Heavy Ion Testing at the Galactic Cosmic Ray Energy Peak


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Abstract

A 1 GeV/u 56Fe 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.

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 56Fe 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

- The NSRL compares to other heavy ion facilities.
- Note that the PYL REF is similar to LBNL BASE facility.

Static Random Access Memories

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

One test in front

- Test setup for normal incidence irradiations
- Taking advantage of 8 in × 8 in beam spot
- Two setups in front and one in back
- Roughly ± 2% uniformity over this area

Two tests in front

- 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

- Extreme variation between configuration and BRAM cross section based on orientation
- Suspect physical layout is responsible

Conclusions

- First time the NSRL facility has been used to characterize highly-scaled commercial technologies
- 1 GeV/u 56Fe 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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