Surface modification of refractory metals by femtosecond laser radiation

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Abstract— In paper the results of nanostructuring of surfaces of tungsten and molybdenum by femtosecond laser radiation in the air and liquid nitrogen are shown.

Keywords— nanostructures; tungsten; molybdenum; femtosecond laser pulses; liquid nitrogen.

I. INTRODUCTION

Nanostructured transition metals and their compounds with oxygen and nitrogen can be effectively used in sensory, electrochromic, photocatalytic devices, photovoltaic and fuel cells. For the formation surface nanostructures and nanostructured layers of such materials laser technologies are perspective to use. However, the synthesis of surface nanostructures of refractory metals, such as tungsten and molybdenum, is obstructed due to their high melting point. The use of the femtosecond laser radiation allows overcoming this obstacle.

II. EXPERIMENTAL PROCEDURE

For experiments samples of tungsten and molybdenum were selected. Surfaces of samples were specially prepared. Samples processing was carried out by femtosecond laser system TETA-10 with Yb:KGW active medium. The main parameters of the laser system: wavelength $\lambda = 1029$ nm, pulse duration $\tau = 300$ fs, repetition rate $f = 10$ kHz, pulse energy $\varepsilon=150$ mJ. Polarization of the laser radiation is linear. The experimental scheme is similar to the scheme of work [1].

Laser radiation was focused on the sample surface to the spot with a diameter of 50 microns. Laser impact on materials was carried out with beam that could move over the surface of samples with speed of 10 mm/s. The distance between centers of the laser processing lines is 100 microns. Study of nanostructured layers formed under the action of laser radiation was made with images obtained using scanning electron microscope (SEM) Quanta 200 3D. The chemical composition of samples was studied with EDAX system (energy-dispersive analysis).

III. RESULTS

As a result of femtosecond laser radiation impact on the surface of samples the nanostructures arrays of tungsten, tungsten nitride, molybdenum oxide and molybdenum nitride were formed. Analysis of the modified surface of the samples showed simultaneous formation of a system of linear structures (ripples) and array of nanorods. Width of linear structures (ripples) is about 400 nm and their spatial period is 800 nm. Diameter of nanorods mainly corresponds to the range from 50 nm to 100 nm.

Modification of samples surface was performed by a moving laser beam. Under conditions of experiments spots of impact laser pulses overlap. Energy distribution of the laser radiation in the beam cross section has a Gaussian form. Depending on degree of overlap and intensity of laser impact the view of nanostructured surface layer was changing. Thus, by changing parameters of the impact you can adjust sizes of formed structures. Continued influence of laser radiation removes polycrystalline material of sample revealing nanorods.

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REFERENCES