GEC09-2009-000429

Abstract for an Invited Paper
for the GEC09 Meeting of
the American Physical Society

Microdischarge plasma thrusters for small satellite propulsion

LAXMINARAYAN RAJA, The University of Texas at Austin

Small satellites weighing less than 100 kg are gaining importance in the defense and commercial satellite community owing to advantages of low costs to build and operate, simplicity of design, rapid integration and testing, formation flying, and multi-vehicle operations. The principal challenge in the design and development of small satellite subsystems is the severe mass, volume, and power constraints posed by the overall size of the satellite. The propulsion system in particular is hard to down scale and as such poses a major stumbling block for small satellite technology. Microdischarge-based miniaturized plasma thrusters are potentially a novel solution to this problem. In its most basic form a microdischarge plasma thruster is a simple extension of a cold gas micronozzle propulsion device, where a direct or alternating current microdischarge is used to preheat the gas stream to improve to specific impulse of the device. We study a prototypical thruster device using a detailed, self-consistent coupled plasma and fluid flow computational model. The model describes the microdischarge power deposition, plasma dynamics, gas-phase chemical kinetics, coupling of the plasma phenomena with high-speed flow, and overall propulsion system performance. Unique computational challenges associated with microdischarge modeling in the presence of high-speed flows are addressed. Compared to a cold gas micronozzle, a significant increase in specific impulse (50 to 100 %) is obtained from the power deposition in the diverging supersonic section of the thruster nozzle. The microdischarge remains mostly confined inside the micronozzle and operates in an abnormal glow discharge regime. Gas heating, primarily due to ion Joule heating, is found to have a strong influence on the overall discharge behavior. The study provides a validation of the concept as simple and effective approach to realizing a relatively high-specific impulse thruster device at small geometric scales.