Effect of secondary electrons on Hall Effect Thruster discharge

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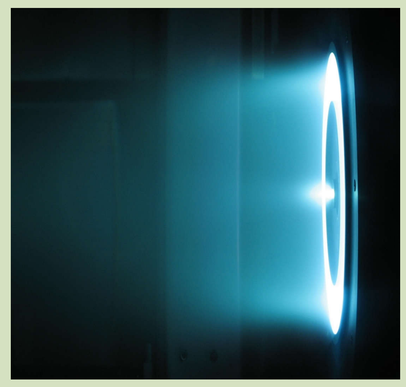
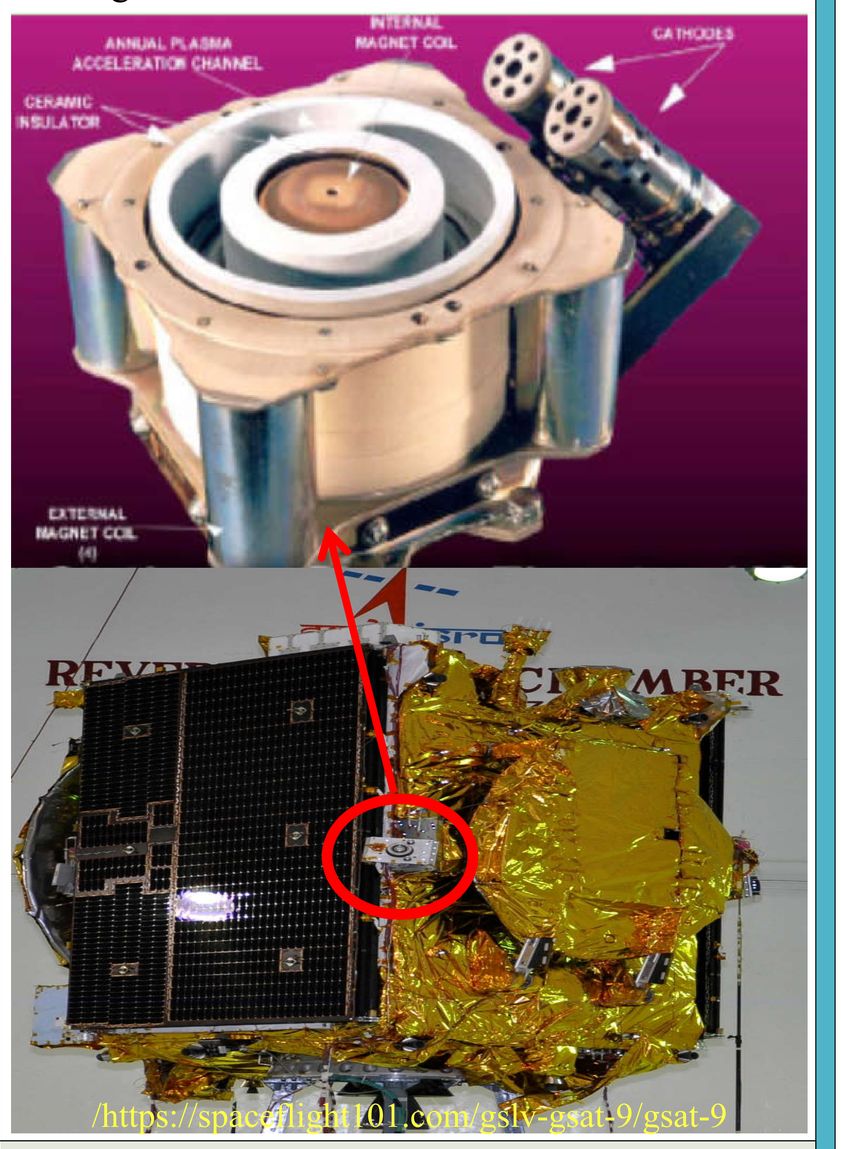


Introduction

➢ Electric Propulsion (EP) - converts electrical energy into kinetic energy by ionizing a gas and then accelerating the exhaust through electrostatic or electromagnetic means.

➢ Hall thrusters [1] - electrostatic thrusters which utilize a cross-field described by the Hall Effect to generate the plasma discharge with magnetized electrons and unmagnetized ions in the axial electric and radial magnetic fields applied in an annular ceramic channel, and the discharge voltage controls the electrons which diffuse across the magnetic field.



PIC-MC Simulation

➢ PIC-MC [2], - a kinetic model [3] for plasma simulations - both the electrons and the ions are treated as particles in a self-consistent electric and magnetic fields.

➢ Computes the motion of a collection of charged particles, interacting with each other and also with the externally applied fields.

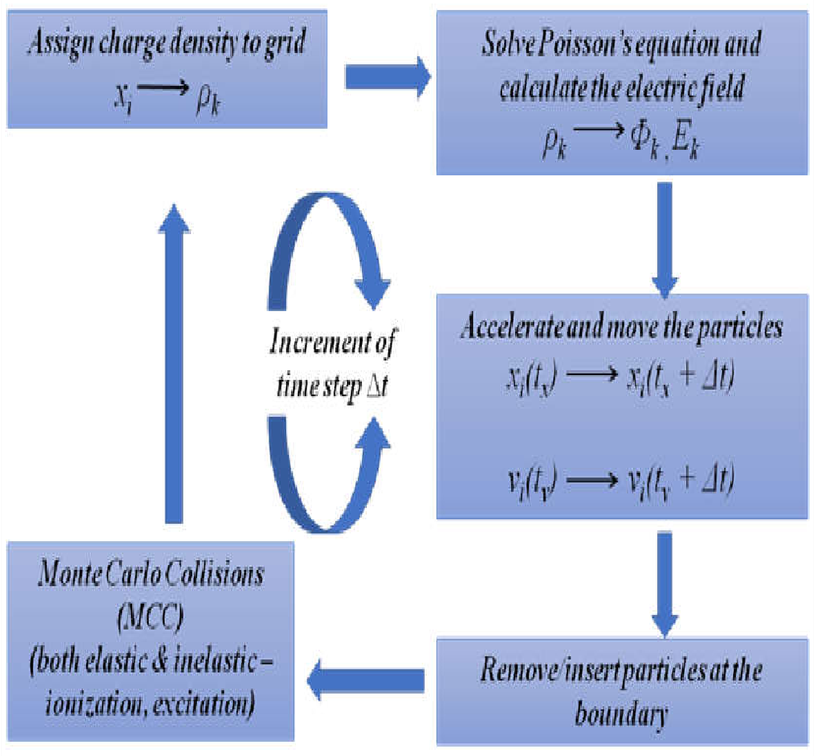


Fig. 1. The schematic diagram for the PIC-MC

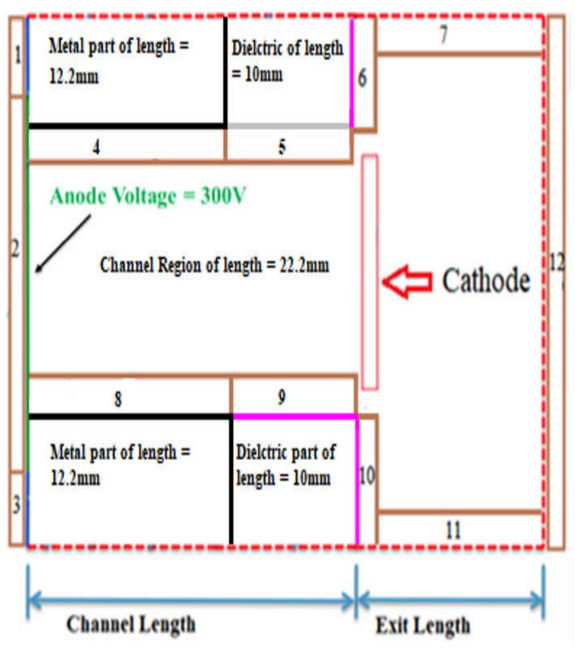
➢ The software used for the simulation is **VSim**, which has been procured by IIST.

Design & Simulation Requirements

➢ The major assumptions used for the simulation are the following.

- Radial magnetic field is considered for simulation.
- Electrostatic solver has been used.
- Neutrals are treated as background gas with linear density drop from anode to exit of channel.
- The Xe neutral density has been predefined as a constant, and is taken as $10^{21}/cm^3$.
- The electron energy is also predefined to be 25eV.
- The cathode has been modelled as electron emitter close to exit.
- The cathode voltage is kept at absolute zero.

➢ The particle collision is handled by MCC. The collisions include electron-neutral collisions (ionization, excitation, and elastic scattering) as well as ion-neutral collisions (charge exchange and elastic scattering).



Particle BCs	Surfaces
Ion Absorbers	1-12
Electron Absorbers	1-12
Ion Source	Through Ionization
Primary Electron Source	Cathode
Secondary Electron Emitters	4, 5, 8, 9
Sputter Emitters	5, 9
Charging Effect	4, 5, 8, 9

Fig. 2. Boundary conditions for 300mN SPT

Magnetic Field Topology

➢ The magnetic field is calculated by the 2D model and the magnetic field topology was simulated and incorporated into the code in analytical form, a combination of 3 Gaussian curves,

$$B_r(r,z) = \frac{A \exp\left[\dfrac{(-4\ln 2)(z-z_c)^2}{w^2}\right]}{w\sqrt{\dfrac{\pi}{4\ln 2}}}$$

➢ The geometry of the new HET has been shown in Fig. 3(a) and the Fig. 3(b) gives the magnetic flux lines (designed using MAXWELL) in the 2D plane.

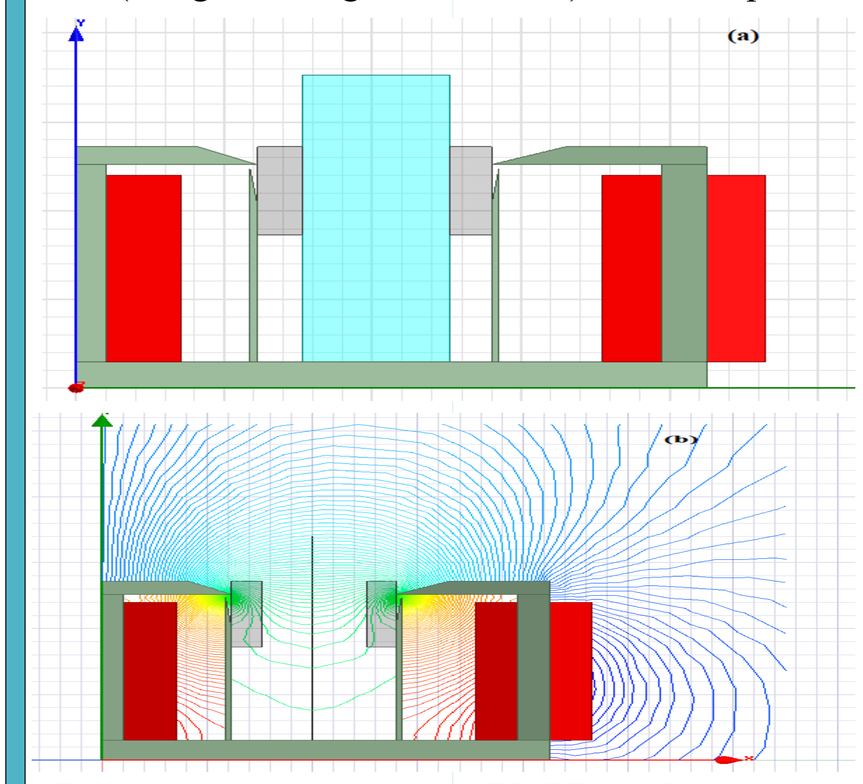


Fig. 3. (a) Geometry of the 300W SPT (b) Magnetic flux lines in the 2D plane.

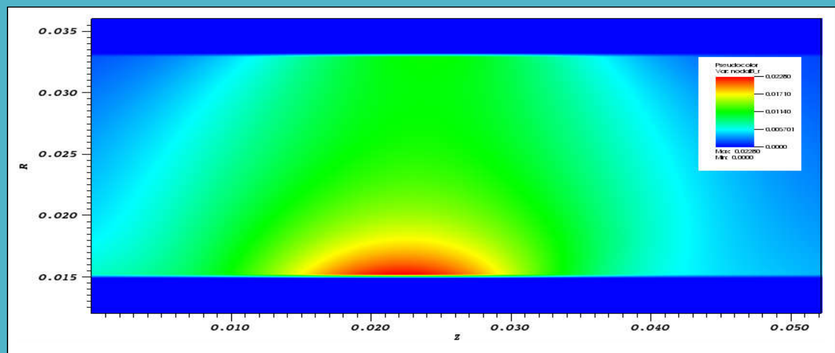


Fig. 4. The magnetic field topology (Max radial magnetic field = 180G).

Results & Discussions

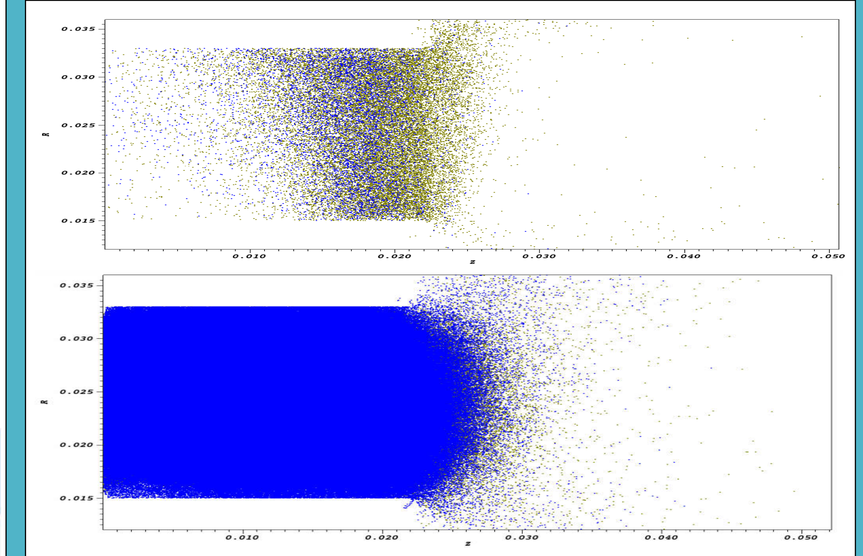


Fig. 5. The general electron and ion distributions in space at (a) 0μs (b) 0.25μs

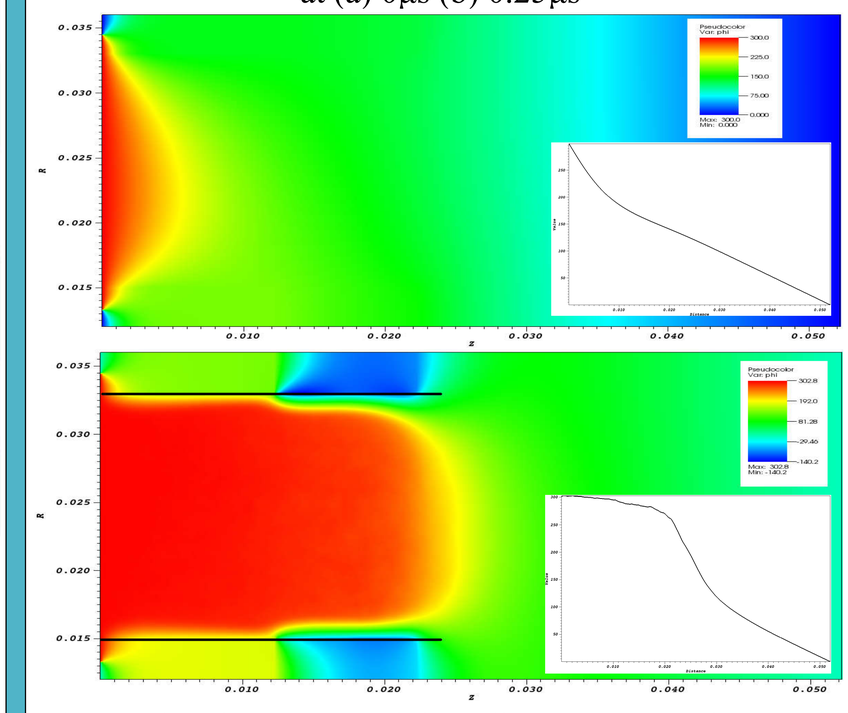


Fig. 6. The plasma potential gradient at (a) 0μs (b) 0.25μs

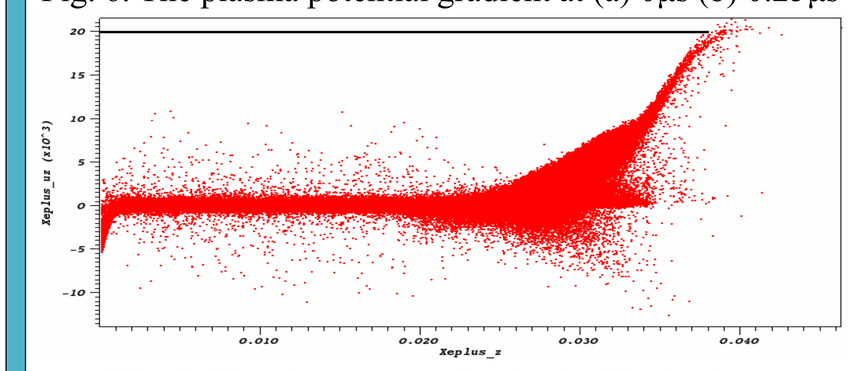


Fig. 8. The phase space plot for the Xeplus ions

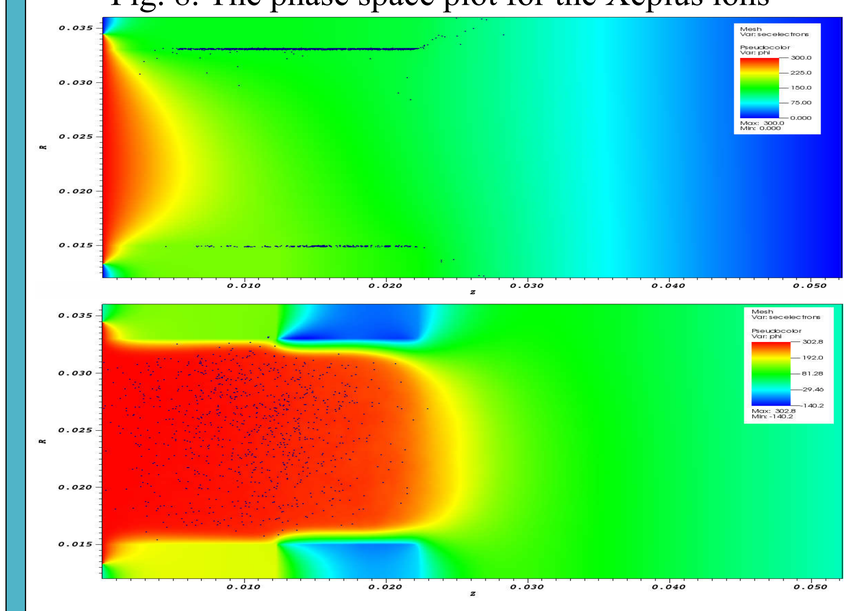


Fig. 10. The secondary e^- distribution (a) 0μs (b) 0.25μs

References

[1] D. M. Goebel and I. Katz, Fundamentals of Electric Propulsion: Ion and Hall Thrusters, John Wiley and Sons (2008).
[2] P. L. Pritchett, Space Plasma Simulation, Lecture Notes in Physics, 615, Springer, Berlin, Heidelberg (2003)
[3] C. K. Birdsall, IEEE Trans. Plasma Science 19, 65 (1991)