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Modification of WC hard alloy by compressive plasma flow

V.V. Uglov[a], V.M. Anishchik[a], V.M. Astashynski[b], N.N. Cherenda[a,*], I.G. Gimro[b], A.V. Kovyazo[b]

[a]Belarusian State University, str. F. Scorina 4, 220080 Minsk, Belarus
[b]Institute of Molecular and Atomic Physics of National Academy of Sciences of Belarus, F. Scorina 70, 220072 Minsk, Belarus

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Abstract

The effect of compressive plasma flows of nitrogen on the mechanical properties, phase and element composition of a WC hard alloy (6 wt.% of Co) has been investigated in this work. Compression plasma flows were obtained using a quasistationary plasma accelerator. X-ray diffraction analysis, Auger electron spectroscopy, scanning electron microscopy and X-ray microanalysis were used as investigation techniques.

It was found that the whole depth of the modified layer amounted to 15 μm. The phase composition analysis showed that plasma treatment resulted in the transformation of a WC phase into a W_2C one. The formation of a graphite phase was also found in the surface layer. The element composition analysis revealed surface segregation of carbon and cobalt. The findings also showed that microhardness of the hard alloy increased 1.7 times after treatment.

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1. Introduction

A WC–Co hard alloy is a widely used instrumental material with enhanced mechanical characteristics. Different types of treatment techniques were used with the aim of hard alloy properties improvement: pulsed electron beam treatment [1], pulsed laser treatment [2,3], microwave treatment [4], ion beam treatment [5,6], plasma beam treatment [7]. The microhardness increase [3,4,7], the wear decrease [1,4], the elimination of WC sputtered films porosity [3] were the results of such processing.

The effect of compressive plasma flows (CPF) of nitrogen on the mechanical properties, phase and element composition of a WC–Co hard alloy was investigated in this work. CPF treatment allows to create a deep (a few tens of micrometers) layer with improved properties in a material in an extremely short period of time [8].

* Corresponding author. Tel.: +375 17 2095512; fax: +375 17 2095445.
E-mail address: cherenda@bsu.by (N.N. Cherenda).

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2. Experimental procedures

The samples used were made of a WC based hard alloy with the following phase composition: 94 wt.% WC, 6 wt.% Co. The WC average grain size was 2 μm. A gas discharge magnetoplasma compressor of compact geometry was used for generating compressive plasma flow [9]. The experiments were performed in a 'residual gas' mode during which the vacuum chamber was filled with nitrogen. Hard alloy samples were treated under the following experimental conditions: the initial voltage of the capacitor bank—4.8 kV, the impulse duration ~100 μs, the nitrogen pressure in the vacuum chamber—1200 Pa, the number of impulses—1, 3, 10. According to the calorimetric measurements the value of energy absorbed by the sample was approximately 25 J—for 1 pulse, 60 J—for 3 pulses and 125 J—for 10 pulses.

The phase composition of the samples was investigated using X-ray diffraction analysis (XRD) in the Bragg–Brentano geometry with Cu Kα radiation. The calculated X-ray penetration depth in WC was approximately 76–150 nm for $2\theta = 25–55^\circ$ assuming the absorption of 75% of X-