Nanostructured surfaces

Influence of deposition conditions on the physico-mechanical properties of nitride coatings obtained from high-entropy alloys

V.F. Gorban'[1], V.N. Voyevodin[2], A.A. Andreev[2], I.V. Serdyuk[2]

[1] *Institute for Problems in Materials Science, National Academy of Sciences of Ukraine, Krzhizhanovsky str., 3, 03680, Ukraine, Kyiv-142.*
e-mail: gvf@materials.kiev.ua

[2] *National Science Center "Kharkov Institute of Physics and Technology", National Academy of Sciences of Ukraine, str. Academicheskaya, 1, Kharkov-61108, Ukraine.*
e-mail: iraserduk@kipt.kharkov.ua

The idea of using multicomponent high entropy alloys (e.g., [1–3]) for the enhancement of thermal stability of the material has been proposed and experimentally verified. According to this conception, a high entropy of mixing can stabilize the formation of the disordered solid solution phase and prevent the formation of intermetallic phases during crystallization. The resulting high entropy alloys may exhibit an increased strength, along with good antioxidation and anticorrosion properties. In order to enhance such a high entropy of mixing, an alloy typically needs to consist of at least five major elements, with atomic concentration varying between 5 and 35%.

In vacuum-arc coatings obtained by evaporation of cast high-entropy Ti-Zr-Nb-V-Hf, Ti-Zr-Nb-V-Hf-Ta, and Ti-Zr-Nb-Ta-Hf alloys, the structural homogeneity of the bcc material is retained when deposited in vacuum. Coatings obtained with a negative bias potential on the substrate in the range from -50 to -200 V and nitrogen pressure ranging from 0,27 to 0,67 Pa are solid solutions based on the cubic (structural type of NaCl) fcc lattice. As the results of instrumental indentation showed, nitride coatings based on the high-entropy Ti-V-Zr-Nb-Hf alloy had the highest hardness values on the order of 40 - 70 GPa (Fig. 1), while the hardness of nitride coatings based on Ti-Zr-Nb-V-Hf-Ta and Ti-Zr-Nb-Ta-Hf alloys (Fig. 2) was in the 34 - 54 GPa and 27,5 - 43 GPa, respectively. The introduction of the sixth element of tantalum into the composition of the five-component Ti-V-Zr-Nb-Hf alloy leads to a decrease in the hardness of the coatings by 6 - 16 GPa, while a complete replacement of vanadium with tantalum further decreases the hardness by 12,5 - 25 GPa. This is due to the different electronic structure and atomic dimensions of vanadium and tantalum, which affect the degree of distortion of the crystal lattice and the formation of cluster structures that prevent the propagation of dislocations and the formation of physical and mechanical properties of the coatings.

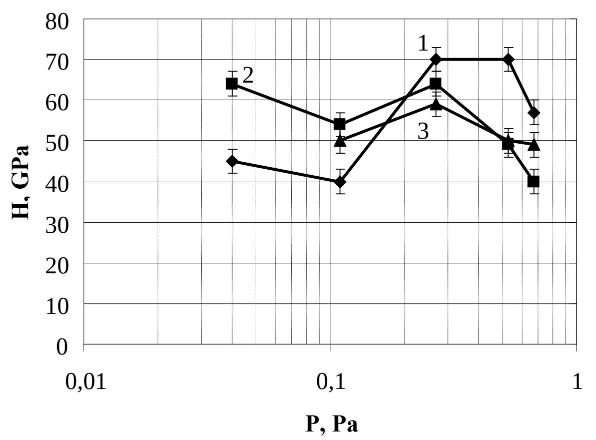

Fig.1. Dependence of the hardness H of the nitride coatings Ti-V-Zr-Nb-Hf-N on the nitrogen pressure P at a bias potential U: -200V (1), -100V (2) and -50V (3).

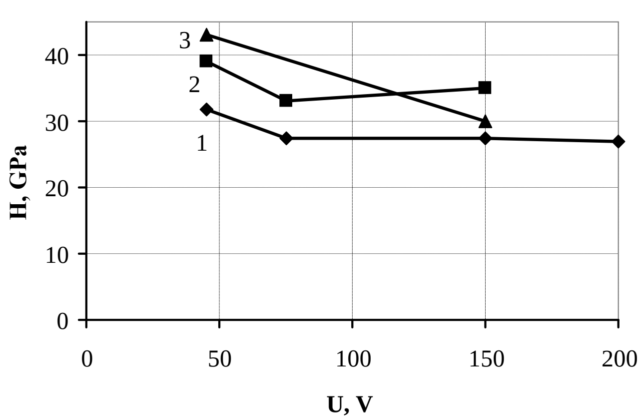

Fig.2. Dependence of the hardness H of the nitride coatings Ti-Zr-Nb-Ta-Hf-N on the bias substrate potential U at a nitrogen pressure in a vacuum chamber: 0,4 Pa (1), 0,09 Pa (2) and 0,04 Pa (3).

1. *Yeh J.W., Chen S.K., Lin S.J., Gan J.Y., Chin T.S., Shun T.T., Tsau C.H., Chang S.Y.* Nanostructured High-Entropy Alloys with Multiple Principal Elements: Novel Alloy Design Concepts and Outcomes // Advanced Engineering Materials. - 2004. – Vol. **6**. – PP. 299–303.
2. *Фирстов С.А., Горбань В.Ф., Даниленко Н.И., Карпец М.В., Андреев А.А., Макаренко Е.С.* Термостабильность сверхтвердых нитридных покрытий на основе многокомпонентного высокоэнтропийного сплава системы Ti-V-Zr-Nb-Hf // Порошковая металлургия. – 2013. - № **9/10**. – С. 93-102.
3. *Sobol' O.V., Andreev A.A., Gorban' V.F., Krapivka N.A., Stolbovoi V.A., Serdyuk I.V., Fil'chikov V.E.* Reproducibility of the single-phase structural state of the multielement high-entropy Ti-V-Zr-Nb-Hf system and related superhard nitrides formed by the vacuum-arc method // Technical Physics Letters, vol. 38, No. 7, pp. 616-619, (2012).