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Design and Experiment Study of a Novel Electrothermal Pulsed Plasma Thruster for Space Applications

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Pulsed plasma thrusters (PPTs) are relatively mature electric propulsion devices for small/micro satellites to complete specific space missions. PPTs are mainly divided into two categories, electromagnetic PPTs and electrothermal PPTs. Under the effect of a current pulse, propellant is ablated and decomposed to form plasma bulk. Afterwards, charged particles are accelerated by Lorentz force or gas dynamic effect to generate thrust. In low power level, the main factor that restrict the development of PPTs is the comparatively low efficiency. Compared to the electromagnetic PPTs, electrothermal PPTs will accelerate neutral particles more effectively to enhance the overall efficiency. Therefore, in the case of low stored energy, electrothermal PPTs have great potential to research and develop.

In this paper, a novel electrothermal PPT, which is based on the capillary discharge, was designed. The prototype has a PTFE cavity with variable dimensions, an inner anode and a hollow outer cathode. Meanwhile, a high-performance spark plug was developed and laid in the slot of cathode to ignite main discharge. The main capacitor capacitance ranged from 0.1 μ F to 3 μ F, the main voltage ranged from 1kV to 3kV. The trigger capacitor capacitance was 0.1 μ F, the trigger voltage was 1kV. Discharge waves were measured and analyzed. Generally, the main discharge was a typical underdamped RLC discharge and the duration time was several microseconds. However, the main discharge is aperiodic for the resistance and inductance in the plasma channel were not constant. The deposition energy in the arc channel was calculated, according to the calculation result, the effect of circuit parameters and structure parameters on the energy deposition efficiency was concluded. Meanwhile, the time delay between the ignition discharge and the main discharge was measured. These parameters also had influence on the time delay, the relationship between these parameters and the time delay was studied.

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