Technical Program

TECHNICAL INFORMATION

"The Technical Program Committee had its hands full with the large number of summary submissions. This enthusiastic response is indicative of strong support by the worldwide radiation effects community. I am confident you will find this a useful conference and look forward to meeting you in Tucson."

Nick van Vonno, Consultant/Intersil
Technical Program Chairman

The Nuclear and Space Radiation Effects Conference technical program will consist of contributed oral and poster papers, three invited papers and the Data Workshop. All oral papers will be 12 minutes in length with an additional 3 minutes for questions and answers. The technical sessions and chairpersons are:

- **Single-Event Effects: Mechanisms and Modeling**
  Chair: Dale McMorrow, Naval Research Laboratory, Washington, DC
- **Basic Mechanisms of Radiation Effects**
  Chair: Robert Weller, Vanderbilt University, Nashville, TN
- **Hardness Assurance**
  Chair: Andrew Chugg, MBDA UK Ltd., Bristol, United Kingdom
- **Space and Terrestrial Environments**
  Chair: Janet Barth, NASA/GSFC, Greenbelt, MD
- **Radiation Effects in Devices and Integrated Circuits**
  Chair: Ray Ladbury, NASA/GSFC, Greenbelt, MD
- **Single-Event Effect; Devices and Integrated Circuits**
  Chair: Philippe Paillet, CEA/DIF, Bruyères-le-Chatel, France
- **Dosimetry and Facilities**
  Chair: Henry Clark, Texas A&M University, College Station, TX
- **Hardening By Design**
  Chair: Nathan Nowlin, Sandia National Laboratories, Albuquerque, NM
- **Photonic Devices and Integrated Circuits**
  Chair: Scott Messenger, Naval Research Laboratory, Washington, DC

POSTER SESSION

Papers that are more effectively presented visually with group discussion will be displayed in the Poster Session Tuesday afternoon through Friday morning in the Arizona Ballrooms 1 – 5. The formal Poster Session will run from 2:30 – 4:30 PM, Wednesday, and authors will be available to discuss their work. The Poster Session chair is Jeff Titus of NAVSEA/Crane, Crane, IN.

RADIATION EFFECTS DATA WORKSHOP

Papers in the Workshop are intended to provide radiation response data to scientists and engineers who use electronic and photonic devices and circuits in a radiation environment and to designers of radiation-hardened systems. Workshop posters can be viewed Tuesday afternoon through Friday morning in the Arizona Ballrooms 8 – 12. Authors will be available to discuss their work during the formal Data Workshop session, 2:30 – 4:30 PM, Thursday, in the Arizona Ballrooms 8 – 12. A copy of the Data Workshop Record will be mailed to all registered attendees after the Conference. The Data Workshop chair is Jim Felix of Sandia National Laboratories, Albuquerque, NM.

INVITED SPEAKERS

James E. Turner, Community Outreach Historian for the Arizona Historical Society will present "The Francisco Vásquez de Coronado Expedition," Martin G. Tomasko of the University of Arizona and Principal Investigator for the Descent Imager/Spectral Radiometer (DISR) instrument on the Huygens entry probe will speak on "The Huygens Mission to Titan," and Ann Garrison Darrin, member of the Principal Professional Staff and Group Manager in the Research Center of the Johns Hopkins University Applied Physics Laboratory will be speaking on "Small Stuff in Space: From Micro and Nano Technologies to Space Debris."

LATE-NEWS PAPERS

A limited number of late news papers will be accepted and included in the Poster Session and the Radiation Effects Data Workshop. The deadline for submission is 1 June 2008. Detailed instructions for submitting a late-news summary to the Technical Program Committee are available on the NSREC Web site at **www.nsrec.com**.

ARIZONA BALLROOMS 6 – 7
8:30 AM

OPENING REMARKS
Paul Dodd, Sandia National Laboratories, General Chairman

8:35 AM

AWARDS PRESENTATION
Tim Oldham, NASA/GSFC, Radiation Effects Steering Group Chairman

9:05 AM

TECHNICAL SESSION OPENING REMARKS
Nick van Vonno, Consultant/Intersil, Technical Program Chairman

SESSION A
9:10 AM

SINGLE-EVENT EFFECTS: MECHANISMS AND MODELING
SESSION INTRODUCTION
Chair: Dale McMorrow, Naval Research Laboratory

A-1
9:15 AM

Investigation of the Propagation Induced Pulse Broadening (PIPB) Effect in Inverter Chains with Focused Pulsed Laser Irradiation
V. Ferlet-Cavrois, P. Paillet, J. Baggio, CEA/DIF; D. McMorrow, J. S. Melinger, NRL

Single event transients are measured in inverter chains. The PIPB effect is analyzed with pulsed laser irradiation and with electrical measurements. The PIPB is induced by floating body charging in both NMOS and PMOS transistors.

A-2
9:30 AM

Generation and Propagation of Single Event Transients in 0.18 um Fully Depleted SOI
Pascale Gouker, Jim Brandt, Peter Wyatt, Brian Tyrrell, Tony Soares, Jeff Knecht, Craig Keast, MIT Lincoln Laboratory; Dale McMorrow, Naval Research Laboratory; Balaji Narasimham, Matthew Gadlage, Barat Bhuva, Vanderbilt University

Single event transients were characterized experimentally in fast logic circuits fabricated in 0.18 um FDSOI CMOS process using laser-probing techniques. We show that the transient pulse widens as it propagates; the widening is eliminated by the body contact.

A-3
9:45 AM

Single-Event Transient Pulse Propagation in Digital CMOS
Lloyd W. Massengill, Vanderbilt University

Propagation characteristics of SET pulses in CMOS logic are derived via closed-form circuit analysis. Recently-observed SET signatures and technology scaling effects are explained in terms of basic technology and circuit design parameters.

A-4
10:00 AM

Waveform Observation of Digital Single-Event Transients Employing Monitoring Transistor Technique
D. Kobayashi, K. Hirose, H. Ikeda, Institute of Space and Astronautical Science, JAXA and Graduate University for Advanced Studies; Y. Yanagawa, University of Tokyo; H. Saito, Institute of Space and Astronautical Science, JAXA and University of Tokyo; V. Ferlet-Cavrois, P. Paillet, CEA/DIF; D. McMorrow, Naval Research Laboratory; Y. Arai, KEK and Graduate University for Advanced Studies; M. Ohno, OKI Electric Industry

Digital single-event transients can be observed by adding two transistors to a target logic-gate. They work for monitoring voltage-transients through their drain-currents observed with the conventional technique for measuring radiation-induced transient-currents in dc-biased single transistors.

10:15 – 10:45 AM
TUCSON BALLROOM

BREAK

A-5
10:45 AM

Device-Orientation Effects on Multiple-Bit Upset in 65-nm SRAMs

Alan D. Tipton, Jonathan A. Pellish, John M. Hutson, Marcus Mendenhall, Robert A. Reed, Ronald D. Schrimpf, Robert A. Weller, Vanderbilt University; Robert Baumann, Xiaowei Deng, Andrew Marshall, Texas Instruments; Michael A. Xapsos, Ken LaBel, NASA/GSFC; Hak Kim, Mark Friendlich, Michael Campola, Christina Seidleck, MEI Technology Inc., NASA/GSFC

The effects of device orientation on heavy ion-induced multiple-bit upset (MBU) in 65 nm SRAMs are examined. For low LET ions, the cross section varies by two orders of magnitude with the orientation.

A-6
11:00 AM

Integrating Circuit Level Simulation and Monte-Carlo Radiation Transport Code for Single Event Upset Analysis in SEU Hardened Circuitry

Kevin M. Warren, Andrew Sternberg, ISDE Vanderbilt University; Robert Weller, Lloyd Massengill, Robert Reed, Ron Schrimpf, Vanderbilt University; Mark Baze, Boeing SSED

Monte-Carlo radiation transport code is coupled with circuit level simulation to identify regions of single event upset vulnerability in a SEU hardened flip-flop, as well as to predict single event upset cross sections under static and dynamic operating conditions.

A-7
11:15 AM

Modeling of Heavy Ion Induced Charge Loss Mechanisms in Nanocrystal Memory Cell

Andrea Cester, Nicola Wrachien, Università di Padova; J. Schwank, G. Vizkelethy, Sandia National Laboratories; R. Portoghese, C. Gerardi, ST Microelectronics

We present the first charge loss model on nonvolatile nanocrystal memories. It predicts the threshold voltage dependence on the ion hit number and position. It also provides an estimation of the ion hit track size.

A-8
11:30 AM

Vulnerable Trench Power MOSFETs Under Heavy Ion Irradiation

Sandra Liu, Max Zafrani, Huy Cao, Robert Berberian, Christopher DiCienzo, Milt Boden, International Rectifier

SEE test results show trench MOSFETs are very vulnerable to heavy ion irradiation. This paper explains that trench structure is responsible for its vulnerability and a new SEE failure mode of power MOSFET is identified.

A-9
11:45 AM

Direct Evidence of Secondary Events Induced by High Energy Protons

Giorgio Cellere, Alessandro Paccagnella, DEI, Università di Padova; Angelo Visconti, Silvia Beltrami, ST Microelectronics; Jim Schwank, Marty Shaneyfelt, Sandia National Laboratories; Philippe Paillet, Véronique Ferlet-Cavrois, Jacques Baggio, CEA/DIF; Ewart Blackmore, TRIUMF

35-500 MeV protons result in both TID effects and a few SEE events, deriving from single secondary particles generated by the high energy protons. We study and quantitatively model these effects using FG memories.

A-10 12:00 PM

SET Sensitive Volume Imaging and Measurement with Two-Photon Absorption Laser Testing

P. Jaulent, V. Pouget, P. Fouillat, IMS; D. McMorrow, NRL; F. Bezerra, CNES

The TPA laser technique is used for the first time to image in 3D and measure the SET sensitive volume of linear devices. Influence of experimental parameters and consequences for rate prediction accuracy are discussed.

POSTER PAPERS

PA-1

LET Dependence of Single Event Transient Pulse-Widths in SOI Logic Cell

Takahiro Makino, The Graduate University for Advanced Studies; Daisuke Kobayashi, Kazuyuki Hirose, The Graduate University for Advanced Studies, and Institute of Space and Astronautical Science; Yoshimitsu Yanagawa, University of Tokyo; Hirobumi Saito, Institute of Space and Astronautical Science, and University of Tokyo; Daisuke Takahashi, Shigeru Ishii, Masaki Kusano, Mitsubishi Heavy Industries, Ltd.; Shinobu Onoda, Toshio Hirao, Takeshi Ohshima, JAEA

SET pulse-widths were measured as a function of LET by using pulse capture circuits and were simulated with mixed-mode 3-D device simulations. We found that the carrier recombination process dominates LET dependence of SET pulse-widths.

PA-2

Examples of Soft-Error Characterization of CMOS Combinational Gate Libraries using 3D TCAD Mixed-Mode Simulations of an Equivalent Inverter

Damien Leroy, Renaud Perez, Hafnaoui Belhaddad, Remi Gaillard, iRoC Technologies; Michael Nicolaidis, IMAG; Francis Benistant, Chartered Semiconductor

We present the specificities of CMOS combinational gates response to heavy-ion strikes, correlating the characteristics of their induced current pulses with the 3D TCAD mixed-mode simulation results of an equivalent inverter.

PA-3

Temperature Dependence of Digital Single Event Transient

Liang Bin, Chen Shuming, Liu Biwei, Liu Zheng, Computer School of National University of Defense Technology (CHN)

Using 3-D mixed-mode simulation, temperature dependence of digital single event transient in an inverter chain has been studied. When temperature increases from -55 to 125° C, width of DSET increases about 58.8% at LET of 60 MeV-cm^2/mg.

PA-4

New SET Characterization Technique Utilizing SPICE for Fully Depleted CMOS/SOI Digital Circuitries

Akiko Makihara, Tsukasa Ebihara, Tamotsu Yokose, Yoshihisa Tsuchiya, Yukio Amano, HIREC; Hiroyuki Shindou, Satoshi Kuboyama, JAXA; Ryo Imagawa, Yoshihiro Takahashi, Kazunori Ohnishi, Nihon University

The new SET characterization technique for 0.15 μm Fully Depleted CMOS/SOI digital circuitries was investigated utilizing the SPICE and TCAD simulations. The SPICE simulation with the switch can easily reproduce the corresponding SET voltage response.

PA-5 **Single Event Transients in Logic Circuits - Evidence for Load Induced Pulse Broadening**

Gilson Wirth, Ivandro Ribeiro, Fernanda Lima Kastensmidt, UFRGS - Univ. Federal do Rio Grande do Sul

We investigate the dependence of the SET pulse width on the struck node capacitance. Rising node capacitance may lead to amplified pulse width. Hence, increasing load capacitance alone is not an option for radiation hardening.

PA-6 **Temperature Dependence of Spatially Resolved Picosecond Laser Induced Transients in a Deep Submicron CMOS Inverter**

Jamie S. Laird, Yuan Chen, Larry Edmonds, Tuan Vo, JPL

Spatially resolved picosecond laser induced transients have been measured in a 0.18 μm CMOS test structure as a function of temperature. Sensitive drain nodes have been scaled to allow optical probing with a picosecond laser. Collection by charge diffusion and its temperature dependence at high-injection levels is shown to dictate the transient current pulse shape.

PA-7 **Single Event Transient Response Dependence on Operating Conditions for a Digital to Analog Converter**

Kirby Kruckmeyer, James S. Prater, Bill Brown, National Semiconductor; Sandeepan DasGupta, Vanderbilt University

Unexpected dependence on operating conditions was seen during the single event transient characterization of a digital to analog converter. Models demonstrate why maximum operating voltage and certain input codes create worst case conditions.

PA-8 **Radiation-Induced Current Transients in SiGe HBTs**

Jonathan A. Pellish, Robert A. Reed, Nicholas D. Pate, John A. Kozub, Robert A. Weller, Ronald D. Schrimpf, Alan D. Tipton, Vanderbilt University; Dale McMorrow, Joseph S. Melinger, Naval Research Laboratory; Paul W. Marshall, Consultant; Akil K. Sutton, Ryan M. Diestelhorst, Stan Phillips, John D. Cressler, Georgia Institute of Technology; Guofu F. Niu, Auburn University

Device-level laser-induced current transients were captured directly using wideband transmission and measurement equipment. Implications for SiGe HBT high-speed serial data applications are discussed.

PA-9 **Characterizing SRAM Single Event Upset in Terms of Single and Double Node Charge Collection**

J. D. Black, D. R. Ball II, K. M. Warren, R. D. Schrimpf, R. A. Reed, D. M. Fleetwood, W. H. Robinson, A. D. Tipton, D. A. Black, Vanderbilt University; P. E. Dodd, Sandia National Laboratories; N. F. Haddad, BAE Systems

A new mode for SRAM SEU is proposed and demonstrated through TCAD modeling. The SRAM recovery is shown to be based on cell imbalance. Implications of this mode are discussed.

PA-10 A Comparison of Single-Event Mechanisms in Dual-Well and Triple-Well 90 nm CMOS Devices

Tania Roy, B. L. Bhuva, Sandeepan DasGupta, Vanderbilt University;
A. F. Witulski, M. L. Alles, L. W. Massengill, Vanderbilt University/ISDE

Single-event behaviors of triple-well and dual-well NMOS transistors are compared and the effect of well contacts on voltage pulse width quantified. Charge collection mechanisms are analyzed. P-well de-bias effects are significant in triple-well structures.

PA-11 Frequency Domain Analysis of Single Event Hardening Techniques for Analog-to-Digital Converters

Brian D. Olson, W. T. Holman, L. W. Massengill, B. L. Bhuva, Vanderbilt University

Frequency domain analysis of the single-event vulnerability of mixed-signal circuits is demonstrated on a pipelined ADC. Design tradeoffs of comparator redundancy are evaluated using a signal-to-noise ratio metric.

PA-12 Analysis of Single-Event Latchup Cross-Section in 65 nm SRAMs

J. M. Hutson, J. A. Pellish, A. D. Tipton, R.A. Reed, R. D. Schrimpf, R. A. Weller, L. W. Massengill, Vanderbilt University; G. Boselli, A. Marshall, X. Deng, R. Baumann, Texas Instruments; M. A. Xapsos, K. LaBel, NASA-GSFC; H. Kim, M. Friendlich, M. Campola, S. Seidleck, MEI Technology Inc., NASA-GSFC

Single event latchup (SEL) in a 65 nm CMOS SRAM technology is observed and explained using three-dimensional device simulations. A new technique for prediction of SEL cross-sections is described.

PA-13 The Role of Ion Range in SEGR in Vertical Power MOSFETs

Leif Scheick, Luis Selva, Larry Edmonds, Philippe Adell, JPL

Experimental data that show the contribution of ion range on single event gate rupture (SEGR) in power MOSFET are presented. The effect of ion range in both the epitaxial and substrate layers at the onset of SEGR is quantified.

PA-14 Upset Rates for Proton Test and Space Radiation Related through Energy Deposition Simulations

Charles C. Foster, Foster Consulting Services, LLC; Patrick M. O'Neill, Coy K. Kouba, Avionic Systems Division, NASA-Johnson Space Center

Simulated distributions of upset rates per energy deposition interval, determined from Weibull parameters, are very similar in shape for proton test and space radiation, which adds validity to proton screening of parts for space use.

PA-15 CODES a SEU Rate Prediction Tool

Ana Keating, LIP/ESA; Ali Mohammadzadeh, Reno Harboe-Sørensen, ESA; Pedro Brogueira, IST; Mario Pimenta, Patricia Gonçalves, Sara Valente, LIP

A framework for simulation of component SEU rate prediction is presented. New features include Geant4 particle transport, Sensitive Volume fit tool based on irradiation test data and possible interface with circuit properties.

12:15 – 1:30 PM LUNCH

SESSION B **BASIC MECHANISMS OF RADIATION EFFECTS**
1:30 PM SESSION INTRODUCTION
Chair: Robert Weller, Vanderbilt University

B-1 **Study of Latent Defects Induced by Swift Heavy Ion Irradiation on MOS Devices Gate Oxide**
1:35 PM
M. Marinoni, IES UMR UM2-CNRS and Université Nice-Sophia-Antipolis; A. D. Touboul, A. M. J. F. Carvalho, R. Arinero, F. Saigné, IES UMR UM2-CNRS; D. Zander, C. Petit, CReSTIC, UFR Sciences Exactes et Naturelles; M. Ramonda, LMCP, Université de Montpellier II; C. Weulersse, N. Buard, T. Carrière, EADS Company; E. Lorfèvre, CNES

From annealing experiments performed on both irradiated SiO_2-Si structures and MOS devices, swift heavy ions-induced morphological oxide defects are proposed to possibly act as latent defects.

B-2 **Radiation Effects on the 1/f Noise of Field Oxide Field Effect Transistors (FOXFETs)**
1:50 PM
X. J. Zhou, D. M. Fleetwood , R. D. Schrimpf, Vanderbilt University; Federico Faccio, Laura Gonella, CERN

We have investigated the low-frequency (1/f) noise characteristics of FOXFETs in a 130 nm technology before and after radiation exposure. Contributions to the noise from a high density of defects near the interface are observed.

B-3 **Total Ionizing Dose Effects on Strained HfO_2-Based nMOSFETs**
2:05 PM
Hyunwoo Park, University of Florida; S. K. Dixit, R. D. Schrimpf, D. M. Fleetwood, Vanderbilt University; Scott E. Thompson, University of Florida

We investigate the radiation response of mechanically strained nMOSFETs with ultra-thin HfO_2 gate dielectrics. The radiation response is characterized as a function of mechanical stress.

B-4 **Electron Capture, Hydrogen Release, and ELDRS in Linear Bipolar Devices**
2:20 PM
D. M. Fleetwood, R. D. Schrimpf, S. T. Pantelides, Vanderbilt University; R. L. Pease, RLP Research; G. W. Dunham, NAVSEA Crane

We present evidence that enhanced low-dose-rate sensitivity (ELDRS) in linear bipolar devices occurs primarily because of the much lower probability for electron capture by protons in SiO_2, as compared to transporting or trapped holes.

B-5 **Amorphous Inclusions in Irradiated Silicon and Their Effects on Material and Device Properties**
2:35 PM
James W. Palko, Joseph R. Srour, The Aerospace Corporation

The structure of radiation-produced amorphous regions in silicon is modeled using atomistic techniques. Those regions consist of a phase distinct from the surrounding crystal and dominate key electronic properties in irradiated bulk material and devices.

POSTER PAPERS

PB-1 Investigation of Proton and X-Ray Irradiation Effects on Nanocrystal and Floating Gate Memory Cell Arrays

Nicola Wrachien, Andrea Cester, Università di Padova; Rosario Portoghese, Cosimo Gerardi, ST Microelectronics

X-ray and proton irradiations impact differently on nanocrystals memories producing charge loss and permanent degradation of the electrical characteristics. These effects are less pronounced than those observed on conventional floating gate based flash memories.

PB-2 Simulations of Radiation Dose-Rate Sensitivity of Bipolar Transistors

Harold P. Hjalmarson, Sandia National Laboratories; Ronald L. Pease, RLP Research; Roderick A. B. Devine, EMRTC/NMT

A bimolecular mechanism for enhanced low dose rate sensitivity (ELDRS) is described. In this mechanism, bimolecular electron-hole recombination dominates the kinetics at high dose rates.

PB-3 Effect of Proton and Silicon Ion Irradiation on Defect Formation in GaAs

Jeffrey H. Warner, Mark E. Twigg, Scott R. Messenger, Robert J. Walters, Naval Research Laboratory; Christophe Inguimbert, ONERA; Manuel J. Romero, National Renewable Energy Laboratory; Geoffrey P. Summers, University of Maryland

Electrical and structural changes in proton and Si ion irradiated GaAs are characterized using EBIC and TEM. The recoil spectra are analyzed to determine the mechanism responsible for introducing localized defects.

PB-4 Displacement Damage Effects in Single-Event Gate Rupture

Matthew J. Beck, Ronald D. Schrimpf, Daniel M. Fleetwood, Sokrates Pantelides, Vanderbilt University; Blair Tuttle, Penn State

Using quantum dynamical calculations we show that single-ion-induced displacement damage in SiO_2 gate oxides produces localized defects with electronic states throughout the oxide band gap that represent low-resistivity paths for dielectric rupture.

PB-5 Annealing Behavior of Oxide Trapped Charge in Bipolar Base Oxides After Radiation Exposure in H_2 Environments

Xiao Jie Chen, Hugh Barnaby, Keith Holbert, Arizona State University; Ronald Pease, RLP Research; Daniel Fleetwood, Ronald Schrimpf, Sokrates Pantelides, Vanderbilt University; Philippe Adell, Jet Propulsion Laboratory

Gated lateral PNP transistors were irradiated in environments containing different amounts of hydrogen. The amount of oxide trapped charge increases with hydrogen content, as does the rate at which this charge anneals.

PB-6 **Effects of Hydrogen Soaking on the Radiation Response of Bipolar Transistors: Experiment and Modeling**

I. G. Batyrev, R. Durand, D. Hughart, M. Bounasser, D. M. Fleetwood, R. D. Schrimpf, Vanderbilt University; B. Tuttle, Vanderbilt University/Penn State; G. W. Dunham, NAVSEA Crane; S. T. Pantelides, Vanderbilt University/Oak Ridge National Laboratory

Reactions of H_2 in lateral PNP BJTs are investigated through experiments and simulations. Hydrogen exposure makes the devices softer, which is explained from first principles based on reactions involving H_2, charge carriers, and protons.

PB-7 **Ion Tracks in Silicon: Spatial and Temporal Evolution**

Michael Murat, Avraham Akkerman, Joseph Barak, Soreq NRC

The spatial and temporal distribution of the deposited energy around ion tracks in silicon is calculated using Monte Carlo simulations. A database of the charge distribution is prepared for calculating single event cross sections in nanometric structures.

PB-8 **Comparison Between Experimental and Simulation Results for Ion Beam and Neutron Irradiation in Silicon Bipolar Junction Transistors**

E. Bielejec, G. Vizkelethy, R. M. Fleming, W. R. Wampler, S. M. Myers, D. B. King, Sandia National Laboratories

We report on an annealing factor comparison between ion and neutron irradiated silicon BJTs as well as experimental to simulation comparison for inverse gain. We find excellent agreement between simulation and experiment across irradiation conditions.

2:50 PM – 3:20 PM
TUCSON BALLROOM

BREAK

SESSION C **HARDNESS ASSURANCE**

3:20 PM SESSION INTRODUCTION

Chair: Andrew Chugg, MBDA UK Ltd.

C-1 **A Comprehensive Methodology for Complex Field Programmable Gate Array Single Event Effects Test and Evaluation**

3:25 PM

Melanie Berg, Hak Kim, Mark Friendlich, Anthony Phan, Chris Perez, MEI Technologies Inc., NASA-GSFC; Kenneth LaBel, NASA/GSFC

A methodology for evaluating various types of FPGAs targeted for space missions is presented. The premise is to supply unambiguous SEE information so that flight-projects may insert the optimal device for their application.

C-2 **An Automated Approach to Estimating Hardness Assurance Issues in Triple-Modular Redundancy Circuits in Xilinx FPGAs**

3:40 PM

Heather Quinn, Paul Graham, Los Alamos National Laboratory

This abstract explores a tool, called the Scalable Tool for the Analysis of Reliable-Circuits (STAR-C), that estimates the static cross-section of triple-modular redundant circuit designs for Xilinx field-programmable gate arrays (FPGAs).

C-3
3:55 PM

Concatenation of SET Pulses in Sequential Circuits Leading to Increased SE Vulnerability

Balaji Narasimham, Oluwole A. Amusan, Bharat L. Bhuva, Ronald D. Schrimpf, Vanderbilt University

Mixed mode simulations and heavy-ion experiments indicate the presence of multi-node charge collection in advanced technologies. For logic circuits, such charge collection may result in concatenation of SET pulses, leading to long, super SETs.

C-4
4:10 PM

From the Reference SEU Monitor to the Technology Demonstration Module On-board PROBA-II

R. Harboe-Sørensen, C. Poivey, European Space Agency; F.-X. Guerre, A. Roseng, F. Lochon, Hirex Engineering; G. Berger, University Catholique de Louvain; W. Hajdas, Paul Scherrer Institut; A. Virtanen, H. Kettunen, University of Jyväskylä; S. Duzellier, ONERA

This paper presents results and experiences obtained with the "Reference SEU Monitor" system. Calibration data, research topics and on-going preparations for flight of the TDM, on-board the PROBA-II satellite, will also be covered.

C-5
4:25 PM

TID Effects in Space-Like Variable Dose Rates

Richard D. Harris, Steven S. McClure, Bernard G. Rax, Robin W. Evans, Insoo Jun, JPL

The degradation of the LM193 comparator is studied during constant TID dose rates and a variable TID dose rate to explore how well typical part testing predicts the performance during a simulated space-like mission.

C-6
4:40 PM

Enhanced Proton and Neutron Induced Degradation and Its Impact on Hardness Assurance Testing

M. R. Shaneyfelt, J. A. Felix, J. R. Schwank, P. E. Dodd, S. Dalton, Sandia National Laboratories; J. Baggio, V. Ferlet-Cavois, P. Paillet, CEA/DIF

Protons and neutrons can induce enhanced degradation in power MOSFETs. This degradation is caused by microdose effects associated with secondary particles produced by proton/material interactions. Hardness assurance implications are discussed.

POSTER PAPERS

PC-1

Review of Deposited Dose Calculation Methods using Ray Tracing Approximations

Philippe Calvel, Catherine Barillot, Thales Alenia Space; Alain Porte, Gerard Auriel, DGA CEG; Christian Chatry, Pierre-François Peyrard, TRAD; Giovanni Santin, ESA/ESTEC; Robert Ecoffet, CNES

Deposited dose calculations calculated, by two ray tracing methods, are compared to 3-D Monte Carlo Reverse-Adjoint results, for both simple and complex geometries. Results are analyzed, ray tracing accuracy discussed, and hardness assurance improvement proposed.

PC-2 **Laser Dose-Rate Simulation to Complement LINAC Discrete Device Data**

Sarah A. Nation, NAVSEA Crane/Vanderbilt University; Lloyd W. Massengill, Vanderbilt University; Dale McMorrow, Naval Research Laboratory; Lydell A. Evans, NAVSEA Crane

Laser-induced dose-rate measurements prove useful for extending the range of LINAC data and for model validation. Results suggest the ability to generate LINAC-equivalent data for dose-rate model development with minimal LINAC calibration.

PC-3 **Recommended Test Conditions for SEB Evaluation of Power MOSFET**

Sandra Liu, Christopher DiCienzo, Huy Cao, Max Zafrani, Milt Boden, International Rectifier; Jeffrey Titus, NAVSEA Crane

This paper discusses the preferred test conditions for SEB evaluation of power MOSFET based on the SEB/SEGR failure mechanisms and test results. Lighter ions, shorter range beams and 0 V gate bias are recommended.

PC-4 **A Built-In Self-Test (BIST) Technique for Hardness Assurance against SETs in Digital Circuits**

Anitha Balasubramanian, Bharat L. Bhuva, Lloyd W. Massengill, Balaji Narasimham, W. Timothy Holman, Vanderbilt University

A built-in self-test technique for hardness assurance for single-event transients in digital circuits is developed. Experimental and simulation results for multiple technology nodes show the feasibility of this approach with reduced testing time and cost.

PC-5 **Importance of Modeling Multiple Transients in Combinational Logic Using a Modified Version of SEUTool**

Megan C. Casey, Bharat L. Bhuva, William H. Robinson, Lloyd W. Massengill, Vanderbilt University; Adam R. Duncan, Motorola, Inc.

A technique for estimating upset cross-section for combinational circuits based on charge collection at multiple nodes is presented. Simulation results for a clock divider show a 5x increase in cross-section when multiple SETs are accounted.

4:55 PM END OF TUESDAY SESSIONS

ARIZONA BALLROOMS 6 – 7

SESSION D — **SPACE AND TERRESTRIAL ENVIRONMENTS**

8:30 AM — SESSION INTRODUCTION

Chair: Janet Barth, NASA/GSFC

D-1 — **Hafnium and Uranium Contributions to Soft Error Rate**

8:35 AM — *Frederic Wrobel, Jean Gasiot, Frederic Saigne, IES, Université de Montpellier II*

Simulations show that natural uranium concentration in a wafer lead to a SER comparable to that due to neutrons at ground level. On the contrary, hafnium used in gate oxide has no effect on SER.

D-2 — **30 MeV and 63 MeV Neutron Induced Energy Deposition in a Silicon Diode: Experimental Validation of Monte Carlo Simulation**

8:50 AM — *Simon Rocheman, Frédéric Wrobel, Jean-Roch Vaillé, IES Université de Montpellier II; Cécile Weulersse, Nadine Buard, EADS IW; Thierry Carrière, EADS Space Transportation*

Energy deposition in a silicon diode irradiated by 30 MeV and 63 MeV neutrons is investigated. Secondary ions induced by nuclear reactions are simulated by Monte Carlo method. Results are in agreement with UCL experiment.

D-3 — **Galileo Giove-A MEORAD Results and Analysis**

9:05 AM — *B. Taylor, C. I. Underwood, Surrey Space Centre, University of Surrey; H. D. R. Evans, E. Daly, G. Mandorlo, M. Falcone, European Space Agency, ESTEC; K. A. Ryden, P. A. Morris, QinetiQ*

A review of the radiation monitoring activities on board the Galileo Giove-A satellite to end of nominal mission life is presented. A comparison of the data with existing monitors and models is also made.

D-4 — **The Mars Energetic Radiation Environment Models**

9:20 AM — *Pete Truscott, Fan Lei, Space Division, QinetiQ; Ana Keating, Sara Valente, Patricia Goncalves, LIP; Laurent Desorgher, SpaceIT; Daniel Heynderickx, DH Consultancy; Normal Crosby, Hilde de Witte, Gerald Degreef, BIRA; Petteri Nieminen, ESA/ESTEC; Giovanni Santin, ESA/ESTEC (Rhea Systems SA)*

This paper reviews engineering and scientific models developed to simulate the radiation environment for future Mars missions. The simulation results from these Geant4- and FLUKA-based models are also presented.

POSTER PAPERS

PD-1 — **An Algorithm for Energy Deposition Profiles in Elemental Slabs by Low (<100 KeV) Energy Electrons: Application for Internal Charging**

Wousik Kim, Insoo Jun, Henry B. Garrett, JPL

An updated internal charging code called NUMIT, originally developed by Frederickson, is reviewed in this paper. The update includes a new energy deposition profile algorithm for the low-energy (< 100 KeV) incident electrons in elemental slabs.

PD-2 **HETC-HEDS Code Validation Using Laboratory Beam Energy Loss Spectra Data**

Youssef M. Charara, Lawrence W. Townsend, University of Tennessee; Tony A. Gabriel, Scientific Investigation & Development; Cary J. Zeitlin, Lawrence H. Heilbronn, Jack Miller, Lawrence Berkeley National Laboratory

Recently, the Monte Carlo transport code HETC has been extended to include the interactions and transport of energetic heavy ions. In this work we compare predictions of fragment production and energy loss with laboratory data.

SESSION E **RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS**

9:35 AM SESSION INTRODUCTION

Chair: Ray Ladbury, NASA/GSFC

E-1 9:40 AM **The Effects of Hydrogen on the Enhanced Low Dose Rate Sensitivity (ELDRS) of Bipolar Linear Circuits**

Ronald Pease, RLP Research; Philippe Adell, Bernard Rax, JPL; Xiao Jie Chen, Hugh Barnaby, Keith Holbert, Arizona State University

It is experimentally demonstrated with test transistors and circuits that hydrogen is correlated with enhanced low dose rate sensitivity (ELDRS) in bipolar linear circuits. We show that the amount of hydrogen determines the total dose response versus dose rate.

E-2 9:55 AM **Review and Analysis of the Radiation Induced Degradation Observed on the Input Bias Current of Linear Integrated Circuits**

L. Dusseau, Y. Gonzalez Velo, N. Roche, J. Boch, F. Saigné, IES-Université de Montpellier II; M. Bernard, EADS ASTRIUM GmbH; E. Lorfèvre, CNES

It is shown that the versatile shape of the degradation curve observed in several ICs is due to circuit effects depending on the architecture, the value of the collector currents and the bias conditions.

10:10 AM – 10:40 AM TUCSON BALLROOM BREAK

E-3 10:40 AM **Microdose and Breakdown Effects Induced by Heavy Ions on Sub 20-nm Triple-Gate SOI FETs**

Alessio Griffoni, Simone Gerardin, Gaudenzio Meneghesso, Alessandro Paccagnella, Università di Padova; Eddy Simoen, IMEC; Sofie Put, Cor Claeys, Katholieke Universiteit Leuven and IMEC

We studied the permanent effects of heavy-ion strikes on decananometer triple-gate SOI devices. We highlighted the role of the geometry and the three-dimensional architecture in the response to heavy ions.

E-4
10:55 AM

Analysis of Proton and Heavy-Ion Irradiation Effects on Phase Change Memories with MOSFET and BJT Selectors

Alberto Gasperin, Nicola Wrachien, Alessandro Paccagnella, Università di Padova; Jim Schwank, Gyorgy Vizkelethy, Sandia National Laboratories; Federica Ottogalli, Fabio Pellizzer, ST Microelectronics

Proton irradiation produces noticeable variations of the cell distributions in phase-change memories with MOSFET selectors mostly due to leakage currents that affect the transistors. Phase-change memory cells do not appear affected by heavy-ion irradiation.

E-5
11:10 AM

Novel Total Dose and Heavy-Ion Charge Collection Phenomena in a New SiGe HBT on Thin-Film SOI Technology

Marco Bellini, Stanley D. Phillips, Ryan M. Diestelhorst, Peng Cheng, John D. Cressler, Georgia Institute of Technology; Paul Marshall, Consultant to NASA-GSFC; Marek Turowski, CFD Research Corporation; Grégory Avenier, Alain Chantre, Pascal Chevalier, ST Microelectronics

We investigate radiation-induced effects on the DC, AC and thermal characteristics of high-performance SiGe HBTs fabricated on thin-film SOI. TCAD simulations indicate novel heavy-ion charge collection phenomena resulting from the unique CBEBC device layout.

E-6
11:25 AM

Radiation Response of NROM-Style SOI Non-Volatile Memory Elements

Bruce Draper, Robert Dockerty, Marty Shaneyfelt, Scott Habermehl, James Murray, Sandia National Laboratories

For the first time, NROM-style nonvolatile memory elements were fabricated in SOI and irradiated. Total dose characterizations of these transistors indicate that this new style of memory can be functional to at least 500 krad(SiO_2).

E-7
11:40 AM

Effects of Moisture Exposure on Radiation-Induced MOS Device Degradation and Its Implications for Long-Term Aging

J. R. Schwank, M. R. Shaneyfelt, J. A. Felix, P. E. Dodd, Sandia National Laboratories; A. Dasgupta, S. A. Francis, X. J. Zhou, D. M. Fleetwood, R. D. Schrimpf, S. T. Pantelides, Vanderbilt University; G. K. Lum, Lockheed Martin Space Systems

Large and unexpected radiation-induced voltage shifts have been observed for some MOS technologies exposed to moisture. The mechanisms for these large voltage shifts and their implications for long-term aging are discussed.

E-8
11:55 AM

Channel Hot Carrier Stresses On Irradiated 130-nm MOSFETs With Enclosed Layout

M. Silvestri, S. Gerardin, A. Paccagnella, Università di Padova; F. Faccio, PH-MIC-FE, CERN

We present new experimental results about channel hot carrier degradation of enclosed layout transistors as a function of previous accumulated total ionizing dose, stress temperature, and transistor geometry.

POSTER PAPERS

PE-1 Origin of High Total Dose Sensitivity on the OP400 Bipolar Operational Amplifier

Muriel Bernard, Thierry Bouchet, EADS Astrium; Laurent Dusseau, Université de Montpellier II

The degradation of electrical and functional parameters of the OP400 is shown to be application and bias dependent. Circuit analysis makes possible to understand these major concerns with regards to test procedures and application design.

PE-2 Analyses of Commercial Trench Power MOSFET's Responses to Co-60 Irradiation

Sandra Liu, Christopher DiCienzo, Martin Bliss, Max Zafrani, Milt Boden, International Rectifier

This paper presents detailed analyses on trench power MOSFETs' responses to Co-60 irradiations for all key electrical parameters. Charge trapped in gate oxide causing large V_{th} shift is responsible for most device performance degradations.

PE-3 Ionizing Radiation Effects on Ferroelectric Non Volatile Memories and its Dependence on the Irradiation Temperature

Mauro Zanata, Andrea Cester, Nicola Wrachien, Università di Padova

We investigated Ferroelectric Random Access Memory subjected to X-ray and proton irradiation. We addressed the radiation damage dependence on irradiation temperature, its stability during annealing and cycling, and the effects of supply voltage and packaging.

PE-4 On the Radiation Tolerance of SiGe HBT and CMOS-Based Phase Shifters for Space-Based, Phased-Array Antenna Systems

Tushar K. Thrivikraman, Peng Cheng, Stanley D. Phillips, Jonathan P. Comeau, Matt A. Morton, John D. Cressler, Georgia Institute of Technology; Paul W. Marshall, Consultant to NASA/GSFC

We report the first irradiation results on high-frequency SiGe HBT and CMOS phase shifters for space-based, phased array antenna systems. Both phase shifters remain functional after 100 krad exposure, thus suitable for many orbital applications.

PE-5 The Effects of Proton Irradiation on the Performance of High-Voltage nMOSFETs Implemented in a Low-Voltage SiGe BiCMOS Platform

Laleh Najafizadeh, Stanley D. Phillips, Peng Cheng, John D. Cressler, Georgia Institute of Technology; Tuan Vo, Mohammad Mojarradi, JPL; Paul W. Marshall, Consultant to NASA/GSFC

A comprehensive investigation of the impact of proton irradiation on the performance of high-voltage nMOS transistors implemented in a SiGe technology is presented. The effects of irradiation temperature, gate, and substrate bias conditions are examined.

PE-6 A Novel Radiation-Tolerant FG Configuration Cell for Flash-Based FPGA

J. J. Wang, S. Rezgui, Y. Sun, F. Hawley, F. Issaq, B. Cronquist, J. McCollum, R. Chan, H. Pan, S. Kabir, Actel

A novel floating-gate cell is proposed as the configuration cell in the Flash-base FPGA to improve the radiation performance. The test data shows that it has more than an order of magnitude improvement.

PE-7 **Gate-Length and Drain-Bias Dependence of Band-To-Band Tunneling (BTB) Induced Drain Leakage in Irradiated Fully Depleted SOI Devices**

Farah E. Mamouni, Ronald D. Schrimpf, Sriram K. Dixit, Vanderbilt University; Michael L. McLain, Hugh J. Barnaby, Department of Electrical Engineering, Arizona State University; Philippe C. Adell, JPL; Wade Xiong, Texas Instruments Inc.

The impact of band-to-band tunneling (BTB) on the drain current of irradiated fully depleted SOI MOSFETs at negative gate voltage is critically examined. The gate length and the drain voltage dependencies are investigated.

PE-8 **Physical Mechanisms of Ion-Induced Stuck Bits in the Hyundai 16Mx4 SDRAM**

Larry D. Edmonds, Leif Z. Scheick, JPL

It was previously thought that stuck bits in the Hyundai 16Mx4 SDRAM were caused by micro-dose. It is argued here that the correct mechanism is micro-displacement damage, creating a leakage current that drains the storage capacitor.

PE-9 **Comprehensive Study of Total Ionizing Dose Damage Mechanisms and their Effects on Noise Sources in a 90 nm CMOS Technology**

V. Re, M. Manghisoni, G. Traversi, Università di Bergamo;
L. Gaioni, L. Ratti, Università di Pavia

Irradiation tests on 90 nm CMOS devices at different TID lead to new insights into degradation mechanisms in gate oxides and lateral isolation structures and into their impact on gate and drain current noise sources.

PE-10 **Experimental Measurement of the Impact of Total Ionizing Dose on SRAM Cell Margins**

Xiaoyin Yao, Lawrence T. Clark, Keith E. Holbert, Arizona State University;
David R. Alexander, Walter M. Shedd, AFRL/VSSE

A test structure allowing direct measurement of SRAM cell electrical characteristics is presented. Experimentally measured results from this structure, fabricated on a 90 nm process, show impact of Co-60 irradiation on SRAM cell margins.

PE-11 **Radiation Induced Inter-Device Leakage Current in 90 nm Bulk CMOS Devices and Circuits**

Michael L. McLain, Hugh J. Barnaby, Lawrence T. Clark, Keith E. Holbert, Harshit Shah, Arizona State University

Recent experiments on field oxide transistors fabricated in a commercial low-standby power 90 nm process indicate that the drain current per unit width exceeds 1 nA/μm after 1 Mrad(SiO_2) of total dose. The standard process from the same technology is much more radiation tolerant.

PE-12 **High Resistance Material for Mitigating Linear Energy Transfer Sensitivities in Nanometer CMOS SRAM Cell Technologies**

Esau Kanyogoro, Harold Hughes, Naval Research Laboratory; Martin Peckerar, University of Maryland; Mike Liu, Honeywell Aerospace

Cross-coupled resistors are a prime method of mitigating single event upsets. Scaling has restricted use of this technique. We present new material with sheet resistance of 8-32 kΩ/sq. and TCR of -0.09%/°C from -55 °C to 125 °C.

PE-13 **Silicon Nanowire Field Effect Transistors for Radiation Hard Electronics**

Loucas Tsakalakos, P. Losee, Joleyn Balch, General Electric; Alexander Bogorad, William Taft, Justin Likar, Roman Herschitz, Lockheed Martin Commercial Space Systems

Silicon nanowire-based transistors were fabricated and tested for their radiation hardness by exposure to Co-60 X-ray radiation at doses ranging from 50-250 kRad. Only minor degradation of the transistor characteristics was observed at 250 kRad.

12:10 – 1:30 PM LUNCH

INVITED TALK
1:30 – 2:30 PM

The Francisco Vásquez de Coronado Expedition

James E. Turner, Arizona Historical Society

Decades before Hudson, LaSalle and Champlain, Spanish conquistadors followed the legend of the Seven Cities of Cibola for thousands of miles across North America in search of gold and jewels. In 1540, Francisco Vásquez de Coronado entered Arizona with the largest Spanish expedition ever gathered. Military reports, diaries, and memoirs describe these explorers' observations and impressions even after four and a half centuries have passed. While Coronado went north by land along the banks of the San Pedro River into Arizona, he sent Hernando de Alarcon up the Colorado River to present-day Yuma. After the successes of Cortes in Mexico and Pizarro in Peru, Coronado expected to find large cities filled with riches. The Coronado Expedition spent the winter of 1541 near present-day Albuquerque. Mr. Turner will present pictures, stories and anecdotes relating to the expedition and trial of Coronado, and how all this affected the eventual settlement of the Southwest.

A Tucson resident since 1951, **James E. Turner** began teaching Arizona history in 1976, and received his M.A. in U.S. History from the University of Arizona in 1999. Jim writes historical articles for several Arizona newspapers and magazines, and he won a writing award for the best article in the *Journal of Arizona History* in 1998. He served as adjunct professor at the University of Arizona, and has taught at Pima Community College and other local organizations. As Community Outreach Historian for the Arizona Historical Society, Turner supports more than 65 local history museums throughout Arizona, and presents workshops and lectures on various topics in museum management and Arizona history.

POSTER SESSION
2:30 – 4:30 PM
ARIZONA BALLROOMS 1 – 5

INTRODUCTION

Jeff Titus, NAVSEA/Crane

4:30 PM END OF WEDNESDAY SESSIONS

ARIZONA BALLROOMS 6 – 7

SESSION F **SINGLE-EVENT EFFECT; DEVICES AND INTEGRATED CIRCUITS**

8:30 AM SESSION INTRODUCTION

Chair: Philippe Paillet, CEA/DIF

F-1 8:35 AM **Multiple Bit Upsets and Error Mitigation in Ultra Deep Submicron SRAMs**

Dave Mavis, M. D. Sibley, E. J. Smith, K. A. Avery, P. G. Eaton, Micro RDC; R. C. Lacoe, The Aerospace Corporation

Recent measurements of the SEU cross-section for 6T SRAMs fabricated in a nano-scale commercial CMOS process were performed. Results indicated that the dominant upset mechanism was associated with multiple-bit upsets (MBUs) strikes on PMOS transistors.

F-2 8:50 AM **Angular Dependence of Single Event Sensitivity in Hardened Flip/Flop Designs**

Mark Baze, Barrie Hughlock, Jerry Wert, Joe Tostenrude, Boeing Phantom Works; Lloyd Massengill, Oluwole Amusan, Vanderbilt University/Institute for Space and Defense Electronics; Ronald Lacoe, The Aerospace Corporation; Mike Johnson, Berkeley National Laboratory

SEU data on 90 nm structures displays a strong dependence on incident angle. A right parallelepiped approximation is not applicable to the observed response. This paper presents data, possible mechanisms, and implications for testing and error rate predictions.

F-3 9:05 AM **Key Contributions to the Cross Section of NAND Flash Memories Irradiated with Heavy Ions**

M. Bagatin, S. Gerardin, G. Cellere, A. Paccagnella, Università di Padova; A. Visconti, S. Beltrami, ST Microelectronics; R. Harboe-Sørensen, ESA/ESTEC; A. Virtanen, University of Jyväskylä

Heavy-ions irradiation of NAND flash memories leads to errors with complex, data-dependent signatures. We propose an “effective cross section,” taking into account the array and peripheral circuitry contributions as well as the operating conditions.

F-4 9:20 AM **Laser Verification of On-Chip Charge Collection Measurement Circuit**

Oluwole A. Amusan, Patrick R. Fleming, Bharat L. Bhuva, Lloyd W. Massengill, Anupama Balasubramanian, Megan C. Casey, Sarah Nation, Matthew Gadlage, T. Daniel Loveless, Arthur F. Witulski, Vanderbilt University; Dale McMorrow, Joseph S. Melinger, Naval Research Laboratory; Frederick Barsun, NSWC Crane

An on-chip charge collection measurement circuit has been designed and fabricated in the 130 nm CMOS process. Laser testing is used to verify the effectiveness of this technique for characterizing single event effects for advanced technologies.

F-5 9:35 AM **Heavy Ions Induced Single Event Gate Damages in Medium Voltage Power MOSFET**

Giovanni Busatto, Antonino Porzio, Francesco Iannuzzo, Annunziata Sanseverino, Francesco Velardi, Università di Cassino; Giuseppe Currò, ST Microelectronics

Starting from a physical model of the electric field that develops into the gate oxide during heavy ion irradiation, we have experimentally and numerically investigated the single event gate damages observed in medium voltage P-MOSFETs.

9:50 – 10:20 AM
TUCSON BALLROOMS A – E

BREAK

F-6
10:20 AM

The Effects of Low Dose-Rate Ionizing Radiation on the Shapes of Transients in the LM124 Operational Amplifier

Stephen Buchner, PSGS/NASA-GSFC; Dale McMorrow, Naval Research Laboratory; Nicolas Roche, Laurent Dusseau, Université de Montpellier II

Transients in an operational amplifier (LM124) have shapes that depend on amplifier configuration and change with radiation dose. Changes in electrical parameters track the changes in transient shapes.

F-7
10:35 AM

Probing the SET Sensitivity of Linear Devices with Heavy Ions

S. Duzellier, C. Inguimbert, T. Nuns, ONERA; F. Bezerra, D. Dangla, CNES

This paper reports on SET heavy ion data used to estimate the depth location of sensitive structures of the LM124. These data are correlated with laser measurements and provide insight into the SET test and prediction methodology.

F-8
10:50 AM

Configuration and Routing Effects on SET Propagation in Flash-Based FPGAs

Sana Rezgui, J.J. Wang, Yinming Sun, John McCollum, Brian Cronquist, ACTEL Corporation

New insights on SET propagation in Flash-Based FPGA are investigated. SET fault injection tests show the broadening and the filtering of SET pulse widths related to its transition and data-path in an FPGA design.

POSTER PAPERS

PF-1

Implications of Total Dose on Single Event Transient (SET) Propagation

Anupama Balasubramanian, Balaji Narasimham, Bharat L. Bhuva, Lloyd W. Massengill, Vanderbilt University; Paul H. Eaton, Mike Sibley, David G. Mavis, Microelectronics Research Development Corporation

Evaluation of a single event transient (SET) pulse width characterization circuit showed reduced number of errors due to total dose exposure. Additional heavy-ion experiments and simulations are used to explain the decrease in error cross-section.

PF-2

Single-Event Effects on Combinational Logic Circuits Operating at Ultra-Low Power

Megan C. Casey, Oluwole A. Amusan, Anupama Balasubramanian, Bharat L. Bhuva, Michael L. Alles, Lloyd W. Massengill, Balaji Narasimham, Vanderbilt University; Sarah Nation, Vanderbilt University/NAVSEA Crane; Dale McMorrow, Joseph S. Melinger, Naval Research Laboratory

The laser energy required to upset a 201-stage ring oscillator operating in subthreshold remains relatively constant. Simulations show that transients are wider than pulsewidths at nominal voltages, with smaller transients from PMOS devices than NMOS.

PF-3 **C-CREST Technique for Combinational Logic SET Testing**

J. R. Ahlbin, L. W. Massengill, O. A. Amusan, A. Balasubramanian, M. C. Casey, D. A. Black, R. A. Reed, B. L Bhuva, Vanderbilt University; J. D. Black, M. W. McCurdy, ISDE, Vanderbilt University

Combinational logic SEE in 90 nm is analyzed using a new design approach called C-CREST. Results confirm that the design is effective in enhancing logic SE testability without sacrificing frequency.

PF-4 **Investigation of Single-Event Transients in Voltage Regulators**

Farokh Irom, Tetsuo F. Miyahira, Jamie S. Laird, Philippe C. Adell, JPL

Single-event transients from heavy ions and laser beam are investigated for the voltage regulators from Linear Technology, RH117. Positive and negative going transients are observed. The role of loading on the SET response is discussed.

PF-5 **Single Event Transient Analysis of Emitter Follower Using SiGe HBT**

Xiaoyun Wei, Tong Zhang, Guofu Niu, Muthubalan Varadharajaperumal, Auburn University; John D. Cressler, Georgia Tech; Paul W. Marshall, NASA-GSFC

This work presents 3D mixed mode SET simulation results of typical emitter follower designs using SiGe HBT, and provides guidelines for SEU hardened emitter follower design.

PF-6 **Single Event Effect Induced Multiple-Cell Upsets in a Commercial 90 nm CMOS Digital Technology**

Reed K. Lawrence, Andrew T. Kelly, BAE Systems

Heavy ion and proton SEU testing on SRAMs from a commercial 90 nm technology indicate multiple-cell upsets. Above a heavy ion LET of 7 MeV-cm^2/mg the multiple-cell upsets dominate the single-cell upsets.

PF-7 **Alpha-Particle and Carbon-Ion-Induced Flip-flop Single-Event-Upsets in 65 nm Bulk Technology**

Larry Wissel, Ethan H. Cannon, IBM Systems and Technology Group; David F. Heidel, Michael S. Gordon, Kenneth P. Rodbell, IBM Research Division

We modeled upset rates of 65 nm bulk flip-flops. We measured the upset rates with thorium foil, 15 MeV carbon ions, and 150 MeV protons, and we compare the measurements to the predictions.

PF-8 **Monte Carlo Analysis of the Effects of Soft Errors accumulation in SRAM-based FPGAs**

Niccolò Battezzati, Luca Sterpone, Massimo Violante, Politecnico di Torino

A new Monte Carlo based methodology is used to evaluate Soft Error accumulation in the configuration memory of Triple Modular Redundancy designs implemented on SRAM-based FPGAs. Analytical predictions are confirmed by means of fault injection.

PF-9 **Upset-Induced Failure Signatures, Recovery Methods, and Mitigation Techniques in a High-Speed Serial Data Link for Space Applications**

Keith Morgan, Michael Caffrey, Mark Dunham, Paul Graham, Heather Quinn, LANL; Carl Carmichael, Tony Duong, Austin Lesea, Greg Miller, Gary Swift, Chen Wei Tseng, Yiding Wu, Xilinx; Roberto Monreal, SEAKR; Greg Allen, JPL

This work classifies the Xilinx high-speed serial transceiver failure signatures and recovery methods, measures its cross-section and provides a mitigation scheme for reliably using it in space.

PF-10 **Study of Latent Damage in Power MOSFETs Caused by Heavy Ion Irradiation**

Naomi Ikeda, Satoshi Kuboyama, Takashi Tamura, JAXA

The latent damages were investigated for Power MOSFETs irradiated by high LET heavy ions. It was demonstrated that the damages were stable or growing depend on the leakage current level introduced by the irradiation.

PF-11 **SEE Test Results and Observed Failure Modes of Trench Power MOSFETs**

Sandra Liu, Huy Cao, Robert Berberian, Christopher DiCienzo, Max Zafrani, Milt Boden, International Rectifier

This paper presents SEE test results and observed failure modes on multiple trench power MOSFETs. Single event function failure (SEFF) and thermal runaway (SEE Thermal RA) are new failure modes observed on power MOSFETs.

SESSION G — DOSIMETRY AND FACILITIES

11:05 AM SESSION INTRODUCTION

Chair: Henry Clark, Texas A&M University

G-1 11:10 AM **A Novel Cylindrical Silicon-on-Insulator Microdosimeter for the Characterisation of Deep Space Radiation Environments**

Amy L. Ziebell, Andrew S. Dzurak, Anatoly B. Rosenfeld, University of Wollongong; Wee Han Lim, Dale. A. Prokopovich, University of New South Wales; Mark I. Reinhard, Iwan Cornelius, Australian Nuclear Science and Technology Organisation

A novel silicon-on-insulator microdosimeter for the characterization of deep space environments is presented. An ion beam induced charge collection study confirms the microdosimeter possesses well defined micron sized 3D cylindrical sensitive volumes.

G-2 11:25 AM **Tissue Equivalence Correction for Silicon Microdosimetry for Space Radiation Protection**

S. Guatelli, M. I. Reinhard, D. A. Prokopovich, ANSTO; A. S. Dzurak, University of New South Wales; M. Zaider, Memorial Sloan-Kettering Cancer Center; A. B. Rosenfeld, University of Wollongong

The tissue equivalence of solid state silicon detectors is under investigation in proton radiation fields, of interest for aviation and space missions. The study is performed by means of Geant4 simulations.

G-3
11:40 AM

Fibered Monitoring Device for Pulsed Dose-Rate Facilities Based on Radioluminescence of SrS:Ce, Sm Phosphor

David Benoit, Jean-Roch Vaillé, Pierre Garcia, Laurent Dusseau, (IES), Université de Montpellier II; Jérôme Lautissier, José Isturiz, Centre de Radiothérapie du Parc; Benoît Brichard, SCK-CEN, Belgian Nuclear Research Centre

We investigate the possibility to monitor pulsed dose-rate facilities by means of real-time fibered dosimetry system based on luminescence of SrS:Ce,Sm phosphor. Comparison between fibered system measurements and accelerator output has shown a good agreement.

POSTER PAPERS
PG-1

A Solar Flare Simulation Wheel for the Radiation Test Beamline at the Francis H. Burr Proton Therapy Center

Ethan W. Cascio, The Francis H. Burr Proton Therapy Center at Massachusetts General Hospital

The design, construction and testing of a rotating energy shifter that simulates the proton energy spectrum of a solar flare event is described.

11:55 – 1:30 PM LUNCH

INVITED TALK
1:30 – 2:30 PM

The Huygens Mission to Titan

Martin G. Tomasko, University of Arizona

Saturn's moon Titan has the second most dense atmosphere in our solar system. A thick layer of photochemically produced haze particles high in Titan's atmosphere hides its surface from outside view. In many ways the moon resembles an early Earth held in deep freeze since the formation of the solar system. The low temperatures and active photochemistry were expected to produce large lakes of liquid ethane/methane–liquid natural gas on the surface. The Huygens probe was launched on the Cassini spacecraft in 1997, and dropped into the atmosphere of Titan in January, 2005. The instruments aboard the probe measured the structure and nature of the atmosphere and included a specially designed camera. The images from the camera have been assembled into a movie showing the descent through Titan's haze and onto a surface more similar to that of the Earth than was expected. The story of the Huygens mission and its findings has shed new light on this distant world.

Dr. Tomasko is interested in the composition, cloud structure, and heat balance of planetary atmospheres. He has pursued these interests through theoretical calculations of the transfer of thermal and solar radiation in scattering atmospheres, as well as in observational programs using entry probes, orbiter and flyby missions, earth-orbiting observatories, laboratory studies, and ground based observations. He currently serves as Principal Investigator for the Descent Imager/Spectral Radiometer (DISR) instrument on the Huygens entry probe of Titan on the Cassini mission. He has served as a co-investigator on the Net Flux Radiometer (NFR) experiment on the Galileo entry probe of Jupiter, as a Co-Investigator on the Imager for Mars Pathfinder (IMP) experiment, as Principal Investigator on Hubble Space Telescope (HST) observing programs aimed at determining the structure of stratospheric and tropospheric clouds and hazes on Saturn and Uranus, and as Principal Investigator on the Solar Flux Radiometer Experiment on the Pioneer Venus Entry Probe.

DATA WORKSHOP
2:30 – 4:30 PM
ARIZONA BALLROOMS 8 – 12

INTRODUCTION

Chair: Jim Felix, Sandia National Laboratories

W-1 Guide to the 2007 IEEE Radiation Effects Data Workshop Record
David M. Hiemstra, MDA Space Missions

The 2007 Workshop Record has been reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

W-2 Compendium of Recent Total Ionizing Dose Results and Displacement Damage Results for Candidate Spacecraft Electronics for NASA
Donna J. Cochran, Martha V. O'Bryan, MEI Technologies Inc., NASA/GSFC; Stephen P. Buchner, Perot Systems, NASA/GSFC; Christian Poivey, Formerly MEI Technologies Inc., NASA/GSFC; Raymond L. Ladbury, Kenneth A. LaBel, NASA-GSFC; Jeffrey L. Titus, NAVSEA-Crane

Vulnerability of a variety of candidate spacecraft electronics to total ionizing dose and displacement damage is studied. Devices tested include optoelectronics, digital, analog, linear bipolar devices, and hybrid devices.

W-3 Compendium of Recent Single Event Effects Results for Candidate Spacecraft Electronics for NASA

Martha V. O'Bryan, Michael J. Campola, Martin A. Carts, Melanie D. Berg, MEI Technologies Inc., NASA/GSFC; Kenneth A. LaBel, Ray L. Ladbury, Anthony B. Sanders, NASA/GSFC; Stephen P. Buchner, Timothy R. Oldham, Perot Systems, NASA/GSFC; Christian F. Poivey, Susan R. Mackey, Formerly MEI Technologies Inc., NASA/GSFC

We present the results of single event effects testing and analysis investigating the effects of radiation on electronics. This paper is a summary of test results.

W-4 Compendium of Test Results of Single Event Effects Conducted by the Jet Propulsion Laboratory

Gregory R. Allen, Farokh Irom, Tetsuo Miyahira, Leif Z. Scheick, Duc N. Nguyen , Heidi Becker, Steven McClure, JPL

This paper reports heavy ion and proton induced single event effects results for a variety of microelectronic devices targeted for possible use in NASA spacecrafts. The compendium covers devices tested over the last eight years.

W-5 TID and SEE Response of Advanced 4G NAND Flash Memories

Timothy R. Oldham, S. P. Buchner, Perot Systems, NASA-GSFC; M. Suhail, Freescale Semiconductor; M. R. Friendlich, M. A. Carts, H. S. Kim, M. D. Berg, MEI Technologies Inc., NASA-GSFC; N. C. Helmold, A. B. Sanders, K. A. LaBel, NASA-GSFC; C. Poivey, European Space Agency

We present total dose and SEE responses for 4G NAND flash memories by three different manufacturers. The SEE response is scaled to predict the response to atmospheric neutrons at aircraft altitudes and at sea level using the Figure of Merit.

W-6 TID and SEE Tests of an Advanced 8 Gbit NAND-Flash Memory

Hagen Schmidt, Dietmar Walter, Fritz Gliem, Technical University of Braunschweig; Bob Nickson, Reno Harboe-Sørensen, ESA/ESTEC; Ari Virtanen, University of Jyväskylä

We report on the dose and operation mode dependence of error percentage, stand-by current, erase and write time of 8-Gbit/4-Gbit NAND-Flash memories as well as on their static, dynamic and SEFI cross sections.

W-7 Radiation Performance of 1 Gbit DDR2 SDRAMs Fabricated with 80-90 nm Minimum Feature Size CMOS

Ray Ladbury, Kenneth A. LaBel, NASA-GSFC; Melanie D. Berg, Mark R. Friendlich, Hak S. Kim, MEI Technologies Inc., NASA-GSFC

We present data on the radiation performance of 1 Gbit DDR2 SDRAMs from three different vendors, including susceptibilities to TID damage and to destructive and nondestructive SEE.

W-8 Investigation of the Mechanism of Stuck Bits in High Capacity SDRAMs

Leif Scheick, Steven Guertin, Duc Nguyen, JPL

The phenomenon of SDRAM cells that will not program after irradiation is examined. This study investigates the exact mechanism of a stuck bit in a commercial SDRAM. The device has non-intuitive effects for various operational modes.

W-9 Results of Single-Event Latchup Measurements Conducted by the Jet Propulsion Laboratory

Tetsuo F. Miyahira, Farokh Irom, JPL

This paper reports recent single-event latchup results obtained by Jet Propulsion Laboratory. Devices tested include digital, analog, and CMOS.

W-10 Results of Single-Event Transient Measurements Conducted by the Jet Propulsion Laboratory

Farokh Irom, Tetsuo F. Miyahira, JPL

This paper reports recent single-event transient results obtained by Jet Propulsion Laboratory. Devices tested include differential line receivers, drivers and transceiver.

W-11 Total Dose and Single Effect Characterization of ECL Devices

Surinder S. Seehra, Audrey J. Esteban, Stephen K. Moyer, Lockheed Martin Commercial Space Systems

Radiation and SEE susceptibility of ECL devices manufactured by ON Semiconductor was studied. Test data shows that these devices are highly susceptible to single event transients and upsets when bombarded with heavy ions.

W-12 Single Event Effects and Total Dose Test Results for TI TLK2711 Transceiver

R. Koga, P. Yu, J. George, The Aerospace Corporation

TLK2711 transceivers belonging to the Class V dice manufactured by Texas Instruments were tested for their sensitivity to radiation. We measured single event effects as well as total ionizing dose effects.

W-13 Single Event Gate Rupture Testing on 22A Gate Oxide Structures from a 90 nm Commercial CMOS Process

Reed K. Lawrence, BAE Systems

Single event gate rupture (SEGR) testing on existing structures from a commercial 90 nm electrical characterization drop-in test-site indicate that classical SEGR, as defined as catastrophic gate oxide breakdown, was not detected.

W-14 A Radiation Hardened High Voltage 16:1 Analog Multiplexer for Space Applications (NGCP3580)

Dennis Adams, Herbert Barnes, Michael Fitzpatrick, Norman Goldstein, William Hand, William Jackson, Henry Remenapp, Joseph Smith, Northrop Grumman Corporation; Rocky Koga, Aerospace Corporation

Northrop Grumman has developed a radiation hardened high voltage (±15 V) 16:1 analog multiplexer for space applications which is described. This device has completed qualification testing and has been in production since January, 2008.

W-15 Single Event Transient Event Rate Prediction Model for a Next Generation PLL

C. Hafer, J. Pfeil, D. Bass, A. Jordan, T. Farris, Aeroflex Colorado Springs

A predictive SET event frequency model is used to describe the SET performance at any operating condition of a next generation PLL with 187,392 combinations of operating conditions.

W-16 **Xilinx Virtex V Field Programmable Gate Array Dose Rate Upset Investigations**

Alonzo Vera, Daniel Llamocca, University of New Mexico; Joe Fabula, Xilinx; William Kemp, SES Consultants; Walter Shedd, David Alexander, Air Force Research Lab

The results of ionizing dose rate experiments on XC5VLX50T FPGAs demonstrate the most susceptible upset mechanism of commercial devices and provide insight into the effectiveness of dose rate hardening of nano-scale technology by using epi substrates.

W-17 **On the Static Cross Section of SRAM-Based FPGAs**

A. Manuzzato, S. Gerardin, A. Paccagnella, Università di Padova; L. Sterpone, M. Violante, Politecnico di Torino

We present new experimental results about the sensitivity of SRAM-based FPGAs to heavy-ions. We analyze the static cross section as a function of the resource type, accumulated total dose, and investigate the occurrence of MBUs.

W-18 **Static Upset Characteristics of the 90 nm Virtex-4 QPro-V FPGAs**

Gary M. Swift, Carl Carmichael, Chen Wei Tseng, Greg Miller, Xilinx, Inc.; Gregory R. Allen, JPL; Jeffrey S. George, The Aerospace Corporation

Consortium single-event measurements for three of the latest generation of radiation-tolerant reconfigurable FPGAs from Xilinx (90 nm, copper-interconnected, thin-epitaxial CMOS) are presented. Results include high-temperature latchup immunity and a low SEFI rate (~one/device-century in GEO).

W-19 **Remote SEE Testing Capabilities with Heavy Ions and Laser Beams at CYCLONE-HIF and ATLAS Facilities**

P. Peronnard, R. Velazco, G. Foucard, TIMA; V. Pouget, IMS; G. Berger, F. Charlier, F. Boldrin, UCL

A state-of-the-art electronic testbed is presented that was successfully used for implementing remote SEE testing capabilities at two European facilities. This new approach proves to be a flexible, cost effective and complete test solution.

W-20 **Low Dose Rate Test Results of National Semiconductor's ELDRS-Free Bipolar Amplifier LM124, and Comparators LM139 and LM193**

Larry McGee, Kirby Kruckmeyer, Bill Brown, National Semiconductor

We present the low dose rate and high dose rate test results and drift data for National Semiconductor's "ELDRS-free" bipolar amplifier LM124 and comparators LM139 and LM193.

W-21 **Neutron Soft Errors in Xilinx FPGAs at Lawrence Berkeley National Laboratory**

Jeffrey George, Rocky Koga, The Aerospace Corporation; Margaret A. McMahan, Lawrence Berkeley National Laboratory

The Lawrence Berkeley National Laboratory cyclotron offers broad-spectrum neutrons for single event effects testing. We present results from this beamline for neutron soft upsets in Xilinx Virtex-4 and -5 FPGA devices.

W-22 **New Proton Irradiation Facility at Paul Scherrer Institute**

U. Grossner, W. Hajdas, K. Egli, R. Brun, Paul Scherrer Institute; R. Harboe-Sørensen, ESA/ESTEC

A new Proton Irradiation Facility for space- and particle-physics communities was installed at PSI. Beam energies between a few MeV to 250 MeV with intensities up to 10 nA and uniform profiles cover up to tens-cm^2-sized targets.

W-23 **Total Ionizing Dose and Dose Rate Effects in Candidate Spacecraft Electronic Devices**

Alexander L. Bogorad, Justin J. Likar, Stephen K. Moyer, Audrey J. Esteban, Graham P. Doorley, Roman Herschitz, Lockheed Martin Commercial Space Systems

Total dose tests of common devices reveal unexpected dose rate sensitivity. Devices from same vendor procured to SMD versus military specifications exhibit drastically different dose rate effects. Behavior and critical parameters are compared and discussed.

W-24 **Evaluation of Static and Dynamic Performance of Silicon-Based Bipolar Phototransistors Under Radiation**

Gianandrea Quadri, Olivier Gilard, Jean-Luc Roux, Centre National d'Etudes Spatiales; Piero Spezzigu, Laurent Bechou, Yves Ousten, Université Bordeaux; Massimo Vanzi, Università degli Studi di Cagliari; Dominique Gibard, Codechamp

Total dose and displacement damage irradiations were performed on two references of silicon-based bipolar phototransistors. The main results are presented in this paper.

W-25 **Standard Practice for Dosimetry for Proton Beams for use in Radiation Effects Testing**

Ewart Blackmore, TRIUMF; Ethan W. Cascio, Massachusetts General Hospital; Carlos Castaneda, University of California at Davis; Margaret A. McMahan, Lawrence Berkeley National Laboratory; Barbara von Przewoski, Indiana University Cyclotron Facility

Representatives of facilities that routinely deliver protons for radiation effect testing are collaborating to establish a set of standard best practices for proton dosimetry. These best practices will be submitted to ASTM for adoption.

4:30 PM END OF THURSDAY SESSIONS

5:15 – 6:30 PM **RADIATION EFFECTS COMMITTEE OPEN MEETING**
ARIZONA BALLROOMS 6 – 7

ARIZONA BALLROOMS 6 – 7
INVITED TALK
8:30 – 9:30 AM

Small Stuff in Space: From Micro and Nano Technologies to Space Debris
Ann Garrison Darrin, Johns Hopkins University Applied Physics Laboratory

Sweating the Small Stuff.....from micron and nanoscale devices and components to the smallest of space debris, this talk covers the man made objects in space from 10^{-3} to 10^{-9} meters. Positive applications of Micro Electro Mechanical Systems (MEMS) have been demonstrated in space flight applications and will be discussed. These micron scale systems are giants compared to the emerging field of nanotechnologies. In spite of what is often a great deal of 'hype,' nanotechnologies are now found in valuable space flight applications. After reviewing the positive benefits of small man made components we will review the counter. That is the corollary to these micro miniature man made items is the small debris fields from dust to small paint flecks and their role and deleterious effects.

Ann Garrison Darrin is a member of the Principal Professional Staff and Group Manager in the Research Center at the Johns Hopkins University Applied Physics Laboratory. She is the author and editor of the book 'MEMS and Microstructures in Aerospace Applications' (CRC Publishers). Prior to joining JHUAPL she was an Aerospace Engineer at NASA Goddard Space Flight Center and the Division Chief for Parts, Packaging and Materials Sciences.

SESSION H
9:30 AM

HARDENING BY DESIGN
SESSION INTRODUCTION
Chair: Nathan Nowlin, Sandia National Laboratories

H-1
9:35 AM

Self-Voting Dual-Modular-Redundancy Circuits for Single-Event-Transient Mitigation
John Teifel, Sandia National Laboratories

Dual-modular-redundancy (DMR) architectures use logic duplication and self-voting asynchronous circuits to mitigate single event transients. Benchmark ASIC circuits designed with DMR logic show a 10-33% area improvement over conventional triple-modular-redundancy (TMR) architectures.

H-2
9:50 AM

Single-Event Effect Mitigation in Switched-Capacitor Comparator Designs
Brian D. Olson, W. T. Holman, L. W. Massengill, B. L. Bhuva, Vanderbilt University; P. R. Fleming, BAE Systems

A radiation-hardened-by-design technique is described for hardening the floating amplifier inputs of a switched-capacitor comparator. The technique is shown to significantly outperform the alternative design choice of increasing capacitor size.

H-3
10:05 AM

A Radiation-Hardened-by-Design Voltage-Controlled-Oscillator for Mixed-Signal Phase-Locked Loops
T. D. Loveless, L. W. Massengill, B. L. Bhuva, W. T. Holman, Vanderbilt University

A voltage-controlled-oscillator circuit has been designed for RHBD SET mitigation. The RHBD technique, which can be readily implemented in mixed-signal phase-locked-loops and delay-locked-loops, shows an 88% decrease in the output phase displacement following single-events.

H-4
10:20 AM

Quantifying the Effect of Guard Rings and Guard Drains in Mitigating Charge Collection and Charge Spread

Balaji Narasimham, Robert L. Shuler, Bharat L. Bhuva, Vanderbilt University; Jody Gambles, NASA JSC

3D-TCAD simulations in a 130-nm process are used to show the effect of guard rings and guard drains in mitigating charge collection and charge sharing between nodes. Experimental results indicating reduction in collected charge are presented.

POSTER PAPERS

PH-1

Design Implications of Single Event Transients in a Commercial 45 nm SOI Device Technology

A. J. KleinOsowski, Ethan H. Cannon, Phil Oldiges, Larry Wissel, IBM; Jonathan A. Pellish, Vanderbilt University

This paper presents modeling and measurements of single event transients in a commercial 45 nm SOI device technology. SETs in clock circuits and pass gates can cause upsets in circuit structures hardened against single event upsets.

PH-2

Comparison of Dual-Rail and TMR Logic Cost Effectiveness and Suitability for FPGA's with Reconfigurable SEU Tolerance

Robert L. Shuler, NASA Johnson Space Center; Bharat Bhuva, Vanderbilt University; Jody W. Gambles, University of Idaho; Sana Rezgui, Actel Corporation

We describe a reprogrammable FPGA architecture piecewise configurable for SEU/SET tolerant or single string applications, and evaluate duplicated vs. TMR logic as to area, speed, robustness and SEU rates. Test results at 180 nm are presented.

PH-3

A Double-Power-MOSFET Circuit for Protection from Single Event Burnout

Joseph Barak, Avner Haran, David David, Meir Shimshon Rapaport, Soreq NRC

We propose circuits which utilizes two power MOSFETs connected in series to replace a power MOSFET which is sensitive to SEB. The MOSFETs protect one another from SEB. The circuits were tested using heavy ions and alpha particles.

10:35 AM – 11:05 AM
ARIZONA FOYER

BREAK

SESSION I
11:05 AM

PHOTONIC DEVICES AND INTEGRATED CIRCUITS

SESSION INTRODUCTION

Chair: Scott Messenger, Naval Research Laboratory

I-1
11:10 AM

Radiation Effects on Silica-Based Preforms and Optical Fibers - I: Experimental Study with Canonical Samples

S. Girard, C. Marcandella, N. Richard, J. Baggio, P. Paillet, CEA/DIF; Y. Ouerdane, G. Origlio, A. Boukenter, J-P. Meunier, LaHC, UMR-CNRS; M. Cannas, R. Boscaino, Università di Palermo

The influence of the F- and Ge-doping on the fiber radiation responses is investigated through online measurements of the UV-visible induced attenuation and spectroscopic studies (ESR, confocal microscopy of luminescence) on prototype samples.

I-2
11:25 AM

Radiation Effects in InGaAs and Microbolometer Infrared Sensor Arrays for Space Applications

Gordon R Hopkinson, Surrey Satellite Technology Ltd; Reno Harboe-Sørensen, Bruno Leone, Roland Meynart, Ali Mohammadzadeh , ESA/ESTEC; Wilfried Rabaud, CEA - LETI

Cobalt-60, 60 MeV proton and heavy ion tests have been performed on InGaAs and amorphous silicon microbolometer arrays with CMOS readout circuits. The readout circuits showed latch-up at threshold LET ~ 14 MeV/mg/cm^2.

I-3
11:40 AM

Total Dose Evaluation of Deep Submicron CMOS Imaging Technology Through Elementary Device and Pixel Array Behaviour Analysis

Vincent Goiffon, Pierre Magnan, Université de Toulouse, ISAE; Olivier Saint-Pé, EADS Astrium; Frédéric Bernard, Guy Rolland, Centre National d'Etudes Spatiales

Ionizing radiation effects on CMOS image sensors implemented in 0.18 μm imaging technology are presented through the analysis of the behaviour of both elementary devices such as photodiodes, gated diodes, MOSFETs and also pixel array.

I-4
11:55 AM

In Situ Irradiation and Measurement of Triple Junction Solar Cells at Low Intensity, Low Temperature (LILT) Conditions

M. Imaizumi, Japanese Aerospace Exploration Agency; R. D. Harris, JPL; R. J. Walters, J. R. Lorentzen, J. G. Tischler, Naval Research Laboratory; T. Ohshima, S. Sato, Japanese Atomic Energy Agency

The performance of triple junction solar cells has been studied following low temperature irradiation while using low intensity illumination. These conditions reflect those found for deep space, solar powered missions far from the sun.

POSTER PAPERS

PI-1

Radiation Effects on Silica-Based Preforms and Optical Fibers - II: Coupling Ab Initio Simulations and Experiments

S. Girard, N. Richard, P. Paillet, CEA/DIF; Y. Ouerdane, G. Origlio, A. Boukenter, J-P. Meunier, LaHC, UMR-CNRS; L. Martin-Samos, Università degli Studi di Modena; M. Cannas, R. Boscaino, Università di Palermo

Both experimental and theoretical approaches are combined to study the nature of precursor sites and radiation-induced point defects in pure and germanium-doped amorphous silica-based glasses.

PI-2

Prediction of Corning InfiniCor 300 Optical Fiber Attenuation at Low Gamma Dose Rates

Keith E. Holbert, D. Michael Geschke, Ryan M. Stewart, Arizona State University; A. Sharif Heger, Los Alamos National Laboratory

Experiments using dose rates of 40 and 1270 rads/min and dual optical wavelengths, 850 and 1310 nm, are conducted to estimate fiber optic attenuation at other dose rates using low order kinetics models.

PI-3 **Characterization of Noise and Radiation Damage Induced in Silicon Photomultipliers by 14 MeV Electron Irradiation**

S. Sanchez Majos, P. Achenbach, J. Pochodzalla, Inst. Kernphysik, Johannes Gutenberg-Univ.

Radiation damage in silicon photomultipliers was studied with 14 MeV electrons at the Mainz microtron. A Monte Carlo model was developed to extract physical parameters of the diodes before and after irradiation.

12:10 PM END OF CONFERENCE