

Technical Program - Monday

RADGROUND Thematic Day

8:15 **RADGROUND opening**

RADGROUND Short Course

8:25 **Short course introduction**

Chairs: R. D. Schrimpf¹ and F. Saigné²

¹ Vanderbilt University, ² University of Montpellier - IES

8:30 **The terrestrial environment (effects of cosmic rays and alpha particles)**

R. Baumann

TEXAS Instrument

9:15 **Real Time Test**

J.L. Aufran

Aix-Marseille University - IM2NP

9:45 **Accelerated testing (ion/neutron beams, alpha foils, laser, ...)**

N. Seifert

INTEL

10:15 *RADGROUND COFFEE BREAK*

10:45 **Simulation tools for prediction**

R. Weller and R. Reed

Vanderbilt University

11:30 **Power (SEB, SEGR, SEL)**

A.D. Touboul

University of Montpellier - IES

12:00 **Radiation effects in medical electronics**

J. Wilkinson

Medtronic

12:30 *RADGROUND LUNCH*

RADGROUND Round Table

14:00 **Round Table**

Chairs: R. Baumann¹ and C. Slayman²

¹ Texas Instrument, ² CISCO Systems

16:00 *RADGROUND BREAK*

Session RG – Radiation Effects at Ground Level

16:30 **Session Introduction**

Chairs: L. Dilillo¹ and D. Truyen²

¹ University of Montpellier - LIRMM, ² ATMEL

RG-1 Proton Flux Anisotropy in the Atmosphere: Experiment and Modeling

16:35

F. Wrobel¹, J.R. Vaillé^{1,2}, D. Pantel¹, L. Dilillo³, J.M. Gallière¹, A.D. Touboul¹, P. Chadoutaud⁴, P. Cocquerez⁴, M. Lacourty⁴, M.A. Clair⁴, J.L. Aufran⁵, C. Chatry⁶, F. Laplanche⁷, B. Azais⁷, F. Saigné¹

¹ University of Montpellier - IES, ² University of Nîmes, ³ University of Montpellier - LIRMM, ⁴ CNES, ⁵ Aix-Marseille University - IM2NP, ⁶ TRAD, ⁷ DGA

We used two detectors differently tilted during stratospheric balloon flights and we proved the proton flux anisotropy. Experimental data are compared to simulations and a good agreement is shown.

RG-2 Neutrons-induced IGBT Failure: Effects of the Number of Tested Devices on the Cross Section Calculation

16:50

A.D. Touboul, L.L. Foro, F. Wrobel, K. Guetarni, J. Boch, F. Saigné

University of Montpellier - IES

Despite the long-range experience of space in testing and qualifying devices, an adaptation of existing guidelines is needed for atmospheric mass applications, especially to take into account the variability of Power-devices failure cross-section.

Technical Program - Tuesday

9:00 Opening Remarks and official talks

P. Fouillat, General Chair
University of Bordeaux - IMS

9:20 Technical session opening remarks

R. Velazco, Technical Chair
CNRS TIMA-Labs

Session A – Space and Terrestrial Environments

9:30 Session Introduction

Chairs: E. Daly¹ and G. Rolland²
¹ ESA-ESTEC, ² CNES

A-1 Jovian Radiation Belt Models, Uncertainties and Margins

9:35 *H. Evans, E. Daly, P. Nieminen, C. Erd*
ESA-ESTEC

Models of Jupiter's radiation belts are based on limited data from instruments with non-ideal characteristics. Radiation hazards are a major risk and driver of design. Environmental variabilities are evaluated, along with other margin factors.

A-2 Outer electron belt nowcast with an advanced data assimilation tool

9:50 *S. Bourdarie¹, V. Maget¹, A. Sicard-Piet¹, G. Rolland²*
¹ ONERA-DESP, ² CNES

A data assimilation tool using a 3D radiation belt model and an ensemble Kalman filter approach has been implemented. High time and space reanalysis of the electron radiation belt fluxes is obtained during magnetic storms.

A-3 Characterizing solar energetic particles access to any Earth-space location

10:05 *V. Maget¹, S. Bourdarie¹, G. Rolland²*
¹ ONERA-DESP, ² CNES

A consistent tool that completely characterizes the Earth's magnetic shielding at any location in space has been developed. The formalism of transmissivity helps the user to rapidly estimate the transmitted SEP flux along any orbit.

A-4 **Characterization of the neutron environment at the CERN-EU High Energy Reference Field and at the Pic du Midi**

10:20

A. Cheminet¹, G. Hubert¹, V. Lacoste², R. Velazco³, D. Boscher¹

¹ ONERA-DESP, ² IRSN, ³ TIMA

A new platform dedicated to the long-term characterization of the Atmospheric Natural Radiative Environment at mountain altitude (Pic du Midi, +2885 m) is presented. The performance of a high energy neutron spectrometer is established by comparison with the neutron monitors.

Session A – Poster papers

PA-1 The Two Towers (TTT) Radiation Monitor for Seosat/Ingenio

J.J. Jiménez, C. Hernando, M.T. Álvarez, M. Gonzalez-Guerrero, J.M. Oter, C.P. Fernández, H. Guerrero

INTA

A description of the radiation monitor “The Two Towers”, developed by INTA that will be onboard Seosat/Ingenio satellite is presented. It includes several radiation sensor technologies that are able to measure the typical LEO radiation environment.

PA-2 Continuous high-altitude measurements of cosmic ray neutrons and SEU/MCU at various locations: correlation and analyses based on MUSCA SEP³

G. Hubert¹, R. Velazco², C. Federico³, A. Cheminet¹, C. Silva-Cardenas⁴, L.V.E. Caldas⁵, F. Pancher², V. Lacoste⁶, F. Palumbo⁷, W. Mansour², L. Artola¹, F. Pineda⁸, S. Duzellier¹

¹ ONERA, ² TIMA, ³ IEAV, ⁴ PUCP, ⁵ IPEN, ⁶ IRSN, ⁷ CNEA, ⁸ Univ. of the Altiplano

In this paper are described measurements at high-altitude of both radiation environment and effects. These measurements integrate cosmic ray neutrons and SEU/MCU on nano-scales devices. Correlation and analyses based-on MUSCA SEP3 are performed.

PA-3 The flight data from the Russian Federal Space Agency monitoring system

V.S. Anashin, G.A. Protopopov, S.V. Balashov, N.V. Sergeecheva, S.P. Gaidash, S.V. Tassenko, P.V. Shatov

Institute of Space Device Engineering

An analysis of placed onboard several spacecraft TID sensors measurements is presented. It was observed an abrupt increasing of dose rate at the March 2012.

PA-4 High-accuracy simulations of the ISS radiation environment and applications to interplanetary manned missions

M.A. Chavy-Macdonald, A. Menicucci, P. Nieminen, S. Hovland
ESA-ESTEC

The ISS radiation environment has been thoroughly characterised by the Monte Carlo-based toolkit Geant4. The ISS structure is quite effective at shielding, and the internal environment found is consistent with literature values and astronaut dosimetry.

PA-5L Optimised shielding for the JUICE mission

M. Ansart¹, P. Nieminen¹, G. Santin¹, L. Desorgher²

¹ ESA-ESTEC, ² Space IT

The future Jovian mission JUICE will encounter a harsh radiation environment and should be thus efficiently protected. This work provides a study of appropriate shielding materials and configurations based on simple 3D geometries.

10:35 *BREAK*

11:05 INVITED TALK : Radiation Testing and Modeling: Practical Challenges and Shortfalls for the Next Five Years

K. LaBel

NASA Goddard Space Flight Center

Researchers are often so focused on their research, they fail to see the practical aspects required. In this regard, predictions for near to mid-term challenges for our community are presented incorporating recent aerospace trends and radiation effects research results.

12:05 *LUNCH*

Session B – Facilities and Dosimetry

14:00 Session Introduction

Chairs: G. Berger¹ and B. Piquet²

¹ UCL, ² University of Montpellier - IES

B-1 Mixed Particle Field Influence on RadFET sensitivities

14:05 *J. Mekki, M. Brugger, S. Danzeca, K. Roed, G. Spiezia*
CERN

While RadFETs are well characterized with Co-60 gamma source, their response can be affected when they are used in mixed particle field. This paper shows simulations and present experimental results to understand this effect.

B-2 Radiation Effects on the Photoluminescence of Rare-earth Doped Pyrochloric Powders

14:20

S.L. Weeden-Wright, S.L. Gollub, R. Harl, A.B. Hmelo, D.M. Fleetwood, B. Rogers, R.D. Schrimpf, D.G. Walker
Vanderbilt University

Pre- and post-irradiation photoluminescence spectra are compared for pyrochloric phosphor powders. When a binder material is present, the relative emission intensities from the phosphor and binder vary with proton exposure.

B-3 Development of a CMOS Oscillator Concept for Particle Detection and Tracking

14:35

K. Castellani-Coulié, H. Aziza, W. Rahajandraibe, G. Micolau, J.M. Portal
Aix-Marseille University – IM2NP

An oscillator concept developed for particle detection and tracking is presented. The methodology used to characterize the currents generated by the particles is detailed and the results extracted from a DOE analysis are presented.

Session B – Poster papers

PB-1 Improved Floating Gate MOS Radiation Sensor with Current Output

E. Garcia-Moreno¹, E. Isern¹, M. Roca¹, R. Picos¹, J. Font¹, J. Cesari², A. Pineda²

¹Electronic Engineering Group, UIB, ²I-C Málaga

This paper presents an improved version of our previous gamma radiation sensor based on a floating gate MOSFET. The new version features much higher supply voltage rejection and much lower sensitivity to ambient temperature.

PB-2 The determination of the linear energy transfer of high-energy ions in the sensitive volume of integrated circuits under single event effects testing

V.F. Zinchenko, K.V. Lavrentjev, A.K. Lipsky
Research Institute of Scientific Instruments

A new method for extraction of the linear energy transfer of high energy ions in the sensitive volume of integrated circuits under single event effects testing from experimental data is described.

PB-3 Ion Beam Diagnostics for SEE Testing at U400M FLNR JINR Cyclotron

V.A. Skuratov¹, Y.G. Teterev¹, V.B. Zager¹, A.I. Krylov¹,
I.V. Kalagin¹, G.G. Gulbekyan¹, V.S. Anashin

¹ Joint Institute for Nuclear Research, ² Institute of Space Device Engineering

This report aims at describing features of diagnostic set-up used for ion beam parameters evaluation and control during SEE testing at the Roscosmos ion beam line at U400M cyclotron at FLNR JINR, Dubna.

PB-4L A new experimental gamma irradiation facility for radiation testing

R.E. Sharp¹, P. Neyssen¹, V. Labeled²

¹ Synergy Health, ² CEA

This presentation describes the design, construction and commissioning of a new gamma irradiation facility at Synergy's Marcoule site in France. By the end of 2012 the facility will be operational and carrying out irradiations

PB-5L A New Cobalt-60 Irradiation Facility For Total Dose Testing At Toulouse

N. Chatry, P.F. Peyrard, C. Doosat, P. Pourrouquet, J.C. Thomas
TRAD

This paper describes the cobalt-60 irradiation facility for total dose testing located at TRAD. The facility offers a gamma ray beam dose rate from 1 krad/h to 7 rad/h. The opening is scheduled at the end of September 2012.

PB-6L Novel CMOS differential and amplified dosimeters. Proposals and simulations

S.H. Carbonetto, M.A. Garcia Inza, J. Lipovetzky, M.J. Carra,
L. Sambuco Salomone, E.G. Redin, A. Faigon
University of Buenos Aires

We propose the use of differential circuit sensors as dosimeters to achieve temperature compensation and sensitivity enhancement. Simulations were performed in a 1dot5µm CMOS process. Results show that amplification is possible along with temperature compensation.

PB-7L A Metric for the Measurement of the Quality of Stimuli in Radiation Testing

J.M. Mogollón, H. Guzmán-Miranda, J. Nápoles, M.A. Aguirre
University of Sevilla

This work introduces a methodology to evaluate the quality of a set of test vectors or workload for radiation testing of digital circuits

PB-8L Development of a Near UV SPA Laser Tool for Wide Band Gap Semiconductor Single Events Assessment

*S. Morand*¹, *F. Miller*¹, *F. Molière*¹, *T. Santini*¹, *E. Celerault*¹,
*B. Foucher*¹, *P. Austin*², *T. Carrière*¹, *R. Gaillard*³

¹ EADS, ² CNRS LAAS ³ RG Consulting

The development of a Single Photon Absorption laser tool has been proposed to evaluate wide bandgap material power technology sensitivity to radiation. First SEB results and technical analysis are presented on a commercial SiC MOSFET.

PB-9L Dosimeter for TTT in SEOSAT-INGENIO based on the TMP36 temperature sensor

M. González-Guerrero, J.J. Jiménez, C. Hernando, M.T. Álvarez, H. Guerrero

INTA

A dosimeter based on the ionization damage of the TMMP36 sensors under TID is presented. The operation mechanism and modes as well as the results obtained in a gamma irradiation to optimize it are shown.

Session C – Basic Mechanisms of Radiation Effects

14:50 Session Introduction

*Chairs: A. Paccagnella*¹ *and A.D. Touboul*²

¹ University of Padova, ² University of Montpellier - IES

14:55 C-1 SEU Measurements and Simulations in a Mixed Field Environment

*R. García Alía*¹, *B. Biskup*¹, *M. Brugger*¹, *M. Calviani*¹, *C. Poivey*²,
*K. Røed*¹, *F. Saigné*³, *G. Spiezia*¹, *F. Wrobel*³

¹ CERN, ² ESA-ESTEC, ³ University of Montpellier - IES

SEU measurement results using SRAM monitors in an accelerator-like mixed-field environment are shown. Monte Carlo simulations of the radiation field and the device cross section, including pions and GeV-energies, are performed using FLUKA, and discussed.

15:10 C-2 Simulation of Radiation Effects in GaAs Solar Cells–Physics Based Models versus Experimental Data

*M. Turowski*¹, *T. Bald*¹, *A. Raman*¹, *A. Fedoseyev*¹, *J.H. Warner*²,
*C.D. Cress*², *R.J. Walters*²

¹ CFD Research Corporation, ² NRL

3-D NanoTCAD simulations with detailed traps/defects parameters from Deep Level Transient Spectroscopy (DLTS), for majority and minority carrier traps, predict solar cell characteristics that agree well with experimental data for proton irradiation at various fluences.

C-3 Modeling the Effect of Hysteresis on Aligned Nanotube FETs exposed to ionizing radiation
15:25

I.S. Esqueda¹, Y. Fu¹, C.D. Cress², J. Zhang¹, C. Zhou¹, J. Ahlbin¹, M. Bajura¹, G. Boverman¹, M. Fritze¹

¹ University of Southern California, ² NRL

We investigate hysteresis in the transfer characteristics of aligned carbon nanotubes (CNT) field-effect transistors (FETs). Experiments support a dynamic screening model for hysteresis. TCAD simulations are used to investigate the combined effect of hysteresis and radiation effects.

C-4 Accurate Model of Surface Recombination for Radiation-Induced Excess Base Current in Bipolar Junction Transistors
15:40

A.M. Campola¹, H.J. Barnaby², B. Vermeire³

¹ NASA, ² Arizona State University, ³ Space Micro

An accurate model for recombination current has been developed which enables the extraction of surface recombination velocities from excess base current readings in bipolar junction transistors. The methodology correlates measurements with degradation caused by irradiation.

Session C – Poster papers

PC-1 Degradation of AlInN/AlN/GaN high electron mobility transistors under proton irradiation

A. Zanandrea, S. Gerardin, F. Rampazzo, G. Meneghesso, E. Zanon, A. Paccagnella

University of Padova

We irradiated AlInN/AlN/GaN High Electron Mobility Transistor with low-energy protons. After fluences larger or equal to 10e13 p/cm2, the devices experience threshold voltage shifts and transconductance degradation, visible in both DC and pulsed measurements.

PC-2 Non-ionizing energy loss: an additional wear-out mechanism in latent reliability degradation

M. Naceur^{1,3}, A. Privat¹, A.D. Touboul¹, J.R. Vaile^{1,2}, E. Lorfèvre³, F. Bezerra³, G. Chaumont⁴, N. Chatry⁵, C. Chatry⁵, F. Saigné¹

¹ University of Montpellier - IES, ² University of Nimes - IES, ³ CNES, ⁴ STMicroelectronics, ⁵ TRAD

Power MOSFET's oxide reliability degradation is studied after heavy ion and neutron irradiation. The worst case of reliability degradation is observed at the lowest ion energy suggesting a synergetic effect between ionizing and non-ionizing processes.

PC-3L Experimental dose enhancement in multi-layer shielding structures exposed to high-energy electron environments

*J. Eck*¹, *S. Ibarria*^{1,2}, *V. Ivanchenko*³, *D. Lavielle*¹, *A. Rivera*⁴, *J. Cueto*⁵, *G. Santin*⁶

¹ TRAD, ² INTA, ³ Geant4 Associate International, ⁴ Elecnor Deimos, ⁵ Thales Alenia Space, ⁶ Rhea System SA & ESA

The impact of energetic electrons in deep shielding structures has been recently measured in terms of dose enhancement effects. New dosimetric data from a extensive experimental campaign have been obtained and compared to Geant4 predictions.

Data Workshop

15:55 **Data Workshop Introduction**

*Chairs: N. Chatry*¹ *and B. Glass*²

¹ TRAD, ² ESA-ESTEC

16:00 to
18:00

Data Workshop – Poster papers

DW-1 Radiation-hardened 250V Super-junction Power MOSFET (CoolMOSTM)

*M. Schmitt*¹, *S. Gamerith*², *G. Sölkner*¹, *W. Kaindl*¹, *B. Eisener*¹

¹ Infineon Technologies Germany, ² Infineon Technologies Austria

We report on the development of a radiation-hardened super-junction (SJ) power MOSFET (CoolMOS) with a breakdown voltage $BVDSS > 250V$ and an area-specific on-resistance $RDS(ON) \cdot A < 1.3 \text{ Ohm} \cdot \text{mm}^2$, focusing of improvement of SEE hardness.

DW-2 SEE test results comparison for differential driver-receiver chain using SET and SEU test approaches

M. Mazurek, F. Lochon, F.X. Guerre

Hirex Engineering

A quad differential line chain composed of 26LV31 driver and 26LV32 receiver was tested for single event effect (SEE) characterization. Two different test approaches were applied: single event transient approach and single event upset approach.

DW-3 Ultralow Dose Rate Test Results at 1 mrad(Si)/s to 100 krad(Si) for Texas Instruments' ELDRS Free Bipolar LDO Regulator, LM2941

K. Kruckmeyer, T. Trinh, L. McGee

Texas Instruments

Ultralow dose rate test data at 1 mrad/s to 100 krad for the bipolar LDO regulator, LM2941, is presented. Data collection at this dose rate took 3 year.

DW-4 The Study of Modeling and Radiation Test for Evaluation of Transient Radiation Effects on the CMOS ICs

S. Oh, N.H. Lee, H.H. Lee

Atomic Energy Research Institute

This study carried out a SPICE simulation and experiment tests to analyzing transient radiation effects on the CMOS devices.

DW-5 Single event upset cross section dose dependence on 90nm SRAM

N. Sukhaseum¹, D. Le Du, B. Vandeveld¹, A. Samaras¹,
N. Chatry¹, F. Bezerra²

¹TRAD, ²CNES

This paper presents radiation test results for two 90nm SRAM characterized for TID and SEE. The experiments are performed in order to study the correlation between the SEE cross and the TID level.

DW-6 Radiation Testing of FPGA-Based High-Speed Serial Communication

K. Ellsworth, A. Harding, C. Ballew, T. Haroldsen, M. Wirthlin,
B. Nelson

NSF Center for High-Performance Reconfigurable Computing

FPGAs with high-speed serial transceivers provide an effective platform for space-based computing systems. This paper tests the reliability of the Aurora serial protocol operating on an FPGA using high-speed MGT links.

DW-7 Terrestrial Neutron Induced Soft Errors from 150nm to 28nm

A. Lesea

Xilinx Research Labs

Atmospheric soft error effects test results for bulk CMOS Xilinx FPGA devices from 150 nanometers to 28 nanometers are presented.

DW-8 Single Event Testing of the Intersil ISL70002SEH Integrated Point of Load Converter

N.W. van Vonno, H.W. Satterfield, J.S. Gill, E. J. Thomson, S.J. Schulte and P.J. Chesley

Intersil

We report the results of SEE testing for both destructive and nondestructive effects of the ISL70002SEH integrated Point of Load (POL) converter together with a discussion of the part's electrical specifications and wafer fabrication process.

DW-9 Switching DC-DC converters' TID and SEE hardness investigation

A.Y. Nikiforov, D.V. Boychenko, L.N. Kessarinskiy
National Research Nuclear University and SPELS

Total dose and SEE experimental data for switching DC-DC converters and its basic parts (MOSFETs, error amplifiers, PWMs, optocouplers) is presented. The most total dose and SEE sensitive parts are revealed.

DW-10 Radiation test of HDTV-Video Cameras for the ISS

A. Schüttauf, S. Rakers, C. Daniel, H. Frerker, T. Jahnke,
M. Mathias
Astrium ST

A proton radiation test has been carried out for all components of the Data and Power boards and two HDTV-Cameras (COTS based). These devices have shown to be quite different sensitive to SEL/SEU errors. Detailed measurements.

DW-11 Automated Laser Mapping of Single Event Transients in Analogue Integrated Circuits

A.M. Chugg¹, P.H. Duncan¹, C. Poivey²
¹ MBDA UK, ² ESA-ESTEC

Automated SET mapping has been performed on various analogue devices using arrays of spiral piezoelectrically driven scans. Results are presented using both spatial maps and amplitude versus duration distributions.

DW-12 Total Ionizing Dose Effects in Ferroelectric Nonvolatile RAMs FM18L08

A.B. Boruzdina¹, A.A. Orlov², A.V. Ulanova², A.G. Petrov¹
¹ SPELS, ² National Research Nuclear University

In this paper we report the results of investigation of Ferroelectric Random Access Memories subjected to Total Ionizing Dose (TID).

DW-13 Functional Control Technique for FPGA Total Ionizing Dose Testing

D.V. Bobrovsky¹, O.A. Kalashnikov², P.V. Nekrasov²
SPELS

The TID FPGA functional control methodology is described. The necessity of 100% FPGA functional blocks testing is demonstrated. Experimental results for FPGA AX1000, EPF10K50, and A3PE600L are presented.

DW-14 Total Dose and Single-Event Testing of SAPJ-18S30A Point-of-Load DC/DC converter

N. Ikeda¹, V. Ferlet-Cavrois², C. Poivey², M. Muschitiello²,
Y. Yano³, T. Suzuki³, A. Zadeh², S. Kuboyama¹, T. Tamura¹

¹ JAXA, ² ESA-ESTEC, ³ Nippon Avionics

TID and SEE test results for the newly developed SAPJ-18S30A Point-of-Load (POL) DC/DC converter are reported. Existence of ELDRS is examined and SET pulses produced by heavy ion irradiation are characterised.

DW-15 SEE Tests of the 4Gb and 8Gb Nand Flash

P. Xiao Wang¹, L. Gouyet², A. Rousset², B. Vandeveld²

¹ 3D Plus, ² TRAD

We report on results of SEE tests of Micron 4Gb and Samsung 8Gb Nand Flash. In particular, the report analyzes and evaluates High current events and other events from the test results.

DW-16 Compendium of Roscosmos Facility Single Event Effect Data Obtained in the Temperature Range

V.S. Anashin, A.E. Kozyukov, V.S. Korolev, A.S. Kuznetsov, L.R. Bakirov, K.A. Artemyev, V.V. Emeliyanov, A.I. Ozerov, A.S. Vatuev, A.V. Besetskiy

Institute of Space Device Engineering

This paper presents the results of tests of COTS and industrial electronic components of different types on heavy ions hardness in the temperature range C °C to 125 °C from 20.

DW-17 Radiation Characterization of high-speed Analog to Digital Converter and Digital to Analog Converter

D. Bellin¹, E. Savasta¹, F. Malou², L. Hili³, E. Le Goulven⁴

¹ e2v, ² CNES, ³ ESA, ⁴ TRAD

This paper presents radiation results of 10-bit 1.5GS/s ADC and 12-bit 3GS/s MUXDAC in term of total dose, SEL, single event upset and transient under heavy ions and protons, demonstrating their suitability for space environment.

DW-18 Compendium of Recent Proton and Co60 Radiation Test Data in Radiation Tolerant Optocouplers and COTS

A. Costantino, S. Hernandez, V. Ferlet-Cavrois, M. Muschitiello,
L. Marchand, A. Mohammadzadeh

ESA-ESTEC

The permanent degradation of electrical parameters in optocouplers is measured as a function of Co-60 total ionizing dose and proton fluence. These data have been gathered for several types of COTS and radiation-tolerant optocouplers.

DW-19 Characterization of RADFET Dosimeters for the ESA ALPHASAT CTTB Experiments

P. Gonçalves¹, A. Keating^{1, 2}, A. Trindade¹, P. Rodrigues¹, M. Ferreira¹, P. Assis¹, M. Muschitiello², B. Nickson², C. Poivey²

¹ Laboratório de Instrumentação e Física Experimental de Partículas (LIP), ² ESA-ESTEC

A calibration test campaign of RADFET dosimeters was conducted at the ESA/ESTEC Cobalt-60 facility. RADFETS were irradiated at high and low dose rates up to 50 krad and underwent annealing under different temperature conditions.

DW-20 SEL and TID Test Results of a Hardened 16Mbit MRAM Device

*A. Jordan, C. Hafer, M. Von Thun, M. Mundie, D. Bass, T. Farris
Aeroflex*

A 16Mbit MRAM device has been hardened for SEL immunity (≤ 100 MeV-cm²/mg) and TID immunity (≤ 1 Mrad(Si)). SEL and TID test data will be presented for the commercial and hardened versions of the device.

DW-21 A 15 Mrad(Si) 512Kbit Rad-Hard SRAM in a standard 0.18um CMOS technology

C. Calligaro¹, A. Arbat Casas¹, Y. Roizin², D. Nahmad²

¹ RedCat Devices, ² Tower Semiconductor Migdal Haemek

Forthcoming outer planet missions such as EJSM (Europa Jupiter System Mission) require very advanced silicon devices able to sustain high TID (Total Ionization Dose) coming both from the exposure during the travel and the harsh environment during the in-depth study of the Jovian system and its four major satellites.

DW-22L X-Ray Radiation Effects in Gate-Leakage of Overlapping Circular-Gate MOSFETs

J.A. De Lima¹, M.A.G. Silveira², K.H. Cirne³, R.B.B. Santos², N. Medina⁴

¹ Federal University of Santa Catarina, ² FEI University Center, ³ EMBRAER, ⁴ University of Sao Paulo

The influence of X-ray radiation on gate leakage of Overlapping Circular-Gate (O-CGT) and conventional MOSFETs are cross-checked after TID between 50-150 Mrad. OCGT's still feature adequate ratio channel/gate currents on strong inversion.

- DW-23L New SEE Test Results of 16/32-Gbit SLC NAND-Flash**
K. Grünmann¹, M. Herrmann¹, F. Gliem¹, H. Schmidt², H. Kettunen³, V. Ferlet-Cavrois⁴
¹ IDA, Technische Universität Braunschweig, ² Astrium GmbH, ³ University of Jyväskylä, ⁴ ESA-ESTEC

16/32-Gbit NAND-Flash memories have been tested under heavy ion irradiation. The cross section and the current waveforms for Destructive Failures and the annealing of hard and soft SEUs are presented.

- DW-24L SEE Test Results for Maestro Microprocessor**
S.M. Guertin¹, L.S. Walling², B. Wie³, M. Plante³, A. Berkley³, M. Cabanas-Holmen⁴
¹ JPL, ² NASA-GSFC, ³ Integrity Applications Incorporated, ⁴ Boeing

Recent testing of the OPERA Program's 49-core Maestro ITC microprocessor is presented. L2cache sensitivity was prevalent with some additional tile sensitivity observed. Other functions, including on-chip networks performed well, within limitations of test sensitivity.

- DW-25L New SEE Test Results for 4 Gbit DDR3 SDRAM**
M. Herrmann¹, K. Grünmann¹, F. Gliem¹, G. Leibelng², H. Kettunen³, V. Ferlet-Cavrois⁴
¹ IDA, Institute of Computer and Network Engineering, ² IOF Fraunhofer, ³ University of Jyväskylä, ⁴ ESA-ESTEC

New generation 4 Gbit DDR3 SDRAMs from Samsung and Elpida have been tested for hard errors and deadlocks under heavy ions.

- DW-26L Comparing of γ -rays, protons and neutrons radiation effects on optoelectronics for space**
L. Luo, Q. Yu, M. Tang, M. Meng, H. Zhang, P. Li, M. Zhu, Y. Sun
China Academy of Space Technology

We performed irradiation test on optoelectronics using γ -rays, protons and neutrons, respectively. The degradation was compared. The effects of displacement damage and total ionizing dose on optoelectronics are analyzed.

- DW-27L Neutron-Induced SER Dependence on Data Types in Graphic Processing Units**
P. Rech¹, C. Aguiar¹, C. Frost², L. Carro¹
¹ Federal University of Rio Grande do Sul, ² ISIS, Rutherford Appleton Laboratories
Experimental results show that the data type has a strong influence on the neutron-induced error rate of algorithms in GPUs. We evaluate the SER dependence and analyze the GPU architecture to explain the observed phenomena.

DW-28L Total Ionizing Dose Engineering Tests of microSD Memories for their use in a Cubesat Satellite

J. Lipovetzky^{1,3}, L. Chiesa¹, A. Burman¹, G. Richarte², S. Carbonetto¹, M. Garcia Inza¹, L. Sambuco Salomone¹, E. Redin¹, A. Faigon^{1,3}

¹ University of Buenos Aires, ² Satellogic, ³ CONICET

Micro Secure Digital memories with a capacity of 8 GB were tested for Total Ionizing Dose (TID) using a ⁶⁰Co source. Parts were functional after the irradiation, but data retention errors were observed.

18:00 WELCOME COCKTAIL

Technical Program - Wednesday

Session D – Photonic Devices and ICs

9:00 Session Introduction

Chairs: V. Goiffon¹ and S. Girard²

¹ ISAE, University of Toulouse, ² CEA DAM

D-1 Proton irradiation effects on InGaAs/InP Photodiodes for Space Applications

9:05

G. Pedroza¹, M. Boutillier², L. Sun How³, L. Bechou⁴, T. Nuns⁵, P. Arnolda⁵, Y. Ousten⁴, J.L. Goudard⁶

¹ ALPhANOV, ² CNES, ³ AdvEOTec, ⁴ University of Bordeaux - IMS, ⁵ ONERA-DESP, ⁶ 3S-PHOTONICS

The performances of COTS InGaAs/InP photodiodes tested with protons are studied for space applications. A dark current increase is observed after irradiation and a degradation model is then applied to assess the EOL performances.

D-2 Monte Carlo based DSNU prediction after proton irradiation

9:20

C. Inguibert¹, T. Nuns¹, E. Martin^{1,2}, D. Falguère¹, O. Gilard²

¹ ONERA-DESP, ² CNES

The 3D Monte Carlo transport code GEANT 4 was used to simulate Dark Signal Non Uniformity (DSNU) of image sensors generated after proton irradiation. Results show a good agreement with experimental measurements on APS.

D-3 Single Event Effects in CMOS Image Sensors

9:35

V. Lалуcaa¹, V. Goiffon¹, G. Rolland², S. Petit², P. Magnan¹

¹ ISAE, University of Toulouse, ² CNES

This article focuses on the study of single event effects on CMOS image sensors. Active Pixel Sensors have been tested under heavy ions irradiation in order to achieve experimental validation of a theoretical approach.

D-4 Proton and γ -rays Irradiation Induced Dark Current Random Telegraph Signal in a 0.18 μ m CMOS Image Sensor

9:50

E. Martin^{1,2}, J.P. David¹, C. Virmontois², T. Nuns¹, O. Gilard²

¹ ONERA-DESP, ² CNES

The dark current random telegraph signal behaviour has been studied in a 0.18 μ m CMOS image sensor. Protons and gamma-rays have been performed in order to assess the ionizing and displacement damage effects on RTS.

D-5 Comparison of gamma-radiation induced absorption of Al-doped, P-doped and Ge-doped fibres

10:05

A. V. Faustov^{1, 2}, A. Gusarov¹, M. Wuilpart³, A.A. Fotiadi^{3,4,5}, L.B. Liokumovich², O.I. Kotov², A. L. Tomashuk^{5, 6}, T. Deschoutheete⁷, P. Mégret³

¹ SCK•CEN, ² Saint-Petersburg State Polytechnical University, ³ University of Mons, ⁴ Ioffe Physical-Technical Institute, ⁵ Ulyanovsk State University, ⁶ Fibre Optic Research Center, ⁷ Laborelec

We have investigated radiation induced absorption in different optical fibres under gamma-radiation up to 110 kGy total dose. At doses below 10 kGy a steep increase of the induced loss was observed in Al-doped fibres.

Session D – Poster papers

PD-1 New Radiation Test Results on HAS2 CMOS Image Sensor

M. Beaumel¹, D. Hervé¹, D. Van Aken², M. Poizat³

¹ EADS SODERN, ² ON Semiconductor, ³ ESA-ESTEC

New cobalt-60, proton, electron and neutron irradiations have been performed on the HAS2 CMOS Image Sensor. Together with previously published test results, this completes a comprehensive dataset on the radiation performance of the device.

PD-2 High Dose Gamma Irradiation of Lasers and p-i-n Photodiodes for HL-LHC Data Transmission

S. Seif El Nasr-Storey, S. Detraz, L. Olantera, C. Sigaud, C. Soos, J. Troska, F. Vasey

CERN

Lasers and photodiodes for HL-LHC data transmission applications were irradiated with a 1 MGy dose of Co60 gammas. Results from the test are presented, and a comparison to other sources of radiation is made.

PD-3 Silicon photodiodes degradation in VUV spectral range

V.V. Zabrodsky¹, V.L. Sukhanov¹, V.P. Belik¹, N.V. Zabrodskaya¹, P.N. Aruev¹, E.V. Sherstnev¹, A.G. Alekseyev²

¹ Ioffe Physical-Technical Institute, ² Troitsk Institute for Innovation & Fusion Research

Studies of detector response spatial profile have been performed for silicon n-p and p-n silicon photodiodes exposed to VUV radiation at 121.6 nm wavelength.

PD-4 Radiation Response of Backside-Illuminated CMOS Image Sensors

I. Chatterjee¹, K. De Munck², K. Minoglou², R.D. Schrimpf¹, B.L. Bhuva¹, P. De Moor²

¹ Vanderbilt University, ² IMEC

Backside-illuminated CMOS imagers have higher quantum efficiency and fill factor compared to front-side illuminated imagers. Gamma, proton and heavy-ion irradiation results on BSI imagers are reported. Traps and fixed charges significantly influence the SE response.

PD-5L Displacement damage effects induced by electron irradiation on 1.55 μ m InGaAsP laser diodes for space laser communication

X. Gao¹, S. Yang¹, Z. Feng¹, L. Zhang¹, Y. Ma¹

¹ Lanzhou Institute of Physics, China Academy of Space Technology

Key parameter degradations were characterized. The damage mechanism is attributed to the displacement effect of electrons accompanied with gamma total dose experiment, and key parameter degradation can be correlated with displacement damage dose.

10:20 *BREAK*

Session E – SEE Mechanisms and Modeling (part I)

10:50 **Session Introduction**

Chairs: S. Buchner¹ and F. Darracq²

¹ NRL, ² University of Bordeaux - IMS

E-1 Single Event Effect analysis on RF operated AlGaIn/GaN HEMTs

10:55

*M. Rostewitz, K. Hirche, J. Lätti, E. Jutzi, J. Daeubler
Tesat-Spacecom*

Heavy ion irradiation testing was performed on AlGaIn/GaN HEMTs both under DC and RF operation. Single gate finger radiation test structures and multiple gate finger RF power cells were tested and failure mechanisms analyzed.

E-2 The Cause of Subthreshold Leakage Currents Induced by Nucleons and Ions in MOSFETs

11:10

*A. M. Chugg¹, S. Parker¹, P.H. Duncan¹, T.S. Barber²,
A. Hands³, P. Morris³, C. Poivey⁴*

¹ MBDA, ² University of Warwick, ³ QinetiQ, ⁴ ESA-ESTEC

Additional evidence is presented and discussed on the mechanism for the subthreshold leakage currents induced in MOSFET's by single nucleon and ion interactions. The new evidence excludes microdose in gate oxides and instead points to m.

E-3 Soft Error Triggering Criterion Based on Simple Electrical Model of the SRAM cell

11:25

F. Wrobel, A.D. Touboul, F. Saigné
University of Montpellier - IES

We simulate the response of SRAM cells to particles by considering a basic electrical model of each transistor with no empirical parameters. Results are in good agreement with experiment for 150nm, 90nm and 65nm SRAMs.

E-4 Effects of Low-Energy Muons on Electronics: Physical Insights and Geant4 Simulations

11:40

S. Semikh¹, S. Serre¹, J.L. Autran¹, D. Munteanu¹, G. Gasio², P. Roche²

¹ Aix-Marseille University - IM2NP, ² STMicroelectronics

The impact of low energy (< 1 MeV) positive and negative muons on SRAMs is investigated using the new TIARA-G4 simulation code. Both direct ionization and negative muon capture mechanisms are in-depth analyzed.

11:55 LUNCH

Session E – SEE Mechanisms and Modeling (part II)

E-5 Investigation of Flip-Flop Effects in a Linear Analog Comparator-with-Hysteresis Circuit

14:00

N.J.H. Roche^{1,2}, S. Buchner², F. Roig³, L. Dusseau¹, J. Warner², J. Boch¹, D. McMorrow², F. Saigné¹, G. Auriel³, B. Azaïs⁴

¹ University of Montpellier - IES, ² NRL, ³ CEA, ⁴ DGA

The impact of the positive feedback loop on ASET shapes was investigated for a comparator-with-hysteresis circuit. Simulation and laser experiments were conducted and have identified that this circuit is sensitive to flip-flop effects.

E-6 SEL sensitive area mapping and the effect of reflections from metal lines on laser SEE testing

14:15

N.A. Dodds¹, N.C. Hooten¹, R.A. Reed¹, R.D. Schrimpf¹, J.H. Warner², N.J.H. Roche², D. McMorrow², S. Buchner², S. Jordan³, J.A. Pellish⁴, W.G. Bennett¹, N.J. Gaspard¹, M.P. King¹

¹ Vanderbilt University, ² NRL, ³ Jazz Semiconductor, ⁴ NASA

Laser mapping of test structures reveals several properties of SEL sensitive areas and provides evidence that laser light reflected from the bottom of metal lines during backside TPA testing can affect SEE test results.

E-7 Trends in Heavy-ion Upset Cross-sections for Flip-flop Designs at Deep Sub-micron Bulk CMOS Technologies

14:30

*N. Gaspard*¹, *S. Jagannathan*¹, *A. Sternberg*¹, *T.D. Loveless*¹, *S.J. Wen*², *R. Wong*², *B.L. Bhuvu*², *L.W. Massengill*¹, *W.T. Holman*¹

¹ Vanderbilt University, ² Cisco Systems

Heavy-ion experiments performed on 28 and 40-nm DFF designs and are compared to results from literature for previous technology generations. Trends show saturated cross section decreases exponentially with scaling while LET threshold does not change.

Session E – Poster papers

PE-1 A Framework for Fully-Physical, Statistically-Enhanced Monte-Carlo Simulation of SEU

S. Chen^{1,2}, *G. Ding*^{1,2}, *Z. Li-Sang*², *J. Dong-Mei*²

¹ Cogenda Pte, ² Ke Jing Da Electronics

We report RunSEU, a fully-physical simulation framework for evaluating SEU cross-section of CMOS circuits. RunSEU uses GEANT4 for particle simulation, fast, parallel 3D TCAD for circuit-response simulation, and improved statistical subset-simulation to reduce computation cost.

PE-2 Experimental Study of Range Dependence of Single Event Upset sensitivity using Different Energy 12C ions

*Q. Zhang*¹, *Y. Wang*¹, *S. Qin*¹, *Y. Zheng*¹, *L. Liu*¹, *Z. Cai*¹, *X. Lu*²

¹ Institute of Spacecraft System Engineering, ² China Institute of Atomic Energy

2-90MeV 12C ions are used to obtain upset cross section of typical static random access memory (SRAM) MT5C1008, HM65642, IDT7164 and IDT71256. The range dependences on single event upset sensitivity are analyzed.

PE-3 A Simple Method for Assessing Power Devices Sensitivity to SEEs in Atmospheric Environment

L.L. Foro, A.D. Touboul, F. Wrobel, F. Saigné

University of Montpellier - IES

Sensitive volume and critical energy are critical features of the triggering mechanism for SEEs in power components. Based on nuclear cross section data and experimental cross section we propose a method for extracting critical parameters.

PE-4 A Novel Framework for Evaluating the SRAM Core-Cell Sensitivity to Neutrons

G. Tsiligiannis¹, L. Dillo¹, A. Bosio¹, P. Girard¹, A. Todri¹, A. Virazel¹, F. Wrobel², F. Saigné²

¹ University of Montpellier – LIRMM, ² IES

The paper proposes a novel framework for the sensitivity evaluation of the SRAM core-cell to neutron radiation through extensive SPICE simulations. As case study, we have applied this method on a 40nm technology core-cell.

PE-5L Analysis of Single Event Effects in an OxRRAM cell by using SPICE level simulations

K. Castellani-Coulié, M. Bocquet, H. Aziza, J.M. Portal, W. Rahajandraibe, C. Muller

Aix-Marseille University – IM2NP

Memories based on resistive switching mechanisms, as OxRRAMs, are attractive candidates to overcome future power issues. An analysis of SEE in circuitry surrounding an OxRRAM is proposed by studying ionizing particles crossing the circuit.

Poster Session

14:45 **Poster Session Introduction**

Chair: V. Ferlet-Cavrois
ESA-ESTEC

14:50 **Poster Session**
to 16:50

16:50 **INVITED TALK**

17:50 *EXHIBITORS'RECEPTION*

Technical Program - Thursday

Session F – Radiation Effects in Devices & ICs (part I)

9:00 **Session Introduction**

Chairs: P. Adell¹ and H. Barnaby²

¹ JPL, ² Arizona State University

F-1 Upset Manifestations in Embedded Digital Signal Processors (DSPs) due to Single Event Effects (SEE)

9:05

R. Monreal¹, G. Swift²

¹ Southwest Research Institute, ² Xilinx

Embedded DSPs are irradiated with heavy ions in order to understand the impact of SEEs to their functionality. Upset duration measurements taken during irradiation experiments provide a portrait of the various contributing upset mechanisms.

F-2 Total Ionization Dose Response of FET-based Wideband, High-Isolation RF Switch in SiGe BiCMOS Technology

9:20

A.S. Cardoso, P.S. Chakraborty, N.E. Lourenco, P. Song, R. Arora, T.D. England, E.W. Kenyon, J.D. Cressler

Georgia Institute of Technology

The effects of 63 MeV proton irradiation on the RF performance of nFET based RF switches designed in a 130nm SiGe BiCMOS technology are investigated. The switches were designed for wide-band operation (1 to 40 Ghz).

F-3 Modeling charge loss in DNW CMOS MAPS exposed to non-ionizing radiation

9:35

L. Ratti^{1,3}, L. Gaioni³, G. Traversi^{2,3}, S. Zucca^{1,3}, S. Bettarini^{3,4}, F. Morsani³, G. Rizzo^{4,3}, L. Bosisio^{5,3}, I. Rashevskaya^{5,3}

¹Univ. degli Studi di Pavia, ² Univ. degli Studi di Bergamo, ³ Istituto Nazionale di Fisica Nucleare, ⁴ Univ. degli Studi di Pisa, ⁵ Univ. degli Studi di Trieste

A simple model, based on pure minority carrier diffusion and random walk mechanisms, is proposed to predict the effects of neutron irradiation on the charge collection properties of deep N-well CMOS monolithic active pixel sensors.

F-4 Improving the Protons Radiation-Robustness of Integrated Circuits By Using The Diamond Layout Style
9:50

S. Pinillos Gimenez, D. Manha Alati, M. Aparecida Guazelli da Silveira, L.E. Seixas Junior, W. Romeiro de Mello, N. Added, N. Medina, M. Harri Tabacniks

FEI University Center and University of Sao Paulo

This paper studies the innovative and promising Diamond layout style to implement MOSFETs in order to improve the protons radiation-tolerance of the integrated circuits for space applications.

10:05 **BREAK**

Session F – Radiation Effects in Devices & ICs (part II)

F-5 Impact of SOI Substrate on the Radiation Response of Ultra-Thin Transistors towards the 20 nm node
10:35

M. Gaillardin¹, M. Martinez¹, P. Paillet¹, F. Andrieu¹, S. Girard¹, M. Raine¹, C. Marcandella¹, O. Duhamel¹, N. Richard², O. Faynot²

¹ CEA DAM, ² CEA LETI

This paper investigates the TID response of ultra-thin body FDSOI transistors designed for the 20 nm node. Various SOI substrate options are studied including ultra-thin BOX substrates.

F-6 Investigations on the Vulnerability of Advanced CMOS Technologies to MGy Dose Environments
10:50

M. Gaillardin¹, S. Girard¹, P. Paillet¹, J.L. Leray², V. Goiffon³, P. Magnan³

¹ CEA DAM, ² CEA Saclay/CabHC, ³ University of Toulouse - ISAE

The TID response of advanced CMOS technologies is investigated up to few MGy. Bulk silicon, Fully depleted SOI and FinFET technologies are studied to get insights on their behaviour in Mgy dose environments.

F-7 Total Dose Effects in Aligned Carbon Nanotube Transistors with Al₂O₃ Gate Dielectrics
11:05

J.R. Ahlbin¹, I.S. Esqueda¹, C.D. Cress², P.J. McMarr², H.L. Hughes², Y. Fu¹, J. Zhang¹, C. Wang¹, C. Zhou¹, M. Bajura¹, G. Boverman¹, M. Fritze¹

¹ University of Southern California, Information Sciences Institute, ² NRL

Gamma ray irradiation of aligned single-walled carbon nanotube (SWCNT) field effect transistors (FETs) were fabricated with an Al₂O₃ dielectric. Results show minimal shifting in the transfer curves for total ionizing dose (TID) up-to 1 Mrad(Si).

F-8 New Testing Methodology of an Analog to Digital Converter for the LHC mixed radiation field
11:20

*S. Danzeca*¹, *L. Dusseau*², *P. Peronnard*¹, *G. Spiezia*¹

¹ CERN, ² University of Montpellier - IES

A new methodology for Analog to Digital Converter testing is proposed in mixed radiation field, such as the LHC. Different radiation environments are used to characterize the device under test for SEU, SEL and TID.

Session F – Poster papers

PF-1 Heavy-Ion Induced Single Event Latch-up in 90nm Inverter CMOS Technology

D. Truyen, E. Leduc, F. Braud
ATMEL

Heavy-ion induced SEL effect in a 90nm CMOS technology is investigated with respect to nMOS, pMOS spacing (SAC), low epilayer thickness, and triple Well implant. TCAD simulations show a good efficiency of these techniques against SEL failures.

PF-2 An Investigation of Total Ionizing Dose Damage on a Pulse Generator Intended for Space-Based Impulse Radio UWB Transceivers

F. Inanlou, Eleazar W. Kenyon, J.D. Cressler
Georgia Institute of Technology

We investigate, for the first time, the effects of total ionizing dose (TID) on a CMOS pulse generator implemented in a SiGe BiCMOS platform which is intended for use in space-based impulse radio ultra-wideband transceivers.

PF-3 Modeling of Single-Event Failures in Divider and PFD of PLL based on Jitter Analysis

S. Kim, A. Tsuchiya, H. Onodera
University of Kyoto

This paper discusses and models the single-event failures in digital sub-circuits, such as divider and phase-frequency detector (PFD), of phase-locked loop (PLL).

PF-4 Enhanced SRAM Noise-Susceptibility Method Based on Energy Analysis

X. Gili, S. Barcelo, S. Bota, J. Segura
University of Baleares Island

We study the latch stability by means of the cell internal energy. This study combined with particle hit simulation provides a method to analyze the latch response to transient events.

PF-5 On-line testing of semiconductor magnetic field sensors during their irradiation with neutrons and electrons up to high fluences

I. Bolshakova¹, V. Borysenko², V. Chekanov³, R. Konopleva³, O. Lyashenko², O. Makido¹, A. Moroz¹, Y. Petrusenko², F. Shurygin¹

¹ Lviv Polytechnic National University, ² Kharkov Institute of Physics & Technology, ³ Petersburg Nuclear Physics Institute

An instrumentation for on-line sensor measurement in reactor neutrons and accelerated electrons up to high fluencies has been created. The results of research into sensors stable under irradiation are discussed.

PF-6 Total Ionizing Dose Effects on Data Retention Capabilities of CMOS SRAMs

D. Nair, R. Gale, T. Karp
Texas Tech University

Data retention capabilities of CMOS SRAMs exposed to different ionizing dose are investigated. Pattern imprinting and room temperature annealing is recorded for devices with high total dose. A model describing this behavior is presented.

PF-7 The Development and Evaluation of a Radiation Hardened 64M SRAM for Space

N.F. Haddad, E. Chan, S. Doyle, T. Grembowski, C. Hill, A.T. Kelly, R.K. Lawrence, J.C. Rodgers, J.F. Ross
BAE Systems

A low-power 64M SRAM was developed and fabricated in a radiation hardened 90nm CMOS technology (RH90), using Hardened-by-Process (RHBP) and Design (RHBD) features. The device was evaluated in multiple radiation environments, and demonstrated compatibility with severe space applications.

PF-8 In-situ system level TID test of RadEx, a CubeSat class radiation experiment module

J. Hofman, R. Sharp
Synergy Health

The work presents the design and TID test of a radiation experiment module to be launched in 2013 on board a CubeSat. In-orbit measurements of the TID induced degradation of mixed-signal circuits to be performed.

PF-9 Dynamic Mode Test of a Commercial 4Mb Toggle MRAM under Neutron Radiation

G. Tsiligiannis¹, L. Dilillo¹, A. Bosio¹, P. Girard¹, A. Todri¹, A. Virazel², A.D. Touboul², F. Wrobel², F. Saigné²

¹ University of Montpellier – LIRMM, ² University of Montpellier - IES

In this paper, we evaluate the soft error resilience of a commercial toggle MRAM in dynamic test mode besides the standard static mode test, under neutron radiation with energies of 25, 50 and 80 MeV.

PF-10 Radiation Effects in CMOS Isolation Oxides: Differences and Similarities with Thermal Oxides

M. Gaillardin¹, V. Goiffon², C. Marcandella¹, S. Girard³, M. Martinez¹, P. Paillet¹, P. Magnan², M. Estribeau²

¹CEA DAM, ²ISAE University of Toulouse, ³CEA Saclay/CabHC

TID effects are investigated on deposited oxides including PMD and STI. Their behaviors under ionizing radiation strongly differ from the one of thermal oxides. They notably show interface traps annealing at low temperature (below 100°C).

PF-11 90nm TID and Aging Characterization of Functional Circuits

P. Milliken, V. Olariu, R. Ciccariello, T. Farris
Aeroflex

TID and aging effects NBIT characterization on discrete transistors and functional circuits, on a 90nm commercial process, will be reviewed. A combined transistor model for degradation effects was extracted and verified using functional circuits.

11:35 INVITED TALK: Plasma and Radiation Environments of Giant Planets and Their Moons

I. Jun, Jet Propulsion Laboratory

The talk will provide a brief overview of discussion on our current understanding of giant planet environments (Jupiter, Saturn, Uranus, Neptune and their moons), more focus on Jupiter. A special attention will be given to lessons-learned from ground-based and space-based (Pioneer, Voyager, Galileo, Cassini, and New Horizon) observations, as well as to the preparation of current/future missions (Juno - launched in August 2011, JUICE). Recent measurements, theory development, and modeling efforts on the plasma and radiation environments at giant planets and their moons will be presented.

12:35 LUNCH

Session G – SEE Transient Characterization

14:20 Session Introduction

Chairs: F. Bezerra¹ and F. Miller²

¹ CNES, ² EADS

G-1 Angular Dependence of Double-Pulse-Single-Event Transients in Bulk CMOS

J.R. Ahlbin¹, N. Atkinson², M.J. Gadlage³, D.R. Ball⁴, B.L. Bhuvu², L.W. Massengill⁴

¹ University of Southern California – ISI, ² Vanderbilt University, ³ NAVSEA Crane, ⁴ Vanderbilt University – ISDE

Double-pulse-single-event transients (DPSETs) are observed at multiple angles during heavy-ion testing. As the angle of incidence increases, the cross-section of DPSETs increases, validating that DPSETs are generated by charge sharing among multiple inverters.

G-2 Impact of NBTI-Induced Pulse-Width Modulation on SET Pulse-Width Measurement
14:40

R. Harada¹, Y. Mitsuyama², M. Hashimoto¹, T. Onoye¹

¹ Osaka University, ² Kochi University of Technology

This paper presents a mechanism of NBTI-induced SET pulse-width modulation, and shows that pulse-width modulation depends on dynamic stress condition before pulse propagation. We reveal that SET-originating SER assuming static stress is pessimistic.

G-3 Negative Bias Temperature Instability Effect on the Single Event Transient Sensitivity of a 65nm CMOS Technology
14:55

I. El Moukhtari¹, V. Pouget¹, F. Darracq¹, C. Larue¹, P. Perdu², D. Lewis¹

¹ University of Bordeaux - IMS, ² CNES

Impact of NBTI degradation on the SET sensitivity of 65nm CMOS test structures is investigated. Pre- and post-aging SET laser thresholds measurements on chains of gates indicate a change of SET sensitivity due to NBTI.

G-4 SET Characterization of two 90-nm Voltage Controlled Delay Line Topologies
15:10

P. Maillard¹, L.W. Massengill¹, W.T. Holman¹, T.D. Loveless¹, Y. Chen¹, N. Roche², J. Warner², S. Buchner², D. McMorrow²

¹ Vanderbilt University, ² NRL

The SET sensitivity of two 90 nm VCDLs, have been characterized using the TPA laser. For both circuits, duty cycle errors were found to increase with operating frequency, but missing output pulses were not observed.

Session G – Poster papers

PG-1 SEE Under Laser Radiation with Different Pulse Durations and Wavelengths

A.I. Chumakov², D.V. Savchenkov¹, A.A. Pechenkin², A.L. Vasil'ev², A.O. Akhmetov¹, A.N. Egorov², O.B. Mavritskiy², A.S. Tararaksin¹, A.V. Yanenko²

¹ Engineering Physics Institute, ² Specialized Electronic Systems

The results are presented of experiment-calculated modeling of radiation-induced Single Event Upsets and Single Event Latchups under different laser radiation parameters (pulse duration and wavelength).

PG-2 Supply Voltage Dependent On-chip Single Event Transient Pulse Shape Measurements in 90 nm Bulk CMOS under Alpha Irradiation

M. Hofbauer¹, K. Schweiger¹, H. Zimmermann¹, U. Giesen², F. Langner², U. Schmid¹, A. Steininger¹

¹ Vienna University of Technology, ² Physikalisch-Technische Bundesanstalt

Pulse shape measurements of single event transients (SETs) in a single inverter in 90 nm bulk CMOS using an on-chip sense amplifier were performed with an 8 MeV alpha-particle microbeam. Supply voltage dependence of SETs was investigated.

PG-3 Heavy ion induced anomalous charge collection from 4H-SiC Schottky Barrier Diodes

T. Makino¹, M. Deki^{1,2}, N. Iwamoto¹, S. Onoda¹, T. Hirao¹, N. Hoshino³, H. Tsuchida³, T. Ohshima¹

¹ JAEA, ² University of Tokushima, ³ Central Research Institute of Electric Power Industry

Heavy-ion induced anomalous charge collection was observed from 4H-SiC Schottky Barrier Diodes. It was suggested that a range of incident ion in the epi-layer of SBDs is a key of the anomalous charge collection mechanism.

PG-4 On the Fidelity of Heavy-Ion Irradiation Test Facilities for Accelerated Single Events Tests

L.D. Tekumala¹, S. Jagannathan¹, B.L. Bhuvu¹, T.D. Loveless¹, M. King¹, R. Reed¹, R. Weller¹, B.D. Sierawski¹, L.W. Massengill¹, S.J. Wen², R. Wong²

¹ Vanderbilt University, ² Cisco Systems

Multiple flip-flops were fabricated in 40 nm bulk CMOS technology and tested at various heavy-ion facilities of different ion-energy and species but similar LETs.

PG-5 Proton-Induced Transients in GaAs and InAlSb/InAs-based FETs

J.H. Warner¹, D. McMorrow¹, S. Buchner¹, J. Brad Boos¹, N. Roche¹, P. Paillet², M. Gaillardin²

¹ NRL, ² CEA DIF

The single-event transient response of two different III–V field-effect transistor technologies (GaAs MESFET, InAlSb/InAs HEMT) is measured for MeV proton irradiation. The InAlSb/InAs HEMTs measurements reveal at least an order of magnitude lower SET susceptibility, smaller.

PG-6 Combinational Logic Soft Error Analysis Methodology Considering Re-convergence with Multi Transient Pulses

B. Zhou, J. Zhang, M. Huo, T. Wang

Harbin Institute of Technology

A combinational logic soft error analysis methodology considering re-convergence with multi transient pulses is proposed. Experiment results show that our proposed soft error analysis method can get more precise results in shorter runtime.

PG-7L Semi-empirical model for SEGR prediction

A. Javanainen¹, V. Ferlet-Cavrois², H. Kettunen¹, M. Muschitiello², F. Pintacuda³, M. Rossi¹, J.R. Schwank⁴, M.R. Shaneyfelt⁴, A. Virtanen¹

¹ University of Jyväskylä, ² ESA-ESTEC, ³ STMicroelectronics, ⁴ Sandia National Labs

The underlying physical mechanisms in Single Event Gate Rupture (SEGR) are not known precisely. This work introduces a semi-empirical model for SEGR prediction based on statistical variations in the energy deposition.

PG-8L Peak Detector Effect in Low-Dropout Regulators

C. Palomar¹, F.J. Franco¹, I. López-Calle^{1, 2}, J.G. Izquierdo¹, J. A. Agapito¹

¹ Complutense University of Madrid, ² ESA

In this paper, lossy peak detector effect is generalized to explain the appearance of long duration pulses in a typical low dropout voltage regulator built with discrete devices.

Session H – SEE Devices and Integrated Circuits

15:25 Session Introduction

Chairs: F. Kastensmidt¹ and D. Alexandrescu²

¹ Federal University of Rio Grande do Sul, ² IROC

H-1 Single and Multiple Cell Upsets in 25-nm NAND Flash Memories

M. Bagatin^{1, 2}, S. Gerardin¹, A. Paccagnella^{1, 2}, V. Ferlet-Cavrois³

¹ University of Padova, ² Istituto Nazionale di Fisica Nucleare, ³ ESA-ESTEC

We analyze FG upsets in 25-nm MLC Flash memories. Compared to previous generations, these devices show no apparent error dependence on the program level, adherence to the cosine law, and a large number of MCUs.

- H-2 Flight Experience of the Xilinx Virtex-4**
15:45 *H. Quinn, P. Graham, K. Morgan, Z. Baker, M. Caffrey, D. Smith, R. Bell, M. Wirthlin*
Los Alamos National Laboratory

This abstract provides information regarding the use of the Xilinx Virtex-4 Field Programmable Gate Array in a spacecraft deployed to low-earth orbit. The results are compared to pre-deployment prediction analysis.

- H-3 SETA: A New Analytical Tool for Single Event Transient Analysis on Flash-based FPGAs**
16:00 *L. Sterpone¹, V. Ferlet Cavois², D. Merodio Codinachs², C. Poivey²*
¹ Politecnico di Torino, ² ESA-ESTEC

We present a new analytical tool able to analyze the propagation and the impact of SETs on Flash-based FPGA devices. Experimental results performed on six complex benchmark circuits demonstrate the effectiveness of the proposed method.

- H-4 An Experimental Technique to Calculate the Temporal Masking Factor**
16:15 *N.N. Mahatme¹, S. Jagannathan¹, T. Assis¹, T.D. Loveless¹, B.L. Bhuva¹, L.W. Massengill¹, S.J. Wen², R. Wong²*
¹ Vanderbilt University, ² CISCO Systems

Experimental results are presented from 40 nm bulk CMOS technology for two different circuits to estimate the temporal masking factors (TMF). Estimating TMF allows predictions to be made about the single-event transient pulses.

- H-5 Characterizing the Effects of Single Event Upsets on Synchronous Data Paths**
16:30 *M. Berg, M. Friendlich, H. Kim, C. Seidlick, K. LaBel, R. Ladbury, J. Pellish*
NASA GSFC

We present a Single Event Upset (SEU) model with supporting data demonstrating frequency effects that deviate from conventional theory. The model emphasizes design topology versus circuit-element contributions to SEU cross sections.

Session H – Poster papers

- PH-1 Efficiency evaluation of the Soft-Errors Analysis techniques in complex ICs**
N. Guibbaud, F. Miller, A. Bougerol, N. Buard
EADS Innovation Works

In this paper, we propose a comparison of the methodologies commonly used to estimate the fault tolerance of complex integrated circuits towards radiation effects.

PH-2 Stability Evaluation of Insulated Gate AlGaIn/GaN Power Switching Devices under Heavy Ion Irradiation

S. Stoffels¹, M. Melotte², M. Haussy², R. Venegas¹, D. Marcon¹,
M. Van Hove¹ and S. Decoutere¹

¹ IMEC, ² THALES Alenia Space

Stability testing of a high voltage GaN technology with an insulated gate under high energetic heavy ion irradiation. Degradation analysis was done by means of statistical distribution functions.

PH-3 Heavy-Ion and Proton Sensitivity Measurements of a Commercial DC/DC Pulse Width Modulator

Y. Ren¹, A.L. He², S.T. Shi², G. Guo², L. Chen¹, S.J. Wen³,
R. Wong³, N. Van Vonno⁴, B.L. Bhuvu⁵

¹ University of Saskatchewan, ² Institute of Atomic Energy, ³ Cisco Systems, ⁴ Intersil, ⁵ Vanderbilt University

This paper discussed the heavy-ion and proton sensitivity measurements of a commercial DC/DC Pulse Width Modulator (PWM) based on a 600-nm Bi-CMOS technology.

PH-4 Reliability Models for SEC/DED Memory with Scrubbing in FPGA-based Designs

Y. Li, B. Nelson, M. Wirthlin

Brigham Young University

This paper presents two MTTF models for SEC/DED memory with scrubbing. The first one considers non-uniform write rates for probabilistic write scrubbing. The second model combines deterministic scrubbing and probabilistic scrubbing into a single model.

PH-5 Single-Event-Induced Charge Sharing Effects in TMR with Different Levels of Granularity

F. Almeida¹, F. Lima Kastensmidt¹, S. Pagliarini¹, L. Entrena²,
A. Lindoso², E. San Millan², E. Chielli¹, L. Naviner³, J.F. Naviner³

¹ University of Rio Grande do Sul, ² University Carlos III of Madrid, ³ TELECOM-ParisTech

The effects of single-event-induced charge sharing are investigated in various TMR schemes with different levels of granularities. Schemes are evaluated under various scenarios of multiple upsets. Results show the best TMR granularity in terms SER.

PH-6 An automated SEU fault-injection method and tool for HDL-based designs

W. Mansour, R. Velazco

CNRS TIMA Labs

A new fully automated SEU fault-injection method is explored. Error rates issued from its application to an 8051 microcontroller were in good agreement with radiation ground testing putting in evidence the accuracy of the studied.

PH-7L Experimental Assessment of Cache Memory Soft Error Rate Prediction Technique

S. Houssany¹, N. Guibbaud¹, A. Bougerol¹, R. Leveugle², F. Miller¹

¹ EADS, ² TIMA Labs

We explain the validation of a SER prediction technique for microprocessors with accelerated test experiments. We present the fault detection system used to detect errors in cache memories and to link them with application failures.

PH-8L Experimental Evaluation of an Efficient Error Detection Technique for FPGAs

G.L. Nazar¹, P. Rech¹, C. Frost², and L. Carro¹

¹ Federal University of Rio Grande do Sul, ² ISIS Rutherford Appleton Labs

We present a fine-grained hardening approach that exploits underused resources to detect radiation-induced errors on SRAM-based FPGAs configuration memories. Neutron experiments demonstrate the proposed technique efficiency when compared to the traditional dual modular redundancy.

PH-9L Neutron-induced Single Event Upset in Mixed-Signal Flash-based FPGA

L.A. Tambara¹, F.L. Kastensmidt¹, M.S. Lubaszewski¹, T.R. Balen¹, P. Rech¹, C. Frost²

¹ Federal University of Rio Grande do Sul, ² ISIS Rutherford Appleton Labs

This paper describes neutron-induced Single Event Upset (SEU) in a commercial Mixed-Signal Programmable System-on-Chip (SoC) FPGA from Microsemi. The goal is to examine the digital and analog parts reliability for critical application projects.

16:45 *BREAK*

18:30 *DEPARTURE BY BUS TO RADECS RECEPTION (ARCANGUES)*

Technical Program - Friday

Session I – Hardening by Design

9:00 **Session Introduction**

Chairs: L. Entrena¹ and D. Hansen²

¹ University Carlos III of Madrid, ² Maxwell

I-1 **A 65 nm Low-Power Adaptive-Coupling Redundant Flip-Flops**
9:05

*M. Masuda¹, K. Kubota¹, R. Yamamoto¹, J. Furuta²,
K. Kobayashi^{1,3}, H. Onodera^{2,3}*

¹ Kyoto Institute of Technology, ² Kyoto University, ³ JST, CREST

We propose a low-power redundant flip-flop based on the low-power ACFF and the highly-reliable BCDMR. Alpha-particle and neutron irradiations reveal its highly-reliable operation without any error at 1GHz.

I-2 **A hybrid technique for soft error mitigation in interrupt-driven applications**
9:20

A. Martínez-Álvarez¹, F. Restrepo-Calle², S. Cuenca-Asensi¹, L. M. Reineri³, A. Lindoso⁴, L. Entrena⁴

¹ University of Alicante, ² University of Seville, ³ Politecnico di Torino, ⁴ University Carlos III of Madrid

We propose a new technique aimed to protect system configuration registers against soft-errors. It is based on low level automatic refreshing which takes advantage of usual COTS microcontroller resources.

I-3 **Using Configurable Temporal Filtering to Reduce Soft Error Rate**
9:35

*J.E. Souza¹, F. Almeida¹, E. Chielle¹, T. Dejoinville², S. Breard²,
F. Lima Kastensmidt¹*

¹ Federal University of Rio Grande do Sul, ² ENSICAEN

This paper proposed and evaluated the use of propagation delay variances among multiple logic paths for soft error rate reduction in integrated circuit by using of D-type Master Slave Flip-flop hardened against SET and SEU.

I-4 9:50 RHBD Technique for Single-Event Charge Cancellation in Folded-Cascode Amplifiers

N.M. Atkinson¹, R.W. Blaine¹, J.S. Kauppila¹, S.E. Armstrong², T.D. Loveless¹, N.C. Hooten¹, W.T. Holman¹, L.W. Massengill¹, J. Warner³

¹ Vanderbilt University, ² NAVSEA Crane, ³ NRL

A novel RHBD technique is implemented in the single-ended output stage of a folded-cascode operational amplifier to mitigate voltage transients due to single events. The efficacy of the technique is demonstrated via two-photon laser experiments.

Session I – Poster papers

PI-1 Investigation of SRAM FPGA based Hamming FSM encoding in beam test

J. Gebelein, U. Kebschull
Frankfurt University

This paper presents beam test results of Hamming-based FSMs encoded with a minimum distance of three combined with blind configuration scrubbing on a Xilinx SRAM-based FPGA. The overall number of system failures strongly decreases.

PI-2 Optimizing the Protection of Narrow Values in Memories Protected with Hamming Code

J. Antonio Maestro¹, A. Sánchez-Macián¹, P. Reviriego¹, S. Baeg²

¹ Universidad Antonio de Nebrija, ² School of Electrical Engineering and Computer Science, Hanyang University

A method to increase the reliability of narrow values in a memory that is protected with a Hamming code is proposed and evaluated showing that protection is significantly increased. The technique is completely implemented in software.

PI-3 Fault-tolerant SOI Microprocessor for Space Applications

P.N. Osipenko¹, A.A. Antonov¹, A.V. Klishin¹, B.V. Vasilegin¹, M.S. Gorbunov¹, G.I. Zebrev², V.S. Anashin³, V.V. Emel'yanov⁴, A.I. Ozerov⁴, A.I. Chumakov⁵, A.V. Yanenko⁵, A.L. Vasiliev⁵

¹ Scientific Research Institute of System Analysis, Russian Academy of Sciences, ² Moscow Engineering Physics Institute, ³ JSC Institute of Space Device Engineering, ⁴ Research Institute of Scientific Instruments, ⁵ SPELS

Various radiation hardening by design (RHBD) methods are implemented to develop the fault-tolerant microprocessor manufactured on 0.35 μm Silicon-on-Insulator (SOI) CMOS technology. These methods and the results of hardness assurance campaign are presented.

PI-4 Evaluating Selective Redundancy in Data-flow Software-based Techniques

E. Chielle, J. Rodrigo Azambuja, R. Sérgio Barth, F. Almeida, F. Lima Kastensmidt

Federal University of Rio Grande do Sul

This paper presents an analysis of using selective redundancy applied to software-based techniques aimed at detecting data-flow errors. The results can help designers in finding the best set of registers, based in performance and memory occupation constraints.

PI-5 Determining the Efficacy of Selective Node Hardening Techniques using Standard Cells

D.B. Limbrick, N.N. Mahatme, W.H. Robinson

Vanderbilt University

This study uses standard cells to selectively harden vulnerable nodes in combinational logic. Results indicate that replacing two-input gates with four-input equivalents reduces pulse widths by 5-20% with less than 1% power overhead.

PI-6L Single Event Performance and Layout Optimization of High Performance Flip-Flops in 28nm Bulk Technology

K. Lilja¹, M. Bounasser¹, S. Wen², R. Wong², J. Holst², N.J. Gaspard³, S. Jagannathan³, D. Loveless³, B.L. Bhuv³

¹ Robust Chip Inc., ² Cisco Systems, ³ Vanderbilt University

This paper presents alpha, neutron, and heavy-ion single event measurements, simulations, and layout optimization results, for high performance flip-flops designs in a 28nm bulk technology.

PI-7L Towards the Mitigation of Multiple Faults Induced by Single Event Effects: Combining Global TMR and Selective Hardening

S.N. Pagliarini, L.A. Naviner, J.F. Naviner

Telecom ParisTech

Circuits are susceptible to multiple faults induced by a single particle strike. we propose a circuit-level hardening methodology that is able to properly mitigate multiple faults in a cost-aware manner.

PI-8L Smart power ASIC Latch-up hardening combining design and test techniques

J. Ricart¹, D. Gonzalez¹, R. Cabas¹, L. de la Fuente², D. Peña², F. Gutiérrez¹

¹ ARQUIMEA, ² EADS

The paper describes how design and test techniques have been combined to get a Latch-up free Smart Power analog ASIC to support the radiation hardening of the digital I/O of a commercial technology.

10:05 **BREAK**

Session J – Radiation Hardness Assurance

10:35 **Session Introduction**

Chairs: S. McClure¹ and R. Marec²

¹ JPL, ² THALES Alenia Space

**J-1 Investigation of 14 MeV Neutron capabilities for SEE
10:40 Radiation Hardness Evaluation**

*F. Miller¹, C. Weulersse², N. Guibbaud¹, S. Morand¹, R. Gaillard³,
T. Carrière⁴*

¹ EADS Suresnes, ² EADS Toulouse, ³ RG Consulting,
⁴ ASTRIUM ST

This work investigates the capabilities of 14 MeV neutron tests to characterize the radiation sensitivity of electronic devices. Analysis of secondary ions, experimental tests and coupling with prediction codes are performed to support the work.

**J-2 Experimental Evaluation of Software Hardening Techniques
10:55 for GPUs**

P. Rech¹, C. Aguiar¹, C. Frost², L. Carro¹

¹ Federal University of Rio Grande do Sul, ² Rutherford Appleton Laboratories

Neutrons generate multiple output errors in modern GPUs. The available hardening strategies may then result ineffective. We developed an optimized and experimentally tuned software hardening strategy for GPUs and evaluate its performance and correcting capability.

**J-3 A Thermal Annealing Approach to Extend Metal Oxide
11:10 Semiconductor Devices Lifetime Exposed to Very High Dose Levels**

*F. Roig^{1,2}, L. Dusseau¹, J. Boch¹, F. Saigné¹, J.R. Vaillé¹,
A. Touboul¹, P.C. Adell³, E. Lorfèvre⁴, R. Ecoffet⁴*

¹ University of Montpellier – IES, ² CEA, ³ JPL, ⁴ CNES

A new thermal annealing approach that helps extend MOS devices lifetime exposed to very high dose levels is investigated. Several isothermal annealing cycles are used to regenerate devices during a mission. Used parameters are determined.

J-4 HETA: Hybrid Error-detection Technique through Assertions

11:25 *J. Rodrigo Azambuja^{1,2}, M. Altieri¹, F. Lima Kastensmidt¹,
J. Becker²*

¹ Federal University of Rio Grande do Sul, ² Karlsruhe Institute of Technology

This paper introduces a non-intrusive hybrid technique to detect control-flow errors in microprocessors. HEDA's implementation combines an enhanced watchdog module with software assertions. A fault injection campaign shows full error detection with small performance degradation.

Session J – Poster papers

PJ-1 TID Hardened SRAMs by Extra Shallow Trench Isolation (STI) Sidewall Doping with Different Implant Particles

L. Liu, Y. Zhao, S. Yue, J. Cheng Li
Beijing Microelectronics Technology Institute

TID hardened SRAMs, formed by adding extra STI sidewall implant to standard process with different implant particles, are discussed. Experiment results indicate Boron sidewall implant STI can effectively suppress radiation_induced leakage current of 512Kbits SRAM.

PJ-2 Instrument Level Design for Radiation Hardness Assurance in The Two Towers Radiation Monitor

J. Martínez-Oter, V. Apéstigue, C. Fernández, J. Rivas, I. Traseira, J.A. Domínguez, B. Martín, I. Arruego
INTA

The electrical architecture of a complex radiation monitor is presented. It mixes Space-level parts, COTS, and different hardening techniques, to provide high reliability and Radiation Hardness Assurance levels while offering huge performance.

PJ-3 SEU Sensitivity Comparison for Different Reconfigurable Technologies with Minority Check Block

A. Vaskova, C. López-Ongil, M. Portela-García, M. García-Valderas, L. Entrena
University Carlos III of Madrid

A method, based in minority calculation, is proposed for obtaining comparable measurements of the SEU sensitivity in commercial reconfigurable devices that present different characteristics like internal architecture, technology or amount of available resources.

PJ-4 SEU Effects on Programmable Interconnections of SRAM-based FPGAs: a Preliminary Analysis

M. Alderighi, F. Casini, S. D'Angelo, A. Gravina, V. Liberali, M. Mancini, P. Musazzi, S. Pastore, M. Sassi, G. Sorrenti
IASF – INAF

A probabilistic model of occurrences of SEU effects in programmable interconnection points of SRAM-based FPGAs is described. The application of the proposed approach to a set of sample designs is illustrated.

PJ-5L NESSY: An Implementation of a Low-cost Fault-injection Platform on a Virtex-5 FPGA

V. Alaminos, F. Serrano, J. Antonio Clemente, H. Mecha
Complutense University of Madrid

In this article we propose a fault-injection platform that evaluates the impact of a bitflip in the configuration memory of a Virtex-5 FPGA. We have tested it using two representative real-world applications.

PJ-6L A 4.5 MGy TID-Tolerant CMOS Bandgap Reference Circuit Using a Dynamic Base Leakage Compensation Technique

Y. Cao^{1, 2}, W. De Cock², M. Steyaert³, P. Leroux^{1, 3}

¹ESAT-MICAS, ² SCK-CEN, ³ ICT-RELIC

A dynamic base leakage compensation technique is proposed to improve the radiation hardness of the CMOS bandgap reference. A TC of 15ppm/C is measured from -40 to 125C, and it has TID tolerance up to 5MGy.

11:40 **Closing remarks**