Heavy Ion Irradiation Fluence Dependence for Single-Event Upsets of NAND Flash Memory

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Abstract: We investigated the single-event effect (SEE) susceptibility of the 16 nm NAND flash, and found the single-event upset (SEU) cross section inversely proportional to fluence. The SEE cross section decreased with increasing fluence. We attribute this decrease to the ion damage to the sensitive elements, which may vary for different device manufacturing. The analysis of the experimental data showed that different ions had different SEE sensitivities. The results of this study will be of interest to other device manufacturers.

INTRODUCTION

NAND Flash memories are the current mainstream storage technology in the commercial market, and they are continuously finding their way into space systems thanks to the technology's high density and low cost [1]. NASA and other government agencies as well as academia have been working on the SEE problem for many years, but the results from different vendors are conflicting [2]. The details of the design, process, and environment all contribute to the SEE problem. In this study, we present our SEE sensitivity to different ions, which is different from previous studies, and we provide a more detailed test guideline specific to current memory devices [3]. However, the current test methodologies need to be continuously updated with test findings.

For the irradiation test protocols, we are predominately assuming that the SEE cross section remains constant with fluence. So the device upset in a steady curve over time. Typically, logic devices are used to temporarily measure SEE sensitivity across the entire device sensitive region. In this investigation, we observe the cross-reference signal inventory with the test fluence, which we attribute to the upset rate sensitivity of the memory cells.

DEVICE DETAILS

The 8T2F210K98C8B08 is a 16 nm NAND flash memory built on Samsung's 16 nm FinFET node. We used the lower density 128 Gb device in a plastic encapsulated ball grid array (BGA) package. Figure 1 shows a photograph of the device under test.

EXPERIMENTAL

Figures 2 and 3 show the single-event upset (SEU) cross section as a function of effective LET for devices that were exposed to a variety of ions at different fluence levels in the Lawrence Berkeley National Laboratory's (LBNL) Berkeley Accelerator Technology Laboratory (BALT). Our data shows that the SEE cross section decreases with increasing fluence. This is consistent with previous studies [4]. To validate this trend, we present our SEE sensitivity to different ions, which is different from previous studies, and we provide a more detailed test guideline specific to current memory devices [3]. However, the current test methodologies need to be continuously updated with test findings.

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RESULTS

The SEE sensitivity for the 16 nm NAND flash devices was determined using a variety of ions, including Silicon, Nitrogen, and Oxygen. The SEE data was collected using a 25 mm x 25 mm grid, and the SEE upset rate was calculated as a function of fluence. The SEE sensitivity was found to be inversely proportional to fluence, and the SEE upset rate decreased with increasing fluence. The SEE upset rate was found to be inversely proportional to fluence, and the SEE upset rate decreased with increasing fluence. The SEE upset rate was found to be inversely proportional to fluence, and the SEE upset rate decreased with increasing fluence. The SEE upset rate was found to be inversely proportional to fluence, and the SEE upset rate decreased with increasing fluence. The SEE upset rate was found to be inversely proportional to fluence, and the SEE upset rate decreased with increasing fluence.

DISCUSSION

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CONCLUSION

The phenomenon raises questions regarding current test standards and typical test methodologies with implications for future SEE studies. The SEE cross section dependence on fluence implies that a space system carrying such a device can potentially experience a higher upset rate earlier in the mission, and this phenomenon is not currently being modeled. Therefore, we may need to systematically test various SEE behaviors and correlate with the mission environment. This could help for any device with varying upset sensitivities of its sensitive volumes. It would be valuable to develop a fluence-dependent SEE threshold. These results will have implications for next-generation for single-event upset testing of flash devices.

REFERENCES


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