MRAM Modules
Single Event Upset Immunity

Revision history:
Rev 1: Document initial

Magnetoresistive random-access memory (MRAM) is a high speed, unlimited read and write endurance and non-volatile random-access memory, a combination not found in any existing memory technology.

MRAM data is stored by changing the magnetic polarity of the memory element. The storage element, called the Magnetic Tunneling Junction (MJT), is composed of two magnetic plates that are separated by a thin insulating layer as showed in Figure 1.

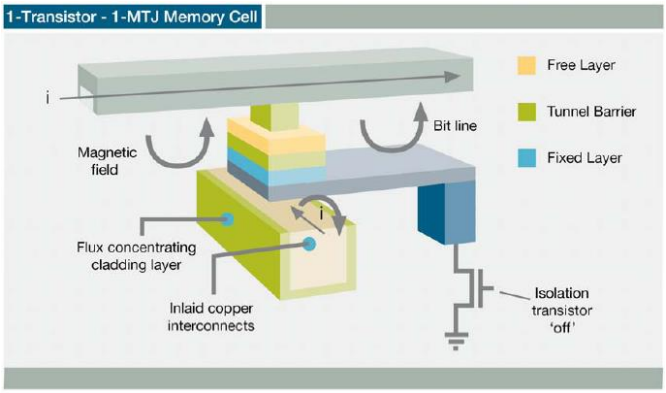

Figure 1: Schematic drawing of MRAM Cell

The thin insulating layer allows tunneling when a current is applied through the cell, allowing current to pass through the junction for reading purposes. The MJT operates similar to a capacitor such that data is stored between two metal plates. One plate is made of soft ferromagnetic material, and the other is permanent magnetic material. Essentially, we store data bits by controlling the plates' magnetic polarities (Figure 2). A memory device consists of an array of these cells. [An Outlook of MRAM Technology Potential, Arif H. Ahmed]

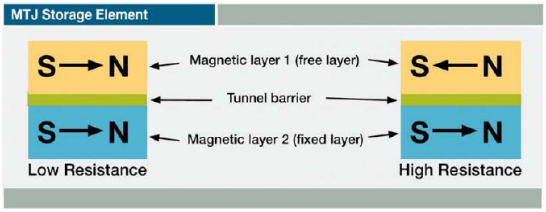

Figure 2: Resistance through the MTJ stack as a function of relative alignment of polarities of the free and fixed magnetic layers [Freescale Semiconductor, Inc]

MRAM is a very promising technology for space application in case that the MRAM stores data using magnetic polarization rather than electric charge, and the change of the electric charge is the main reason of Single Event Upset (SEU) in radiation environment as showed in Figure 3. Because MRAM does not use electric charge to store the data, it is a SEU immune technology.

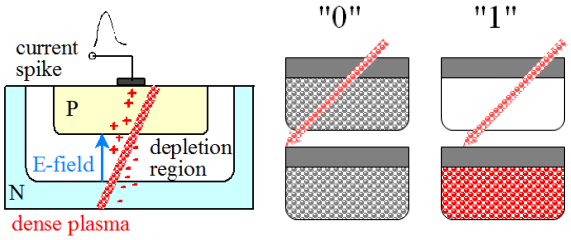

Figure 3: SEU Effects [Radiation Effects Analysis – Single Event Effects, Sophie Duzellier, RADECS 2003]

To verify the MRAMs Single Event Effect (SEE) characteristics, several SEE campaigns have been launched by 3D PLUS at TAMU (Texas A&M University, Cyclotron Institute).

Single Event Latch-up (SEL) tests were performed at TAMU with biased to VDD =3.6V and temperature at 125°C; No SEL observed during the tests both under Xenon (LET= 51.5MeV.cm^2/mg) and Gold (LET= 85.4MeV.cm^2/mg) irradiation with the total fluence equal to 1E7particles/cm^2.

Memory cell Single Event Upset (SEU) immunity tests were performed also at TAMU at room temperature at Standby mode: No SEU observed till Gold (LET= 85.4MeV.cm2/mg) irradiation with the total fluence equal to 1E6particles/cm^2.

The result showed that 1Mb MRAM basic component (3D Plus Part Numbers included in the table 1) is both Single Event Latch-up (SEL) & SEU Immune:

- SEL LET Threshold > 85 MeV-cm^2/mg
- Standby Mode SEU LET Threshold > 85 MeV-cm^2/mg (Memory Cell SEU Immune)

P/N	Density	Configuration	SEE Characteristics
3DMR1M08VS1426	1M	128Kx8b	SEL LET> 80Mev.cm^2/mg; SEU Immune
3DMR2M16VS2427	2M	128Kx16b	SEL LET> 80Mev.cm^2/mg; SEU Immune
3DMR4M08VS4428	4M	512Kx8b	SEL LET> 80Mev.cm^2/mg; SEU Immune
3DMR8M32VS8471	8M	256x32b	SEL LET> 80Mev.cm^2/mg; SEU Immune
3DMR8M32VS8420	8M	256x32b	SEL LET> 80Mev.cm^2/mg; SEU Immune

Table 1: SEL & SEU Immune MRAM