Magnetically-Enhanced Vacuum Arc
Microthruster for Small Satellite Control

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Principal of thruster operation

Two types design of micro-cathode thruster (µCT) were investigated and tested at MPNL. The thruster utilizes magnetically enhanced vacuum arc between tubular solid anode and cathode separated by isolator as shown in Figure1. The operation of the µCT relies on the natural expansion of arc plasma jet in vacuum. As a result of self-consistent ambipolar electric field in the expanded plasma, ions are accelerated in plasma jet up to 10^4 - 3·10^4 m/s. An applied magnetic field works to transform radial cathodic jet flow into axial flow as shown in Figure 1. The arc spot is developed at the boundary between the metallic cathode and ceramic spacer ring. Multiple spots are exist with current per spot of about 10-30 A dependent on cathode material. A magnetic coil has been placed outside of the cathode to obtain a highly directional plasma plume, and create a rotating cathode arc-spot the increases the operational lifetime of the thruster.

µCT with magnetic field as a plasma source was used to provide hollow shape plasma plume to simulate the weekly ionized plasmas for hypersonic applications. Plasma spots are generated along the cathode and stay close to the magnetic field lines that pass through the spots. A conical column body is placed co-axis with thruster which as shown in the Figure 2. The experiment results will be used for simulation code development and theoretically analysis.

Hypersonic project

Figure 2. (a) Schematic of experiment setup. (b) 4 co-axis probes are placed on the surface of conical to measure the ion current of the current. (c) Experiment results.

PPU developed to MCU control

Figure 4. (a) PPU is based on generation of high voltage pulse (of about Ld/dt) at fast break of circuit containing inductor. Utilization of this PPU allows arc initiating without a need in external high voltage source for breakdown. (b) Atmel MCU is used to build digital control power process unit.

Thruster thrust experiment

Figure 5. Experiment results of thruster impulse distribution with different magnetic field strength.

Velcocity Measurement

Figure 7. (a) Velocity distribution along the outside the source channel with different magnetic field strength. (b) grids experiment setup.

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Microthruster for cube satellite

High speed camera observation experiment

Figure 3. IStar high speed camera was used to visually measure the plasma plume distribution on the conical column surface. The camera explosion time is 30us. Time is the delay time after discharge.

PPU developed to MCU control

Figure 4. (b) Experimental observation for vacuum arc thrusters.

Thruster thrust experiment

Figure 5. Thruster impulse vs. magnetic field strength.

Velocity Measurement

Figure 7. Velocity distribution along the outside the source channel with different magnetic field strength.