OBTAINING AND RESEARCH OF ELECTRODEPOSITED CHROMIUM NANODIAMOND COATINGS

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Abstract

The paper presents the results of electrodeposition for obtaining chromium coatings with the addition of nanodiamonds with a thickness of 10 and 50 µm. The topography of the coatings was investigated by scanning electron microscopy (SEM), and the qualitative composition by energy dispersive microanalysis (EDX). Potential use as coatings for detail parts has been identified. The hardness and wear resistance of chrome coatings have been investigated. It is shown that the addition of 1 mass. % of nanodiamonds in the electrolyte significantly improves the properties of the coating even at a thickness of 10 µm.

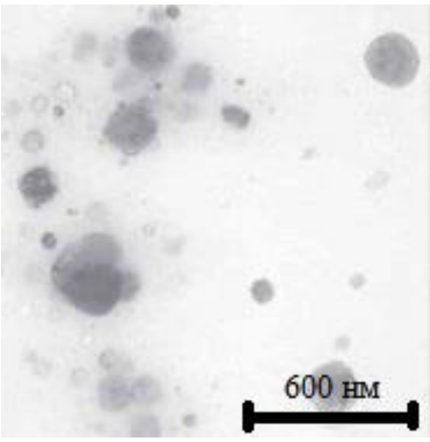
Keywords: Chromium, protective coating, electrodeposition, nanodiamond coatings

1. INTRODUCTION

Chromium is widely used as a protective coating, as well as for shiny luster such as auto parts or home accessories. Chromium coatings can improve corrosion resistance, hardness, and resistance to aggressive environments in addition to improving wear resistance [1]. Electrodeposition is the main industrial chromium plating method today. This method has a such of problems, in particular: coarse deposition of chromium, insufficient thickness and hardness [2]. Each stage requires strict adherence to the technological regulations, which, depending on the substrate on which the deposition takes place and the conditions of further operation, has significant differences and is selected individually. Modern research is carried out in the field of new compositions of electrolytes, as well as the addition of various substances to improve the resulting coatings [3-6]. The purpose of this study is to develop a composition, as well as obtain chromium nanodiamond coatings with improved characteristics.

2. EXPERIMENTAL AND DISCUSS OF RESULTS

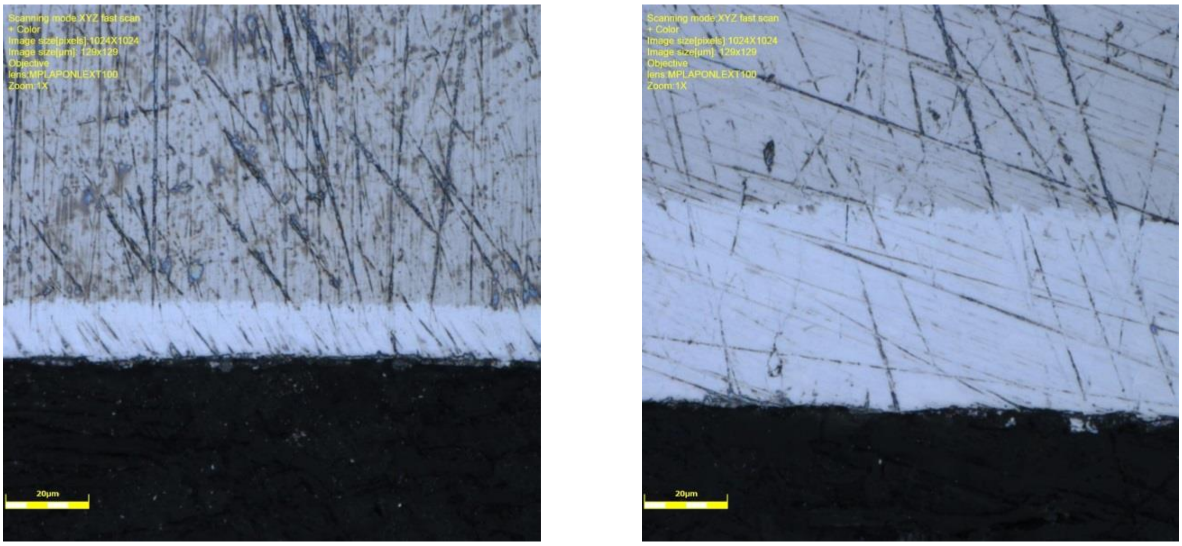
Chromium-diamond coatings were obtained by electrodeposition, using a mixture of nanodispersed particles of diamonds of static synthesis with a range of particle sizes from 2 to 300 nm, as seen in (**Figure 1**). Control of the size of nanoparticles was carried out by transmission electron microscopy. Coatings of different thickness were obtained on a standard electrolyte (CrO_3 – 250 g/l, H_2SO_4 – 2,5 g/l) in wear-resistant chrome plating mode (55°C) with a cathode current density of 50-60 A/dm^2. It should be noted that higher current densities, as a rule, give better results in terms of the quality of the coating, however, they are rarely used in industry due to their high cost and inconvenience in operation (strong gas evolution, electrolyte splashing, difficulty in maintaining temperature).



600 nm

Figure 1 TEM micrograph of diamond nanoparticles

As a result of the deposition, chromium-diamond coatings with a predetermined thickness of 10 μm and 50 μm were obtained. The exact thickness of the obtained coatings was determined using an OLYMPUS LEXT OLS4100 confocal laser scanning microscope. For research, three microsections were prepared with a cross-section of the coating, which were then polished. The results are shown in (**Figure 2**).



a *b*

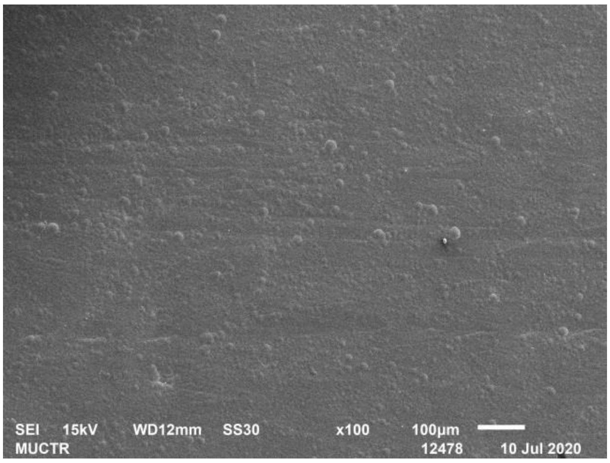
Figure 2 Images obtained by measuring the coating thickness on an OLYMPUS LEXT OLS4100 microscope: a sample with an assumed thickness of a) 10 μm, b) 50 μm

The exact values of the thickness for the samples were: 11.8 ± 0.2 μm and 46.3 ± 0.2 μm, which corresponds to the specified range. It should be noted that the determination of the roughness on the microscope showed the arithmetic mean of the absolute values of the profile deviations at a distance of the base length of 0.336 and 0.395 microns.

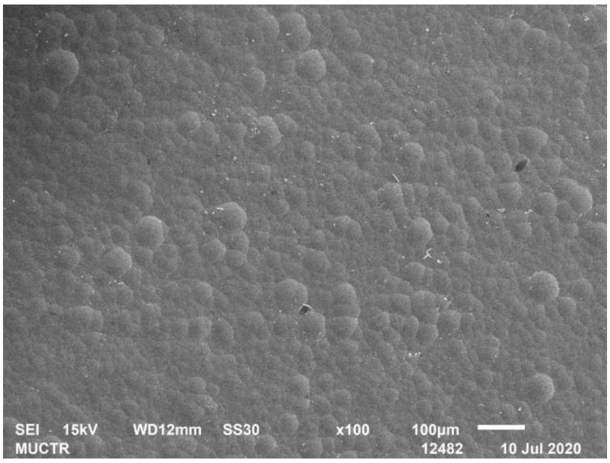
The microstructure of the surface and the qualitative composition were determined by scanning electron microscopy with an attachment for energy dispersive microanalysis on a scanning electron microscope JEOL JSM 6510 LV + SSD X-MAX of the Center for Collective Use. DI. Mendeleev. As can be seen from (**Figure 3**), the coating is a continuous layer without pores and significant flaws. A larger increase shows the presence of agglomerates of particles on the surface, which can probably be explained by the uneven distribution of nanodiamonds in the coating (taking into account the size and shape of the particle surface). In this case, energy dispersive microanalysis shows the presence of carbon in the coating of the order of 5 wt%.

The most characteristic indicator in this case is the microhardness of the coatings, which is characteristic for industrial applications. The data on the obtained microhardness of the coating without additives of nanodiamonds and with an additive for coating of 10 μm are 858 and 932 kg/mm^2, respectively. Taking into account that nanodiamonds will increase the cost of coatings by no more than 15%, these values are significant.

Separately, it should be noted that the use of this type of electrolyte at industrial scale can cause significant damage to the environment. Unfortunately, from an economic point of view, replacing chromium can significantly increase the cost, therefore, it is necessary to include wastewater treatment in the industrial design stage of chromium plating. In this case, both traditional and new methods of recovery and deposition can be used [7-10].



a



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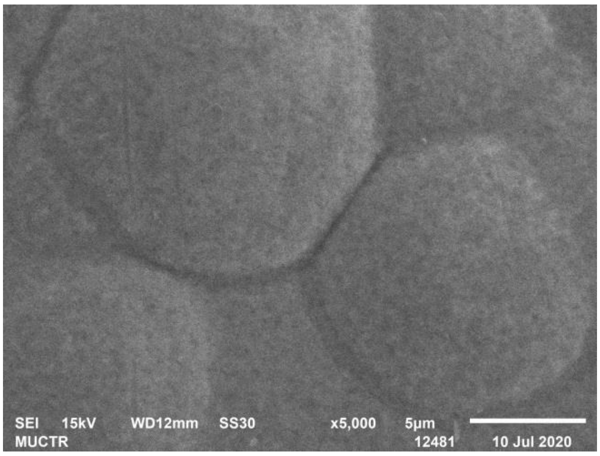
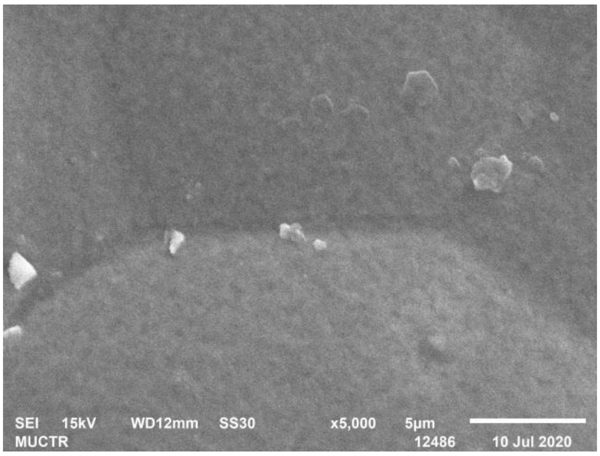
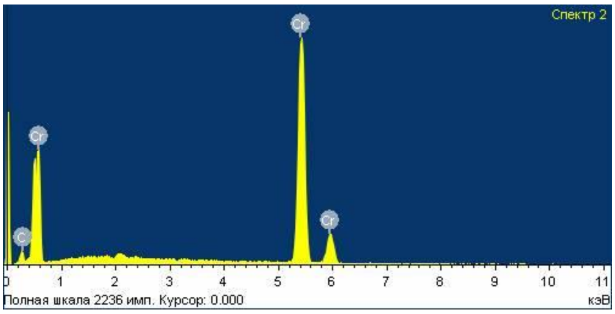


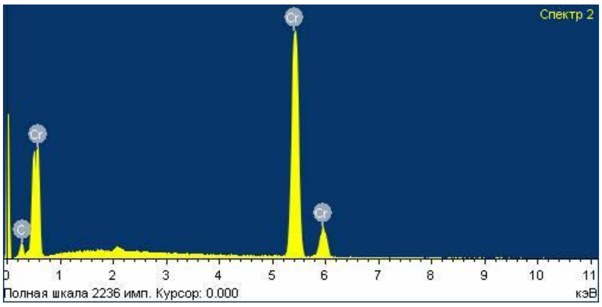
c



d



e



f

Figure 3 SEM micrographs (a-d) and spectra of energy dispersive microanalysis (e, f) of samples 10 μm thick (a, c, e) and 50 μm (b, d, f).

3. CONCLUSION

Thus, due to its more pore-free structure, the chromium-diamond coating also has a higher corrosion resistance. Thus, having better properties, the proposed coatings at a cost of 10-15% higher than hard chromium plating, can double or more to increase the operating time of parts and assemblies operating under conditions of abrasive and corrosive wear.

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