PL0004

Transport of neutral and charged species in conventional magnetrons, RF-IPVD and HiPIMS

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Low pressure plasmas operate generally in the intermediary pressure regimen, between ballistic and diffusive. This is the case of magnetron discharges – conventionally DC (direct current) or RF (radio frequency) excited, and improved Ionized Physical Vapor Deposition magnetrons with additional RF plasma (RF-IPVD), High Power Impulse Masgnetron Sputtering (HiPIMS), as well as other plasmas such as Inductive Coupled Plasmas (ICP), Negative Ion (NI) plasma sources, etc.
The ionization efficiency of low pressure plasmas is boosted by the use of external magnetic fields that traps the electrons and hence strongly localizes the ionization region. Moreover, the use of additional RF discharges and especially HiPIMS introduces the time dependency of plasma parameters and transitory phenomena.
This plasma anisotropy affects directly the neutral species transport, especially when the ionization degree exceeds 50% as it is the case in HiPIMS. Comparative analysis on neutral transport is presented for different magnetron excited discharges operating in noble gases and in reactive gas mixtures, showing undoubtedly the ‘wind effect’ and gas rarefaction.
The electron transport in magnetized plasma is governed by the anisotropy as well. The transverse diffusion generally obeys Bohm formulation, but for several situations such as HiPIMS, high density NI beam sources... the electrons escaping the magnetic trap can overcome the Bohm limit.
The positive and negative ions transport in magnetized plasmas is strongly dependent of the eedf and the electric field distribution in the ion generation region. Positive ion production requires highly populated eedf tail, while only low energy electrons attach leading to negative ion formation. However, neutral-surface charge transfer can efficiently generate negative ions, being dragged into the discharge by the sheath field.
From all these cases, common features of the transport of plasma species in similar magnetized plasmas can be identified, aiming to propose a general scenario.

Keywords
HiPIMS