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OPTIMIZATION OF THE PRELIMINARY ELECTRON-ION-PLASMA TREATMENT OF THE SILUMIN SURFACE LAYER BEFORE NITRIDE COATING DEPOSITION*

N.A. PROKOPENKO, O.V. KRYSINA, A.D. TERESOV, M.E. RYGINA, E.A. PETRIKOVA

Institute of High Current Electronics SB RAS, Tomsk, Russia

The purpose of this work is to reveal the effect of an additional stage of electron-ion-plasma surface treatment (electron-beam treatment, ion-plasma etching, sublayer deposition) on the adhesion strength, wear resistance, and physical and technical properties of the coating/substrate system. The selection of optimal modes for pre-treatment of the surface of silumin samples was carried out on installations included in the list of unique scientific installations of the Russian Federation (https://ckp-rf.ru/usu/434216/?sphrase_id=9096861). To reduce roughness, heal pores, and increase the uniformity of the composition of the surface of silumin samples, a SOLO vacuum electron-beam installation was used. In order to clean the surface from possible contaminants, remove the oxidized surface layer, heat the sample, and activate the surface for better adhesion of the formed coating to the substrate, preliminary ion-plasma etching of the surface of the samples was carried out. To improve the adhesion of nitride coatings to the substrate, a thin sublayer from the group of transition metals (Ti, Cr, Mo, Zr) was deposited. Experiments on the ion effect on the surface of materials were carried out on an automated vacuum ion-plasma installation QUINTA. The following binary systems of transition metal nitrides were taken as model wear-resistant coatings: TiN, CrN, MoN, ZrN.

The following diagnostic equipment and techniques were used to test the coated samples. The thickness of the coatings was controlled on a Calotest CAT-S-0000 instrument (CSEM, Switzerland) by the Calotest method using images of spherical sections. Transverse cleavages and the surface of the coatings were studied by scanning electron microscopy (SEM) using a Philips SEM-515 electron microscope with an EDAX ECON IV microanalyzer (Netherlands). The hardness (HV) of the “coating/substrate” system was measured on a PMT-3 instrument. Tribological studies were carried out using a tribometer Pin on Disc and Oscillating TRIBOtester (TRIBOtechnic, France) in the "ball-disk" geometry. Adhesion strength was tested on a Micro-Scratch Tester MST-S-AX-0000. The crystal structure, phase composition, and crystal lattice deformation of the coatings were identified by X-ray diffraction on a Shimadzu XRD-6000 diffractometer (Japan).

Based on the results of the work done, the following conclusions were drawn:

1) To increase the adhesion of the "nitride coating/substrate" system and its wear resistance, where the binary systems TiN, ZrN, CrN, MoN act as a coating, it is rational to use the preliminary stages of electron-ion-plasma processing, such as ion-plasma etching in gas arc discharge plasma with heated and hollow cathodes, deposition of a metal sublayer (≈100 nm) and submillisecond pulsed electron-beam action.

2) When choosing the modes of preliminary electron-beam processing in order to improve the adhesion, mechanical and tribological properties of the "nitride coating/silumin substrate" system, it is rational to choose the number of exposure pulses of 15 or more, the duration of exposure is ≈150 μs, the energy density of the electron beam is 25-30 J/cm^2 .

3) High-cycle (at least 2 cycles) electronic processing leads to a significant increase in the hardness and wear resistance of the "nitride coating/silumin substrate" system.

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