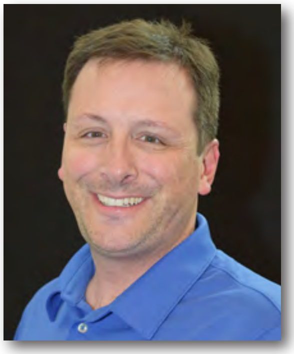
Technical Program

TECHNICAL INFORMATION



"On behalf of the Technical Program Committee, I invite you to attend the 2023 NSREC Technical Program. Rapid advancements in microelectronics, significant new investments on the horizon, and ever-expanding mission scope make events like NSREC more important than ever. Students and seasoned professionals alike will benefit from broad topic coverage and robust technical debates. The chairpersons for these eleven sessions will assemble an exceptional program covering the latest developments in nuclear and space radiation effects. I look forward to working with all the session chairs, reviewers, and authors who will contribute to an outstanding technical program."

Jonny Pellish, NASA,
Technical Program Chair

The NSREC technical program consists of contributed oral and poster papers, a data workshop, and invited talks. The oral presentations will be 12 minutes in duration with an additional three minutes for questions. The technical sessions and their chairpersons are::

- **Basic Mechanisms**
  Chair: Ani Khachatrian, U.S. Naval Research Laboratory
- **Dosimetry and Facilities**
  Chair: Richard Sharp, Radtest Ltd.
- **Hardening by Design**
  Chair: Paula Chen, AMD, Inc.
- **Hardness Assurance: Piece Parts to Systems and Testing Approaches**
  Chair: Courtney Matzkind, Missile Defense Agency
- **Photonic Devices and Integrated Circuits**
  Chair: George Tzintzarov, The Aerospace Corporation
- **Radiation Effects in Devices and Integrated Circuits**
  Chair: Rudy Ferraro, CERN
- **Single-Event Effects: Devices and Integrated Circuits**
  Chair: Françoise Bezerra, CNES
- **Single-Event Effects: Mechanisms and Modeling**
  Chair: Jason Osheroff, NASA Goddard Space Flight Center
- **Space and Terrestrial Environments**
  Chair: Scott Messenger, Northrop Grumman Corporation
- **Poster Session**
  Chair: Jeff George, Los Alamos National Laboratory
- **Radiation Effects Data Workshop**
  Chair: Andrea Coronetti, CERN

POSTER SESSION

Those papers that can be presented more effectively in a visual format with group discussion will be displayed in the Poster Session in the Chicago Ballroom. The formal Poster Session will be held on Wednesday from 1:45 – 4:30 PM and the authors will be available at that time to discuss their work. The Poster Session is chaired by Jeff George from Los Alamos National Laboratory.

RADIATION EFFECTS DATA WORKSHOP

Workshop papers provide piece part radiation response data and radiation test facilities technical information. The intent of the workshop is to provide data and facilities information to support design and radiation testing activities. Workshop papers can be viewed Tuesday through Friday in the the New York Ballroom. Authors will be available on Thursday to discuss their work from 1:45 – 4:30 PM. A workshop record will be provided to all registered conference attendees. The Data Workshop chair is Andrea Coronetti from CERN.

Technical Program

INVITED SPEAKERS

There will be three invited speakers

- **Negro League Baseball—The Giants. Why is it important to us today?**
  Phil S. Dixon, Researcher, Writer, and Co-Founder of the Negro League Baseball Museum, Kansas City, Missouri
- **Brewing Beer: Process Overview from Grain to Package**
  Rob Odell, Filtration Supervisor,
  Taran Winnie, Brewing Team Member
  Boulevard Brewing Company, Kansas City, Missouri
- **Kansas City National Security Campus Through the Decades**
  John Jungk, Ph.D., Chief Technology Officer, Honeywell Federal Manufacturing & Technologies, Kansas City, Missouri

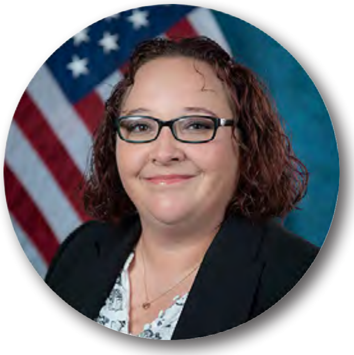
LATE-NEWS PAPERS

A limited number of late-news papers will be accepted and included in the Poster Session and the Radiation Effects Data Workshop. The submission window for these newsworthy papers will be open from April 14, 2023 through May 12, 2023. Detailed instructions for submitting late-news summary will be available on the NSREC website at ***www.nsrec.com.***

Session Chairs

Ani Khachatrian,
U.S. Naval Research Laboratory
Basic Mechanisms of Radiation Effects

Richard Sharp,
Radtest Ltd.
Dosimetry



Courtney Matzkind,
Missile Defense Agency
Hardness Assurance—Piece Parts to Systems and Testing Approaches

Paula Chen,
AMD, Inc.
Hardening by Design

Rudy Ferraro,
CERN
Radiation Effects in Devices and Integrated Circuits

George Tzintzarov,
The Aerospace Corporation
Photonic Devices and Integrated Circuits

Jason Osheroff, NASA Goddard Space Flight Center
Single-Event Effects: Mechanisms and Modeling

Françoise Bezerra,
CNES
Single-Event Effects: Devices and Integrated Circuits

Scott Messenger,
Northrop Grumman Corporation
Space and Terrestrial Environments

Technical Program Tuesday

EXHIBIT HALL B

8:15 AM **OPENING REMARKS**
Keith Avery, Air Force Research Laboratory, General Chairman

8:20 AM **AWARDS PRESENTATION**
Robert Reed, Vanderbilt University, Radiation Effects Steering Group, Executive Chair

9:05 AM **TECHNICAL SESSION OPENING REMARKS**
Jonathan Pellish, NASA Goddard Space Flight Center, Technical Program Chair

SESSION A RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS

9:10 AM SESSION INTRODUCTION
Chair: Rudy Ferraro, CERN

A-1 9:15 AM Origin of Post-Irradiation Vt-Loss Variability in 3-D NAND Memory Array

M. Kumar[1], M. Raquibuzzaman[1], M. Buddhanoy[1], T. Boykin1, B. Ray[1]
1. University of Alabama in Huntsville, USA

We measure total-ionizing-dose induced threshold-voltage (Vt) loss of commercial 64-layer 3-D NAND memory. Measurements show significant Vt-loss variability among the memory cells which we model using pre-existing trap-states in the tunnel oxide and Poly-Si interface.

A-2 9:30 AM Total Ionizing Dose Effects in 3D NAND Replacement Gate Flash Memory Cells

M. Bagatin[1], S. Gerardin[1], A. Paccagnella[1], S. Beltrami[2]
1. University of Padova, Italy
2. Micron Technology, Italy

Total ionizing dose effects in 3D NAND flash memories with replacement gate technology are evaluated. Threshold voltage shifts, underlying mechanisms, and bit error rates are studied and compared with 3D cells with floating gate technology.

A-3 9:45 AM Radiation-Induced Effects in SiC Vertical Power MOSFETs Irradiated at Ultra-High Doses

C. Martinella[1], S. Bonaldo[2], S. Race[1], N. Fuer[1], S. Mattiazzo[3], M. Bagatin[2], S. Gerardin[2], A. Paccagnella[2], U. Grossner[1]
1. ETH Zurich - APS Laboratory, Switzerland
2. University of Padova, Italy
3. University of Padova - INFN, Italy

TID effects in SiC are evaluated by DC measurements at ultra-high 10-keV X-ray doses up to 100 Mrad(SiO2). Significant parametric shifts are observed depending on the bias condition and on the technology generation.

A-4
10:00 AM

Radiation-Induced Charge Trapping in Shallow Trench Isolations of FinFETs

S. Bonaldo[1], T. Wallace[2], H. Barnaby[2], G. Borghello[3], G. Termo[3], F. Faccio[3], D. Fleetwood[4], A. Baschirotto[5], S. Mattiazzo[1], M. Bagatin[1], A. Paccagnella[1], S. Gerardin[1]

1. University of Padova, Italy
2. Arizona State University, USA
3. CERN, Switzerland
4. Vanderbilt University, USA
5. University of Milano Bicocca, Italy

TID mechanisms in Si FinFETs are investigated through DC measurements and TCAD simulations. Results show that transconductance degradation and leakage current increase due to non-uniform generation of trapped charges in STI.

10:15 AM – 10:45 AM
EXHIBIT HALL A

BREAK

A-5
10:45 AM

Ion-Induced Stuck Bits in 5-nm bulk FinFET SRAMs at High Fluences

Y. Xiong[1], N. Pieper[1], N. Dodds[2], G. Vizkelethy[2], N. Nowlin[2], B. Bhuva[1]

1. Vanderbilt University, USA
2. Sandia National Laboratories, USA

Experiments were performed to search for single-ion-induced displacement damage effects in 5-nm FinFET SRAM arrays. Stuck bits were observed that are consistent with cumulative displacement damage effects and inconsistent with other possible failure mechanisms.

A-6
11:00 AM

Total Ionizing Dose Response of 128 Analog States in Computational Charge-Trap Memory

T. Xiao[1], D. Wilson[2], C. Bennett[1], B. Feinberg[1], D. Hughart[1], V. Agrawal[3], H. Puchner[3], M. Marinella[2], S. Agarwal[1]

1. Sandia National Laboratories, USA
2. Arizona State University, USA
3. Infineon Technologies, USA

The total ionizing dose response of analog memory states (128 levels/device) in 40 nm SONOS charge-trap memory was experimentally characterized to 1.5 Mrad(Si), and the image recognition accuracy of SONOS analog accelerators under radiation was simulated.

POSTER PAPERS

PA-1 Radiation Response of Domain-Wall Magnetic Tunnel Junction Logic Devices

C. Bennett[1], T. Xiao[1], T. Leonard[2], J. Young[1], G. Vizkelethy[1], E. Bielejec[1], D. Hughart[1], M. Marinella[3], J. Incorvia[2]

1. Sandia National Laboratories, USA
2. University of Texas, Austin, USA
3. Arizona State University, USA

Domain-wall magnetic tunnel junction (DW-MTJ) parts were exposed to total ionizing doses, ion displacement damage, or both. The parts demonstrated resilience to ionizing radiation, but degraded similarly to other MTJs in response to heavy ions.

PA-2 Total-Ionizing-Dose Effects in IGZO Thin-Film Transistors with SiO2 Tunnel Layers

Z. Guo[1], E. Zhang[1], D. Fleetwood[1], R. Schrimpf[1], R. Reed[1], A. Chasin[2], J. Mitard[2], D. Linten[2], A. Belmonte[2], G. Kar[2]

1. Vanderbilt University, USA
2. imec, Belgium

TID effects are evaluated in IGZO thin-film transistors irradiated under different gate biases. The largest degradation occurs at negative bias. Comparison with back-gated devices indicates that hydrogen plays an important role in degradation.

PA-3 Impact of Back-Gate Bias on the DSOI SRAMs Under Total Ionizing Dose Irradiation

H. Ren[1], F. Liu[1], B. Li[1], Z. Han[1], S. Chen[1], L. Wang[1], S. Ma[1], G. Zhang[1], J. Li[1], P. Cui[1], J. Gao[1], J. Wan[2], H. Wang[3]

1. Institute of Microelectronics and Key Laboratory of Science and Technology on Silicon Devices, Chinese Academy of Sciences, University of Chinese Academy of Sciences, China
2. State Key Lab of ASIC and System, Fudan University, China
3. College of IoT Engineering, Hohai University, China

The impact of back-gate bias and film thickness on TID effect of Double-SOI SRAM are experimentally compared with and without floating body devices. Negative back-gate bias can efficiently improve TID tolerance with thin film.

PA-4 The Effects of Threshold Voltage and Number of Fins per Transistor on the TID Response of GF 12LP Technology

A. Vidana[1], J. Trippe[1], N. Dodds[1], N. Nowlin[1], J. Kauppila[2], L. Massengill[2], H. Barnaby[3]

1. Sandia National Laboratories, USA
2. Reliable MicroSystems, USA
3. Arizona State University, USA

We present experimental total ionizing dose data on GlobalFoundries 12LP 12 nm FinFET technology. The TID response depends on both the transistor threshold voltage and on the number of fins per transistor.

PA-5

Bias Dependence of Total Ionizing Dose Effect in Top-Gate CNTFET

H. Ding[1], Q. Zheng[1], H. Xu[2], C. Jiangwei[1], N. Gao[3], M. Xun[1], Y. Gang[1], C. He[1], Y. Li[1], Q. Guo[1]

1. *Xinjiang Technical Institute of Physics and Chemistry, Chinese Academy of Sciences (CAS), China*
2. *Shanxi Institute for Carbon-based Thin Film Electronics, Peking University, China*
3. *Beijing Institute of Carbon-based Integrated Circuits, China*

The bias dependence of TID in top-gate CNTFET is studied in this paper. ON state is the worst bias condition for the threshold voltage degradation. Abnormal shift of threshold voltage is found under TG bias.

PA-6

Towards Ensuring SRAM-PUF Integrity Under Ionizing Radiation

U. Surendranathan[1], H. Wilson[1], A. Milenkovic[1], B. Ray[1]

1. *University of Alabama in Huntsville, USA*

Power-up states of SRAM chips are routinely used to derive their PUFs. This paper shows that the data stored in SRAM during irradiation as well as the technology-node impact integrity of SRAM PUFs.

SESSION B
11:15 AM

SINGLE-EVENT EFFECTS: MECHANISMS AND MODELING

SESSION INTRODUCTION

Chair: Jason Osheroff, NASA Goddard Space Flight Center

B-1
11:20 AM

Depth Dependence of Neutron-induced Errors in 3D NAND Floating Gate Cells

S. Gerardin[1], M. Bagatin[1], A. Paccagnella[1], S. Beltrami[2], A. Benvenuti[2], C. Cazzaniga[3]

1. *University of Padova, Italy*
2. *Micron Technology, Italy*
3. *STFC, United Kingdom*

The sensitivity of vertical-channel 3D NAND Flash memories to wide-energy spectrum neutrons is investigated, through experiments and simulations, as a function of cell depth in the pillars.

B-2
11:35 AM

Single-Event Burnout in Vertical PtOx/β-Ga2O3 Schottky Diodes with Extreme-k TiO2 Field Plates

S. Islam1, A. Senarath1, D. Ball1, A. Sengupta1, E. Zhang1, D. Fleetwood1, R. Schrimpf1, F. Esmat2, N. Hendricks2, J. Speck2

1. *Vanderbilt University, USA*
2. *University of California, Santa Barbara, USA*

Structural and process changes to vertical β-Ga2O3 Schottky diodes enable significantly improved electrical performance. Enhanced resistance to ion-induced burnout is demonstrated via alpha particle and Cf-252 testing.

11:50 AM - 1:15 PM
EXHIBIT HALL A

LUNCH

B-3
1:15 PM

Single Event Transient in Body Contacted PDSOI Technology: Compact Modeling and Statistical Experimental Calibration

N. Rostand[1], D. Lambert[1], O. Duhamel[1], M. Gaillardin[1], M. Raine[1], S. Vigne[1], M. Sall[1], C. Grygiel[1]

1. CEA, France

We propose a Single Event Transient compact model for 65nm Body Contacted PDSOI technology along with TCAD analysis and experimental statistical calibration based on the collected charge.

B-4
1:30 PM

The Contribution of Secondary Alpha Particles to Soft Error Rates in Space Systems

R. Cadena[1], N. Dodds[2], K. Warren[1], B. Sierawski[1], R. Reed[1], D. Ball[1], R. Schrimpf[1]

1. Vanderbilt University, USA
2. Sandia National Laboratories, USA

The importance of including secondary particles in environment simulations is demonstrated by comparing MRED and CREME96 simulations. CREME96 underpredicts the flux of secondary alpha particles, which can cause an artificially low soft error rate calculation.

POSTER PAPERS

PB-1

Investigation of the Impact of Angles and Rotation of Low Energy Protons in SRAM Cells Beyond 16nm

L. Artola[1], M. Glorieux[2], G. Hubert[1], C. Inguimbert[1], T. Bonnoit[2], R. Rey[1], T. Lange[2], D. Levacq[3], C. Poivey[3]

1. ONERA, France
2. IROC Technologies, France
3. ESA, Netherlands

This work presents the impact of the angle of incidence of low-energy protons in SRAM cells of several deep sub-micron technologies. Experimental data are presented and discussed with the support of multi-physics and multi-scales simulations.

PB-2

Using Track Structure Theory to Predict Heavy-Ion and Neutron Cross-Sections

D. Hansen[1], S. Resor[1], D. Czajkowski[1], B. Vermeire[1]

1. Space Micro, USA

This paper uses a track structure theory (TST) model for the calculation of 14 MeV neutron, and heavy-ion cross-sections from measured data. The TST model performs well compared to other models in the literature.

PB-3

Influence of Well Contact on Single Event Transient in Sub-20 nm FinFET Process

Q. Sun[1], Y. Guo[1], B. Liang[1], M. Tao[2], Y. Chi[1], P. Huang[1], Z. Wu[1], J. Chen[1], D. Luo[1], H. Sun[1]

1. National University of Defense Technology, China
2. College of Electrical and Information Engineering, Hunan University, China

This paper discusses the influence of well contact on SET in sub-20 nm FinFET. Experiment and high-precision TCAD simulation results show that well contact has less impact on SET, which is different from planar CMOS.

PB-4 **Quantitative Analysis on Multi-Factor Coupling Influence Effects of Single Event Transient Characteristic Dependence of 22 nm FDSOI Circuits**

L. Tongde[1], *Z. Yuanfu*[1]

1. Beijing Microelectronics Technology Institute, China

A 22nm FDSOI test chip is designed for obtaining SET characteristics. The contribution of the influencing factors is quantified. The research results can support the flexible selection of low-cost radiation hardened methods considering conventional performance.

PB-5 **Laser-Induced Micro-SEL Current Profile Modeling for High-Accuracy ML-Based Micro-SEL Detection**

J. Zhao[1], *Y. He*[1], *Z. Qin*[1], *K. Chong*[2], *W. Shu*[2], *Y. Sun*[1], *P. Chan*[1], *J. Chang*[1,2]

1. Nanyang Technological University, Singapore
2. Zero-Error Systems Pte Ltd, Singapore

We present a novel laser-induced micro-Single-Event-Latchup current-profile model for Machine-Learning-based micro-SEL detection. The detection accuracy and delay are improved to ~95% from ~73% and to the microseconds range, respectively, thereby rendering practical real-time detection.

SESSION C BASIC MECHANISMS OF RADIATION EFFECTS

1:45 PM SESSION INTRODUCTION

Chair: Ani Khachatrian, Naval Research Laboratory

C-1 **Effects of Interface Traps on the Low-Frequency Noise of Irradiated MOS Devices**
1:50 PM

D. Fleetwood[1], *E. Zhang*[1], *R. Schrimpf*[1], *S. Pantelides*[1], *S. Bonaldo*[2]

1. Vanderbilt University, USA
2. University of Padova, Italy

Experimental results suggest that interface traps may contribute significantly to the low-frequency noise of some irradiated MOS devices. Hydrogen-induced trap activation and passivation are identified as likely origins of the observed fluctuations.

C-2 **Neutron Displacement Damage in Bipolar Junction Transistors Isolated from an Integrated Circuit**
2:05 PM

J. Young[1], *T. Ho*[2], *S. Banerjee*[1], *X. Gao*[1], *L. Musson*[1], *H. Barnaby*[2], *T. Buchheit*[1]

1. Sandia National Laboratories, USA
2. Arizona State University, USA

Lateral pnp and vertical npn transistors were isolated from the LM741 circuit and irradiated with 14 MeV neutrons. TCAD modeling confirms shortened minority lifetime responsible for gain degradation due to displacement damage.

C-3
2:20 PM

The Effects of Heavy Ion Induced Displacement Damage on WO3-x ECRAM

M. Marinella[1], C. Bennett[2], B. Zutter[2], M. Siath[1], G. Vizkelethy[2], T. Xiao[2], E. Fuller[2], D. Hughart[2], S. Agarwal[2], Y. Li[3], A. Talin[1]

1. Arizona State University, USA
2. Sandia National Laboratories, USA
3. University of Michigan, USA

Displacement damage in WO3-x ECRAM is experimentally characterized for the first time. At moderate levels, metal oxide ECRAM does not exhibit significant changes. At high displacement per atom levels, conductivity increases with increasing vacancy concentration.

C-4
2:35 PM

Analysis of Total Ionizing Dose Effects using Electron Holography

C. Chang[1], H. Barnaby[1], D. Smith[1], M. Mccartney[1], P. Apsangi[2], K. Muthuseenu[3], K. Holbert[1], A. Privat[1], B. Kennedy[1]

1. Arizona State University, USA
2. Tower Semiconductor, USA
3. Intel, USA

Electrical characterization and electron holography on metal-oxide-semiconductor devices confirm the presence of net positive oxide charge build-up after total-ionizing dose. Holography also identifies the buildup of net negative charge trapping near oxide-metal interface.

POSTER PAPERS

PC-1

Closing the “10-100 eV Gap” for Electron Thermalization in GaN Devices from First Principles

D. Nielsen[1], C. Van de walle[2], S. Pantelides[3], R. Schrimpf[3], D. Fleetwood[3], M. Fischetti[1]

1. University of Texas at Dallas, USA
2. University of California, Santa Barbara, USA
3. Vanderbilt University, USA

We report full-band Monte Carlo simulations of electron thermalization in GaN from 100 eV, where energy-loss processes are poorly known. Electrons thermalize in ~1 ps, generating electron-hole pairs with an average energy of ~9.4 eV/pair.

PC-2

Modeling of Total Ionizing Dose Effects in SOI FinFETs at High Temperature

X. Zhang[1], F. Liu[1], B. Li[1], Y. Huang[1], S. Chen[1], J. Li[1], T. Zhang[1], Q. Zhang[1], H. Yin[1], J. Wan[2], H. Wang[3], Y. Guo[4], J. Luo[1]

1. Institute of Microelectronics and Key Laboratory of Science and Technology on Silicon Devices, Chinese Academy of Sciences, China
2. State Key Laboratory of ASIC and System, Fudan University, China
3. College of IoT Engineering, Hohai University, China
4. Nanjing University of Posts and Telecommunications, China

Considering the repair effect of fixed-trapped charges and temperature dependence of threshold voltage, an electrostatic potential model of TID effect at high temperature is proposed for SOI FinFETs. Both simulations and experiments validate it.

PC-3 **Ultra-high Energy Heavy Ion Irradiation Effects on Carbon Nanotubes**

H. Shu[1], P. Lu[1], J. Gao[1], P. Zhao[2], M. Zhu[3], J. Yan[3], B. Li[1]
1. Institute of Microelectronics and Key Laboratory of Science and Technology on Silicon Devices, Chinese Academy of Sciences, China
2. Institute of Modern Physics, Chinese Academy of Sciences, China
3. School of Information Science and Technology, North China University of Technology, China

Ultra-high energy heavy ion irradiation causes physical interaction between carbon nanotubes and the SiO2 substrate, forming distinct micrometer-size damages. The damaged region close to the incident site is insulating while adjacent carbon nanotubes are relocated.

PC-4 **Investigation of Elements Migration of Organic-Inorganic Metal Halide Perovskite Films Materials Induced by Proton Irradiation**

X. Zhang[1], L. Wang[1], H. Zhu[1], P. Lu[1], X. Li[1], B. Li[1]
1. Institute of Microelectronics and Key Laboratory of Science and Technology on Silicon Devices, Chinese Academy of Sciences, China

XPS and EDS analytical technology were carried out to investigate the elements migration phenomenon in perovskite materials under high fluence proton irradiation. This basic analysis is advantageous to explore the high radiation resistance of perovskite..

2:50 PM – 3:20 PM
EXHIBIT HALL A
BREAK

SESSION D **SPACE AND TERRESTRIAL ENVIRONMENTS**
3:20 PM SESSION INTRODUCTION
Chair: Scott Messenger, Northrop Grumman Corporation

D-1 **Global Ionizing Radiation Environment Mapping Using Starlink Satellite Data**
3:25 PM

H. Shah[1], R. Van cleave[1], C. Jeffrey[1], K. Pham[1], Z. Fleetwood[1], S. Shermer[1]
1. SpaceX, USA

Global simultaneous spatiotemporal mapping of ionizing radiation environments is provided for the first time on the Starlink satellite fleet utilizing sensor and circuit detection methods.

D-2 **Radiation Environment in the Large Hadron Collider During the 2022 Restart and Related RHA Implications**
3:40 PM

K. Bilko[1], R. Garcia[2], Y. Aguiar[2], S. Danzeca[2], S. Girard[3], M. Sebban[3], S. Uznanski[2]
1. Université Jean Monnet, France
2. CERN, Switzerland
3. Université de Saint Etienne, France

Radiation levels measured in 2022 along the CERN Large Hadron Collider are presented, focusing on the TID comparison with the 2015-2018 years. Measurements from more than 750 SRAMs distributed across the accelerator are discussed.

D-3
3:55 PM

NAIRAS Atmospheric and Space Radiation Environment Model

C. Mertens[1], G. Gronoff[2], Y. Zheng[3], J. Buhler[4], E. Willis[5], M. Petrenko[3], D. Phoenix[2], I. Jun[6], J. Minow[5]

1. *NASA Langley Research Center, USA*
2. *Science Systems and Applications, Inc., USA*
3. *NASA Goddard Space Flight Center, USA*
4. *NASA Kennedy Space Center, USA*
5. *NASA Marshall Space Flight Center, USA*
6. *Jet Propulsion Laboratory, USA*

This paper describes the NAIRAS model now publicly available at NASA's Community Coordinated Modelling Center. NAIRAS predicts dosimetric and radiation flux quantities for assessing human radiation exposure and radiation effects to flight vehicle electronic systems.

4:10 PM END OF TUESDAY SESSIONS

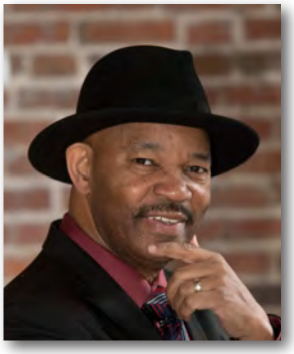
5:30 – 7:30 PM
EXHIBITOR RECEPTION

EXHIBIT HALL A

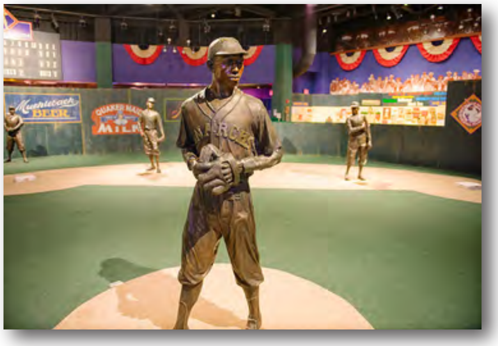
EXHIBIT HALL B
INVITED TALK
8:30 AM - 9:30 AM

Negro League Baseball—The Giants. Why is it important to us today?

Phil S. Dixon, Researcher, Writer, and Co-Founder of the Negro League Baseball Museum, Kansas City, Missouri



Phil S. Dixon is a road warrior, a veracious interviewer, a tireless researcher and writer who has interviewed over 500 players, wives and their offspring for a unique perspective of the American and Negro League baseball experience, works for which he won a SABR MacMillan Award (Society of American Baseball Researchers) for his excellence in historical research. He is best known for his 7 non-fiction books which includes "The Negro Baseball Leagues A Photographs History, 1867-1955," a Casey Award winner as the best baseball book of the year in 1992.



He is a proud member of SABR, the Missouri Writers Guild, the IBWAA (Internet Baseball Writers Association of America) and serves on the National Advisory Board for the Negro Leagues Baseball Museum. His work has been praised by a range of luminaries from Fay Vincent "Baseball Commissioner" to Stephen Jay Gould the famous "American Paleontologist." Dixon is a Humanities Kansas presenter and a past Missouri Humanities speaker. Dixon's most resent adventure was presenting in over 200 American cities and internationally into Canada with a presentation titled the "Kansas City Monarchs In Our Hometown," in an effort to improve race relations. In true barnstorming fashion, he drove the entire route that covered 17 states and over 75,000 miles. His presentations and books are a fluid mix for those who enjoy professional journalism that is both humorous and insightful. Phil's motto is "why bore your audiences and readers with sabermetrics when a touch of humor and non-sports history will suffice."

Baseball's quintessential barnstormer is a designation he embraces. His latest release, "The Dizzy and Daffy Dean Barnstorming Tour; Race, Media and America's National Pastime," continues that tradition. His writings are illustrated with stories and photographs which familiarize readers with baseball's forgotten Negro stars through primary source research obtained during his many years of dedication to this topic. In addition to books he owns copyrights for poems and a movie script. He is a true American griot and 40 years of presenting in the Negro League genre hasn't dulled his pursuit for greater knowledge.

Dixon left home at age-17 to pursue a musical career. He traveled the mid-west and Southern Chitlin' Circuit and journaled his experiences. He returned to Kansas City where he earned a bachelor's degree from the University of Missouri at Kansas City. His free-lance writing for the African American owned Kansas City Call led to a major league press pass, which eventually landed him a job with the American League Kansas City Royals where he worked in Public Relations. In 1990 he co-founded the Negro League Baseball Museum in Kansas City. Phil is the husband of Dr. (Kerry) his wife of 36 years, and father of three HBCU college graduates who represent: (Langston, Howard and Fisk). Dixon, a Kansan at birth, now makes his home in Missouri with the wife, the children, his trumpet and album collection while eagerly awaiting his weekly edition of the Kansas City Call.

EXHIBIT HALL B
SESSION E
9:30 AM

HARDNESS ASSURANCE: PIECE PARTS TO SYSTEMS AND TESTING APPROACHES

SESSION INTRODUCTION
Chair: Courtney Matzkind, Missile Defense Agency

E-1
9:35 AM

Quantitative Laser Testing for Predicting Heavy-Ion SEE Response – Part 1: Metrics for Assessing Response Agreement

A. Ildefonso[1], J. Hales[1], A. Khachatrian[1], G. Allen[2], D. Mcmorrow[1]
1. U.S. Naval Research Laboratory, USA
2. Jet Propulsion Laboratory, USA

An approach to quantitatively assess the agreement between laser- and ion-induced single-event transients is presented. While demonstrated with laser and ion data, this approach can be applied to other surrogates for heavy ion testing.

E-2
9:50 AM

Quantitative Laser Testing for Predicting Heavy-Ion SEE Response – Part 2: Accurately Determining Laser-Equivalent LET

J. Hales[1], A. Ildefonso[1], A. Khachatrian[1], G. Allen[2], D. McMorrow[1]
1. U.S. Naval Research Laboratory, USA
2. Jet Propulsion Laboratory, USA

An accessible approach for estimating the laser-equivalent LET for any laser geometry is presented and validated for various testing conditions. Such calculations are key for laser testing to serve as a surrogate for heavy-ion testing.

E-3
10:05 AM

In-Situ Observation of Circuit Behavior Using Pump-Probe Laser Voltage Probe Technique

M. King[1], J. Beutler[1], T. Meisenheimer[1], N. Smith[1], K. Mai[2], P. Mohan[2], O. Atli[2]
1. Sandia National Laboratories, USA
2. Carnegie Mellon University, USA

A novel combination of techniques provides feedback RHA and RHBD activities. A pump-probe TPA and LVP technique shows radiation response of a D-Flip-Flop and shows operational circuit response of simulated radiation events.

10:20 AM – 11:00 AM
EXHIBIT HALL A

BREAK

E-4
11:00 AM

SRAM Electrical Variability and SEE Sensitivity at 5-nm Bulk FinFET Technology

Y. Qian[1], N. Pieper[1], Y. Xiong[1], J. Pasternak[2], D. Ball[1], B. Bhuva[1]
1. Vanderbilt University, USA
2. Synposys, USA

Process-induced critical charge variability and SEE sensitivity for SRAM at 5-nm bulk FinFET technology are investigated. Results show laboratory-based electrical measurements do not accurately predict SE vulnerability of SRAMs at either cell-level or IC-level.

E-5
11:15 AM

Measuring Zero: Neutron Testing of Modern Digital Electronics

H. Quinn[1], G. Tompkins[1]

1. Los Alamos National Laboratory, USA

With the recent changes in transistor design has made it harder to measure neutron-induced single-event upset (SEU) cross sections. Statistical guidance is given for testing components that are designed to be SEU hardened.

E-6
11:30 AM

Probabilistic Risk Assessment of System-Level Radiation Effects Using Fault Tree Analysis

S. Lawrence[1], L. John[1], C. James[1], D. Loveless[1]

1. University of Tennessee at Chattanooga, USA

A new Probabilistic-Risk-Assessment methodology is used to predict radiation-induced unavailability for a system within an arbitrary environment. A study of the NASA SpaceCube processor in ISS and GEO environments justifies mitigation strategies and quantifies risk.

POSTER PAPERS

PE-1

Review of Artemis I Mission Radiation Challenges and Data for the Crew Module

C. Bailey[1], R. Gaza[1], C. Patel[2], J. Pritts[3], K. Nguyen[3]

1. NASA Johnson Space Center, USA
2. Lockheed Martin Corporation, USA
3. Jacobs Technology Incorporated, USA

We review the Artemis-I mission and corresponding radiation hardness assurance (RHA) process. We discuss the RHA methodologies employed, design challenges overcame, in-flight anomalies observed, and lessons learned from the mission and by the program.

PE-2

Under-Constrained SEE Data: Implications for Estimating and Bounding SEE Rates

R. Ladbury[1]

1. NASA Goddard Space Flight Center, USA

Increasingly scarce SEE testing resources and rapid growth of the New Space sector have in-creased the prevalence of under-constrained SEE data. We develop Monte Carlo tools to assess implications for SEE rate estimation.

PE-3

FIERA: An FPGA Emulation-based Hardware Soft Error Tolerance Evaluation Platform for SoCs

O. Atli[1], P. Mohan[1], M. King[2], K. Mai[1]

1. Carnegie Mellon University, USA
2. Sandia National Laboratories, USA

We introduce FIERA, an FPGA-accelerated flexible error injection tool 104x faster than RTL simulation-based methods. We demonstrate the FIERA by evaluating soft error vulnerabilities of SoCs under deep learning workloads and present our test chip.

PE-4 **A Confidence-Based Approach to Including Survivors in a Probabilistic TID Failure Assessment**

C. Champagne[1], B. Sierawski[1], R. Ladbury[2], M. Campola[2], D. Fleetwood[1]

1. Vanderbilt University, USA
2. NASA Goddard Space Flight Center, USA

A probabilistic TID failure assessment is extended to include survivor data. This enables a formal analysis of radiation tolerant devices tested to a maximum dose, as well as flight heritage, in a hardness assurance methodology.

PE-5 **Correlating Historical Device Degradation Data to Radiation-Induced Degradation System Effects for a LiDAR System**

R. Nederlander[1], A. Witulski[1], A. Sternberg[1], R. Reed[1], G. Karsai[2], R. Ladbury[3], E. Zhang[1], J. Evans[1], R. Schrimpf[1], K. Ryder[3], M. Campola[3], N. Mahadevan[2], R. Austin[3]

1. Vanderbilt University, USA
2. Institute for Software Integrated Systems, Vanderbilt University, USA
3. NASA Goddard Space Flight Center, USA

Bayesian fault probabilities are used to predict TID effects in systems. These probabilities are combined to predict system level effects on a LiDAR system. This model allows for efficient prescreening of radiation sensitive systems.

PE-6 **Applicability of the Accelerated ELDRS Test Method - Temperature Switching Irradiation**

X. Li[1], X. Wang[1], M. Liu[1], Y. Xin[1], Q. Zheng[1], J. Cui[1], Y. Li[1], W. Lu[1], Q. Guo[1]

1. Xinjiang Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, China

A temperature-switching irradiation (TSI) sequence based on first-principles understanding of inter-face-trap buildup and annealing is shown to be a conservative test for ELDRS at ultra-low dose rate in linear bipolar devices.

POSTER SESSION
11:45 AM

INTRODUCTION

Chair: Jeff George, Alamos National Laboratory

11:50 AM TO 1:30 PM

LUNCH / EXHIBIT RAFFLE
EXHIBIT HALL A

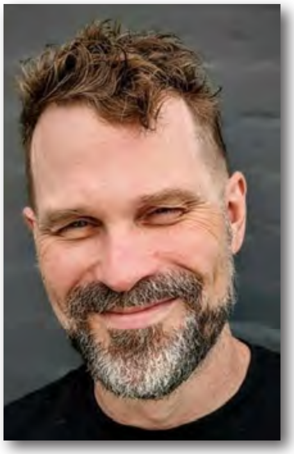
Technical Program Wednesday

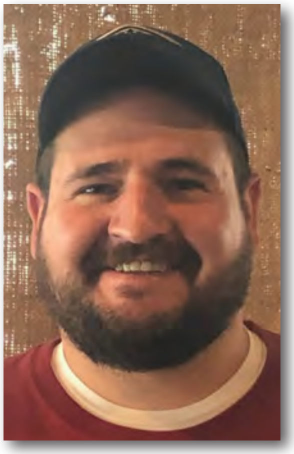
POSTER SESSION 1:45 PM TO 4:30 PM	CHICAGO BALLROOM
4:30 PM	END OF WEDNESDAY SESSIONS
6:00 PM TO 10:00 PM (Busses load at 5:30 PM)	**CONFERENCE SOCIAL** **NEGRO LEAGUES BASEBALL MUSEUM** **AND AMERICAN JAZZ MUSEUM**

EXHIBIT HALL B
INVITED TALK
8:30 - 9:30 AM

Brewing Beer: Process Overview from Grain to Package

Rob Odell, Filtration Supervisor, Boulevard Brewing Company, Kansas City, Missouri
Taran Winnie, Brewing Team Member, Boulevard Brewing Company, Kansas City, Missouri





It was the summer of 1984, and John McDonald was thirsty. On vacation in Europe, the future founder of Boulevard Brewing Company wandered into a bar specializing in Belgian beers. He tried one, then another and another, amazed by the variety, the aromas, and the flavors. He was hooked. Back home, John couldn't stop dreaming about those beers. But dreaming was all he could do, because American beers of the time were homogenous and unremarkable. Kansas City, once home to more than a dozen breweries producing a wide array of beers, had succumbed to the industrial onslaught. Nothing was left.

After art school John made his living as a carpenter, always fascinated by the creative process. He couldn't shake the memory of those amazing beers, and he began to wonder, began to consider the possibilities. He started homebrewing. He visited breweries. He put together a business plan, sold his house to raise money, and set out to find the rest of the resources he would need to start a brewery.

He didn't have to look far to get started. John lived and worked in an old brick building on Southwest Boulevard that had once housed the laundry for the Santa Fe Railroad. He moved his carpentry shop to a corner and began to build a brewery. It wasn't ideal, but it was his. It took more than a year and every bit of the money he'd raised to retrofit the building, find the equipment – including a vintage 35-barrel Bavarian brewhouse – and get everything up and running. Finally, in November 1989, the first keg of Boulevard Pale Ale was ready. John loaded it into the back of his pickup and delivered it to a restaurant just a few blocks away.

Word was spreading – Boulevard was making surprisingly good beer. The original business plan called for someday selling 6,000 barrels a year. By the third year sales passed 7,000 barrels, and continued to climb. Boulevard began selling its beers in neighboring cities and states. The original Bavarian brewhouse, designed to produce only a few thousand barrels a year, was approaching 100,000 barrels by 2004, turning out a dozen 1,000 gallon brews each and every day. But it had reached its limit, and a decision loomed.

When John built the brewery deep in the heart of a century-old urban neighborhood, he hadn't worried about outgrowing it. But it had happened. Now, consultants said the smart move was to relocate to a new site with plenty of room. But the brewery was tightly woven into the fabric of the city, and the Boulevard team was committed to its continued revitalization. So in 2006 a $25 million expansion project brought a new building with a 150-barrel brewhouse, packaging halls, offices and hospitality spaces.

For years John had been eager to drive more experimentation and innovation, but the continuing growth of Unfiltered Wheat Beer and Pale Ale meant the brewery's limited resources were devoted to the existing line-up. Now, with a new brewhouse, the team's creative energies were unleashed. The Smokestack Series was launched, featuring an ever-evolving array of even bigger, bolder beers.

Boulevard loves hosting visitors, but as time went on their limited capacity meant they were turning away tens of thousands of people every year. So, in 2016 they opened the Tours & Rec Center next door to the brewery. The fully restored 1929 building serves as a hub for tours, swag, sampling and entertainment, including an experience area with exhibits about beer and Boulevard, a gift shop, and a 10,000 square foot Beer Hall. In 2019, the Tours & Rec Center was further enhanced with the opening of the Rec Deck, a fourth floor gathering space featuring deck and tabletop shuffleboard (and of course, beer).

Mr. Odell has been with Boulevard since 2007. He has held various roles within the brewery, and is currently the Filtration Supervisor. Mr. Winnie joined the Boulevard brewing team in 2022. He's been working on the Brewhouse since arriving last year. Taran has been involved the industry since 2017 after finishing a Master's program in Brewing Science.

EXHIBIT HALL B
SESSION F
9:30 AM

PHOTONIC DEVICES AND INTEGRATED CIRCUITS

SESSION INTRODUCTION
Chair: George Tzintzarov, The Aerospace Corporation

F-1
9:35 AM

Online DCR Measurements in 150 nm CMOS SPADs Exposed to Low Neutron Fluxes

L. Ratti[1,5], P. Brogi[2,5], G. Collazuol[3,5], G. Dalla Betta[4,5], J. Delgado[3,5], P. Marrocchesi[2,5], J. Minga[1,5], F. Morsani[5], L. Pancheri[4,5], F. Pino[3,5], A. Selva[5], F. Stolzi[2,5], G. Torilla[1,5], C. Vacchi[1,5]
1. *University of Pavia, Italy*
2. *University of Siena, Italy*
3. *University of Padova, Italy*
4. *University of Trento, Italy*
5. *National Institute for Nuclear Physics, Italy*

Dark count rate is monitored in single- and dual-layer 150 nm CMOS SPADs, during and after irradiation with a neutron source, to investigate the dynamics of defect formation and short- and mid-term annealing.

F-2
9:50 AM

Effect of Energy, Flux and Bias Conditions on Proton-Irradiated CMOS Single Photon Avalanche Diodes

A. Jouni[1], V. Malherbe[2], B. Mamdy[2], T. Thery[2], V. Correas[2], S. De Paoli[2], V. Lalucaa[1], C. Virmontois[1], G. Gasiot[2], V. Goiffon[3]
1. *CNES, France*
2. *STMicroelectronics, France*
3. *ISAE-SUPAERO, France*

Different proton energies and fluxes were used to irradiate single photon avalanche diodes. Mean dark count rate increase slightly depends on the incident energy and discrepancies are underlined for different fluxes and bias conditions.

F-3
10:05 AM

Impact of Irradiation Temperature, Doping and Proton Energy on InGaAs Photodiodes

M. Benfante[1], J. Reverchon[1], C. Virmontois[2], S. Demiguel[3], V. Goiffon[4]

1. III-V Lab, France
2. CNES, France
3. Thales Alenia Space, France
4. ISAE-SUPAERO, France

In this work we show the effects of different parameters on the Dark Current-related Damage Rate. We investigate the proton energy effects with reverse bias, the effects of irradiation temperature and doping.

10:20 AM – 11:05 AM
PRE-FUNCTION

BREAK

F-4
11:05 AM

Effects of High Fluence Particle Irradiation on Silicon Photonics Photodiodes

L. Olantera[1], C. Scarcella[1], M. Lalovic[1], S. Detraz[1], C. Soos[1], T. Prousalidi[1], C. Sigaud[1], U. Sandven[1], J. Troska[1]

1. CERN, Switzerland

Germanium-on-Silicon photodiodes were irradiated with highly-energetic protons and neutrons to fluences exceeding 3x1016 particles/cm2. Observed changes in responsivity, dark current, and capacitance indicate excellent radiation tolerance that meets the requirements of next-generation high energy physics experiments.

F-5
11:20 AM

Analysis of Optical Single-Event Transients in Integrated Silicon Photonics Mach-Zehnder Modulators for Space-based Optical Communications

M. Hosseinzadeh[1], J. Teng[1], B. Ringel[1], D. Nergui[1], A. Ildefonso[2], A. Khachatrian[2], D. Mcmorrow[2], J. Cressler[1]

1. Georgia Institute of Technology, USA
2. U.S. Naval Research Laboratory, USA

Integrated SiPh MZMs are exposed to pulsed-laser-induced TPA, and the sensitivity to single-event transients is measured. A numerical model to predict the SET effects on SiPh MZM is developed, as well as a simulation path to validate the model.

F-6
11:35 AM

Temperature Cycling Effects on Infrared Radiation-Induced Attenuation of Silica-based Optical Fibers

M. Roche[1], A. Morana[1], E. Marin[1], A. Boukenter[1], Y. Ouerdane[1], G. Melin[2], T. Robin[2], N. Balcon[3], J. Mekki[3], S. Girard[1]

1. Laboratory Hubert Curien, France
2. iXBlue, France
3. CNES, France

Combined radiation and temperature cycling effects on the 1550 nm radiation-induced attenuation (RIA) levels and kinetics of three commercial optical fibers with different doping (Germanium, Fluor and Phosphorus) have been investigated.

POSTER PAPERS

PF-1 **TID-Induced Loss and Optical-Power Annealing of Straight and Curved Silicon Photonic Waveguides Using Pulsed X-rays**

B. Ringel[1], J. Teng[1], M. Hosseinzadeh[1], J. Heimerl[1], Z. Brumbach[1], A. Little[2], G. Tzintzarov[2], D. Monahan[2], S. Lalumondiere[2], J. Cressler[1]

1. Georgia Institute of Technology, USA
2. The Aerospace Corporation, USA

The TID response of straight and curved integrated silicon-photonic waveguides are evaluated. Transmission degradation, irrespective of curvature, was observed above 5 Mrad(Si). Optical-power-induced annealing due to heating was also observed and shown to recover performance.

PF-2 **Electrical Characteristics and Defect Dynamics Induced by Swift Heavy Ion Irradiation in ε-Ga_2O_3 Thin Films**

Y. Tang[1], Y. Yang[2], L. Wang[1], M. Li[1], H. Zhu[1], Z. Wu[2], B. Li[1]

1. Institute of Microelectronics and Key Laboratory of Science and Technology on Silicon Devices, Chinese Academy of Sciences, China
2. Beijing University of Posts and Telecommunications, China

1907 MeV Ta ions were employed to irradiate epitaxial ε-Ga_2O_3 thin films. Morphological variations and crystallographic transformations are observed in the post-irradiated films. Despite obvious degradation, ε-Ga_2O_3 photodetectors still operate normally under high irradiation fluences.

PF-3 **Influence of Hydrogen on the Radiation-Induced Attenuation of Ge-doped Optical Fiber**

A. Morana[1], M. Roche[1], E. Marin[1], A. Boukenter[1], Y. Ouerdane[1], S. Girard[1]

1. Laboratory Hubert Curien, France

We studied the combined radiation and hydrogen effects on the NIR attenuation of a standard Ge-doped fiber up to a dose of 100 kGy, to characterize the influence of the molecular or bonded atomic hydrogen.

PF-4 **Alpha Particle-Induced Persistent Effects in a COTS 3D-Integrated Imager**

M. Hu[1], M. Mccurdy[1], B. Sierawski[1], R. Schrimpf[1], R. Reed[1], M. Alles[1]

1. Vanderbilt University, USA

The nature and rate of alpha-particle-induced persistent effects observed in a heterogeneously integrated COTS 3D-IC imager are shown to be dependent on operating condition and the functional layer in which the alpha particles stop.

EXHIBIT HALL B
SESSION G **DOSIMETRY AND FACILITIES**
11:50 AM SESSION INTRODUCTION
Chair: Richard Sharp, Radtest Ltd

G-1
11:55 AM

Ultra-Large Silicon Solid-State Detector for Characterizing Low-Intensity Radiation Environments

K. Bilko[1], R. Garcia[2]
1. Université Jean Monnet, France
2. CERN, Switzerland

A large silicon solid-state detector is demonstrated as a solution for low-flux radiation field monitoring. The calibration of the detector is presented, with the measurements and simulations from the spectral neutron fields, e.g., atmospheric.

G-2
12:10 PM

Progress on a Modeling Framework for GaN FinFET Time-Dependent Responses after Radiation Damage

B. Davidson[1], A. Bahadori[1], K. Huddleston[1], M. Pfeifer[1], W. Mcneil[1], D. Mcgregor[1], S. Sharma[1], E. Giunta[1]
1. Kansas State University, USA

A simulation framework was developed to predict signal formation from radiation events in GaN-based semiconductors before and after ionizing radiation exposure. Progress on modeling response of a FinFET device is shown.

POSTER PAPERS

PG-1

Mixed-Field Radiation Monitoring and Beam Characterization Through Silicon Solid-State Detectors

K. Bilko[1], R. Garcia[2]
1. Université Jean Monnet, France
2. CERN, Switzerland

Silicon solid-state detector for the monitoring of the mixed radiation field is presented with the focus on the CERN’s CHARM facility. The use of the detector for indirect beam characterization is demonstrated.

PG-2

Correlative Single Event Latchup (SEL) Characterization of the ADMV1013 Wideband Microwave Upconverter at Multiple Heavy Ion Laboratories

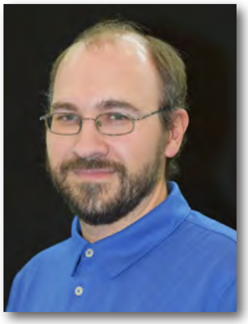
J. Likar[1], E. Shi[1], C. Pham[1], T. Decker[2], S. Lidia[3]
1. Johns Hopkins University / Applied Physics Laboratory, USA
2. Analog Devices, Inc., USA
3. Facility for Rare Isotope Beams / Michigan State University, USA

The ADMV1013 wideband, microwave upconverter was subjected to heavy ion testing at three different accelerators. Combined results illustrate the compatibility of the Michigan State University Facility for Rare Isotope Beams Single Event Effects laboratory (FSEE).BREAK

Technical Program Thursday

RADIATION EFFECTS DATA WORKSHOP
12:25 PM

INTRODUCTION



Chair: Andrea Coronetti, CERN

12:30 PM TO 1:45 PM

LUNCH
ON YOUR OWN!

RADIATION EFFECTS DATA WORKSHOP
1:45 PM - 4:30 PM

NEW YORK BALLROOM

DW-1 **Single Event Upset Results from the Radiation Hardened Electronic Memory Experiment in a Geosynchronous Orbit**

A. Vera[1], A. Cover[2], J. Love[1], D. Alexander[2]

1. IDEAS Engineering and Technology, LLC, USA
2. COSMIAC, USA

Results are presented from the Radiation Hardened Electronic Memory Experiment (RHEME-3) performed on the STPSat-6 mission in a polar orbit.

DW-2 **Proton Radiation Effect on Barrier Infrared Detector Focal Plane Arrays**

A. Azizi[1]

1. Jet Propulsion Laboratory, USA

This work reports effect of proton radiation on barrier infrared detector. The results indicate that proton radiation causes slow increase in dark current. The radiation effect on quantum efficiency of detector is not conclusive.

DW-3 **Review of TID Effects Reported in ProASIC3 and ProASIC3L FPGAs for 3D PLUS Camera Heads**

A. Bosser[1], P. Kohler[1], J. Salles[1], M. Foucher[1], J. Bezine[1], N. Perrot[1], P. Wang[1]

1. 3D PLUS, France

This paper compares original TID data from ProASIC3L FPGAs with existing literature, discusses the impact of different test flows on the TID response, and correlates the data with TID tests of 3D PLUS camera heads.

DW-4 **Investigation of the Zynq-7000 Integrated XADC Under Proton Irradiation**

J. Budroweit[1], F. Eichstaedt[1], F. Stehle[1]

1. DLR e.V., Germany

This paper presents the investigation of the Xilinx Zynq-7000 system on-chip (SoC) integrated analog to digital converter (XADC) for single event effects (SEE) under proton irradiation.

DW-5 **Investigation of the Xilinx SEM Core on a Zynq-based Software-Defined Radio Under Proton Irradiation**

J. Budroweit[1], F. Stehle[1], F. Eichstaedt[1]

1. DLR e.V., Germany

This paper presents the latest SEE test results of the Xilinx soft error mitigation (SEM) core under proton irradiation on the Zynq-7000 SoC family.

DW-6L **Total Dose and Single-Event Effects Testing of the Intersil ISL73041SEH 12 V Half Bridge GaN FET Driver**

M. Campanella[1], W. Newman[1], N. Van vonno[1], D. Wackley[1], T. Lok[1], L. Pearce[1], E. Thomson[1]

1. Renesas Electronics America, USA

We report the single event effects and low dose rate total ionizing dose test results for the ISL73041SEH radiation hardened PWM input 12 V Half Bridge GaN FET driver.

DW-7 **The Aerospace Corporation's Compendium of Recent Radiation Testing Results**

S. Davis[1], A. Yarbrough[1], R. Koga[1], A. Wright[1], J. Shanney[1], K. Pham[1], C. Cao[1], J. Dixon[1], J. Taggart[1], B. Davis[1], D. Mabry[1]

1. The Aerospace Corporation, USA

Radiation testing was performed on several commercial components to determine the response of these components to the space radiation environment. Testing was mostly focused on SEE from protons and heavy ions.

DW-8 **A53 SEE Performance in Raspberry Pi and MX8M**

S. Guertin[1]

1. Jet Propulsion Laboratory, USA

We report SEE performance of A53 processors in Raspberry Pi 3B+ (BCM2837) and MYiRTech MYC-C8MMQ6 (IMX8M). Error correction features and process SEE performance result in significant reduction in SEFI sensitivity

DW-9 **Comparison of Figure of Merit Calculations to On-Orbit Data**

R. Sean[1], C. David[1], B. Vermeire[1], D. Hansen[1]

1. Space Micro, USA

This paper compares upset rates calculated using figure-of-merit methods to on-orbit data in the literature. At GEO, the FOM overestimates the rate except for missions subject to high fluxes of anomalous cosmic rays.

DW-10 Total Dose Performance at Low Dose Rate of Isolated Switching Regulator Evaluation Kits

D. Hiemstra[1], S. Shi[2], L. Chen[2]
1. MDA, Canada
2. University of Saskatchewan, Canada

Results of Cobalt-60 low dose rate irradiation of isolated switching regulator evaluation kits are provided. Their performance in the space radiation environment is discussed.

DW-11 Guide to the 2022 IEEE Radiation Effects Data Workshop Record

D. Hiemstra[1]
1. MDA, Canada

The 2022 Workshop Record has been, reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

DW-12 Single-Event Effects Measurements on COTS Electronic Devices for Use on NASA Mars Missions

F. Irom[1], S. Vartanian[1], G. Allen[1]
1. Jet Propulsion Laboratory, USA

This paper reports recent single-event effects measurements results for a variety of microelectronic devices that include a voltage level translator, bus driver/buffer, DC-DC buck converter, load switch, power protection mux, transceiver, wireless transceiver, and wireless MCU.

DW-13 NVIDIA Jetson TX2i TID and Proton SEE Testing: Results and a Comparison of Two Proton Beam Facilities

S. Katz[1], C. Heistand[2], E. Miller[3]
1. Johns Hopkins University Applied Physics Laboratory, USA
2. STOKE Space Technologies Colorado, USA
3. Amazon.com, Inc., USA

Proton SEE test results for similar irradiations of the TX2i by two groups at different facilities show important discrepancies. APL's radiation test results (proton and TID) are presented; discrepancies are explored through particle transport modelling.

DW-14 Recent Developments to the Texas A&M University Cyclotron Institute Radiation Effects Facility from 2019-2023

M. Kennas[1], B. Roeder[1], B. Hyman[1], C. Parker[1], G. Tabacaru[1], G. Avila[1], G. Kim[1], H. Clark[1], H. Park[1], V. Horvat[1]
1. Texas A&M University Cyclotron Institute, USA

The Texas A&M University Cyclotron Institute Radiation Effects Facility has recently made facility developments that improved the availability of beam hours to address the growing demand for beam time in the radiation effects testing industry.

DW-15 **Qualification of a New Total Ionizing Dose Facility Using a Hopewell GR420 Irradiator**

S. Khan[1], T. Vigilant[1]

1. Texas Instruments Inc, USA

We report on the qualification of a new Total Ionizing Dose facility using a Hopewell GR420 gamma irradiator with a Cobal-60 source. Device data is correlated to the widely used Gammacell GC220-E

DW-16 **DW-16 Radiation Effects Testing of the Agilex Commercial Off-The-Shelf CMOS Field Programmable Gate Array with Protons**

R. Koga[1], S. Davis[1], A. Yarbrough[1], J. Shanney[1], K. Pham[1], C. Cao[1], K. Pham[1], J. Dixon[1]

1. The Aerospace Corporation, USA

Observations of proton induced single event effects on the 10 nm Agilex commercial off-the-shelf CMOS FPGA were made at three proton energy levels. The SRAM-based FPGA was sensitive to protons at these energy levels.

DW-17 **High-Energy Atmospheric Neutrons Characterization of Microchip LX4580**

M. Leuenberger[1], R. Stevens[1], S. Spanoche[1], D. Johnson[1]

1. Microchip Technology, USA

The high-energy atmospheric neutron single event effect characterization results of Microchip Technology 24 Channel Data Acquisition System with Synchronized Motor Control Interface IC, the LX4580, are presented.

DW-18 **Characterization of Low Dose Rate Ionizing Radiation Effect on the Micropac 66266-303 Optocoupler**

Y. Liu[1], G. Armstrong[1], B. Campanini[1], S. Messenger[2], J. Rodriguez[2]

1. Micropac Industries Inc, USA
2. Northrop Grumman Corporation, USA

This paper reports low dose rate radiation test results for the Micropac 66266-303 optocoupler and presents LDR effects on the device current transfer ratio. CTR degradations are also compared between 66266 and 66224 optocouplers.

DW-19 **Heavy-ion and proton characterization of AMD 7 nm Versal™ Multicore Scalar Processing System (PS)**

P. Maillard[1], P. Chen[1], J. Arver[1]

1. AMD Inc., USA

This paper presents the heavy-ion and proton single event responses of Xilinx’s 7 nm Versal™ multicore scalar processing system (PS) using Xilinx System Validation Tool (SVT) design suite. SEU, SEFI and SEL results are presented.

DW-20 A Rad-Hard Time-to-Digital Converter ASIC with Sub-10 ps Single-Shot Precision

B. Van Bockel[1], S. Ali[1], N. Jadhav[1], Y. Cao[1], H. Marien[1]

1. Magics Technologies, Belgium

A rad-hard-by-design time-to-digital converter ASIC with a single-shot precision of sub-10 ps is designed and validated in a standard CMOS technology. The presented electrical characterization and radiation results demonstrate the in-spec performance of the ASIC.

DW-21 Effects of Neutron Radiation on the Current Transfer Ratio of GaAsP and AlGaAs Optocouplers

P. Martin Holgado[1], A. Romero Maestre[1], J. De Martin Hernandez[2], J. González Luján[2], M. Dominguez[2], Y. Morilla[1]

1. Centro Nacional de Aceleradores, Spain

2. ALTER TECHNOLOGY TÜV NORD S.A.U., Spain

This work presents the degradation of GaAsP and AlGaAs optocouplers as a result of the 14.5 MeV monoenergetic neutron displacement damage. The exponential degradation of the Current Transfer Ratio parameter is studied.

DW-22 Consistent and Repeatable Transistor Level TID Transistor Array Measurement

R. Melendez[1], M. Lenoardo[1], L. Clark[2], C. Youngsciortino[1], S. Guertin[1], J. Yang-scharlotta[1]

1. Jet Propulsion Laboratory, USA

2. Arizona State University, USA

We present 22 nm FDSOI transistor total ionizing dose (TID) induced threshold voltage (Vt) shifts measured on a packaged array test structure. Results demonstrate high current fidelity and Vt vs. dose consistency and repeatability.

DW-23 SEE Test Results for SRAM and Register File structures compiled on 22 nm FDSOI (22FDX)

R. Melendez[1], S. Guertin[1], J. Yang-scharlotta[1], L. Clark[2]

1. Jet Propulsion Laboratory, USA

2. Arizona State University, USA

SEE performance of 22 nm FDSOI compiled SRAM and Register File structures presented. SRAM and Register File showed sensitivity to the lowest tested LET (~3 MeV-cm2/mg), and an approximate saturated cross section around 10-10 cm2/bit.

DW-24 SEU and SEFI Characterization of a Frontgrade QCOTS 512 Gb NAND Flash Nonvolatile Memory for Space Applications

P. Nelson[1], M. Von thun[1], A. Turnbull[1], T. Meade[1], B. Baranski[1]

1. Frontgrade Technologies, USA

Single Event Upset (SEU) and Single Event Functional Interrupt (SEFI) radiation characterization was performed on a Frontgrade quantified-off-the-shelf (QCOTS) 512 Gb 3D NAND flash memory. The device was shown to be suitable for space applications.

DW-25 Combined Displacement Damage and LDR Results of the Intersil ISL73141SEH 3.3 V Analog to Digital Converter

W. Newman[1], N. Van vonno[1], C. Michalski[1], D. Thornberry[1], J. Harris[1], L. Pearce[1]

1. Renesas, USA

We report the combined results of the high-precision, 14-bit, 1 MSPS SAR analog-to-digital converter after exposure to 5 x 1011, 2 x 1012, and 1013 neutrons/cm2 followed by 100 krad(Si) LDR total ionizing dose.

DW-26 SEE and TID Test Results of Radiation Hardened Superjunction P-channel MOSFETs

R. Patel[1], O. Mansilla[1]

1. IR HiRel an Infineon Technologies Company, USA

A family of radiation hardened P-channel power MOSFETs is developed that are the first P-channel FETs based on Superjunction technology. This work discusses SEE and TID test results of -60 V, -100 V and -200 V P-channel MOSFETs.

DW-27 Comparison of MSU and TAMU Heavy Ion Test Results and Evaluation Output Dependencies of SEUs for the LMK04832-SP (5962R1722701VXC) 3.2 GHz JESD204B Clock Jitter Cleaner with 14 Outputs

K. Kruckmeyer[1], R. Gooty[1], S. Williams[1], V. Vanjari[1], D. Payne[1]

1. Texas Instruments, USA

The LMK04832-SP went through heavy ion testing at MSU and TAMU. SEU results from the two facilities are compared and the impact of a single ion strike on multiple outputs is evaluated.

DW-28 NASA Goddard Space Flight Center's Current Radiation Effects Test Results

M. Obryan[1], E. Wilcox[2], M. Joplin[2], T. Carstens[2], J. Barth[2], M. Casey[2], J. Lauenstein[2], M. Campola[2], J. Osheroff[1], E. Wyrwas[1], A. Antonsanti[3], A. Le Roch[4], L. Ryder[2], K. Ryder[2], R. Austin[2], M. Berg[1], P. Majewicz[2], J. Pellish[2]

1. SSAI, Inc., USA
2. NASA Goddard Space Flight Center, USA
3. Southeastern Universities Research Association, USA
4. NASA, Oak Ridge Associated Universities, USA

We present results and analysis investigating the effects of radiation on candidate spacecraft electronics to heavy ion and proton induced single-event effects (SEE), proton-induced displacement damage dose (DDD), and total ionizing dose (TID).

DW-29 Follow-on Testing of the Xilinx Versal Prime

H. Quinn[1], C. Corley[2], G. Tompkins[1], P. Thelen[3]

1. Los Alamos National Laboratory, USA
2. University of Texas, USA
3. Sandia National Laboratories, USA

Update results for neutron testing of the 7 nm Xilinx Versal Prime microprocessors are presented. Results show an improvement over the 2021 results.

DW-30 Irradiation Effects on Power and Timing Characteristics of Commercial 3D NAND Flash Memories

M. Raquibuzzaman[1], U. Surendranathan[1], M. Buddhanoy[1], B. Ray[1]

1. University of Alabama in Huntsville, USA

We explore TID effects on power and timing characteristics of 3D NAND chip. We observe a significant increase in erase time and active power dissipation during memory operations.

DW-31 An Examination of the Radiation Sensitivity of Electronic Display Pixel Technologies

L. Ryder[1], E. Wyrwas[1], G. Cisneros[2], J. Bautista[2], X. Xu[3], M. Campola[1], R. Gaza[2]

1. NASA Goddard Space Flight Center, USA
2. NASA Johnson Space Center, USA
3. NASA Langley Research Center, USA

64 MeV proton irradiation was conducted on pixel technologies that span the range of commercially available electronic displays for crewed missions. Human-centric optical performance metrics are discussed and reported for assessment of pixel radiation susceptibilities.

DW-32 Proton and Heavy Ion SEE Data on NVIDIA and AMD Graphical Processing Units

M. Cannon[1], D. Lee[1], W. Evans[1], I. Troxel[2], M. Gruber[2], D. Sabogal[2]

1. Sandia National Laboratories, USA
2. Troxel Aerospace Industries, USA

We present the single-event upset sensitivity and single-event latch-up results from proton and heavy ion testing performed on NVIDIA Xavier NX and AMD Ryzen V1605B GPU devices in both static and dynamic operation.

DW-33 Accelerated Nuclear Radiation Effects on the Raspberry Pi3B+ and Pi4

C. Corley[1], H. Quinn[2], E. Swartzlander, Jr.[1]

1. University of Texas, USA
2. Los Alamos National Laboratory, USA

Raspberry Pis running Linux and embedded benchmarks were subjected to radiation testing in the neutron beam at LANSCE. ARM A53 versus A72, single-core versus multi-core, and small versus large array SEE cross sections are compared.

DW-34 DW-34 Single Event Effects and TID Characterization of the Frontgrade Technologies UT24C407 CertusTM-NX-RT FPGA for Space Applications

M. Von Thun[1], B. Baranski[1], A. Turnbull[1]

1. Frontgrade Technologies, USA

Single Event Effects (SEE) and Total Ionizing Dose (TID) radiation characterization was performed the Frontgrade Technologies UT24C407 CertusTM-NX-RT FPGA. The device was shown to be suitable for space applications.

DW-35 **SEE and TID Characterization of the Frontgrade Technologies 1 Gb NOR Flash Nonvolatile Memory**

M. Von Thun, D. Bass[1], S. Ashenafi[1], G. Hoglund[1], A. Turnbul[1]

1. Frontgrade Technologies, USA

A Frontgrade Technologies SONOS based 1 Gb NOR Flash non-volatile memory has been designed, manufactured, and characterized for radiation effects. Heavy Ion single event effects data covering SEL, SEGR, SEU, SET and SEFI will be presented.

DW-36 **Single-Event Effects Response of 96- and 176-Layer 3D NAND Flash Memories**

E. Wilcox[1], M. Joplin[1], M. Berg[2]

1. NASA Goddard Space Flight Center, USA
2. SSAI, Inc., USA

Single-event effects testing (heavy-ion and proton) is presented for 96- and 176-layer commercially available 3D NAND flash memory, with emphasis on SEFI detection and recovery.

DW-37 **Total Ionizing Dose and Proton Single Event Effects in AMD Ryzen Processor Fabricated in a 12 nm Bulk FinFET Process**

J. Taggart[1], S. Davis[1], R. Daniel[1], B. Foran[1], D. Bohra[1], A. Hall[1], A. Wright[1]

1. The Aerospace Corporation, USA

AMD Ryzen 3200G were tested for TID and SEE effects using Cobalt-60 and 200 MeV protons. The integrated GPU experienced TID effects prior to the CPU and SEFIs were observed during proton testing.

DW-38 **Single Event Effects Results for COTS Microcontrollers and Microprocessors**

S. Vartanian[1], G. Allen[1], F. Irom[1], A. Daniel[1], S. Zajac[1]

1. Jet Propulsion Laboratory, USA

We present single event effects results for a variety of microcontrollers and microprocessors. The devices tested include Blackfin embedded processors from Analog Devices, automotive-grade TI and Infineon microcontrollers with multiple safety features, and the MSP430FR4994.

4:30 PM END OF THURSDAY SESSIONS

4:45 PM - 7:00 PM
EXHIBIT HALL B
RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

EXHIBIT HALL B
INVITED TALK
8:30 - 9:30 AM

Kansas City National Security Campus Through the Decades

John Jungk, Ph.D., Chief Technology Officer, Honeywell Federal Manufacturing & Technologies, Kansas City, Missouri

The Kansas City National Security Campus (KCNSC) is a multi-mission engineering and manufacturing enterprise delivering trusted national security products and government services, producing 80% of the country's non-nuclear components. This presentation will provide a stroll through the history of the KCNSC, from its inception as the Kansas City Plant (KCP), including some pre-history of the campus in the 1920s, through the transition from the KCP to the current KCNSC in the 2010s. We'll also look briefly at the core missions served by the talented people at KCNSC, how our core capabilities have evolved and changed over time, and how KCNSC fits within the Department of Energy / National Nuclear Security Administration and the broader Nuclear Security Enterprise.

Dr. Jungk is the Chief Technology Officer at Honeywell Federal Manufacturing & Technologies (FM&T), which manages and operates the Department of Energy's KCNSC. With more than 6,000 employees in Kansas City and Albuquerque, the KCNSC provides diverse engineering, manufacturing and secure sourcing services for national security.

In his role, John is responsible for developing technology initiatives and providing direction in technology-related issues in support of the company's goals and strategies. To drive that effort, he ensures that technology roadmaps are aligned with business strategy to efficiently and intentionally integrate science-based technologies into products and services. John is also responsible for engaging with customers, partners, commercial industry, and academic institutions to develop collaborations for mutual benefit. Finally, he directs and manages the leaders in the Centers of Excellence organization (which has responsibility for developing the strategies to advance and deploy the technologies necessary to achieve the site's strategic goals), Advanced and Exploratory Systems Engineering, the Materials Engineering organization, and the Global Security Engineering organization.

John has authored/coauthored more than 18 peer reviewed journal articles and conference proceedings and is an Adjunct Professor at Missouri University of Science and Technology. He has a B.S. in Materials Science and Engineering from Washington State University, a Ph.D. in Materials Science and Engineering from the University of Minnesota, an MBA from Rockhurst University, and has more than 23 years of experience supporting of national security and defense research and development.

Honeywell Federal Manufacturing & Technologies, LLC operates the Kansas City National Security Campus for the United States Department of Energy / National Nuclear Security Administration under Contract Number DE-NA0002839.

EXHIBIT HALL B

SESSION H **HARDENING BY DESIGN**

9:30 AM SESSION INTRODUCTION

Chair: Yanran Chen, AMD, Inc.

H-1
9:35 AM

Estimation of Single-Event Upset and Performance using Back-Gate Bias in a 0.18 µm DSOI SRAM

Y. Wang[1], S. Chen[1], F. Liu[1], B. Li[1], J. Gao[1], J. Li[1], C. Wang[1], L. Wang[1], P. Cui[1], S. Ma[1], Y. Liao[1], T. Wang[2], J. Liu[2], P. Zhao[3], J. Liu[3], C. Huang[4], Z. Han[1], T. Ye[1]

1. Institute of Microelectronics, Chinese Academy of Sciences, China
2. Space Environment Simulation Research Infrastructure (SESRI), Harbin Institute of Technology, China
3. Institute of Modern Physics, Chinese Academy of Sciences, China
4. College of Computer Science and Technology, National University of Defense Technology, China

By adjusting back-gate bias, 6T SRAM circuit has been experimentally demonstrated with extreme tolerance to SEU. A back-gate biasing strategy is proposed in DSOI SRAM circuits which significantly lowers SEU and power without performance loss.

H-2
9:50 AM

The Effect of Error Amplifiers on Analog Single-Event Transient in Two Low-Dropout Regulators on a 28 nm CMOS Technology

F. Shen[1], J. Chen[1]

1. College of Computer Science and Technology, National University of Defense Technology, China

SET sensitivity of two 28 nm CMOS low drop-out regulators with different error amplifier were studied by experiments and simulations. The regulator with rail-to-rail error amplifier has much worse response to SET.

POSTER PAPERS

PH-1

Fault-tolerant Convolutional Neural Networks with Reconfigurable Processing Element Arrays

C. Jin[1], Y. Ibrahim[1], H. Tian[1], S. Ko[1], L. Chen[1]

1. University of Saskatchewan, Canada

This paper adopts multiple processing arrays with dynamic partial reconfiguration for radiation tolerance CNNs in FPGA. Fault injection and laser experiments show that critical error rate reduces by 25x, while overall accuracy remains 99%.

PH-2

In-Situ Single-Event Effects Detection in 22 nm FDSOI Flip-Flops

K. Appels[1], R. Weigand[2], W. Dehaene[1], J. Prinzie[1]

1. KU Leuven, Belgium
2. European Space Agency, Netherlands

A novel Single-Event Effects in-situ error detection methodology for high-speed radiation tolerant integrated circuits. Two error detection flip-flops implemented in a 22 nm Silicon-on-Insulator technology are presented, compared and experimentally verified with two-photon absorption injection.

PH-3

A Radiation-Hardened Optical Transceiver in 180 nm CMOS Technology

Y. Luo[1], C. Hong[1], A. Anderson[1], D. Dolt[1], S. Palermo[1]

1. Texas A&M University, USA

This paper presents the design and characterization of a radiation-hardened, VCSEL-based optical transceiver operating at 0.5 Gb/s and transmitter at 2 Gb/s. Single-event effect (SEE) and Total ionizing dose (TID) have been verified for the circuit operation.

EXHIBIT HALL B
SESSION I
10:05 AM

SINGLE-EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS

SESSION INTRODUCTION
Chair: Francoise Bezerra, CNES

I-1
10:10 AM

Single-Event Effects in Neutron-Irradiated High-Temperature DC Superconducting Quantum Interference Devices

E. Auden[1], S. Wender[1], K. Gunthoti[1], P. Rech[2]

1. Los Alamos National Laboratory, USA
2. University of Trento, Italy

We present the first neutron-induced single-event effect experiment on a superconducting quantum interference device (SQUID). The measured neutron-induced electrical transients in SQUIDs provide insight to coherence loss in superconducting qubits exposed to ionizing radiation.

I-2
10:25 AM

LET and Voltage Dependence of Single-Event Burnout and Single-Event Leakage Current in High-Voltage SiC Power Devices

A. Sengupta[1], D. Bal[1], S. Islam[1], A. Senarath[1], A. Witulski[1], R. Schrimpf[1], K. Galloway[1],
E. Zhang[1], M. Alles[1], R. Reed[1], M. Mccurdy[1], J. Osheroff[2], B. Jacob[3], C. Hitchcock[3],
S. Goswami[3], J. Hutson[4]

1. Vanderbilt University, USA
2. NASA Goddard Space Flight Center, USA
3. General Electric Global Research, USA
4. Lipscomb University, USA

Heavy-ion single-event burnout and leakage behavior of 1.2 kV and 3.3 kV silicon carbide power devices are analyzed based on radiation tests. The voltage capability of these devices affects the burnout and leakage thresholds differently.

10:40 AM – 11:10 AM
PRE-FUNCTION

BREAK

I-3
11:10 AM

Effects of Collector Profile on the SET Response of 130-nm High-Speed and High-Breakdown SiGe HBTs

Z. Brumbach[1], D. Nergui[1], J. Teng[1], Y. Mensah[1], D. Sam[1], A. Ildefonso[2], A. Khachatrian[2], D. Mcmorrow[2], J. Cressler[1]

1. Georgia Institute of Technology, USA
2. U.S. Naval Research Laboratory, USA

SET responses of high-speed and high-breakdown SiGe HBT variants in the same technology platform were compared using laser pulses. The lower-performance, high-breakdown SiGe HBT showed a larger transient response, which is investigated using TCAD.

I-4
11:25 AM

Comparing Digital Modulation Schemes in RF Receivers for Bit Errors Induced by Single-Event Transients in the Low Noise Amplifier

D. Nergui[1], J. Teng[1], Z. Brumbach[1], A. Ildefonso[2], A. Khachatrian[2], D. McMorrow[2], J. Cressler[1]

1. Georgia Institute of Technology, USA
2. U.S. Naval Research Laboratory, USA

Standard digital modulation schemes are compared for receiver-level SEU sensitivity using pulsed laser. Frequency shift keying demonstrated a better SEU resilience than phase shift keying despite having a worse baseline (no SET) noise performance.

I-5
11:40 AM

SET-Induced Drop-out and Recovery of Cross-Coupled and Differential-Colpitts Microwave Oscillators Using SiGe HBTs

J. Teng[1], Y. Mensah[1], Z. Brumbach[1], A. Ildefonso[2], A. Khachatrian[2], D. McMorrow[2], J. Cressler[1]

1. Georgia Institute of Technology, USA
2. U.S. Naval Research Laboratory, USA

SET responses of cross-coupled and Colpitts LC oscillators are compared using laser-induced TPA and circuit simulations. The Colpitts oscillator demonstrated smaller amplitude disturbances and faster recovery time following SET-induced drop-out.

I-6
11:55 AM

SEU Cross-Sections at High Frequencies for RHBD Flip Flop Designs at the 5-nm Bulk FinFET Node

Y. Xiong1, N. Pieper1, Y. Qian1, S. Wodzro1, B. Narasimham2, R. Fung3, S. Wen3, B. Bhuva1

1. Vanderbilt University, USA
2. Broadcom, USA
3. Cisco Systems Inc., USA

Single-event upset cross-section trends for high frequency operation of RHBD FF designs are evaluated at the 5-nm bulk FinFET node. Results show reduced RHBD efficacy at the GHz range of frequencies.

POSTER PAPERS

PI-1 Synergism between Stress and Cosmic Ray Neutron Irradiation in 650 V Rated IGBTs for Automotive Applications

D. Bae1, S. Khan2, K. Kim1, S. Chung3, J. Kih1, S. Woo1, C. Cho1, J. Kim1, S. Yoon1, S. Wender4, Y. Kim1

1. QRT, Republic of Korea
2. QRT, Pakistan
3. QRT, USA
4. Los Alamos National Laboratory, USA

This paper investigates the potential synergism between various stress conditions (temperature, humidity, and bias) and cosmic ray neutron irradiation and its impact on single event burnout (SEB) endurance of insulate-gate bipolar-transistor (IGBT) in terrestrial environment.

PI-2 Reliability Evaluation of Convolutional Neural Network's Basic Operations on a RISC-V Processor

F. Santos[1], O. Sentieys[1], A. Kritikakou[1]

1. INRIA, France

We evaluate the neutron-induced error rate of Convolutional Neural Network basic operations on a RISC-V processor. Although executing the algorithm in parallel increases performance, memory errors are the major contributors to the device error rate.

PI-3 Impact of High-Level-Synthesis on Reliability of Neural Network Hardware Accelerators

M. Traiola[1], F. Fernandes dos santos[1], O. Sentieys[1], A. Kritikakou[1]

1. INRIA / IRISA, France

We characterize the impact of High-Level Synthesis (HLS) on the reliability of Neural Networks on FPGAs exposed to neutron. Our results show that the larger the circuit generated by HLS, the larger the error rate.

PI-4 Tensor Processing Unit Reliability Dependence on Temperature and Radiation Source

P. Bodmann[1], P. Rech[2]

1. UFRGS, Brazil
2. University of Trento, Italy

We compare high-energy neutrons and heavy ion cross-sections of Coral TPU, considering different temperatures. The TPU's cross-section for heavy ions is ~ 20x higher than for neutrons and higher temperatures reduce the neutron-induced error rate.

PI-5 Telemetry-Based Analysis of Single-Event-Induced Failures in Unmanned Aerial Vehicles

S. Wang1, D. Goloubev2, S. Wen3, C. Cazzaniga4, C. Frost4, B. Bhuva1

1. Vanderbilt University, USA
2. Cisco Systems Inc., Belgium
3. Cisco Systems Inc., USA
4. Science & Technology Facilities Council, United Kingdom

Telemetry-based data collection and analysis is used to characterize single-event effects for commercially-available drones for terrestrial-neutron beam. FIT rates for different failure mechanisms show very high vulnerability.

PI-6 Temperature Dependence of Single-Event Upsets and Multi-Cell Upsets in 5-nm FinFET SRAMs

N. Pieper[1], Y. Xiong[1], D. Ball[1], R. Fung[2], S. Wen[2], J. Pasternak[3], B. Bhuva[1]

1. Vanderbilt University, USA
2. Cisco Systems, Inc., USA
3. Synopsys, Inc., USA

Single-event upset cross-sections are investigated for SRAM cells as a function of temperature for nominal and reduced supply voltages. Experiments show SEU cross-section and MCU rates decrease with increasing temperature.

12:10 PM TO 12:15 PM CONFERENCE CLOSING