Determination of sputtered species densities in HIPIMS discharge by optical emission spectroscopy

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Plasma emission from sputtered species is routinely measured in HIPIMS discharge with aim to e.g. assess ionized fraction of sputtered species, prove gas rarefaction or determine moment of transition from argon to metal dominated regimes. Direct measurements of the sputtered species ground state number densities is performed employing either laser induced fluorescence or absorption measurements. Since the ground or metastable levels of sputtered species do not produce any optical signal directly, it is difficult to obtain information about the number densities of the species in these levels from optical emission spectroscopy. A variety of indirect methods, however, have been developed mainly for rare gases to obtain information about the metastable state number densities. The indirect methods include detailed modeling of the production and loss mechanisms of levels of interest, the effect of metastables and ground state species on plasma emissions, self-absorption of plasma radiation and the effect of metastable atoms on the effective branching fractions of the specific transition. The aim of our research is to accommodate mainly the technique based on effective branching fraction developed previously for rare gases on HIPIMS conditions. Titanium was selected as a case study to test the suitability of the technique. The intensity ratios of carefully selected lines are used to determine the absolute densities of sputtered species. At low sputtered species ground state densities, these ratios of line intensities follow the ratios of corresponding Einstein coefficients. At significant sputtered species ground state densities, these ratios differ as the lines with higher oscillator strength are more effectively absorbed. Fitting theoretically calculated branching rations to experimentally measured ratios of the line intensities enables us to determine number densities of ground state sputtered species from optical emission spectroscopy in a HIPIMS discharge. This research has been supported by the CZ.1.05/2.1.00/03.0086 and GACR P205/12/0407 projects.

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