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A simplified model of a high-power pulsed magnetron sputtering discharge

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We present a one-dimensional volume-averaged non-stationary model of a high-power pulsed magnetron sputtering discharge. The model splits the magnetron discharge into two regions of interest, the high density plasma ring above the target racetrack including a target sheath, and the transport region between the plasma ring and the substrate. By solving the conservation equations for these regions, the model makes it possible to evaluate the time evolutions of averaged process gas and target material neutral and ion densities, as well as the fluxes of these particles to the target and substrate during a pulse period. Consequently, the target current density waveforms can be calculated by the model. The inputs of the model are the process gas pressure, target-substrate distance, magnetic field strength above the racetrack and the voltage waveform during a pulse period. Furthermore, additional parameters, such as the sputtering yields, secondary electron emission coefficients, ionization and excitation cross sections for the process gas and target material must be provided. The model is used to study high-power pulsed magnetron discharges, where a high flux of sputtered target material atoms from the cathode and a high plasma density change the plasma composition and the deposition characteristics. The model gives qualitative predictions of the target and substrate current densities and of the charged and neutral particle densities in the discharge. It also shows that under certain conditions a steady state can be reached during long pulses. This is in agreement with our experimental results. The current density waveforms predicted by the model for a large spectrum of variable parameters were compared with the experimental results. From the comparison we can get an insight into the physical processes that influence the evolution of a high-power pulsed discharge in a simplified manner.

Keywords
high-power magnetron sputtering
pulsed sputtering
non-stationary model