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Proton Beam Induced SRAM SEU Measurement Depending on the Temperature

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1. Introduction

A space simulation chamber was developed in order to do the single event upset (SEU) test of the semiconductor device under various operation conditions at Korea Multi-Purpose Accelerator Complex (KOMAC). The chamber was designed such that 100-MeV proton beam can be irradiated to the device under test (DUT) inside the chamber where the temperature can be controlled under vacuum condition. The design parameters are summarized in Table 1 [1].

Table 1: Space simulation chamber parameters

Radiation	Proton
Proton energy	Max. 100 MeV
Temperature	-55~125 °C
Vacuum	< 10^{-5} Torr
DUT size	254 mm × 254 mm

The size of the device under test (DUT) was decided according to the European Space Components Coordination (ESCC) specification [2]. The space simulation chamber has been developed and installed inside the low flux target room at KOMAC as shown in Figure 1.

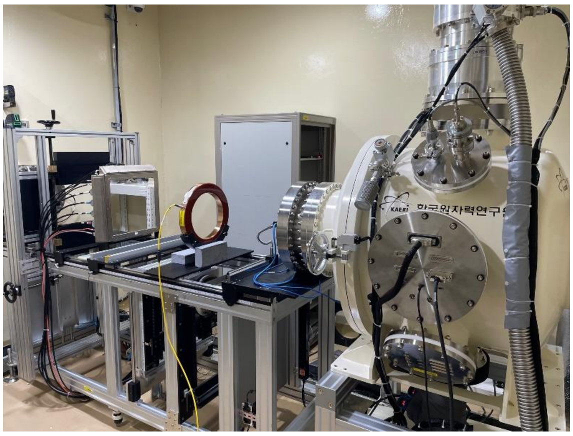

Fig. 1. Space simulation chamber installed in the target room of the low flux beam line at KOMAC

Because maximum energy of 100-MeV proton beam should be irradiated to the sample located inside the chamber, the beam window was installed downstream as well as upstream of the DUT stage. The upstream window is due to the proton beam transmission to the DUT and the downstream window is also due to the transmission of the proton beam to the external beam dump. Generally, two methods are used to cool or heat the DUT in thermal vacuum chamber. A shroud is used for radiation heat transfer and a platen for conduction heat transfer. But a platen was not used in this case, because a platen is located in the beam path, which will produce unnecessary radiation in the platen. The chamber size to accommodate the DUT is such that the shroud diameter and length were 500 mm and 500 mm respectively. And the gap between shroud and vacuum chamber is 100 mm [1].

2. Thermal-Vacuum Test

After the installation, a thermal-vacuum test has been carried out. A dummy DUT (254 mm × 254 mm) was installed and 16ea. thermocouples were installed at the DUT to measure the temperature uniformity as shown in Figure 2.

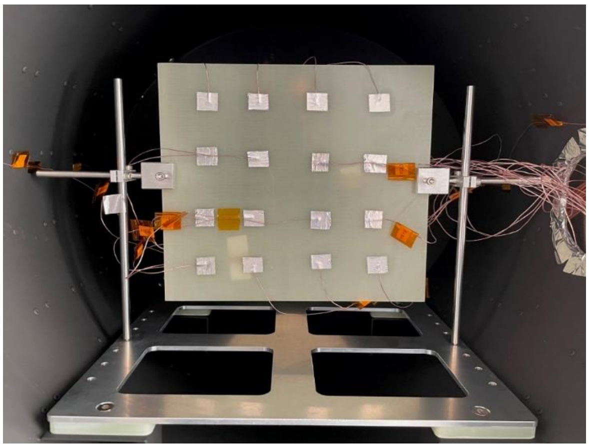

Fig. 2. DUT and thermocouple installed in the space simulation chamber

The temperature was cycled from -70°C to 130°C and both the DUT and shroud temperatures were measured. The ramping rate of the temperature was 2°C per minute and the vacuum level was less than 1 × 10^{-5} torr after bake out. The temperature uniformities of the DUT after 1 hour were ±0.4°C at 130°C and ±2.6°C at -70°C as shown in Figure 3. The temperature and vacuum level during temperature cycling are shown in Figure 4 too. The test results showed that the space simulation chamber satisfied the design parameters [3].

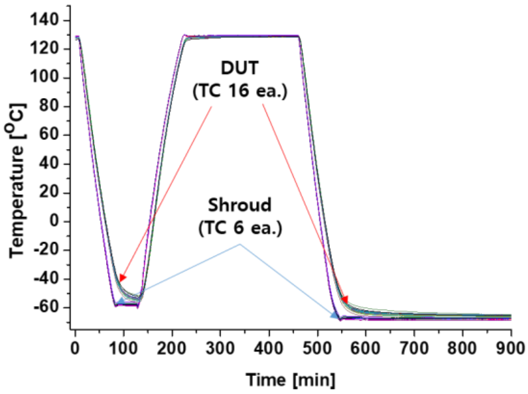

Fig. 3. Temperature measurement of DUT and shroud during temperature cycling

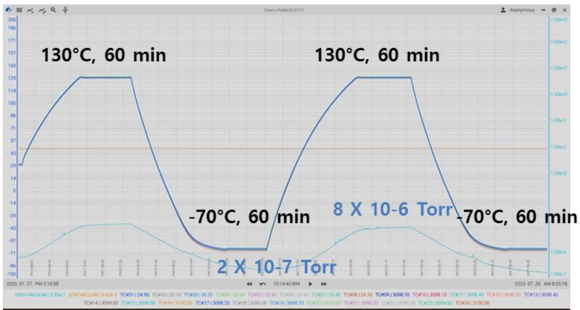

Fig. 4. Temperature and vacuum level during temperature cycling

3. SRAM SEU Test

A semiconductor memory device (SRAM, NETSOL S6R1616W1M) was installed inside the space simulation chamber as shown in Figure 5. The signal processing unit was installed outside the chamber as shown in Figure 5.

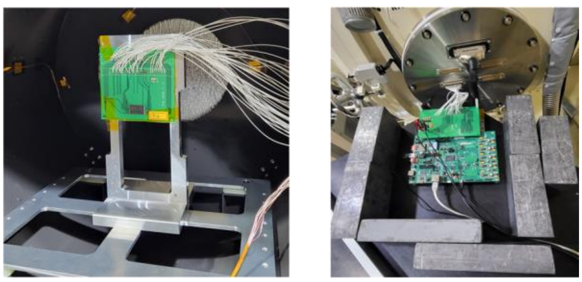

Fig. 5. SRAM installed inside the space simulation chamber (left) and signal process unit outside the chamber (right)

The vacuum level during test was 3×10^{-6} torr and we measured the SEU in three temperature range, -40°C, 25°C and 85°C. Also, we measured the effect depending on the proton beam energy, 100 MeV, 50 MeV respectively. The total fluence was 2.0×10^{9} #/cm^2. We measured the number of SEU and expressed it as a device cross section which is a number of SEU divided by the fluence. The results were summarized in Figure 6. This is the preliminary result because of the limited beam time. But we can observe the dependency of the SEU on the temperature and proton beam energy. As the temperature increases, the SEU decreases consistently whereas it increases when proton beam energy increases.

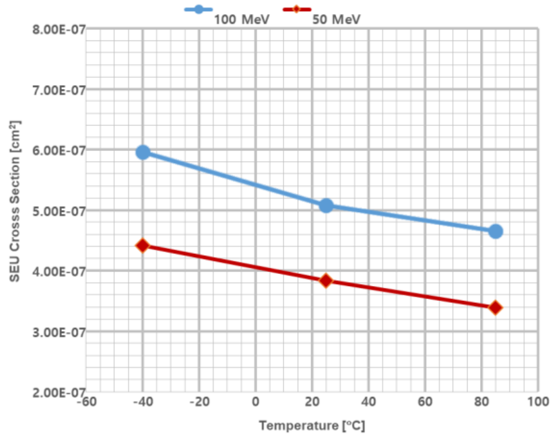

Fig. 6. SEU cross section depending on the temperature and proton beam energy

5. Conclusions

A space simulation chamber was developed and installed in the target room of the low flux beam line at KOMAC. Thermal – vacuum test results satisfied the design parameters. The SRAM SEU test was done with different temperature and proton energy and the results showed that the cross section depends on the temperature and beam energy consistently. But the test was done once because of the limited beam time, therefore it is strongly demanded to test the same device several times in order to setup the test technology and get the statistically meaningful data.

ACKNOWLEDGMENT

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REFERENCES

[1] Hyeok-Jung Kwon, et al, Design of the Space Simulation Chamber for the Space Part Test Based on the Proton Beam, Transactions of the Korean Nuclear Society Autumn Meeting, Korea, October, 21-22, 2021.

[2] ESCC Basic Specification No. 25100, Single Event Effects Test Method and Guildlines, European Space Agency, October 2022.
[3] Han-Sung Kim, Hyeok-Jung Kwon, Seunghyun Lee, Dong-Hwan Kim, Sang-Pil Yun, "Development of a thermal-vacuum chamber for simulation of space environments with proton beam irradiation", Journal of the Korean Physical Society (2023) 83:416~425.