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PIC simulations of spoke structures in the dcMS and HiPIMS regimes of magnetron discharges

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Sputtering in magnetron plasma discharges remains one of the main technologies used for thin film deposition owing to relatively large deposition rates in the dcMS regime and high film density along with improved control over film properties in the HiPIMS regime, where plasma is highly ionized. Plasma dynamics is an essential part of this kind of technology, its understanding enables better control and forms a path for possible optimizations. One of the most prominent features of such magnetized discharges still lacking full understanding is the emergence of self-organized nonlinear structures dubbed spokes. The spokes strongly affect many important discharge aspects, such as electron transport and energy of the ions impinging on the substrate. The present work uses an implicit energy-conserving PIC code to self-consistently model the formation and dynamics of the spoke structures in the two basic regimes used for the film deposition, dcMS and HiPIMS, and demonstrates that although the spokes have a relatively large spatial scale, they are generated by much finer plasma instabilities. Differences between the spoke structures in the considered regimes are discussed.

Keywords
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