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Titanium Atom and Ion Number Density Evolution in Reactive High Power Impulse Magnetron Sputtering

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The hysteresis curve in R-HiPIMS generally exhibits a narrower shape compared to dcMS, or it can even be entirely suppressed, which is beneficial for high-rate deposition of stoichiometric compound films. However, the main effect behind the hysteresis suppression is not yet completely understood. We report on evolutions of titanium atom, and ion ground state densities in R-HiPIMS discharges in oxygen for constant mean power and pulse duration, when varying the repetition frequency. A fast feedback system is employed to allow working in the transition region of the hysteresis curve in a well-controlled manner. A recently developed effective branching fraction (EBF) method is utilized to determine absolute ground state number densities of sputtered titanium species from the optical-emission signal. The ionization fraction of sputtered species increases with the partial pressure of the reactive gas. The increased ionization of titanium is attributed to the combination of the following effects: a longer residual time of sputtered species in the target vicinity; a higher maximal discharge current attained at the end of the pulse; enhanced ionization. It is furthermore found that the hysteresis curve shape changes when varying the repetition frequency at the same mean power. The difference is more pronounced for R-HiPIMS with higher sputtered species ionization fraction. The experimental results are compared to the results obtained by a reactive ionization region model (R-IRM). The absolute ground state number densities of Ti atoms and Ti ions measured at the target vicinity are also substituted into the Berg model. The Berg model is modified to include ion back attraction, and a rather good match between the measurements and simulation results for different experimental conditions is found. This research has been financially supported by the LO1411 (NPU I) funded by Ministry of Education Youth and Sports of Czech Republic. Matej Fekete is a Brno Ph.D. Talent Scholarship Holder – Funded by the Brno City Municipality.

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