Characterization of the Micro-Pulsed Inductive Thruster (µPIT)

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High Speed Camera Results

The need for micro-propulsion for high resolution mapping and attitude control and primary propulsion has grown exponentially in recent years. Examples of the former include the NASASAMO and International Space Station (LSSA) and Larga Camera 21. Both of these missions employ a constellation of spacecraft that are required to fly in formations with tight tolerances on satellite distance and positions. The thruster requirements for LSSA include a maximum thrust of ~20 µN with a thrust resolution of 0.1 µN and a total impulse of 5000 Ns. Also the thrust mass change must be small enough to allow the required lifetime. Thrust duration impacts the thruster with a thrust of 53 µN and a total impulse of 47 Ns. The requirements for LSSA and Larga Camera 21 are representative of the requirements of the next generation of micro-propulsion.

In addition to precision pointing, the next generation of micro-propulsion is needed for station keeping and attitude control on nano (~10–50 kg) and micro- (<10 kg) satellites. The power supply must fit into the volume (~< 0.1 m³) and mass constraints of these satellites. Generally these satellites require ~10 µN for station keeping and impulse bits on the order of 0.1 µN for attitude control.

One example technology is the micro-pulsed plasma thruster (µPPT). The µPPT utilizes an arc discharge across a parallel surface, which generates a plasma that is accelerated away from the thruster. Using solid fuel, eliminates a significant amount of mass from the thruster design in terms of propellant, pressure, and power supply. However, due to the innovative power supply design, µPPT is believed to be capable of liberating macro-particles from the surface. Due to an innovative power supply design, the µPIT is capable of in-air discharge. This type of operation has applications to surface discharge cleaning, fluid flow control over a surface, and other applications that require a high power in-air discharge.

In order to demonstrate improved performance of µPIT with an inductive drive, experiments were conducted with µPIT mode and without µPIT mode: 31.9 km/s and 19.9 km/s, respectively. The inductive coil remained in the circuit while in PPT mode so as not to alter the characteristics of the power supply.

Effect of the Inductive Coil

In PPT mode, the discharge energy was 6 J in both cases.

A. µPIT Mode (includes inductive coil)

B. PPT Mode (no inductive coil)

The average time of flight between the arc and when plasma is detected downstream at a Langmuir probe is in good agreement with estimates of flight time data shown above Langmuir probes. This gives a plasma speed of 35 km/s on average. Further work will characterize the complete exhaust velocity due to both plasma and neutrals. Other groups studying PPSs have estimated that neutrals could account for 40–50% of the total mass ablated.

Other Applications

In addition to operating in a vacuum chamber, µPIT is also capable of in-air operation. This type of operation has applications to surface discharge cleaning, fluid flow control over a surface, and other applications that require a high power in-air discharge.

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