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Characterization of Modern Spacecraft Materials under Space-simulated Environment

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External spacecraft materials play an important role in satellite protection from the harsh space environment. Research has shown that the physical, chemical, and optical properties of matter change continuously as a result of exposure to solar radiation and aggressive chemical species produced in Earth's upper atmosphere. Thorough knowledge of the material properties evolution throughout a planned mission lifetime helps to improve the reliability of spacecraft. Moreover, the establishment of correlation factors between true space exposure and accelerated space weather experiments at ground facilities enables accurate prediction of on-orbit material performance based on laboratory-based testing. The presented work aims to evaluate the radiation effects of low Earth orbit (LEO) environment, namely, exposure to the high-energy electrons, atomic oxygen (AO), and vacuum ultraviolet (VUV), of several modern spacecraft materials.

The studied materials represent the "flight duplicates" of samples that will be launched as a part of the Materials International Space Station Experiment Flight Facility (MISSE-FF) mission in 2022. MISSE-FF flight sample collection comprises different classes of polymers, including polyimides from the Kapton® family, manufactured by E.I du Pont de Nemours and Co., Polyethylene terephthalate (PET) materials, liquid crystal polymers, PI/Polyhedral Oligomeric Silsesquioxanes (POSS), and carbon and glass fiber reinforced polymers. A sequential exposure approach was undertaken to allow monitoring of degradation induced by each environmental component (electrons, AO, and VUV) separately. Surface morphology, optical, and charge transport properties of selected materials were characterized using different techniques, namely, atomic force and scanning electron microscopy, ultraviolet visible (UV/Vis) transmission, reflectance, Bidirectional Reflectance Distribution Function (BRDF), and surface potential decay measurements.