Numerical investigation of a Hall thruster plasma including sputter yield

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The effect of inelastic collisions and sputter yield is of vital importance in predicting the thrust and lifetime of an electric propulsion device, namely a Hall thruster. The walls of the discharge chamber of a stationary plasma thruster are commonly made of composite ceramic materials, namely, boron nitride and silicate oxide. Among many reasons limiting the efficiency and lifetime of a thruster, the most critical is the wear of the surface layer of the ceramic walls. The coaxial wall erosion of a thruster occurs due to sputtering, re-deposition, cracking, etc. Further, sputtered material may contaminate the spacecraft surface and affect the working parameter optimization. In the present work, the dynamics of stationary plasma thruster is investigated numerically in the presence of plasma-wall interaction. The effect of secondary electron emission and sputter yield has been considered simultaneously. The plasma-wall interaction is a function of wall potential, which in turn is determined by the secondary electron emission and sputtering yield. Owing to disparate temporal scales, ions and neutrals have been described by set of time-dependent equations while electrons are considered in steady state. Based on the experimental observations, a third order polynomial in electron temperature is used to calculate ionization rate. The changes in plasma density, potential and azimuthal electron velocity due to sputter yield are significant in the acceleration region. The change in ion and electron velocity and temperature is small. The neutral velocity, which decreases initially, starts increasing toward the exit consistent with the computed neutral density profile. The full paper will document numerical details and comparison of predicted results with the experimental data.

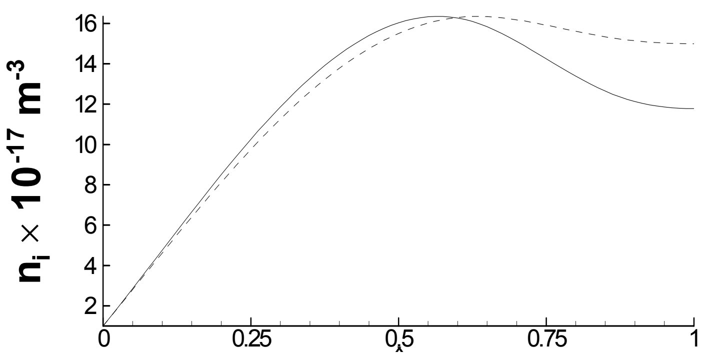

Figure 1. Ion density increases towards the exit by an order of magnitude; bold line shows the distribution predicted with the sputter yield, while dotted line shows the trend without sputtering.

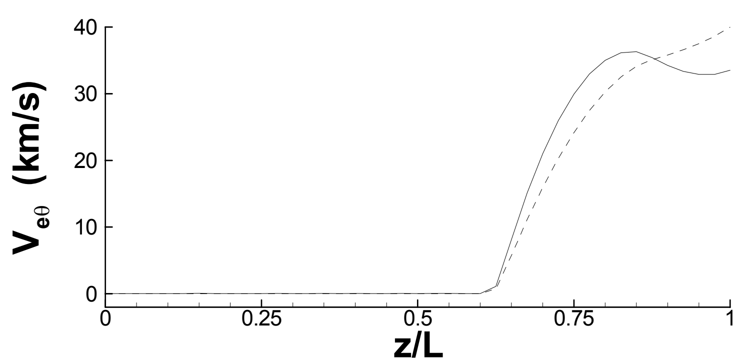

Figure 2. Electron drift velocity with sputter yield predicts the maximum just upstream of the channel exit (bold); the trend is significantly different in the case without the sputter (dotted line) where the peak is at the exit plane.