to bed. Therefore the modular design of the setup allows more flexibility to customize the setup parts according to different specimen.

The power supply can be changed to transformer that provides voltages of up to 100 kV. As the isolation of the chamber is not designed for such high voltages experiments with more than 10 kV has to be made outside of the chamber. The room conditions are not equivalent to underground conditions. Thus this variation of setup is used for oil shale breakdown voltage testing if the shale does not breakdown at 10 kV. The type of transformer used for voltage regulation has energy loss caused by coils magnetic leakage. The coils are moved relative to each other and at low voltages the magnetic field mostly scattered during operation. This loss can be minimized by changing the transformer type to autotransformer or thyristor regulator.

Described setup allows investigate electrophysical phenomena under electromagnetic affect with large range currents and voltages in modeled underground conditions. These phenomena could be used for in-situ oil shale pyrolytic processing due to electromagnetic affect.

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ИССЛЕДОВАНИЕ СВОЙСТВ ПОКРЫТИЯ TIAL НА ЦИРКОНИЕВОМ СПЛАВЕ

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RESEARCHING OF PROPERTIES OF TiAl COATING ON A ZIRCONIUM ALLOY

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Coatings based on titanium aluminide alloy deposited on the Zr1% Nb obtained by vacuum arc plasma-assisted method. The coating thickness was 3 microns. Investigated the structure of the surface by scanning electron microscopy. The results of the study of mechanical properties of zirconia samples before and after coating. It has been established that the TiAl has good coating adhesion strength, and increases durability.

Zirconium alloys are important structure materials in water-cooled fission nuclear reactors due to their corrosion resistance, good mechanical properties and low thermal neutron absorption [1]. However, current trends in nuclear reactors to higher fuel burnup, extended recycle, high pH operation and higher operating temperatures have led to the need for improving the corrosion and wear resistance of Zr alloys [2]. The proper surface treatment might be an effective method to improve the corrosion and wear properties and inhibit from the hydrogen diffusion. Thus, the purpose of the present work was to study the properties of the TiAl coating fabricated on samples of Zr1% Nb. Thus, titanium aluminide (TiAl) was chosen as a coating formed on Zr1%Nb due to their high chemical and mechanical properties [3,4]. Titanium aluminide is an alloy formed by combination of two low density metals of aluminum and titanium [3]. It is resistant to corrosion and capable of withstanding relatively high temperatures.

Samples were prepared from Zr1% Nb alloy with the size 15 × 15 × 0,7 mm. TiAl coatings were produced by vacuum arc plasma-assisted method with ion-plasma installation "TRIO-M". The surface of the samples was purified using argon ion beam. Deposition of TiAl coatings was carried out at the following operating modes: current of gas plasma generator - 30 A, current of arc evaporator - 100 A, pressure - 10^{-3} Pa, the processing time - 33 min. Adhesion properties of TiAl coatings were tested by CSEM MicroScratchTester installation. Wear resistance was determined by measuring complex «High Temperature Tribometer». The microstructure of the coating was analyzed by Philips SEM 515 scanning electron microscope.

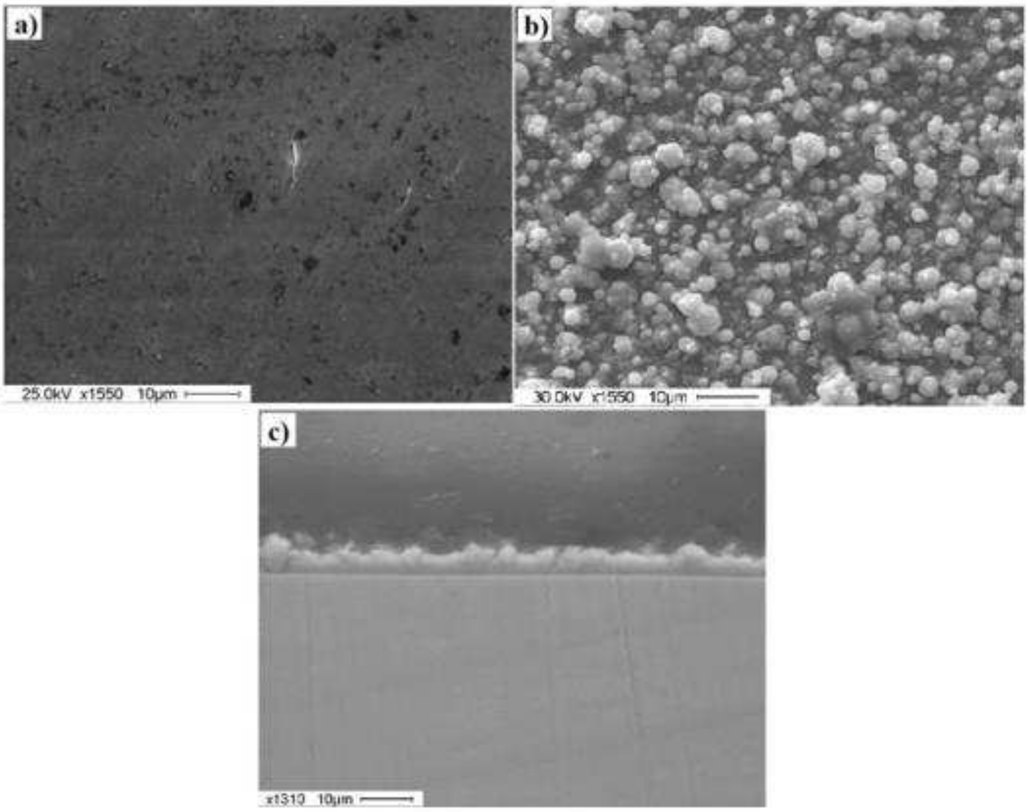

Fig.1. The structure of Zr1%Nb surface: a – original sample, b – sample with TiAl coating, c – lateral side of sample with TiAl coating

Microstructures of zirconium alloy surface before and after coating are shown in Figure 1. As follows from the scanning electron microscopy TiAl coating is friable. It precipitates in the form of drip factions formed during the spraying process. The coating thickness is 3 mm (Fig.1c). The average diameter of droplet is ~2 nm TiAl coatings were examined for mechanical properties such as wear resistance and adhesion strength.

Table 1. Results of the study of wear resistance of original sample and sample with coating

`	Friction coefficient	Transverse area, μm^2
Zr	0,421	8090
Zr + TiAl	0,412	6813

The results of wear resistance study of Zr1% Nb alloy with TiAl coating are presented in Table 1.

The magnitude of the wear resistance is determined by transverse area of the wear track. For initial samples of zirconium alloy this value is 8090 μm^2 and for samples coated with TiAl - 6813 μm^2. From these results it can be concluded that the TiAl-based coating improves the wear resistance of zirconium alloy.

The results of the study of adhesive properties are presented in Figures 2.

The value F1 indicates the maximum load when the coating begins to delaminate. At the critical load F2 coating is separated from the substrate. The friction coefficient of original sample is higher than the sample with protective coating. Destruction of coating of the samples coated with TiAl begins at the critical load F1 = 1,17 N. The coating break away at a load F2 = 2,64 N. These results show that TiAl coatings adhere well to zirconium substrate

The value F1 indicates the maximum load when the coating begins to delaminate. At the critical load F2 coating is separated from the substrate. The friction coefficient of original sample is higher than the sample with protective coating. Destruction of coating of the samples coated with TiAl begins at the critical load F1 = 1,17 N.

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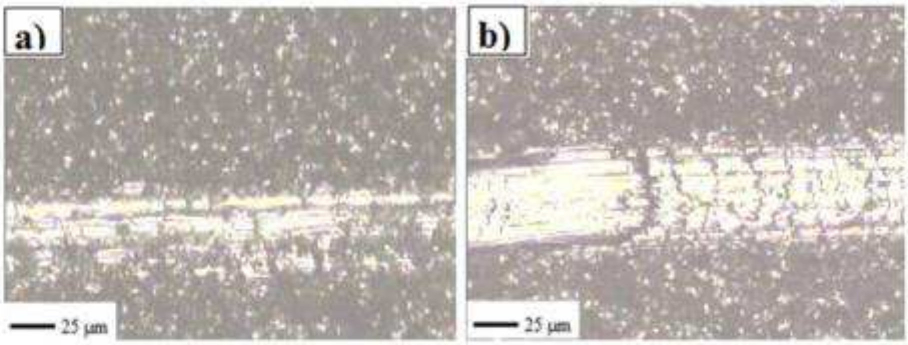

Рис.2. Scratches of zirconium alloy with TiAl coating a) at the critical load F1, b) at the critical load F2

The investigation of properties of the coating based on TiAl on the Zr1%Nb alloy has showed:

1. Deposition of coating occurs in the form of drops.
2. ZrO_2 coating increases the wear resistance (~1,2 times).
3. TiAl coatings have good adhesive properties.

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ВЛИЯНИЕ РАЗМЕРА ЗЕРНА НА ДИСПЕРСИОННОЕ УПРОЧНЕНИЕ СПЛАВА ВТ1-0, ИМПЛАНТИРОВАННОГО ИОНАМИ АЛЮМИНИЯ

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INFLUENCE GRAIN SIZE DISPERSION-STRENGTHENED ALLOY VT1-0 IMPLANTED ALUMINIUM

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The method of translucent diffraction electronic microscopy conducted researches of a microstructure and phase structure of a titanic alloy of VT1-0 implanted by ions of aluminum. Researches are executed on grains of two types; 1) large grains (KRZ) with an average size of 1.4 microns and 2) the fine grains (FG) with an average size of 0.5 μm. It is established that as a result of radiation the ion-alloyed layer, on the basis of α-Ti grains is formed. The sizes, form and places of localization of secondary phases (Ti_3Al, Al_3Ti and TiO_2) depend on the size of grain of a titanic matrix. The size of dispersive hardening of σ_{or} for different type of grains on depth of the ion-alloyed layer is calculated. It is shown that in MZ the size σ_{or} is provided only with TiO_2 particles, in KRZ – generally TiO_2 particles.

К настоящему времени установлено, что прочность любого металлического материала определяется многими факторами [1], одним из которых является наличие в материале карбидных, оксидных частиц и других вторичных фаз. Известно также, что число присутствующих частиц, их размер, характер распределения и расстояние между ними, а также степень несоответствия кристаллических решеток матрицы и выделения влияет на дисперсионное упрочнение материала [2]. Механизмы дисперсионного упрочнения разработаны для некогерентных частиц, когда дислокации обходят выделения, и когерентных