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Title

Electric field simulation of FEEP thruster for cubesat application

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Abstract

Nowadays, as the CubeSat applications are becoming more complex and diversified, various propulsion types are being developed for the CubeSats. Especially, the Field Emission Electric Propulsion (FEEP) system is preferred for its simplicity, small size, high efficiency, etc. Thus, more than one hundred FEEP systems have flown. The FEEP system technologies have been studied by a few European research groups for decades, however, it is difficult to adopt their specialized data directly to a new development of the FEEP system by other groups.

To investigate the core technologies of the FEEP system and set up useful design methodologies, the present study summarized firstly the principles of the FEEP system and the various types of the emitter, which is a major component of the FEEP thruster.

Next, the modified mathematical analytical models for various single-emitter types are proposed to evaluate the major performances of the FEEP thruster during an initial design phase. The relations between electric current and voltage can be predicted and compared with experimental data to verify the accuracy by using this model. Also, important performance parameters such as a specific impulse and a thrust level can be estimated.

Finally, numerical simulations are performed to investigate the electric field behaviors of the various single-emitter types using Gauss's law in Maxwell's equation and Laplace's equation. By integrating the simulation results, the emission current and onset voltage of the emitters can be predicted to evaluate the overall performance of the FEEP system. To investigate theoretically FEEP thruster, we developed a simulation model to calculate numerically electric field distribution for FEEP thruster by solving Maxwell's equation depending on voltage condition applied to emitter and extractor using finite element and boundary element methods. Using this model, we have performed some simulations for external wetted emitter and single porous emitter with 2D axisymmetric configuration. In addition, the validity of the electric field analysis models is verified by comparing with the mathematical analytical models and experimental data.

Consequently, we expect that the present mathematical analytical and simulation models of the various single-emitters to be useful to evaluate the more detailed design of the new FEEP system under development and improve its performance better.

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