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Deposition of functional layers by pulsed laser deposition

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Nanoscale thin films are widely used in various technological and scientific domains, forming the basis for numerous advancements that have propelled human progress, thanks to their highly tunable functional properties based on chemical composition. Pulsed laser deposition is one of several physical vapor deposition methods employed to fabricate thin films, utilizing laser energy to eject material from a target as plasma. A substrate, often a single-crystal oxide, is positioned in the path of the plasma plume and acts as a template for the incoming species from the target to coalesce and self-assemble into a thin film. This technique is incredibly useful for producing crystalline films due to the broad range of atmospheric conditions and the potential chemical complexity of the target. However, this flexibility introduces significant complexity, often necessitating meticulous optimization of growth parameters to achieve high-quality crystalline films with the desired composition. In this work, we present our results on the synthesis of Au [1], SiO_x [2] and Al_2O_3 [3] films by pulsed laser deposition in vacuum or background gas.

The dynamics of heating and vaporization of gold in vacuum under the action of laser pulses of low intensity, when the main ablation products are neutral particles, is investigated by mass spectrometry and numerical modeling. The laser-ablation plume is found to consist of gold atoms and dimers with kinetic energies considerably higher than their thermal energy upon evaporation. Nanostructured gold films are synthesized by depositing the ablation products onto a substrate.

The nanosecond laser ablation technique was used to synthesize thin silicon oxide films of various stoichiometry in vacuum and in a background gas. The local oxidation degree of specimens was evaluated using three different characterization methods. It was found that, on increasing the distance to the laser-plume axis, there occurred a monotonic increase in the oxygen content of the films due to their oxidation inhomogeneity. A profound decrease in ablated mass, related to an increased reverse flow of substance to the target, was found to occur when the pressure of the ambient mixture was increased from 20 to 60 Pa. A comparison was made of the oxidation efficiencies of the films heated at the stage of their

synthesis and at the stage of annealing of already formed films. It is shown that the composition of the films could be controlled by varying the inert-gas pressure at the constant pressure of the chemically active component in ambient mixture.

Transparent aluminum oxide nanostructures with extreme wetting properties were synthesized by nanosecond laser deposition in background oxygen. The transparency and morphology of the samples were analyzed. Non-monotonic behavior of the transmittance coefficient was observed with varying background oxygen pressure in the range of 20 to 140 Pa, attributed to differences in the kinetics of ablation product dispersion. The evolution of the contact angle was studied, ranging from ~ 5 to ~ 120°, during the storage of coatings in air under normal conditions.

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