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Investigation of Electron Cross-field Transport in Hall Thrusters with Inhomogeneity of Plasma Density and Potential in Azimuth

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Hall thrusters have been known to show a certain level of inhomogeneity in the azimuthal direction due to a strong instability excited by electron ExB drift in azimuth. Various analytical and numerical researches suggests the azimuth inhomogeneity can result in anomalous electron cross-field transport.

Regarding the electron transport, Yoshikawa et al. reported that when there is a plasma density fluctuation, the electron diffusion became proportional to n/B both theoretically and experimentally. Hirakawa et al.[1] carried out a numerical simulation to find the transverse electron velocity induced by out-of-phase of electric field and density in azimuth is close to the velocity expected from the Bohm diffusion. Also, recent numerical simulation by Smolyakov et al.[3] shows the anomalous current is a result of the phase shift between density and potential, and Kawashima et al.[4] who carried out the simulation on non-uniform operation reported the out-of-phase of density and potential in plume region. These series of researches suggests that the phase shift of density and potential may closely relate to the anomalous electron transport.

However, due to the small level of this inhomogeneity ~ 1%[5] and time-varying turbulent characteristics, it has been difficult to capture this phenomenon experimentally. In this research, we artificially introduce inhomogeneity in azimuth through non-uniform propellant supply (Fig. 1) and generate similar order of azimuthal electric field (Fig. 2), and investigate electron cross-field transport on steady distribution with azimuthal inhomogeneity and comparison of the obtained result from non-uniform operation to the uniform reference is also discussed in further detail.

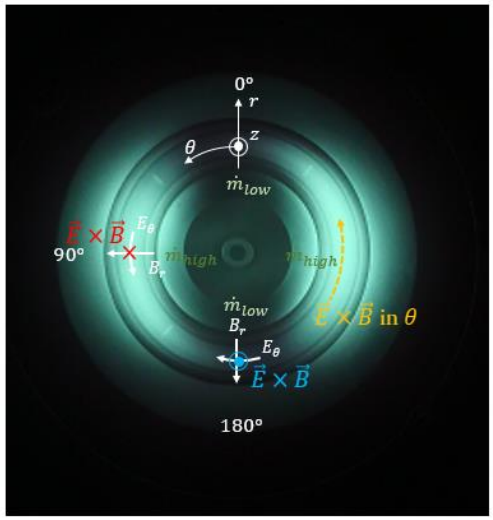

Figure 1. A still-shot of non-uniform propellant operation of a Hall thruster, and ExB direction is shown with the coordinate system used in this research are shown.

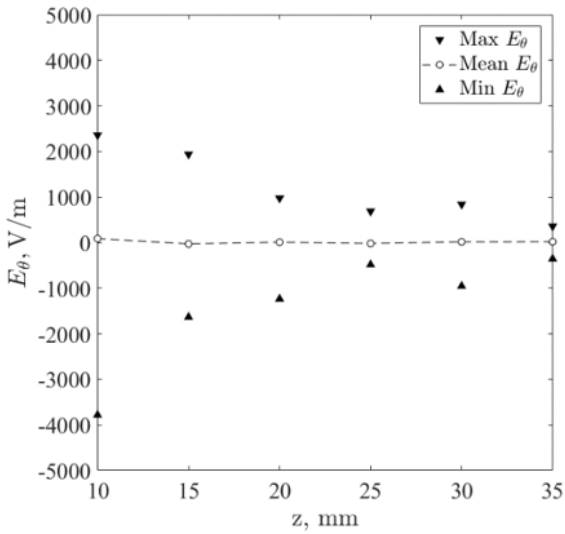

Figure 2. Induced azimuthal electric field by the non-uniform propellant along axial location.

References

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