MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Environmental Effects and Spacecraft Protection (6)

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THE SIMULATION OF INTERNAL CHARGING EFFECT IN FR-4 PCB OF SATELLITE BY USING ATICS

Abstract

Internal charging, which is defined as the process of the establishment of the internal electric field caused by the transport of energetic electrons and build-up of charge in the spacecraft dielectric materials, has been regarded as the reason of many satellite faults. Sometimes, internal charging can lead to some serious damages, even system failures. In order to eliminate these problems in design stage, engineering analyzing simulation is necessary to evaluate internal charging effect of satellite. Therefore, we develop a software tool, called ATICS (Assessment Tool of Internal Charging for Satellite), to simulate internal charging effect of satellite in space.

In this paper, the calculating principle and software structure of ATICS were briefly introduced. Then, a calculating example of ATICS for FR-4 printed circuit board in common use in satellite was provided. The simulation of ATICS consists of three parts: the model of electrons environment in space, the process of electrons transport in the materials and the process of build-up electric field in the dielectric. A specific example was given to demonstrate the software. The electron transport in FR-4 PCB of satellite was carried out based on open source code GEANT4 which is a toolkit for the simulation of the passage of particles through matter. After that, the build-up electric field was calculated by fundamental physical principles. Considering the planar FR-4 PCB with different thickness, perpendicular incidence or cosine law incidence and several mono-energy electrons beams (0.5MeV-3MeV), we obtained the flux distribution with PCB depth, the charge deposit and the energy deposit, etc. Consequently, using the different grounding mode, build-up electric fields in FR-4 PCB were calculated.

The result shows that in the case of perpendicular incidence, the depth of maximum deposit electrons is 2 times as much as depth of energy deposit. That means perpendicular incidence electrons lost their most energy at the half-path. Meanwhile, the cosine law incidence electrons lost their most energy on the surface of the board. Furthermore, the result of build-up electric field calculation indicates that maximum electric field is mainly determined by depositing electrons and charge leakage rate. Additionally, the maximum build-up electric field always increases with the thickness of dielectric board. In the case of front grounding, the maximum electric field increases with the incidence electrons energy firstly and then declines consistently. Compared with DICTAT software (decrease gradually), in the aspect of low energy electrons, the result is slightly different.