It is well accepted that the bulk gas in magnetron sputtering undergoes rarefaction near the cathode. This effect, known in direct current (DC) and pulsed-DC sputtering, is especially pronounced in the high-power impulse magnetron sputtering (HiPIMS) case, where it may affect numerous discharge parameters, and is not yet well understood [1].

This study is devoted to the rarefaction related phenomena in short-pulsed (< 50μs) HiPIMS. The time-resolved diagnostics of the HiPIMS discharges is performed using optical emission spectroscopy (OES), resonant optical absorption spectroscopy (ROAS), laser-induced fluorescence (LIF), and LIF imaging techniques. Both non-reactive and reactive cases are characterized.

The obtained data is analysed in order to generalize the observed time-resolved effects, which may be related to gas rarefaction. The time-resolved behaviour of the neutral and ionized ground state (Ti, W, Ti⁺), as well as metastables (ArM, TiM, O₉M) species is analyzed. The obtained time-resolved patterns are compared in terms of the particles number density, their velocity distribution functions, ground state/metastable sub-levels populations, etc. In addition, the non-reactive HiPIMS cases are compared to the reactive ones (Ar+O₂ mixture).

One of the main conclusions which can be drawn is the rarefaction in HiPIMS affects not only the bulk gas, but to a certain extent the sputtering species, which is related to the species number density and their velocity distribution. In the first case, a depletion of the ground state density at the end of the plasma on-time is observable, whereas in the second case the sputtered particles velocity may increase several times in the same time interval [2].


Keywords
HiPIMS
plasma diagnostics
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