Paper ID: 40022
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SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations (IP)

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SPACECRAFT-PLASMA INTERACTIONS OF A CUBESAT EQUIPPED WITH MINIATURIZED FEEP THRUSTERS

Abstract

A miniaturized FEEP (Field-Emission Electric Propulsion) system, also called NanoFEEP, is a novel technology of electric propulsion developed by TU Dresden that shall be tested providing attitude and orbital control (AOC) on UWE-IV, a 1U (Unit) CubeSat developed by Wuerzburg University. In this paper, we present the simulation results of the CubeSat interaction with ambient plasma in several mission scenarios, to determine whether high electrostatic charging may appear when operating the NanoFEEP thrusters without neutralization units in the ionosphere.

Numerical simulations are performed with the open-source 3D-PIC (Particle in Cell) code SPIS. The simulated thruster currents are varied in the range of 0 to 250 μA, while plasma O^+ ions and NanoFEEP ion distributions are modeled with a full PIC scheme following a drifting Maxwellian distribution. In contrast, ambient electrons are modeled as a fluid following a Maxwell-Boltzmann model. The electric field calculations are performed by an implicit Newton-type solver for the Poisson equation, based on Dirichlet boundary conditions in spacecraft and Robin at the boundaries of computational domain.

In particular, we observe space-charge sheath and wake phenomena as spacecraft dimensions are larger compared to the Debye length. The plasma disturbances form electrostatic barriers preventing ambient electrons to reach the CubeSat surface which drastically reduced the electron current collected at typical plasma densities. Moreover, our simulations show that passive ion collection is slightly increasing with increasing emitted thruster current due to growing of the surrounding sheath. These results expose that no substantial electrostatic charging leading to discharges or material damage should be present in the UWE-IV platform, if thruster currents of not more than 23 μA are emitted without neutralization for AOC.