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ALTERNATIVE PROPELLANTS FOR LOW-POWER PULSED PLASMA THRUSTER

Abstract

Nowadays small satellites, especially CubeSat nanosatellites, became frequently used ones. Manufacturing and launch price of such satellites is low, so this fact makes them an attractive option for testing new technologies, for Earth diagnostics and etc. Sometimes these satellites require a propulsion system for an increase of lifetime, disposal or group flight implementation. Since nanosatellites have small mass, their space missions requires low-thrust propulsion systems.

Electric propulsion systems, which can generate thrust about $1 \mu\text{N} \dots 10 \text{ mN}$ fit this requirement the best. However not all electric propulsion can be used for such missions. Nanosatellites have restriction on power supply, propulsion system volume and mass. Some electric propulsion systems (for example, GIT or Hall thrusters) suffer from performance degradation and manufacturing complication while decreasing power supply. Also propulsion propellant supply subsystem, which is high-pressure tank with gas interchanges, is one of the largest subsystems in propulsion system. Some electric propulsion systems require cathode-neutralizer for neutralizing positive charged ion beam. This makes satellite design more complex and expensive. In this regard pulsed plasma (PPT) thruster is considered as a propulsion system for such satellites.

PPT can operate in low power supply conditions without significant performance degradation. It does not require cathode-neutralizer usage, as neutral plasma flows from thruster head. This thruster operates on solid non-conductive propellant. This makes propellant supply subsystem simpler, which make propulsion system cheaper. Polytetrafluoroethylene (PTFE) (also known as Teflon[®]) is usual propellant for pulsed plasma thrusters. However, due to some researches, operating with low charge energies can lead to strong propellant surface carbonization. This phenomenon decreases thruster performance. As carbon layer on propellant surface is conductive, it creates short circuit. For all these reasons, low-power pulsed plasma thruster requires some new alternative solid propellants. According to different researches, Celcon, Halar, EFTE, HTPB-AP and others were tested as alternative propellants. But all these experiments were done by different research groups, which mean different experimental conditions, and high charge energies (more than 10 J). For these reasons it is hard to draw a conclusion about alternative propellant for nanosatellite low-power pulsed plasma thruster.

Alternative propellants for low-power coaxial pulsed plasma thruster are considered in this report. PTFE, polyamide-6, polyurethane, polyoxymethylene and others were tested. Obtained results are discussed.

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