Heavy Ion Testing at the Galactic Cosmic Ray Energy Peak


1: Radiation Effects and Analysis Group, NASA/GSFC Code 561.4, 8800 Greenbelt Rd, Greenbelt, MD 20771 USA;
2: NASA Consultant, Brookhaven, VA 24112 USA;
3: IBM T. J. Watson Research Center, Yorktown Heights, NY 10598 USA;
4: Formerly with IBM System and Technology Group, Essex Junction, VT 05452 USA;
5: Sandia National Laboratories, Albuquerque, NM 87185 USA;
6: Texas Instruments, Dallas, TX 75243 USA;
7: Department of Electrical Engineering and Computer Science, Vanderbilt University, Nashville, TN 37235 USA;
8: ME Technologies (NASA/LSFC), Greenbelt, MD 20771 USA.

Abstract

A 1 GeV/u 56 Fe Ion beam allows for true 90° tilt irradiations of various microelectronic components and reveals relevant upset trends for an abundant element at the galactic cosmic ray (GCR) flux-energy peak.

Jonathan Pellish

Space Environment

- The galactic cosmic ray (GCR) environment has a flux-energy peak at 1 GeV/u.
- At this level of kinetic energy, LETs > 1 ((MeV·cm²)/mg) are dominated by iron.
- 1 GeV/u 56 Fe has an LET of 1.2 ((MeV·cm²)/mg) and a range in silicon of 15 cm.

GCR Fluxes for geostationary orbit at solar minimum (CREME96)

Facility

The NASA Space Radiation Effects Laboratory

Brookhaven National Laboratory, Long Island, NY USA

Target Room
- Facility has rotation and translation stages
- Can stack multiple experiments
- Experiments conducted <±20 in from beam exit

Static Random Access Memories

Note: Different scales for Vendor A's SOI and Vendor B's bulk CMOS

65 nm SOI Vendor A 45 nm SOI Vendor B: 65 nm bulk CMOS

→ Solid lines connect 1 GeV/u MBU cross sections
- Vendor A's SOI devices have both a data pattern and orientation dependence
- Vendor B's bulk CMOS device only has an orientation dependence

Pattern and orientation sensitivities arise from SOI's inter-device isolation and bit cell layout. These features are muted in bulk CMOS due to charge transport.

Field Programmable Gate Array

→ Solid lines connect 1 GeV/u configuration and BRAM cross sections

Conclusions

- First time the NSRL facility has been used to characterize highly-scaled commercial technologies
- 1 GeV/u 56 Fe beam allowed for true 90° tilt irradiations
- Extreme upset cross section variation observed as a function of roll angle, data pattern, and storage elements
- Data provides impetus to study these limiting irradiation conditions with radiation transport modeling since studies like these are not feasible on a regular basis

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