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BASIC RESEARCH ON RADIATION TESTS SUITABLE FOR NANO-SATELLITES

Abstract

In recent years, many nano-satellites are being developed in universities and private enterprises. Characteristics of nano-satellites include low cost and a short development period. Therefore, COTS ICs are often used in nano-satellite projects. However, COTS ICs are not designed for use in space. They may break-down due to strong radiation in space. So, radiation testing should be performed before launch. Generally speaking, space radiation is mainly protons. To radiate protons, an accelerator is required. However, using an accelerator requires significant cost and prep time. This is contrary to nano-satellites advantages: low cost and short development period. The purpose of this research is to establish suitable radiation testing methods and evaluation standards for nano-satellites. We are focusing on Californium252 (252Ca) as an alternative to an accelerator. 252Ca is a radio isotope that continuously emits heavy ions. In this research, the bombardment target is the On-Board-Computer (OBC) of Horyu-3. Horyu-3 is a nano-satellite that is being developed by Kyushu Institute of Technology in Japan. One of the main abnormal phenomenon caused by radiation is Single-Event-Effect (SEE). When a particle strikes a semiconductor surface, many charges are generated. SEE is a failure caused by those charges. Both Single-Event-Latchup (SEL) and Single-Event-Upset (SEU) are in SEE. SEL is the phenomenon that generates over-current in the IC. SEU is the phenomenon that reverses memory values. We performed two radiation tests, one using 252Ca and one using an accelerator. Then, we compared SEL and SEU occurrence probability in the two tests. In each test, we locally radiated the microprocessor H8/36057 in the OBC. After that, we calculated SEE occurrence probability when single particles struck an IC surface. As a result, 252Ca could cause SEE easier than the accelerator. One of the reasons is the difference of Linear-Energy- Transfer (LET). Heavy ion's LET from 252Ca is larger than proton's LET from the accelerator. Then, we derived an expression to relate the two tests. Next, we set proton flux and LET to values expected on orbit. Finally, we calculated average time to occur SEE on orbit using the 252Ca result. We can estimate radiation resistance by using 252Ca. These results will be compared to the operational result of Horyu-3. By the way, Horyu-2, which is Horyu-3's predecessor, was embedded in radiation protection. However, the protection was not effective. So, Horyu-3 will be embedded in new protection. We will also examine this protection and the radiation test result.