IEEE NUCLEAR & SPACE RADIATION EFFECTS CONFERENCE

JULY 16TH-20TH, 2012
INTERCONTINENTAL MIAMI HOTEL
MIAMI, FLORIDA

Sponsored by IEEE/NPSS Radiation Effects Committee

Supported by Defense Threat Reduction Agency | Air Force Research Laboratory | Sandia National Laboratories | Jet Propulsion Laboratory | NASA Electronic Parts and Packaging Program | NASA Living With A Star | Atmel | BAE Systems | Boeing | Honeywell | International Rectifier | Intersil Corporation | Northrop Grumman | Southwest Research Institute | Synopsys, Inc. | Texas Instruments | Aeroflex
Monday July 16

7:15 [7:15] Continental Breakfast – Chopin Ballroom

7:30 [7:30] Continental Buffet – Chopin Ballroom

8:00 [8:00] Short Course Introduction
Ron Schrimpf
Grand Ballroom

Jonathan Pellish

8:30 [8:30] Conference Opening
Grand Ballroom


9:30 [9:40] Break – Grand Ballroom Foyer

10:00 [10:10] Part 2 – Radiation Effects in Emerging Technologies
Steven Koester


11:30 [11:40] Short Course Luncheon – Bayfront Room

12:00 [12:00] Lunch

1:00 [1:00] Session B – Single Event Effects: Transient Characterization

2:00 [2:00] Session C – Single Event Effects: Devices and Integrated Circuits

3:00 [2:50] Break – Grand Ballroom Foyer

Subhasish Mitra

4:00 [4:00] Session D – Hardening by Design

4:30 [4:50] Wrap-up

5:00 [5:00] Exam (for students requesting CEU credit only)

5:30 [5:30] End of Short Course

6:00 [6:00 to 9:00] Industrial Exhibits Reception
6:00 Cocktails
7:00 Buffet Dinner
Grand Ballroom Foyer, Mezzanine and Chopin Ballroom

6:30 [6:30] End of Sessions

Thursday July 19

7:30 [7:30] Continental Buffet – Chopin Ballroom

8:00 [8:00] Invited Talk – Working and Living in the International Space Station
Paolo Nespoli
Grand Ballroom

9:00 [9:40] Session I – Dosimetry

10:00 [9:40] Session I – Space and Terrestrial Environments


10:45 [10:45] Session G – Radiation Effects in Devices and Integrated Circuits (continued)

11:10 [11:30] Lunch

11:30 [11:00] Session E – Radiation Effects in Devices and Integrated Circuits (continued)

12:00 [12:05] End of Conference
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On behalf of the IEEE, NPSS, and the Radiation Effects Steering Committee, it is my privilege to invite you to attend the 49th Annual International Nuclear and Space Radiation Effects Conference (NSREC) to be held July 16-20, 2012 at the InterContinental Hotel in downtown Miami, Florida. The 2012 Conference will follow previous editions and showcase:

- An exceptional Technical Program, the prime underpinning of the conference
- A novel one-day Short Course preceding the Technical Program
- An informational Radiation Effects Data Workshop (REDW) incorporated into the Technical Program
- An Industrial Exhibit providing valuable insight into participating vendor offerings and plans

The Technical Program Chair, Christian Poivey (European Space Agency), and his hard-working program committee along with the Poster and REDW Chairs have established a series of outstanding technical oral and poster papers, as well as informative, high-quality REDW papers. The Technical Chair has gathered a captivating set of invited general talks that are open to attendees and their guests.

This year’s Short Course Theme, Testing and Simulation Methods for Characterizing Radiation Effects in Advanced Electronics, is organized by Ron Schrimpf (Vanderbilt University). The short course, being offered on July 16 will provide an introduction to space radiation environments and their effects on devices and systems for those new to the field, as well as introducing advanced concepts and emerging issues for those experienced in the field.

The Industrial Exhibit, organized by Penny Meeker with Chuck Tabbert, Ultra Communications, as Acting Exhibit Chair, opens Tuesday morning and runs through lunch on Wednesday. Included is an evening reception on Tuesday night open to registered attendees and their guests. The exhibit showcases the products and capabilities of the exhibitors in areas such as semiconductors, systems, modeling, and test resources.

Keys to the decision to select Miami were accessibility for both domestic and international visitors, the vibrancy of a major city, affordability for all attendees, and, of course, a fantastic venue. The internationally-flavored InterContinental Miami Hotel is located in downtown Miami right along the Biscayne Bay. Impressive views of the water and cityscape are seen from many of the hotel rooms while a myriad of dining and shopping options abound within a few short city blocks. Just short distances away are spectacular tourist sites ranging from South Beach to the Everglades. The Local Arrangements Chair, Lew Cohn (National Reconnaissance Office), has planned a series of social options capturing the multi-cultural and truly unique nature of Miami. The highlight will be the Conference Social to be held on Wednesday, July 18 with private access to one of the most vibrant restaurants/clubs on South Beach: Mango’s Tropical Café.

Your 2012 Conference Committee looks forward to seeing you in Miami and all that it has to offer!

Visit us on the web at: www.nsrec.com
TESTING AND SIMULATION METHODS FOR CHARACTERIZING RADIATION EFFECTS IN ADVANCED ELECTRONICS
GRAND BALLROOM – MONDAY, JULY 16

7:15 AM REGISTRATION/CONTINENTAL BREAKFAST (CHOPIN BALLROOM)

8:00 AM SHORT COURSE INTRODUCTION
Ron Schrimpf, Vanderbilt University

8:10 AM PART 1 — SINGLE-EVENT AND TOTAL DOSE TESTING FOR ADVANCED ELECTRONICS
Jonathan Pellish, NASA Goddard Space Flight Center

9:40 AM BREAK

10:10 AM PART 2 — RADIATION EFFECTS IN EMERGING TECHNOLOGIES
Steven Koester, University of Minnesota

11:40 AM SHORT COURSE LUNCHEON (BAYFRONT ROOM)

1:20 PM PART 3 — MONTE CARLO BASED SINGLE-EVENT EFFECT AND SOFT-ERROR RATE PREDICTION METHODS
Kevin Warren, Vanderbilt University

2:50 PM BREAK

3:20 PM PART 4 — SYSTEM-LEVEL SINGLE-EVENT EFFECTS
Subhasish Mitra, Stanford University

4:50 PM WRAP-UP

5:00 PM EXAM (only for students requesting CEU credit)

5:30 PM END OF SHORT COURSE
A one-day Short Course “Testing and Simulation Methods for Characterizing Radiation Effects in Advanced Electronics” will be presented at the 2012 IEEE Nuclear and Space Radiation Effects Conference (NSREC). This short course will provide an introduction to space radiation environments and their effects on devices and systems for those new to the field, as well as introducing advanced concepts and emerging issues for those experienced in the field. The 2012 Short Course will cover topics ranging from the interaction of radiation with electronic materials, to device response, to effects on system reliability.

The Short Course is organized into four sessions, with the first session emphasizing practical issues related to evaluation of microelectronics for use in radiation environments. This session will include the basics of radiation environments and effects, as well as application to advanced technologies. The second session covers radiation effects in emerging technologies, ranging from sub 22-nm CMOS to FinFETs and alternate-channel devices. The third session focuses on methods for predicting single-event and soft-error rates, while the final session focuses on single-event effects at the system level. The presenters for the 2012 Short Course are all well-known experts in their respective areas. They will cover the background needed for newcomers to the radiation-effects field, as well as addressing current topics and advanced technologies.

The course is intended for designers, radiation effects engineers, component specialists, and other technical and management personnel who are involved in developing reliable systems designed to operate in radiation environments. This course provides a unique opportunity for NSREC attendees to benefit from the expertise of the instructors, as well as the in-depth coverage and application-oriented perspective provided by the short course format. In-depth notes will be provided at registration.

For those interested in Continuing Education Units (CEUs), there will be an open-book test at the end of the course. The course is valued at 0.6 CEUs and is endorsed by the IEEE and the International Association for Continuing Education and Training (IACET).

Ron Schrimpf received B.E.E., M.S.E.E., and Ph.D. degrees from the University of Minnesota. He was a Professor at the University of Arizona before joining Vanderbilt University, where he is currently the Orrin Henry Ingram Professor of Engineering and Director of the Institute for Space and Defense Electronics. Ron has served as Chairman of the Radiation Effects Steering Group, as well as General Chairman and Technical Chairman of NSREC. He has authored or co-authored more than 400 papers on semiconductor devices and radiation effects in electronics.
Dr. Pellish will give an overview of the end-to-end radiation evaluation of advanced electronics as it applies to civilian space systems. The term “advanced” means the electronic devices in question improve the tradespace of size, weight, and power. The presentation will be broken down into several sections, including: 1) an overview and introduction to the different space radiation environments common to a broad range of mission designs, as well as perspectives on deriving meaningful requirements used in electronic component evaluation; 2) definitions and impacts of effects due to impinging particles in the space environment – e.g., total ionizing dose (TID) and single-event effects (SEE); 3) testing for and evaluation of parametric degradation in advanced electronics; and 4) testing for and evaluation of SEE in advanced electronics. The latter two topics will include content aimed at helping engineers estimate survival probabilities and on-orbit event rates utilizing available data, as well as considerations for ground-based accelerated testing.

**Introduction**
- Why the space environment threatens advanced electronics

**Overview of space radiation environments**
- Types of space radiation
- Low-Earth orbit to interplanetary space

**Impact of space radiation on advanced electronics**
- Total ionizing and non-ionizing dose
- Non-destructive and destructive single-event effects

**Evaluation of parametric degradation in advanced electronics**
- Test methods and radiation sources
- Part-to-part and lot-to-lot variability
- Special considerations for high-speed and/or complex devices
- Estimating survival probabilities

**Evaluation of single-event effects in advanced electronics**
- Test methods and radiation sources
- Protons versus heavy ions
- Special considerations for high-speed and/or complex devices
- Estimating on-orbit event rates and propagation to the system-level
RADIATION EFFECTS IN EMERGING TECHNOLOGIES

Steven J. Koester

University of Minnesota

Dr. Koester will provide an introduction to radiation effects in emerging semiconductor device technologies. The course will begin with an introduction to radiation effects in silicon-based sub-22-nm node device architectures, including fully-depleted SOI, finFETs, tri-gate and nanowire devices. Both total-dose and single-event behavior will be reviewed as part of this discussion. The effect of radiation on devices with high-κ dielectrics and metal gates will also be reviewed. Next, an overview of the effect of alternative channel materials such as SiGe, Ge and compound semiconductor on radiation response will be provided. Finally, the course will close with a discussion of radiation effects in emerging materials for transistor applications, such as carbon nanotubes, graphene, and organic semiconductors.

Introduction

■ Overview of device requirements for post-22-nm node CMOS

Radiation effects in advanced Si-based CMOS device geometries

■ Planar fully-depleted SOI
■ FinFET and tri-gate MOSFETs
■ Nanowire MOSFETs
■ Total-dose / single-event effects

Impact of surrounding materials

■ Metal-gate
■ High-κ dielectrics

Radiation effects in alternative and emerging channel materials

■ Strained Si CMOS
■ Ge MOSFETs
■ III-V MOSFETs
■ Carbon nanotubes FETs
■ Graphene FETs
■ Organic transistors

Steven J. Koester (M’96–SM’02) received the B.S.E.E. and M.S.E.E. degrees from the University of Notre Dame in 1989 and 1991, respectively, and his Ph.D. in 1995 from the University of California, Santa Barbara. In 1995, he joined the IBM T. J. Watson Research Center, in Yorktown Heights, New York, as a post-doctoral researcher. From 1997 to 2006, he was a research staff member at IBM and performed research on a wide variety of SiGe devices including MODFETs, MOSFETs and high-speed photodetectors. From 2006-2010, he served as manager of Exploratory Technology at IBM where his team investigated novel devices and 3D integration solutions for post 22-nm-node CMOS technology. Since 2010, he has been a Professor of Electrical and Computer Engineering at the University of Minnesota where his research focuses on nanostructured electronic and photonic devices. Dr. Koester has authored or co-authored over 150 technical publications and conference presentations, and holds 32 United States patents.
The course will provide an introduction to Monte-Carlo simulation methods for single event upset (SEU) rate prediction. A brief introduction to classical methods of SEU prediction for the space environment will be presented, as well as their potential limitations when applied to modern processes, both commercial and radiation hardened. A short mathematical description of the key concepts in Monte Carlo sampling will be discussed with applications specific to microelectronics including the multiple sensitive volume model, groups, and detectors. The course will continue with the inclusion of physics based radiation transport codes, defining input parameters and interpreting simulation output. Case studies of simulation flow will be presented for both a basic static random access memory as well as a radiation hardened latch.

Introduction
- Basics mechanisms of single event upset
- Methods of SEU rate prediction in the space environment
- Limitations of classical methods

Monte Carlo Simulation
- Definition and mathematical background
- Solving classical SEU problems with Monte Carlo approximation
- Sensitive volume model concepts

Radiation Transport
- Key concepts and terminology
- Defining simulation parameters
- Interpreting simulation output

Case Studies
- The Static Random Access Memory
- Radiation hardened latch
The course will provide an introduction to the design of globally-optimized robust systems with built-in protection from Single Event Single Upsets (i.e., single errors) and Single Event Multiple Upsets (SEMs). This is possible through an inter-disciplinary approach that uniquely combines semiconductor device physics, circuit and logic design, system-level design, coding theory, and formal methods.

Design techniques for soft error resilience at various layers of abstraction
- Circuit-level techniques
- Logic-level techniques
- Architecture techniques
- Software techniques requiring minimal or no changes to the underlying hardware

Quantification of the system-level impact of soft errors
- Error injection techniques and their associated issues
- Fault-free simulation-based techniques
- Verification-guided soft error resilience

Optimization and validation of soft error resilience
- Globally optimized resilience across multiple abstraction layers through new design algorithms for maximized protection at minimized cost (expressed in terms of power, performance, area, and design complexity)
- Sound experimental and formal approaches for validation of resilience mechanisms embedded in the system
The NSREC technical program will consist of contributed oral, poster papers, a data workshop and three invited papers. The oral presentations will be 12 minutes in duration with an additional 3 minutes for questions. The Technical Sessions and Chairpersons are:

- **Single Event Effects: Mechanisms and Modeling**  
  Chair: Marta Bagatin, University of Padova
- **Single Event Effects: Transient Characterization**  
  Chair: Matthew Gadlage, NAVSEA Crane
- **Single Event Effects: Devices and Integrated Circuits**  
  Chair: Melanie Berg, MEI Technologies, Inc./NASA Goddard Space Flight Center
- **Hardening By Design**  
  Chair: Andrew Sternberg, ISDE/Vanderbilt University
- **Photonic Devices and Integrated Circuits**  
  Chair: Jim Pickel, PRT, Inc.
- **Hardness Assurance**  
  Chair: David Hansen, Maxwell Technologies, Inc.
- **Radiation Effects in Devices and Integrated Circuits**  
  Chair: Kirby Kruckmeyer, Texas Instruments
- **Basic Mechanisms of Radiation Effects**  
  Chair: Harold Hjalmarson, Sandia National Laboratories
- **Dosimetry**  
  Chair: Ari Virtanen, University of Jyväskyla
- **Space and Terrestrial Environments**  
  Chair: Insoo Jun, NASA-Jet Propulsion Laboratory

"On behalf of the Technical Program Committee, I would like to invite you to attend the 2012 NSREC Technical Sessions. We have assembled a great program that will provide information on the latest developments in the field of nuclear and space radiation effects."

Christian Poivey,  
European Space Agency,  
Technical Program Chairman

**POSTER SESSION**  
Those papers that can be presented more effectively in a visual format with group discussion will be displayed in the Poster Session on Tuesday through Friday in the Bayfront room. The formal Poster Session will be held on Wednesday from 2:15 to 4:30 PM and the authors will be available at that time to discuss their work. The Poster Session is chaired by Stephen Buchner, Naval Research 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 afternoon through Friday morning in the Sevilla room. Authors will be available on Thursday to discuss their work from 2:30 to 4:15 PM. A workshop record will be mailed to all registered conference attendees. The workshop chair is Paul Eaton, Micro-RDC.

**INVITED SPEAKERS**  
There will be three invited talks:
- **Bizarre in Biscayne**  
  Gary Bremen, National Park Ranger Biscayne National Park
- **Single Malt Scotch Whisky**  
  Ron Pease, RLP Research
- **Working and Living in the International Space Station**  
  Paolo Nespoli, ESA astronaut

**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 June 1, 2012. Detailed instructions for submitting a late-news summary are available on the NSREC web site at [www.nsrec.com](http://www.nsrec.com).
GRAND BALLROOM
8:30 AM OPENING REMARKS
Ken LaBel, NASA Goddard Space Flight Center, General Chairman

8:35 AM AWARDS PRESENTATION
Dan Fleetwood, Vanderbilt University, Radiation Effects Steering Group Committee

9:05 AM TECHNICAL SESSION OPENING REMARKS
Christian Poivey, ESA ESTEC, Technical Program Chairman

SESSION A
9:10 AM SINGLE EVENT EFFECTS: MECHANISMS AND MODELING
SESSION INTRODUCTION
Chair: Marta Bagatin, University of Padova

A-1 Effectiveness of SEL Hardening Strategies and Mapping of SEL Sensitive Volumes

We present laser and neutron experimental data that show the effectiveness of various SEL hardening strategies. Laser mapping reveals the shapes of the SEL sensitive volumes and their positions relative to the affected PNPN regions.

A-2 Effect of Negative Bias Temperature Instability on the Single Event Upset Response of Flip-Flops

Heavy-ion data shows that NBTI has a sizeable effect on the SE sensitivity of flip-flops designed in 40nm CMOS bulk technology. Analysis shows a 2X increase in cross-section of typical FF designs.

A-3 Soft-Error Rate Induced by Thermal and Low Energy Neutrons in 40 nm SRAMs
J.-L. Autran, S. Serre, S. Semikh, D. Munteanu, IM2NP, UMR CNRS; G. Gasiot, P. Roche, STMicroelectronics

The interactions of thermal and low energy (<1 MeV) atmospheric neutrons with natural boron-doped silicon is investigated using Geant4. Consequences on the SER at ground level are analyzed and quantified for 40 nm SRAMs.

A-4 Soft Error Susceptibilities of 22 nm Tri-Gate Devices
N. Seifert, B. Gill, S. Jahinuzzaman, J. Basile, A. Bramnik, R. Allmon, V. Ambrose, Q. Shi, Intel Corporation

We report on measured radiation-induced soft error rates of memory and logic devices built in a 22 nm high-k + metal gate bulk Tri-Gate technology.
Heavy-Ion-Induced Current Transients in Bulk and SOI FinFETs

Measured heavy-ion induced current transients are compared for two different junction contact schemes (dumbbell and saddle) in bulk FinFETs. Distinct signatures of a transient shunt effect are observed in bulk and SOI FinFETs.

Single Event Response of the SiGe HBT Operating in Inverse-Mode
S. D. Phillips, K. A. Moen, N. E. Lourenco, J. D. Cressler, Georgia Institute of Technology

The single event sensitivity of SiGe HBTs and circuits operated in inverse-mode is investigated and compared with those operating in forward-mode. Experimental data and simulation show reduced transient peak and total collected charge.

Single-Event Transient Response of InAlSb/InAs/AlGaSb High Electron Mobility Transistors
V. Ramachandran, R. A. Reed, R. D. Schrimpf, M. P. King, X. Shen, S. T. Pantelides, Vanderbilt University; D. McMorrow, J. B. Boos, Naval Research Laboratory; G. Vizkelethy, Sandia National Laboratories

We present experimental evidence confirming SE transient generation from ion strikes directly into the drain region of an InAlSb_InAs_AIGaSb HEMT. Threshold voltage shift effects on the corresponding SE response are examined through experiments and simulation.

Single Event Effects in Power MOSFETs During Heavy Ions Irradiation Performed after Gamma-Rays Degradation
G. Busatto, V. De Luca, F. Iannuzzo, A. Sanseverino, F. Velardi, Università degli studi di Cassino e del Lazio Meridionale and INFN sezione di Roma; S. Baccaro, INFN sezione di Roma and ENEA UTTMAT, Research Centre Casaccia; A. Lanza, INFN sezione di Pavia; M. Alderighi, INAF - IASF Milano and INFN sezione di Milano; M. Citterio, S. Latorre, INFN sezione di Milano; M. Riva, INFN sezione di Milano and Università degli Studi di Milano; A. Paccagnella, G. Spiazzi, P. Tenti, Università degli Studi di Padova and INFN sezione di Padova; M. Bernardoni, N. Delmonte, R. Menozzi, Università degli Studi di Parma; P. Cova, Università degli Studi di Parma and INFN sezione di Pavia

An experimental study about the combined effects of gamma-rays irradiation followed by heavy ions irradiation shows that TID degradation of the gate oxide severely worsen heavy ions SEE robustness of commercial power MOSFETs.

M. Raine, M. Gaillardin, P. Paillet, CEA DAM DIF; A. Valentin, CEA and Université Paris

New models are developed and implemented in Geant4 for the generation and transport of very low energy electrons in silicon, thus allowing a more accurate modeling of ion tracks and their effect in advanced technologies.
POSTER PAPERS

PA-1  Efficient Method for Estimating the Characteristics of Radiation-Induced Current-Transients

An efficient method for estimating the characteristics of ion-induced transient current pulses is described. The resulting description of the current transient is highly accurate for circuit level simulations.

PA-2  The Significance of High-Level Carrier Injection Conditions for Charge Collection in Devices
N. C. Hooten, W. G. Bennett, N. A. Dodds, R. A. Reed, R. D. Schrimpf, Vanderbilt University; L. D. Edmonds, ICS Electronics Company; J. R. Ahlbin, University of Southern California; D. McMorrow, J. H. Warner, Naval Research Laboratory

Pulsed-laser induced charge-collection measurements in a bulk silicon diode indicate that typical single-event tests cause high-injection conditions, emphasizing the need for charge-collection models that adequately consider the high-injection regime.

PA-3  Effects of Neutron-Induced Well Potential Perturbation for Multiple Cell Upset of Flip-Flops in 65 nm
J. Furuta, H. Onodera, Kyoto University; R. Yamamoto, K. Kobayashi, Kyoto Institute of Technology

We measure well-potential perturbation with embedded detectors by neutron irradiation. There is strong correlation between MCU and well-potential perturbation. It is possible to detect faults of redundant systems by well-potential perturbation.

LUNCH

SESSION B  SINGLE-EVENT EFFECTS: TRANSIENT CHARACTERIZATION

SESSION INTRODUCTION
Chair: Matthew Gadlage, NAVSEA Crane

B-1  Single Event Transients Induced by the Absorption of Picosecond X-Ray Pulses in III-V High Electron Mobility Transistors

The Advanced Photon Source was used to demonstrate pulsed xray induced single event transient (SET) generation in GaAs and GaN high electron mobility transistors (HEMTs) through device metallization. An analysis of the transients is presented.
A Comprehensive Methodology to Rate SETs of Complex Analog and Mixed-Signal Circuits Demonstrated on 16-bit A-to-D Converters

3D histograms classifying the occurrence frequency of pulsed-laser induced ASETs against their durations and amplitudes are interpreted on 16bit ADCs operated at 10MSps, proposing a comprehensive tool for rating radiation hardness in analog circuits.

On-Chip Measurement of Single-Event Transients in a 45nm Silicon-on-Insulator Technology

On-chip testing often involves uncertainty due to limitations of monitoring circuitry. A BIST circuit for measurement of SETs has been implemented in a 45nm SOI technology that allows for extraction of measurement-induced uncertainty.

Correlation of Dynamic Parameter Modification and ASET Sensitivity in a Shunt Voltage Reference
N. J.-H. Roche, L. Dusseau, J. Boch, F. Saigne, Université Montpellier 2; S. P. Buchner, J. H. Warner, D. McMorrow, Naval Research Laboratory; K. Kruckmeyer, Texas Instruments; G. Auriel, CEA GRAMAT; B. Azais, Direction Generale de l’Armement

ASETs in two different shunt voltage regulators are investigated. Modifications of the dynamic parameters of the circuit are calculated by step response measurement. A correlation between dynamic parameters and ASET laser testing results is proposed.

Single-Event Transient Testing of Linear Regulators
G. R. Allen, P. C. Adell, JPL; D. Chen, NASA Goddard Space Flight Center; P. Musil, M.S. Kennedy

Recommendations for Single Event Transients (SETs) testing of linear regulators are provided. Output capacitor’s equivalent series resistance (ESR), loading conditions and regulator stability are the key elements that govern regulators SET response.

Characteristics of the Transient Currents Induced by Atmospheric Neutrons on a 40 nm Electrode of an NMOS Transistor
F. Wrobel, L. Dilillo, A. Touboul, J.-R. Vaille, F. Saigne, Université Montpellier 2

We simulate atmospheric neutron-induced transient current on a 40 nm electrode. We propose an analytical law expressing the cross section of obtaining a transient with a given collected charge and a given pulse width.
Impact of Circuit Placement on Single Event Transients in 65 nm Bulk CMOS Technology
H. Yibai, C. Shuming, C. Jianjun, C. Yaqing, L. Biwei, Q. Junrui, National University of Defense Technology

Heavy ion experiments on inverter chains demonstrate the impact of circuit placement on single event transients. The horizontal placement significantly reduces the pulse width and SET cross section compared to the vertical one.

Power Voltage Scaled Dependency of Propagating SET Pulse width in 90 nm CMOS Technology
J. Qin, S. Chen, J. Chen, B. Liang, B. Liu, Y. He, P. Huang, National University of Defense Technology

The pulse width propagating decreases with voltage reducing in circuits that have remarkable charge sharing, which rectifies the pessimistic conclusion that ultra-low power applications are much more susceptible to the particle strike.

Retention Errors in 65 nm Floating Gate Cells after Exposure to Heavy Ions
M. Bagatin, S. Gerardin, A. Paccagnella, University of Padova

The retention of floating gate cells is studied up to one year after heavy-ion exposure, without using accelerated tests. Retention errors cross sections and threshold voltage shifts are discussed and compared with previous generations.

Angular Dependency of Neutron Induced Multiple Cell Upsets in 65-nm 10T Subthreshold SRAM
R. Harada, M. Hashimoto, Osaka University and JST; S.-I. Abe, Y. Watanabe, Kyushu University; H. Fuketa, University of Tokyo; T. Uemura, Fujitsu Semiconductor Ltd.

We present a measured dependency of neutron induced multiple cell upsets on incident angle in 0.4V 65-nm 10T SRAM, and show that it is well explained by simulated scattering of secondary ions.

Frequency Dependence of Alpha-Particle Induced Soft Error Rates of Flip-Flops in 40 nm CMOS Technology

D and DICE flip-flops designed in 40nm CMOS technology show 1.5X & 2.2X increase in alpha SER over 80MHz - 1.3GHz frequency. Simulations show transient mechanism of upset becoming prominent with increasing frequencies.
**POSTER PAPERS**

**PC-I**

**A Neutron Cross Section Model for a Multicore Server**

S. S. Stolt, E. Normand, Boeing

A neutron radiation test of Intel X5570 based server blades was conducted. The server blades were exercised with fifteen different operating and idle conditions. A mathematical model was then fit to those operating conditions.

**PC-2**

**Including Process-Related Variability in Soft Error Rate Analysis of Advanced Logic Design down to 28 nm Based on a Foundry Process Design Kit**

J. Yao, Y. Wang, Tsinghua University; M. Li, Y. Li, Accelicon Technologies, Inc.; R. Schrimpf, D. Fleetwood, Vanderbilt University

We have developed a statistical soft error rate (SER) analysis that incorporates response surface modeling and a neuron modeling algorithm, which is calibrated to silicon. Experimental results verify faster and more accurate SER estimation.

**PC-3**

**Real-Time Soft-Error Testing Results of 45 nm, High-K Metal Gate, Bulk CMOS SRAMs**

N. Seifert, M. Kirsch, Intel Corporation

We report on soft error rates (SER) of 45 nm bulk CMOS SRAMs measured in real-time testing experiments. Results are consistent with accelerated testing and demonstrate that alpha-particle induced SER is negligible.

**PC-4**

**Large-Scale Multiple Cell Upsets in 90 nm Commercial SRAMs During Neutron Irradiation**

A. Hands, P. Morris, K. Ryden, C. Dyer, P. Truscott, QinetiQ

During neutron irradiation of 4-Mbit SRAMs, large-scale MCU were observed. These manifest in 2D patterns encompassing scores of cells which, even with bit interleaving, lead to uncorrectable MBU in the same word.

**PC-5**

**Correlation of Heavy Ion and Laser Testing on a DC/DC PWM Controller**

Y. Ren, H. Wang, L. Chen, University of Saskatchewan; S. Shi, G. Gang, L. Gao, China Institute of Atomic Energy; S. Wen, R. Wong, Cisco Systems Inc.; N. V. Vonno, Intersil Inc.; B. Bhuva, Vanderbilt University; R. Sammynaiken, University of Saskatchewan

Heavy ion and pulsed laser experiments were carried out on a commercial DC/DC PWM Converter. The correlation between heavy ion LET and laser energy were obtained based on cross-sections for each experiment.

**PC-6**

**Correlation of Laser Test Results with Heavy Ion Results for NAND Flash Memory**


Pulsed laser test results are compared with heavy ion results obtained with the Milli-Beam(TM), with good agreement at some power levels. Laser results at higher power levels may also lead to new insights.
HARDENING BY DESIGN
SESSION INTRODUCTION
Chair: Andrew Sternberg, ISDE/Vanderbilt University

D-1
3:45 PM
An 8-16 GHz SiGe Low Noise Amplifier with Self-Healing Capability for Mitigation of Radiation-Induced Performance Loss

A self-healing approach for mitigating RF performance loss due to total dose exposure is investigated in a 8-16 GHz SiGe low noise amplifier and is intended for potential use in space-based transceivers.

D-2
4:00 PM
Single Event Performance and Layout Dependence for Hardened Flip-Flops in a 28 nm Bulk Technology
K. O. Lilja, M. Bounasser, Robust Chip Inc.; B. L. Bhuva, N. J. Gaspard, Vanderbilt University

Alpha, neutrons, and heavy-ion single event measurements were performed on 28 nm bulk flip-flops. The measurements agree excellently with simulation predictions confirming that event error rates can be reduced dramatically using effective layout design.

D-3
4:15 PM
A Hysteresis-Based D Flip-Flop Design in 28 Nm CMOS for Improved SER Hardness at Low Performance Overhead
B. Narasimham, K. Chandrasekharan, Z. Liu, J. K. Wang, G. Djaja, Broadcom Corporation; N. J. Gaspard, B. L. Bhuva, Vanderbilt University

A novel D Flip-Flop design using hysteresis in 28 nm with improved SER hardness and low performance overhead is presented. Alpha, neutron, and heavy-ion test results indicate significant improvement in SER compared with standard DFF.

D-4
4:30 PM
DARA: a Low-Cost Reliable Architecture Based on Unhardened Devices and Its Case Study of Radiation Stress Test
J. Yao, Y. Nakashima, Nara Institute of Science and Technology; S. Okada, Kyoto Institute of Technology; H. Shimada, Nara Institute of Science and Technology and CREST; K. Kobayashi, Kyoto Institute of Technology and CREST

A redundancy architecture is proposed to tolerate soft and hard errors. For the soft error, our radiation stress test on an ASIC from this architecture, without circuit hardening, demonstrates the same dependability as hardened devices.
POSTER PAPERS

PD-1 Effects of a Leakage Current Blocking P+ Layer on a Dummy Gate-Assisted N-MOSFET Layout for Total Ionizing Dose Mitigation
M. S. Lee, T. H. Kim, H. C. Lee, KAIST

This study investigates the effects of a leakage current blocking p+ layer on a dummy gate-assisted N-MOSFET layout, which is proposed to mitigate the leakage current induced by gamma radiation.

PD-2 Novel Layout Techniques for N-Hit Single-Event Transient Mitigation by Source Extension
J. Chen, Chen Shuming, He Yibai, Chi Yaqing, Qin Junrui, Liang Bin, Liu Biwei, National University of Defense Technology

Source extension layout technique is proposed for N-hit SET mitigation. 3D TCAD simulations and heavy-ion experiments show that SET pulse widths are efficiently reduced. The reversed parasitic bipolar effect is used to explain the mechanism.

PD-3 Applicability of Redundant Pairs of SOI Transistors for Analog Circuits and Their Applications to Phase-Locked Loop Circuits
A. Makihara, T. Yokose, K. Tani, Y. Tsuchiya, Y. Miyazaki, HIREC; H. Abe, JAEA; H. Shindou, T. Ebihara, A. Maru, S. Kuboyama, T. Tamura, JAXA

Redundant pairs of SOI transistors have been utilized as radiation hardening by design technique. Their applicability was extended for analog circuits such as current mirror circuits, and successfully demonstrated with a phase locked loop circuit.

PD-4 Selective Hardening Methodology Concerning Multiple Faults

This paper proposes a methodology for selective hardening combinational cells concerning multiple faults induced by Single-Event-Effects. Hardening costs and locality bias are taken into account. Results show a cost effective improved reliability.

4:45 PM END OF TUESDAY SESSIONS
GRAND BALLROOM
INVITED TALK
8:30 – 9:40 AM

**Bizarre in Biscayne**
*Gary Bremen, National Park Ranger, Biscayne National Park*

The largest marine park in the US National Park System, Biscayne National Park, is home to sea turtles, sharks, crocodiles and manatees, but it is also home to a myriad of other, less glamorous wildlife that tend to get short shrift from the so-called charismatic megafauna. Presented in a lively and entertaining style, these are the stories of just a few of those animals and their bizarre habits. They include pregnant fathers, decidedly independent female fish, some rather strange bedfellows, and a whole new perspective on the phrase “living in a dump!” What do these animals have to teach us about the world around us, and about ourselves?

**Gary Bremen** is a native South Floridian. As a boy, his parents took him to places with names like Yellowstone, Grand Canyon and Carlsbad, and in so doing, set him on a career path as a National Park Ranger. Twenty-six years into that career (with 17 years of that being at Biscayne), he still finds enormous satisfaction in discovering the lesser-known aspects of the world around him. He is the recipient of the National Park Service’s Freeman Tilden award for excellence in interpretation and the Crystal Owl award for training excellence, as well as a special award from the United States Coral Reef Task Force for his efforts to educate South Floridians about the park and its inhabitants. A graduate of the University of Miami, he lives in the little town of Wilton Manors with his partner Roger and their cats Buster and Neko.

**SESSION E** 9:40 AM

**PHOTONIC DEVICES AND INTEGRATED CIRCUITS**

**SESSION INTRODUCTION**
*Chair: Jim Pickel, PRT, Inc.*

**E-1** 9:45 AM

**Displacement Damage Effects in Pinned Photodiode CMOS Image Sensors**
*C. Virmontois, A. Bardoux, CNES; V. Goiffon, F. Corbiere, P. Magnan, Université de Toulouse; S. Girard, CEA DAM DIF*

Displacement damage effects in pinned photodiode CMOS image sensors are investigated through several measurements on dark current, quantum efficiency and charge to voltage conversion factor.

**E-2** 10:00 AM

**Radiation Effects in Pinned Photodiode CMOS Image Sensors: Pixel Performance Degradation Due to Total Ionizing Dose**
*V. Goiffon, M. Estrébeau, P. Magnan, C. Virmontois, P. Martin-Gonthier, R. Molina, P. Cervantes, F. Corbiere, Université de Toulouse, ISAE; S. Girard, M. Gaillardin, P. Paillet, C. Marcandella, CEA DAM DIF*

We present an analysis of TID effects on pixel performances (QE, transfer, dark current, full well…) of Pinned Photodiode CMOS Image Sensors manufactured in two widely used commercially available CIS foundries. New effects are discussed.
Rad Tolerant CMOS Image Sensor Based on Hole Collection 4T Pixel Pinned Photodiode
S. Place, J.-P. Carrere, F. Roy, ST Microelectronics; P. Magnan, V. Goiffon, Université de Toulouse

A pinned photodiode collecting holes based on 1.4 μm pixel pitch design has been irradiated with Co-60 source. A comparison with NMOS pixel reference is evaluated to discuss the interest of holes detection.

Evaluation of 0.18 micrometer CMOS Image Sensors Tolerance for Space Applications
E. Martin, O. Gilard, M. Boutillier, CNES; T. Nuns, J.-P. David, ONERA; J. Vaillant, P. Feyrere, V. Prevost, E2V

The radiation tolerance of a 0.18 μm technology CMOS commercial image sensor has been evaluated with Co-60 and proton irradiations. The effect of protons incident angle value and dynamic bias conditions are studied.

Transient Radiation Effects on Optical Fibers for Megajoule Class Lasers: Influence of MCVD Process Parameters
S. Girard, C. Marcandella, CEA DAM DIF; A. Alessi, A. Boukenter, Y. Ouerdane, Université de Saint-Etienne

Based on a set of 15 dedicated optical fibers, we studied the influence of composition and drawing parameters on the response of fibers exposed to the harsh environment associated with fusion by inertial confinement experiments.

Electroluminescence Measurement Techniques for Radiation Effects Characterization of Solar Cells
R. R. Hoheisel, Naval Research Laboratory and The Georgetown University; S. R. Messenger, M. Gonzalez, P. P. Jenkins, R. J. Walters, Naval Research Laboratory

This paper shows how electroluminescence (EL) measurements can be very useful in determining subcell voltage degradation in advanced multijunction solar cells for space applications. Radiation hardening techniques for array voltages may now be necessary.

Study of the Effects of UV-Exposure on Dye-Sensitized Solar Cells
D. Bari, A. Cester, N. Wrachien, G. Meneghesso, University of Padova; R. Tagliaferro, T. M. Brown, A. Reale, A. Di Carlo, University of Rome

We subjected dye-sensitized solar cells to UV irradiation. Irradiation induces ionic species degradation allowing electron to recombine with ionic acceptor species in the electrolyte. Remarkably open-circuit voltage reduction was observed during UV-exposure.
Modeling of the X-ray Irradiation Response of the Carrier Relaxation Time in P3HT:PCBM Organic Based Photo-Cells
K. Kambour, SAIC; N. Rosen, C. Kouhestani, D. Nguyen, C. Mayberry, FRL/RVSE; R. Devine, Think-Strategically; A. Kumar, C.-C. Chen, G. Li, Y. Yang, UCLA

X-ray irradiation generated trapped charge induces open-circuit voltage (Voc) variations and carrier relaxation time. This is modeled using a standard drift/diffusion program. Voc shifts and anomalous behavior of relaxation time are accounted for.

### Session F

#### RADIATION HARDNESS ASSURANCE

### Session Introduction

Chair: David Hansen, Maxwell Technologies, Inc.

#### F-1

**Qualification of Parts for Space with the Variable Depth Bragg Peak Method**

C. C. Foster, Foster Consulting Services, LLC; P. M. O’Neill, B. D. Reddell, NASA Johnson Space Center; K. V. Nguyen, B. H. Jones, Jacobs Technology; S. P. Buchner, Naval Research Laboratory

Use of the VDBP method to qualify parts for destructive SEE's and determine the failure threshold LET(Si) is demonstrated with two power monitor/reset chips that qualified and a rad hard MOSFET that failed.

#### F-2

**Process Variability Effect on Soft Error Rate by Characterization of Large Number of Samples**

G. Gasiot, A. Castelnovo, M. Glorieux, E. Abouzeid, S. Clerc, P. Roche, STMicroelectronics

For the first time the effect of process variability on SER is experimentally characterized with a large number of samples. SER analysis as a function of position on wafer and samples capacity impacts hardness assurance.

#### F-3

**Statistical Analysis of Heavy Ion Induced Gate Rupture in Power MOSFETs - Methodology for Radiation Hardness Assurance**

V. Ferlet-Cavrois, C. Poivey, A. Zadeh, ESA ESTEC; C. Binois, A. Carvalho, EADS Astrium; G. Chaumont, STMicroelectronics; N. Ikeda, JAXA; J. R. Schwank, Sandia National Laboratories

A methodology for power MOSFET radiation hardness assurance is proposed. It is based on the statistical analysis of destructive events, such as gate oxide rupture. Examples of failure rate calculations are performed.

#### F-4

**A Robust Strategy for Total Ionizing Dose Testing of Field Programmable Gate Arrays**


We present a novel method of FPGA TID testing that measures delay between flip-flops operating at maximum speed. Measurement is performed internally and provides a key design metric when building system-critical synchronous designs.
POSTER PAPERS

PF-1  Worst-Case Test Vectors for Delay Failures Induced by Total Dose in ASICs  
A. A. Abou-Auf, H. A. Abdel-Azziz, The American University in Cairo; M. M. Abdel-Azziz, A. G. Wassal, Cairo University

We developed a methodology for identifying worst-case test vectors (WCTV) for delay failures induced in ASIC devices exposed to total dose. We developed a fast search algorithm for WCTV in large ASICs.

PF-2  On the Calculation of Single Event Rates for Devices Sensitive to Test Conditions  
L. D. Edmonds, Private Consultant; L. Z. Scheick, JPL; M. W. Banker, University of Florida

Single event rates include contributions from low-energy particles where LET varies. A formalism for a comprehensive rate estimate utilizing limited test data is presented with the optimal testing conditions and refined environmental data.

POSTER SESSION  
2:15 – 4:30 PM  
BAYFRONT ROOM

INTRODUCTION

Chair: Stephen Buchner, Naval Research Laboratory

4:30 PM  END OF WEDNESDAY SESSIONS
SESSION G
8:55 AM
RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS
SESSION INTRODUCTION
Chair: Kirby Kruckmeyer, Texas Instruments

G-I
9:00 AM
Degradation of sub 40 nm NAND Flash Memories under Total Dose Irradiation
S. Gerardin, M. Bagatin, A. Paccagnella, University of Padova; V. Ferlet-Cavrois, ESA/ESTEC

We study total dose effects in advanced multi- and single-level NAND Flash memories. We discuss retention and erase failures, analyzing the role of floating gate cells and peripheral circuitry as compared to previous generations.

G-2
9:15 AM
Total-Dose Radiation Tolerance of 32 nm RF-CMOS-on-SOI Technology

nMOSFETs built in 32 nm RF-CMOS-on-SOI technology with high-k dielectrics show increased off-state leakage current and electron trapping in the gate oxide. Hole trapping is observed in pMOSFETs.

G-3
9:30 AM
On Extra Combinational Delays in SRAM FPGAs Due to Radiation
C. Thibeault, S. Pichette, Ecole de Technologie Superieure; Y. Audet, Y. Savaria, Ecole Polytechnique de Montreal; H. Rufenacht, MDA Corporation; E. Gloutnay, Canadian Space Agency; Y. Blaquiere, Universite du Quebec a Montreal; F. Moupfouma, Bombardier Aerospace; N. Batani, ISR Technologies

This paper presents a new setup and (to our knowledge the first ever) experimental results reporting extra combinational delays (up to 400ps) in an SRAM FPGA (Virtex-5) due to radiation (proton irradiation at TRIUMF).

G-4
9:45 AM
Total Ionizing Dose Effects on Ultrathin-Body-and-Buried-Oxide MOSFETs.
N. N. Mahatme, E. Zhang, R. A. Reed, B. L. Bhuvva, R. D. Schrimpf, D. M. Fleetwood, Vanderbilt University; D. Linten, M. Aoulaiche, E. Simoen, G. Groeseneken, M. Jurczak, IMEC; A. Griffoni, OSRAM

X-ray irradiation of thin silicon body FD-SOI devices on ultrathin buried oxide shows that the thin body and buried oxide have competing effects on the device radiation-tolerance. Device geometry effects are studied.

G-5
10:00 AM
Total Ionizing Dose Effects on Graphene-Based Non-Volatile Memory Devices

The irradiation and annealing responses of graphene-based ferroelectric memory devices are investigated as a function of applied gate bias. Excellent stability and memory retention are observed.
**Technical Program Thursday**

10:15 – 10:45 AM  
GRAND BALLROOM  
FOYER

**BREAK**

**G-6**  
10:45 AM

**Improved Tolerance Against UV and Alpha Irradiation of Encapsulated Organic TFTs**  
N. Wrachien, A. Cester, D. Bari, G. Meneghesso, University of Padova; J. Kovac, J. Jakabovic, D. Donoval, Slovak University of Technology

We irradiated organic thin-film-transistors with UV and alpha particles. Noticeable degradation occurs on unencapsulated devices. The encapsulation provides increased robustness by reducing the air absorption. However, charge trapping still occurs on encapsulated devices.

**G-7**  
11:00 AM

**Effect of X-Ray and Proton Radiation on the Electrical Characteristics of TaOx Memristors**  

Radiation-induced degradation of TaOx memristors is experimentally assessed. X-ray and proton irradiation are observed to cause switching of the memristors from high to low resistance states, and functional failure due to cumulative dose.

**G-8**  
11:15 AM

**Total Dose Effects on Bipolar Integrated Circuits at Low Temperature**  
A. H. Johnston, R. T. Swimm, D. Thorbourn, NASA JPL

The effects of radiation damage and low temperature are examined for bipolar linear circuits. No damage is observed in lateral pnp transistors after low temperature irradiation until the device is warmed above -50 °C.

**POSTER PAPERS**

**PG-1**

**Combined Effects of Cobalt-60 Dose and High Frequency Interferences on a Discrete Bipolar Transistor**  
A. Doridant, Université Montpellier 2 IES and TRAD; J. Raoult, S. Jarrix, A. Blain, L. Dusseau, Université Montpellier 2 IES; P. Hoffmann, CEA DAM CEG; N. Chatry, TRAD; P. Calvel, Thales Alenia Space

A discrete transistor is subject to Cobalt-60 irradiation and electromagnetic interference. Two phenomena occur under interference: rectification and current crowding. TID enhance these mechanisms, leading to drastic changes in the output parameters of the transistor.

**PG-2**

**Effects of Bias, Electrical and Thermal Stress on DDR SDRAM Total Ionizing Dose Response**  
R. L. Ladbury, D. Chen, M. C. Casey, K. A. LaBel, NASA Goddard Space Flight Center

We investigate whether bias conditions and electrical and thermal stresses affect the Total Ionizing Dose response of double data rate SDRAMs.
**PG-3**  
**A Radiation Hardening Method for Shallow Trench Isolation in SRAMs**  
L. Liu, Y.-F. Zhao, S.-G. Yue, J.-C. Li, Beijing Microelectronics Technology Institute  

TID hardened STI, formed by adding an extra STI sidewall implant step to a commercial process, is presented. Experiment results indicate this method can effectively suppress the radiation-induced leakage current of a 4M SRAM.

**PG-4**  
**Worst-Case Failure Analysis of Total Dose Effect in Deep-Submicron SRAM Circuits**  
L. Ding, Tsinghua University  

Worst-case TID effect in deep-submicron SRAM circuits is studied. Analysis is presented and experiment is designed for 0.25um SRAM circuit. Failure level concluded from the worst-case test scheme is much lower.

**PG-5**  
**Retention Characteristics of Commercial NAND Flash Memory after Radiation Exposure**  

We have compared the data retention of irradiated commercial NAND flash memories at different doses. Activation energies for retention testing at high temperatures have also been determined.

**PG-6**  
**Analysis of the TID Induced Failure Mode in NOR and NAND Flash Memories**  

TID response for several NOR and NAND flash memories under the read only mode is investigated. Significant address errors, increasing invalid blocks and the functional failure mode are tentatively interpreted with the related peripheral circuit.

**PG-7**  
**Ionizing Radiation Effects on NROM Memory Cells**  
S. Libertino, D. Corso, S. A. Lombardo, IMM-CNR; M. Lisiansky, Y. Roizin, Tower Semiconductor; F. Palumbo, CONICET-CNEA; F. Principato, Univ. of Palermo; C. Pace, Univ. of Calabria; P. Finocchiaro, INFN  

Threshold voltage (Vth) behaviour of NROM memories was studied after irradiation with photons and ions. Vth loss exhibits a variability well explained by the same Weibull statistics regardless of the irradiation species and total dose.

**PG-8**  
**Effects of Ionizing Radiation in Undoped Double-Gate FinFETs**  
J. Nam, B. J. Lee, J.-W. Yang, Korea University; C. Y. Kang, SEMATECH; K. P. Kim, Kyung Hee University  

Effects of γ-ray irradiation in DG FinFETs are examined for different $W_{fin}$ and $L_{g}$. Different behaviors of SCEs, capacitance, and mobility in NMOS and PMOS by the irradiation are analyzed with physical insight.
PG-9  **Radiation Studies of Spin-Transfer Torque Materials and Devices**  
H. L. Hughes, K. Bussmann, P. J. McMarr, S. Cheng, Naval Research Laboratory; R. Shull,  
A. P. Chen, National Institute of Standards and Technology; S. Schauer, T. Mewes, University  
of Alabama; A. Ong, E. Chen, Grandis, Inc.

Spin-transfer torque film and devices were irradiated using a Cobalt-60 source.  
Irradiation had no effect on the magnetic properties and tunnel magnetoresistance of  
the films and no effect on device performance.

PG-10  **Radiation Tolerance of Magnetic Tunnel Junctions with MgO Tunnel Barriers**  
F. Ren, A. Jander, P. Dhagat, Oregon State University; C. Nordman, NVE Corporation

The gamma and neutron radiation tolerance of magnetic tunnel junctions with MgO  
barriers was investigated. The characterization results show no statistically significant  
change in either transport or magnetic properties from the radiation.

PG-11  **Capabilities of a 180 nm SiGe BiCMOS Technology Platform for Focal Plane Array Applications in an Unshielded Europa Environment**  
E. W. Kenyon, N. E. Lourenco, S. Jain, J. D. Cressler, Georgia Institute of Technology; E. X.  
Zhang, D. M. Fleetwood, R. D. Schrimpf, Vanderbilt University

The TID response of a previously uncharacterized SiGe BiCMOS platform has been  
assessed using 10-keV X-rays and 63-MeV protons up to Europa total dose conditions  
(worst case of 6 Mrad).

**SESSION H**  
**BASIC MECHANISMS OF RADIATION EFFECTS**

**SESSION INTRODUCTION**  
Chair: Harold Hjalmarson, Sandia National Laboratories

H-1  **Surface reactions and defect formation in irradiated graphene devices**  
Y. S. Puzyrev, B. Wang, E. X. Zhang, C. X. Zhang, R. D. Schrimpf, D. M. Fleetwood,  
Vanderbilt University; S. T. Pantelides, Vanderbilt University and Oak Ridge National  
Laboratory

Quantum mechanical-based kinetic Monte-Carlo calculations are used to evaluate  
degradation mechanisms for Graphene devices subjected to irradiation and high-  
temperature annealing. Graphene surface damage is caused by desorption of CO and  
CO₂.

H-2  **Total Ionizing Dose Induced Charge Scattering in Cu-CVD Graphene Devices**  
C. D. Cress, J. T. Robinson, A. L. Friedman, Naval Research Laboratory; J. J. McMorrow,  
Sotera Defense Solutions and Northwestern University

This paper investigates the total ionizing dose effects in Cu-CVD Graphene devices.  
Trapped charges near the SiO₂-Graphene interface cause increased carrier scattering  
with a concomitant reduction in mobility and an increased minimum conductivity.
Quantifying the Effects of Single Particle Displacement Damage in Si Diodes

Single particle displacement damage events are reported in silicon diodes irradiated with Cf-252. The size, frequency, and contribution to cumulative leakage current of individual events are analyzed.

Charge Pumping Measurements of Radiation-Induced Interface-Trap Density in Floating-Body SOI FinFETs

We demonstrate a new measurement and analysis technique that combines charge-pumping and DCIV currents to obtain accurate estimates of radiation-induced interface-trap densities for conventional floating-body SOI FinFETs without body contacts.

Controlling Mechanisms Separating Time Dependent and True Dose Rate Effects in Irradiated Bipolar Oxides

A model for radiation-induced interface-trap buildup distinguishes between the contributions of hydrogen dimerization and space-charge mechanisms, quantitatively explaining time-dependent and true dose-rate effects in irradiated bipolar isolation oxides.

Displacement Damage Effects in AlGaN/GaN High Electron Mobility Transistors
B. D. Weaver, J. B. Boos, C. D. Cress, Naval Research Laboratory; P. A. Martin, Air Force Research Laboratory

Results on irradiated AlGaN/GaN HEMTs are presented. The basic mechanism underlying the high rad-tolerance appears to be a strong internal piezoelectric field near the 2DEG that causes re-injection of scattered carriers.

Radiation-Induced Degradation of Top-Gated Epitaxial Graphene FETs
I. Sanchez Esqueda, J. R. Ahlbin, University of Southern California; C. D. Cress, T. J. Anderson, Naval Research Laboratory

This paper investigates TID effects in top-gated epitaxial graphene field-effect-transistors (GFETs). Measurements reveal voltage shifts in the I-V and field-effect mobility characteristics, consistent with the buildup of charged impurities.
PH-3  **Total Dose Degradation Mechanisms of GLPNP and LDMOS Transistors at Low Temperature (< 125 K)**

*P. C. Adell, B. Rax, A. H. Johnston, NASA JPL; I. S. Esqueda, USC Information Science Institute; H. J. Barnaby, Arizona State University*

Commercial transistor technologies are evaluated combining total ionizing dose, dose rates and low temperature conditions. Holes transport is the key mechanism governing electrical degradation.

PH-4  **The Effects of Proton-Defect Interactions on Radiation-Induced Interface Buildup and Annealing**

*D. R. Hughart, R. D. Schrimpf, D. M. Fleetwood, B. R. Tuttle, S. T. Pantelides, Vanderbilt University; N. L. Rowsey, M. E. Law, University of Florida*

The presence of singly and doubly hydrogenated oxygen vacancies in oxide are shown through numerical simulation to alter proton and H$_2$ concentrations during irradiation, affecting buildup and annealing of interface traps, consistent with observed response.

PH-5  **Experimental Study of Defect Formations in GaAs Devices Using Gain, Photoluminescence and Deep Level Transient Spectroscopy**


We present an experimental methodology developed to probe the clustered defect formation in GaAs devices under both neutron and ion irradiations. The strengths, limitations, and path forward to gather structural defect information will be addressed.

RADIATION EFFECTS DATA WORKSHOP
2:30 – 4:15 PM
SEVILLA ROOM

INTRODUCTION

*Chair: Paul Eaton, Micro-RDC*

W-1  **Compendium of Recent Test Results of Single Event Effects Conducted by the Jet Propulsion Laboratory**

*G. R. Allen, L. Z. Scheick, F. Irom, S. M. Guertin, NASA JPL*

This paper reports heavy-ion, proton, and laser induced single-event effects results for a variety of microelectronics targeted for possible use in NASA spacecraft. The compendium covers devices tested over the last two years.
W-2 Radiation Test Results on COTS and Non-COTS Electronic Devices for NASA Johnson Space Center Spaceflight Projects
K. K. Allums, C. R. Bailey, K. V. Nguyen, P. M. O’Neill, B. D. Reddell, NASA Johnson Space Center

This paper reports the results of recent proton and heavy ion Single Event Effect (SEE) testing on a variety of COTS and non-COTS electronic devices and assemblies tested for Space Shuttle, ISS and MPCV.

W-3 Equipment and Results of the Electronic Component Tests to SEE in the Temperature Range
V. Anashin, A. Kozyukov, Institute of Space Device Engineering; V. Emelyanov, A. Ozerov, A. Vatuev, Research Institute of Scientific Instruments; A. Bakereko, V. Belyakov, Moscow Engineering Physics Institute; V. Skuratov, Joint Institute for Nuclear Research (JINR)

The paper presents the description of the equipment and results of the electronic component tests at the heavy ion accelerators of U-400 and U-400M in vacuum and temperature range.

W-4 A Comparison of High-Energy Electron and Cobalt-60 Gamma Ray Radiation Testing

A comparison between irradiating with high energy electrons and Cobalt-60 gammarays is examined. The effect of electron energy is also discussed. A variety of part types are investigated, including BJTs, hybrids, and JFETs.

W-5 Evaluation of Enhanced Low Dose Rate Sensitivity in Discrete Bipolar Junction Transistors

We evaluate the low dose rate sensitivity in several families of discrete bipolar transistors across device parameter, quality assurance level, and irradiation bias configuration. We discuss the implications of the results for radiation hardness assurance.

W-6 Compendium of Total Ionizing Dose and Displacement Damage for Candidate Spacecraft Electronics for NASA

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-7  PICO-4 Single Event Effects Evaluation and Testing Facility Based on Wavelength Tunable Picosecond Laser
A. N. Egorov, A. I. Chumakov, O. B. Matrityshk, A. A. Pechkin, D. O. Koltsov, A. V. Yanenko, NRNU MEPhI and SPELS

Technical characteristics of “PICO-4” SEE simulation facility utilizing tunable picosecond laser are presented. Its capabilities aimed on simulation of single event effects under space environment in Si, GaAs, SiGe etc. microelectronic devices are discussed.

W-8  Radiation Hard High Bandwidth (10Gb/s) Optical Links Based on Electro-Optical Modulators
W. Fernando, D. Underwood, R. Stanek, Argonne National Laboratory

We are investigating light modulators as an alternative to VCSELs for rad-hard high speed data links. We present SEE and TID results of these links for modulators based on LiNbO3, InP, and Si.

W-9  Heavy Ion Sensitivity of 16/32-Gbit NAND-Flash and 4-Gbit DDR3 SDRAM
K. Gruermann, M. Herrmann, F. Gliek, Technische Universitaet Braunschweig; H. Schmidt, Asteria GmbH; G. Liebeling, Institut fuer Angewandte Optik und Feinmechanik; H. Kettunen, University of Jyvaskyla; V. Ferlet-Cavrois, ESA-ESTEC

16/32Gbit NAND-Flash and 2/4Gbit DDR3 SDRAM devices have been tested under heavy ion irradiation. At high LET, 25 nm Flash show MBUs at normal incidence. DDR3 SEF mitigation means have been studied.

W-10  Programmatic Impact of SDRAM SEFIs
S. M. Guertin, G. R. Allen, D. J. Sheldon, NASA JPL

SDRAM SEFI modes are examined for impact of structure and mode register reloading. Recent testing of Elpida devices shows that some missions have limited sensitivity while others benefit from detailed summary of device impacts.

W-11  Guide to the 2011 IEEE Radiation Effects Data Workshop
D. M. Hiemstra, MDA

The 2011 Workshop Record has been reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

W-12  Single Event Upset Characterization of the Virtex-6 Field Programmable Gate Array Using Proton Irradiation
D. M. Hiemstra, V. Kirischian, MDA

Proton induced SEU cross-sections of the SRAM which stores the logic configuration and certain functional blocks of the Virtex-6 FPGA are presented. Upset rates in the space radiation environment are estimated.
W-13  **Measurement Methods for Total Ionising Dose Testing: in-Situ Versus Standard Practice**  
*J. Hofman, R. Sharp, Synergy Health plc*

This work discusses test methodologies for TID testing and ways it can be improved. Emphasis is given to fully automated test solutions, using in-situ measurement methods. Results from in-situ tests are also presented.

W-14  **Compendium of Single-Event Latchup and Total Ionizing Dose Test Results of Commercial Analog to Digital Converters**  
*F. Irom, S. G. Agarwal, NASA JPL*

This paper reports single-event latchup and total dose results for a variety of analog to digital converters targeted for possible use in NASA spacecrafts. The compendium covers devices tested over the last 15 years.

W-15  **Scaling Effects in Highly Scaled Commercial Nonvolatile Flash Memories**  
*F. Irom, D. N. Nguyen, NASA JPL*

SEU measurements and TID response for 25 nm Micron Technology NAND flash memories are reported. Radiation results of MLC 64Gb parts are compared with results from SLC 32Gb parts. Also, scaling effects are discussed.

W-16  **Single Event Effects Sensitivity of DDR3 SDRAMs to Protons and Heavy Ions**  
*R. Koga, J. George, P. Yu, S. Bielat, The Aerospace Corporation*

SEE sensitivity to protons and heavy ions is observed with several types of DDR3 SDRAMs. Upsets in control sections with various error output patterns have been measured along with upsets in memory storage elements.

W-17  **Radiation Effect Characterization on the QorIQ P2010 Microprocessor**  
*D. Lambert, X. Vega, EADS Nucletudes; D. Gauthier, EASII IC; B. Azais, DGA*

Upset susceptibilities are measured for the QorIQ P2010 Microprocessor. SEE cross-sections for protons (3.5 to 105 MeV) and heavy ions have been tested for registers and caches. Main characteristics of susceptibility are given.

W-18  **Electrical Test Conditioning Influence on Total Ionizing Dose Response of SRAMs**  
*R. K. Lawrence, BAE Systems*

For CMOS, memory array power up (no pattern loaded) is an acceptable TID worst-case dosing condition; however, this condition may not represent a post exposure worst-case electrical characterization.

W-19  **Single Event Effects Characterization of Maxwell 7846B DAC**  
*S. E. Stone, R. E. Lombardi, S. S. Seehra, J. J. Likar, J. Begovic, R. Herschitz, Lockheed Martin Space Systems*

Heavy ion test results indicate that the Maxwell 7846B 16 Bit DAC is susceptible to SET and SEU in the form of stable level changes at the device output.
W-20 Total Dose and Transient Response of SiGe HBTs from a New 4th-Generation, 90 Nm SiGe BiCMOS Technology


Total dose and transient responses of a new 4th generation 90 nm IBM SiGe 9HP technology are investigated. The SiGe HBTs are multi-Mrad dose tolerant and exhibit reduced single event transients compared to prior generations.

W-21 Characterization of Radiation Hardened Bipolar Linear Devices for High Total Dose Missions

S. S. McClure, R. Harris, B. Rax, D. Thorbourn, NASA JPL

Radiation hardened linear devices are characterized for performance in combined total dose and displacement damage environments. Performance in different dose rate and bias conditions is compared and the impact to hardness assurance methodology is discussed.

W-22 Compendium of Single Event Effects for Candidate Spacecraft Electronics for NASA


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

W-23 On-Orbit Results for the Xilinx Virtex-4 FPGA

H. Quinn, P. Graham, K. Morgan, Z. Baker, M. Caffrey, D. Smith, Los Alamos National Laboratory; R. Bell, NNSA

This abstract provides information regarding the use of the Xilinx Virtex-4 field-programmable gate array in a spacecraft deployed to low-earth orbit. The results are compared to accelerated radiation testing.

W-24 Neutron-Induced Soft Errors in Graphic Processing Units

P. Rech, C. Aguiar, R. Ferreira, L. Carro, UFRGS; M. Silvestri, University of Bristol; A. Griffoni, OSRAM; C. Frost, ISIS, RAL

We present the results of neutron experiments on 40 nm GPUs. Internal resources are characterized and a new Threads Cross Section is defined. Matrix multiplication error rate is experimentally measured and analytically predicted.

W-25 Comprehensive Radiation Characterization and Hardening of an Innovative Hybrid Micro-Module Switch Regulator

S. Rezgui, T. Crane, H. Soleimani, T. Sheehan, T. Hage, R. Dobkin, R. Albarian, B. Scott, S. Pietkiewicz, Linear Technology

This paper details a comprehensive radiation characterization of a new hybrid micro-module, which serves as a high voltage, synchronous, current mode controller used for medium to high power supply (4 to 60V).
W-26  **SEE Results for Newly Available MOSFETs**  
L. Z. Scheick, NASA JPL  

Recently available power MOSFETs were tested and the results are presented. Also, the effect of testing approach and conditions are discussed.

W-27  **Compendium of Radiation Test Results from Ball Aerospace & Technologies Corp.**  
K. A. Scott, Ball Aerospace & Technologies Corp.

Test results are presented for a number of electronic devices tested for sensitivity to non-ionizing displacement damage dose and total ionizing dose for space applications at Ball Aerospace & Technologies Corp.

W-28  **Single-Event Immune Point-of-Load Buck Regulators for Space Applications**  
J. W. Swonger, G. Horvath, Anup Singh, Peregrine Semiconductor

The effects of radiation on electronic components in the space environment are a perennial concern to spacecraft designers. This paper presents a power management solution to systems requiring small size, design versatility and radiation immunity.

W-29  **TID in a Mixed-Signal System-on-Chip: Analog Components Analysis and Clock Frequency Influence in Propagation-Delay Degradation**  

We exposed a mixed-signal system-on-chip to gamma radiation in order to measure variations in current, temperature, propagation-delay and duty-cycle in its components, such as configurable array, analog blocks and microprocessor.

W-30  **Accelerated Aging Testing of Intersil Bipolar and BiCMOS Parts**  

We report results of 100°C accelerated aging testing of the Intersil ISL75051SRH low dropout regulator and the ISL70417SRH quad operational amplifier. Accelerated aging was performed for 168 hours after Co-60 irradiation to 150 krad(Si).

W-31  **Results of Displacement Damage Testing of the Intersil ISL70227SRH Dual Operational Amplifier**  

We report results of displacement damage testing of the Intersil ISL70227SRH dual operational amplifier. This part uses a complementary bipolar SOI process. Samples were irradiated using 1MeV neutrons at the WSMR Fast Burst Reactor.
**W-32** Total Dose and Single Event Testing of the Intersil ISL75051SRH Low Dropout Regulator  

We report the results of high dose rate total dose and heavy ion SEE testing of the Intersil ISL75051SRH low dropout regulator. We also discuss the part’s electrical specifications and fabrication process.

**W-33** Low-Energy Proton Testing Using the Boeing Radiation Effects Laboratory 2.2 MeV Dynamitron  

This paper describes the use of the BREL Dynamitron accelerator for low-energy (= 2MeV) single event effects testing of semiconductor devices. A description of the Dynamitron and test data will be given.

**W-34** Verification of Enhanced Low Dose Rate Sensitivity (ELDRS) Accelerated Test Method  
M. Wind, P. Beck, M. Latocha, AIT; L. Dusseau, J. Boch, F. Saigné, UM2; A. Zadeh, M. Poizat, ESA/ESTEC  

Low dose rate testing is performed at AIT using the accelerated switching test method developed at UM2. Experiments are done to validate the accelerated low dose rate test method for selected parts.

**W-35** Total Ionizing Dose and Single Event Latch-up Characterization of a 16-bit A-to-D Converter Fabricated in 0.18um Triple-Well CMOS Process  
A. Zanchi, S. Hisano, C. C. Hafer, D. B. Kerwin, Aeroflex Colorado Springs  

A RadHard 16 bit pipeline ADC shows <130mV bandgap voltage variation and minimal performance shifts vs. TID, maintaining 73.5dBFS SNR, 92dBc SFDR to 2 Mrad(Si). Selected blocks tested SEL-immune to 121 MeV-cm²/mg LET.
You may be wondering why there is an invited talk on Single Malt Scotch Whisky at NSREC in Miami. The reason is that various organizing committees over the years have threatened to have Ron Pease talk about his favorite subject (outside of radiation effects) in an invited talk. Ron has bent many an ear about single malts at NSRECs since the early 1990s and has given numerous talks and tastings to select attendees. His interest began in 1989 at a conference in Edinburgh where he was introduced to single malts at an invited talk by an engineering professor from the University of Edinburgh. It was love at first dram. Since then he has amassed a collection of single malts from nearly all Scottish distilleries, acquired about 80 books on Scotch whisky, given numerous lectures and tastings, visited over 30 distilleries in Scotland, purchased a hogshead cask of Port Charlotte whisky from Bruichladdich on Islay, attended the Bruichladdich Single Malt Academy, attended four Whiskyfests (two in Chicago and two in San Francisco) and has had a letter to the editor and his picture appear in the magazine Malt Advocate (now Whisky Advocate).

In this talk Ron will introduce you to the world of Scotch whisky, with an emphasis on single malts. He will cover general facts, legal definitions, how Scotch whisky is made, why it tastes the way it does, and the history of Scotch whisky. The talk will cover the various regions of single malts, information on distilleries, ownership, production and markets and recent trends in single malts. If the legal issues can be worked out with US customs in time, Ron will be able to share with you a taste of his recently bottled Port Charlotte single malt.

Ron Pease first attended NSREC in 1969 and has been an active member of the radiation effects community ever since. He has held every technical position on the Conference Committee and was the Conference Chairman in 2000. He just ended a four year term as TNS Associate Editor. Ron has served on the RESG both as a member-at-large and as Vice Chairman of Publications. He is the recipient of four Outstanding Conference Paper Awards and four Outstanding Data Workshop Presentation Awards. In 2007 he received the Peter H. Haas award at the HEART Conference for “outstanding technical contributions to the understanding of radiation effects and furthering the exchange of information at international conferences, short courses and publications”. Ron became an IEEE Life Fellow this year.

5:25 PM END OF THURSDAY SESSIONS

GRAND BALLROOM

RADIATION EFFECTS COMMITTEE OPEN MEETING

5:30 – 7:00 PM
Paolo Nespoli, astronaut of the European Space Agency (ESA) has flown twice in space. From 23 October to 7 November 2007, he flew as Mission Specialist on board Space Shuttle Discovery for the STS-120 flight to the International Space Station (ISS). This mission delivered and installed the Node-2, a major building block essential for further expansion of the ISS, including the addition of the European Columbus laboratory. Another important task was the relocation of one of the four solar arrays that provide power to the Station. Nespoli played a key role as the intravehicular activity astronaut (or IVA) for the mission’s spacewalks, including the installation of Node-2. During his mission, named Esperia, Nespoli also performed a number of European experiments for the European scientific community in the area of human physiology and biology. Nespoli also took part in educational activities.

In November 2008, Nespoli was assigned to his second spaceflight. Expedition 26/27, a long duration mission to the ISS was launched on 15 December 2010. Nespoli’s duties as ISS flight engineer during his MagISStra mission included conducting scientific experiments and technology demonstrations, as well as performing educational activities. After having spent 159 days in space, he returned to Earth on 24 May 2011.

In his talk Nespoli will present his experience about living and working in the ISS. He will also show some of the amazing pictures he took during expedition 26/27.

He received a Bachelor of Science in Aerospace Engineering in 1988 and a Master of Science in Aeronautics and Astronautics in 1989 from the Polytechnic University of New York. He was awarded the Laurea in Ingegneria Meccanica by the Università degli Studi di Firenze, Italy, in 1990.

Nespoli was drafted by the Italian army in 1977 and became a non-commissioned officer working as a parachute instructor at the Scuola Militare di Paracadutismo of Pisa. In 1980 he joined the 9° Btg d’Assalto “Col Moschin” of Livorno where he became a Special Forces operator. From 1982 to 1984, he was assigned to the Italian contingent of the Multinational Peacekeeping Force in Beirut, Lebanon. Following his return to Italy he was appointed an officer and continued working as a Special Forces operator.

Nespoli resumed his university studies in 1985. He left active army duty in 1987. Upon completing his M.Sc. in 1989, he returned to Italy to work as a design engineer for Proel Tecnologie in Florence, where he conducted mechanical analysis and supported the qualification of the flight units of the Electron Gun Assembly, one of the main parts of the Italian Space Agency’s Tethered Satellite System (TSS).

In 1991 he joined ESA’s European Astronaut Centre in Cologne, Germany. As an astronaut training engineer, he contributed to the preparation and implementation of basic training for the European astronauts and he was responsible for the preparation and management of astronaut proficiency maintenance. He was also responsible for the Astronaut Training Database, a software system used for the preparation and management of astronaut training.

In 1995, he was detached to the EUROMIR project at ESA’s ESTEC establishment in Noordwijk, the Netherlands, where he was responsible for the team that prepared, integrated and supported the Payload and Crew Support Computer used on the Russian space station Mir.
In 1996, he was detached to NASA’s Johnson Space Center in Houston, Texas, where he worked in the Spaceflight Training Division on the preparation of training for the ground and in-orbit crews of the International Space Station.

In July 1998, he was selected as an astronaut by the Italian space agency (ASI), and one month later, joined ESA’s European Astronaut Corps, whose homebase is the European Astronaut Centre (EAC) in Cologne, Germany.

In August 1998, he was relocated to NASA’s Johnson Space Center in Houston, Texas, and assigned to the XVIIth NASA Astronaut class. In 2000 he obtained the necessary basic qualifications for being assigned to a mission on the Space Shuttle and to the International Space Station. In July 2001, he successfully completed the course for operating the Space Shuttle robotics arm and, in September 2003, successfully completed the Extra Vehicular Activities advanced skills training.

In August 2004, he was temporarily assigned to the Gagarin Cosmonaut Training Center in Star City (near Moscow/Russia), where he followed the initial training for the Soyuz spacecraft.

After that, Nespoli returned to NASA’s astronaut office in JSC/Houston, where he performed proficiency training to maintain the acquired qualifications and attended advanced courses. He also carried out several technical duties for NASA, ESA and the Italian Space Agency (ASI).

In June 2006, Nespoli was assigned to the Space Shuttle mission STS-120.
POSTER PAPERS

PI-1 Equivalent Displacement Damage Dose for on-Orbit Space Applications
C. Inguimbert, DESP, ONERA; S. Messenger, NRL

This paper introduces the concept of equivalent displacement damage dose (EDDD) in evaluating DDD depth-dose calculations for space applications. The results are shown to be dependent on the device degradation characteristics.

PI-2 Real Time Beam Profile Uniformity Monitoring System
I. Britvitch, W. Hajdas, S. Scherrer, K. Egli, A. Mozzanica, B. Schmitt, Paul Scherrer Institut

New, multi-pixel, air-filled ionization chamber for beam monitoring is constructed. For processing of 400 input signals it utilizes a dedicated ASIC. Device parameters are discussed together with results from particle beam tests.

PI-3 Radiation Induced Conductivity in Gadolinium Oxide-Based Capacitors Due to Thermal Neutron and Gamma Ray Interactions

We present direct evidence that Gadolinium Oxide films exhibit radiation induced conductivity (RIC) when exposed to thermal neutrons. We also correlate process / property / performance relationships, and elucidate the source of RIC via experiment and theory.

PI-3 Silicon Microdosimetry in Heavy Ion Radiation Fields
J. Livingstone, M. Petasecca, M. L. F. Lerch, A. B. Rosenfeld, University of Wollongong; D. A. Prokopovich, M. I. Reinhard, Australian Nuclear Science and Technology Organisation; H. Yasuda, National Institute of Radiological Sciences; M. Martisikova, German Cancer Research Centre (DKFZ); M. Zaider, Memorial Sloan-Kettering Cancer Centre; J. F. Ziegler, V. L. Pisacane, United States Naval Academy; J. F. Dicello, Loma Linda University Medical Centre

First and second generation SOI microdosimeters have been tested under radiation fields relevant to heavy ion therapy and space radiation fields. The charge collection of a third generation of microdosimeters has been characterized.

BREAK

10:30 – 11:00 AM
GRAND BALLROOM FOYER

SESSION J

SPACE AND TERRESTRIAL ENVIRONMENTS

11:00 AM

SESSION INTRODUCTION

Chair: Insoo Jun, NASA-Jet Propulsion Laboratory


We describe a tool suite, CREME, which combines existing capabilities of CREME96 and CREME86 with new radiation environment models and new Monte Carlo computational capabilities for single event effects and total ionizing dose.
**J-2**
11:20 AM
**On-Orbit SEU Rates of UC1864 PWM: Comparison of Ground Based Rate Calculations and Observed Performance**

More than 10 years of on-orbit UC1864 SEU data are compared with typical upset rate calculation methodologies and GCR and SPE environments. Mitigation techniques are also verified via direct in orbit observations.

**J-3**
11:35 AM
**Impact of Terrestrial Gamma-Ray Flashes on Avionics**
M. Tavani, INAF-IAPS, Universita’ Tor Vergata, and INFN; A. Argan, INAF; A. Paccagnella, S. Gerardin, M. Bagatin, P. Benvenuti, Universita’ di Padova; A. Pesoli, F. Palma, Universita’ Tor Vergata; A. Trois, Osservatorio Astronomico di Cagliari; P. Picozza, Universita’ Tor Vergata and INFN; E. Flamini, Agenzia Spaziale Italiana

We address possible effects of terrestrial gamma flashes on aircraft electronics. In addition to the electromagnetic component, secondary neutrons obtained by gamma-ray photoproduction in the aircraft structure substantially contribute to radiation effects in avionics.

**J-4**
11:50 AM
**Monte-Carlo Single-Event-Upset Simulation of 65nm SRAMs in the LHC Mixed Field Radiation Environment**
S. Uznanski, M. Brugger, CERN; J.L. Autran, S. Serre, IM2NP; S. Semikh, Dzhelepov Laboratory of Nuclear Problems; G. Gasiot, M. Glorieux, L. Dugoujon, P. Roche, STMicroelectronics

The radiation response of a 65nm bulk SRAM is studied in LHC mixed field radiation environment using coupled GEANT4/TIARA simulations. The soft-error rates for different locations and projections for future operations are discussed.

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**POSTER PAPERS**

**PJ-1**
12:05 PM
**Operational Risk Assessment at Solar Events Using a New Statistical Approach for SEU Rate Prediction**
G. Hubert, S. Bourdarie, L. Artola, S. Duzellier, ONERA; R. Velazco, TIMA; R. Ecoffet, CNES

A new statistical approach based on MUSCA SEP3 is presented. It shows that to adequately assess the operational SEE risk, it is necessary to investigate several statistical parameters. Analyses were applied to in-flight data.

**PJ-2**
12:05 PM
**Single Event Effects in Power MOSFETS Due to the Secondary Neutron Environment in a Proton Therapy Center**
E. W. Cascio, K. Riley, J. McCormack, Francis H. Burr Proton Therapy Center at Massachusetts General Hospital; R. Flannagan, MPI Software Inc.

Secondary neutron induced single event effects in power MOSFETS installed in an X-ray generator located in a proton therapy treatment vault are characterized. This is done using both accelerated and in situ testing.
NSREC 2012 will be held in Miami, Florida, July 16 – 20, 2012 at the InterContinental Miami. This is the first time NSREC has been held in Miami. Ken LaBel and his 2012 conference committee have assembled a strong technical program and social events that will provide abundant opportunities for discussing radiation effects with old and new friends in the international radiation effects community. I want to again invite IEEE Graduates Of the Last Decade (GOLD) members to take advantage of the complimentary breakfast on Wednesday morning.

Supporters of the NSREC include the Defense Threat Reduction Agency, Air Force Research Laboratory, Sandia National Laboratories, Jet Propulsion Laboratory, NASA Electronic Parts and Packaging Program, NASA Living With a Star, Aeroflex, Atmel, BAE Systems, Boeing, Honeywell, International Rectifier, Intersil Corporation, Northrop Grumman, Southwest Research Institute, Synopsys, Inc., and Texas Instruments. We thank our supporters for their significant and continuing commitments to the conference, and we welcome other organizations to consider becoming supporters of the IEEE NSREC.

NSREC 2013 will be held in San Francisco, California, July 8 – 12 at the Hyatt Embarcadero. This is the 50th NSREC and downtown San Francisco and the Bay is the perfect site to celebrate NSREC heritage! The conference chair is Jeff Black of Sandia National Labs. Robert Ecoffet of CNES will be the 2014 chairman which is planned for Paris, France. Michael Xapsos, NASA/GSFC, has been named the 2015 chairman.

As always, papers presented at the NSREC are eligible for publication in the December issue of the IEEE Transactions on Nuclear Science. It is particularly important for authors to upload their papers prior to the conference for consideration for publication in the December TNS Special Issue. Detailed instructions can be found at www.nsrec.com/editmsg.htm.

Keep visiting our web site at www.nsrec.com for author information, paper submission details, exhibitor links, on-line registration, and the latest NSREC information.

IEEE FELLOWS

Two distinguished members of the international radiation effects community were elected to the grade of IEEE Fellow on January 1, 2012.

Nadim F. Haddad, BAE Systems

Nadim’s citation reads, “For development of radiation hardened semiconductor device technology and products for space applications.”

Peter J. McNulty, Clemson University

Peter’s citation reads, “For contributions to radiation-induced soft errors in microelectronics.”
All papers accepted for oral or poster presentation to the technical program will be eligible for publication in a special issue of the *IEEE Transactions on Nuclear Science* (December 2012), based on a separate submission of a complete paper. Each paper will be subject to the standard full peer review given all papers submitted to the *IEEE Transactions on Nuclear Science*. All papers must be submitted on IEEE ScholarOne. Instructions for submitting papers can be found at the Conference web site [www.nsrec.com](http://www.nsrec.com). The deadline for submission of papers is the Friday before the Conference (July 13, 2012). Data Workshop papers are published in a Workshop Record and are not candidates for publication in the *IEEE Transactions on Nuclear Science*. This process is managed by the Workshop chairman.

The review process for papers submitted to the Transactions is managed by a team of editors. To provide consistent reviews of papers throughout the year, this editorial team manages the review process for all radiation effects papers submitted to the Transactions throughout the year. The editorial team consists of a senior editor and six associate editors who are technically knowledgeable in one or more specializations and are experienced in the publication process. If you would like to serve as a reviewer for the December issue of the Transactions or for radiation effects papers submitted throughout the year, please contact one of the editors. The editors for the 2012 NSREC are:

Jim Schwank, Senior Editor  
Sandia National Laboratories  
Email: schwanjr@sandia.gov

Dennis Brown, Associate Editor  
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**ARE YOU A MEMBER OF IEEE?**

Now is the time to join the Institute of Electrical and Electronics Engineers (IEEE) and the Nuclear Plasma Sciences Society (NPSS). Why? First of all, you’ll become a member of the largest professional engineering society in the world. About 60% of NSREC attendees are IEEE members. Full membership in IEEE costs less than $200. IEEE members receive access to a broad range of benefits, including a terrific insurance program, on line access to IEEE publications, and reduced rates at all IEEE sponsored conferences, including, of course, the IEEE NSREC and Short Course!

NPSS membership is $35. NPSS members receive a free subscription to NPSS News, and free on-line electronic access via IEEE Xplore to the IEEE Transactions on Nuclear Science (TNS) and the NSREC Data Workshop Record. Now members can search and view digital copies of all IEEE TNS papers on-line all the way back to the first IEEE NSREC in 1964. NPSS members get to vote in our NSREC elections, held at the annual open meeting on Thursday of the conference. What are you waiting for? Apply for membership at [ewh.ieee.org/soc/nps/join-npss.html](ewh.ieee.org/soc/nps/join-npss.html) or visit the IEEE registration desk.

**NSREC PUBLICATIONS**

NSREC has three publications each year:

- **IEEE Transactions on Nuclear Science.** This IEEE journal is the official archive of research papers presented at the NSREC Conference.

- **Radiation Effects Data Workshop Record.** Published each year in October, this IEEE proceedings has become the source for radiation test data on semiconductor components.

- **NSREC Short Course Notebook.** Published each July, this notebook contains tutorial presentations on the basic physics of radiation effects in circuits and systems. It includes the instructor’s notes and text, given to participants of the annual Radiation Effects Short Course.

A complimentary copy of the 2012 IEEE Radiation Effects Data Workshop Record and the December special NSREC issue of the IEEE Transactions on Nuclear Science will be mailed to each NSREC technical session attendee. A copy of the NSREC Short Course Notebook will be given to short course attendees in Miami.

**RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING**

You are invited to attend the IEEE Radiation Effects Committee’s Annual Open Meeting on Thursday, July 19, from 5:30 – 7:00 PM in the Grand Ballroom. All conference attendees and spouses are encouraged to attend. We will discuss the 2012 conference and future IEEE Nuclear and Space Radiation Effects Conferences. There will be an election for the Junior Member-at-Large on the Radiation Effects Steering Group. Nominations will be taken from the floor. All IEEE NPSS members present are eligible to vote. Refreshments will be provided.
Awards

2011 NSREC OUTSTANDING CONFERENCE PAPER AWARD

Variable Depth Bragg Peak Method for Single Event Effects Testing
S. Buchner, N. Kanyogoro, D. McMorrow, C. Foster, P. O’Neill, and K. Nguyen

2011 OUTSTANDING STUDENT PAPER AWARD

TID Versus DDD Induced Random Telegraph Signal in CMOS Image Sensors
C. Virmontois, V. Goiffon, P. Magnan, S. Girard, O. Saint-Pe, S. Petit, and G. Rolland

2011 OUTSTANDING DATA WORKSHOP PRESENTATION AWARD

SEU and MBU Angular Dependence of Samsung and Micron 8Gb SLC NAND-Flash Memories under Heavy-Ion Irradiation
K. Gruermann, D. Walter, M. Herrmann, F. Gliem, H. Kettunen, and V. Ferlet-Cavrois

2011 RADIATION EFFECTS AWARD

The 2011 Radiation Effects Award was presented to Lew Cohn, National Reconnaissance Office, during the opening ceremonies of the 2011 conference. Lew’s citation reads “For sustained and enabling contributions to the development of radiation hardened technology, research on radiation effects in microelectronics, and the IEEE NSREC.”

2012 RADIATION EFFECTS AWARD

The winner of the 2012 Radiation Effects Award will be announced Tuesday morning, July 17. The purpose of the award is to recognize individuals who have had a sustained history of outstanding and innovative technical and/or leadership contributions to the radiation effects community.

2013 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2013 IEEE Nuclear and Plasma Sciences Society (NPSS) Radiation Effects Award. The basis of the award is for individuals who have: (1) a substantial, long-term history of technical contributions that have had major impact on the radiation effects community. Examples include benchmark work that initiated major research and development activities or a major body of work that provided a solution to a widely recognized problem in radiation effects; and/or (2) a demonstrated long-term history of outstanding and innovative leadership contributions in support of the radiation effects community. Examples include initiation or development of innovative approaches for promoting cooperation and exchange of technical information or outstanding leadership in support of the professional development of the members of the radiation effects community.

A cash award and plaque will be presented at the 2013 IEEE NSREC, San Francisco, California in July 2013. Nomination forms are available electronically in PDF Format or in Microsoft Word format at www.nsrec.com/nominate.htm. Additional information can be obtained from Vincent Pouget, Member-at-Large for the Radiation Effects Steering Group. Vincent can be reached in France at 33-5-4000-2859 or at Vincent.pouget@ims-bordeaux.fr.
MIAMI gives us images of modern high rise buildings, all vying for the best views of the Atlantic’s blue-green waters. It gives us great diversity, such as miles of long beaches versus miles of incredible shopping or ethnic colonial neighborhoods versus a vibrant downtown. It shows us that Florida has major pods of incoming international business which have lead to an immense variety of dining, nightlife and daytime activities. In short, you will be surprised and fascinated by Miami … a city which has become an economic powerhouse and a social hot spot in recent years.

Several meeting rooms at the InterContinental are available for use by any registered conference attendee on a first come, first served basis. NSREC encourages side meetings to be scheduled at times other than during technical sessions. Contact ETC Services at 720-733-2003 or send an e-mail to etcservices@qwestoffice.net to make side meeting reservations before the conference. To make a side meeting room reservation during the conference, see the NSREC Registration staff in the Oxford Room on the second level of the hotel.

Notes: You must register for the conference before a side meeting room can be reserved! All audio/visual equipment and refreshments must be coordinated through the hotel and are the responsibility of the attendee hosting the meeting.

A message board for incoming messages will be located in the pre-function area outside the Grand Ballroom during the conference. Faxes can be received through the hotel’s guest fax, but there must be a cover sheet stating the recipient’s name and advising the total number of pages being sent. Notification that a fax has arrived will be made via a message on the attendee’s guestroom telephone. A fee may apply and these can be accepted for hotel guests only.

The 2012 IEEE NSREC will provide continental style breakfasts and refreshments at breaks during the NSREC Short Course and Technical Sessions. Breakfast on Monday-Friday will begin at 7:30 AM for registered conference attendees only.

The InterContinental has a full-service business center that can handle photocopying, faxing, computers with internet access, shipping/receiving and equipment rental. They are open Monday through Friday from 7:00 AM – 7:00 PM. Costs associated with the Business Center may be put on your room account or they can be paid via credit card.
NSREC encourages Pre-Registration and offers a lower registration rate (“Early Registration”) if the payment is received by no later than Friday, June 15. After that date, the “Late Registration” rates will apply.

There are two acceptable forms of payment of registration and activity fees:
1) check made payable to “IEEE NSREC” in U.S. dollars and drawn on a U.S. bank, or 2) MasterCard, VISA, or American Express credit card.

Mail the conference registration form with your remittance to ETC Services, Inc. The registration form, with payment, should be mailed to arrive no later than seven days prior to the conference, or arrangements should be made to hand carry fees for on-site registration. E-mail or faxed registrations will be accepted with credit card payment. Telephone registrations will not be accepted.

You can also register via the internet, as long as all of the credit card information is included. Go to the NSREC web site for on-line registration at www.nsrec.com

Conference registration will take place on the second floor of the InterContinental. If you have not yet registered, go to “On-Site Registration” in the Oxford Room. If you have already registered, go to “Pre-Registration” in the hotel’s Registration Office (near the elevators) to pick up your prepared packets.

A $25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 15, 2012 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. To request a refund, you must notify ETC Services by fax at 720-733-2046 or e-mail at etcservices@qwestoffice.net
The NSREC will be held at the InterContinental Miami, located on beautiful Biscayne Bay at the eastern edge of downtown Miami. This high-rise property is situated next to Bayfront Park (which hosts numerous summertime activities) and the Bayside Marketplace (with over 100 shops and restaurants). In fact, there are innumerable things to do and restaurants to enjoy within just a mile of the hotel!! Hotel amenities include two restaurants, a Starbucks, two cocktail lounges, 24-hour health club (complimentary to NSREC hotel guests), outdoor pool, concierge, business center, room service, parking garage, lobby ATM, and a delightful spa with a full range of treatments.

The 641 spacious guest rooms are comfortably furnished in contemporary design. All rooms, with the exception of one floor, are non-smoking and feature huge windows with dramatic views, individual climate control, flat-screen cable TV with pay movies, wireless and high-speed internet (at a fee), work desk, CD player or iPhone dock, coffee maker, minibar, hairdryer, iron and ironing board, dual-line speaker phone with voice mail, one king or two queen plush beds, a safe, and 24-hour room service.

For non-government attendees, the negotiated group room rate is $139.00 + tax for single or double occupancy. The government rate is offered @ $105.00 plus tax, single or double. To be eligible for the government rate, the guest must present a government-employee ID at check-in.

There is no additional charge for children 18 years of age and under when sharing a room with an adult and utilizing existing beds. Each third and fourth adult in the room (19 years of age and older) will be charged $20.00 + tax per night.

Based on availability, the conference room rates will be offered three days before and three days after the conference.

Reservations can be made by calling InterContinental Hotel Reservations toll-free at 800-327-3005 within the U.S. or Canada. Tell them that you want to book within a “group block” and give them the appropriate code for your rate. To get the government rate, you must call this number; you cannot use a weblink.

Negotiated group rate: code KCV $139.00 per night single/double
Government rate: code KRG $105.00 per night single/double

All rooms must be guaranteed by providing a one-night DEPOSIT to the hotel. This can be done via credit card or by mailing a check to the hotel. The cut-off for IEEE NSREC reservations is at 8:00 PM Eastern Daylight Time on June 15, 2012. Once the room block has been filled OR after the cut-off date (whichever comes first!), room accommodations will be confirmed on a space or rate available basis. Early reservations are strongly suggested!

Please be certain to notify the hotel of any change to your arrival or departure dates. When you check into the hotel, be sure to verify your departure date. Any cancellation must be made by no later than 6:00 PM on the day prior to your arrival. If the cancellation is made by that time, then the deposit will be refunded.

In the InterContinental’s reservation website, there is a point that you’ll come to that mentions a $100 “early departure fee.” The NSREC has been exempted from this charge but there is no way to remove it from the online reservation template. Please check that box and proceed.
AIRPORT AND TRANSPORTATION INFORMATION

Miami International Airport (code MIA) is 6 miles (10-15 minutes) northwest of the InterContinental Miami. A taxi between these two will cost approximately $25.00 one way. Direct flights are available from major hubs all over the world into this international airport.

Ft. Lauderdale Airport is a good alternative airport that is 25 miles north of the InterContinental. On this route, a taxi will cost about $70.00 one way and will take about 35 minutes... unless you travel during rush hour, in which case, it could easily take over an hour. However, the domestic U.S. airfares are frequently lower into Ft. Lauderdale than they are into Miami.

AIRPORT SHUTTLES

There is no scheduled service but Super Shuttle offers frequent non-scheduled service from the Miami International Airport to the downtown hotels. The normal rate from the airport to the InterContinental is $16.00 one way, per person, plus gratuity; there is no discount for a roundtrip. For NSREC attendees, Super Shuttle is providing a $2.00 discount that can be redeemed by utilizing a discount certificate.

After you have claimed your luggage on the airport’s lower level, look for the nearest Super Shuttle Guest Service Representative wearing a bright yellow shirt. If you do not see one, then call 305-871-2000, press 3, and let the operator know where you are. Someone will be sent to meet and assist you with your shuttle. Identify yourself as part of the “IEEE NSREC” group in order to be directed to the proper shuttle.

A coupon is required in order to get the $2.00 each-way discount. You can secure this coupon by going to the NSREC website and clicking on “Shuttle Discount.” Print two of these since you can use one for each direction. Give the discount coupon to your driver.

If you are flying into/out of Ft. Lauderdale International, your best shuttle service option would be Florida Limo at 800-244-8252 tollfree or 954-561-8888 long distance. You can also get complete data on their website: www.floridalimo.com

DRIVING DIRECTIONS

Directions from Miami International Airport (MIA)
1. Take 836 East to I-95 South to Biscayne Boulevard (Exit 2A)
2. Take the ramp down through two red lights
3. Turn left at the stop sign (get in the far right lane)
4. Turn right at first red light (one half-block)
5. The InterContinental Miami is on your right at 100 Chopin Plaza

Directions from Kendall, Homestead or Key West
US 1 North to I-95 – Exit at Biscayne Boulevard – Follow directions from step two above.

Directions from Palm Beach, Fort Lauderdale or Pompano
Take I-95 South to Biscayne Boulevard exit – Follow directions from step two above.
A rental car is not really necessary in Miami but one can come in handy if you want to do a lot of sightseeing OR if you plan to extend your trip before or after the conference.

**HERTZ RENT-A-CAR**  
**HERTZ CV#03S20007**

Hertz has been selected as the official car rental agency for the 2012 NSREC and is offering discounted rates for conference attendees. For reservations and information, call Hertz at 800-654-2240 (tollfree) or 405-749-4434 and mention CV #03S20007. Or you can use the Hertz weblink (see below.) The special conference rates will be available from July 9 – 27, 2012, and are valid at any Florida location provided that you pick-up and return to a Florida location (a few exceptions apply.)

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Rental cars are subject to availability so advance reservations are recommended. When making reservations, the agent will check to see if this is the best rate for you at the time. Government surcharges, taxes, airport related fees, vehicle licensing fees and optional items, such as refueling or additional driver fees, are extra. Renters must meet Hertz age, driver and credit requirements. Additional restrictions, terms and conditions may apply.

The direct weblink to the NSREC special deal is:  
http://link.hertz.com/link.html?id=28715&LinkType=HZLK&TargetType=Homepage &ret_url=http://www.nsrec.com/

**PARKING**

Parking in any major metropolis can be pricey and Miami is no different. The daily “overnight” rate at the InterContinental is currently $36.00. HOWEVER, NSREC attendees, who are staying at the InterContinental, are eligible for a discount of 50% off the overnight parking rate in the hotel’s garage. At check-in, advise the hotel that you have a car and that you want the 50% discount on parking.

For those attendees who are not staying at the InterContinental but who need to park a car just for the day during sessions, the daily rate is $15.00. Stickers will be available at the NSREC Registration Desk to validate this discount.
The 2012 NSREC Industrial Exhibits will feature the leading worldwide suppliers of radiation hardened products, related materials, and services. This will be an excellent opportunity for key suppliers, technical engineers and managers to meet and discuss the needs and solutions for electronics used in space vehicles, military electronics, and applications requiring radiation tolerance in harsh environments.

The 2012 NSREC Industrial Exhibits will be in the InterContinental Hotel Mezzanine, Atrium and Foyer on Tuesday and Wednesday. This is located on the second level of the hotel and is adjacent to the Grand Ballroom where the technical sessions are being held. A spacious open layout spread throughout this level has been created to maximize traffic flow to all areas of the exhibit. Conference breaks will be hosted in the Exhibit Area on Tuesday and Wednesday.

Tuesday evening, the exhibitors will host the Industrial Exhibits Reception featuring complimentary drinks in the Exhibit Area and a complimentary dinner buffet in and around the Exhibit Area. The Reception is open to all NSREC attendees and their guests.

NOTE: Children under 16 must be accompanied by an adult in the Exhibit Area.

For more information, or to get on the waiting list for a booth, contact:

Chuck Tabbert
Ultra Communications, Inc.
Phone: 505-823-1293
Email: ctabbert@ultracomm-inc.com

Or visit the 2012 NSREC Industrial Exhibits web site: [www.nsrec.com/exhibit.htm](http://www.nsrec.com/exhibit.htm)
## Industrial Exhibits

Please check our web site (www.nsrec.com) for a current listing of companies exhibiting at 2012 NSREC.

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2012 IEEE NSREC Technical Sessions and Short Course Registration Form

Mail or Fax this form and your remittance (payable to IEEE NSREC) to:
ETC Services, Inc.
2254 Emerald Drive
Castle Rock, CO 80104
720-733-2003 Fax: 720-733-2046

REGISTRATION FEES (in U.S. dollars)
Late fee REQUIRED if payment received after June 15, 2012.

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TOTAL AMOUNT ENCLOSED:  $________

IEEE MEMBERSHIP

☐ I am an IEEE GOLD MEMBER and will attend the Gold Member Breakfast

☐ I am an IEEE Member.

☐ I am not a Member, but I wish to join the IEEE. Non-members must register at the non-member rate.

PAYMENT OF FEES

☐ Enclosed is a check or in U.S. DOLLARS ONLY, drawn on or payable through a U.S. bank. Payable to: IEEE NSREC

☐ Charge registration fees to my credit card (U.S. dollars):

☐ American Express ☐ Master Card ☐ Visa

Card No. _____________________________
Exp. Date _____________________________
Printed Name _____________________________
Address _____________________________
Address _____________________________
Signature _____________________________

If your company or agency is going to pay by check at a later date, please do not complete the credit card portion of this form. Only one form of payment is needed.

* To obtain IEEE rates, you must provide your IEEE number on this form.

CANCELLATIONS

A $25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 15, 2012 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.
2012 IEEE NSREC
Activities Registration Form

ACTIVITY FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 15, 2012. We strongly encourage early registration; the number of tickets available for each event is limited. Children must be accompanied by an adult during all tours and social events.

<table>
<thead>
<tr>
<th>Event</th>
<th>Early</th>
<th>Late</th>
<th>Number</th>
<th>Total</th>
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<tr>
<td>Miami Sightseeing Cruise:</td>
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<tr>
<td>Tuesday, July 17</td>
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<td>Adult (13+ yrs)</td>
<td>$25</td>
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<tr>
<td>Child (3-12 yrs)</td>
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<td>Infant (0-2 yrs)</td>
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<tr>
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<tr>
<td>Miami Science Museum and Coconut Grove:</td>
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<tr>
<td>Thursday, July 19</td>
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<tr>
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<td>Big Bus Tour:</td>
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<tr>
<td>Family (2 adt/2 chd)</td>
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</tr>
</tbody>
</table>

TOTAL AMOUNT ENCLOSED: $_______

CANCELLATIONS
To encourage advanced registration for conference social activities, we will refund all activity fees for conference attendees and/or their companions who for any reason are unable to attend the conference. If your plans change after this form is submitted and you would like to request a refund, you must notify ETC Services by email at etcservices@qwestoffice.net or FAX at 720-733-2046 no later than July 6, 2012.

PAYMENT OF FEES
☐ Enclosed is a check in U.S. DOLLARS ONLY, drawn on or payable through a U.S. bank. Payable To: IEEE NSREC
☐ Charge registration fees to my credit card (U.S. dollars):
  ☐ American Express ☐ Master Card ☐ Visa

Mail or Fax this form and your remittance (payable to IEEE NSREC) to:
ETC Services, Inc.
2254 Emerald Drive
Castle Rock, CO 80104
720-733-2003 Fax: 720-733-2046
The 2012 IEEE NSREC will be held at the 4-star InterContinental Hotel in downtown Miami located on scenic Biscayne Bay. The greater Miami area, including Miami Beach and nearby localities, has a rich history beginning as a humble trading post in nearby Mary Brickell Village. Now populated with trendy restaurants and clubs, the city is now known as the “American Riviera”.

Greater Miami is a culturally diverse area with over 150 ethnicities and 60 languages. Known in the past as the playground of American millionaires, such as the Vanderbilt’s, Morgan’s, Flagler’s and others, their erstwhile mansions and other artifacts still remain to provide a unique insight into this aspect of American culture.

The conference committee has designed a social program that will allow you to explore and experience many of the diverse areas that constitute greater Miami by both land and water. In the unique “cities-within-a-city,” the variety of neighborhoods includes the vibrant Hispanic culture of Little Havana, the primitive art and colors of Little Haiti, the charming streets of Coral Gables, known as “The City Beautiful”, and the historical “mix” of Coconut Grove.

So come and join us as we explore the greater Miami area and enjoy a truly unique experience through the various activities provided by the 2012 NSREC Social Program.

Children must be accompanied by an adult during all tours and social events.

**SUNDAY, JULY 15**

**6:00 TO 9:00 PM**

**SHORT COURSE RECEPTION**

Join your colleagues for complimentary refreshments in the Chopin Ballroom on the InterContinental’s second floor. This reception is open to all Short Course attendees and their registered guests as a great opportunity to meet new friends and renew old acquaintances. NSREC badges are required for entrance to the Short Course Reception. The conference registration desk is open from 5:00 to 9:00 PM to obtain your badges.
TUESDAY, JULY 17
9:30 TO 11:30 AM
MIAMI SIGHTSEEING CRUISE

Sit back and relax during an unforgettable, fully-narrated sightseeing cruise along scenic Biscayne Bay. See Miami’s spectacular coastal sites including the beautiful downtown skyline, the Port of Miami, Fisher Island, Miami Beach and Millionaires Row – the homes of the rich and famous. Beverages and light snacks will be available for purchase onboard during this 90 minute cruise. The cruise ship features an air-conditioned lower deck with huge picture windows, and an open-air (but covered) upper-deck where you can enjoy the fresh ocean breeze, yet still be protected from direct sunlight and light seasonal showers.

Boarding for the Island Queen Cruise is at the Bayside Marketplace – only a 5-10 minute walk from the hotel. Everyone should meet in the InterContinental Lobby by no later than 9:30 AM for the short walk to the pier.

As a bonus, all NSREC companions on this event will receive a 15% discount coupon for lunch at the Tradewinds Bar & Grill in the Bayside Marketplace. Simply tell your server that you are part of the IEEE NSREC group that just got off the cruise and they will honor the 15% discount on your meal. Enjoy a leisurely lunch at a great discount!

TUESDAY, JULY 17
6:00 TO 9:00 PM
INDUSTRIAL EXHIBITS RECEPTION

Join us for the 2012 Industrial Exhibits Reception hosted by your NSREC exhibitors. NSREC attendees and their registered guests are invited to the InterContinental’s Mezzanine to visit the booths and participate in the late-evening raffle. Drinks and a full buffet dinner will be available in the Grand Ballroom Pre-function area with ample seating in the Mezzanine, Chopin and Grand Ballroom. NSREC attendees and registered guests must show their badges to enter the Exhibit and Reception areas.

WEDNESDAY JULY 18
7:30 TO 8:15 AM
IEEE GOLD MEMBER BREAKFAST

A special breakfast will be held in the Flagler Room (2nd floor), for IEEE member attendees who have graduated within the last decade. This is an excellent opportunity for newer industry members to informally discuss radiation effects and to become better acquainted. For more information, contact Jonathan Pellish, jonathan.a.pellish@nasa.gov.
Like the city itself, the conference social emphasizes the energy and unique vibe of Miami. On Wednesday evening, we invite you to participate in a Miami South Beach experience at the world famous Mango’s Tropical Cafe: a two level facility on fabulous Ocean Avenue with seven bar areas and equally as many places to dine. Enjoy the electric energy and unique atmosphere of this high-energy restaurant/club, along with exotic Caribbean food and beverage. With live music and choreographed dance performances, Mango’s provides a true trip into the South Beach culture. Featuring salsa that is essentially Cuban in origin, it also provides music styles mixed with pop, jazz, rock, and R&B. In addition to the world class Salsa dancing, the entertainment may also include a Michael Jackson Tribute and Samba, Conga, and Belly Dancing routines.

The evening begins with your choice of exotic Caribbean drinks, beer, wine, or soda alongside a Caribbean-themed dinner buffet with multiple food options. Following dinner, there will be more stage performances, PLUS the dance floor will be opened to all attendees. You may even have the opportunity to take Salsa dance lessons from the professional staff. Don’t forget to indulge in dessert later in the evening.

Sometime during the evening, be sure to explore this unusual facility. Those who are less attuned to pulsating music can find a quiet refuge in the hidden nooks while enjoying the fine art and artifacts on the walls of the Vodou and Mojito rooms upstairs. Please note that after dinner, one room will be set aside for children’s activities, complete with adult supervision and a sign in/sign out requirement ensuring a family-friendly event. In addition, indoor areas will be non-smoking during event hours.

This is a unique venue and we know that you will leave with an enhanced understanding of the South Beach Culture and maybe, just maybe, recapture a bit of the fountain of youth!

Our private party at Mango’s runs from 6:30 until 10:30 PM. Buses will depart the hotel starting at 5:45 PM and continue to depart as they are filled until 6:30 PM. Since this event is in the South Beach area, consider taking one of the early bus departures so that you’ll have time for a nice walk along the ocean before going into Mango’s!!

Buses will return to the hotel starting at 9:30 PM and will continue, as they are filled, until 10:30 PM.

Suggested attire: Casual, fun, Caribbean attire. Bright colors and prints encouraged.

Choreographed dancers are just part of the entertainment. Photo: Courtesy of Ken LaBel.

Eat, drink, dance, or just watch: the choice is yours! Photo: Courtesy of Ken LaBel.
On Thursday morning, we will depart from the hotel at 9:30 AM to the Miami Science Museum and Planetarium. An affiliate of the Smithsonian Institution, the Museum and planetarium offer a variety of shows that include:

- **Planetarium Star Show:** Leave the Earth behind and travel through the solar system to the outer reaches of the known Universe.

- **Featured Exhibitions:** Tour the latest and greatest exhibits. A gallery guide will be available to answer questions and provide food for thought. Current exhibits include an energy tracker dance floor to measure your energy output as you move! Just one of the many hands-on exhibits at MiaSci.

The Falcon Batchelor Bird of Prey Center of the Miami Science Museum is a facility dedicated to the ecological research, rehabilitation, and release of injured birds of prey. This is a unique facility that the conference committee highly recommends. Admission to the Science Museum allows you to enjoy it at your leisure. This venue is best suited for a self-guided visit rather than an organized tour group. For more information, see website: [www.miamisci.org](http://www.miamisci.org).

At approximately 11:30 AM, we will reboard the bus for a short trip to Coconut Grove (CG) for lunch (on your own), shopping, art galleries, or a leisurely stroll through this historical town. CG contains many fine restaurants and shops and a number of nearby parks. It has been described as a charming and eclectic mix of the “funky, upscale, and touristy”. CG is a pedestrian-friendly series of streets anchored by the Cocowalk mall with a unique mix of sidewalk cafes, galleries, boutiques, and air-conditioned restaurants. Relax and stroll to one of the nearby waterfront parks or go back to old Florida with a visit to Barnacle Historic State Park.

The bus will depart at 3:30 PM for the return transfer to the InterContinental.

**ON YOUR OWN OPTION
9:00 TO 4:30 PM**

**CREATE YOUR OWN GROUP EVENT**

Want to explore Miami on your own? Don’t want to just sit and sightsee, but stop and explore? The Big Bus Tour (BBT) with their double-decker buses is your answer! The BBT will provide conference attendees with the opportunity to experience the diverse multi-cultural neighborhoods that constitute the great Miami and Miami Beach areas. The BBT is an established touring company that provides tours (Loops) of the Miami area (see map) – one is the City Loop and the other is the Beach Loop. Participants can opt for one or both loops or multiple times on one route per day.

The way the hop-on, hop-off works is that the initial loading for either loop is in front of the Bayside Marketplace (Central Station is a 5-10 minute walk from the InterContinental). Participants can get off at any stop(s), at their leisure, and then get on a later bus to a stop further down the line or back to the Central Station. Buses leave the Central Station on a strict schedule between 9:00 AM and 4:30 PM. If you board a bus and stay on it for the entire loop, it will take about 90 minutes in duration. An “entertaining” docent narrates the history and sites on each trip. Buses can seat up to 44 people on the top open deck and 27 on the lower closed deck.
Some of the tourist options include:

- Shopping and dining at Coconut Grove, Coral Gables and Lincoln Road
- Culture (Art Deco, South Beach, Little Havana) or Versailles Restaurant, famous for Cuban food
- Museums
- Luxury spas – Note that July is Miami Spa Month with many specials available at multiple world-class venues near stops, including the famous Biltmore Hotel
- Beach and recreation (Venetian Pool) and many others

NSREC has been able to secure group ticket prices at about a 25% discount from public rate, but you don’t have to travel as a group; you can choose your day. Tickets can be used any day but once validated, at the first usage, the 24-hour clock starts the countdown. Two-day tickets must be used on consecutive days.

<table>
<thead>
<tr>
<th>Pass Type</th>
<th>Adult (12+ yrs)</th>
<th>Child (3-11 yrs)</th>
<th>Family (maximum of two adults and two children)</th>
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<tr>
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<tr>
<td>2-Day Group rate</td>
<td>$36.75</td>
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<td>$102.75</td>
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</tbody>
</table>

**AEROBICS**

As in prior conferences, Dave Bushmire, our own certified aerobics instructor, will be conducting morning fitness classes. The classes will be held from 6:30 to 7:30 AM in the Raphael and Michelangelo rooms on Tuesday, Wednesday and Thursday.

**ACTIVITIES CANCELLATION POLICY**

To encourage advance registration for conference social activities, NSREC will refund all activity fees for conference attendees and/or their companions who, for any reason, are unable to attend the conference. If your plans change after your Activities Registration form is submitted, simply request a refund by notifying ETC Services by fax or e-mail no later than July 6. Fax: 720-733-2046. E-mail: etcservices@qwestoffice.net
Miami and the beaches provide a myriad of exciting visitor options with an amazing array of international flavor. Excellent information can be found at the Miami Convention Bureau’s website – www.miamiandbeaches.com. Join us as we discuss just a few of the many sights, sounds, and tastes that make Miami great!

ACTIVITIES WITHIN WALKING DISTANCE OR VIA METROMOVER RAIL SERVICE

Metromover rail service is a free aboveground tram with multiple city loops with a stop a ½ block from the hotel entrance. www.miamidade.gov/transit/mover.asp, www.downtownmiami.com

BAYFRONT PARK

Right outside the entrance of the InterContinental Miami is an oasis in the heart of downtown: Bayfront Park. Choose from a peaceful walk along the Biscayne Bay or partake in one of the many activities available. www.bayfrontparkmiami.com

BAYSIDE MARKETPLACE

A short 10 minute walk away, the Bayside Marketplace is a downtown hub with over 100 shops and restaurants. The variety of dining experiences ranges from Cuban to Argentinean to Italian to the more traditional tourist food options (Hard Rock Café, for example). www.baysidemarketplace.com

JEWELRY DISTRICT

Starting just five blocks away from the hotel entrance, the Downtown Miami Jewelry District is the third largest jewelry district in the United States. Here you’ll find four blocks anchored by the Historic Seybold Building where there are over 280 tenants specializing in jewelry. In addition to retailers, you’ll find all the specialties like necklace stringing, gemologists, and repairs.

MARY BRICKELL VILLAGE

Located about a 20 minute walk or a 20 minute Metromover ride away (<10 minute return), Mary Brickell Village offers an upscale setting with a host of shops, restaurants, and bars. marybrickelevisione.com. Be sure to check out one of the general chair’s favorite restaurants: My Name is Dolores, But You Can Call Me Lolita. doloreslolita.com
MIAMI AND THE BEACHES

What would a trip to Miami be, without a stop at its world-famous beaches? Whether it’s the hip and happening South Beach or the more family-oriented beaches of North Miami and Key Biscayne, take advantage of your free time to explore the Art Deco architecture, the beach culture, nature preserves, and of course, shopping, restaurants, and bars. www.visitsouthbeachonline.com, www.miami-beach-travel-guide.com, www.key-biscayne.com. Remember, parking on South Beach can be troublesome, so taxis or other means of travel may prove a better option.

Some of the many options include:

■ Shopping and dining on Lincoln Road Mall, Collins Ave, or Espanola Way on Miami Beach
■ Beach snorkel at the Jose Cuervo (man-made) Reef in South Beach
■ Bill Baggs Cape Florida State Recreation Area in Key Biscayne, where the beach invites swimming or kayaking and the historic Cape Florida lighthouse is open for tours
■ Of course, the South Beach’s ever-present nightlife!

MIAMI NEIGHBORHOODS AND SURROUNDING AREAS

LITTLE HAVANA
Experience the unique Cuban culture with a visit to Little Havana. Stroll along the world-famous “Calle Ocho” and experience the site, sounds, and smells of hand-rolled cigars being made, elderly men playing dominoes in the parks, strong Cuban coffee being brewed, delectable tastes of Cuban food, or the pulsating sound of Cuban music! About 15 minutes by car from the hotel. littlehavanaguide.com

MIAMI DESIGN DISTRICT
Looking to stroll through art galleries and designer clothing shops? Then the Miami Design District is your place! About a 10 minute drive north of the hotel, the Design District provides an upscale option for shopping and looking with an emerging list of fine dining. miamidesigndistrict.net/guide.php

COCONUT GROVE
About a 15-20 minute drive south of the hotel, Coconut Grove (CG) is a charming and eclectic mix of “funky”, upscale, and touristy. CG is a pedestrian-friendly series of streets anchored by the Cocowalk and provides a unique mix of sidewalk cafes, galleries, boutiques, as well as air-conditioned restaurants. Relax and take some down time and stroll over to one of the nearby waterfront parks or go back to old Florida with a visit to Barnacle Historic State Park - www.floridastateparks.org/thebarnacle/default.cfm - or just watch the boats sail by! www.coconutgrove.com/index.php

CORAL GABLES
Long known as “The City Beautiful” for its tree-lined streets and green spaces, Coral Gables also hosts the world famous shopping Mecca: the Miracle Mile – home of the hottest styles and chicest restaurants. www.coral-gables.com/CGWeb/visitors.aspx. A visit to Coral Gables wouldn’t be complete without a stop at the Biltmore Hotel: a historic hotel, restaurant, and world-class spa set in 150-acre tropical enclave. www.biltmorehotel.com

The famous Biltmore Hotel. Photo: Courtesy of Ken LaBel.
LITTLE HAITI

Though not as well known as its Cuban counterpart, Little Haiti represents a cultural heart for the Haitian Diaspora. The area boasts a cultural center, many fine art galleries, shops, and dining (Creole!). About 15 minutes by car from the hotel.

STATE AND NATIONAL PARKS

Besides Bill Baggs Cape Florida State Recreation Area in Key Biscayne and the Barnacle Historic State Park in Coconut Grove, Miami is surrounded by an array of outstanding State and National Parks including:

- Biscayne National Park: about an hour south of the hotel, the Biscayne National Park provides amazing waters, sea life, and the only living coral reef in the U.S. can be visited by boat (glass bottom option!) for viewing or snorkeling. Or be an active tourist and boat or canoe the waters or hike one of the adjacent nature trails. [www.nps.gov/bisc/index.htm](http://www.nps.gov/bisc/index.htm)

- Everglades National Park: just over an hour away by car, the Everglades have been made famous through many appearances in movies and television. The largest subtropical wilderness in the U.S., Everglades Park is a key portion of the area’s ecosystem. Visitors can choose between the visitor center, ranger activities, hiking, or even air-boat tours to visit the flora and fauna of this park. We note that July is hot and humid and considerations for insects and the heat should be taken. [www.nps.gov/ever/index.htm](http://www.nps.gov/ever/index.htm)

- Oleta River State Park - Florida’s largest urban park, Oleta River is located on Biscayne Bay just 20 minutes from the hotel by car in North Miami. With a wide variety of recreational opportunities, the park is best known for miles of off-road bicycling trails, ranging from novice trails to challenging trails for experienced bicyclists. Enjoy the hardwood hammocks and a mangrove estuary by either foot or by renting a kayak. [www.floridastateparks.org/oletariver](http://www.floridastateparks.org/oletariver)

MUSEUMS, TROPICAL ATTRACTIONS, AND AMUSEMENT PARKS

MUSEUMS

The Miami area is host to a large number of museums including: [www.miami.com/south-florida-museum-guide](http://www.miami.com/south-florida-museum-guide)

- Miami Science Museum
- Vizcaya Museum and Gardens
- Miami Art Museum
- Ten Museum Park
- Frost Art Museum
- Gold Coast Railroad Museum
- Miami Children’s Museum
- Jewish Museum of Miami
- History Miami
- Miami World Erotic Museum

TROPICAL ATTRACTIONS

Fairchild Tropical Botanic Garden is a place to escape the hustle and bustle of the city. The focus of the Garden is the 4,000 colorful and vibrant species of plants including, cycads, ferns, orchids, aroids and bromeliads. Among the many plant collections are the new Tropical Fruit Pavilion which features rare fruit trees from Southeast Asia and the Keys Coastal Habitat where a marsh-like ecosystem runs wild with birds, insects and even butterflies. [www.fairchildgarden.org](http://www.fairchildgarden.org)
Venetian Pool in Coral Gables – Built in 1923 and fed by coral aquifers, the Venetian Pool is a glamorous city-run facility utilizing limestone to build a little bit of Venice for the pool crowd on a hot day. [www.coralgables.com/CGWeb/parks_rec_files/vp_home.aspx](http://www.coralgables.com/CGWeb/parks_rec_files/vp_home.aspx)

**AMUSEMENT PARKS AND ZOOS**

Looking for a family outing? Interested in the local fauna? See one of the many amusement parks or zoos in the greater Miami area.

- Jungle Island – just a short trip on the way to Miami beach, Jungle Island is a unique mix of garden, zoo, and beach experiences focusing on unique animals such as lemurs and leopards. [www.jungleisland.com/index.cfm](http://www.jungleisland.com/index.cfm)

- Miami Seaquarium – on the way over the Rickenbacker Causeway to Key Biscayne, lies the Miami Seaquarium, a 38 acre extravaganza with whale and dolphin shows as well as interactive experiences such as swim with the dolphins! [www.miamiseaquarium.com](http://www.miamiseaquarium.com)

- Monkey Jungle – about 1 half hour from downtown Miami lies a place where the people are caged and monkeys run wild! Wear your safari outfit and begin your great exploration. [www.monkeyjungle.com](http://www.monkeyjungle.com)

- Zoo Miami – about 30 minutes from the hotel, the zoo provides a variety of animal attractions that change throughout the year. [www.miamimetrozoo.com](http://www.miamimetrozoo.com)

**FOR THE ACTIVE TOURIST**

No description of Miami is complete without a nod to Golf. Whether it’s a local municipal or world-renown tournament course, Miami area has it all. For challenge, play Doral’s Blue Monster or Fairmont Turnberry Isle or Miccosukee, all of which have been pro tournament courses. [www.miamiandbeaches.com/visitors/miami_golf_map.pdf](http://www.miamiandbeaches.com/visitors/miami_golf_map.pdf)

Or maybe you need to relax after an active day? Take advantage of the planned Miami Spa Month where $99 receives special values at many world-class spas including our host hotel. [www.miamispamonth.com](http://www.miamispamonth.com)

**AND MORE...**


Chairman’s Tip: Living Social and Groupon can provide some EXCELLENT discounts on dining and events in the Miami area.

**WEATHER AND CLOTHING**

Florida is hot in July.
2012 Conference Committee

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The 2013 IEEE Nuclear and Space Radiation Effects Conference will be held July 8-12 at the Hyatt Regency San Francisco. The conference features a technical program consisting of eight to ten technical sessions of contributed papers describing the latest observations in radiation effects, a Short Course on radiation effects offered on July 8, a Radiation Effects Data Workshop, and an Industrial Exhibit. The technical program includes oral and poster sessions.

Papers on nuclear and space radiation effects on electronic and photonic materials, devices, circuits, sensors, and systems, as well as semiconductor processing technology and design techniques for producing radiation-tolerant (hardened) devices and integrated circuits, will be presented at this meeting of engineers, scientists, and managers. International participation is strongly encouraged.

We are soliciting papers describing significant new findings in the following or related areas:

Basic Mechanisms of Radiation Effects in Electronic Materials and Devices
- Single Event Charge Collection Phenomena and Mechanisms
- Radiation Transport, Energy Deposition and Dosimetry
- Ionizing Radiation Effects
- Materials and Device Effects
- Displacement Damage
- Processing-Induced Radiation Effects

Radiation Effects on Electronic and Photonic Devices and Circuits
- Single Event Effects
- MOS, Bipolar and Advanced Technologies
- Isolation Technologies, such as SOI and SOS
- Optoelectronic and Optical Devices and Systems
- Methods for Hardened Design and Manufacturing
- Modeling of Devices, Circuits and Systems
- Particle Detectors and Associated Electronics for High-Energy Accelerators and Nuclear Power Facilities
- Cryogenic or High Temperature Effects
- Novel Device Structures, such as MEMS and Nanotechnologies

Space, Atmospheric, and Terrestrial Radiation Effects
- Characterization and Modeling of Radiation Environments
- Space Weather Events and Effects
- Spacecraft Charging
- Predicting and Verifying Soft Error Rates (SER)

Hardness Assurance Technology and Testing
- New Testing Techniques, Guidelines and Hardness Assurance Methodology
- Unique Radiation Exposure Facilities or Novel Instrumentation Methods
- Dosimetry

New Developments of Interest to the Radiation Effects Community

PAPER SUMMARY DEADLINE: FEBRUARY 1, 2013

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PROCEDURE FOR SUBMITTING SUMMARIES

Authors must conform to the following requirements:

1. Prepare a single Adobe Acrobat file consisting of a cover page and an informative two to four page summary describing results appropriate for 12-minute oral or a poster presentation. The cover page must provide an abstract no longer than 35 words, the title, name and company affiliation of the authors, and company address (city, state, country). Identify the author presenting the paper and provide telephone, fax, and email address. The summary must include sufficient detail about the work to permit a meaningful technical review. In the summary, clearly indicate (a) the purpose of your work, (b) significant new results with supporting technical material, and (c) how your work advances the state of the art. Show key references to other related work. The summary must be no less than two and no more than four pages in length, including figures and tables. All figures and tables must be large enough to be clearly read. Note that this is more than an abstract, but do not exceed four pages.

2. Prepare your summary in single-column format, using 11 point or greater font size, formatted for either U.S. Standard (8.5 x 11 inch) or A4 (21 x 29.7 cm) page layout, with 1 inch (2.5 cm) margins on all four sides.

3. Obtain all corporate, sponsor, and government approvals and releases necessary for presenting your paper at an open attendance international meeting.

4. Summary submission is electronic only, through www.nsrec.com. The submission process consists of entering the paper title, author(s) and affiliation(s), and an abstract no longer than 35 words. Authors are prompted to state their preference for presentation (oral, poster, or data workshop poster) and for session. Details of the submission process may be found at www.nsrec.com. The final category of all papers will be determined by the Technical Program Committee, which is responsible for selecting final papers from initial submissions.

Papers accepted for oral or poster presentation at the technical program will be eligible for publication in the IEEE Transactions on Nuclear Science (December 2013) based upon papers from the Conference. Selection for this issue will be based on a separate submission of a complete paper. These papers will be subject to the standard full peer review given all papers submitted to the IEEE Transactions on Nuclear Science. Further information will be sent to prospective authors upon acceptance of their NSREC summary. It is not necessary to be an IEEE member to present a paper or attend the NSREC. However, we encourage IEEE and NPSS membership of all NSREC participants.

RADIATION EFFECTS DATA WORKSHOP

The Radiation Effects Data Workshop is a forum for papers on radiation effects data on electronic devices and systems. Workshop papers are intended to provide radiation response data to scientists and engineers who use electronic devices in a radiation environment, and for designers of radiation-hardened systems. Papers describing new simulation or radiation facilities are also welcomed. The procedure for submitting a summary to the Workshop is identical to the procedure for submitting NSREC summaries. Radiation Effects Data Workshop papers will be published in a Workshop Record and are not candidates for publication in the Conference issue of the IEEE Transactions on Nuclear Science.

SAN FRANCISCO, CALIFORNIA

San Francisco is often called “Everybody’s Favorite City,” a title earned by its scenic beauty, cultural attractions, diverse communities, and world-class cuisine. Measuring 49 square miles, this very walk-able city is dotted with landmarks like the Golden Gate Bridge, cable cars, Alcatraz and the largest Chinatown in the United States. A stroll of the City’s streets can lead to Union Square, the Italian-flavored North Beach, Fisherman’s Wharf, and the Mission District, with intriguing neighborhoods to explore at every turn.

Views of the Pacific Ocean and San Francisco Bay are often laced with fog, creating a romantic mood in this most European of American cities. The City is home to world-class theatre, opera, symphony and ballet companies and often boasts premieres of Broadway-bound plays and culture-changing performing arts.

Luxury and location converge in perfect balance at Hyatt Regency San Francisco. The only AAA Four Diamond downtown San Francisco hotel situated right on the Embarcadero waterfront, our guests will enjoy immediate access to both the Financial District and the city’s most famous attractions. You’ll find the historic Ferry Building on one side of our expansive San Francisco California hotel, the ferry to Alcatraz and the Bay on the other, and stunning views all around.
The InterContinental Lobby to meet friends.

MySpa features 10 treatment rooms, including one duet suite and one with a unique hydrotherapy capsule, separate manicure & pedicure.

Indigo Bar offering refreshments before dinner at the Indigo Restaurant.

Blue Water Cafe—Enjoy light fare by the rooftop pool while gazing at the best panoramic view of the Miami River and Biscayne Bay in the city.

A view from your InterContinental room.

Stroll over to the Bayfront Park for a relaxing view.

Return to the InterContinental from Bayside Marketplace—you can’t miss the NSREC hotel!
FROM MIAMI INTERNATIONAL AIRPORT:

◆ TAKE 836 EAST TO I-95 SOUTH TO BISCAYNE BOULEVARD (EXIT 2A).
◆ TAKE THE RAMP DOWN THROUGH TWO RED LIGHTS.
◆ TURN LEFT AT THE STOP SIGN (GET IN THE FAR RIGHT LANE).
◆ TURN RIGHT AT FIRST RED LIGHT (ONE HALF-BLOCK). THE INTERCONTINENTAL MIAMI IS ON YOUR RIGHT AT 100 CHOPIN PLAZA.

Approximate travel time: 15 minutes.

NOTE: VALET PARKING ONLY IS AVAILABLE AT THE HOTEL HOWEVER, WE RECOMMEND THE USE OF SHUTTLES OR TAXI SERVICE IN LIEU.

FROM PALM BEACH (PBI) OR FORT LAUDERDALE (FLL) INTERNATIONAL AIRPORTS:

◆ TAKE I-95 SOUTH TO BISCAYNE BOULEVARD (EXIT 2A) THEN FOLLOW THE DIRECTIONS ABOVE.

Approximate travel time: 40 minutes from Fort Lauderdale (FLL).