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Title

Design and testing of a heaterless hollow cathode for a low-current electric thruster

Authors

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Abstract

Hollow cathodes are widely utilised for plasma generation in electric thrusters[1]. The use of an external heater to bring the emitter material to the point of thermionic emission is common but is associated with a long warm-up period and complicates design of a power processing unit [2]. Consequently, the adoption of heaterless hollow cathodes (HHCs) have gained traction in space applications. In HHCs, the application of a large voltage across the propellant leads to a Paschen discharge. The resulting plasma is sufficient to heat the emitter to the point of thermionic emission However, despite their potential, an HHC has never been operated in space [3]. Development of compact high-voltage circuitry needed for the discharge, changes in characteristics over time due to erosion and heat protection of non-emitting elements are still to be addressed to mature the technology.

This study has involved the development of an HHC for use in low current (<10A) thruster discharge. Two different cathode designs (1) one with open-end tantalum emitter keeper utilised and (2) second with orifice lanthanum hexaboride emitter working with argon propellant has been designed for characterisation This work reports results on the role of high voltages employed to ignite HHCs, issues regarding arcing and methods of preventing them. Significant attention has been dedicated to the development of electronic circuitry that enables the reliable ignition of a stable thermionic glow discharge. Parameter sweeps such as the propellant flow rate, current and voltage limits, keeper geometry, and specific timings of the ignition procedure will be discussed in the context of their role in the reliability of ignition, time to ignite the cathode to thermionic temperatures, and the steady state operation. The work also presents characteristics of the HHC such as its Paschen curve, steady state electrical characteristics and plasma appearance, temperature, and how these have changed over time due to erosion and other modes of degradation.

Reported results the comparative study between two different HHC cathodes. The paper illustrates the technical challenges of lab-scale cathode testing and exemplifies means of reducing them. It also forms a comparative study between the two different HHC designs, and aims to indicate design choices for designers of future electric thrusters

References

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