New Voltage and Current Thresholds Determined for Sustained Space Plasma Arcing

Sustained arc on the Terra satellite test article in ground tests at Glenn.

It has been known for many years, based partly on NASA Glenn Research Center testing, that high-voltage solar arrays arc into the space plasma environment. Solar arrays are composed of solar cells in series with each other (a string), and the strings may be connected in parallel to produce the entire solar array power. Arcs on solar arrays can damage or destroy solar cells, and in the extreme case of sustained arcing, entire solar array strings, in a flash. In the case of sustained arcing (discovered at Glenn and applied to the design and construction of solar arrays on Space Systems/Loral (SS/Loral, Palo Alto, CA) satellites, Deep-Space 1, and Terra), an arc on one solar array string can couple to an adjacent string and continue to be powered by the solar array output until a permanent electrical short is produced. In other words, sustained arcs produced by arcs into the plasma (so-called trigger arcs) may turn into disastrous sustained arcs by involving other array strings.

Previous work at Glenn has shown that for each solar array design there is a voltage threshold for the trigger arc, and voltage and current thresholds for the sustained arcs. Trigger arc thresholds vary from about -100 to about -250 V, depending on solar array design parameters, such as the thickness of the solar cell coverglasses and the amount of coverglass overhang beyond the cell edges. Sustained arc voltage thresholds can be less than the trigger arc thresholds. For instance, if two adjacent solar array strings have a difference in cell voltage of 60 V but either is operating at -250 V, a trigger arc can occur that will evolve into a sustained arc between strings. Among the techniques used to prevent sustained arc discharges are lowering the voltage between adjacent strings and lowering the current that can get to the trigger-arc site. If either or both of these values are less than the thresholds, a sustained arc cannot get started. Previously, the lowest sustained arc voltage threshold was determined to be about 55 V. The work described here showed that sustained arcs can occur at voltages as low as 40 V and currents as low as 1 amp.

Several small solar array samples were tested in a simulated plasma in a vacuum-plasma chamber in the Plasma Interactions Facility at Glenn. The plasma was produced by a Penning type source, using xenon gas. The array panels were 3 by 12 solar cells, and the cells were 4 by 6 silicon cells on a Kapton (Dupont) substrate. Adjacent strings were separated by 0.8 mm. The strings were biased from -400 to -450 V, and the voltage difference between the strings was increased until the arcs produced became sustained arcs. The lowest sustained arc thresholds were obtained for solar cells for which the coverglass thickness was 300 μm (6 mils) and the coverglasses did not overhang the cell edges. For thinner (150 μm) coverglasses with no overhang, the thresholds found were 60 V and 2 amp. Coverglasses that were 150 μm thick with a 250-μm (10-mil) overhang had thresholds of 80 V and 1.6 amp. These new sustained arcing thresholds will allow array designers to prevent sustained arcing that could damage or destroy their satellite arrays in the harsh space environment.

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