

Plasma-Wall Interaction in Presence of Intense Electron Emission from Walls

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There have been sufficient experimental and theoretical evidence that strong secondary electron emission (SEE) from the channel walls affects thruster operation. SEE enhances the heat losses to the walls and increases electron conductivity, which, consequently, degrades thruster performance [1]. The plasma-surface interaction in presence of strong thermionic or secondary electron emission has been studied theoretically and experimentally. The electron flux to the wall is determined by the electron velocity distribution function (EVDF) and by the sheath potential, which is set by ambipolar condition consistent with the EVDF and the wall emitting properties [2,3]. Nonlinear coupling between EVDF and sheath potential is responsible for a number of unusual phenomena. For example, we observed relaxation sheath oscillations [3]. We have shown that the criterion for instability is that the secondary electron emission coefficient of electrons with energy normal to the wall bordering the wall potential becomes larger than unity [4]. We observed new regime where all plasma electrons leave and are substituted by secondary electrons [5]. In this regime, there is practically no electric field in plasma and sheath, so that ions are not drawn to the wall, plasma electrons are not confined and the plasma potential is negative. Sheath instabilities influence the current balance, energy loss, cross-B-field transport and even the bulk plasma properties. The results show that common theories that treat emission as an effective averaged “coefficient” do not capture the full extent of SEE effects [6]. Emitted electrons can excite electron plasma waves due to the two-stream instability [7]. The two-stream instability can affect the sheath potential. Numerical study showed that intense electron beams from cathode could also excite ion acoustic waves that may modify plasma properties.

The SEE fluxes on the inner and outer walls of Hall thruster might be asymmetric due to specially designed wall materials, asymmetric wall erosion, mirror or centrifugal forces [8,9]. We have performed theoretical and numerical investigations of asymmetric regime where walls have different emission properties [8].

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References

- [1] Y. Raitses, I. D. Kaganovich, A. Khrabrov, D. Sydorenko, N.J. Fisch, A. Smolyakov, IEEE Trans. on Plasma Scie. **39**, 995 (2011).
- [2] I. D. Kaganovich, Y. Raitses, D. Sydorenko, A. Smolyakov, Phys. Plasmas **14**, 057104 (2007).
- [3] D. Sydorenko, I. D. Kaganovich, Y. Raitses, A. Smolyakov, Phys Rev Lett. **103**, 145004 (2009).
- [4] M. D. Campanell, A. V. Khrabrov, I. D. Kaganovich, Phys Rev Lett. **108**, 235001 (2012).
- [5] M. D. Campanell, A. V. Khrabrov, I. D. Kaganovich, Phys Rev Lett. **108**, 255001 (2012).
- [6] M. D. Campanell, A. V. Khrabrov, I. D. Kaganovich, Phys. Plasmas **19**, 123513 (2012).
- [7] D. Sydorenko, A. Smolyakov, I. Kaganovich, and Y. Raitses, Phys. Plasmas **14**, 013508 (2007)
- [8] Y. Raitses, M. Keidar, D. Staack and N. J. Fisch, J. Appl. Phys. **92**, 4906 (2002).
- [9] Y. Raitses, D. Staack, N. J. Fisch, IEEE Transactions on Plasma Science **36**, 1202 (2008).