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SPACE WEATHER INDUCED OPTICAL CHANGES IN HAMR DEBRIS MATERIALS

Abstract

Ground- and space-based optical observations of space objects rely on knowledge about how spacecraft materials interact with light. However, this is not a static property. We have shown that the optical fingerprints of several commonly used spacecraft surface materials change continuously under exposure to high energy electrons, the primary damaging species in geostationary Earth orbit (GEO). Laboratory observations have also shown that these changes in a material's optical signature are to some degree transient. In the first part of this study, we investigate the rate and degree of optical darkening and "optical healing" in vacuum for electron damaged polyimide (Kapton-H®) and polyethylene teraphthelate (Mylar®), major components in many varieties of multilayer insulation (MLI). Characterization of optical damage as a function of electron exposure and optical healing as a function of time in vacuum represents a major step toward a predictive model for optical characterization of space objects.

In polymers, the changes in optical signature occur due to surface degradation, leading to altered reflectivity, and due to radiation induced chemical modification, leading to an alteration of a material's absorption/transmission properties. Electrons can be expected to primarily alter the bulk of the material with minimal effect on surface morphology due to the nature of energy deposition. However, proton damage is a second significant source of energy deposition in GEO. Due to the greater mass of protons, the mechanism of energy deposition is fundamentally different from that of electrons. Therefore, in the second part of this study we have evaluated the optical changes in polyimide as a function of simultaneous electron and proton exposure. The results of both parts of this investigation will find use in the space environmental remediation community for characterization of high area to mass ratio (HAMR) objects as MLI fragments comprise a large portion of HAMR space debris.