The harsh space environment can modify materials and cause detrimental effects to satellites. If these modifications are not understood, the spacecraft will not operate as designed or fail altogether. In an ideal situation a full spacecraft would be tested in all applicable space environments prior to the mission start-up [1]. This, however, is obviously not practical. The key to understanding and mitigating these deleterious effects is the ability to accurately simulate space environment effects through long-duration, characterized testing in an accelerated, versatile laboratory environment.

Space Environment Effects

The Utah State University Materials Physics Group (MPG) and Space Dynamics Laboratory (SDL) have developed an extensive versatile and cost-effective pre-launch test capability for verification and assessment of small satellites, system components, and spacecraft materials. The facilities can perform environmental testing, component characterization, system level hardware-in-the-loop testing, and qualification testing to ensure that each element is functional, reliable, and working per its design. A wide array of tests related to typical CubeSats— including performance of solar arrays, electronics, sensor and memory components, radiation damage, basic communication responses, structural integrity, etc.—acquired at the SEEM and NOVA facilities are presented to demonstrate their combined test capabilities.

Space Environment Characteristics

The Space Survivability Test (SST) chamber simulates several critical characteristics of the space environment: electron flux, ionization, radiation, photon, flux, and temperature. Table 1 shows representative electron spectra for several common environments. The solar UV/VIS/NIR spectrum is shown in Fig. 3. The range of electron, photon radiation, and photon sources are shown above the environmental flux graphs. Samples are in a low density particle environment, using a vacuum or controlled neutral environment, representing the plasma fluxes, and temperatures. Testing is available for a 10 cm × 10 cm Cubesat face sample (maximum sample area of 16 cm × 16 cm or 20 cm diameter), with exposure to within ±5% uniformity at intensities for >10 accumulated doses. A 5.6 MeV incident beam source produces a higher-energy (~2 MeV) spectrum similar to the GEO spectrum for testing of radiation damage, single event integrals, and COTS parts [2]. An automated data acquisition system periodically records real-time environmental conditions—such as the sample’s electric and magnetic field, from the satellite component/sample performance metrics and characterization of material properties and calibration standards—during the sample exposure.

Electron Flux

A high energy electron flux gun (4) (20 keV – 100 keV) provides 5.5 × 10^8 electrons/cm^2 (~1 pA/cm^2) to fabricate cells for simulation of the solar wind and plasma sheet at more than the 100X cumulative electron flux. A low energy electron beam (4) (10 keV - 20 keV) simulates higher flux conditions. Both have interchangeable electron filaments.

Ionizing Radiation

A 100 mCi encapsulated S² source (4) mimics high energy (~500 keV to 2.5 MeV) geostationary electron flux (see Fig. 2). An Infrared-Ultraviolet/Visible Spectra

A commercial Class AAA solar simulator (4) provides NIR/VIS/UV/EB and electron energy-radiant flux. Figure 3 shows 200 cm x 200 cm sample area up to 4 times sun equivalent intensity. Source uses a Xe discharge tube bulbs with >1 month lifetimes for long-term use.

Far Ultraviolet Flux

Kr resonance lamps (C) provide FUV radiation flux (ranging from 10 to 300 nm) at 4 times sun equivalent intensity. Kr bulbs have >3 months lifetimes for long-term use.

Temperature

Temperature range from 60 K [4] to 450 K is maintained to ±2 K [5].

Vacuum

Ultrahigh vacuum chamber allows for pressures <10⁻⁸ Pa to simulate LEO.