47th SYMPOSIUM ON SAFETY, QUALITY AND KNOWLEDGE MANAGEMENT IN SPACE ACTIVITIES (D5)
Prediction and measurement of space weather conditions and impacts on space missions (3)

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ANTI-RADIATION INDEX RESEARCH OF PHOTOELECTRICAL DEVICES FOR LONG LIFE HIGH-ORBIT SPACECRAFTS

Abstract

Photoelectrical devices are threatened by the non-ionizing displacement damage effect in space radiation environment, which possibly leads to poor reliability, short life, or even completely failure of the photoelectrical devices. Recently, more and more photoelectrical devices are used by long-life-span spacecrafts, which mostly work in high orbits of the Earth. Therefore, the design of radiation environment adaptability needs to be strengthened. The anti-radiation index of the photoelectrical devices should be put in the first place during research.

Two types of photoelectrical devices, GaAs solar cell wafer and CCD (Si substrate), are chosen for the research on the mechanism and anti-radiation index of non-ionizing displacement energy damage effect. The performance of the GaAs solar cell is characterized by open circuit voltage Voc, short circuit current Isc, and maximum power Pmax. The performance of the CCD is characterized by charge transfer efficiency and dark current.

Firstly, several non-ionizing displacement energy damage models were built for the above two photoelectrical devices respectively. Then, the radiation environment of the spacecraft orbit was simulated using the SPENVIS software. Besides, the displacement damage dose of different life span was simulated by using Monte-Carlo program, based on NIEL curves of proton and electron from ground tests. And then, an on-orbit degradation prediction model could be obtained by non-ionizing displacement energy damage models built previously. Subsequently, the anti-radiation indexes of photoelectrical devices for different life periods can be achieved. Lastly, by choosing a typical GaAs solar cell wafer and a CCD chip of a GEO spacecraft for simulation and prediction, the anti-radiation index of 1MeV equivalent fluency was given under the condition that characteristic degrade was no less than 15