5 - 19 Simulating SEU in Multi-Technology Node Devices under Ultra-high-energy Proton Irradiation*

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According to the international guidelines for proton single event effect ground test, the single event upset (SEU) cross-section induced by protons with energy levels around 200 MeV is widely recognized as the saturation SEU cross-section[1,2], which serves as the fundamental basis for predicting error rates of devices in realistic proton radiation environments. However, with the device technology scaling down to 90 nm and even below, the SEU cross-section induced by 200 MeV proton incident may not reach the saturation point, due to the dominant SEU contribution from low-Z secondary ions. To address this issue, we have developed a device model based on actual devices and utilized Geant4 to explore the SEU caused by the protons, with the energy levels ranging from 10 MeV to 100 GeV and in the devices of feature sizes ranging from 7 to 350 nm.

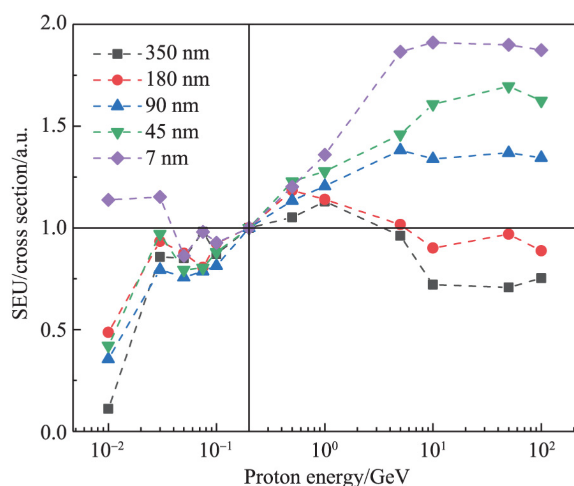

Fig. 1 (color online) Normalized SEU cross-section as a function of incident proton energy for devices with different technology nodes.

Based on the simulation results shown in Fig. 1, it is evident that the SEU cross-section induced by 200 MeV proton incident has attained saturation for the large technology node devices, with dimensions of 180 and 350 nm. As the proton energy increases, the SEU cross-section for these devices shows negligible changes, justifying the adoption of the SEU cross-section induced by 200 MeV proton incident as the saturation cross-section. Conversely, for small technology node devices with dimensions of 7, 45, and 90 nm, the induced SEU cross-section elevates incessantly with increasing proton energy beyond 200 MeV but only reaches saturation at approximately 10 GeV. Specifically, for the 45 and 7 nm devices, the saturation cross-section induced by protons is roughly 1.7 and 1.91 times the SEU cross-section induced by 200 MeV protons, respectively.

References

[1] European Space Agency, Single Event Effects Test Method and Guidelines, (Escies, 2014).
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