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MODIFICATION OF NANODIAMONDS FOR THEIR USE IMPROVEMENT

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Currently, development of methods for obtaining new materials with desired exploitation characteristics is actual. Method of chemical surface modification is widespread for various types of materials with desired properties: selective adsorbents, heterogeneous catalysts, implants, corrosion-resistant coatings, biological and chemical sensors, etc. The effectiveness of this method is especially high for these materials, which are characterized by a large value of the ratio of surface area to volume.

Nanodiamonds are extensively used in many industries. Nanodiamond powders were obtained by detonation of carbon-containing explosives with negative oxygen balance. Production, modification and application of nanodiamonds is of great interest for researchers. Nanodiamonds of detonation synthesis are perspective class of nanomaterials.

For preparation of materials based on nanodiamonds with specified characteristics, above all, it is necessary to change the chemical composition of the diamonds surface deliberately, modify nanodiamonds.

It is known that nanodiamonds surface composition is formed already in the process of nanodiamonds extraction from detonation mix, which influences the characteristics and efficiency of various nanodiamonds applications.

Thus, during nanodiamonds extract the use of boron compounds increases nanodiamonds thermal stability in an oxidizing atmosphere. Thermal stability of nanodiamonds is an important characteristics for their various applications. It was suggested that islands of boron nitride were formed on the surface of nanodiamonds, according to X-ray photoelectron spectroscopy (XPS).

We have processed the experimental XPS-spectrum of nanodiamonds levels B1s to test the boron form on the surface of nanodiamonds. Nanodiamonds were obtained with the use of boric anhydride in extraction process. X-ray photoelectron spectrum was approximated by the sum of five curves, described by the Lorentz function. The obtained values of energy – 189,8 and 191,3 eV, which correspond to compounds BN and B_2O_3.

Amount of boron in nanodiamonds is not reduced as a result of their treatment by acids and alkalis, including dissolving oxide and boron nitride. This shows chemical bonding of boron to nanodiamonds surface.

These results allow to suggest that influence of boron on nanodiamonds thermal stability is blocking active sites of nanodiamonds surface, adsorbing oxygen molecule. Adsorbing oxygen molecule is the first stage of oxidation.

The same result can be achieved by chemical modification of nanodiamond`s surface. The implementation of this method does not require specialized equipment or prior preparation of powders. It is important to apply corresponding temperature while using modifying compounds.

Structured suspension of nanodiamond is used for experiments. Then the boric acid solution is added to suspension and is dispersed by ultrasonic disperser. As a result we get nanodiamond powders after acid cleaning with low rate of oxidation during heating in air. We can assume that the modification leads to the formation of these compounds (see Figure 1) on the nanodiamonds surface, based on XPS-spectrums research.

There are practically no publications on modification and application of modified nanodiamonds for coatings based on nickel. We have carried out nanodiamonds modification by nickel chloride. Stage of modification is fully consistent with the previously used method. Modification of nanodiamonds trivalent metals (aluminum, chromium and iron) leads to reversal of particle charge in nanodiamonds from negative to positive.

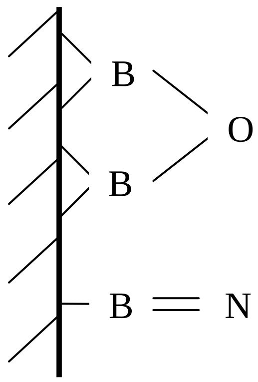

Figure 1 − Kinds of compounds on nanodiamond surface modified by boric anhydride

Electrokinetic potential of initial and modified nanodiamonds was calculated by the formula Duhin-Derjaguin. The value of electrokinetic potential of nanodiamonds initial particles was −19,6 ± 1,15 mV. As a result of modification absolute value of electrokinetic potential decreased to nearly zero. It can be assumed that the main factor, of charge particles absents − reduced valence of nickel compared to previously applied metal.

The nickel content in modified nanodiamonds was determined by difference of incombustible residual (determined in accordance with specifications on nanodiamonds) of initial and modified nanodiamonds. It should be take into account the formation of nickel oxide during combustion of modified nanodiamonds. Nickel concentration was 2,9%, it corresponds to ~ 1 atom/nm^2. The total number of oxygen-containing groups (protogenic) at nanodiamonds surface is ~ 2 groups /nm^2 determined by titration with alkali. We find that one atom of nickel corresponds to two functional groups (see Figure 2). This is two-point modifier chemisorption on the surface of nanodiamonds.

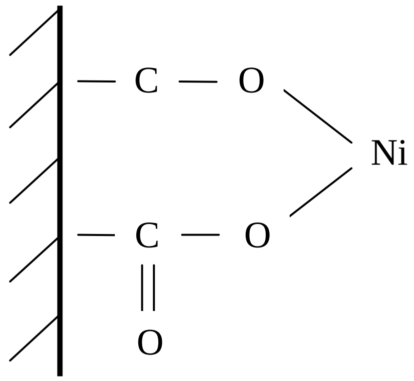

Figure 2 − The two-point chemisorption of Ni on the nanodiamonds surface

Modified nanodiamonds were used to obtain composite galvanic coatings with nickel matrix. Microhardness of coatings with modified nanodiamonds had risen over nickel coatings and co coatings with nanodiamonds.

So we can conclude that nanodiamonds modification improvise nickel-diamond coatings mechanical characteristics.