying a protective coating of intermetallide.



UUAZ samples from VT-6 titanium alloy:
a - initial; b - with synthesized intermetallic coating

Layers of thickness up to 100 μm over the entire surface of the part are formed on all samples

Conclusion

This paper presents a method for the synthesis of Ni_3Al intermetallide from Ni-Al powders and reaction coatings of stoichiometric composition $NiO-Al_2O_3-C$ on a titanium alloy using an electron beam of specific power $W=5.7 \times 10^2$ W/mm^2 in vacuum.

On the surface of VT-6 titanium alloy we synthesized Ni_3Al intermetallic layers of two polymorphic modifications (PDF 00-050-1265 and PDF 00-021-0008), as well as Ni_5Al_3 (PDF 03-065-8542). The thickness of the layers is 50-100 microns.

The microhardness of the intermetallic layers is 3000-3500 MPa