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Laser modification of the titanium surface covered with a tantalum film

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Modern titanium medical products, for example, bone implants, must have specified properties and surface morphology. Modern coatings are formed by PVD, CVD and other methods. Morphology and roughness can be formed by high-energy methods. The question of biocompatibility of coatings remains topical. The paper proposes to modify the tantalum-containing coating by laser radiation. The selection of processing modes will allow obtaining the required surface morphology. The presence of tantalum in the coating will shape its electret properties.

As samples, grade 2 alloy wheels with a hole in the center were used. Disc diameter 13.9±0.1 mm, thickness 1.9±0.1 mm. A tantalum (Ta) film with a thickness of 400, 800, and 1200 nm was preliminarily deposited on the disks by magnetron PVD sputtering. Then the surface was modified using a laser model LRS - 50. To study the surface morphology, local pulses were produced on a pure grade 2 alloy and on samples with a tantalum film. The following regimes were used: Pump lamp voltage U = 350 V, pulse duration τ = 0.5, 1, and 1.5 ms, radiation spot diameter d = 1, 1.5, 2 mm. In modes with U = 350 V , τ = 1.5 ms, d = 1 mm and U = 350 V , τ = 1.5 ms, d = 1.5 mm, modified layers of the sample surface were obtained (fig.1).

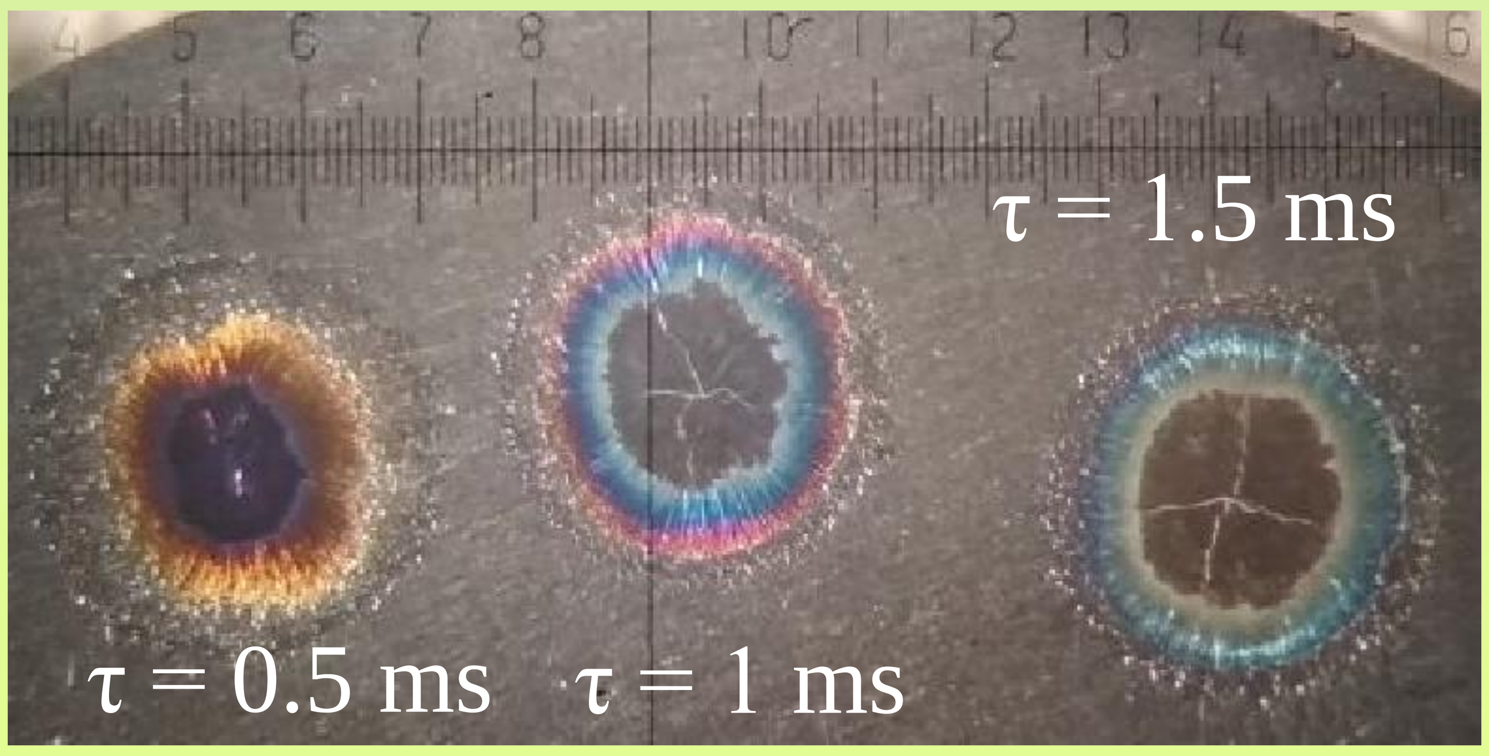

Figure 1. Local exposure to a laser beam d = 1.5 mm

Surface morphology after modification was studied using an MBS-10 microscope and an optical system of a PMT-3 microhardness tester. The surface roughness was measured using a profilometer Veeco Dektak 150, the stylus radius was 2 µm. Microhardness was measured with a PMT-3 microhardness tester with an indenter load of 50 and 100 gf in accordance with the requirements of GOST 9450-76, ISO 6507-1:2005.

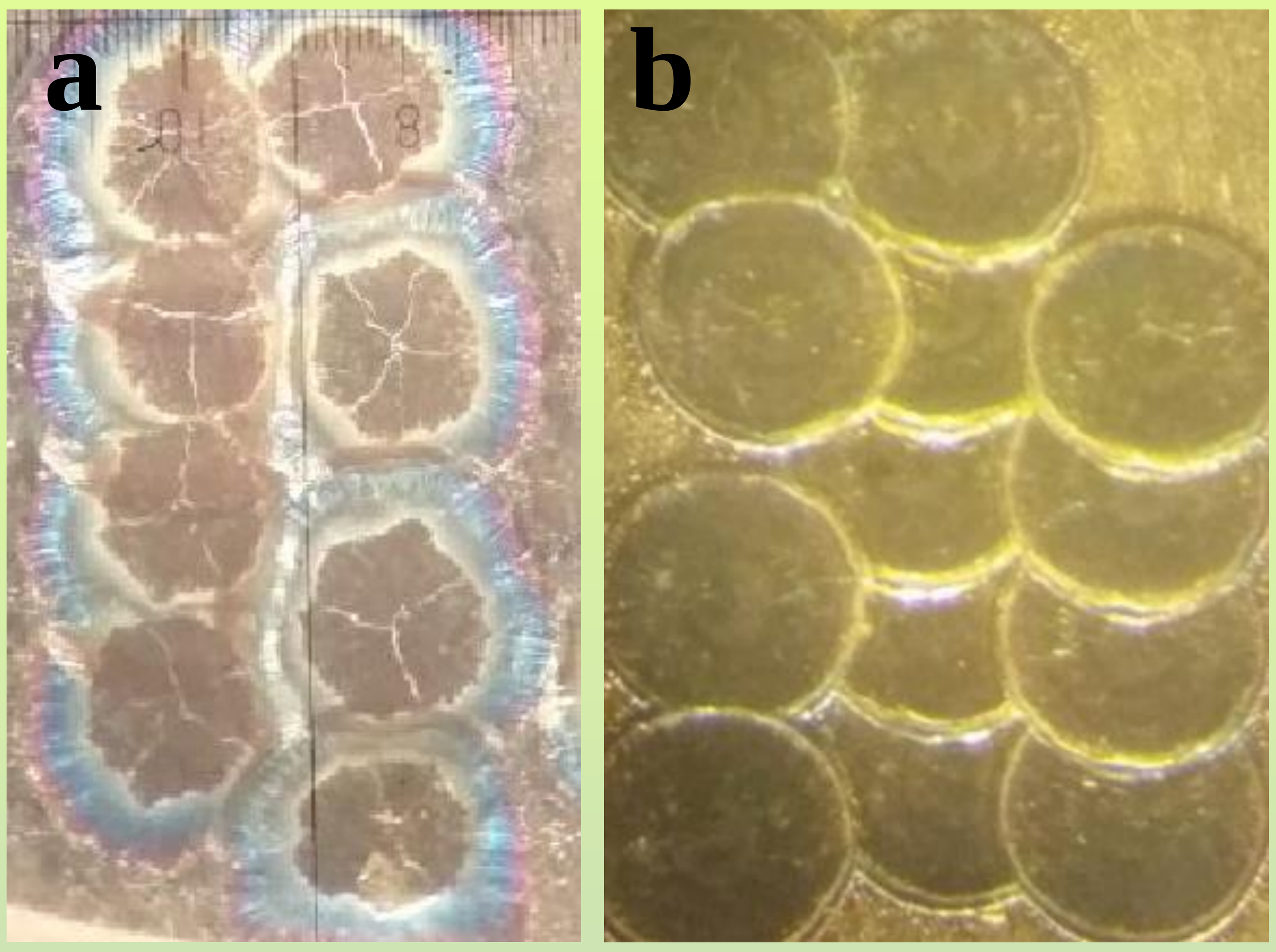

Figure 2(a, b). Morphology of the modified surface. a – U = 350 V , τ = 1.5 ms, d = 1 mm, step 0.5 mm; b – U = 350 V , τ = 2 ms, d = 1 mm, step 0.4 mm;

The coatings obtained on the Grade 2 alloy are formed by melting the surface layer of the material (fig. 2). The depth and diameter of the penetration zone depend on the pulse energy and the diameter of the laser beam. Also, the duration of the radiation pulse affects the melting zone. Changing the scanning step of the laser beam makes it possible to form the roughness parameter Sm. The pulse energy largely affects the roughness parameters Ra and Rz. The zone of metal melting borders on the zone of high temperatures, in which oxides of tantalum and titanium are intensively formed. Oxide inclusions form an increased hardness of the coating. It is of interest to study the dependence of the tantalum content in the modified layer on the regimes of laser exposure.

In this work, the microhardness and surface morphology of titanium after laser processing are studied. A tantalum film up to 1.2 µm thick was preliminarily deposited on the samples. The possibility of formation on titanium of layers characterized by microhardness up to 18 GPa has been established. The possibility of forming the specified roughness parameters by selecting the laser processing modes is shown.

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