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PRELIMINARY STUDY OF LET SPECTRUM AND TOTAL DOSE PREDICTIONS IN SEMICONDUCTOR MATERIALS WITH MONTE CARLO CODE COMPARING WITH STANDARD TOOLS

Abstract

This paper presents the prediction of effective linear energy transfer (LET) spectra and total doses in semiconductor materials using Monte Carlo code. The effective LET spectrum is needed for upset rate prediction of semiconductor devices and total dose is necessary to estimate the deposited energy in the device. The code used here is Particle and Heavy Ion Transport code System (PHITS). PHITS is a general purpose 3-D Monte Carlo particle transport simulation code including collision processes for all particles with energy ranges up to 100 GeV/nucleon using several nuclear reaction models and nuclear data libraries. PHITS is developed under the collaboration of JAEA (Japan Atomic Energy Agency) and several institutes in Japan and Europe. In the field of space development, several prediction tools, for example CREME 86, 96, Shieldose-2 etc., had been developed to calculate effective LET spectrum and total dose in semiconductor devices against space radiations. Space radiations are galactic cosmic rays, trapped electrons, trapped protons and solar protons. Those standard tools allow engineers to quickly estimate reasonable effective LET spectra and total doses. Engineers can iteratively design the shielding thickness and shapes of components and consider the electronic device to use. Although they are very powerful and valuable tools, they have some restrictions on its utilization. They assume the very simple shielding structures for semiconductor devices, for example solid sphere, semi-infinite medium and finite thickness slab. However, it is difficult to accurately convert the omnidirectional thickness distribution as seen from an interest device to a single thickness. Moreover, secondary particles generated by the shielding due to spacecraft and component structures are not considered. These tools assume the shielding material is aluminum but the actual spacecraft and component consist of several materials. For considering the actual complex 3-D structure (thickness and material distributions) and contribution of secondary particles, Monte Carlo code like PHITS are very realistic solutions to accurately predict the LET spectrum and total dose deposited in semiconductor materials. In this paper, we firstly report the comparisons between our calculations and results of standard tools. The shielding structure was a finite aluminum slab. The results obtained were in good agreement and we confirmed the validity of each calculation. Furthermore, we assume the simple spacecraft structure having thickness distribution and predict the effective LET spectrum and total dose in semiconductor materials placed on its spacecraft. The prediction results are compared with the results calculated by standard tools.