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MODELING OF REACTIVE SPUTTERING AND EVAPORATION IN A HOT-TARGET MAGNETRON DISCHARGE*

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The processes of obtaining oxide and nitride coatings in magnetron sputtering systems are associated with known effects of a complex nonlinear and often unstable behavior of the deposition rate and film stoichiometry depending on the reactive gas flow. Controllability and productivity of such processes can be largely improved through modification of existing technologies and the development of new approaches. In particular, one can find evidences of a positive effect that a high temperature of a magnetron target has on the stability of the characteristics of the reactive sputtering process [1]. On the other hand, a number of scientific groups have been actively studying reactive deposition of oxides and nitrides in the high-power pulsed magnetron discharges (see e. g. [2] and references therein), and have found favorable effects of high-power pulses on the controllability of the process.

In the present work, we theoretically consider the joint influence of hot-target effects and the pulsed nature of the discharge on the state of the target surface. We enhance the previously modified time-dependent Berg model [3] by taking into account the evaporation of target material as well as the influence of target temperature on the rate of chemical reactions on its surface. The system of equations describes the state of the target in terms of poisoned area fractions θ_1 and θ_2, where index 1 corresponds to the monoatomic surface layer, and index 2 — to the layer beneath the surface (sub-surface layer). The processes of chemisorption on target surface, sputtering of reactive gas atoms from target, implantation of reactive gas ions to the sub-surface layer, material evaporation, and transfer between the layers are considered. A separate equation connects the atomic fluxes of reactive gas associated with target and substrate surfaces with the volumetric characteristics, such as gas injection rate and pumping speed. The equations are solved numerically for the conditions relevant to the experimental hot-target magnetron setup. The results are then discussed in connection with the experimental observations of magnetron discharge with hot Cu, Cr, and Si targets in O_2/Ar and N_2/Ar environments.

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