SYMPOSIUM ON SAFETY, QUALITY AND KNOWLEDGE MANAGEMENT IN SPACE ACTIVITIES (D5)
Space Weather Prediction and Effects on Space Missions (3)

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MULTI-SCALE MODELING TO INVESTIGATE THE SINGLE EVENT EFFECTS FOR SPACE MISSIONS

Abstract

Space environment studies and its effects on electronic systems are fundamental for space applications. Single Event Effects (SEE) induced by proton and heavy ions are identified as a major reliability issue for complex electronics systems for decades. Heavy ions are ionizing particles and create directly charges in semiconductor, whose density depends on the ion species and energy; the linear energy transfer of proton is very small but protons can indirectly induce SEE by creating secondary ions (recoils and fragments) due to a nuclear reaction with a nucleus of the device. However, experimental results have been recently presented and indicate that direct ionization of proton is able to induce SEE for nanometric devices.

The calculations of soft error rates (SER) are still a challenge to obtain the device sensitivity of evolving technologies and investigate the emerging SEE mechanisms. In fact, between the incoming particle and SEE occurrence, many physical mechanisms intervene. These last ten years, multi-scale modeling and physics-based Monte-Carlo simulations have been widely developed to overcome the obsolescence of engineering models at predicting SEE rates and investigate sub-micron technology response. More recently, SEE prediction methodologies have been developed aiming at proposing new and adapted approaches for modern electronics in order to investigate the SEE trends induced by the technological roadmap and to predict the emerging SEE problematic.

The Multi-Scale Single Event Phenomena Predictive Platform (MUSCA SEP3) has been developed by ONERA and consists in sequentially modeling all the physical and electrical mechanisms, from the system down to the semiconductor target, involved in the SEE occurrence. It aims at calculating both the SEE cross section and SER i.e. at ground and for operational flight configurations. The particularity of this approach is to model the whole device, its local and global environment (shielding, package ...) and the detailed characteristics of the radiative environment (nature, direction, spectrum and dynamics).

In this context, MUSCA SEP3 is used to evaluate the SER trends for modern devices in space applications and more specifically the emergent impact induced by the direct ionization from protons for nanometric devices. We discuss the impact and the importance of each modeling layer of the SER analysis, especially the radiative environment characteristics i.e. spectrum, directional properties and space weather dynamics. These results demonstrate the relevance and basic requirement for a multi-scale approach for assessing the criticality of reliability issues.