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Abstract

Various highly insulating materials used in spacecraft construction can exhibit glow (electron-induced luminescence or cathodoluminescence) when exposed to the space plasma environment. Measurements of the absolute and relative cathodoluminescent intensity per incident electron flux of spacecraft materials are essential to predict and mitigate consequences for optical detection and for stray light contamination in space-based observatories. They also provide important information about the defect structure and electron transport properties of these materials. Previous studies have focused on how the relative spectral radiance of cathodoluminescent materials varies with changes in environmental conditions, including electron energy, current density, absorbed power density, and temperature. The present study focuses on variations associated with the materials.

We present measurements from a wide variety of thin film dielectric and nanodielectric composite samples. These include: polyimide films, neat urethane and bisphenol/amine epoxy films; bulk and thin optical coatings of disordered SiO_2; several grades of commercially available high-conductivity carbon-loaded polyimide nanodielectric composites; cyanate ester and urethane epoxy resins in graphite fiber and fiberglass composites; and multilayer dielectric/conductor composites. Comparisons of the absolute spectral intensities per incident electron flux for various materials show three orders of magnitude variation. These absolute spectral intensities for isolated samples exposed to electron fluxes comparable to solar wind intensities span the intensity of the zodiacal background in the visible and near infrared wavelength range. In general terms, we found that the relative cathodoluminescence for a given electron flux ranks from lowest to highest intensity for bulk polyimide, polyimide nanodielectric composites, disordered SiO_2, epoxy resin composites, and bulk epoxy materials.

Finally, we describe a study of the variability of a large set of similar bisphenol/amine epoxy samples exposed simultaneously, in the same space environment test chamber, to similar space-like monoenergetic electron flux conditions. The observed statistical fluctuations provide measures of both the instrumentation precision and the stochastic variations inherent to the material. This allows us to estimate the accuracy and precision to which laboratory studies may be able to determine the response of spacecraft materials in the actual space environment. It also provides guidance as to the distribution of emissions that may be expected for sets of similar flight hardware under similar environmental conditions.

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