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The Influence of Thickness of the Layers on Structural-Phase and Strained State of Multiperiod Nanolayer Ti/TiN Coatings

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The influence of condition of vacuum-arc multi-layer TiN/Ti coatings on their phase composition, structure, stress state and mechanical properties has been studied. The regularities of the phase composition, structural state of stress, hardness with dependence on the magnitude of the negative bias applied to the substrate during the deposition and the thickness of the Ti and TiN layers in a multilayer coating were obtained. The analysis of the causes of observed changes, based on the mechanism of formation of surface layers of vacuum-arc coatings in the condition of implantation processes stimulated by applying a negative bias to the substrate was held.

Keywords: Vacuum-arc coating, Multilayer TiN/Ti, Phase composition, Structure, Stress state.

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1. INTRODUCTION

The introduction of Ti in titanium nitride in the form of intermediate layers, i.e., obtaining, thus, a multilayer system TiN/Ti, can increase the level of plastic deformation and, in connection with a low modulus of elasticity of Ti compared with TiN, slow down the development of cracks in the plane of such layered coating [1-3].

2. METHODS OF SAMPIE MANUFACTURING AND ANALYSIS

Coatings were deposited on "Bulat-6" (NSC "KPTI") and APP-1 (Stankin) plants, using high temperature titanium 1-0 as evaporated material. The substrates were located at a distance of 250 mm from the evaporator. Polished stainless steel 12X18H9T substrates with dimensions 20x20x3 mm and copper foil substrates with a thickness of 0.2 mm (which were pre-washed with an alkaline solution in an ultrasonic bath and then with nephras S2-80/120) were used as the base substrates. Deposition of layers of titanium was carried out at a residual gas pressure $P = 2 \cdot 10^{-5}$ Torr, and deposition of TiN layers with a nitrogen pressure of $5 \cdot 10^{-3}$ Torr. The average deposition rate was 1 nm/s.

3. RESULTS AND DISCUSSION

The number of layers with different thickness was chosen so that the total thickness of coating was about 7 microns.

There was held a comparison of the structure and strained state of the system TiN/Ti with different thickness (size factor) of Ti layer (Fig. 1).

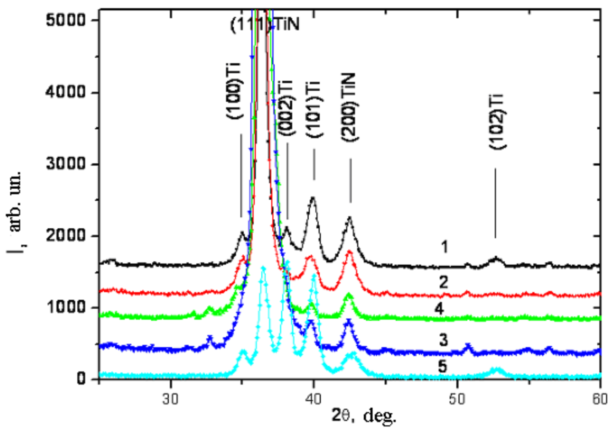

Fig. 1 – Diffraction spectra of the multilayer system TiN / Ti with different thicknesses of the layers obtained at $U_b = -200$: 1 - 780 nm/240 nm, 2 - 780 nm/120 nm, 3-300 nm /30nm, 4 - single-layer TiN, 5 - 120 nm/120 nm

It is seen that even with the smallest thickness of the TiN layer (120 nm) there is the formation of texture (111) but the degree of its perfection is low, while in the layers of titanium with a hexagonal (*hcp*) lattice the texture (001) is formed. The formation of such a texture in the crystal lattice of titanium of hexagonal type can be specified by the situation of titanium atoms in the (111) plane of face-centered cubic lattice of TiN.

The period of the hexagonal lattice of titanium a = 0.29586 nm, which is close to the tabulated value, and the lattice period of titanium is c = 0.47249 nm, which is slightly higher than the tabulated values. For a thinner layer of titanium such as 30 nm the lattice period a = 0.29601 nm and c = 0.48344 nm period are both increased, which indicates a very high content of impurity (nitrogen) atoms in such titanium layer and

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the development of compressive stresses.

Data analysis of X-ray strain measurement («$\alpha - \sin^2\psi$»-method) showed that at the minimal thickness of TiN layer of 125 nm (the specific volume in the multilayer coating is about 50%, which is equivalent to the thickness of the TiN layer of 3.5 microns), the compressive stresses at $U_b = -200$ V are −5.5 GPa, which is slightly lower than in the thicker layers (300 nm). Thus, with increasing the thickness of the TiN layer from 125 nm to 300 nm and the growth of perfection of the texture with plane (111) parallel to the growth surface macrostresses (i.e. change of the interplanar distances in the crystal lattices correlated in macrovolume) are somewhat increased, reaching, apparently, the limit value of about −7 GPa for the elastic deformation by means of the crystal lattice contraction of the vacuum-arc TiN coatings. With further increase of the thickness of TiN coatings the value of macrodeformation under increase of perfection of texture varies little.

4. CONCIUSION

Thus, in the layers of titanium nitride with thickness of 300 nm and more when applying a potential bias develops the texture [111]. The degree of perfection of texture increases with increasing the thickness of layer, which indicates the growing origin of this type of texture which is stimulated by radiation bombardment during the deposition of vacuum-arc coatings.

Ti layer thickness of more than 30 nm is sufficient to develop the stress-strained state in the layers of TiN without significant relaxation. This is also revealed in the thicker titanium layers: 125 nm and 250 nm.

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