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Measurement of Effects of Long Term Ionizing Radiation on High Efficiency Solar Arrays

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I. Introduction

On any space flight mission it is crucial that all systems have sufficient power to complete the mission starting on day one and continuing through the duration of the mission. High Efficiency Solar Arrays provide a lightweight and compact method of generating the power needed. However, a major obstacle is the degradation of solar array efficiency over time due to long term exposure to the space environment. This can lead to unreliable satellites, erratic readings or even complete loss of functionality.

The Space Survivability Test (SST) Chamber is designed to provide a controlled space environment for in situ testing of samples with intensities for >5X accelerated testing[1,2]. The SST simulates Ionizing Radiation, Electron Flux, Infrared/Visible/Ultraviolet Flux, Far Ultraviolet Flux, Temperature and Vacuum. (Poster #50,3)[4]

Using the SST, solar arrays can be exposed to a controlled space environment. In situ power and efficiency measurements can quantify the degradation of solar array efficiency with respect to total exposure during the course of exposure.

II. Degradation Causes

There are two major types of radiation in the space environment which cause degradation of the solar array power output.

UV Light - UV light radiation darkens coverglass materials through prolonged exposure[4]. This causes a reduction in the transmissivity of coverglasses, decreasing flux incident on the solar cell. Experiments are underway to quantify this effect. Further tests will be done in the SST to measure power output loss as a function of total UV light dose. (Poster #51,5)

Energetic Electrons – ionizing radiation consists of energetic electrons having sufficient energy to penetrate coverglass and displace orbital electrons within the solar cell semiconductor. Coverglass thicknesses generally range from about 100-300 μm, thus requiring ~1000 keV electrons to penetrate the coverglass(see Fig. 2). A 1MeV β radiation source produces the high energy electrons (~200 keV to >2.5 MeV) necessary for this experiment.

Figure 2 – SiO2, Electron Range vs Incident beam energy with the average thickness of coverglass marked at ~100 μm corresponding to an incident energy ~100 keV.[6]

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By taking these measurements in situ we can quantify the degradation of the solar panel as a function of total incident radiation dose. Because the power output and the efficiency of solar cells are temperature dependent IV curves under light must be taken in quick flashes (~100 ms) in order to minimize cell heating.

IV. Experiment

SST tests currently underway described in Table I include a set of Vanguard solar cell arrays(see Figs. 3 and 5)[6] as well as a set of COTS parts to test their radiation hardness. In both tests electron radiation damage is the topic of study. A Sr90 source is used to simulate the geosynchronous space environment. A class AAA solar simulator light source is used to acquire the solar cell IV curves as shown in Fig. 1.

The data collected in these experiments can be used in the design of satellites to ensure that the components of the satellite will continue to provide the needed power for the entire duration of the planned mission. It also provides valuable data for solar array manufacturers to be able to demonstrate that their components will be able to withstand the space radiation environment. These experiments are capable of providing more controlled data much more quickly and with less lead time than sending the components into space.

Table I – Current experiments using the Sr90 β radiation source to test component degradation.

References

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