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Origin and mechanism of plasma instabilities in HIPIMS

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Observed with a low time resolution, the optical emission from HIPIMS discharge may appear to be homogeneous during the pulse. However, we have shown recently that the HIPIMS plasma may develop drift wave type instabilities [1]. They are characterized by well defined regions of high and low plasma emissivity along the racetrack of the magnetron and cause periodic shifts in floating potential. The structures rotate in ExB direction at velocities of ~10 kms^{-1} and frequencies up to 200 kHz. It has already been shown in literature that the magnetron configuration may exhibit two-stream instabilities [2]. However the characteristic frequency of these instabilities is of the order of a few MHz, well above the frequencies associated to the drift wave type instabilities we have observed.
In this paper a detailed analysis of the temporal evolution of the saturated instabilities using four consequently triggered fast ICCD cameras is presented. In order to better understand the mechanisms involved, different optical interference band pass filters were used to observe the spatial distribution of different species within the instability. It was found that the optical emission from the instabilities comprises ion emission (both target material and gas ion lines) with strong depletion of the emission lines of the target material atom lines, concluding that instabilities are driven by ions. The form of the instability with final avalanche phase where high portion of hot electrons is created can be described by violation of β limit, where plasma pressure is increased up to the point to overcome the magnetic confinement resulting in the stream of electron emitted perpendicular to the static magnetic field lines. Furthermore double flat probe confirm the finding of streaming electrons followed by ions.
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