Microscopic analysis of nanostructured plasma coatings

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Abstract. In the course of the study, it was found that plasma nanocomposite coating obtained from a mixture of powders of BRS, VK8 and nichrome with a portable plasma device “ALPES-02M” has high performance properties, which significantly expands the scope of its application.

1. Introduction
Nanotechnology is a field of fundamental and applied science and technology dealing with a combination of theoretical justification, practical methods of research, analysis and synthesis, as well as methods for the production and application of products with a given atomic structure through controlled manipulation of individual atoms and molecules.

Among the intensively developing areas of modern researches, a special place is given to small-sized objects, for example, powders of various metals [1-4]. The unique microstructure of nanopowders gives them a number of new properties compared to conventional materials. At present, nanopowders are of great interest.

Powder metallurgy is a branch of technology, including the production of powders from metals and their alloys and the preparation of blanks and products from them without melting the main component. By methods of powder metallurgy, it is possible to create materials from various components with sharply differing properties and melting points, new materials with a diverse range of physico-mechanical properties. Powder metallurgy is used both for creating fundamentally new materials and products from them and for manufacturing the widest range of structural parts for general use [5-10].

2. Materials and methods
The most promising method for obtaining nanopowders from metal waste is the method of electroerosive dispersion. The EED method is characterized by ecological purity, low energy costs, good process controllability [11, 12].

The EED process is the destruction of a conductive material as a result of a local effect of short-term electrical discharges between the electrodes [12].

To obtain a powder from wastes by the method of electroerosion dispersion, the EED device for conductive materials and high-speed steel waste (HSS) of the brand R6M5, hard alloy VK8 and nichrome Kh15N60 were used.

Wastes were loaded into a reactor filled with working liquid, distilled water; the process was carried out with the following electrical parameters: capacitance of discharge capacitors is 55 µF,
voltage is 120 ... 130 V, pulse frequency is 100 ... 110 Hz. As a result of local exposure to short-term electrical discharges between the electrodes, the waste material was destroyed with the formation of dispersed powder particles.

For the preparation of plasma coatings, mixtures of the following compositions were used: for sample No. 1 - HHS 60%, VK8 15%, Kh15N60 25%; for sample No. 2 - HSS 70%, VK8 15%, Kh15N60 15%.

Mixtures of powders were applied using a portable plasma device “ALPLAZ-02m”. Plasma device ALPLAZ-02m is designed for cutting various materials, welding and soldering ferrous metals, copper and its alloys.

The purpose of this work was to study the microstructure of the nanocomposite plasma coatings obtained.

The microstructure was studied on an inverted OLYMPUS GX51 optical microscope, which is designed to produce in reflected light: light-field and darkfield images; differential interference contrast images (DIC); images in polarized light. Limit magnification of the microscope: x1000 (interchangeable lenses x5, x10, x20, x50, x100). The OLYMPUS GX51 microscope is additionally equipped with a precision scanning automated table “PS 11”, a digital microscopic video camera “SIMAGIS 2P-2C” and an automated image analysis system “SIAMS Photolab (SIMAGIS Research)” and “ImageScope M”. The system of image analysis "SIAMS Photolab" is a software product designed for processing and analyzing images obtained with digital and analog photo and video cameras, as well as scanners during micro and macro photography. Image processing in SIAMS Photolab is performed in a chain of interconnected cells containing the original image, the results of intermediate processing steps, the final processed image and measurement results in the form of numbers, graphs and histograms. After creating a chain for processing a new sample using a given algorithm, it is sufficient to replace the original image. In this case, the user has the ability to visually control and manually adjust the parameters of any stage of processing. In addition to automated processing, the system allows editing images in manual and semi-automatic modes.

Using the method of optical microscopy, a study was made of the microstructure of the samples (over the cross-section). The surface of the samples was ground and polished. Grinding was made with metallographic paper with a large (No. 60-70) and fine grain (№№ 220-240). During the grinding process, the sample was periodically rotated by 90 °. The abrasive particles were washed with water and subjected to polishing on a circle with suspensions of metal oxides (Fe3O4, Cr2O3, Al2O3). After achieving a mirror gloss, the surface of the section was washed with water, alcohol and dried with filter paper.

3. The study of the structure of the microscopic analysis of nanostructured plasma coatings
The results of the study of samples 1 and 2 are shown in Figures 1 and 2.
Figure 1. Microstructure of sample 1: a – x500, b – x1000.
Figure 2. Microstructure of sample 2: a – x500, b – x1000.
The photographs show that the obtained coating has a fine-grained microstructure, which significantly increases its operational properties.

4. Conclusion
Thus, in the course of the study it was established that the nanocomposite plasma coating obtained from a mixture of powders of HSS, VK8 and nichrome with the help of the portable plasma apparatus “ALPLAZ-02m” has high operational properties, which significantly expands its field of application.

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