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Influence of plasma self-organization on the ground state atoms in HiPIMS discharge

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High power impulse magnetron sputtering (HiPIMS) is a versatile PVD technique for growth of the thin films with advanced properties. Versatility of HiPIMS originates not only from the additional external parameters such as pulse duration and frequency, but also from the complex plasma where the plasma composition and the charge state of the metal ions can be controlled. Understanding the complex nature of the HiPIMS plasma is necessary in order to exploit its full potential.
Recently, there have been a large number of reports on plasma fluctuations in HiPIMS discharge, so called spokes or ionisation zones. Spokes are represented by localised light emission patterns rotating in the ExB direction with different mode numbers at angular velocities of an order of 10 km/s. There is necessity to understand the physics of the spokes since the spokes have been correlated to the enhanced diffusion across the magnetic field, sometimes called anomalous cross-B diffusion.
This work deals with the influence of the spoke dynamics (as emission zones) on the ground state density of the main discharge species. Time-resolved correlation between the spokes and the ground state/metastable atoms has been investigated for the first time in HiPIMS discharge using Laser induced fluorescence. The ground states of atomic Ti ($3d^24s^2\ a^3F_2$), Ti^+ ($3d^2(^3F)4s\ a^4F_{3/2}$), and the metastable state of Ar ($3s^23p^54s\ (1s_5)$) have been considered. The correlation between the density of the studied states and spoke dynamics has been observed in some cases, which is explained by the phenomena inherent in HiPIMS, such as (i) the difference in the excitation thresholds, and (ii) the over-excitation of the low electronic states during the plasma on-time.
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