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Experimental Measurement of Low-Intensity, Long-Duration Internal Charging Behaviour

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"The intensity of trapped high energy electrons in the Van Allen belts is sufficient to cause a significant hazard to spacecraft via internal charging of dielectric materials [1]. Existing design guidelines for internal charging mitigation ([2], [3]) typically assume a safety threshold for electron current density of 0.1 pA/cm2 over a ten hour period, based primarily on electrostatic discharges measured in situ on the CRRES satellite in the early 1990s [4]. However, more recent work has suggested that dielectric materials with long charging time constants may be vulnerable to significant accumulation of charge in far less severe environments [5]. In cases where the time constant exceeds one month, the synodic cycle of electron enhancements, linked to the rotation of solar coronal holes, can lead to the progressive build-up of charge in insulating materials within spacecraft, even with much lower average levels of incident current. This means that peak electric fields do not necessarily coincide with peak electron fluxes and therefore damaging electrostatic discharges (ESDs) may not be directly associated with observations of enhanced environmental conditions or space weather events. This could have significant consequences for anomaly investigations on satellites following such discharge events. As part of the EU FP7 Spacestorm project [6], we are investigating the experimental behaviour of various commonly-used space dielectric materials in an electron environment where the incident electron current is significantly below that specified as a safe level by design standards. The REEF facility [7], which uses an intense strontium-90 beta-emitting radioactive source to simulate the space environment, has been recommissioned at the University of Surrey for this purpose. Using a combination of shielding and variable source-sample separation REEF can achieve a very wide dynamic range in electron current, from the very high levels associated with an extreme space weather event, down to the level currently under consideration as a revised safety threshold of 0.01 pA/cm2. In order to allow for the accumulation of significant levels of charge at such a low current, these experiments need to be run continuously for several weeks, far in excess of typical experimental investigations of internal charging phenomena. Here we report our early results from these experiments on samples of PEEK thermoplastic polymer material. Irradiating using a range of electron currents provides insight into the effect not just of inherent material properties, but also of secondary effects such as radiation-induced conductivity (RIC). References [1]

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