

Effect of Ion Composition and Ion-Neutral Collisions on the Negative Ion Plasma Sheath with Surface Produced Negative Ions

S. Samanta^{1,3}, R. Moulick^{1,2,3}, P. J. Bhuyan¹ and B. J. Saikia¹

¹ Centre of Plasma Physics-Institute for Plasma Research, ² Homi Bhabha National Institute

³ Gauhati University

e-mail: sutapa.samanta@cpiplr.res.in

Plasma sheath has been investigated using a theoretical model for Hydrogen negative ion plasma, consisting of electrons, positive ions, volume negative ions and surface produced negative ions. The structure of a plasma sheath formed in front of a low work-function (Caesium coated) metallic plate in a Hydrogen negative ion plasma is of crucial importance, especially for negative ion based neutral beam injector (n-NBI) systems. For such a case, volume negative ions are generated within the bulk of the plasma through dissociative attachment; while, the surface negative ions are produced via the attachment of resonantly tunnelled electrons from the coated metallic plate with neutral atoms and/or positively charged ions [1]. The surface-produced negative ions are considered as a primary source of negative ions due to their high extraction efficiency [2]. Furthermore, it has been observed that in order to make the electrons suitable for dissociative attachment, it is necessary to reduce their temperature by putting an inert gas (e.g. Argon), into the negative ion source in addition to Hydrogen [3].

In this work, sheath characteristics are investigated highlighting the influence of volume electronegativity on the sheath profiles. The study goes further to investigate the effect of Argon addition on the production of surface negative ions [4]. In addition, the effect of ion-neutral collisions is highlighted. Since the production of surface negative ions depends on the

incoming flux of positive ions and neutral atoms towards the metallic plate, ion-neutral collisions play a critical role on the sheath formation. It is observed that ion-neutral collisions have a diminishing effect on the ion velocity and ion impact energy at the wall. Consequently, it affects the production of surface negative ions [5].

References

- [1] M Seidl et al. “Negative surface ionization of hydrogen atoms and molecules”. In: Journal of Applied Physics 79.6 (1996), pp. 2896–2901.
- [2] Sejal Shah and M Bandyopadhyay. Effect of surface produced negative ions on near wall sheath. Plasma Physics and Controlled Fusion, 51(3):035015, 2009.
- [3] B Kakati et al. “Effect of energetic electrons on dust charging in hot cathode filament discharge”. In: Physics of Plasmas 18.3 (2011).
- [4] Sutapa Samanta, Rakesh Moulick, PJ Bhuyan, and BJ Saikia. Plasma sheath with multi-species of positive ions and surface produced negative ions. Contributions to Plasma Physics, 63(8): e202300044, 2023.
- [5] Sutapa Samanta, Rakesh Moulick, PJ Bhuyan, and BJ Saikia. Effect of ion-neutral collisions on the plasma sheath in the presence of surface-produced negative ions. Contributions to Plasma Physics, page e202400088, 2024.