3 - 26 Threshold Ion Range for Accurate Single Event Upset Measurement in SOI SRAM Devices

Zhang Zhangang, Liu Jie, Hou Mingdong, Sun Youmei, Zhao Fazhan, Liu Gang[1], Han Zhengsheng[1]
Gu Song, Liu Tianqi, Geng Chao, Xi Kai, Yao Huijun, Luo Jie, Duan Jinglai and Mo Dan

Single event upsets (SEU) arise from the deposited energy by single energetic particle in sensitive volumes of a memory circuit. Before reaching the sensitive volume, incident particles must have enough projected range to penetrate throughthe top overlayers (e. g., metallization layer, passivationlayer, or substrate in the flip-chip package). During earth-based SEU testing, the accelerator shall be capable of delivering ions with a range of at least 30 μm in silicon[1-2], which has been recognized widely as the threshold ion rangein past decades. However, advanced integrated circuit (IC) technologies can utilize many layers of metallization[3]. The threshold ion range for accurate SEU testing of modern ICs should be reconsidered.

In the experiment, 64 kb and 1 Mb silicon-on-insulator (SOI) static random access memories (SRAMs) were irradiated at HIRFL by using ^{86}Kr, ^{112}Sn and ^{209}Bi ions with initial energy of 25, 3.7 and 9.5 MeV/u, respectively. For the ^{86}Kr and ^{209}Bibeam, the ion range in the de-capped device was changed continuously via inserting energy degraders or changing the thickness of air in the beam line. The measured SEU cross sections of 1 Mb and 64 kb SOI SRAMs are shown in Figs. 1 and 2, respectively, as a function of ion LETs. In Fig. 1, Squares represent data points which fit in the Weibull curve of SEU cross section versus LET, i. e., correspond to ions with enough range. On the contrary, up-triangles correspond to ions with limited range. The threshold ion ranges for Kr and Bi ions are indicated in the figure. For the 1 Mb SRAM, the threshold range depends on the ion species (Fig. 1). In Fig. 2, the threshold ion range for the 64 kb SRAM is smaller than that for the 1 Mb SRAM, owing to thinner overlayers for device with lower capacity. The SEU cross section is saturated in this LET region.

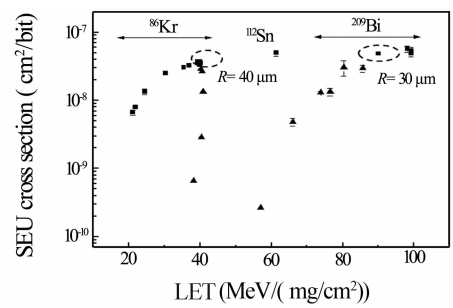

Fig. 1 The SEU cross sections of 1 Mb SOI SRAM plotted as a function of ion LETs.

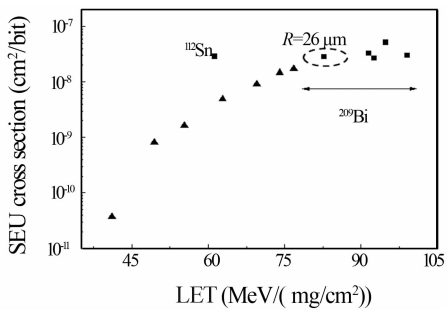

Fig. 2 The SEU cross sections of 64 kb SOI SRAM plotted as a function of ion LETs.

In conclusion, ion range in device is a key parameter for accurate SEU measurements. The threshold ion range is not a fixed value which depends on the ion species and the thickness of top overlayers.

References

[1] ESA/SCC Basic Specification No. 25100: Single Event Effects Test Method and Guidelines, (2002).
[2] EIA/JESD57: Test Procedure for the Measurement of Single-event Effects in Semiconductor Devices from Heavy Ion Irradiation, (1996).
[3] M. R. Shaneyfelt, J. R. Schwank, P. E. Dodd, et al., IEEE Trans. Nuc. Sci., 59(2012)1142.

1 Institute of Microelectronics of Chinese Academy of sciences, Beijing 100029, China.