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Electron dynamics in HiPIMS discharges: A self-consistent model

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High Power Impulse Magnetron Sputtering (HIPIMS) is a physical vapor deposition (PVD) technique which utilizes magnetron discharges of extremely high power (kW/cm^2) in short pulses (tens to hundreds microseconds). Compared to conventional magnetron sputtering, HIPIMS is capable of generating films of high density and advantageous microscopic morphology. This capability is generally attributed to the fact that the critical figure of merit of PVD processes, the average energy per deposited atom, is nearly a factor of ten higher [Anders 2009]. Recent research has studied the complex pathway of the process energy from the power supply to the substrate.This contribution will focus on the first stages of this process. The electrons, released as secondaries from the cathode, are accelerated in the boundary sheath and enter the ionization zone above the "racetrack" where they are confined by the electric and magnetic field. In a sequence of successive collisions, the fast electrons deposit their energy to the other plasma species, particularly to the neutrals (via excitation and ionization) and to the less energetic but much more frequent background electrons (via Coulomb interaction). Both groups of electrons also exhibit complex spatial motion which gives rise to localized plasma structures (known as "spokes" or "humps"). To capture the processes just described, a model is investigated which comprises a gyro-kinetic sector for the energetic electrons, a gyro-fluid sector for the background electrons, and the assumption of quasi-neutrality. The relevance of this model to the simulation of HiPIMS discharges [Gallian et al. 2015] and to the interpretation of recent experimental findings [Anders et al. 2013] is discussed.
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