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DEVELOPMENT OF NOVEL ELECTRODELESS PLASMA THRUSTER WITH MULTIPLE THRUST VECTORING CAPABILITY

Abstract

Since the first proposal of wave plasma source application for plasma propulsion by Australian physicist R. Boswell, multiple concepts in the area of electrodeless plasma thruster have emerged, ranging from the helicon thrusters for small satellite applications to the most advanced concept of a nuclear fusion propulsion system proposed by the Princeton Plasma Physics Laboratory. Although the electrodeless plasma thrusters have critical benefits, such as the capabilities to produce high density plasma and even to operate in nuclear fusion regime, but they have been criticized for: high mass magnetic system that is inherent in electrodeless propulsion systems; potential gas discharge chamber erosion caused by the configuration of electromagnetic fields characterized wave plasma regime; plasma instabilities that alter plasma characteristics during thruster operations and deteriorate thrust performance and reliability of the propulsion system. Despite the notable shortcomings, in this paper it is proposed to take a fresh look at the electrodeless propulsion technologies beyond the conventional views on space thruster application, by proposing a novel configuration of electrodeless thruster that is only made possible by the electrodeless technologies. The proposed thruster configuration is a thruster with ring-shaped gas discharge chamber and guide tubes attached to the chamber that determine thrust vector directions. This novel configuration allows to create multiple thrust force vectors within one thruster, while significantly increasing orbital maneuverability for spacecraft. For ionization, this thruster can utilize either high frequency or radiofrequency (RF) electromagnetic waves, while the former prevents capacitive coupling from occurring and the latter allows to achieve full wave energy absorption in the ring-shaped discharge tube and wave propagation regime. For plasma acceleration, this thruster can use magnetic nozzles or ion-optical system with RF electric field for elimination of cathode-neutralizer. The proposed thruster configuration can be a game changer particularly for small form factor CubeSat applications by enabling new space missions that are otherwise not achievable in and beyond low Earth orbit (LEO).