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RETURN PLASMA CURRENT INTERACTIONS BETWEEN A CAPACITIVELY COUPLED PLASMA THRUSTER AND SPACECRAFT SURFACES

Abstract

Development of micro-propulsion systems for CubeSats and other small satellites is increasing the duration and complexity of potential small satellite missions. Numerous micro-propulsion systems are now under development, including an electrothermal plasma micro-thruster known as Pocket Rocket. Pocket Rocket uses radio-frequency power to generate a weakly ionized capacitively coupled plasma. Charge-exchange collisions within the plasma volume and surface heating from ion neutralization on thruster walls increases propellant temperatures, with Pocket Rocket operating as an electric hot gas thruster. Capacitively coupled plasma is highly affected by the ratio of positive to negative electrode area. Integrating the thruster into a spacecraft structure will change the negative electrode area, thereby altering the plasma state generated in the thruster when compared to independent lab operation. Additionally, the system relies on consistent return currents from the artificially generated plasma plume to establish and maintain a constant density discharge within the thruster. Operating in an ambient plasma environment rather than a neutral environment such as ground based vacuum systems will induce environmental plasma currents that when combined with the plume return currents may alter thruster operation. Simulations of thruster performance for varying negative electrode areas based on satellite integration design and varying spacecraft surface potentials from an ambient plasma environment show significant changes in thruster operation. Experimental results for varying grounded surface areas validate the simulation results. The outcome of this work demonstrates the large impact plume-spacecraft interactions can have on capacitively coupled plasma propulsion system integration and highlights considerations for design.