Nanocomposite Nanomaterials

Multilayer coatings based on nitrides of refractory alloys with nanometer thickness

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One of the ways to improve the functional properties of coatings based on refractory compound nitrides is creating multilayer structures with layers of nanometer thickness, in which it is possible to achieve new quality characteristics by combining layers from different nitrides. Such characteristics may exceed the ones of each individual layer. The influence of physical and technological deposition parameters (partial pressure of nitrogen, bias potential) on the structural-phase state, mechanical, and tribological characteristics of multilayer nitride structures with nanometer thickness of the layers: (TiAlSi)N/MoN and (TiAlSi)N/ZrN; (TiAlSiY)N/MoN and (TiAlSiY)N/ZrN has been studied. Deposition of the coatings in the nitrogen atmosphere leads to formation of cc crystal lattice with (111) preferred orientation. Annealing at 700 °C does not change structural state, leading to relaxation of compression stresses, which is manifested in the diffraction spectra by the proportional shift of the diffraction peaks to the region of large diffraction angles.

For the system (Ti, Al, Si)N/MoN the annealing at 700 °C practically does not change hardness. The increase in hardness as a result of annealing was detected for systems (Ti, Al, Si)N/ZrN from HV0.05 = 37.9 GPa to HV0.05 = 47.6 GPa, and for systems (Ti, Al, Si, Y)N/ ZrN - from HV0.05 = 43.9 GPa to HV0.05 = 49.1 GPa. A detailed analysis of the X-ray diffraction spectra after annealing with the separation of constituents of the complex spectra has shown that there is practically no relaxation of the initial compression deformation and of the displacement of the diffraction peaks, but there is a change in their width, which indicates a change in the dislocation structure. It has also been found out that in the layers (Ti, Al, Si)N, the average crystallite size changes from 3.4 to 3.8 nm as a result of annealing, and from 5.2 to 6.3 nm in the ZrN layers.

Such a change in the average size of the crystallites in the nanometer range leads to a transition from rotational to shear deformation, which leads to an increase in the hardness of the material.