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STRUCTURE AND PROPERTIES OF MULTILAYER CERMET FILMS PRODUCED BY THE ION-PLASMA METHOD*

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Ceramic-metal films based on a high-entropy alloy (HEA) were formed using the vacuum-arc plasma-assisted deposition method on the «KVINTA» setup («UNIQUUM» complex, included in the unique scientific setups catalogue of the Russian Federation, http://ckp-rf. ru/usu/434216/), the design and operation of which are described in detail in [1, 2]. Cathodes made of chromium, molybdenum, niobium, as well as a composite cathode of (50% Ti-50% Al) composition were used for deposition. The chromium cathode was mounted on extended arc evaporator DP400, the niobium cathode - on a DI80 arc evaporator, and the composite Ti-Al and molybdenum cathodes were mounted on DI100 arc evaporators. After installing the specimens on the tooling, the vacuum chamber was evacuated to a pressure of $5\cdot10^{-3}$ Pa. Then, argon was injected to a pressure of 0.3 Pa, the extended gas plasma generator «PINK-P» was turned on, and ion-plasma cleaning of the specimen surface took place. After cleaning, the metal plasma generators were simultaneously turned on, which ensured the generation of a multicomponent gas-metal plasma. The formation of the coating was carried out in a mixture of argon and nitrogen gases in equal proportions, the pressure was 0.3 Pa. After the deposition was completed, the specimens were cooled in a vacuum chamber to a temperature below 100°C.

Studies of the phase composition of the ceramic-metal high-entropy coating formed on the WC-8%Co hard alloy, performed by X-ray diffraction analysis, showed that the coating is an X-ray amorphous material.

Using transmission electron diffraction microscopy, it was established that HEA cermet films are a multilayer material. The multilayer nature of the films is revealed at two scale micro- and nano - levels. At the microscale level, the thickness of the dark contrast layers is 0.21 μm, and that of the light contrast layer is 0.19 μm. Each of these layers has a layered substructure at the nanoscale level. The substructure thickness of dark layers is ≈20 nm, light layers is ≈12 nm.

The results of X-ray microanalysis show that the layers of both levels differ in elemental composition. Layers enriched in nitrogen, chromium, and aluminum are revealed at the microscale level. The layers enriched in nitrogen are depleted in chromium and aluminum atoms. Layers enriched in aluminum and layers enriched in chromium, molybdenum, and niobium are revealed at the nanoscale level. Titanium atoms are located quasi-uniformly in the HEA film.

Microhardness (measurements were carried out at an indenter load of 0.5 N) of a high-entropy alloy ceramic-metal film deposited on a WC-8%Co hard alloy substrate is 27.0 GPa (exceeds the hardness of the HEA metal film by 1.8 times), Young's modulus is 176 GPa (exceeds Young's modulus of the HEA metal film by 1.6 times).

The wear parameter (the value inversely proportional to the wear resistance) of the high-entropy alloy cermet film deposited on the WC-8%Co hard alloy substrate is 6.4 10^{-6} mm^3/N m (the wear parameter of the HEA metal film is 23 times less); the friction coefficient of the ceramic-metal film of the high-entropy alloy is 0.20 (the friction coefficient of the HEA metal film is 3.3 times less).

REFERENCES

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