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Electrostatic discharges on very large spacecrafts solar panels: coupled model of a cathode spot and flash-over expansion in vacuum

The increase of the onboarded power on Spacecraft is actually still limited by the charging issue due to the plasma natural environment. The charging of the external dielectrics is due to the complex geometry, the number of different materials and the presence of biased conductor. It leads to a high potential difference on solar cells edges that can reach several kilo-volts. In this conditions, an electrostatic discharge (ESD) may appear. The ESD emits a current called a flash-over that will expand on the surface of the solar panel. It takes the form of a plasma bubble i.e. a conductor environment in which secondary arcs may appear. Our objective is to identify the duration and extinction conditions of the flash-over. Indeed, it has been shown that the plasma bubble can cover panels a few meters long but there is no clue about bigger ones (some dozen of meters long). Based on known literature, we tailored cathode spot and plasma expansion in vacuum models to our specific case and coupled them. Both models are developed in parallel to create a closed system without free parameters other than the ESD initial position and the initial charging state of the solar panel surface (obtained from the known environment).

We present the coupled cathode spot-plasma expansion model, detailing the physical assumptions made to fit to our particular environment and close our system. The cathode spot model is developed for different materials and we focus on the impact of the cathode spot on the extinction of the flash-over. The results of the coupled model are compared to experimental measurements of flash-over expansion on large solar panel area performed at ONERA's facilities. Those measurements reveal that the extinction occurs before the complete neutralization of the charge. We show that, even-though the cathode spot has a direct impact on the plasma bubble lifetime, the characteristics of the solar panel also have its influence on the flash-over extinction.

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