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CHARACTERIZATION OF AN ADAPTIVE HALL THRUSTER

Abstract

Electric propulsion for spacecraft is known for its high specific impulse, a measure of the magnitude of the impulse which can be imparted per mass of fuel, up to 10x to 20x higher than chemical rockets. The trade off of such high fuel utilization is lower thrust, so low that their use is generally constrained to space applications, such as satellite propulsion. One variety of an electric propulsion device is a Hall Thruster, which uses crossed electric and magnetic fields to ionize and accelerate particles. Hall Thrusters are further divided into stationary plasma thruster (SPT) and thruster with anode layer (TAL) configurations, the differentiator being whether the channel material between the thruster and the plasma is an insulator or a conductor. Changing the material affects the secondary electron emission and number densities, which will result in changes to the specific impulse and thrust.

In its 2015 Nanotechnology Roadmap, NASA noted that nanotechnology is mature enough to use for in flight adaptation. It has been demonstrated that electric conductors such as graphene can be converted to electric insulators such as graphane, through the addition of nanoparticles under plasma conditions similar to those seen in Hall Thrusters. This paper will investigate the physical phenomena via simulation of an SPT and TAL Hall Thruster using 2D particle in cell methods. Comparisons in the variations of specific impulse and thrust between the configurations will be observed, in addition the nanoparticle flux to the wall will be observed and an attempt to match flux to those observed in previous research. An experimental thruster will then be designed and constructed based on the results of the simulation. It will be tested on a thrust stand located in a vacuum chamber at RAPPEL, in order to compare simulations to experimental results.

The expected results will allow Hall Thrusters to adapt between SPT and TAL configurations during operation, as well as reposition the anodes. This will allow for variation in the specific impulse and thrust during the mission, ensuring the optimization is achieved during different segments of the mission. The results will provide a foundation for further experimentation examining the self healing properties due to the addition of nanoparticles, this will counteract erosion of channel walls, which is the primary limit on thruster life.