INVESTIGATION OF BIPROPELLANT PLUME-INDUCED CONTAMINATION EFFECTS ON COVERGLASS MATERIALS

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Contamination and degradation of external spacecraft materials by unburned and partially combusted species from bipropellant thruster plumes has long been observed as a key component of the induced space environment. Space shuttle flight experiments and returned flight hardware from the International Space Station (ISS) have both experienced microscopic impact features induced by high-velocity thruster plume droplets. Analytical results have shown that droplet impingement angle relative to a receiving surface plays a key role in the surface damage. Although impacts with normal impingement angles contribute more severely to surface degradation than highly oblique angles, surface effects at higher impingement angles should not be dismissed.

Thruster plume-induced materials degradation is a complex phenomenon that depends on a variety of parameters, including but not limited to material type, system temperature and pressure, plume composition, and thruster firing specifications such as number of pulses, pulse duration, and sample distance from the thruster. For space applications, attaining the vacuum pressure and temperature conditions necessary for flight-like plume expansion and exposure conditions is not a trivial task. The German Aerospace Center (*Deutsches Zentrum für Luft- und Raumfahrt, DLR)* is a facility uniquely capable of simulating such conditions.

Test coupons were exposed to bipropellant thruster firings under high vacuum at the *DLR* facility. Percent area coverage (PAC) and droplet size distributions were evaluated for the uncoated and coated solar array coverglass materials over a range of impingement angles (0° to 75°). A post-test imaging workflow was developed that aimed to quantify changes in sample surface morphology obtained from scanning electron microscopy (SEM) images using the Image Processing and Analysis in Java (ImageJ) tool; an opensource image processing software. The goal was to create a framework through which to evaluate the effect of bipropellant-induced PAC and droplet size distribution on solar array coverglass optical transmission losses. Understanding this relationship is important because optical transmission losses are known to lead to current reduction in solar power generation systems.

In addition to the development of surface characterization workflows, valuable lessons learned as they pertain to future investigations and experiments will be discussed. The authors hope that sharing these lessons will facilitate more utilization of *DLR*'s unique capabilities as well as open the conversation for how best to address experimental characterization of flight-like plume expansion and its impacts on materials surface degradation effects.