2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Influence of the Decelerator Grid on the Optical Performance of the Ion Thruster

Chang Lu[1], Yong Cao[1]
[1] Department of Mechanical Engineering and Automation, Harbin Institute of Technology(Shenzhen)
e-mail:yongc@hit.edu.cn

The failure of the accelerator grid structure is mainly caused by the Charge Exchange ion (CEX ion) sputtering, which erodes the downstream of the accelerator grid and the electron backstreaming due to enlargement of the accelerator grid apertures from its Barrel erosion. In order to avoid the accelerator structural failure caused by the CEX ion sputtering, which is also called Pits & Grooves erosion, the decelerator grid is added. Many ion thruster tests had shown that the decelerator grid can significantly reduce the Pits & Grooves erosion.

However, the effects of the decelerator grid on the optical system, such as on the extraction process of beam ions and CEX ions, have not been fully studied. The performance of the thrust and specific impulse of the electric thruster is determined by the extraction capability of the optical system to the beam ion, and the extraction characteristics of the optical system on the CEX ion determine its service life.

Therefore, it is crucial to investigate the influence of the decelerator grid on the optical system so that it can provide theoretical guidance to the optimal design of the optical system and ultimately prolong the service life of the optical system. The influence of the decelerator grid on the optical system can be investigated by experimental tests and numerical simulations. Very few experiments have been conducted since they are time-consuming and expensive, and no relevant experimental results can be employed to help understand the influence of the decelerator grid on the optical system.

Hence, the influence of the decelerator grid on the optical performance is investigated. In order to explore the impact of the decelerator grid on the optical system, a 3-grid system is constructed on the basis of the 2-grid optics of NSTAR.

The results indicate that the decelerator grid has no effect on the beam ions, as well as the CEX ions from the upstream and extraction (center), but significantly affects the reflux CEX ions from the downstream. Under all working conditions, the Pits & Grooves erosion of the accelerator grid is significantly reduced. The Barrel erosion of the accelerator grid changes with the variation of the working conditions. After adding the decelerator grid, the negative potential inside the hole of the decelerator grid attracts more CEX ions to impinge the downstream end of the accelerator grid(Fig.1), while the CEX ions from the upstream and extraction (center) leading to the Barrel erosion of the accelerator grid are basically the same. It causes the significant increase of the erosion of the accelerator grid aperture barrel.

However, with the increase of the upstream number density, the potential inside the hole gradually increases to the level greater than the potential of the wall in the decelerator grid(Fig.2). Then the decelerator grid begins to effectively intercept the reflux CEX ions in the downstream, and the Barrel erosion rate of the accelerator grid of the 3-grid optics is basically the same as that of the 2-grid optics.

References

R. E. Wirz, J. R. Anderson, D. M. Goebel, I. Katz, Decel grid effects on ion thruster grid erosion, IEEE Transactions on Plasma Science 36 (5) (2008) 2122–2129.

J. Wang, J. Polk, J. Brophy, I. Katz, Three-dimensional particle simulations of ion-optics plasma flow and grid erosion, Journal of Propulsion and Power 19 (6) (2003) 1192–1199.

J. J. Wang, Y. Cao, R. Kafafy, R. Martinez, J. Williams, Numerical and experimental investigations of crossover ion impingement for subscale ion optics, Journal of Propulsion and Power 24 (3) (2008) 562–570.

R. Kafafy, J. Wang, Whole ion optics gridlet simulations using a hybrid-grid immersed-finite-element particle-in-cell code, Journal of propulsion and power 23 (1) (2007) 59–68.

H. Cao, Y. Chu, E. Wang, Y. Cao, G. Xia, Z. Zhang, Numerical simulation study on barrel erosion of ion thruster accelerator grid, Journal of Propulsion and Power 31 (6) (2015) 1785–1792.

C. Lu, T. P. Zhang, P. Qiu, J. J. Chen, Y. Cao, Barrel erosion of ion thruster accelerator grid under different operating conditions, submitted.

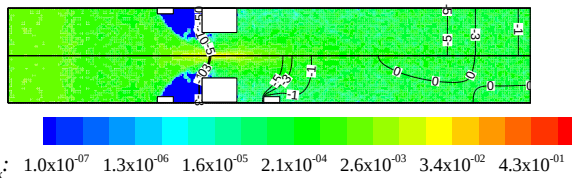

Figure 1. CEX ions and potential distribution at n_0=0.075.

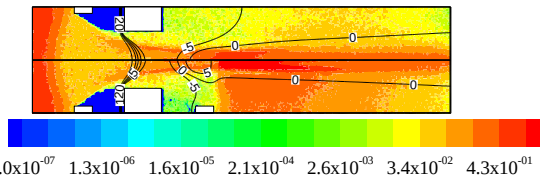

Figure 2. CEX ions and potential distribution at n_0=2.0.