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On behalf of the Institute of Electrical and Electronics Engineers (IEEE) and its Nuclear and Plasma Sciences Society (NPSS), Radiation Effects Steering Committee (RESG) and the 2013 Nuclear and Space Radiation Effects Conference (NSREC) committee, I am pleased to invite you to attend the 50th NSREC to be held July 8 - 12, 2013. The conference will be held at the Hyatt Regency San Francisco in the heart of the Financial District near many of the city’s attractions.

The conference begins Monday, July 8, with a one-day Short Course titled, “Evolution of Radiation Studies on the Path of Moore’s Law: Past Present and (Foreseeable) Future.” The Short Course is organized by Alessandro Paccagnella (University of Padova) and features five parts taught by experts from our community. This Short Course will provide an introduction to the basic radiation effects on devices and systems. In addition, it will offer a valuable retrospective of 50 years of radiation studies and a perspective for future challenges coming from radiation effects in contemporary technologies and devices.

The main technical program is from Tuesday, July 9 to Friday, July 12. Cheryl Marshall, NASA Goddard Space Flight Center, is the conference Technical Program Chair. She, along with her technical committee, has chosen an outstanding set of contributed papers organized into 10 sessions of oral presentation and a poster session encompassing papers from all 10 sessions. In addition to the main technical sessions, the technical committee has also selected outstanding papers for the Radiation Effects Data Workshop. This is an additional poster session describing radiation effects data on electronics and photonic devices and systems and new simulation or test facilities. Finally, Cheryl has invited three speakers to give talks of more general interest to start each morning from Wednesday to Friday.

The Industrial Exhibit, organized by Marc Owens, Air Force Research Laboratory, opens Tuesday morning and concludes Wednesday around lunchtime. Attendees will be able to visit the booths during scheduled breaks and a lunch on Tuesday. Attendees and guests are invited to attend a cocktail reception in the exhibit hall on Tuesday evening. The exhibit showcases the products and capabilities of the exhibitors in areas such as semiconductors, systems, modeling, and test resources.

I hope that you will enjoy our social program in San Francisco organized by Dolores Black, Embry-Riddle Aeronautical University. Two companion tours are scheduled, Tuesday going to Alcatraz Island, and Thursday going to Muir Woods National Park and Sausalito. On Wednesday evening, we have planned a dinner cruise for attendees. In addition, the conference hotel is well located for use of the many public transportation options in San Francisco.

In celebration of the 50th conference, we are providing two things. First, all attendees will receive a DVD containing the IEEE publications produced by the first 49 conferences. The DVD is indexed by conference year, author, and session. Second, we invite all attendees and guests to a reception on Monday evening. This reception will give all the chance to relive memories of past conferences.

Your 2013 Conference Committee looks forward to seeing you in San Francisco this July.

Visit us on the web at: www.nsrec.com
EVOLUTION OF RADIATION STUDIES ON THE PATH OF MOORE’S LAW: PAST, PRESENT AND (FORESEEABLE) FUTURE

GRAND BALLROOM – MONDAY, JULY 8

7:15 AM  REGISTRATION/CONTINENTAL BREAKFAST (13 Views Lounge)

8:00 AM  SHORT COURSE INTRODUCTION
Alessandro Paccagnella, University of Padova

Section 1: Lessons Learned From Our Past

8:10 AM  PART A1 — TID THROUGH THE LOOKING GLASS
Ken Galloway, Vanderbilt University

8:55 AM  PART A2 — DISPLACEMENT DAMAGE EFFECTS IN DEVICES
Joseph R. Srour, The Aerospace Corporation

9:40 AM  BREAK (Grand Ballroom Foyer)

10:10 AM  PART B — LANDMARKS IN TERRESTRIAL SINGLE-EVENT EFFECTS (SEE)
Robert C. Baumann, Texas Instruments

11:40 AM  SHORT COURSE LUNCHEON (13 Views Lounge)

Section 2: Behind the Corner

1:20 PM  PART C — CHALLENGES OF TESTING COMPLEX SYSTEMS
Heather Quinn, Los Alamos National Laboratory

2:50 PM  BREAK (Grand Ballroom Foyer)

3:20 PM  PART D — WHERE RADIATION EFFECTS IN EMERGING TECHNOLOGIES REALLY MATTER
Kenneth Rodbell, IBM T.J. Watson Research Center

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 “Evolution of Radiation Studies on the Path of Moore’s Law: Past, Present and (Foreseeable) Future” will be presented at the 2013 IEEE Nuclear and Space Radiation Effects Conference (NSREC). This Short Course will provide an introduction to the basic radiation effects on devices and systems. At the same time, it will offer a valuable retrospective of 50 years of radiation studies, and a perspective for future challenges coming from radiation effects in contemporary technologies and devices.

The Short Course is organized into two sections. The first section, “Lessons Learned From Our Past,” will be in the morning and include three presentations. The morning section aims to illustrate the basic radiation effects in electronic and optoelectronic components, occurring when they are exposed to the different radiation sources. This section will highlight the most important and still valuable scientific and technological breakthroughs, how they have been found and the men and women that brought those findings to light. The presenters of this section are highly reputed for their long experience and knowledge of both radiation effects and radiation effects history.

The afternoon section, “Behind the Corner,” will emphasize the present and future of radiation studies and includes two presentations. The first presentation covers methods and procedures needed to test complex electronic systems, and in particular multi-component devices. The second presentation is devoted to exploring new device design and technologies, for both the “more Moore” and the “more than Moore” options of the microelectronic industry. Presenters are well known for their active involvement in the research themes related to their presentations at this Short Course.

This Short 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, along with a critical review of the knowledge developed in the field. 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).

Alessandro Paccagnella graduated in Physics at the University of Padova. After appointments at the Universities of Modena, Trento and Cagliari, he is now Full Professor of Electronics and Chair of the Department of Information Engineering at the University of Padova. His research activity has been directed to the study of different aspects of physics, technology, and reliability of semiconductor devices, with more than 400 published scientific papers. He has also spent some research periods at the University of California, San Diego, and at the IBM T.J. Watson Research Center. At present, he coordinates the research activity of a group working on radiation effects and reliability of semiconductor devices and circuits, with emphasis on non-volatile memories. He has been session chair and short course instructor in previous NSREC editions. He has co-authored works, which received Awards at various NSREC and RADECS conferences.

Alessandro Paccagnella
Short Course Chairman
Ken Galloway, Vanderbilt University, will open the Short Course with a lecture that reviews 50 years of total ionizing dose (TID) research in semiconductor electronics at the NSREC. The perspective will be from that of an interested observer of the research over time rather than that of an expert attempting to present the physics in detail. The emphasis will be on the people, research groups, organizations, signature discoveries, and the time evolution of our knowledge of total ionizing dose physics and effects. Where did we start? Where are we today? How did we get here? Where are we going? He will try to place TID radiation effects research into context with the rapid evolution of semiconductor technology over these 50 NSREC years. For technical detail, the lecture will refer attendees to original papers, many good reviews, previous Short Courses, and other sources.

**TID THROUGH THE LOOKING GLASS**
Ken Galloway  
*Vanderbilt University*

Ken Galloway, Vanderbilt University, will open the Short Course with a lecture that reviews 50 years of total ionizing dose (TID) research in semiconductor electronics at the NSREC. The perspective will be from that of an interested observer of the research over time rather than that of an expert attempting to present the physics in detail. The emphasis will be on the people, research groups, organizations, signature discoveries, and the time evolution of our knowledge of total ionizing dose physics and effects. Where did we start? Where are we today? How did we get here? Where are we going? He will try to place TID radiation effects research into context with the rapid evolution of semiconductor technology over these 50 NSREC years. For technical detail, the lecture will refer attendees to original papers, many good reviews, previous Short Courses, and other sources.

**Introduction**

What are total ionizing dose (TID) and TID effects?
- Ionizing dose, electron-hole pair generation, charge trapping, interface-trap formation

What are the key device-level effects?
- Leakage currents, BJT gain degradation, threshold-voltage shifts

Where we are today? How did we get here?

The 60s and 70s
- BJTs, early BJT TID results, researchers, organizations
- Enter the MOSFET, early MOS TID results, technology, researchers
- Understanding the physics, who?, where?
- Efforts to harden MOS technology

The 80s and 90s
- The commercial drive, Moore’s Law
- Concurrently, what is happening in the rad effects world?
- The discovery of ELDRS – new BJT TID problems

The 2000s
- Scaling continues
  - High-K dielectrics, new isolation technologies, FinFETs
- TID challenges with new technology
- New levels of understanding

Where do we go next?
Joe Srour will describe the effects of radiation-induced displacement damage on electronic and electro-optical devices, with emphasis placed on silicon technology. The history of displacement damage effects on semiconductor devices will be reviewed, and notable achievements will be described. The underlying physical mechanisms responsible for device degradation will be discussed. Key displacement damage studies performed in recent years will be reviewed. Special topics and case studies will be presented to illustrate how displacement damage can have a significant impact on the performance of electronic and electro-optical devices in the space radiation environment. Particle detectors, solar cells, and imaging arrays will be included as examples. Topics needing further study will be identified, including consideration of notable unanswered questions.

Introduction to Displacement Damage Effects
- Damaging Environments
- Susceptible Device Technologies
- Nomenclature

History of Displacement Damage Studies

Displacement Damage Mechanisms
- Isolated and Clustered Defects
- Energy Levels in Bandgap: Generation, Recombination, Trapping, and Removal

Displacement Damage Effects
- Degradation of Imagers, Detectors, Solar Cells, and Bipolar Transistors

Special Topics
- NIEL Scaling
- Carrier Concentration Changes
- Silicon Particle Detectors
- Visible Imaging Arrays, Random Telegraph Signals
- Solar Cells
- Displacement Damage Simulation
- Hardness Assurance

Areas for Further Study

Summary
This short course is focused on single-event effects (SEE) in the terrestrial environment. We start with a short review of the terrestrial radiation mechanisms and how they cause a variety of reliability failures in modern electronics. The interplay between the “signal” or “critical charge” and the “noise” or “charge collected” is also explained in the context of the basic digital building blocks of memory and logic. In the second part of this course taking a retrospective view, through the lens of the Thomas Kuhn’s “The Structure of Scientific Revolutions” we chronologically touch on some of the key revolutionary and evolutionary findings from the discovery of earth and space radioactivity to studies of SEEs on the complex circuit architectures of modern electronics.

Background
- Why we care about SEEs in the terrestrial environment
- Ions in matter, the “FIT”, and definitions of failure modes
- The dominant radiation mechanisms in the terrestrial environment
- Critical Charge vs. Collected Charge
- DRAM, SRAM, and logic

Radiation Effects History – Landmarks in the Early Years
- Another 50th anniversary - Thomas Kuhn on Scientific Progress by Paradigm Shift
- Examples of “paradigm shifts” and “normal science” in the History of Astronomy
- 1900: Bequerel & Curie: Materials in the Earth give off radiation spontaneously
- 1912: Hess: Space is a source of radiation
- 1958: Greater Understanding of Space Radiation (NASA Explorer probes)
- 1975-78: Errors caused by space radiation and first estimates of radiation responsible

Terrestrial Radiation Effects – Landmarks from 1978 - 2012
- 1978: Alpha particles cause DOMINANT soft failure rate in DRAMs
- 1979: Sea-level Cosmic Ray effects in Electronics
- 1978-90: Fighting alphas - shielding, materials, alpha counting and neutron activation analysis
- 1990-95: DRAM becoming more robust & Terrestrial Neutrons DOMINATE Reliability
- 1994: Thermal neutrons and BPSG
- 2000 – 2012: Failures in Logic, de-rating, new mechanisms, and new techniques

Conclusions
Heather Quinn will present a tutorial that provides practical advice for testing systems for heightened radiation environments. Radiation testing can reduce the risk to space missions by allowing design teams to avoid electronics that have permanent failure modes and mitigate electronics with temporary failure modes. Over the years radiation testing has become challenging as components and systems have become complex. This complexity is expressed in many different forms in present-day systems, including the internal organization of state-of-the-art electronics, the continued shrinking feature size and the new layout techniques for increasing radiation hardness. This course will cover designing tests, designing test fixtures, executing tests, and analyzing test data.

**Background**
- Has Testing Changed?
- Principles Behind Component Testing
- Performance Metrics For Testing

**Test Design**
- Standards for Test Design
- Guidance on Temperature, Voltage And Functionality Requirements
- Designing Tests For Complex Systems

**Test Fixture Design**
- Test Fixtures for Monitoring Current And Functionality
- Advancements In Test Fixture Design
- Designing Test Fixtures For Complex Systems

**Test Execution**
- Practical Advice For Test Execution

**Analysis of Test Data**
- Statistical Principles For Event Categorization And Error Bars
- Calculating Cross Sections
- Fitting Data To Curves

**Topics for Further Study**

**Summary**
WHERE RADIATION EFFECTS IN EMERGING TECHNOLOGIES REALLY MATTER
Kenneth Rodbell
IBM T.J. Watson Research Center

Kenneth Rodbell, IBM T.J. Watson Research, will provide an introduction to radiation effects caused by voltage scaling requirements of newly proposed advanced terrestrial systems, such as Exascale. Low voltage systems will require additional mitigation to maintain high reliability, since a 3 - 4X increase in latch Single Event Upsets (SEU’s) can be expected in reducing the voltage from 1.0 to 0.5 V. This is a conservative estimate as the latch cross-section, and Qcrit needed to upset a device, will decrease substantially with scaling, increasing the susceptibility to SEU events caused by low energy particles. In addition, beyond 22 nm, the SEU rate becomes much less predictable through scaling rules because of emerging technologies such as FinFET’s and ultra-thin, fully depleted SOI, and the increased sensitivity to previously negligible upset sources for terrestrial applications, such as chip manufacturing impurities (e.g., alpha particles), daughter product-induced multi-bit upsets and sea level muons from neutron induced secondary reactions. Using error detection circuitry to mitigate SEU’s and Single Event Transients (SET’s) is an intricate trade-off because of application masking. Using parity and residue checking for arithmetic operations to detect SEU’s and SET’s may be more power efficient than using SEU hardened latches alone, however, they also detect bit-flips that otherwise disappear as characterized by architectural vulnerability factors (AVF). These effects will be considered in an effort to understand the system vulnerability and mitigation requirements for new, large, low voltage terrestrial systems.

Introduction – Problem Definition(s)
■ How did we get here?
■ How big a problem is this?
■ Failure Rate Projections and Historical Trends
■ Exascale Systems (circa 2018 - 2020 with 14 nm, 11 nm and/or 7 nm nodes)

Voltage Scaling Requirements
Soft Error Rate (SER) Effects with Voltage Scaling
Technology Options
■ Planar devices
  • SOI vs. Bulk
■ FinFET (Tri-Gates)
  • SOI vs. Bulk
■ Nanowires

Application Masking
Parity Checking
Hardened Latches
Cross Layer Resiliency, Modeling and Mitigation
Design Automation for Resiliency
Power Efficiency Concerns
Outlook
Summary and Conclusions
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:

- **Space and Terrestrial Environments**  
  Chair: Joe Mazur, The Aerospace Corporation

- **Basic Mechanisms of Radiation Effects**  
  Chair: Enxia Zhang, Vanderbilt University

- **Single Event Effects: Mechanisms and Modeling**  
  Chair: Mark Law, University of Florida

- **Single Event Effects: Devices and Integrated Circuits**  
  Chair: Steve Guertin, Jet Propulsion Laboratory

- **Dosimetry**  
  Chair: Ethan Cascio, Massachusetts General Hospital

- **Photonic Devices and Integrated Circuits**  
  Chair: Vincent Goiffon, ISAE - Université de Toulouse

- **Hardening By Design**  
  Chair: Manuel Cabanas-Holmen, The Boeing Company

- **Single Event Effects: Transient Characterization**  
  Chair: Véronique Ferlet-Cavrois, ESA/ESTEC

- **Hardness Assurance**  
  Chair: Jean-Marie Lauenstein, NASA/GSFC

- **Radiation Effects in Devices and Integrated Circuits**  
  Chair: Gary Lum, Lockheed Martin

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 Sealcliff Room (A-D). The formal Poster Session will be held on Wednesday from 2:20 to 4:50 PM and the authors will be available at that time to discuss their work. The Poster Session is chaired by Pascale Gouker, MIT Lincoln Laboratory.

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 Bayview Room (AB). Authors will be available on Thursday to discuss their work from 1:35 to 4:00 PM. A workshop record will be mailed to all registered conference attendees. The workshop chair is Philippe Paillet, CEA.

There will be three invited talks:

- **Atmospheric River Storms and Megafloods: Are we Prepared?**  
  B. Lynn Ingram, University of California, Berkeley

- **Robots and Humans in Spaceflight: Technology, Evolution, and Interplanetary Travel**  
  Roger D. Launius, Smithsonian Institution’s National Air and Space Museum

- **Gendered Innovations in Science and Engineering**  
  Londa Schiebinger, Stanford University and Gendered Innovations in Science, Health & Medicine, Engineering, and Environment Project

Late-news papers will be accepted and included in the Poster Session and the Radiation Effects Data Workshop. The deadline for submission is May 31, 2013. 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

8:00 AM  OPENING REMARKS
Jeffrey Black, Sandia National Laboratories, General Chairman

8:05 AM  AWARDS PRESENTATION
Marty Shaneyfelt, Sandia National Laboratories, Radiation Effects Steering Group Committee

8:35 AM  TECHNICAL SESSION OPENING REMARKS
Cheryl Marshall, NASA/GSFC, Technical Program Chairman

SESSION A

8:40 AM  SPACE AND TERRESTRIAL ENVIRONMENTS
SESSION INTRODUCTION
Chair: Joe Mazur, The Aerospace Corporation

A-1  8:45 AM  TacSat-4 Radiation Environment and Solar Cell Degradation
Correlations Using Onboard Experiments
S. R. Messenger, P. P. Jenkins, J. H. Warner, W. J. Barnds, W. C. Raynor, M. S. Hurley,
Naval Research Laboratory; C. D. Lindstrom, W. R. Johnston, Air Force Research Laboratory;
S. Huston, AER, Inc.; D. C. Bentz, Harris Corp.

TacSat-4 carries the CEASE radiation spectrometer and a full I-V characterization
experiment on 3J solar cells. CEASE measured much higher proton contributions than
predicted, well correlating the experimental solar cell degradation using SCREAM.

A-2  9:00 AM  Early Results from the Engineering Radiation Monitor (ERM) on the
Van Allen Probes Mission
Physics Laboratory; A. G. Holmes-Siedle, REM Oxford Ltd.

The Engineering Radiation Monitor measures dose, dose rate and charging cur-
rents on the Van Allen Probes mission to study the dynamics of Earth’s Van Allen
Radiation Belts. We report early results from this monitor.

A-3  9:15 AM  Comparisons of AE9 and AP9 with Legacy Trapped Radiation Models
S. L. Huston, Atmospheric and Environmental Research, Inc.; G. P. Ginet, MIT Lincoln
Laboratory; W. R. Johnston, Air Force Research Laboratory

Electron and proton fluxes from the new AE9 and AP9 models are compared with
AE8, AP8, and other older models for several common orbits.

POSTER PAPERS

PA-1  A Probabilistic Model for Solar Energetic Proton Fluences
J. H. Adams, Jr., Z. Robinson, University of Alabama; M. Xapsos, C. Stauffer, NASA/GSFC

A tool for calculating a Design Reference Radiation Environment is presented that is
mission specific. This tool provides an upper bound on the proton differential energy
spectrum for the solar particle event episode integrated fluence.
PA-2  Analytical Method to Evaluate Soft Error Rate Due to Alpha Pollutants
A. Kaouache, F. Wrobel, F. Saigné, A. D. Touboul, Université Montpellier 2; R. D. Schrimpf, Vanderbilt University

An analytical model for the alpha-particle induced soft-error rate of SRAMs is validated for different technologies by comparing the error rate due to uranium and thorium with that obtained from Monte Carlo simulations.

PA-3  Anomalies of the ADSP 21060 Onboard the DEMETER Satellite
C. Inguimbert, S. Bourdari, D. Falguère, ONERA; R. Ecoffet, N. Balcon, CNES

The microcomputer ADSP21060 of the DEMETER satellite experienced a number of Single Event Effects (SEE). The correlation of these events with both the proton fluxes and the electron fluxes of the space environment is shown.

9:30 – 9:55 AM  BREAK
PACIFIC BALLROOM

SESSION B  BASIC MECHANISMS OF RADIATION EFFECTS
9:55 AM  SESSION INTRODUCTION
Chair: Enxia Zhang, Vanderbilt University

B-1  Potential Evidence for Post-Irradiation Defect Evolution Resulting in Enhanced Gain Degradation
E. Bielejec, G. Vizkelethy, B. L. Doyle, G. A. Patrizi, D. B. King, Sandia National Laboratories

We present newly observed post-irradiation enhanced gain degradation in PnP HBTs under short pulse ion irradiations. This effect is potentially linked to defect evolution resulting in a defect complex with larger recombination cross-sections.

B-2  Ionizing Radiation Induced Threshold Voltage Shifts in GaN MOS-HEMTs on Si Substrates
X. Sun, S. Cui, T. P. Ma, Yale University; O. I. Saadat, T. Palacios, Massachusetts Institute of Technology; E. X. Zhang, D. M. Fleetwood, Vanderbilt University

X-ray irradiation of MOS-HEMTs and conventional HEMTs shows that both gate oxides and AlGaN/GaN on Si contribute to total ionizing dose induced $V_{th}$ shifts. Al₂O₃ and HfO₂ are benchmarked as gate oxides.

B-3  Proton-Induced Dehydrogenation of Defects in AlGaN/GaN HEMTs

Changes in defect energy distributions of AlGaN/GaN HEMTs during proton irradiation are characterized via temperature-dependent low-frequency noise measurements. Density functional calculations show these changes are consistent with dehydrogenation of oxygen-related defects.
Characterization of Radiation Damage in Carbon Nanotube Field-Effect Transistors

S. A. Francis, J. S. Best, J. C. Petrosky, J. W. McClory, Air Force Institute of Technology; C. D. Cress, Naval Research Laboratory

Charge-pumping and Raman spectroscopy are used to evaluate the radiation damage in carbon-nanotube field-effect transistors after alpha-particle irradiation. Contributions from damage to nanotubes and surrounding materials to device performance are investigated.

Correlation of Current-Voltage Characteristics for $P^+n$ and $N^+p$ GaAs Devices

J. H. Warner, S. R. Messenger, R. J. Walters, Naval Research Laboratory; R. Hoheisel, The George Washington University

The current-voltage characteristics of proton irradiated GaAs photodiodes are analyzed and correlated with NIEL. The forward biased dark current data are shown to be dominated by recombination effects and correlate with the total NIEL.

Effects of High Electric Fields on the Magnitudes of Current Steps Produced by Single Particle Displacement Damage


Distributions of current step magnitudes from $^{252}$Cf fission fragment irradiation of a silicon diode are presented. Nonionizing energy deposition scaled by field enhancement factors is not sufficient to explain the variation in observed step magnitudes.

A Modeling Study of Proton Irradiation in AlGaN/GaN HEMTs Applied to Understanding the Increase of Critical Voltage for Pit-Shaped Defect Formation

E. E. Patrick, M. E. Law, L. Liu, F. Ren, S. Pearton, University of Florida

A combination of SRIM and FLOODS models the effect of irradiation damage on AlGaN/GaN HEMTs. While excellent fits are obtained for threshold voltage shift, the models do not explain the increased reliability observed experimentally.

Interface Effects on Total Energy Calculations for Radiation-Induced Defects

A. H. Edwards, Air Force Research Laboratory; H. J. Barnaby, Arizona State University; A. C. Pineda, University of New Mexico

Long-range, electrostatic interactions are crucial for accurate defect levels. We report a novel, multiscale technique, combining density functional theory with device modeling. Results predict that defect levels depend on substrate doping and gate bias.

The Effects of Pulsed Radiation on Fused Silica and Sapphire Films

M. McLain, F. Hartman, T. Sheridan, H. Hjalmarson, T. Zarick, Sandia National Laboratories

The effects of 20 MeV electron beam exposures on fused silica and sapphire films are investigated. The data indicate that the electrical conductivity in each film increases significantly during a pulsed radiation event.
SESSION C
1:00 PM
SINGLE EVENT EFFECTS: MECHANISMS AND MODELING
SESSION INTRODUCTION
Chair: Mark Law, University of Florida

C-1 1:05 PM
Singly Charged Particle Single-Event Upsets in 45 nm Bulk SRAMs

Experimental results with low-energy protons and muons demonstrate a strong bias sensitivity of critical charge in SRAMs belonging to sub-45 nm nodes. Sensitivity to energetic electron-induced SEU at low bias is observed.

C-2 1:20 PM
Proton-Induced Upsets in SLC and MLC NAND Flash Memories with Sub-40nm Feature Size
M. Bagatin, S. Gerardin, A. Paccagnella, University of Padova; V. Ferlet-Cavrios, ESA/ESTEC; J. R. Schwank, M. R. Shangle, Sandia National Laboratories

We present new results on proton upsets in NAND Flash memories. The different dependence on proton energy between samples with single and multiple bits per cell is studied using heavy-ion data and device simulations.

C-3 1:35 PM
Investigation of Supply Current Spikes in Flash Memories Using Ion Electron Emission Microscopy
S. Gerardin, University of Padova; M. Bagatin, A. Paccagnella, D. Bisello, P. Giubilato, S. Mattiazzi, D. Pantano, L. Silvestrin, M. Tessaro, University of Padova and INFN; J. Wyss, INFN, and University of Cassino and Lazio Meridionale; V. Ferlet-Cavrios, ESA/ESTEC

We studied the occurrence of supply current spikes in NAND Flash memories under heavy-ion exposure. In addition to broad-beam experiments, we used sophisticated ion electron emission microscopy to investigate the phenomenon.

C-4 1:50 PM
SEE Measurements and Simulations Using Mono-Energetic GeV-Energy Hadron Beams
R. Garcia Alia, S. Danzeca, CERN and Université Montpellier 2; M. Brugger, G. Spiezia, S. Uznanski, CERN; V. Ferlet-Cavrios, C. Poivey, F. Saigné, F. Wrobel, ESA

SEU measurements were performed on the ESA SEU Monitor using monoenergetic GeV-energy hadron beams available at CERN (120 and 400 GeV). Resulting cross section values are discussed and compared to standard measurements and simulations.

C-5 2:05 PM
The Impact of Depletion Region Potential Modulation on Ion-Induced Current Transient Response
N. C. Hooten, W. G. Bennett, R. A. Reed, R. D. Schrimpf, R. A. Weller, Vanderbilt University

Transient capture measurements on an irradiated diode show the effect of ion LET on transient current response. Significant modulation of the device depletion region potential during and after the strike profoundly affects transient characteristics.
Device-Level Multi-Node Charge Collection Mechanisms During Irradiation


Device-level mechanisms of multi-node charge collection (MNCC) are investigated using heavy ion induced current transients. The dependence of MNCC on strike location is determined using backside two-photon absorption laser analysis.

Post-Irradiation-Gate-Stress on Power MOSFETs: Quantification of Latent Defects-Induced Reliability Degradation

A. Privat, A. D. Touboul, R. Arinero, F. Wrobel, F. Saigné, Université Montpellier 2; J.-R. Vaillé, Université Montpellier 2 and Université de Nîmes; S. Bourdarie, ONERA; N. Chatry, TRAD; G. Chaumont, STMicroelectronics

Electrical characterizations are used to understand different failure mechanisms after heavy ion irradiation of power MOSFETs. This work addresses the limit of the post-irradiation gate stress relevance used for power MOSFETs space qualification.

BREAK

SINGLE EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS

An Investigation of Single-Event Effects and Potential SEU Mitigation Strategies in 4th Generation 90nm SiGe BiCMOS


The heavy-ion response of forward and inverse-mode SRs designed in 4th generation 90nm SiGe BiCMOS technology is investigated for the first time. TPA measurements and TCAD simulations were used to understand the results.

Single-Event Effects in Silicon Carbide Power Devices


The single-event effects observed in two 1200 V power MOSFETs, a 1200 V JFET, a 1700 V JFET, and a 1200 V BJT are investigated. All are commercial SiC devices.

Single-Event Upsets in Substrate-Etched CMOS SOI SRAMs Using Ultraviolet Optical Pulses with Sub-Micrometer Spot Sizes


Ultraviolet optical pulses with a full-width-at-half-maximum focused spot size of less than 0.35 µm are generated, characterized, and used to produce SEUs in 90 nm and 150 nm SRAM devices.
Unanticipated Multiple Bit Upsets (MBUs) in Complex Designs and the Effects of Logic Masking

M. D. Berg, H. S. Kim, A. M. Phan, C. M. Seidleck, MEI Technologies Inc.; K. A. LaBel, J. Pellish, NASA/GSFC

We show that the effects of SEUs in synchronous systems are highly likely to cause unexpected MBUs. Consequently, the efficacy of error-correction codes implemented across synchronous data-paths can be significantly reduced.

Impact of Supply Voltage and Particle LET on Logic Circuit Single-Event Error Rates

N. N. Mahatme, N. J. Gaspard, S. Jagannathan, D. Loveless, B. L. Bhava, W. H. Robinson, L. W. Massengill, Vanderbilt University; S.-J. Wen, R. Wong, CISCO Systems Inc.

Alpha and heavy-ion irradiation of 28 nm circuits for different voltages is performed to determine the threshold frequency at which logic errors exceed flip-flop errors. Frequency and voltage aware hardening guidelines are provided.

At-Speed SEE Testing of RHBD Embedded SRAMs


We describe test structures that allow at-speed Single Event Effects testing on embedded memory arrays. The test structures allow identification of Multiple Cell Upsets, Multiple Bit Upsets, persistent errors, and transient errors.

Using Charge Accumulation to Improve the Radiation Tolerance of Multi-GB NAND Flash Memories

M. J. Kay, M. J. Gadlage, A. Duncan, D. Ingalls, M. W. Savage, NSWC Crane

Consecutive write operations on 42nm and 60nm single-level cell (SLC) Samsung NAND flash memories are shown to significantly improve both the total ionizing dose response and the single event upset tolerance of the memory.

Threads Distribution Effects on GPU Neutron Sensitivity

P. Rech, L. Carro, Universidade Federal do Rio Grande do Sul; T. Fairbanks, Los Alamos National Laboratory

GPUs sensitivity strongly depends on throughput and threads distribution. Experiments found that increasing the block size minimizes the application neutron-induced output error rate. GPU parallelism management is analyzed as a method to increase reliability.

Experimental Soft Error Rate of Several Flip-Flop Designs Representative of Production Chip in 32nm CMOS Technology

G. Gasiot, M. Glorieux, S. Clerc, D. Soussan, F. Abouzeid, P. Roche, STMicroelectronics

Experimental Soft Error Rate characterization of several standard and hardened Flip-Flops in a 32nm technology are presented. Effect of Flip-Flop features and of new data patterns on SER are reported.
Scaling Trends of SRAM and FF of Soft-Error Rate and Their Contribution to Processor Reliability on Bulk CMOS Technology
T. Uemura, T. Kato, H. Matsuyama, Fujitsu Semiconductor; M. Hashimoto, Osaka University

This paper discusses scaling trends of SRAM and Flip-Flop soft-error rates and their contribution to processor reliability on bulk CMOS technology with results of neutron and alpha irradiation tests up to 28nm process.

Soft-Errors in SRAM at Ultra Low Voltage and Impact of Secondary Protons in Terrestrial Environment
T. Uemura, T. Kato, H. Matsuyama, Fujitsu Semiconductor; M. Hashimoto, Osaka University

This paper presents soft-error measurement results through neutron and alpha irradiation tests and simulation in SRAM at ultra-low voltage, 0.19V. We experimentally observe large impact of secondary protons for neutron soft-errors.

Temperature Impact on the Neutron SER of a Commercial 90nm SRAM
G. Tsiligiannis, L. Dilillo, A. Bosio, P. Girard, S. Pravossoudovitch, A. Todri-Sanial, A. Virazel, LIRMM; C. Frost, ISIS-Rutherford Appleton Laboratory; F. Wrobel, F. Saîgné, IES

We study the response of a commercial 90nm 32Mbit SRAM under the ISIS atmospheric neutron beam, applying temperature. Experimental results show that the device SER is strongly related to both temperature and operation mode.

Error-Rate Estimation Combining SEE Static Cross-Section Predictions and Fault-Injections Performed on HDL-Based Designs
R. J. Velazco, W. M. Mansour, TIMA Labs; G. Hubert, ONERA

An approach estimating ICs SER early in the design phase is presented. It combines cross-sections predicted from models and results of fault-injection performed at netlist level. SER predictions agree with radiation ground-testing.

Combining Hardware- and Software-Based Techniques to Detect and Diagnose Neutron Induced Single Event Effects in SRAM-Based FPGA

We combined software-based techniques with hardware module to detect neutron induced SEEs in MIPS softcore processor implemented in Virtex5 FPGA. Results demonstrate the efficiency in diagnosing effects to help partial reconfiguration and redundancy optimization.

Functional Interrupts and Destructive Failures from Single Event Effect Testing of Point-of-Load Devices
D. Chen, K. LaBel, NASA/GSFC; A. Phan, H. Kim, MEI Technologies Inc; J. Swonger, Peregrine Semiconductor; P. Musil, M. S. Kennedy Corporation

We show examples of single event functional interrupt and destructive failure in modern POL devices. Various mechanisms can trigger the hard SEE modes, owing to the increasing complexity and diversity of the processes and designs.

4:40 PM    END OF TUESDAY SESSIONS
Atmospheric River Storms and Megafloods: Are we Prepared?
B. Lynn Ingram, Professor of Earth and Planetary Science, University of California, Berkeley

Atmospheric river storms are responsible for most of the largest historical floods in California and many western states, as well as megafloods found in the geologic record that occurred every 100 to 200 years. The only megaflood to strike the American West in recent history occurred during the winter of 1861-62. Although many western states experienced their worst floods on record that year, California bore the brunt of the damage. This deluvial disaster turned enormous regions of California into inland seas for months, and took thousands of human lives. The costs to the state were devastating; one quarter of California’s economy was destroyed, forcing the state into bankruptcy.

Today, the same regions that were submerged in 1861-62 are home to California’s fastest-growing cities. Although this flood is all but forgotten today, important lessons from this catastrophe can still be learned.

B. Lynn Ingram is a professor in the Earth and Planetary Science Department at the University of California, Berkeley. She studies past climatic and environmental change in California and other locations around the Pacific Rim using sedimentological, paleontological, and geochemical data from aquatic environments (estuarine, lacustrine, riverine, and marine). Her expertise includes sedimentary geochemistry, specifically using environmentally-sensitive isotopic tracers ($^{87}$Sr/$^{86}$Sr, $^{18}$O/$^{16}$O, $^{13}$C/$^{12}$C, and $^{14}$C/$^{12}$C) to document changes in salinity, streamflow, temperature, ocean circulation, and coastal upwelling.

Professor Ingram is a co-author (with Dr. Frances Malamud-Roam) of a forthcoming book about: THE WEST WITHOUT WATER: What Past Floods, Droughts, and Other Climatic Clues Tell Us About Tomorrow (University of California Press, Spring of 2013). The book documents the tumultuous climate of the American West over twenty thousand years, with tales of past droughts and deluges and predictions about the impacts of future climate change on water resources. The book merges climate and paleoclimate research and introduces readers to key discoveries in cracking the secrets of the region’s past, describing how droughts and catastrophic floods have plagued the West with regularity over the past two thousand years, and what this means for our future.

Education
Ph.D. Geology, Stanford University, 1992
M.S. University of California, Los Angeles, 1989
B.S. University of California, Los Angeles, 1984
SESSION E  
9:10 AM  
SESSION INTRODUCTION  
Chair: Ethan Cascio, Massachusetts General Hospital

E-1  
9:15 AM  
Performance of Ge-Doped Optical Fiber as a Thermoluminescent Dosimeter  
M. Benabdesselam, F. Mady, Y. Mebrouk, J. B. Duchez, Université de Nice Sophia Antipolis; S. Girard, Université de Saint Etienne; M. Gaillardin, P. Paillet, CEA

The TSL response of Germanium doped optical fiber shows a good neutron- and proton- detection efficiency and high gamma ray sensitivity. This opens the way to a universal dosimeter, particularly interesting at therapy levels.

E-2  
9:30 AM  
Sensors Based on Radiation-Induced Diffusion of Silver in Germanium Selenide Glasses  
P. Dandamudi, M. N. Kozicki, H. J. Barnaby, Y. Gonzalez-Velo, K. E. Holbert, Arizona State University; M. Mitkova, Boise State University

In this study we demonstrate the radiation-sensing capabilities of devices which utilize radiation-induced diffusion of silver in germanium selenide glasses. The migration of the Ag produces large changes in electrical resistance between electrodes.

E-3  
9:45 AM  
Selected Topics in Ultra-Low Emissivity Alpha-Particle Detection  
M. S. Gordon, K. P. Rodbell, H. H. K. Tang, E. Yashchin, IBM; E. Cascio, Massachusetts General Hospital; B. McNally, XIA LLC

Initial results of proton irradiation on the XIA counter and neutron-induced proton modeling results are shown. A Poisson model is described which gives guidance on making appropriate measurement times and acceptance criteria.

POSTER PAPERS

PE-1  
Extreme Value Analysis in Flash Memories for Dosimetry Applications  
M. W. Savage, M. J. Gadlage, M. Kay, J. D. Ingalls, A. Duncan, NSWC Crane

A flash memory is repurposed for use as a dosimeter. Target theory is used to derive fitting curves which are used to predict first failures that correspond to an accumulated dose.

PE-2  
Total Ionizing Dose Characterization of a Prototype Floating Gate MOSFET Dosimeter for Space Applications  
M. T. Alvarez, C. Hernando, INTA; J. C. Bohigas, A. Pineda, Palma de Mallorca; E. García-Moreno, Universidad Islas Baleares

An initial characterization has been performed in a new floating gate MOSFET dosimeter to evaluate its suitability for space. The results show that it is suitable for space missions with TID up to 10krad(Si)
Multicenter Comparison of Alpha Emissivity Measurements Using the UltraLo-1800 Alpha Particle Counter
B. D. McNally, S. Coleman, W. K. Warburton, XIA LLC; J.-L. Autran, Aix-Marseille University and CNRS; B. M. Clark, Honeywell; J. Cooley, Southern Methodist University; M. S. Gordon, Z. Zhu, IBM

Recent work has been published showing wide unexplained variation in emissivity results from measurements of the same sample. The experiment is repeated using a new counter, results are compared, and new variability mechanisms are explored.

PHOTONIC DEVICES AND INTEGRATED CIRCUITS

Modeling Approach for the Prediction of Transient and Permanent Degradations of Image Sensors in Complex Radiation Environments
M. Raine, A. Rousseau, P. Paillet, M. Gaillardin, O. Duhamel, CEA, DAM, DIF; V. Goiffon, ISAE - Université de Toulouse; S. Girard, Université de Saint-Etienne; C. Virmontois, CNES

A modeling approach, combining Monte Carlo simulation and analytic calculation, is proposed to predict the transient and permanent degradation of image sensors in complex radiation environments. It is validated by comparison with experimental data.

Combined High Dose and Temperature Radiation Effects on Silica-Based Multimode Optical Fibers
S. Girard, A. Morana, D. Di Francesca, A. Boukenter, M. Leon, Y. Ouerdane, Université de Saint-Etienne; C. Marcandella, P. Paillet, M. Gaillardin, N. Richard, M. Raine, CEA, DAM, DIF; J. Perisse, J.-R. Mace, AREVA

We investigate combined effects of high temperature (up to 300°C) and high doses (up to 2MGy) on the radiation response of various optical fiber types in the ultraviolet and visible parts of the spectrum.

Single Event Effects in 4T Pinned Photodiode Image Sensors
V. Laluca, V. Goiffon, P. Magnan, Université de Toulouse; C. Virmontois, G. Rolland, S. Petit, CNES

Several Pinned Photodiode CMOS Image Sensors manufactured in two widely used commercially available CIS foundries are exposed to heavy ion beams. The causes of the observed SEE are discussed at the device and circuit level.

Dark Current Random Telegraph Signal in Solid State Image Sensors
C. Virmontois, CNES; V. Goiffon, P. Magnan, ISAE - Université de Toulouse; S. Girard, Université de Saint-Etienne

The dark current random telegraph signal is investigated in solid-state imagers. TID and DDD-induced DC-RTS is studied in numerous imager technologies using various foundry and process splits, and detector materials.
POSTER PAPERS

PF-1  
**An Assessment of the Bias Dependence of Displacement Damage Effects in Silicon CCDs**
M. S. Robbins, Surrey Satellite Technology Ltd.

The bias dependence of displacement damage effects has been assessed for silicon charge coupled devices. Bias dependence was observed in the room temperature annealing behaviour of CTE, dark signal and RTS generation measurements.

PF-2  
**Global View on Dose Rate Effects in Silica-Based Fibers and Devices Damaged by Radiation-Induced Carrier Trapping**
F. Mady, M. Benabdesselam, J.-B. Duchez, Y. Mebrouk, University of Nice Sophia Antipolis; S. Girard, Université de Saint-Etienne

We give a global approach clarifying the conditions of enhanced low and high dose rate sensitivity to help in reconciling contradictory results on dose rate dependences. An experimental example on silica optical fibers is presented.

PF-3  
**Hardening Approach to Use CMOS Image Sensors for Fusion by Inertial Confinement Diagnostics**
P. Paillet, A. Rousseau, S. Darbon, O. Duhamel, M. Raine, M. Gaillardin, J.-L. Bourgade, CEA; V. Goiffon, ISAE - Université de Toulouse; S. Girard, Université de Saint-Etienne; V. Glebov, G. Pien, University of Rochester

A hardening method is proposed to enable the use of CMOS image sensors for Fusion by Inertial Confinement Diagnostics.

11:35 AM – 1:00 PM  
LUNCH

SESSION G  
HARDENING BY DESIGN

SESSION INTRODUCTION
Chair: Manuel Cabanas-Holmen, The Boeing Company

G-1  
**Radiation Hardening of a SiGe BiCMOS Wilkinson ADC for Distributed Motor Controller Application**
P. C. Adell, J. A. Yager, M. M. Mojarradi, G. R. Allen, R. R. Some, Jet Propulsion Laboratory; B. Blalock, University of Tennessee

The radiation robustness of a newly designed SiGe Wilkinson ADC is investigated. The ADC showed SEUs sensitivity that is significantly dependent on its input channel configuration. Mitigations at the circuit and system level are proposed.

G-2  
**The Quad-Path Hardening Technique for Switched-Capacitor Circuits**

A novel RHBD technique is implemented in a switched-capacitor sample/hold amplifier and demonstrated using laser testing. With minimal speed, power and area penalties, single-event sample errors are reduced by up to 90%.
Mitigating Multi-Cell-Upset with Well-Slits in 28nm Multi-Bit-Latch

T. Uemura, T. Kato, H. Matsuyama, Fujitsu Semiconductor; M. Hashimoto, Osaka University

We propose a technique for mitigating multi-cell-upset (MCU) in multi-bit-latch (MBL) with well-slits. Sixty-hour neutron irradiation test observed no MCUs on mitigated-MBL while nineteen MCUs on unmitigated-MBL.

Technology Scaling Effects on Hardened Flip-Flop Heavy-Ion Single-Event Cross Sections


Heavy-ion experiments for flip-flops designed and fabricated in 180-nm through 28-nm technologies are compared to show that spatially-hardened and unhardened flip-flop single-event cross sections become comparable with scaling.

Robust SEU Mitigation of 32nm Dual Redundant Flip-Flops Through Interleaving and Sensitive Node-Pair Spacing

M. Cabanas-Holmen, E. Cannon, S. Rabaa, A. Amort, J. Ballast, M. Carson, D. Lam, R. Brees, The Boeing Company

We present SEU experimental data for 32nm SOI Boeing Interleaved Flip-Flops, and compare against unhardened Flip-Flops and 90nm DICE Flip-Flops. Critical node separation through interleaving effectively mitigates SEUs in redundant Flip-Flops.

A 65nm CMOS Platform for Space Applications: Performance Appraisal on Rad-Hard Microprocessors

P. Roche, G. Gasiot, S. Clerc, J.-M. Daveau, C. Bottoni, M. Glorieux, V. Huard, L. Dugoujon, STMicroelectronics

Our new CMOS65nm Space platform shows how small modifications to commercial process combined with design reinforcements allow higher density and better energy efficiency while ensuring space-grade resilience. Extensive testing on quadprocessors demonstrate those capabilities.

New D-Flip-Flop Design in 65nm CMOS for Improved SEU and Low Power Overhead at System Level

M. Glorieux, STMicroelectronics and Aix-Marseille University and CNRS; S. Clerc, G. Gasiot, P. Roche, STMicroelectronics; J.-L. Autran, Aix-Marseille University and CNRS

A new Schmitt-Trigger-based latch is experimentally evaluated in CMOS 65nm and shows enhanced SEU hardness and better performance than DICE.

Soft-Error Tolerant N-P Reversed 6T SRAM Cell

S. Yoshimoto, S. Izumi, H. Kawaguchi, M. Yoshimoto, Kobe University

We present a soft-error tolerant nMOS-pMOS reversed 6T SRAM cell. The proposed cell reduces MCU and SBU SERs by 34% and 51% over the conventional cell at a 22-nm node.
A High Performance Microprocessor Hardened by Microarchitecture and Circuit Techniques
L. T. Clark, D. W. Patterson, C. Ramamurthy, S. Chellappa, K. E. Holbert, Arizona State University

An embedded microprocessor core with dual redundant self-checking datapaths, triple-mode redundant architectural state, and 32kB caches is presented. The 400MHz 90-nm design is hardened to 1Mrad and LET eff over 100MeV-cm²/mg.

A New Error Correction Circuit for Delay Locked Loops
P. Maillard, T. W. Holman, T. D. Loveless, L. W. Massengill, Vanderbilt University

A new error correction circuit (ECC) for single-event mitigation in DLLs is proposed. This ECC, implemented using a “peeled” VCDL layout, mitigates missing output pulses due to lower critical charges in scaled CMOS processes.

Efficacy of Capacitive Hardening for Flip-Flops in Advanced Technology Nodes
Z. J. Diggins, N. J. Gaspard, S. Jagannathan, B. Bhuva, L. W. Massengill, Vanderbilt University; S.-J. Wen, R. Wong, Cisco Systems, Inc.

Capacitive radiation hardened by design (RHBD) techniques for flip flops are shown to continue to be effective at advanced technology nodes, but with diminishing returns for large values of added capacitance and high LET values.

INTRODUCTION

Chair: Pascale Gouker, MIT Lincoln Laboratory

END OF WEDNESDAY SESSIONS
Robots and Humans in Spaceflight: Technology, Evolution, and Interplanetary Travel

Roger D. Launius, Senior curator in the Division of Space History at the Smithsonian Institution’s National Air and Space Museum

This presentation is based on a forthcoming book that explores the history and possible futures for human/robotic spaceflight. While writing *Imagining Space: Achievements, Possibilities, Predictions, 1950-2050* (Chronicle Books, 2001), my co-author and I realized that the one area where all spaceflight visionaries failed to make meaningful predictions was in the rapidly advancing capabilities of robotics and electronics. For example, when Arthur C. Clarke envisioned geosynchronous telecommunications satellites in 1945 he believed that they would require humans working onboard to change the vacuum tubes. In such a situation, it is easy to conceive of the motivation that led people like Clarke and Wernher von Braun to imagine the necessity to station large human crews in space. Some of the most forward-thinking spaceflight advocates, in this instance, utterly failed to anticipate the electronics/digital revolution then just beginning. Humans, spaceflight visionaries always argued, were a critical element in the exploration of the Solar System and ultimately beyond. Human destiny required our movement beyond this planet, ultimately to the colonization of the galaxy as a means of assuring the survival of the species. With the rapid advance of electronics in the 1960s, however, some began to question the role of humans in space exploration. It is much less expensive and risky to send robot explorers than to go ourselves. This debate reached saliency early on and became an important part of the space policy debate by the latter twentieth century. This presentation offers a history and analysis of how we came to the point that we have in human spaceflight, as well as a discussion of the relative merits of human versus robotic space exploration. In essence, I shall suggest that the old paradigm for human exploration—ultimately becoming an interstellar species—is outmoded and ready for replacement. I will specifically look to the future of humans and robots in space and suggest that the possibility exists that perhaps a post-human cyborg species may realize a dramatic future in an extraterrestrial environment.

Roger D. Launius is senior curator in the Division of Space History at the Smithsonian Institution’s National Air and Space Museum in Washington, D.C., where he was division chair 2003-2007. Between 1990 and 2002 he served as chief historian of the National Aeronautics and Space Administration. A graduate of Graceland College in Lamoni, Iowa, he received his Ph.D. from Louisiana State University, Baton Rouge, in 1982. He has written or edited more than twenty books on aerospace history, most recently *Exploring the Solar System: The History and Science of Planetary Probes* (Palgrave Macmillan, 2013); *Coming Home: Reentry and Recovery from Space* (NASA SP-2011-593, 2012), which received the AIAA’s history manuscript prize; *Globalizing Polar Science: Reconsidering the International Polar and Geophysical Years* (Palgrave Macmillan, 2010); *Smithsonian Atlas of Space Exploration* (HarperCollins, 2009); *Robots in Space: Technology, Evolution, and Interplanetary Travel* (Johns Hopkins University Press, 2008); *Societal Impact of Spaceflight* (NASA SP-2007-4801, 2007); and *Critical Issues in the History of Spaceflight* (NASA SP-2006-4702, 2006). He is a Fellow of the American Association for the Advancement of Science, the International Academy of Astronautics, and the American Astronautical Society, and associate fellow of the AIAA. He also served as a consultant to the Columbia Accident Investigation Board in 2003 and presented the prestigious Harmon Memorial Lecture on the history of national security space policy at the United States Air Force Academy in 2006. He is frequently consulted by the electronic and print media for his views on space issues, and has been a guest commentator on National Public Radio and all the major television network news programs.
SESSION H
9:10 AM
SINGLE EVENT EFFECTS: TRANSIENT CHARACTERIZATION
SESSION INTRODUCTION
Chair: Véronique Ferlet-Cavrois, ESA/ESTEC

H-1
9:15 AM
SET Pulse Width Trends in 45 nm and 32 nm SOI

The first reported heavy-ion induced SET pulse widths are provided for CMOS devices in a 32 nm SOI technology, with comparisons to data from similar test structures in a 45 nm SOI technology.

H-2
9:30 AM
Charge Collection Analysis under Heavy Ion Irradiation in Multiple-Gate Devices: FinFETs and Nanowires
M. Gaillardin, M. Raine, P. Paillet, O. Duhamel, CEA, DAM, DIF; S. Girard, Université de Saint-Etienne; P. C. Adell, Jet Propulsion Laboratory; F. Andrieu, S. Barraud, O. Faynot, CEA, LETI-Minatec

We investigate SETs in FinFETs and nanowires. Heavy ion experimental results are explained by using a thorough charge collection analysis of fast transients. Implications for device design hardening are discussed.

H-3
9:45 AM
An Investigation of Single Event Transient Response in 45 nm and 32 nm RF-CMOS on SOI Devices and Circuits

We use charge deposition by TPA to investigate the SET response of 45-nm cascodes, compare SET in 45-nm vs. 32-nm RF-CMOS/SOI devices, and provide calibrated TCAD simulations supporting our analysis.

10:00 – 10:30 AM
BREAK
GRAND BALLROOM FOYER

H-4
10:30 AM
Evaluating the Effects of Single Event Transients in FET-Based Single-Pole Double-Throw RF Switches

The impact of single event transients (SETs) on single-pole double-throw (SPDT) RF switch circuits designed in a 180 nm SiGe BiCMOS technology is investigated, potentials implications are discussed, and mitigation strategies proposed.

H-5
10:45 AM
Correlation of Pulsed-Laser Energy and Heavy-Ion LET by Matching Analog SET Ensemble Signatures and Digital SET Thresholds
A. Zanchi, Y. Lotfi, S. Hisano, C. Hafer, D. B. Kerwin, Aeroflex Colorado Springs; S. Buchner, Naval Research Laboratory

Correlation between laser pulse energy and heavy-ion LET is verified by matching an ADC’s ASET ensemble signatures and voltage supervisor DSET thresholds, discussing the laser pulselength impact over SETs for mixed-signal circuits.
PH-1 Single-Event Transient Modeling in a 65-nm Bulk CMOS Technology Based-on Multi-Physical Approach and Electrical Simulations
G. Hubert, L. Artola, DESP

This paper presents a SET predictive methodology based-on coupled MUSCA SEP3 and electrical simulations. The method is validated by comparisons with SET measured in an inverter chain based-on 65-nm bulk CMOS technology.

PH-2 Investigations on TID-ASETs Synergistic Effect in LM124 Operational Amplifier from Three Different Manufacturers

The impact of TID on ASET shapes in LM124 opamps from three different manufacturers is investigated. TID and laser experiments are conducted and the ASET responses obtained are modeled with a previously developed simulation tool.

PH-3 Single Event Transient Pulse Shape Measurements by On-chip Sense Amplifiers in a Single Inverter for Intermediate Input States under Alpha Particle Irradiation

The input of an inverter was swept between digital ground and digital supply voltage. A strong increase of alpha particle induced SETs for voltages close to half of the supply voltage could be observed.

PH-4 Charge Collection Mechanisms in AlGaN/GaN MOS High Electron Mobility Transistors

Charge collection mechanisms in AlGaN/GaN MOS-HEMTs are investigated. There is significant simultaneous charge collection at the gate and drain. The sensitivity of collected charge to gate bias is discussed.

PH-5 Enhanced Charge Collection by Single Ion Strike in GaN HEMTs

Transient current in GaN HEMTs induced by focusing ion-beam is measured. It is found that the enhanced charge collection caused by bipolar and back channel effects, occurs at on- and pinch-off bias configurations.

11:00 AM – 12:45 PM  LUNCH
SESSION 1

12:45 PM
SESSION INTRODUCTION
Chair: Jean-Marie Lauenstein, NASA/GSFC

1-1
12:50 PM
Destructive Single-Event Failures in Diodes

We examine single-event induced destructive failures in Schottky diodes. We first identified failures in DC-DC converters, and later confirmed their existence in independent diodes. The failure mechanism along guard rings is also discussed.

1-2
1:05 PM
Implications of the Logical Decode on the Total Ionizing Dose Response of a Multi-Level Cell NAND Flash Memory
J. D. Ingalls, M. J. Gadlage, A. R. Duncan, M. Kay, P. Cole, NSWC Crane

The total ionizing dose response of a multi-level cell NAND flash elucidates the logical decode of the bit cells, employable in a robust test methodology and implementation of a “pseudo single-level cell” device.

1-3
1:20 PM
Use of Commercial FPGA-Based Evaluation Boards for Single-Event Testing of DDR2 and DDR3 SDRAMs

We investigate the use of commercial FPGA based evaluation boards for testing DDR2 and DDR3 SDRAMs. We evaluate the resulting data quality and the tradeoffs involved in the use of these boards.

POSTER PAPERS

PI-1
Bayesian Methods for Bounding Single-Event Related Risk in Low-Cost Satellite Missions
R. L. Ladbury, M. J. Campola, NASA/GSFC

We develop SEE risk related prior probability distributions based on many types of data. The priors can be used to bound SEE risk for purposes of decisions for testing, part selection and design.

RADIATION EFFECTS
DATA WORKSHOP
1:35 – 4:00 PM
SEACLIFF

INTRODUCTION

Chair: Philippe Paillet, CEA/DIF SEIM
The 2012 Workshop Record has been reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

Heavy ion irradiation facility dedicated for single-event effect ground simulation testing has been developed on Beijing HI-13 tandem accelerator. A large and uniformly distributed beam is produced by magnetic scanning technique.

Orbital soft protons (tens of keV to few MeV) can seriously degrade the performance of astronomical X-ray detectors. This paper presents a facility with setups for homogeneous irradiation of large detectors and for instrument testing.

Proof-of-principle experiments are reported in which a 150-TW Ti:Sapphire-based laser-plasma-accelerator was used as a novel radiation source to reproduce radiation belt electrons and to irradiate electronic components.

MCNPX calculation, dosimetry, and gain degradation have been conducted to validate neutron radiation effects facility at Indiana University. The results show that pulse-based neutron source is obviously different from traditional, fast-burst neutron source.

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.
Los Alamos National Laboratory has been testing COTS electronic parts for potential use in spacecrafts. The highest risk parts were identified and tested for radiation effects.

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.

This paper reports the methodology, requirements, test methods, challenges and processes defined for the Exploration Flight Test-1 and Orion/MPCV development process for certification for manned use in a deep space ionizing radiation environment.

The paper presents the COTS and industrial electronic components SEE tests results. Tests were provided to estimate electronic components for space missions. The article is experimental data compilation obtained at the Roscosmos (ISDE) Test Facility.

Vulnerability of a variety of components for particle accelerators electronics to single event effects, total ionizing dose and displacement damage has been analyzed. The tested parts include analog, linear, digital, and hybrid devices.

We present recent results of Single Event Effects and Total Ionizing Dose tests performed in the framework of the new power converter controls project for the Large Hadron Collider.
**W-13**  
**Compendium of Total Ionising Dose, Displacement Damage and Single Event Transient Test Data of Various Optocouplers for ESA**  
*M. Poizat, ESA/ESTEC; M. Sauvagnac, A. Samaras, TRAD*  
We present radiation test data on optocouplers from three different vendors including results on neutron (1MeV) and proton (30, 60, 190MeV) induced displacement damage, total ionising dose (Co60) and proton induced Single Event Transients.

**W-14**  
**TID Tolerance of Popular CubeSat Components**  
*R. Kingsbury, F. Schmidt, K. Cahoy, D. Sklair, Massachusetts Institute of Technology*  
In this paper we report total dose test results of COTS components commonly used on CubeSats. We investigate a variety of analog integrated circuits, a popular microcontroller (PIC24) as well as SD memory cards.

**W-15**  
**TID Test Results for 4th Generation Ipad**  
*S. M. Guertin, G. Allen, S. S. McClure, Jet Propulsion Laboratory; K. A. LaBel, NASA/GSFC*  
TID testing of 4th generation iPads is reported. Of iPad subsystems, results indicate that the charging circuitry and display drivers fail at lowest TID levels. Details of construction are investigated for additional testing of components.

**W-16**  
**Cosmic Ray Effects on Personal Entertainment Applications for Smartphones**  
*Y. Chen, Lynbrook High School*  
Neutron exposures on smartphones are conducted to identify major failure modes and mean-time-to-failure for these failure modes. Test setup, data collection, and detailed experiment methodology are discussed.

**W-17**  
**Radiation Qualification of an Automotive-Grade, State-of-the-Art ASIC for Natural Space Applications**  
*L. Hoffmann, V. Lam, Honeywell International*  
An ASIC capable of performance appropriate for processor replication and Time-Triggered Gigabit Ethernet applications was needed for the Multi-Purpose Crew Vehicle (MPCV) avionics suite. Innovative test methodologies were utilized, and favorable results obtained.

**W-18**  
**Single Event Upset Characterization of the Spartan-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 Spartan-6 FPGA are presented.

**W-19**  
**Single Event Effect Rate Analysis and Upset Characterization of FPGA Digital Signal Processors**  
SEEs in DSPs are analyzed for on-orbit upset rates. Various fitting techniques are applied to the experimental data in order to generate the rates, demonstrating the criticality the fit parameters have on rate calculations.
**W-20 Dynamic and Static Cache SEE Results for a 49-core Processor**  
B. Wie, M. K. Plante, A. Berkley, R. J. Nejad, Integrity Applications Incorporated; S. M. Guertin, Jet Propulsion Laboratory

Recent dynamic and static results are presented on a 49-core RHBD processor. Dynamic cache results show increased SEE susceptibility over static tests.

**W-21 The Reliability of Software Algorithms and Software-Based Mitigation Techniques in Digital Signal Processors**  
H. Quinn, T. Fairbanks, J. L. Tripp, Los Alamos National Laboratory; A. Manuzzato, STMicroelectronics

Digital signal processors (DSP) are microprocessor-like hardware that specifically designed for signal and image processing algorithms. In this abstract we present data on how to improve DSP reliability through software techniques.

**W-22 Characterization and Mitigation of the MGT-Based Aurora Protocol in a Radiation Environment**  
A. Harding, K. Ellsworth, B. Nelson, M. Wirthlin, Brigham Young University

The radiation test results of the Aurora protocol operating on an FPGA with MultiGigabit Transceivers are reported. An FPGA mitigation circuit was also developed and tested to repair SEU-induced faults seen in radiation testing.

**W-23 VCSEL and Photodiode Beam Test Results for an Optical Communications Link**  

We present proton damage and single-event test results for two VCSEL laser diodes and matching PIN photodiode. The optical components are part of a communication link for which bit-error-rates were also measured.

**W-24 Single Event Effect and Total Ionizing Dose Results of Highly Scaled Flash Memories**  
F. Irom, D. N. Nguyen, A. R. Allen, Jet Propulsion Laboratory

SEE measurements and TID response for 25-32 nm Micron Technology NAND flash memories are reported. Radiation results of SLC parts are compared with results from MLC and TLC parts.

**W-25 SEE Test Report on the Samsung 16 Gb NAND Flash Memory**  
T. R. Oldham, Ball Aerospace; M. R. Friendlich, E. P. Wilcox, MEI Technologies Inc.

We have conducted heavy ion tests of the Samsung 16Gb NAND flash memory, with very good results. The only functional failure seems to have been the result of cumulative damage over many beam runs, not SEE.

**W-26 Total Dose and Single Event Effects Testing of the Intersil ISL70444SEH Hardened Operational Amplifier**  
N. W. van Vonno, B. Williams, R. Hood, E. J. Thomson, S. K. Bernard, Intersil

We report the results of SEE and low and high dose rate total dose testing of the Intersil ISL70444SEH hardened operational amplifier together with a discussion of the part’s electrical specifications and fabrication process.
W-27  **Radiation Testing Results for the Intersil ISL71590SEH Temperature Sensor**  

We report the results of low and high dose rate total dose testing of the Intersil ISL71590SEH hardened temperature sensor together with limited data on the neutron and SEE performance of the part.

W-28  **Radiation Tolerant SOI MESFET-CMOS Low Dropout Linear Regulator for Integrated Power Management at the 45nm Node**  
T. Thornton, M. Goryll, B. Chen, J. Kam, B. Bakkaloglu, K. Holbert, Arizona State University; W. Lepkowski, S. Wilk, SJT Micropower Inc.

A low dropout linear regulator comprising a MESFET pass transistor with an integrated CMOS error amplifier has been fabricated using a commercial 45nm SOI foundry. Good regulation is observed after irradiation to 1 Mrad(Si).

W-29  **Single Event Transient (SET) Susceptibility of the Texas Instruments LM139 Quad Comparator under Proton Irradiation**  
R. Gaza, J. Cooper, IS&S/GS

Proton Single Event Transient (SET) data are presented for the Texas Instruments (National Semiconductor) LM139AxQMLV (5962R9673801VxA).

W-30  **Single Event Effects Sensitivity of 180 and 350 nm SiGe HBT Microcircuits**  
R. Koga, The Aerospace Corp

SEE sensitivity to protons and heavy ions is observed with 180 and 350 nm SiGe HBT microcircuits incorporating identical ADC converters. Comparisons show 180 nm devices with relatively reduced sensitivity at low LET regions.

W-31  **Effects of Ion Energy on Single Event Effect Performance of LM139 and AD9042**  

High energy heavy ion testing of LM139 and AD9042 performed at NASA Space Radiation Laboratory offers new insight into device SEE response in the space environment.

W-32  **Total Ionizing Dose Characterization of the Calibration Circuit of Texas Instruments ADC12D1600CCMLS, 12b, 3.2 GSPS Analog-to-Digital Converter**  
K. Kruckmeyer, T. Trinh, L. Park, Texas Instruments

In situ testing of high speed ADCs under gamma irradiation is impractical. A test was developed to characterize the stability of the calibration of TI’s ADC12D1600CCMLS over a TID exposure to 300 krad(Si).
W-33 Single Event Characterization of a Family of Voltage Supervisors Designed in a 0.35-µm Triple-Well CMOS Technology
D. B. Kerwin, Y. Lotfi, A. Zanchi, C. Hafer, Aeroflex Colorado Springs

We present single-event latch-up and single-event transient data for a family of radiation-hardened voltage supervisors designed in a 0.35-µm, triple-well, mixed-signal CMOS process.

W-34 Dose Rate Effects on Bipolar Components
F. Toscano, STMicroelectronics; F. Thilac, Hirex Engineering

The TID Co60 Dose rate effects have been examined in bipolar transistors at high and low dose rates. The aim of the radiation tests is to study the ELDRs on NPN and SPNP elementary transistors.

W-35 Single Event Burnout Observed in Schottky Diodes
J. S. George, R. Koga, The Aerospace Corporation

We present observations of single event burnout in 200V Schottky diodes used in hybrid DC-DC converters. Two diode types were tested and showed varying sensitivity to heavy ions and protons.

W-36 Specific Characterization for Destructive Single Event Effects on GaAs Power P-HEMT MMIC

Specific Single Event Effects characterization based on RF and worst case DC conditions are used to demonstrate that two European GaAs power P-HEMT MMIC processes are safe under heavy ions.

W-37 Radiation Effects of High Voltage MESFETs at the 45nm Node
S. J. Wilk, W. Lepkowski, T. J. Thornton, SJT Micropower Inc.; B. Chen, J. Kam, M. Goryll, K. Holbert, Arizona State University

A high voltage MESFET transistor has been fabricated using a commercial 45nm SOI foundry. The device has a breakdown voltage >25X the nominal CMOS and is shown to be radiation tolerant to 1Mrad(Si).

W-38 Recent Radiation Test Results for Power MOSFETs

Single-event effect (SEE) and total ionizing dose (TID) test results are presented for various hardened and commercial power MOSFETs, including vertical planer, trench, superjunction, and lateral process designs.

4:00 PM END OF THURSDAY SESSIONS

GRAND BALLROOM 4:30 – 6:00 PM RADIATION EFFECTS COMMITTEE OPEN MEETING
GENDERED INNOVATIONS IN SCIENCE AND ENGINEERING
Londa Schiebinger, John L. Hinds Professor of History of Science, Stanford University and Director, Gendered Innovations in Science, Health & Medicine, Engineering, and Environment Project

This talk identifies three major approaches to gender in science research, policy, and practice: 1) efforts to increase the numbers of women; 2) programs to remove bias and barriers from research institutions; and 3) sex and gender analysis to create new knowledge. The talk will treat each approach, but focus on introducing the Gendered Innovations project. Through international collaborations, this project: 1) develops state-of-the-art methods of sex and gender analysis for scientists and engineers; 2) provides case studies as concrete illustrations of how gender analysis leads to innovation. Case studies to be profiled are:

1. Conventional seatbelts do not fit pregnant women properly, and motor vehicle crashes are the leading cause of fetal death related to maternal trauma. Gendered innovations have led to the development of pregnant crash test dummies that enhance safety in automobile testing and design.

2. Men account for nearly a third of osteoporosis-related hip fractures. Nonetheless, osteoporosis is considered primarily a disease of postmenopausal women. Gendered Innovations in osteoporosis research has led to better diagnosis and treatment of osteoporosis in men.

3. As the world’s population ages, robust new markets for assistive technologies are emerging. Elderly men and women may have different needs. Designing with these distinctive needs in mind assists engineers develop technologies that best fit user needs.

The case studies illustrate the goals of the gendered innovations project to:

- **Add value to research and engineering** by ensuring excellence and quality in outcomes and enhancing sustainability.
- **Add value to society** by making research more responsive to social needs, thereby enhancing the quality of life for both women and men worldwide.
- **Add value to business** by developing new ideas, patents, and technology.

Gendered Innovations (http://genderedinnovations.stanford.edu/) is funded by Stanford University, the European Commission, and the National Science Foundation.

Londa Schiebinger is the John L. Hinds Professor of History of Science in the History Department at Stanford University and Director of the EU/US Gendered Innovations in Science, Medicine, and Engineering Project. From 2004-2010, Schiebinger served as the Director of Stanford’s Clayman Institute for Gender Research. Over the past twenty years, Schiebinger’s work has been devoted to teasing apart three analytically distinct but interlocking pieces of the gender and science puzzle: the history of women’s participation in science; the structure of scientific institutions; and the gendering of human knowledge.

Londa Schiebinger presented the keynote address and wrote the conceptual background paper for the United Nations’ Expert Group Meeting on Gender, Science, and Technology, September 2010 in Paris. She presented the finding at the United Nations in New York, February 2011. The UN Resolutions of March 2011 call for “gender-
based analysis ... in science and technology” and for the integrations of a “gender perspective in science and technology curricula.”

She has worked with the European Commission on a number of projects. January 2011 she entered into a major collaboration with the European Union for her Gendered Innovations project. In addition to drawing experts from across the US, this project now has access to experts from the EU 27 member states.

Her study, “Housework is an Academic Issue,” with Shannon Gilmartin, Academe (Jan/Feb. 2010): 39-44, was profiled on ABC News. Londa Schiebinger’s research has been featured in the New York Times, the New Yorker, Die Zeit, Frankfurter Allgemeine Zeitschrift, La Vanguardia, El País, at the London Museum of Natural History, on NPR, and elsewhere.

Schiebinger’s work in the eighteenth century investigates colonial science in the Atlantic World. In particular she explores medical experimentation with slave populations in the Caribbean. Her project reconceptualizes research in four areas: first and foremost knowledge of African contributions to early modern science; the historiography of race in science; the history of human experimentation; and the role of science in the eighteenth-century Atlantic world.

Londa Schiebinger has been the recipient of numerous prizes and awards, including the prestigious Alexander von Humboldt Research Prize and John Simon Guggenheim Fellowship. Schiebinger has just been appointed a Distinguished Affiliated Professor at the Technical University—the only humanist so honored. Londa Schiebinger was awarded the 2010 Interdisciplinary Leadership Award from Women’s Health at Stanford Medical School; 2005 Prize in Atlantic History from the American Historical Association; and the 2005 Alf Andrew Heggoy Book Prize from the French Colonial Historical Society both for her Plants and Empire: Colonial Bioprospecting in the Atlantic World. She also won the 2005 J. Worth Estes Prize from the American Association for the History of Medicine for her article “Feminist History of Colonial Science,” Hypatia 19 (2004): 233-254.

Education
Ph.D. Harvard University, Department of History, 1984
M.A. Harvard University, Department of History, 1977
B.A. University of Nebraska, Department of English, 1974

**SESSION J**

**9:10 AM**

**RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS**

**SESSION INTRODUCTION**

*Chair: Gary Lum, Lockheed-Martin*

**J-1**

**9:15 AM**

**Time-Domain Reflectometry Measurements of Total-Ionizing-Dose Degradation of nMOSFETs**

*E. X. Zhang, D. M. Fleetwood, N. D. Pate, R. A. Reed, A. F. Witulski, R. D. Schrimpf, Vanderbilt University*

We have performed time-domain reflectometry measurements on nMOSFETs before and after irradiation on time scales relevant to 28-nm MOS RF response. Signal losses correlate strongly with impedance increases caused by interface trap buildup.
Bias Dependence of Total-Dose Effects in Triple-Well FinFETs
I. Chatterjee, E. X. Zhang, B. L. Bhuva, R. D. Schrimpf, D. M. Fleetwood, Vanderbilt University; Y.-P. Fang, T. S. Oates, Taiwan Semiconductor Manufacturing Company

The total ionizing dose response of triple-well FinFETs is investigated for various bias conditions. Experiments and simulations show that irradiation with the drain terminal high is the worst-case bias configuration.

Intrinsic Tolerance to Total Ionizing Dose Radiation in Gate-All-Around MOSFETs
E. S. Comfort, M. Rodgers, W. Allen, S. Gausephol, J. U. Lee, University at Albany; E. X. Zhang, M. Alles, Vanderbilt University; H. Hughes, P. McMarr, Naval Research Laboratory

We measured the TID response of GAA SiNW MOSFETs to doses of 2MRad(SiO2). We show they are intrinsically radiation hard and no degradation is observable in threshold voltage, subthreshold slope, and off-state current.

Charge Yield at Low Electric Fields: Considerations for Bipolar Integrated Circuits
A. H. Johnston, R. T. Swimm, D. O. Thorbourn, Jet Propulsion Laboratory

Reduced radiation damage is observed during low-temperature irradiations of bipolar ICs compared to room temperature. The difference can be explained by the strong temperature dependence of charge yield for oxides with low fields.

Sensitivity of High-Frequency RF Circuits to TID Degradation

A 22 GHz CMOS VCO is used demonstrate that the compound effects of process variation and relatively small TID parametric degradation can lead to analog RF circuit specification failures.

Total Ionizing Doses Effects in Piezoelectric MEMS Relays
R. M. Proie, R. G. Polcawich, US Army Research Laboratory; C. D. Cress, S. P. Buchner, H. L. Hughes, Naval Research Laboratory

This paper investigates total ionizing dose (TID) effects on the piezoelectric properties of lead zirconate titanate (PZT). Thin-film PZT-based relays were exposed to a Co-60 source with capacitance and contact voltage monitored.
The Effects of Total Ionizing Dose and Displacement Damage on TaO$_x$ and TiO$_2$ Memristive Memories


TaO$_x$ memristors show little response to ionizing doses from multiple sources, but degrade with oxygen vacancy creation through displacement damage at high fluences. TiO$_2$ memristor variability and instability increase from 800 keV Ta irradiation.

Investigation on the Response of TaO$_x$-Based Resistive Random-Access Memories to Heavy-Ion Irradiation


The impact of heavy-ion irradiation on the TaO$_x$-Based resistive random-access memory (RRAM) is investigated. Experiment results indicate that the TaO$_x$-based RRAM device need to be carefully designed for future space applications.

First Study of the Radiation Tolerance of Devices and Circuits in a 3D Technology Based on the Vertical Integration of Two 130 nm CMOS Tiers

V. Re, M. Manghisoni, G. Traversi, University of Bergamo and INFN; L. Gaioni, A. Manazza, INFN; L. Ratti, INFN and University of Pavia

TID effects are studied for the first time in 130nm transistors and pixel sensors in a vertically integrated 2-tier CMOS technology, evaluating the possible impact of 3D processing on radiation tolerance and damage mechanisms.

Impact of X-Ray Exposure on a Triple-Level-Cell NAND Flash

M. J. Gadlage, M. J. Kay, D. Ingalls, A. R. Duncan, S. A. Ashley, NSWC Crane

The total ionizing dose response of a triple-level-cell (TLC) NAND flash is shown to be low enough that data corruption can occur as a result of an x-ray circuit board inspection.

Dose Rate Effects of SiGe HBT for Gamma Rays under Different Biases

J. Zhang, X. Wang, L. Wen, Q. Zheng, W. Deng, Xinjiang Technical Institute of Physics & Chemistry Chinese Academy of Science, and Key Laboratory of Functional Materials and Devices under Special Environments, CAS, and University of Chinese Academy of Sciences; H. Guo, J. Cui Xinjiang, Technical Institute of Physics & Chemistry Chinese Academy of Science, and Key Laboratory of Functional Materials and Devices under Special Environments, CAS, and Northwest Institution of Nuclear Technology; D. Ren, Q. Guo, W. Lu, X. Yu, C. He, Xinjiang Technical Institute of Physics & Chemistry Chinese Academy of Science, and Key Laboratory of Functional Materials and Devices under Special Environments, CAS

SiGe HBT is irradiated by $^{60}$Co $\gamma$ of high and low dose rate under different biases. SiGe HBT shows ELDRS under positive and saturated biases. However, high dose rate damage is worse under cutoff biases.
PJ-4  **Total-Dose Response of HfO$_2$/Hf-Based Bipolar Resistive Memories**  
J. Bi, E. X. Zhang, M. McCurdy, R. A. Reed, R. D. Schrimpf, D. M. Fleetwood, M. L. Alles, R. A. Weller, Vanderbilt University; Z. Han, Chinese Academy of Sciences; D. Linten, M. Jurczak, A. Fantini, IMEC  
Radiation-induced effects on the electrical characteristics of HfO$_2$/Hf-based bipolar RRAMs are experimentally evaluated using 10 keV x-ray and 1.8 MeV proton irradiation. The results are promising for radiation-hardened memory applications.

PJ-5  **Simulation of TID Effects in a High Voltage Ring Oscillator**  
G. J. Schlenvogt, H. J. Barnaby, Arizona State University; J. Wilkinson, S. Morrison, L. Tyler, Medtronic Inc.  
Oscillation frequency of a high voltage ring oscillator is observed to change non-linearly with increasing dose. These results are explained analytically and re-created by radiation-enabled simulation.

PJ-6  **Radiation Effects on Lithium Niobite Memristors for Neuromorphic Computing Applications**  
The radiation tolerance and self-healing (annealing) properties of a new type of lithium-based memristor are investigated. Memristors based on this technology, in combination with Si CMOS, have the potential to improve neuromorphic computing.

PJ-7  **Total-Ionizing-Dose Effects on the Switching Characteristics of Chalcogenide (Ge$_{30}$Se$_{70}$) Programmable Metallization Cells**  
Y. Gonzalez Velo, H. J. Barnaby, M. N. Kozicki, P. Dandamudi, A. Chandran, K. E. Holbert, Arizona State University; M. Mitkova, M. Ailavajhala, Boise State University  
Programmable metallization cells (PMCs) are memristive devices exhibiting resistance switching due to silver ion transport and electrodeposition in solid electrolytes. Impact of ionizing dose on the switching response of PMCs is experimentally characterized and analyzed.

PJ-8  **Expanded Transient Junction Photocurrent Modeling with a Variable Impedance Equivalent Circuit**  
J. D. Gleason, H. J. Barnaby, G. J. Schlenvogt, Arizona State University; M. L. Alles, Vanderbilt University  
The use of a time-variant equivalent circuit to support expanded modeling of transient junction photocurrent into the high-level injection regime is examined. This expansion uses a variable impedance circuit model.

11:45 PM  **END OF CONFERENCE**
NSREC 2013 will be held in San Francisco, California, July 8 – 12, 2013 at the Hyatt Regency San Francisco. Jeff Black and his 2013 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.

Supporters of the NSREC include Sandia National Laboratories, Jet Propulsion Laboratory, 3D Plus, Aeroflex, Atmel, BAE Systems, Boeing, Honeywell, International Rectifier, Intersil Corporation, Northrop Grumman, Peregrine Semiconductor Corporation, Southwest Research Institute, 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 2014 will be held in Paris, France, July 14 – 18 at the Marriott Rive Gauche Hotel and Conference Center. The conference chair is Robert Ecoffet of CNES. Michael Xapsos of NASA/GSFC will be the 2015 chairman which is planned for Boston. Robert Reed, Vanderbilt University, has been named the 2016 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.nsr.com.

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

A distinguished member of the international radiation effects community was elected to the grade of IEEE Fellow on January 1, 2013.

Paul Marshall, Consultant

Paul’s citation reads, “For contributions to understanding the impact of particle radiation on satellite reliability and survivability.”
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 2013), 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. The deadline for submission of papers is the Friday before the Conference (July 5, 2013). 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 2013 NSREC are:

Dan Fleetwood, Senior Editor
Vanderbilt University
Email: dan.fleetwood@vanderbilt.edu

Dennis Brown, Associate Editor
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Email: brownden_1@yahoo.com

Sylvain Girard, Associate Editor
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Heather Quinn, Associate Editor
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Hugh Barnaby, Associate Editor
Arizona State University
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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 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 2013 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 San Francisco.

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

You are invited to attend the IEEE Radiation Effects Committee’s Annual Open Meeting on Thursday, July 11, from 4:30 - 6:00 PM in the Grand Ballroom. All conference attendees and spouses are encouraged to attend. We will discuss the 2013 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.
2012 NSREC OUTSTANDING CONFERENCE PAPER AWARD

Radiation Effects in Pinned Photodiode CMOS Image Sensors: Pixel Performance Degradation Due to Total Ionizing

2012 OUTSTANDING STUDENT PAPER AWARD

Impact of Back-Gate Bias and Device Geometry on the Total Ionizing Dose Response of 1-Transistor Floating Body RAMs

2012 OUTSTANDING DATA WORKSHOP PRESENTATION AWARD

On-Orbit Results for the Xilinx Virtex-4 FPGA

2012 RADIATION EFFECTS AWARD

The 2012 Radiation Effects Award was presented to Dave Alexander, consultant with COSMIAC (Configurable Space Microsystems Innovations & Applications Center) of the University of New Mexico, during the opening ceremonies of the 2012 conference. Dave’s citation reads “For contributions to the development of Qualified Manufacturers List (QML) procedures for radiation hardened components and to the foundations of radiation hardening by design concepts.”

2013 RADIATION EFFECTS AWARD

The winner of the 2013 Radiation Effects Award will be announced Tuesday morning, July 9. 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.

2014 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2014 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 2014 IEEE NSREC, Paris, France in July 2014. 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 Nick van Vonno, Member-at-Large for the Radiation Effects Steering Group. Nick can be reached at 321-725-7546 or at nvanvon@intersil.com
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. 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 has a colorful past, growing from a small village to a major city nearly overnight as a result of the 1849 Gold Rush. San Francisco is home to world-class theater, opera, symphony, and ballet companies and often boasts premieres of Broadway-bound plays and culture-changing performing arts.

Several meeting rooms are available for use by any registered conference attendee at the Hyatt on a first come, first served basis. NSREC encourages side meetings to be scheduled at times other than during technical sessions. Contact NSREC Registration at 720-733-2003 or send an e-mail to registration@nsrec.com 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 Regency Room on the street 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 Business Center’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 guest room telephone. These can be accepted for hotel guests only and a fee may apply.

The 2013 IEEE NSREC will provide breakfasts and refreshments at breaks during the NSREC Short Course and Technical Sessions. These functions are for registered conference attendees only. Please see schedule for times and locations.

The Hyatt has a full-service business center that can handle color and black/white photocopying, faxing, computers with internet access, shipping/receiving, laminating, graphic design, and equipment rental. They are open Monday through Friday from 7:00 AM - 8:00 PM and Saturday from 9:00 AM - 2:00 PM. Guests can have 24-hour access for internet access and black/white copies only. 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 7. After that date, the "Late Registration" rates will apply.

There are three 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, 2) U.S. Money Order, or 3) MasterCard, VISA, American Express, or Discover credit card.

The preferred method for registration is via the online Registration link on the NSREC website: www.nsrec.com. Or, you can go directly to the secured registration website: www.regonline.com/2013ieeensrec. E-mailed or faxed registrations will be accepted with a credit card payment or you can mail the conference registration form along with your payment to the address shown to the left. If your registration form and payment do not arrive at NSREC Registration by June 28, then it would be better to hand-carry the payment to the conference for on-site registration. Telephone registrations will not be accepted.

All conference registration will take place on the street level of the Hyatt. If you have not yet registered, go to “On-Site Registration” in the Regency Room. If you have already registered, go to “Pre-Registration” in the Grand Ballroom Foyer 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 7, 2013 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. To request a refund, you must notify NSREC Registration by fax at 720-733-2046 or e-mail at registration@nsrec.com
The 4-star Hyatt Regency Embarcadero on the west shore of San Francisco Bay will be the host hotel for the 2013 NSREC. This high-rise property is dramatically set on the waterfront across the street from the historic Ferry Building. It is a short walk to the Financial District and all of the sites along the Bay. Walking a little farther will take you to Chinatown in one direction and to Fisherman’s Wharf in another. There are so many things to do and restaurants to experience that it will be hard to set priorities! Hotel amenities include one restaurant, one cocktail lounge, 24-hour health club (complimentary to hotel guests), concierge, business center, room service, parking garage, and one of the most incredible lobbies that you’ll EVER see!!

The 802 spacious guest rooms are comfortably furnished in contemporary design. All rooms are non-smoking and feature huge windows with dramatic views, individual climate control, flat-screen TV with video-on-demand and cable, wireless and high-speed internet ($9.95/day), work desk, iHome stereo with iPod docking station, coffee maker, refrigerator, hairdryer, iron and ironing board, multiple phones with voice mail, one king or two double plush beds, a safe, and room service.

Standard and upgraded room rates are as follows:
- $185.00 single/double per night for a standard king or double-double
- $210.00 single/double per night for a Bayview room
- $225.00 single/double per night for a Bayview Balcony room
- $260.00 single/double per night for the Regency Club Level
- $299.00 single/double for a one-bedroom Balcony Suite

Taxes will be added to all rates listed above. There is no additional charge for children 18 years of age and under when sharing a room with an adult and utilizing existing beds. A charge of $25.00 + tax per night will be added for each third and fourth adult in the room (19 years of age and older).

The June 2013 government rate for San Francisco is $155.00. The standard Group Rate above is about 19% above the government per diem. This is an allowable amount for most government agencies when attending a conference and staying in the conference hotel.

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

The preferred method to make reservations is by using the weblink: resweb.passkey.comigo/NSREC2013. Simply enter your dates and follow the prompts. Based on availability, you will be given the opportunity to choose a standard room type or one of the possible upgrades.

Reservations can also be made by calling Hyatt Reservations toll-free at 800-228-9000 within the U.S. or Canada. To get the group rate, advise the agent of the following group code: NSREC2013.

All rooms must be guaranteed by providing a credit card or a one-night check deposit to the hotel. The cut-off for IEEE NSREC reservations is at 5:00 PM Pacific Daylight Time on June 7, 2013. Once the room block has been filled OR after the cut-off date
Registration and Travel

(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 3:00 PM on the day prior to your scheduled arrival. If the cancellation is made by that time, then any deposit will be refunded.

Two airports are easily accessible in this area. San Francisco International Airport (code SFO) is 14.5 miles (20 to 35 minutes) south of the Hyatt. Direct flights or excellent connections are available from major cities all over the world into this airport. Taxis to the Hyatt are based on time and distance so could cost between $37.00 and $45.00 one way.

Oakland International Airport (code OAK) is a great alternative airport that is 18.5 miles (30 to 45 minutes) southeast of the Hyatt, across the bay. On this route, a taxi will cost between $54.00 and $65.00 one way. It may be helpful to note that competitive airfares are sometimes lower into one of these airports than they are into the other – it’s wise to check both.

There is no scheduled shuttle service from San Francisco International Airport to the downtown hotels, but Super Shuttle and GO Lorries Shuttle offer door-to-door service. The normal rate from the airport to the Hyatt is $17.00 one way, per person, plus gratuity; there is no discount for a roundtrip.

**Super Shuttle**
Hours: 4:00 AM - 11:30 PM       Tel: 415-558-8500     Tollfree: 800-258-3826
Website: [www.supershuttle.com/Locations/SFOAirportShuttleSanFrancisco.aspx](http://www.supershuttle.com/Locations/SFOAirportShuttleSanFrancisco.aspx)

**GO Lorries Shuttle**
Hours: 24 hours/7 days a week       Tel: 415-334-9000
Website: [www.lorries-shuttles.com](http://www.lorries-shuttles.com)

From San Francisco International Airport, all of the northbound BART rail lines will stop at the Embarcadero Station which is just across the street from the Hyatt, exit the BART Embarcadero Station to Drumm St. The one-way BART fee is $8.10.

There is no scheduled shuttle service from Oakland International Airport to the downtown hotels, but the BayPorter and City Express offer door-to-door transportation. The normal rate from the airport to the Hyatt is $39.00 for the first person and $10.00 for each additional person, one way, plus gratuity.

**BayPorter Shuttle**
Hours: 6:00 AM - 10:00 PM       Tel: 415-457-1800
Website: [www.bayporter.com](http://www.bayporter.com)

**City Express**
Hours: 24 hours/7 days a week       Tel: 510-475-1803
Website: [www.cityexpressshuttle.com](http://www.cityexpressshuttle.com)
From Oakland Airport, the direct BART line is not yet finished (2014!) but you can take the AirBART Shuttle bus ($3.00) from the airport to the Coliseum/Oakland Airport Station and then jump on the BART ($3.80) to the Embarcadero Station. Use trains going to Daly City (blue or green lines). Exit BART Embarcadero Station to Drumm St.

PARKING AND DRIVING
Parking in any major city is expensive and San Francisco is exceptional in that respect. The daily “overnight” rate at the Hyatt is currently $57.00 per day and no discounts are available to groups! We encourage you to use public transportation. If you wish to drive to the hotel, please consult the Hyatt Regency San Francisco Embarcadero website for directions, sanfranciscoregency.hyatt.com/hyatt/hotels-sanfranciscoregency/services/maps/index.jsp

GETTING AROUND TOWN
In lieu of driving to and parking at the conference hotel in order to explore San Francisco, we are strongly encouraging attendees to use alternate means as described below.

SAN FRANCISCO PUBLIC TRANSPORTATION
The Hyatt Regency San Francisco Embarcadero is well placed in the city for the use of public transportation. Just outside the hotel is an entrance to the BART Embarcadero Station. BART connects the San Francisco Peninsula with Oakland, Berkeley, Fremont, Walnut Creek, Dublin/Pleasanton and other cities in the East Bay. For more than 40 years BART has provided fast, reliable transportation to downtown offices, shopping centers, tourist attractions, entertainment venues, universities and other destinations. (www.bart.org)

Across The Embarcadero is the San Francisco Ferry Building Terminal. Three ferry companies operate out of this terminal. Golden Gate Ferry (www.goldengateferry.org) provides service to Larkspur and Sausalito. San Francisco Bay Ferry (www.sanfranciscobayferry.com) provides direct service to Alameda, Oakland, and Vallejo and indirect service to Angel Island and South San Francisco. Blue & Gold Fleet (www.blueandgoldfleet.com) provides direct service to Tiburon, Vallejo, Alameda, Oakland, Harbor Bay, and Pier 41 (Fisherman’s Wharf) and indirect service to Sausalito.

San Francisco Municipal Railway (Muni) operates approximately 80 routes throughout San Francisco with stops within two blocks of 90% of all residences in the city. Operating Historic streetcars, modern light rail vehicles, diesel buses, alternative fuel vehicles, electric trolley coaches, and the world famous cable cars, Muni’s fleet is among the most diverse in the world. Major Muni lines operate out of the Embarcadero Station as well as along The Embarcadero and Market Street. The California Street Cable Car originates/terminates at the Hyatt Regency San Francisco Embarcadero.

CITIPASS
San Francisco CitiPASS is a great option for weeklong visitors to San Francisco. For one price, you receive a passport for seven days usage of Muni and admission to select city attractions. Please check the CitiPASS website, www.citypass.com/san-francisco, for latest pricing and attraction information.

BICYCLES/WALKING
Finally, many restaurants, shopping centers, and attractions are within walking distance of the conference hotel. And, bicycles can be typically rented for daily use in the plaza outside the hotel.
The **2013 NSREC Industrial Exhibits** will feature the leading worldwide suppliers of radiation hardened products, related materials, services, and research and development. 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 **2013 NSREC Industrial Exhibits** will be in the Pacific Concourse Level on Tuesday and Wednesday. This is located on the lower level and the Exhibits will use the entire level. Conference breaks will be hosted in the Exhibit Area on Tuesday and Wednesday along with a buffet lunch on Tuesday (for registered attendees only).

Tuesday evening, the exhibitors will host the **Industrial Exhibits Reception** featuring complimentary drinks in the Exhibit Area along with light hors d’oeuvres in 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:

Marc Owens  
AFRL/RVSE  
Email: marc.owens@kirtland.af.mil

Or visit the 2013 NSREC Industrial Exhibits web site: [www.nsrec.com/exhibit.htm](http://www.nsrec.com/exhibit.htm)

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**NSREC INDUSTRIAL EXHIBITS**

**HYATT REGENCY SAN FRANCISCO**

**PACIFIC CONCOURSE LEVEL**

**EXHIBIT HALL HOURS**

**TUESDAY, JULY 9**

9:30 AM – 4:00 PM  
— includes —  
9:30 AM MORNING BREAK  
11:00 AM BUFFET LUNCH  
(for registered attendees only)  
2:35 PM AFTERNOON BREAK

6:00 PM – 7:30 PM  
— Reception —  
LIGHT HORS D’OEUVRES  
COCKTAILS AND BARS

**WEDNESDAY, JULY 10**

9:30 AM – 12:00 NOON  
— includes —  
10:00 AM MORNING BREAK
Industrial Exhibits

Please check our website (www.nsrec.com) for a current listing of companies exhibiting at 2013 NSREC.

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<td>XIA LLC</td>
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## 2013 IEEE NSREC Technical Sessions and Short Course Registration Form

### Name
Last Name: ____________________________  First Name: ____________________________  Middle Initial: ____________________________

### Name to appear on badge
__________________________________

### Company/Agency
__________________________________

### Mailing Address
__________________________________

### City
__________________________________

### State ______ Zip Code ____________

### Country
__________________________________

### Telephone Number
__________________________________

### Fax Number
__________________________________

### E-mail Address
__________________________________

### IEEE MEMBERSHIP
☐ I am an IEEE Member.  Membership Number: ____________________________

### SPECIAL BREAKFAST
☐ I will attend the IEEE GOLD MEMBER Breakfast
☐ I will attend the Women in Engineering Breakfast

### CANCELLATIONS
A $25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 7, 2013 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.

### REGISTRATION FEES (in U.S. dollars)

<table>
<thead>
<tr>
<th>Membership Type</th>
<th>Early</th>
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### TOTAL AMOUNT ENCLOSED: $______

### 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.
2013 IEEE NSREC
Activities Registration Form

Conference Participant __________________________________________

Company/Agency ________________________________________________

Address ________________________________________________________

City ___________________________________________________________

State __________ Zip Code ____________________________

Country ______________________________________________________

Telephone Number _______________________________________________

Fax Number ____________________________________________________

Accompanying Persons
Name __________________________________________________________

Please list ages for children under age 21 only

Name __________________ Age ______

Name __________________ Age ______

Name __________________ Age ______

ACTIVITY FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 7, 2013. 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></th>
<th>Early</th>
<th>Late</th>
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<td>Child (0-20 yrs)</td>
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<td>Alcatraz Island/Fisherman’s Wharf:</td>
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</table>

TOTAL AMOUNT ENCLOSED: $__________

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

Card No. ____________________________

Exp. Date __________________________

Printed Name _______________________

Address ___________________________

Address ___________________________

Signature _________________________

Mail or Fax this form and your remittance (payable to IEEE NSREC) to:

IEEE NSREC REGISTRATION
P.O. Box 398
Castle Rock, CO 80104
720-733-2003 Fax: 720-733-2046

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 NSREC Registration by e-mail at registration@nsrec.com or FAX at 720-733-2046 no later than June 28, 2013.
San Francisco is one of my favorite cities and I hope you will be able to enjoy it with me. Alcatraz Island and Muir Woods are can’t miss experiences.”

Dolores Black, Embry-Riddle, Local Arrangements Chairman

San Francisco is a wonderful city to visit. It is rich in history and diversity. From the Ohlone native people to the Spanish explorers to 49ers seeking gold to Chinese immigration, the cultural diversity of San Francisco was founded. The 20th century provided vast growth to the city following the 1906 earthquake. The Panama-Pacific Exposition built the Marina District by filling in land. The Golden Gate Bridge connected San Francisco to Marin County and was completed in 1933. Around the beginnings of our conference, San Francisco was the center of the Hippie generation with Haight and Ashbury cross streets still remembering the times. Today, the city is mired in technology development and is a leader in green energy.

The conference committee has designed a great social program to mix with your own exploration of the city. So come and join us for this special year of the conference.

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

**SUNDAY, JULY 7**
5:00 TO 7:00 PM

Join your colleagues for complimentary refreshments in the 13 Views Lounge on the Hyatt Regency’s Atrium Lobby Level. This reception is open to all Short Course and Technical Session 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 Registration Reception. The conference registration desk is open from 5:00 to 8:00 PM to obtain your badges.

**MONDAY, JULY 8**
8:30 TO 9:30 AM

Conference attendee companions are invited to meet the Local Arrangements Chair, Dolores Black, and to learn about the planned events for the week, as well as how to navigate the city of San Francisco to various sites of interest. This will be a chance to meet other companions, renew past acquaintances, and pick up maps and city guides. This orientation will be held in the Hospitality Room at the Hyatt Regency on the Atrium Lobby Level.

**MONDAY, JULY 8**
7:30 TO 9:30 PM

In recognition of reaching the 50th NSREC, the IEEE Nuclear and Plasma Sciences Society, Radiation Effects Steering Committee, and 2013 NSREC Conference Committee invite all NSREC attendees and their registered guests to join us for the celebration of 50 years of NSREC in the Grand Ballroom with a toast at 8:30 PM. NSREC badges and tickets will be required to attend. The conference registration desk will be open from 7:00 to 8:00 PM for those attendees who have not already picked up their registration packets.
Alcatraz and history go hand in hand. Once home to some of America’s most notorious criminals, the federal penitentiary that operated here from 1934 to 1963 brought a dark mystique to the Rock. Many people, though, are unaware of the wealth of other stories to be learned on the island. Alcatraz is now home to rare flowers and plants, marine wildlife, and thousands of roosting and nesting sea birds. Civil War-era buildings dotting the island give insight into the 19th century when the island served as both a harbor defense fort and a military prison. You can also see visible reminders of the American Indian Occupation that started in 1969 after the prison closed, highlighting an important milestone in the American Indian rights movement.

There’s something for everyone at Fisherman’s Wharf: food, views, history, family fun and more. During the day, street performers are here to tirelessly entertain you: magicians, mimes, musicians, jugglers, clowns and fire-eaters take pride in their efforts to make you feel welcome. Hyde Street Pier is home of the world’s largest collection of historic ships by tonnage, where visitors can board several National Landmark vessels, including the schooner Alma and the 1890 ferryboat Eureka.

Our tour will start at the Hyatt Regency in the Market Street Foyer. You will be taken by bus on a short, one-mile ride to Pier 39 for a scheduled ferry to Alcatraz Island. Once on the island you will be free to experience the beauty, history, and infamy of Alcatraz. When finished, take one of the ferries back to Pier 39 and feel free to enjoy Fisherman’s Wharf on your own. Your tour will end when you want as we will provide several pick up times for return to the conference hotel or you can simply choose to walk back yourselves.

Notes: The designated time for the Alcatraz Island Ferry has not been provided prior to printing, so this schedule may vary. It is also likely that we will receive tickets for two separate ferries, so companions who do not sign up together may not be on the same ferry. This tour will happen rain or shine, there will be no refunds.

Join us for the 2013 Industrial Exhibits Reception hosted by your NSREC exhibitors. NSREC attendees and their registered guests are invited to the Hyatt Regency’s Pacific Concourse to visit the booths and participate in the raffle. Drinks and light hors d’oeuvres will be available in the exhibit hall. NSREC attendees and registered guests must show their badges to enter the Pacific Concourse.

Note: in a change from previous NSRECs, the 2013 Industrial Exhibit Reception does not include dinner.
**Social Program**

**WEDNESDAY JULY 10**

7:15 TO 8:00 AM

**IEEE GOLD MEMBER BREAKFAST**

A special breakfast will be held in the Marina Room (Bay Level), for IEEE member attendees who are Graduates Of the Last Decade (GOLD). This is an excellent opportunity for newer industry members to informally discuss radiation effects and to become better acquainted. This year, the GOLD Member breakfast will include individuals representing IEEE, RESG, and NSREC committees for discussions of how to become involved in IEEE NPSS activities. For more information, contact Jonathan Pellish, [jonathan.a.pellish@nasa.gov](mailto:jonathan.a.pellish@nasa.gov).

**WEDNESDAY, JULY 10**

5:45 TO 9:30 PM

**CONFERENCE SOCIAL BAY DINNER CRUISE**

All aboard the San Francisco Belle for dinner, drinks, and a cruise around the bay. The beautifully renovated San Francisco Belle is the crown jewel of San Francisco Bay. From bow to stern, her decks are a grand expression of Art Nouveau. This sternwheeler features three enclosed decks, a spacious sun deck and complete wrap-around decks. Enjoy the sights of San Francisco, Treasure Island, Oakland, Berkeley, Tiburon, Sausalito, Alcatraz Island, and Angel Island as we cruise for three hours starting in the light of day and ending after dusk.

Our conference social will start with a short walk from the Hyatt Regency to Pier 3. Meet at the 13 Views Lounge; conference committee members will guide the way down steps that lead to the cruise. Transportation will be provided for those attendees with special needs. Boarding will start at 6:00 PM with the boat departing at 6:30 PM sharp. A buffet dinner will be available after 6:45 PM on two decks. The 3rd deck will have a DJ and a dance floor. We will return to the Pier at 9:15 PM for disembarkation and the short walk back to the conference hotel. This is an excellent opportunity to socialize with other conference attendees and their guests.

*Photo: Courtesy of Jeff Black*
Muir Woods National Monument is a remnant of ancient coast redwood forests that blanketed many northern California coastal valleys before the 1800s. Coast Redwoods are the tallest living things. They have obtained a height of 379 ft. with a trunk diameter of 22 ft. The trees can live for 2000 years. In Muir Woods, the tallest of the Redwoods is over 250 ft., the widest trunk is over 14 ft., and some trees are over 1000 years old. This 560 acre park was proclaimed a national monument by President Theodore Roosevelt in 1908 and is named for conservationist John Muir.

Picturesque Sausalito, California is a leading destination for visitors to San Francisco and the Bay Area, as well as a highly desirable residential community. Just across the Golden Gate Bridge from San Francisco, the pedestrian-friendly Mediterranean-style village of Sausalito provides boutique hotels, a selection of celebrated restaurants that range from seafood and Italian to Japanese, as well as specialty shops, art galleries and fashion boutiques. Its location on the waterfront (tucked into the Marin headlands) offers gorgeous scenery, ocean breezes and beautiful California weather.

Our tour will commence with a bus ride from the conference hotel, through the city of San Francisco, across the Golden Gate Bridge, arriving at Muir Woods National Monument. You will have an hour or so to walk around the park’s trails or just sit and enjoy the views and sounds of nature. The busses will then depart Muir Woods for Sausalito. Time and weather permitting, the busses will make stops at scenic viewpoints for photo opportunities. Once in Sausalito, we will say goodbye to the busses and all will be given a ferry ticket. You will have as much time as your desire to enjoy the city of Sausalito for lunch, shopping, or just enjoying the views. The ferry will bring you back to the Ferry Building across from the conference hotel.

Notes: The trails in Muir Woods National Monument and many of the streets in Sausalito are easy to walk upon, being mostly flat. The roads into and out of Muir Woods have steep curves, so individuals with motion sickness issues may find this bus ride challenging.
**Social Program**

**FRIDAY, JULY 12**
**7:00 TO 8:00 AM**

**WOMEN IN ENGINEERING BREAKFAST**
A special breakfast will be held in the Garden Room A (Atrium Level), for Women in Engineering and is sponsored by the IEEE NPSS. This event is open to women attendees and is a chance to meet and socialize with each other. This breakfast is also an opportunity to meet with our Invited Speaker for the morning, Londa Schiebinger, who will be speaking on “Gendered Innovations in Science and Engineering.” For more information, please contact Kay Chesnut, kay.c.chesnut@boeing.com.

**AEROBICS**
As in prior conferences, Dave Bushmire, our own certified aerobics instructor, will be conducting morning fitness classes. The classes will be held from 6:00 to 7:00 AM in the Hospitality Room on Tuesday and in Garden Room B on Wednesday and Thursday. Both rooms are on the Atrium Lobby Level.

**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 provided that notice is provided as follows. If your plans change after your Activities Registration form is submitted, simply request a refund by notifying NSREC Registration via fax or e-mail by no later than June 28. Fax: 720-733-2046. E-mail: registration@nsrec.com
GENERAL INFORMATION

There is plenty to do and see in the 49 square miles of San Francisco. 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. San Francisco is also one of America’s greatest dining cities. The diverse cultural influences, proximity of the freshest ingredients and competitive creativity of the chefs result in unforgettable dining experiences throughout the City.

Surrounding San Francisco is the rest of the bay area and Silicon Valley. North of San Francisco, across the Golden Gate Bridge, is the Napa Sonoma Wine Country, housing over 400 wineries. East of San Francisco, across the Bay Bridge, is Oakland and Berkeley. So, if you run out of things to do in San Francisco, which you probably won’t, there is much more to see and do in the surrounding areas.

ACTIVITIES WITHIN THE CITY OF SAN FRANCISCO

EMBARCADERO CENTER

Connected to the Conference Hotel is the four block Embarcadero Center; a destination for shopping, dining and entertainment. The center features more than 70 nationally and locally renowned retailers, a wide selection of dining venues, a five-screen cinema, and over street walkways. www.embarcaderocenter.com

FERRY BUILDING MARKETPLACE

Across The Embarcadero from the Conference Hotel is the Ferry Building Marketplace, noted for its clock tower. The 65,000 square foot Marketplace brings together the Bay Area’s agriculture wealth and renowned specialty food purveyors under one roof. The Ferry Plaza Farmers Market is open on Tuesday, Thursday, and Saturday. www.ferrybuildingmarketplace.com

GHIRARDELLI SQUARE

With shops, wineries and award-winning restaurants, Ghirardelli Square is the premier San Francisco destination. Enjoy spectacular views of the Golden Gate Bridge to Alcatraz, landscaped gardens, one-of-a-kind shopping and, of course the famous Ghirardelli Chocolate. www.ghirardellisq.com

UNION SQUARE DISTRICT

Experience the unique character of San Francisco’s Union Square District, where the best names in fashion, dining and theater can be found. Union Square is a great place to meet friends or family and enjoy a day of shopping, dining, theater or a movie at San Francisco Centre or the Metreon. www.unionsquareshop.com

CITY HALL

San Francisco City Hall, re-opened in 1915, in its open space area in the city’s Civic Center, is a Beaux-Arts monument to the City Beautiful movement that epitomized the high-minded American Renaissance of the 1880s to 1917. The structure’s dome is the fifth largest in the world. The Rotunda is a spectacular space and the upper levels are public and handicapped accessible.
Local Activities

CHINATOWN

The entrance to Chinatown at Grant Avenue and Bush Street is called the “Dragon’s Gate.” Inside are 24 blocks of hustle and bustle, most of it taking place along Grant, the oldest street in San Francisco. This city within a city is best explored on foot; exotic shops, food markets, temples and small museums comprise its boundaries. The former central telephone exchange of the Pacific Telephone and Telegraph Company stands at 743 Washington St. Now a bank, it is the first Chinese-style building constructed in San Francisco on the exact site where California’s first newspaper was printed.

COIT TOWER

Coit Tower atop Telegraph Hill is blessed with marvelous views. Murals on its ground floor walls were painted in 1933 by some 30 local artists; each piece depicting a different aspect of the Great Depression. A 360-degree view of the city is visible from the observation platform at the top of the tower. To gain access to the observation deck, there is a fee to ride the elevator up.

EXPLORATORIUM

The Exploratorium is a museum in San Francisco that has created over 1,000 participatory exhibits that mix science and art, all of which are made onsite. It is considered by some to be the prototype for participatory museums around the world. The move to Pier 15 (opening April 2013) has paved the way for a number of new exhibit topic areas. Many of these will make use of site-specific factors such as the Bay itself, the investigation of complex systems visible through the windows of the facility’s new Bay Observatory, and an examination of the normally invisible life indigenous to the water under the piers. Other new topic areas include outdoor exhibits involving the water, wind, fog, rain, sun, and other elements, and a gallery looking at human behavior such as cooperation, competition, and sharing. www.exploratorium.edu

CALIFORNIA ACADEMY OF SCIENCES

The California Academy of Sciences, located in Golden Gate Park, is home to Steinhart Aquarium, Morrison Planetarium, Kimball Natural History Museum, and world-class research and education programs. The California Academy of Sciences museum is one of San Francisco’s must-see destinations. From the splashing penguins in African Hall to the wildflowers on the roof, the building is bursting with life. A four-story living rainforest and awe-inspiring coral reef ecosystem will delight visitors of all ages, while immersive planetarium shows will transport audiences through space and time for a new perspective on our planet. www.calacademy.org
Local Activities

DE YOUNG MUSEUM

The de Young Museum, located in Golden Gate Park, showcases American art from the 17th through the 21st centuries, international textile arts and costumes, and art from the Americas, the Pacific and Africa. The museum is the fourth-most-visited art museum in North America, and the 16th-most visited in the world. Housed in a state-of-the-art, accessible, and architecturally significant facility, it provides valuable art experiences to generations of residents and visitors. www.deyoungmuseum.org

CONSERVATORY OF FLOWERS

Historic San Francisco landmark in Golden Gate Park since 1879 boasting rare tropical flowers and plants from around the world. The building is an architectural gem with five distinct galleries. The Conservatory is open Tuesday through Sunday. www.conservatoryofflowers.org

PALACE OF FINE ARTS

Originally built for the 1915 Panama-Pacific Exposition, the Palace of the Fine Arts and the surrounding tranquil lagoon are one of the most photographed spots in the city. Some say it’s because of the reflection in the lagoon that makes the site uniquely San Francisco, but don’t underestimate the Merchant-Maybeck designed dome. It will take your breath away.

THE PRESIDIO

Formerly a military post, The Presidio is a national park site and recreational paradise featuring spectacular vistas, beautiful trails, and historic and architectural treasures. Come for a hike, a walking tour, a picnic, to view an exhibit or take a stroll back in time. The Presidio also features the Walt Disney Family Museum which tells the story of the life and work of Walt Disney. www.presidio.gov

LOMBARD STREET

Lombard Street is best known for the one-way section on Russian Hill between Hyde and Leavenworth Streets, in which the roadway has eight sharp turns (or switchbacks) that have earned the street the distinction of being the crookedest (most winding) street in the world. The crooked section of the street, which is about 1/4 mile long, is reserved for one-way traffic traveling east (downhill) and is paved with red bricks and is decorated with flower gardens.

MISSION DISTRICT

Boasting some of the best weather in the city, the Mission District, Bernal Heights and Potrero Hill take advantage of an abundance of fog-free days. New restaurants and night spots are a draw while Mission Dolores, 16th and Dolores streets, is the oldest structure in San Francisco. The largest concentration of murals in the city adorn buildings, fences and walls throughout the district. Potrero Hill’s Dogpatch neighborhood is one of 11 historic districts in the city and home to the second crookedest street (after Lombard) in the city.
CLIFF HOUSE

The Cliff House is a restaurant perched on the headland above the cliffs just north of Ocean Beach, on the western side of San Francisco, California. It overlooks the site of the former Sutro Baths and is now part of the Golden Gate National Recreation Area, operated by the National Park Service. On the terrace of the Cliff House is a room-sized camera obscura. More than thirty ships have been pounded to pieces on the southern shore of the Golden Gate below the Cliff House.

GOLDEN GATE BRIDGE

The Golden Gate Bridge is a suspension bridge spanning the Golden Gate, the opening of the San Francisco Bay into the Pacific Ocean. The bridge links the city of San Francisco, on the northern tip of the San Francisco Peninsula, to Marin County. It is one of the most internationally recognized symbols of San Francisco, California, and the United States. It has been declared one of the Wonders of the Modern World by the American Society of Civil Engineers. The bridge is popular with pedestrians and bicyclists, and was built with walkways on either side of the six vehicle traffic lanes.

ANGEL ISLAND

Angel Island is a wonderful natural resource, rich with California history and perfect for a family outing. The Island offers miles of hiking trails, including a wonderful trek to the top of Mt. Livermore (the Island’s highest point) where you’ll find spectacular panoramic views of the entire Bay. Or for a more leisurely day, stroll the paved Perimeter Road around the Island, taking in the views of Tiburon, San Francisco, the East Bay, and the Golden Gate Bridge. Visit the U.S. Immigration Station on Angel Island that was in operation from 1910 - 1940. Today the U.S. Immigration Station serves as a house museum dedicated to interpreting and making connections between the experiences of those who made the journey to America over 100 years ago and the continuing story of immigration in America today. www.angelisland.com

WEATHER AND CLOTHING

The weather in San Francisco in July can be colder than you expect, so please plan to bring jackets along with you. Layering is encouraged for walking around the city as the temperature might vary a bit during your outing. If you are going on any of the planned socials, then jackets are a must as all three events will involve a boat ride around the bay.
Official Reviewers

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Sarah Armstrong, NSWC Crane
Jean-Luc Autran, Aix-Marseille University
Marta Bagatin, University of Padova
Hugh Barnaby, Arizona State University
David Beutler, Manna Tech Engineering
Sebasiten Boudarie, ONERA
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Sharon Cui, Yale University
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William Heidegott, General Dynamics
David Hiemstra, MDA
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Rokutaro Koga, The Aerospace Corporation
Kirby Kruckmeyer, Texas Instruments
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Damien Lambert, EADS Nuclestudes
Reed Lawrence, BAE Systems
Jean-Luc Leray, CEA
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The 2014 IEEE Nuclear and Space Radiation Effects Conference will be held July 14 - 18 at the Marriott Rive Gauche, Paris, France. 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 14, 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
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 or IEEE TNS standard two-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 2014). 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.

PARIS, FRANCE

Paris is called “the City of Lights” and comes to mind immediately as one of the world’s most romantic and lovely cities to visit. A capital of the arts, Paris possesses a tremendous cultural richness from its 2000 year history and formidable heritage. With its monuments, museums, great buildings, and its famous characters, Paris never ceases to transport us through time and space. Stroll along the wonderful banks of the Seine river, walk around the artists’ village of Montmartre or explore the nearby Luxembourg gardens and you will see why! Paris is a world capital of gastronomy, and the iconic “French gastronomic meal” now has Unesco humanity heritage status. Plan to discover the French and Parisian art de vivre!

The Paris Marriott Rive Gauche, located in the heart of the famous “Paris Rive Gauche”, is the site for NSREC. It offers a unique atmosphere, just a short walk from the Butte aux Cailles and Mouffetard neighborhoods. All major sightseeing attractions are easily accessible from the hotel: Musée d’Orsay and the Louvre, the Eiffel Tower, Champs Elysees, the Arc de Triomphe, Notre Dame, the Latin Quarter, etc. With its variety and specific architecture, the “City of Lights” definitely has something for all tastes.
Free DVD for All Conference Attendees

50 Years of IEEE NSREC Publications
(1963-2012)

This DVD contains the publications from the Nuclear and Space Radiation Effects Conference (NSREC) sponsored by The Institute of Electrical and Electronics Engineers (IEEE). The first NSREC was in 1964 in Seattle, WA, but the first publications were in 1963 when NSREC was part of the IRE/AIEE Summer General Meeting. Papers on this DVD were published in the Transactions on Nuclear Science (TNS) from 1963 to present and in the Radiation Effects Data Workshop (REDW) from 1992 to present. All of these papers are copyright to the IEEE and are included in the special DVD with permission.

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Notes:
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2. Author names listed on this DVD may be different then on the publication; for example, an author name on a publication may have the first name abbreviated or may not contain a middle initial. This was done to collect all papers together for each author. To cite a paper on this DVD, please obtain the appropriate information from either the paper itself or the IEEE website.

Come join us at the 50th NSREC Celebration Reception and remember…

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… interesting talks ………

… special people ………

… exhibit raffles ………
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Pier 39
Pier 3
Financial District
Chinatown

Wednesday Conference Social - Bay Dinner Cruise