Investigation of Techniques to Mitigate the Erosion of a Mesh Reflector Exposed to a Hall Thruster Plume

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Hall effect thrusters (HETs) have many advantages over traditional chemical systems. Due to their high specific impulse HETs have much higher propellant efficiencies. Thus, they can support a wider range of missions ranging from LEO to deep space. It is no surprise then that they have become one of the most popular choices for many new and upcoming missions. While EP devices can offer a higher propellant fraction, they also present a unique problem for spacecraft integration: the higher exhaust velocities —typically in the 10's of km/s— produced by EP devices can bombard spacecraft surfaces and cause erosion [1]. This is especially problematic for deployable structures, like communication dishes, which can extend into denser plume regions. Previously, we developed a model to predict the erosion of the meshed reflector surface used in these dishes [2]. The predictions of this model were experimentally verified [3]. We found that material sustained significant damage to the material in a short period of time when exposed to the plume of a hall thruster, in accordance with our predictions.

When we then use the calibrated model to predict the erosion of a dish in a typical orbital configuration we find that although there is not significant damage initially, over the long operational lifetime of an EP missions even the relatively low ion flux at the reflector location can become a issue. Given that this erosion is unavoidable, there is an apparent need to develop methods to mitigate this erosion. To this end, we devised an experiment to examine systematically two different mitigation strategies. The first was an active method, reverse biasing. By raising the electrical potential of the reflector array it may be possible to repel and reduce the energy of incoming ions, thereby reducing erosion. The second is a passive method, shadow shielding. A small obstruction is placed upstream, near the thruster, in order to shadow a large downstream area from plume ions. The effect of this obstruction (carbon shield) is shown in Fig. 1. We found that both mitigation strategies were successful in either reducing, or completely eliminating the erosion of the reflector material.

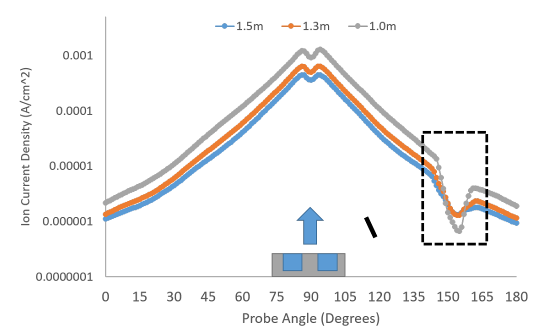

Figure 1 - Plot showing the effects of the carbon shield on the measured ion current density at three different radial distances.

References

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[2] Meyer, M. E., Byrne, M. P., Jorns, B. A., and Boyd, I. D. "Erosion of a meshed reflector in the plume of a Hall effect thruster, Part 1: Modeling," AIAA Propulsion and Energy Forum and Exposition, 2019.

[3] Byrne, M. P., Meyer, M. E., Boyd, I. D., and Jorns, B. A., "Erosion of a meshed reflector in the plume of a Hall effect thruster, Part 2: Experiments," AIAA Propulsion and Energy Forum and Exposition, 2019.