Sputtered atom density – target heating correlation in hot magnetron sputtering discharge

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Hot magnetron sputtering (HMS) is a perspective way to increase the deposition rate as compared to the classical sputtering systems. In the HMS configuration, a target is thermally insulated from a water-cooled system. It allows a higher power density to be safely applied and lets the bombarding ions to heat the target up. Ultimately, when high temperatures are achieved, additional mechanisms start to contribute to the discharge behaviour: evaporation/sublimation of target atoms [1] or intense thermionic emission [2].

This work was aimed to evaluate the impact of the intense thermionic emission and high target temperatures on the behaviour of Nb sputtering species in the HMS system. For this purpose, laser-induced fluorescence (LIF) spectroscopy was used. Both ground state Nb neutrals and ions were monitored as a function of power in the range from 5 to 40 W/cm^2. Moreover, time-resolved 2D LIF-imaging of the magnetron discharge area was performed during the target heating interval (about 900 s).

Our results show that the density of ground state Nb neutrals saturates when the target temperature reaches 1600-2000 K. Afterwards, it starts decreasing as the applied power continues to grow. To the contrary, the density of Nb ions increases together with the target temperature, showing twice faster growth at 1900 K. Based on this, we can claim that the HMS of Nb target provides 2 times higher ionization degree as compared to classical magnetron system that may lead to a change of the deposited thin film properties.

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[1] Kaziev A. V., Kolodko D. V., Tumarkin A. V., Kharkov M. M., Lisenkov V. Y., Sergeev N. S. (2021). Comparison of thermal properties of a hot target magnetron operated in DC and long HIPIMS modes. Surface and Coatings Technology, 409, 126889.
[2] Leonova K., Britun N., Konstantinidis S. (2022). Target heating and plasma dynamics during hot magnetron sputtering of Nb. Journal of Physics D: Applied Physics, 55(34), 345202.