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JR Dennison
Utah State University

Justin Dekany

Kent Hartley
Utah State University

James S. Dyer
Space Dynamics Laboratory, Utah State University

Robert H. Johnson
Utah State University

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JR Dennison,[1] Kent Hartley,[1,2] Justin Dekany,[1]
James S. Dyer,[3] and Robert H. Johnson,[1,2,4]

[1] *Materials Physics Group, Physics Department, Utah State University*
[2] *Mechanical Engineering Department, Utah State University*
[3] *Space Dynamics Laboratory, Utah State University*
[4] *Kern River Gas Transmission Company*

Abstract

A versatile space environments test facility has been designed and built to study the effects on small satellites and system components. Testing for potentially environmental-induced modifications of small satellites is critical to avoid possible deleterious or catastrophic effects over the duration of space missions. This is increasingly more important as small satellite programs have longer mission lifetimes, expand to more harsh environments (such as polar or geosynchronous orbits), make more diverse and sensitive measurements, minimize shielding to reduce mass, and utilize more compact and sensitive electronics (often including untested off-the-shelf components). Our vacuum chamber is particularly well suited for cost-effective, long-duration tests of modifications due to exposure to simulated space environment conditions for cubesats, system components, and small scale materials samples. The facility simulates critical environmental components including the neutral gas atmosphere [ultrahigh vacuum (10^{-7} Pa) to ambient], the FUV/UV/VIS/NIR solar spectrum (120 nm to 2000 nm), electron plasma fluxes (10^1 eV to 10^6 eV), and temperature (100 K to 450 K). The UV/VIS/NIR solar spectrum is simulated using an external class AAA Solar Simulator source, with standard Air Mass Zero (AM0) filters to shape the incident radiation spectrum. This Xe arc discharge tube source has a 200 nm to 2000 nm range, with up to four Suns light intensity over a cubesat face. Far ultraviolet (FUV) radiation is provided by Kr discharge line sources, with a primary emission lines at 124 nm and 117 nm and up to four Suns intensity. This provides an adequate substitution for the solar FUV spectrum, which is dominated by the ultraviolet hydrogen Lyman α emission line at 122 nm. An electron flood gun provides a uniform, stable, low-energy, monoenergetic (~20 eV to ~15 keV) electron flux of <1 pA-cm^{-2} to >1 μA-cm^{-2} over the cubesat surface. A second medium-energy (~20 keV to ~100 keV), low-flux electron source uses filament-free photemission. A Sr^{90} β radiation source produces a high-energy (~100 keV to >2 MeV) spectrum similar to the geosynchronous spectrum; intensities of >5X the geosynchronous spectrum are possible. Electron and photon fluxes are continuously monitored during the sample exposure cycle, using standard Faraday cups and photodiode sensors. All of the electromagnetic and electron radiation sources maintain uniform exposure to within <5% over a cubesat face. A stable, uniform temperature range from 100 K to 450 K is achieved using a cryogenic reservoir and resistance heaters with standard PID controllers. An automated data acquisition system periodically monitors and records the environmental conditions, sample photographs, UV/VIS/NIR reflectivity, IR absorptivity/emissivity, and surface voltage over the cubesat face and calibration standards in the main chamber, *in situ* during the sample exposure cycle. Samples can be mounted in the main chamber on single-axis rotation high-temperature or cryostat stages. Alternately, the modular design allows the sources to mate separately with a larger chamber with an ion gun and beam diagnostics which can emulate ion drift measurement environments. This chamber has a 5-axis rotation/translation manipulator that can position the faces of a cubesat relative to all incident beams.

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