6-2024

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17th Spacecraft Charging Technology Conference

Avignon, France
June 17-21, 2024

Radiation Induced Conductivity of PEEK: Effects of Temperature and Total Ionizing Dose*

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Radiation induced conductivity (RIC) plays a critical role in space charge dissipation within insulating materials used in spacecraft. Ionizing radiation present in harsh space plasma environments deposits energy into materials via inelastic scatter, exciting electrons into the conduction band without depositing charge for penetration radiation. RIC is expected to be affected by temperature and total ionizing dose (TID); temperature primarily affects the rate of promotion of electrons in localized trap states within the band gap to the conduction band, while TID can create additional traps states thereby increasing trap density and reducing mean trap separation.

RIC was measured in a new test system employing a closed-cycle He cryostat with a custom test fixture using a parallel plate geometry. An 80 keV electron beam exposed samples to penetrating electron radiation, with dose rates ranging over ~20 µGy/s to 0.2 Gy/s. 25 µm thick polyether ether ketone (PEEK) samples, with 500 nm of vapor deposited copper electrodes on either side, were held under a constant electric field of ~1 MV/m (~220 V) provided by a very stable current battery power supply. The resulting increased equilibrium current during bombardment is used to infer the enhanced RIC conductivity above the dark current conductivity (with limiting ranges of ~1 fA and $<5\cdot10^{-21}$ $(\Omega\text{-cm})^{-1}$.

Results show that RIC of PEEK follows a standard theoretical power law model proposed by Fowler, $\boldsymbol{\sigma = k_{RIC} \cdot \dot{D}^{\Delta}}$, where $\boldsymbol{\dot{D}}$ is the incident dose rate and k_{RIC} and Δ are material dependent parameters. TID and temperature dependence of the $k_{RIC}(T, \dot{D})$ and $\Delta(T, \dot{D})$ parameters for PEEK are determined; RIC exhibits weak temperature and TID dependence, with less than a 20% change observed in k_{RIC} and Δ over the experimentally accessed ranges. Data were acquired over temperatures from ~180 K to room temperature with temperature sensitivity of <5K and for TID ranging from ~0.6 kGy to 8 kGy,

*Research was supported by the NASA Jet Propulsion Laboratory for the Europa Clipper mission though award 1584146.

Joshua Boman, Brian Wood, Jordan Lee, JR Dennison, Kim M. Aaron, and Wousik Kim "Radiation Induced Conductivity of PEEK: Effects of Temperature and Total Ionizing Dose," 17th Spacecraft Charging Technology Conference, (Avignon, France, June 17-21, 2024).

$\sigma_{RIC} = k_{RIC} \cdot D_{\Delta}$