Space Environments and Missions A – P1

Research of the radiation tolerance in space environment of general electronic devices

Takahiro MAEDA*[1], Yukitaka KAKIMI[1], Kenji AKASHI[1],
Takeshi OHSHIMA[2] and Shinobu ONODA[2,]
1 Advanced Engineering Services Co., Ltd. (AES), Japan
2 Japan Atomic Energy Agency (JAEA), Japan
*Email: t_maeda@aes.co.jp

Keyword(s): small satellite, general electric devices, single event effect

Abstract

In small satellite development, general electronic (COTS) devices are needed to use due to some severe restrictions of resource for installed components. For this reason, it is important to keep reliability for using COTS devices in small satellite development. Therefore, in order to ensure reliability for small satellite, our company has evaluated COTS devices mainly for tolerance of single event at Japan Atomic Energy Agency (JAEA) Takasaki Advanced Radiation Research Institute from fiscal year 2008.

1. Introduction

We are developing 50cm-class small satellite, “SOCRATES” (See Fig. 1), which will be launched in 2013. Spacecraft generally use high reliability devices, such as devices for space. However there are many severe restrictions of power, size and so on for components of small satellite, we have to use COTS devices which are favorable than devices for space. But radiation tolerance of COTS devices is not understood. For this reason, it is important to keep reliability by radiation tests for using COTS devices in small satellite development.

We have evaluated COTS devices mainly for single event tolerance at Japan Atomic Energy Agency (JAEA) Takasaki Advanced Radiation Research Institute from fiscal year 2008.

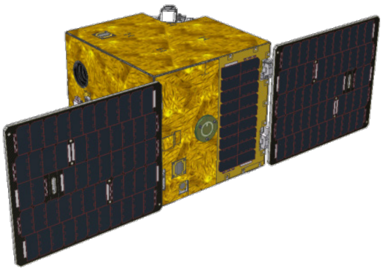

Fig. 1. Our satellite "SOCRATES"

In this paper, we report how to conduct the tests, the method of evaluation and their results.

2. Effects of radiation to electronic devices

In the space environment, various failures are caused to electronic devices by space radiation such as β, γ, proton and heavy-ion. Total ionization dose (TID) effect arose by β, γ and proton is a performance degradation of electronic device by space radiation. Since we plan a short term operation (One year) for our small satellite, we believe that risk of failure caused by TID effect is very small. However, single event effect (SEE) may occur in a short term operation, because it is caused by even one particle, and it can lead to a fatal error of satellite. Therefore, it is required to understand single event tolerance of electronic device to ensure reliability.

3. Test and evaluation method

The radiation test is conducted by using AVF cyclotron of JAEA Takasaki Advanced Radiation Research Institute. In this test, test circuit board is made for every specimen, and installed in a chamber on the beam line (See Fig. 2). During the test, specimen is operated and its consumption current, output voltage, etc. are monitored from outside of a chamber. We can evaluate linear energy transfer (LET) dependence of single event because we use 4 kinds of different LET rays, i.e. Nitrogen, Neon, Argon, and Krypton. Radiation test is conducted with over 10^6 fluencies for each kind of rays.

In evaluation of the tolerance, we presume threshold of LET and cross-sectional area for single event from test results, and then evaluate on-orbit single event probability with on-orbit integral flux of heavy-ion calculated by Cosmic Ray Effects on Micro-Electronics (CREME).

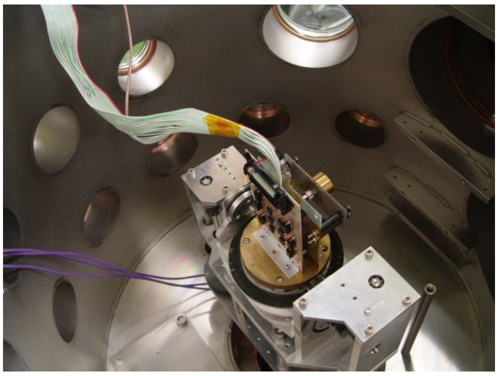

Fig. 2 Test circuit boad in the chamber

4. Test result and utilization

The test results of Field Effect Transistor (FET), Micro-Processing Unit (MPU) and multiplexer (MUX) which will be loaded in SOCRATES are shown in Table I. As shown in Table I, we figured out that FET, MPU and MUX have low probability of single event occurrence in assumption orbit during operating term and sufficient reliability for loading to SOCRATES.

Thus, we can use COTS devices in our small satellite development with satisfying resource restriction and ensuring reliability.

Finally, all specimens are COTS devices, which are not made for the space environment. The test results are probabilities of occurrence predicted when they are brought to orbit, and these do not mean the superiority or inferiority of parts.

Table I. Single Event Probability

No.	Specimen	Evaluation Item*[1]	Single Event Probability	Installed Component
1	FET	SEGR	< 0.16 [event/year]@max. rating	PCU (See Fig. 3)
			< 10^{-8} [event/year] @63% rating	
2	MPU	SEL	< 0.08 [event/year]	VSGA (See Fig. 4)
		SEU	< 0.007 [bit/year]	
3	MUX	SEL	< 10^{-10} [event/year]	OBC (See Fig. 5)

*1
SEGR: Single Event Gate-Rapture
SEL: Single Event Latch-up
SEU: Single Event Upset

Fig. 3 PCU (Power Control Unit)

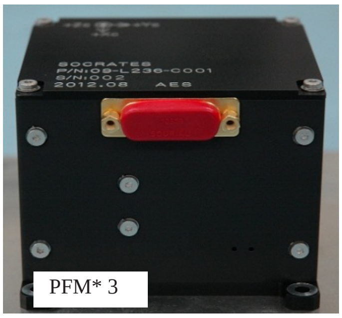

Fig. 4 VSGA (Vibrating Structure Gyroscope Assembly)

Fig. 5 OBC (On Board Computer)

* 2 BBM: Bread Board Model
* 3 PFM: Proto Flight Model