Single-Event Effect Performance of a Commercial ReRAM

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Abstract: We show heavy ion test results of a commercial production ReRAM. We found no single-event effects (SEE) and few multibit upsets. The ReRAM’s memory array is robust to SEE and allows for spaceflight applications.

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1. Introduction

The ReRAM device is a metal-insulator-metal (MIM) structure, where a metallic top electrode (TE) is separated from a bottom electrode (BE) by an insulating material (IM) (Fig. 1) [1]. The IM can be reduced to form a conductive link between the TE and BE, creating an electrically conductive memory state. This structure can be used as a memory cell in a non-volatile memory array, or as a crossbar switch for neuromorphic and analog circuit applications. The ReRAM device can be fabricated using CMOS compatible processes, making it an attractive candidate for space flight applications, where radiation tolerance is critical.

2. Experimental Details

The MN101L ReRAM device was provided by Panasonic [2]. The MN101L device consists of a 1k×1k memory array and peripheral circuits on a microcontroller (Fig. 6). The MN101L is a 56-pin microcontroller manufactured using a 180 nm CMOS process. The device uses an Ir/Ta2O5-ReRAM stack. The MN101L microcontroller contains 32 kbit of flash memory for program and data storage, a 16-bit ARM7 T51 ultra-low-power microcontroller, 32 kbit of dedicated non-volatile memory for configuration and backup, 8 kbit of data RAM, 8 kbit of program RAM, and peripheral control circuits. The lack of charge pump circuits serves to reduce power and radiation sensitivity of the microcontroller. The MN101L ReRAM electrical characteristics and reliability specifications are available online [3].

3. Results

We performed a series of tests on the MN101L ReRAM device. We irradiated the device with a 15 MeV/amu heavy ion beam at Texas A&M University (TAMU) in air using a 1955 µm diameter collimator, revealing only the ReRAM. The heavy ions were produced using the Texas A&M University (TAMU) 1225 MeV cyclotron. The energy and angular distribution of the 15 MeV/amu heavy ions were determined using a Faraday cup and a silicon surface barrier detector, respectively. The energy loss of the heavy ions in the air was calculated using the stopping power tables for air [4]. The energy of the heavy ions was fine-tuned to determine the upset energy threshold (Fig. 7).

4. Discussion

The ReRAM device was subjected to different types of radiation testing to assess its suitability for spaceflight applications. The results of these tests provide insights into the performance of ReRAM devices under radiation conditions. The analysis of the results can inform the development of more radiation-tolerant ReRAM devices.

5. Conclusion

We have demonstrated that a commercial production ReRAM is susceptible to single-event effects (SEE). However, the memory array is robust to SEE and allows for spaceflight applications.

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References