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DEMONSTRATION OF EXHAUST PLUME QUASI-NEUTRALITY IN A PULSED CATHODIC ARC THRUSTER

Abstract

Electric propulsion is rapidly maturing as the preferred type of satellite propulsion for large spacecraft and small satellites for constellations, but the options for cubesats are still limited at this time. One of the challenges that many electric propulsion technologies must overcome relates to spacecraft charging effects; since the ions produced by these plasma propulsion systems are far more massive than the electrons in the discharge plasma, most electric propulsion systems are designed to accelerate and eject the ions to generate thrust. Without a system to inject electrons into the exhaust, which will neutralise the total charge of the thruster exhaust, ions from the exhaust will be attracted back to the spacecraft. This process will not only reduce thruster efficiency, but also degrade sensitive devices on spacecraft through ion bombardment and associated sputtering effects. Exhaust neutralisation systems have extensive flight heritage but are among the most challenging components in Hall Effect or ion thrusters from an engineering standpoint. In particular, the cathodes of these neutralisers are often made from brittle materials such as tungsten or lanthanum hexaboride, which can fracture under vibrational load, and often require warm-up time and input heating power to remove various oxide coated layers. While the development of a more effective and reliable neutraliser cathode is still an active area of research, there also exist propulsion technologies which do not require an exhaust neutraliser, as they utilise a fundamentally different ion acceleration strategy. In this work we present Neumann Space's demonstration of plasma plume quasi-neutrality in the exhaust of a pulsed cathodic arc thruster. While the volumetric quasi-neutrality of arc derived plasma is known to the thin-film deposition and materials science research communities, there has been little work to validate this knowledge from a propulsion system perspective. Here we present the engineering model design concept, the test parameters, and the results of testing performed to satisfy standard integration challenges in an upcoming mission by comparing the total charge and current entering the test environment to that conducted to ground from the test environment.