6. Electrical Equilibration of Dielectrics When Exposed to Energetic Electron Beams

William Saylor
General Electric Company
Philadelphia, Pa.

Abstract

In recent years, anomalous behavior has been noted for synchronous orbit spacecraft, These anomalies are now generally correlated with the occurrence of solar magnetic substorm activities when the spacecraft is in the plasma sheath environment. This can result in a nonuniform distribution of surface charge on the spacecraft dielectric thermal control surfaces. The resulting surface charge accumulation can leave large potential gradients for electrical discharges to occur whi h can pose a serious threat to the operational integrity of a spacecraft.

The purpose of this research experiment then was to gain an understanding of the complex nature of electrostatic charging. This experiment consisted of a series of measurements of electrical equilibration of selected dielectric materials when exposed to energetic electron charging beams. The electron beatn simulates the environmental conditions in a magnetic substorm region of space, and the dielectric samples are representative of those found on the surface of a typical synchronous orbit spacecraft. The materials investigated were: Woven Silica Fabric, Thermal Control Paints, Solar Array Cover Glass, Teflon, Kapton and Mylar Films, and various composite combinations of the above. Also examined were polymeric films with special static charge control coatings applied. The Electrical Equilibration Measurement apparatus is shown and the results of the experiment are presented and discussed. The parameters that were determined include: The through conduction and surface leakage currents; the rurface charge and equilibration potential; the bulk and surface resistivity; all as a function of the electron beam energy.

In general, the measurement results demonstrate that the magnitude of the surface charge potential is highly dependent upon (1) the bulk arld surface resistivities bf the dielectrtc materials, (2) the average energy of the bombarding electron beam, and (3) the secondary omission characteristlcs of the dielectric materials. The bulk and surface resistivities require threshold criteria for charge storage and/or leakage to take place, wlth the surface resistivity usually the dominant controlling factor, The criterion for charge storage versus charge leakage begins to show itself at a resistivity value of about 10^{12} ohms. Significant charge leakage or storage can be obtained at values slightly less than or more than 10^{12} ohms. The electrbn beam energy and the effective secondary emission "second cross-over potential" also play a large role in determining the magnitude and polarity of the surface charge potentials.