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3D - PIC-MC simulation of DC magnetron sputter discharges at realistic plasma densities

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High Power Impulse Magnetron Sputtering (HiPIMS) is a further development of magnetron sputtering, where short pulses with very high peak power density lead to a high ionization degree of the sputtered metal. This may have considerable impact on growing film properties such as increased density or conformal coating of 3D structures.
One issue in HiPIMS technology is the very high complexity of the process dynamics, whereof a full theoretical knowledge has not yet been obtained. From the many various mechanisms relevant in HiPIMS processes, this work focuses on the internal structure of the ring discharge plasma:While it usually appears homogeneously in lab-scale, it was recently revealed by high-speed imaging and other methods that it rather consists of a number of travelling density fluctuations. The number and travelling speed of these fluctuations depend on process parameters such as power density and total pressure, and we assume a significant impact of these phenomena on the overall discharge characteristics.
To address this topic more in detail, we performed parallel Particle-in-Cell Monte-Carlo (PIC-MC) simulations of a DC ring discharge within a 3D geometry. Even if the power density reachable in PIC-MC simulations is quite limited by numerical restrictions, we observe similar travelling plasma density fluctuations also for the low and medium power density range. From the simulations we qualitatively explain the origin of these fluctuations and their impact on the discharge characteristics in comparison with experimental findings. Besides of that, numerical issues in simulation of high-density sputter discharges are discussed, and an outlook on the feasibility of simulating HiPIMS conditions by PIC-MC is given.

Keywords
Magnetron Sputtering
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