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MINIATURIZED PULSED PLASMA THRUSTERS FOR CUBESATS: MODELLING AND DIRECT THRUST MEASUREMENT

Abstract

Miniaturized satellites like CubeSats pose stringent requirements to a possible propulsion subsystem regarding mass, volume and power budget. De-orbiting manoeuvres to avoid space debris and enabling formation flying make autonomous thrust generation yet desirable for this satellite class. Due to the opportunity of low frequency pulsed operation, adapting well to limited energy budget available, and their mechanical simplicity, Pulsed Plasma Thrusters are best suited for miniaturization.
An electromechanical model for performance simulation, based on accurate inductance gradient description and especially adapted to the miniaturized geometry, has been developed and compared to established analytical descriptions of PPTs. The impact of miniaturization of various design parameters on performance has been theoretically investigated.
An experimental thrust balance able to resolve forces in μN scale has been designed and put in operation. It consists of a horizontal 70cm arm, an eddy current brake, an electrical comb structure and a precision optical reflective sensor. Two modes of operation have been developed: firstly the arm is deflected by the reacting force of the mounted thruster and knowing the spring constant of the hangers the force can be calculated. Secondly a voltage is applied to the electrical combs, which equals the reacting force of the thruster to keep the arm in resting position. Knowing the voltage which is proportional to the square root of the generated force, the thrust can easily be calculated.
Since these types of balances are commonly used to measure constant thrust, it has been necessary to optimize the device for measuring pulsed thrusters with ignition frequencies below 1Hz. Direct thrust measurements of μPPTs with highly miniaturized, parallel-plate thrust chambers have been performed and put in correlation to the electrical circuit parameters, validating the theoretical predictions. In addition, the impact of the electrode opening angle on the generated thrust has been examined.