Reverse deposition of nanoporous titanium oxides by laser ablation of titanium in air

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Oxides deposition during titanium laser ablation in the air has been experimentally and numerically investigated. A nanosecond pulsed Yb fiber laser was used for Ti surface texturing. The hierarchical structure was observed consisting of a microrelief formed by the laser ablation and a nanoporous coating—by the reverse deposition from the laser-induced plasma plume. The physical-chemical characteristics of the nanoporous coating were studied using scanning and scanning transmission electron microscopy, atomic force microscopy, and x-ray diffraction analysis. The deposit consists mostly of porous TiO_2 and inclusions of TiO, Ti_2O_3, and Ti_2O_3N. optical emission spectrometer analysis was used to estimate the composition and effective temperature of the plasma plume. The chemical-hydrodynamic model of laser-induced plasma was developed and predicts that condensed titanium oxides gradually accumulate on the surface during the plasma plume evolution. A satisfactory agreement between the experimental and calculated chemical composition of the plasma plume as well as between the experimental and calculated composition and thickness of the deposited film was demonstrated. This allows a cautious conclusion that the key mechanism of the porous surface films formation is the oxides condensing in the plasma and their consequent deposition onto the ablated surface. The study was supported by the Russian Science Foundation (project No. 20-62-46045).