2008 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE

JULY 14 - 18, 2008
JW MARRIOTT STARR PASS RESORT & SPA
TUCSON, ARIZONA

Sponsored by IEEE/NPSS Radiation Effects Committee

IEEE

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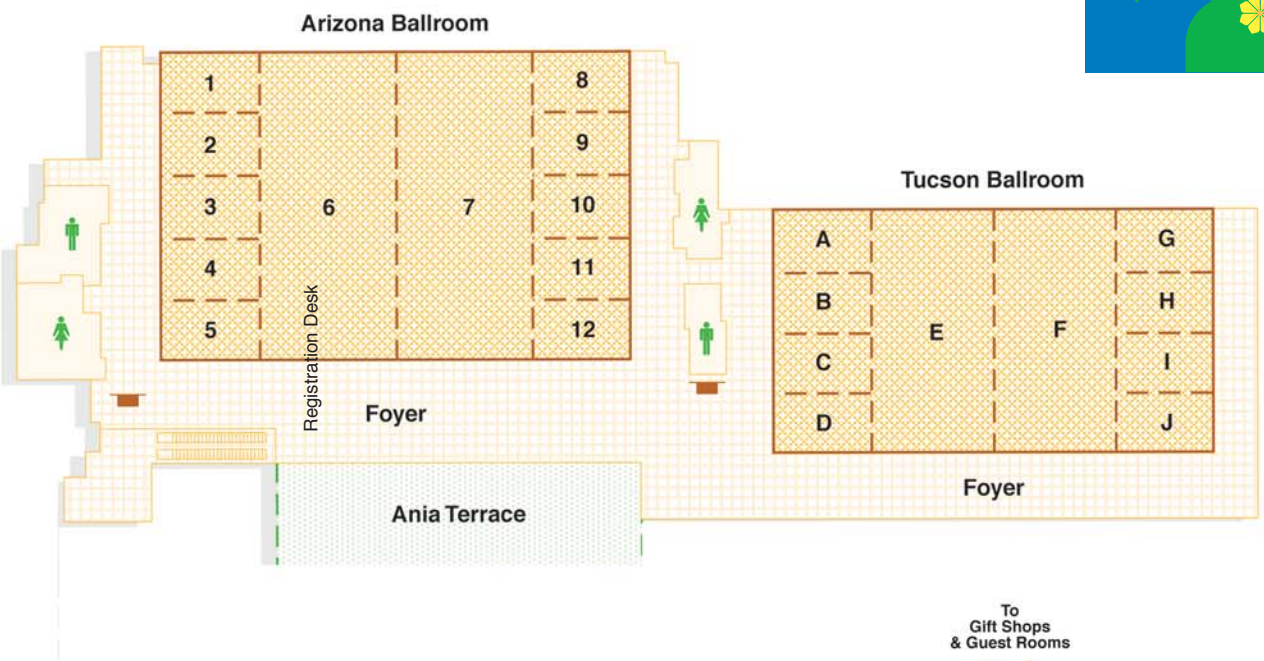
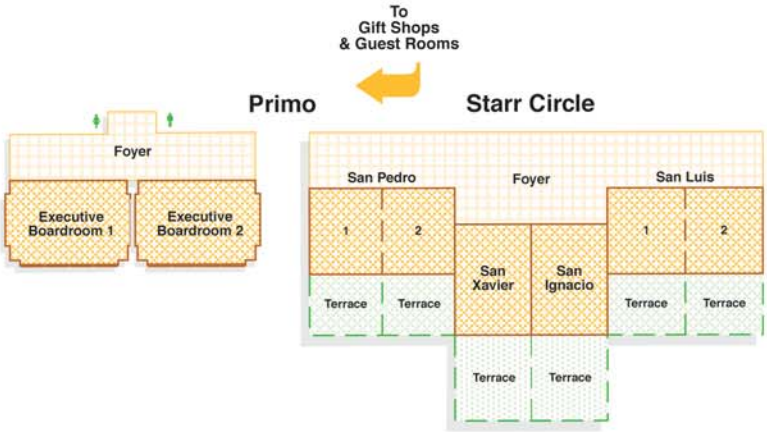
NSREC 2008 Tucson Arizona

Starr Pass Conference Facilities





SCHEDULE OF EVENTS

ARIZONA BALLROOMS 1 to 5
Tuesday thru Friday ~ Posters

ARIZONA BALLROOMS 6 and 7
Monday ~ Short Course
Tuesday thru Friday ~ Technical Sessions

ARIZONA BALLROOMS 8 to 12
Tuesday thru Friday ~ Data Workshop

TUCSON BALLROOM
Sunday ~ Short Course Reception
Monday ~ Short Course Lunch
Tuesday & Wednesday ~ Exhibits

FRONT LAWN
Monday, Tuesday & Wednesday ~ Aerobics

TBD
Monday, Tuesday & Wednesday ~ A/V Previews

Schedule

Time	Monday July 14	Tuesday July 15	Wednesday July 16	Thursday July 17	Friday July 18
7:30	[7:30] Continental Breakfast, Tucson Ballroom	[7:45] Continental Breakfast, Arizona Foyer	[7:45] Continental Breakfast, Arizona Foyer	[7:45] Continental Breakfast, Tucson Ballroom	[7:45] Continental Breakfast, Arizona Foyer
8:00	[8:00] **Short Course Introduction** Jeffrey Black Arizona Ballrooms 6 – 7				
8:15	[8:10] **Part 1 – Fundamental Mechanisms for Single Particle-Induced Soft Errors** Robert Reed				
8:30		[8:30] **Conference Opening** Arizona Ballrooms 6 – 7	[8:30] **Session D Space and Terrestrial Environments** Arizona Ballrooms 6 – 7	[8:30] **Session F Single-Event Effect; Devices and Integrated Circuits** Arizona Ballrooms 6 – 7	[8:30] **Invited Talk Small Stuff in Space: From Micro and Nano Technologies to Space Debris** Ann Garrison Darrin Arizona Ballrooms 6 – 7
9:00		[9:10] **Session A Single-Event Effects: Mechanisms and Modeling**	[9:35] **Session E Radiation Effects in Devices and Integrated Circuits**		
9:30	[9:45] Break, Arizona Foyer			[9:50] Break, Tucson Ballrooms A – E	[9:30] **Session H Hardening By Design**
10:00		[10:15] Break, Tucson Ballroom	[10:10] Break, Tucson Ballroom		
10:30	[10:10] **Part 2 – Ground-Based Testing and Evaluation of Soft Errors** Craig Hafer	[10:45] **Session A (continued)**	[10:40] **Session E (continued)**	[10:20] **Session F (continued)**	[10:35] Break, Arizona Foyer
11:00				[11:05] **Session G Dosimetry and Facilities**	[11:05] **Session I Photonic Devices and Integrated Circuits**
11:30	[11:45] Short Course Luncheon, Tucson Ballroom				
12:00		[12:15] Lunch	[12:10] Lunch	[11:55] Lunch	[12:10] End of Conference
12:30					
1:00	[1:00] **Part 3 – Soft Error Results Analysis and Error Rate Prediction** Edward Petersen				
1:30		[1:30] **Session B Basic Mechanisms of Radiation Effects**	[1:30] **Invited Talk The Francisco Vásquez de Coronado Expedition** James E. Turner	[1:30] **Invited Talk The Huygens Mission to Titan** Martin G. Tomasko	
2:00					
2:30	[2:35] Break, Arizona Foyer	[2:50] Break, Tucson Ballroom	[2:30] **Poster Session** Arizona Ballrooms 1 – 5	[2:30] **Data Workshop** Arizona Ballrooms 8 – 12	
3:00	[3:00] **Part 4 – Soft Error Case Studies: Single Event Functional Interrupts (SEFIs) in COTS SDRAMs and Implantable Defibrillators and Pacemakers** Joseph Benedetto and Jeff Wilkinson	[3:20] **Session C Hardness Assurance**			
3:30					
4:00					
4:30	[4:40] Wrap-up		[4:30] End of Sessions	[4:30] End of Sessions	
5:00	[4:50] Exam (for students requesting CEU credit only)	[4:55] End of Sessions			
5:30	[5:20] End of Short Course		[5:30 to 10:30] Conference Social **Pima Air & Space Museum** 7:00 Dinner	[5:15 to 6:30] Radiation Effects Committee Open Meeting, Arizona Ballrooms 6 – 7	
6:00		[6:00 to 10:00] Industrial Exhibits Reception 6:00 Cocktails 7:00 Buffet Tucson Ballroom			
6:30					
7:00					

Contents

Chairman's Invitation

NSREC 2008

Tucson Arizona

"Thanks in advance to all the volunteers, authors, exhibitors, supporters, and attendees who will make NSREC 2008 a success. We're looking forward to an engaging technical meeting and fantastic social program and I hope you'll make plans to join us in Tucson!"

Paul E. Dodd
NSREC 2008 General Chairman

Visit us on the web at:
www.nsrec.com

On behalf of the IEEE Nuclear and Plasma Sciences Society Radiation Effects Committee, it is my pleasure to invite you to join us for the 45th annual IEEE International Nuclear and Space Radiation Effects Conference (NSREC). This year's conference will be held July 14-18, 2008, at the fabulous new JW Marriott Starr Pass Resort and Spa in Tucson, Arizona. We will continue the tradition of previous NSRE Conferences by offering an outstanding Technical Program, a one-day Short Course, a Radiation Effects Data Workshop, and an Industrial Exhibit. Engineers, scientists, managers, and other interested people from around the world will attend.

Technical Program Chairman Nick van Vonno and his committee have assembled an outstanding program of contributed papers describing the latest information on nuclear and space radiation effects on electronic and photonic materials, devices, circuits, and systems, and the engineering of radiation-tolerant devices and integrated circuits. Presentations will include nine oral sessions and a poster venue allowing direct discussions with authors. In addition, there will be a Radiation Effects Data Workshop consisting of poster presentations describing new radiation effects data and simulation and test facilities. Three invited talks on local history, unmanned space exploration, and space technology are also planned.

Jeff Black has organized this year's Short Course with a theme of "Soft Errors: From the Ground Up." This Short Course is an excellent learning opportunity for those who are new to the radiation effects community and need a quick introduction to the field, as well as those who want to stay abreast of current issues in single-event effects. The Short Course will start Monday morning with tutorials on "Fundamental Mechanisms for Single Particle-Induced Soft Errors" and "Ground-Based Testing and Evaluation of Soft Errors." Monday afternoon will include tutorials on "Soft Error Results Analysis and Error Rate Prediction," and "Soft Error Case Studies." This year's Industrial Exhibits, organized by John Jewell, will permit one-on-one discussions between conference attendees and exhibitors on the latest developments in radiation-hardened and radiation-tolerant electronics, engineering services, facilities, and equipment. On Tuesday evening, attendees and their companions are invited to a reception that showcases the Industrial Exhibit.

Social events have been planned to give Conference attendees and their guests many opportunities to informally discuss business and to become better acquainted. Local Arrangements Chairman, Bill Heidergott has planned a fun and memorable social program. The main conference social on Wednesday night will be held at the Pima Air and Space Museum. Attendees and their guests will be fascinated by numerous displays of aircraft (including a newly-exhibited SR-71 Blackbird) and dine under the wings of a WWII B-29 Superfortress while enjoying dinner music. Our hotel will be the 4-star JW Marriott Starr Pass Resort and Spa. In the short time that this hotel has been open, it has garnered multiple awards including its chef being chosen as Marriott's Chef of the Year, and being selected as one of the top 40 meeting facilities worldwide *within their first year of opening*. Although you'll never want to leave the easy comfort of our gorgeous hotel, we have planned three companion events during the week to introduce (or re-introduce) you to the vibrant city of Tucson and its surroundings. Over the past three centuries, Tucson has grown from a Native American farming community, to Spanish outpost, to today's Southwestern metropolis of a million people. Due to its heritage, Tucson benefits from a rich cultural diversity and offers numerous attractions for any taste. Whether you're interested in artisan shopping, outdoor activities, or my favorite, southwestern cuisine, you'll find plenty for you and your family to enjoy in Tucson.

I'm anticipating another outstanding NSREC this year, and look forward to meeting you in Tucson.

Short Course Program

SOFT ERRORS: FROM THE GROUND UP

ARIZONA BALLROOMS 6 AND 7 – MONDAY, JULY 14

7:30 AM	**REGISTRATION/CONTINENTAL BREAKFAST**
8:00 AM	**SHORT COURSE INTRODUCTION** Jeffrey Black *Vanderbilt University*
8:10 AM	**PART 1 – FUNDAMENTAL MECHANISMS FOR SINGLE PARTICLE-INDUCED SOFT ERRORS** Robert Reed *Vanderbilt University*
9:45 AM	**BREAK (ARIZONA FOYER)**
10:10 AM	**PART 2 – GROUND-BASED TESTING AND EVALUATION OF SOFT ERRORS** Craig Hafer *Aeroflex Colorado Springs*
11:45 PM	**SHORT COURSE LUNCHEON (TUCSON BALLROOM)**
1:00 PM	**PART 3 – SOFT ERROR RESULTS ANALYSIS AND ERROR RATE PREDICTION** Edward Petersen *Consultant*
2:35 PM	**BREAK (ARIZONA FOYER)**
3:00 PM	**PART 4 – SOFT ERROR CASE STUDIES** Joseph Benedetto *Radiation Assured Devices* Jeff Wilkinson *Medtronic, Inc.*
4:40 PM	**WRAP-UP**
4:50 PM	**EXAM (only for students requesting CEU credit)**
5:20 PM	**END OF SHORT COURSE**

Short Course

COURSE DESCRIPTION

A one-day Short Course "Soft Errors: From the Ground Up" will be presented at the 2008 Nuclear and Space Radiation Effects Conference (NSREC). This Short Course will provide a review of soft errors, also known as single event upsets, applying the "From the Ground Up" theme in many ways. The Short Course is organized into four sessions starting from a foundation of the mechanisms for the generation of soft errors. The second session will build on that foundation and cover the ground-based testing and evaluation of soft errors. How the results of soft error testing and evaluation are analyzed and applied to predict soft error rates follows in the third session of the Short Course. Finally, the last session will provide two different case studies of soft errors in microelectronic systems, one looking at a complex device in a space-based application and one looking at a simple device in a ground-based medical application.

The speakers for the 2008 Short Course are all experts in their respective area of soft errors. They will present the traditional knowledge base in their topical area and build upon that knowledge with current results that demonstrate where the knowledge base is being stretched. Examples of this include the decrease of the separation of charge collection volumes, the increase in the speed of microelectronic devices, and the application of novel circuit design techniques. The speakers will also discuss the challenges of applying ground-based testing and evaluation results to the prediction of space-based soft error rates.

The course is applicable to designers, radiation effects engineers, component specialists, and other technical and management personnel who are involved in developing reliable systems designed to operate in terrestrial and space environments. This course provides a unique opportunity for NSREC attendees to benefit from the expertise of the instructors as well as the in-depth coverage and application-oriented perspective provided by the short course format. Each instructor will develop the core content of their respective topics from background material largely found in the literature. As such, the course will benefit both new and experienced engineers, scientists, and managers. In-depth notes will be provided at registration.

CONTINUING EDUCATION UNITS (CEUS)

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).

SHORT COURSE CHAIRMAN

Jeffrey Black
Short Course Chairman

Jeffrey Black is a Senior Research Engineer in the Institute for Space and Defense Electronics (ISDE) at Vanderbilt University. He received his BSEE at the United States Air Force Academy in 1988 and MSEE at the University of New Mexico. He expects to complete his Ph.D. degree at Vanderbilt University in 2008. Jeff's research interests run the gamut of radiation effects as they relate to circuit design and hardness assurance. Prior to joining ISDE in 2004, Jeff worked for Mission Research Corporation in Albuquerque, NM. He has served NSREC as Secretary of the Radiation Effects Steering Group from 2003-2006, Short Course Speaker in 2006, Radiation Effects Data Workshop Chair in 2004, and Local Arrangements Chair in 2002.

After completion of his Ph.D. (Clemson 1994), **Robert Reed** worked as a post-doctoral fellow at the Naval Research Laboratory and later worked for Hughes Space and Communication. From 1997 to 2004, Robert was a research physicist at NASA's Goddard Space Flight Center where he supported NASA space flight and research programs. He is currently an Associate Professor at Vanderbilt University. His radiation effects research activities include topics such as single event effect basic mechanisms and on-orbit performance prediction techniques. He has authored over 80 papers on various topics in the radiation effects area. He was awarded the 2004 Early Achievement Award from IEEE/NPSS and the 2000 Outstanding Young Alumni Award from Clemson University. Robert has been active in the NSREC community since 1992, serving as 2006 Short Course Chairman, 2004 Finance Chairman, 2002 Poster Session Chairman, and 2000 Short Course Instructor.

FUNDAMENTAL MECHANISMS FOR SINGLE PARTICLE-INDUCED SOFT ERRORS

Robert Reed
Vanderbilt University

Prof. Robert Reed will present a discussion on the basic energy deposition, charge generation and collection mechanisms for single event soft errors. The course will begin with a discussion of the physical interactions of radiation with matter that are important to understand single event soft errors. This will be followed by a brief discussion of radiation environments (space and terrestrial). Then he will discuss basic charge generation, transport, and collection mechanisms during a single particle event. Throughout the talk, Prof. Reed will relate the basic mechanism issues to soft error effects in advanced technologies.

Introduction

Interaction of Radiation with Matter

- "Ion Stopping" (Stopping Force)
- Nuclear Reaction (Nuclear Forces)
- Ion Tracks

Radiation Sources

- Space Environment
- Terrestrial Environment

Simple Device Physics

- Holes and Electrons
- The P-N Junction

Charge Generation

- Energy Loss to Ionization
- Direct Ionization
- Indirect Ionization

Charge Collection Mechanisms

- Drift
- Diffusion
- Carrier Density Modulation of Electrostatic Potentials

Summary

Craig Hafer received his B.S. degree from Montana State University and his M.S. Physics degree from Idaho State University in 1989. He started in the industry at AMIS working as a fabrication process engineer for over two years. He began his work at Aeroflex Colorado Springs in 1984 (then Mostek) as a wafer fab process integration engineer. Then at Aeroflex (UTMC) he worked on developing a RadHard wafer fab process, device physics, wafer foundry engineering, and product engineering. Since 2003 he has been responsible for single event effects, total ionizing dose, proton, and prompt dose radiation effects testing of Aeroflex's RadHard standard products (memory, interconnect, logic) and RadHard digital and mixed-signal ASICs. He has authored over 25 papers and presentations at NSREC, GOMAC, HEART, SEE Symposium, RADECs, and has presented radiation effects training at NASA Johnson along with customer training worldwide. He is an IEEE Member and has qualified for and run the Boston Marathon three times since 2006.

GROUND-BASED TESTING AND EVALUATION OF SOFT ERRORS

Craig Hafer
Aeroflex Colorado Springs

Craig Hafer will discuss soft error (SE) testing of modern digital integrated circuits (ICs). SEs due to single ion events can be problematic for proper IC and system level operation. This section of the short course will introduce the purpose of terrestrial SE testing as a method to determine the effects and frequency of single event SEs on IC operation in a space environment. A comparison of galactic cosmic ray (GCR) flux and linear energy transfer (LET) to terrestrial testing flux and LET will be reviewed. Terrestrial ion accelerator SE test facilities will be listed along with a general discussion of test facility considerations. SE test planning, sample preparation, and test hardware and software preparation will be examined. An overview will be made of recent challenges due to complex, dense, high speed, small geometry technology IC devices. By the end of this portion of the short course, attendees will be acquainted with single event upsets (SEUs), single event transients (SETs), and single event functional interrupts (SEFIs).

Introduction

Galactic Cosmic Rays versus Terrestrial Testing

- Galactic Cosmic Ray Flux versus Test Facility Flux
- Galactic Cosmic Ray Ion Energies versus Terrestrial Test Facility Ion Energies
- Linear Energy Transfer versus Depth

Test Facilities

- Soft Error Test Techniques
- Test Facilities
- Test Facilities Considerations

Terrestrial Soft Error Testing

- Test Planning Considerations
- Test Sample Preparation
- Test Hardware Considerations
- Test Software Considerations
- Recent Technology Challenges to Terrestrial Testing

Soft Error Effects on Integrated Circuits

- Single Event Upset
- Single Event Transient
- Single Event Functional Interrupt
- Test Results

Summary

Edward Petersen received his B.S. and M.S. degrees in physics from Oregon State in 1954 and 1956, and his Ph.D. in nuclear physics from UCLA in 1966. From 1963 through 1969, he taught at San Fernando Valley State College and Oberlin College. In 1969, he joined the Naval Research Laboratory (NRL) cyclotron branch as a research physicist. In 1980, he transferred to the NRL Radiation Effects branch, retiring in 1993. He has primarily studied single events with more than 30 publications in the area. In 1982 he presented an analysis of device threshold versus feature size that is still valid, and he developed the widely used Figure of Merit approach for upset rate calculations. He presented Single Event Tutorials at NSREC in 1983 and 1997. Dr. Petersen was awarded the IEEE NPSS Radiation Effects Award in 1998 and is an IEEE Fellow.

SOFT ERROR RESULTS ANALYSIS AND ERROR RATE PREDICTION

Edward Petersen
Consultant

Dr. Edward Petersen will discuss the analysis and use of various types of single event data. He will discuss how to examine for valid data. This will be followed by a discussion of the analysis and interpretation of various types of heavy ion data and how to interpret parametric studies of device sensitivity. The section will then discuss the various approaches to heavy ion and proton rate predictions for the space environment, and present a variety of sample calculations. The final portion will be a summary of the success of the predictions in various space experiments.

Introduction

Data Qualification and Analysis
- Illegitimate, Systematic, and Random Errors
- Samples of Problem Data – Rejection of Data
- Possible Problems with Fitting Data
- Geometrical and Other Adjustments to the Data

Analysis of Various Types of SEU Data
- Efficacy (Variation of SEU Sensitivity Within a Cell)
- Mixed Mode Simulations
- Parametric Studies of Device Sensitivity
- Single-Event Multiple-Bit Upset

Cosmic Ray Single Event Rate Calculations
- Introduction to Rate Prediction Methods
- The RPP Approach to Heavy Ion Upset Rates
- Effective Flux Approach
- Generalized Figure Of Merit

Proton Single Event Rate Calculations
- Semi-Empirical Approaches
- The Log Normal Distribution and the Proton Cross Section Curve
- Proton and Heavy Ion Upsets – Generalized Figure of Merit

Samples of Heavy Ion Rate Prediction
- Choosing Area and Depth for RPP Rate Calculations
- Geosynchronous Orbit
- SEE Sensitivity and the LET Threshold

Samples of Proton and Combined Environment Rate Prediction
- Circular, Elliptical and Ballistic Orbits
- Calculation of Combined Rates using the Figure of Merit

Samples of Solar Event Extreme Situations

Predictions and Observations Of SEU Rates In Space
- Results of Space Observations
- Constituents of a Good Rate Comparison Paper

Summary

Joseph M. Benedetto received his B.S. in Physics from the State University of New York and M.S.E.E. and Ph.D. degrees from the University of Maryland, College Park, MD. Dr. Benedetto began his career in radiation effects over 25 years ago as a Graduate Research Fellow at the National Bureau of Standards. In 1983 he joined the US Army's Harry Diamond Laboratories to work on hardening electronic components for strategic military systems and in 1995 he joined Aeroflex UTMC where he helped guide UTMC from a military components manufacturer with a dedicated fab to a "fab-independent" manufacturer of spacecraft electronics. His work included developing new methods for hardening and qualifying commercial integrated circuits for spaceborne applications. Dr. Benedetto is currently serving as Chief Technology Officer for Radiation Assured Devices, specializing in qualifying components for military and spaceborne applications. He has published over 75 technical articles in a wide variety of publications, including, IEEE Transactions on Nuclear Science, Journal of Applied Physics and IEEE Spectrum. To date he has been awarded three US Patents related to hardening spacecraft electronics.

SOFT ERROR CASE STUDY: SINGLE EVENT FUNCTIONAL INTERRUPTS (SEFIS) IN COTS SDRAMS

Joseph Benedetto
Radiation Assured Devices

Dr. Joseph Benedetto will present a case study in the evaluation of commercial memory circuits. Memory circuits are the subject of many soft error tests as they can sometimes dominate soft error rate predictions in a microelectronics system. Recent test results demonstrate the complexity involved in preparing for soft error testing as the observed failure modes are increasing. Additionally, memory devices are challenging to evaluate due to increasing speed of operation and increasing number of operating modes.

Introduction

Single Event Functional Interrupts (SEFIs) in Commercial SDRAMs Currently In Space Systems

- Initial SEFI Definitions
- Measuring SEFIs During Heavy Ion Beam Testing
- Expanded SEFI Definitions
- SEFI Error Rates with Increasing Memory Density
- Improving Error Rates via Operating Conditions

Distinguishing Between Single Event Latchup and SEFI Events

- Device Current as a Function of Fluence
- Non-Power Cycle Register Resets
- Unrecoverable SEFIs
- Test Methodologies to Help Distinguish between SEL and SEFIs

SEFIs in Commercial DDR SDRAMs

- DDR Devices Add Additional Complexity
- High Speed Testing Requirement
- Unrecoverable SEFIs in Addition to Recoverable SEFIs
- Need to Test as Used in System

Summary

Jeff Wilkinson joined Medtronic, Inc. in 1983 and is now a Technical Fellow and Senior Principal R&D Engineer with the Cardiac Rhythm Device Technology group. He has worked in product development on a variety of internal and external medical devices. Since 1999 he has been a part of the Device Technology group, developing and adapting technologies to meet the unique challenges of the implanted medical device. This work has included microprocessor design, ultralow power DSP, implantable sensors, and high reliability non-volatile memory. Since 2003 he has concentrated on ionizing radiation effects with a particular emphasis on soft-errors in implanted devices. Mr. Wilkinson is a member of the AAAS, senior member of the IEEE and holds a B.A. degree in Mathematics, Physics and Computer Science from St. Olaf College. He holds 10 US and international patents related to implantable medical device design.

SOFT ERROR CASE STUDY: IMPLANTABLE DEFIBRILLATORS AND PACEMAKERS

Jeff Wilkinson
Medtronic, Inc.

Jeff Wilkinson will discuss the challenges in designing for soft errors in the ultralow power regime of implanted medical devices. Implanted electronic medical devices are required to operate reliably for many years using a non-renewable power source. Mr. Wilkinson will review the functions and operating requirements for implanted electronics emphasizing the particular case of a life-critical cardiac pacemaker. Error mitigation strategies that may be appropriate for this application will be presented and compared. Finally, some surprising results related to other radiation effects will be briefly discussed.

Introduction

Implanted Medical Devices
- Types of Devices
- Distribution of Patients and Therapies

Implanted Electronics
- Pacemakers
- Defibrillators
- Other Electronic Implants

Radiation Environment for an Implant
- Environmental
- IC Packaging
- Clinical Radiation

Unique Challenges for an Implant
- Ultralow Power
- Surgical Barrier
- Pre-implant Environment

Total Dose and Dose Rate Effects

Summary

Technical Program

TECHNICAL INFORMATION

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

Nick van Vonno, Consultant/Intersil Technical Program Chairman

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

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

POSTER SESSION

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

RADIATION EFFECTS DATA WORKSHOP

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

INVITED SPEAKERS

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

LATE-NEWS PAPERS

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

Technical Program Tuesday

ARIZONA BALLROOMS 6 – 7
8:30 AM **OPENING REMARKS**
Paul Dodd, Sandia National Laboratories, General Chairman

8:35 AM **AWARDS PRESENTATION**
Tim Oldham, NASA/GSFC, Radiation Effects Steering Group Chairman

9:05 AM **TECHNICAL SESSION OPENING REMARKS**
Nick van Vonno, Consultant/Intersil, Technical Program Chairman

SESSION A **SINGLE-EVENT EFFECTS: MECHANISMS AND MODELING**
9:10 AM SESSION INTRODUCTION
Chair: Dale McMorrow, Naval Research Laboratory

A-1 9:15 AM **Investigation of the Propagation Induced Pulse Broadening (PIPB) Effect in Inverter Chains with Focused Pulsed Laser Irradiation**
V. Ferlet-Cavrois, P. Paillet, J. Baggio, CEA/DIF; D. McMorrow, J. S. Melinger, NRL

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

A-2 9:30 AM **Generation and Propagation of Single Event Transients in 0.18 um Fully Depleted SOI**
Pascale Gouker, Jim Brandt, Peter Wyatt, Brian Tyrrell, Tony Soares, Jeff Knecht, Craig Keast, MIT Lincoln Laboratory; Dale McMorrow, Naval Research Laboratory; Balaji Narasimham, Matthew Gadlage, Barat Bhuva, Vanderbilt University

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

A-3 9:45 AM **Single-Event Transient Pulse Propagation in Digital CMOS**
Lloyd W. Massengill, Vanderbilt University

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

A-4 10:00 AM **Waveform Observation of Digital Single-Event Transients Employing Monitoring Transistor Technique**
D. Kobayashi, K. Hirose, H. Ikeda, Institute of Space and Astronautical Science, JAXA and Graduate University for Advanced Studies; Y. Yanagawa, University of Tokyo; H. Saito, Institute of Space and Astronautical Science, JAXA and University of Tokyo; V. Ferlet-Cavrois, P. Paillet, CEA/DIF; D. McMorrow, Naval Research Laboratory; Y. Arai, KEK and Graduate University for Advanced Studies; M. Ohno, OKI Electric Industry

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

10:15 – 10:45 AM
TUCSON BALLROOM

BREAK

A-5
10:45 AM

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

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

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

A-6
11:00 AM

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

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

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

A-7
11:15 AM

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

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

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

A-8
11:30 AM

Vulnerable Trench Power MOSFETs Under Heavy Ion Irradiation

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

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

A-9
11:45 AM

Direct Evidence of Secondary Events Induced by High Energy Protons

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

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

A-10
12:00 PM

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

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

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

POSTER PAPERS

PA-1

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

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

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

PA-2

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

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

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

PA-3

Temperature Dependence of Digital Single Event Transient

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

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

PA-4

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

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

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

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

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

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

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

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

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

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

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

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

PA-8 Radiation-Induced Current Transients in SiGe HBTs

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

PA-15 **CODES a SEU Rate Prediction Tool**

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

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

12:15 – 1:30 PM LUNCH

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

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

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

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

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

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

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

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

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

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

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

POSTER PAPERS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Michael Murat, Avraham Akkerman, Joseph Barak, Soreq NRC

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

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

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

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

2:50 PM – 3:20 PM
TUCSON BALLROOM

BREAK

SESSION C **HARDNESS ASSURANCE**

3:20 PM SESSION INTRODUCTION

Chair: Andrew Chugg, MBDA UK Ltd.

C-1 3:25 PM **A Comprehensive Methodology for Complex Field Programmable Gate Array Single Event Effects Test and Evaluation**

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

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

C-2 3:40 PM **An Automated Approach to Estimating Hardness Assurance Issues in Triple-Modular Redundancy Circuits in Xilinx FPGAs**

Heather Quinn, Paul Graham, Los Alamos National Laboratory

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

C-3
3:55 PM

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

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

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

C-4
4:10 PM

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

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

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

C-5
4:25 PM

TID Effects in Space-Like Variable Dose Rates

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

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

C-6
4:40 PM

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

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

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

POSTER PAPERS

PC-1

Review of Deposited Dose Calculation Methods using Ray Tracing Approximations

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4:55 PM END OF TUESDAY SESSIONS

ARIZONA BALLROOMS 6 – 7

SESSION D **SPACE AND TERRESTRIAL ENVIRONMENTS**

8:30 AM SESSION INTRODUCTION

Chair: Janet Barth, NASA/GSFC

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

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

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

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

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

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

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

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

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

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

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

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

POSTER PAPERS

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

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

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

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

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

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

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

9:35 AM SESSION INTRODUCTION

Chair: Ray Ladbury, NASA/GSFC

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

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

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

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

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

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

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

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

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

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

E-4
10:55 AM

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

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

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

E-5
11:10 AM

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

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

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

E-6
11:25 AM

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

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

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

E-7
11:40 AM

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

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

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

E-8
11:55 AM

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

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

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

POSTER PAPERS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Larry D. Edmonds, Leif Z. Scheick, JPL

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

12:10 – 1:30 PM LUNCH

INVITED TALK
1:30 – 2:30 PM

The Francisco Vásquez de Coronado Expedition

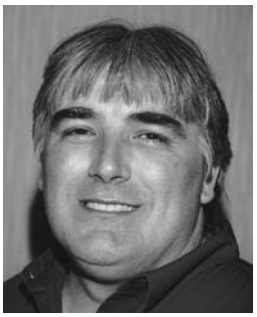
James E. Turner, Arizona Historical Society

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

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

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

INTRODUCTION



Jeff Titus, NAVSEA/Crane

4:30 PM END OF WEDNESDAY SESSIONS

ARIZONA BALLROOMS 6 – 7

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

8:30 AM SESSION INTRODUCTION

Chair: Philippe Paillet, CEA/DIF

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

BREAK

F-6
10:20 AM

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

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

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

F-7
10:35 AM

Probing the SET Sensitivity of Linear Devices with Heavy Ions

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

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

F-8
10:50 AM

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

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

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

POSTER PAPERS

PF-1

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

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

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

PF-2

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

PF-9 **Upset-Induced Failure Signatures, Recovery Methods, and Mitigation Techniques in a High-Speed Serial Data Link for Space Applications**
Keith Morgan, Michael Caffrey, Mark Dunham, Paul Graham, Heather Quinn, LANL; Carl Carmichael, Tony Duong, Austin Lesea, Greg Miller, Gary Swift, Chen Wei Tseng, Yiding Wu, Xilinx; Roberto Monreal, SEAKR; Greg Allen, JPL

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

PF-10 **Study of Latent Damage in Power MOSFETs Caused by Heavy Ion Irradiation**
Naomi Ikeda, Satoshi Kuboyama, Takashi Tamura, JAXA

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

PF-11 **SEE Test Results and Observed Failure Modes of Trench Power MOSFETs**
Sandra Liu, Huy Cao, Robert Berberian, Christopher DiCienzo, Max Zafrani, Milt Boden, International Rectifier

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

SESSION G **DOSIMETRY AND FACILITIES**
11:05 AM SESSION INTRODUCTION
Chair: Henry Clark, Texas A&M University

G-1 11:10 AM **A Novel Cylindrical Silicon-on-Insulator Microdosimeter for the Characterisation of Deep Space Radiation Environments**
Amy L. Ziebell, Andrew S. Dzurak, Anatoly B. Rosenfeld, University of Wollongong; Wee Han Lim, Dale. A. Prokopovich, University of New South Wales; Mark I. Reinhard, Iwan Cornelius, Australian Nuclear Science and Technology Organisation

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

G-2 11:25 AM **Tissue Equivalence Correction for Silicon Microdosimetry for Space Radiation Protection**
S. Guatelli, M. I. Reinhard, D. A. Prokopovich, ANSTO; A. S. Dzurak, University of New South Wales; M. Zaider, Memorial Sloan-Kettering Cancer Center; A. B. Rosenfeld, University of Wollongong

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

G-3
11:40 AM

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

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

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

POSTER PAPERS
PG-1

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

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

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

11:55 – 1:30 PM LUNCH

INVITED TALK
1:30 – 2:30 PM

The Huygens Mission to Titan

Martin G. Tomasko, University of Arizona

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

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

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

INTRODUCTION

Chair: Jim Felix, Sandia National Laboratories

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Leif Scheick, Steven Guertin, Duc Nguyen, JPL

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

W-9 Results of Single-Event Latchup Measurements Conducted by the Jet Propulsion Laboratory
Tetsuo F. Miyahira, Farokh Irom, JPL

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

W-10 Results of Single-Event Transient Measurements Conducted by the Jet Propulsion Laboratory
Farokh Irom, Tetsuo F. Miyahira, JPL

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

W-11 Total Dose and Single Effect Characterization of ECL Devices
Surinder S. Seehra, Audrey J. Esteban, Stephen K. Moyer, Lockheed Martin Commercial Space Systems

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

W-12 Single Event Effects and Total Dose Test Results for TI TLK2711 Transceiver
R. Koga, P. Yu, J. George, The Aerospace Corporation

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

W-13 Single Event Gate Rupture Testing on 22A Gate Oxide Structures from a 90 nm Commercial CMOS Process
Reed K. Lawrence, BAE Systems

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

W-14 A Radiation Hardened High Voltage 16:1 Analog Multiplexer for Space Applications (NGCP3580)
Dennis Adams, Herbert Barnes, Michael Fitzpatrick, Norman Goldstein, William Hand, William Jackson, Henry Remenapp, Joseph Smith, Northrop Grumman Corporation; Rocky Koga, Aerospace Corporation

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

W-15 Single Event Transient Event Rate Prediction Model for a Next Generation PLL
C. Hafer, J. Pfeil, D. Bass, A. Jordan, T. Farris, Aeroflex Colorado Springs

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Larry McGee, Kirby Kruckmeyer, Bill Brown, National Semiconductor

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

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

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

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

W-22 **New Proton Irradiation Facility at Paul Scherrer Institute**
U. Grossner, W. Hajdas, K. Egli, R. Brun, Paul Scherrer Institute; R. Harboe-Sørensen, ESA/ESTEC

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

W-23 **Total Ionizing Dose and Dose Rate Effects in Candidate Spacecraft Electronic Devices**
Alexander L. Bogorad, Justin J. Likar, Stephen K. Moyer, Audrey J. Esteban, Graham P. Doorley, Roman Herschitz, Lockheed Martin Commercial Space Systems

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

W-24 **Evaluation of Static and Dynamic Performance of Silicon-Based Bipolar Phototransistors Under Radiation**
Gianandrea Quadri, Olivier Gilard, Jean-Luc Roux, Centre National d'Etudes Spatiales; Piero Spezzigu, Laurent Bechou, Yves Ousten, Université Bordeaux; Massimo Vanzi, Università degli Studi di Cagliari; Dominique Gibard, Codechamp

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

W-25 **Standard Practice for Dosimetry for Proton Beams for use in Radiation Effects Testing**
Ewart Blackmore, TRIUMF; Ethan W. Cascio, Massachusetts General Hospital; Carlos Castaneda, University of California at Davis; Margaret A. McMahan, Lawrence Berkeley National Laboratory; Barbara von Przewoski, Indiana University Cyclotron Facility

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

4:30 PM END OF THURSDAY SESSIONS

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

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

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

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

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

SESSION H
9:30 AM

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

H-1
9:35 AM

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

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

H-2
9:50 AM

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

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

H-3
10:05 AM

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

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

H-4 10:20 AM

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

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

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

POSTER PAPERS

PH-1

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

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

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

PH-2

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

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

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

PH-3

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

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

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

10:35 AM – 11:05 AM
ARIZONA FOYER

BREAK

SESSION I 11:05 AM

PHOTONIC DEVICES AND INTEGRATED CIRCUITS

SESSION INTRODUCTION

Chair: Scott Messenger, Naval Research Laboratory

I-1 11:10 AM

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

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

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

I-2 11:25 AM

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

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

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

I-3 11:40 AM

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

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

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

I-4 11:55 AM

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

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

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

POSTER PAPERS

PI-1

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

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

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

PI-2

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

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

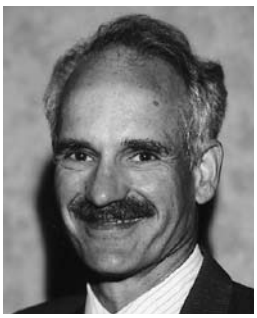
Experiments using dose rates of 40 and 1270 rads/min and dual optical wavelengths, 850 and 1310 nm, are conducted to estimate fiber optic attenuation at other dose rates using low order kinetics models.

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

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

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

12:10 PM END OF CONFERENCE



Tim Oldham
Chairman

Dan Fleetwood
Executive Vice Chairman

NSREC 2008 will be held at the JW Marriott Starr Pass Resort cradled in the Tucson Mountains just west of Tucson, Arizona. The resort is Tucson's premier convention destination, featuring a newly redesigned 27-hole Arnold Palmer signature golf facility offering views of the city and a majestic landscape of towering Saguaros and the Sonoran Desert. A fitness center, hiking the mountain desert terrain, swimming and whirlpools, and the Hashani Spa may be followed by dining at one of the five restaurants located at Starr Pass. Paul Dodd and his 2008 conference committee have put together a strong technical program as well as social events that provide frequent opportunities for discussing radiation effects with friends, old and new.

Supporters of the conference include the Defense Threat Reduction Agency, Air Force Research Laboratory, Sandia National Laboratories, the NASA Electronic Parts and Packaging Program, the Jet Propulsion Laboratory, BAE Systems, Micro-RDC, Honeywell, Boeing, Northrop Grumman, and Aeroflex Colorado Springs.

The 2009 NSREC will be held in Québec City, Québec, Canada at the Conference Center of Québec and the Québec City Hilton, July 20-24, 2009. A historic walled city, celebrating its 400th birthday this year, will be the second time NSREC has been held in Canada. The conference chair is Mark Hopkins, The Aerospace Corporation. The 2010 NSREC will be held in Denver, Colorado and is being chaired by Joe Benedetto of Radiation Assured Devices. Kay Chesnut Jobe of Boeing will be chairwoman for the 2011 conference.

As always, papers presented at the NSREC are eligible for publication in the December issue of the *IEEE Transactions on Nuclear Science*. This year we will continue the fully electronic submission and review process inaugurated last year. 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 **http://www.nsrec.com/editmsg.htm**.

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

GUEST EDITORS

Fred Sexton
Vice-Chairman of Publications

To provide consistent reviews of papers throughout the year, the *IEEE Transactions on Nuclear Science* has made structural changes in its editorial process. The editorial structure now relies on the year-round editorial board that manages reviews for submissions throughout the year to the Transactions in the area of radiation effects. Consistent with last year, the review process for the December issue of the Transactions will continue to be aligned with this process. The review process is managed by Senior Editor Dr. Jim Schwank, assisted by six assistant editors who are technically knowledgeable in one or more specializations and are experienced in the publication process. The year-round editorial board is not directly associated with the annual conference, and consequently they are not included in the conference committee. The December issue of the *Transactions on Nuclear Science* has been the official record of refereed papers for the conference. The Radiation Effects Steering Committee is committed to retaining the feel of the December issue as the "conference record." If you have questions or comments I can be reached via email at **sextonfw@sandia.gov**, while Jim's email address is **schwanjr@sandia.gov**.

RESG NEWS

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 get to be a member of the largest professional engineering society in the world. **About 60% of NSREC attendees are IEEE members.** Full membership in IEEE costs $156. NPSS membership is $30. NPSS members receive a free subscription to *NPSS News* and have an opportunity to purchase a subscription to the *IEEE Transactions on Nuclear Science* for $65 (print) or $25 (on-line).

NPSS members get to vote in our NSREC elections, held at the annual open meeting on Thursday of the conference. If that is not enough, **members receive a significant discount on registration fees** for the NSREC and Short Course. With a subscription to IEEE Xplore, members can search and view digital copies of NSREC papers (published since 1988) from an on-line web-based database. What are you waiting for? Apply for membership at **http://www.ieee.org** 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. A six issue/year subscription is $1140 (only $65 for IEEE/NPSS members).

- **Radiation Effects Data Workshop Record**. Published each year in October, this IEEE proceedings has become the source for radiation test data on semiconductor components. A copy of the Workshop Record is available for $180 ($90 IEEE members).

- **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. The *Archive of Radiation Effects Short Course Notebooks 1980-2006* is available on CD-ROM for $200 ($160 IEEE members). To obtain individual copies of this CD, please visit **http://www.nsrec.com/editor.htm**.

A complimentary copy of the *2008 IEEE Radiation Effects Data Workshop Record* and the 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 Tucson.

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

You are invited to attend the IEEE Radiation Effects Committee's Annual Open Meeting on Thursday, July 17, from 5:15 – 6:30 PM in the Arizona Ballrooms 6 – 7. All conference attendees and spouses are encouraged to attend. We will discuss the 2008 conference and future IEEE Nuclear and Space Radiation Effects Conferences. There will be an election for the Junior Member-at-Large on the Radiation Effects Steering Group. Nominations will be taken from the floor. All IEEE NPSS members present are eligible to vote. Refreshments will be provided.

Awards

2007 OUTSTANDING CONFERENCE PAPER AWARD

Impact of Heavy Ion Energy and Nuclear Interactions on Single-Event Upset and Latchup in Integrated Circuits
P. E. Dodd, J. R. Schwank, M. R. Shaneyfelt, J. A. Felix, P. Paillet, V. Ferlet-Cavrois, J. Baggio, R. A. Reed, G. L. Hash, S. M. Dalton, K. Hirose, and H. Saito

2007 OUTSTANDING STUDENT PAPER AWARD

Mechanisms of Enhanced Radiation-Induced Degradation due to Excess Molecular Hydrogen in Bipolar Oxides
X. J. Chen, H. J. Barnaby, B. Vermeire, K. Holbert, D. Wright, R. L. Pease, G. Dunham, D. G. Platteter, J. Seiler, S. McClure, and P. Adell

2007 DATA WORKSHOP PAPER AWARD

Compendium of Current Single Event Effects Results for Candidate Spacecraft Electronics for NASA
M. V. O'Bryan, C. Poivey, J. W. Howard, K. A. LaBel, R. Ladbury, S. P. Buchner, T. R. Oldham

RICHARD F. SHEA DISTINGUISHED MEMBER AWARD

Kenneth F. Galloway has been selected to receive the Richard F. Shea Distinguished Member Award. His citation reads "For leadership, technical, and educational contributions to the field of radiation effects on microelectronics."

Dr. Galloway received the BA degree from Vanderbilt University in 1962 and the Ph.D. from the University of South Carolina in 1966, both in Physics. Since 1996, he has been Dean of Engineering at Vanderbilt, where he leads an engineering school of approximately 125 faculty members. Prior to that he served as Department Head for Electrical and Computer Engineering at the University of Arizona and he also held professional appointments at the National Bureau of Standards, the University of Maryland, the Naval Weapons Support Center-Crane, and Indiana University.

In his current position as Dean of Engineering, Vanderbilt University has grown to become the foremost academic program in the world dealing with radiation effects on electronics. Dr. Galloway received the NSREC Distinguished Poster Paper Award in 1984 for his work on mobility degradation and charge separation in MOSFETs, the NSREC Outstanding Paper Award in 1991 for work on single-event burnout of power bipolar junction transistors, and the NSREC Outstanding Paper Award in 1998 for contributions to the understanding of enhanced low-dose-rate sensitivity (ELDRS) in bipolar transistors.

Dr. Galloway has served the NSREC in many capacities, including General Chairman (1985), Technical Program Chairman (1982), Awards Committee Chairman (1980), Short Course Instructor (1996), and Session Chair (2004). He also has been very active in the IEEE Nuclear and Plasma Sciences Society AdCom, serving as Vice President (1989), Vice Chairman/Standards (1978), and Member (1987, 1991-1994, 2000-2003). He has served the Radiation Effects Committee as Executive Vice Chairman (1988-1991), Chairman (1991-1994), Past Chairman (1994-1997), Member at large (1975-1977), and Secretary/Treasurer (1985-1988).

During Dr. Galloway's tenure as Executive Vice-Chair and Chairman of the NPSS Radiation Effects Committee, a comprehensive set of guideline documents describing every aspect of organizing the Nuclear and Space Radiation Effects Conference was created and the Radiation Effects Data Workshop began. He played a key role in developing the strong and cordial relationship that exists between NPSS and the premier European radiation effects conference, RADECS.

Awards

2007 RADIATION EFFECTS AWARD

The 2007 Radiation Effects Award was presented to Reno Harboe-Sørensen, European Space Agency, during the opening ceremonies of the 2007 conference. Reno's citation reads "For contributions to the dissemination and advancement of radiation effects research associated with hardened systems for space applications."

2008 RADIATION EFFECTS AWARD

The winner of the 2008 Radiation Effects Award will be announced Tuesday morning, July 15. 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 but who may not have been honored by being elected Fellows of the IEEE or receiving other IEEE awards such as a Merit Award, the Shea Award, or an IEEE Medal.

2009 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2009 IEEE Nuclear and Plasma Sciences Society (NPSS) Radiation Effects Award. 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.

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 2009 IEEE NSREC in Québec City, Québec, Canada in July 2009. Nomination forms are available electronically in PDF Format or in Microsoft Word format at **http://www.nsrec.com/nominate.htm**. Additional information can be obtained from Marty Shaneyfelt, Member-at-Large for the Radiation Effects Steering Group. Marty can be reached at 505-844-6137, **shaneymr@sandia.gov**.

Conference Information

CONFERENCE LOCATION

Photo: courtesy of JW Marriott Starr Pass Resort

Cradled in the Tucson Mountains, the 575-room **JW Marriott Starr Pass Resort & Spa** is the newest Tucson resort to open in 18 years. Rich in culture, history and natural beauty, this area, called Starr Pass, is an excellent location for a fabulous resort! The hotel features a 20,000 square foot spa, 27 holes of golf, seven dining options, and 88,000 square feet of indoor and outdoor event space. A fun-filled waterpark, including a lazy river and 100' waterslide, has recently opened as an exciting complement to the Marriott's adult, children and spa pools. All of this is chiseled into a mountainside in the Tucson Mountain Park preserve, providing opportunities for hiking, mountain biking, and desert educational tours right from the front door of the resort. The JW Marriott Starr Pass Resort encompasses everything you might want in a desert getaway!

ROOMS FOR SIDE MEETINGS

Several meeting rooms are available for use by any registered conference attendee at the JW Marriott Starr Pass Resort on a first come, first served basis. *NSREC encourages side meetings to be scheduled at times other than during technical sessions.* Contact ETC Services at 720-733-2003 or send an e-mail to etcservices@qwestoffice.net to make side meeting reservations **before** the conference. To make a side meeting reservation **during** the conference, see the NSREC Registration Desk staff in the San Ignacio Room.

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.

MESSAGES

520-791-6201
FAX: 520-792-3351

A message board for incoming messages will be located in the pre-function area outside the Arizona Ballroom during the NSREC. Faxes can be received through the hotel's guest fax but there must be a cover sheet stating the recipient's name, noting the NSREC conference, and advising the total number of pages being sent. There is no fee for incoming faxes but they will be accepted for hotel guests only.

CONTINENTAL BREAKFAST AND COFFEE BREAKS

The 2008 IEEE NSREC will provide continental style breakfasts and refreshments at breaks during the NSREC Short Course and Technical Sessions. Breakfast on Monday will begin at 7:30 AM; Tuesday-Friday breakfasts will begin at 7:45 AM for *registered conference attendees only*.

BUSINESS CENTER

The JW Marriott Starr Pass Resort has a Business Center that is operated by QuikPrint. Their summer hours are 7:30 AM - 5:30 PM Monday through Saturday, closed on Sunday. Services available are photocopies, incoming and outgoing fax service, messenger service, computer internet service, and overnight delivery/pickup. Costs associated with the Business Center services may be charged to your room or paid by cash or credit card.

Registration and Travel

CONFERENCE REGISTRATION

To pre-register for NSREC, complete the conference registration form enclosed in this booklet, or register on-line at **www.nsrec.com**. **Please note that registration fees are higher if payment is received after June 13, 2008.**

ETC SERVICES, INC.
2254 EMERALD DRIVE
CASTLE ROCK, CO 80104

720-733-2003
FAX: 720-733-2046

ETCSERVICES@ QWESTOFFICE.NET

Mail the conference registration form with your remittance to ETC Services, Inc. The registration form, **with payment**, should be mailed to arrive no later than seven days prior to the conference, or arrangements should be made to hand carry fees for on-site registration. Faxed registrations will be accepted with credit card payment. Telephone registrations will not be accepted. You can also register via the internet, provided all of the credit card information is included. Go to the NSREC web site for on-line registration at **www.nsrec.com**.

Registration fees should be made payable to the "IEEE NSREC" and must be in U.S. funds only. There are three ways to remit advanced payment of registration and activity fees: 1) check made out in U.S. dollars and drawn on a U.S. bank, 2) U.S. Money Order, or 3) Mastercard, VISA, or American Express credit card.

On-site conference registration will take place at the JW Marriott Starr Pass in the San Ignacio room (Lobby Level/3rd floor.) For those who have pre-registered, your packets can be picked up at the Tucson Registration Desk (Ballroom Level/2nd floor), on Sunday through Tuesday and in the San Ignacio Room after that. The following is the conference registration schedule:

ON-SITE REGISTRATION HOURS

Sunday, July 13	**5:00 PM – 9:00 PM**
Monday, July 14	**7:30 AM – 4:00 PM** **6:00 PM – 9:00 PM**
Tuesday, July 15	**7:45 AM – 5:30 PM**
Wednesday, July 16	**7:45 AM – 3:00 PM**
Thursday, July 17	**7:45 AM – 3:00 PM**
Friday, July 18	**7:45 AM – 10:00 AM**

CONFERENCE CANCELLATION

A $25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 13, 2008 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. To request a refund, you must notify ETC Services by fax at 720-733-2046 or e-mail at etcservices@qwestoffice.net.

Registration and Travel

HOTEL RESERVATIONS AND INFORMATION

JW MARRIOTT STARR PASS RESORT

3800 W. STARR PASS BLVD.
TUCSON, AZ 85745
USA

520-792-3500
FAX: 520-792-3351

WWW.JWMARRIOTTSTARRPASS.COM

Our conference hotel will be the JW Marriott Starr Pass Resort located amongst the saguaro cactus forest of Tucson Mountain Park. The rooms in this all non-smoking hotel feature Marriott's Revive Bedding, available high-speed internet access, coffee maker, safe, alarm clock, minibar, iron and ironing board, multi-line phone, and a private balcony or patio with wonderful views. The bathrooms boast granite counters, separate tub, walk-in shower and a hairdryer.

Photo: courtesy of JW Marriott Starr Pass Resort

HOTEL RESERVATIONS

The negotiated group rate for a standard room is $107.00 + tax for single and double occupancy. The government rate for a standard room is $86.25 + tax for single and double occupancy. A fee of $20.00 + tax per night, per guest will be levied for additional adults (more than two) in a room. There is no additional charge for children 18 years of age and younger when sharing a room with their parents and utilizing existing bedding.

All rooms must be guaranteed with a credit card or deposited by check. The cut-off for IEEE NSREC reservations is at 5:00 PM MST on **June 13, 2008**. Once the room block has been filled OR after the cut-off date (whichever comes first!), room accommodations will be confirmed on a space available basis and the room rate may be higher.

Reservations can be made by calling Marriott Central Reservations at **800-228-9290** or by calling the JW Marriott Starr Pass Resort directly at **888-527-8989**. Provide the following to ensure that you are getting our special rates:

Group rate booking code: NSRNSRA
Government rate booking code: NSGNSGA

OR you can book through the internet on the following web sites:

Group rate: **http://marriott.com/tussp?groupCode=NSRNSRA&app-resvlink**
Government rate: **http://marriott.com/tussp?groupCode=NSGNSGA&app-resvlink**

GOVERNMENT RATE

All government rate attendees will be asked to provide a federal government ID upon registration at the JW Marriott Starr Pass. This form of ID will be necessary to guarantee the "government rate" at check in.

Registration and Travel

AIRPORT AND TRANSPORTATION INFORMATION

Tucson International Airport (code TUS) is on the south side of the city, about 13 miles from the JW Marriott Starr Pass Resort. The average taxi rate is about $32.00 one way.

AIRPORT SHUTTLE

Arizona Stagecoach has a counter in the baggage claim area (across from bag claim 4 & 5) at the Tucson Airport. They offer shuttle service to the JW Marriott Starr Pass Resort. Reservations are not required (but are suggested) on the airport-hotel transfer but they are required on the hotel-airport transfer.

The NSREC has special group rates of $26.00 per person one way and $44.00 per person round trip, OR $30.00 per couple one way and $52.00 per couple round trip. Reservations can be made by calling toll free 877-782-4355, or locally at 520-889-1000, or by visiting their web site: **www.azstagecoach.com**. To get the special group rate, use group code **IEEE708**.

DRIVING DIRECTIONS

Tucson is undergoing major Interstate freeway construction through 2010. Therefore we are providing two sets of directions between the airport and the JW Marriott Starr Pass. Average travel time is 20 minutes. Route A uses the Interstate, which may have major delays. Route B uses main city streets. ***See back cover for a map.***

Route A – North on Tucson Blvd.; left on Valencia Rd.; right onto I-19 Freeway north; exit at Starr Pass Blvd./22nd St.; from ramp, left on Starr Pass Blvd.; continue west into the mountains. Starr Pass Boulevard ends at the JW Marriott.

Route B – North on Tucson Blvd.; left on Valencia Rd.; right on Campbell Ave.; left on 22nd Street which becomes Starr Pass Blvd.; continue west into the mountains. Starr Pass Boulevard ends at the JW Marriott.

RENTAL CAR DISCOUNT
HERTZ

HERTZ NUMBER
CV #03S20003

This is one place where a car rental might actually come in handy. The hotel is located in the Sonoran Desert at the edge of Tucson Mountain Park, so its serene setting places you outside the city. Except for some areas of highway construction, driving to area attractions and restaurants is fairly easy.

Hertz has been selected as the official car rental agency for the 2008 NSREC and is offering discounted rates for conference attendees. For reservations and information, call Hertz at 800-654-2240 and mention CV #03S20003 or use the Hertz web site at **www.hertz.com**. The special conference rates will be available from July 6, 2008, to July 25, 2008. The rates are valid at any Tucson or Phoenix Hertz location as long as pick-up/return are at the same location. Note also that Hertz has a rental office conveniently located on the JW Marriott Starr Pass property.

Class	Car type	Daily (per day)	Weekend (per day)	Weekly (5 - 7 days)
A	Economy	$41.00	$30.00	$173.00
B	Compact 2/4-door	$46.00	$33.00	$191.00
C	Midsize	$51.00	$34.00	$201.00
D	Standard	$55.00	$36.00	$212.00
F	Fullsize 4-door	$59.00	$40.00	$229.00
G	Premium	$63.00	$43.00	$247.00
I	Towncar	$72.00	$72.00	$319.00
L	4WD/AWD SUV	$78.00	$78.00	$350.00
Q4	Midsize SUV	$73.00	$73.00	$325.00
R	Minivan 2WD	$78.00	$78.00	$350.00
T	Expedition or similar	$95.00	$95.00	$412.00
U	Convertible	$72.00	$72.00	$319.00

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

PARKING

Self-parking is complimentary to NSREC attendees in a covered, underground parking garage. Valet parking is $15.00 per day, chargeable to your room account.

Industrial Exhibits

John Jewell
Industrial Exhibits Chairman

The **NSREC 2008 Industrial Exhibits** will be located in the Tucson Ballroom begining at 10:00 AM on Tuesday and until 1:30 PM on Wednesday. It will feature the leading suppliers of radiation-hardened products, related materials, and services. The exhibit offers companies the opportunity to showcase their products, technologies, and services to key technical and management personnel associated with electronics used in space vehicles, military electronics, and applications requiring radiation tolerance in harsh environments. Attendees are encouraged to stop by and visit the vendors. Breaks will be held in the exhibitor areas on Tuesday and Wednesday.

A reception, hosted by the exhibitors and open to all conference attendees and their guests, will be held Tuesday evening and will feature complimentary beverages followed by a full dinner buffet.

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

For additional information, contact:

John Jewell
Sandia National Laboratories

Phone: 505-797-8846
Fax: 505-844-7210
Email: jewelljr@sandia.gov

Or contact us through the internet at: **www.nsrec.com/exhibit.htm**

EXHIBIT HALL HOURS

Tuesday, July 15	10:00 AM - 3:30 PM 6:00 PM - 10:00 PM *6:00 PM cocktails* *7:00 PM buffet* *9:00 PM Raffle drawing*
Wednesday, July 16	9:30 AM - 1:30 PM

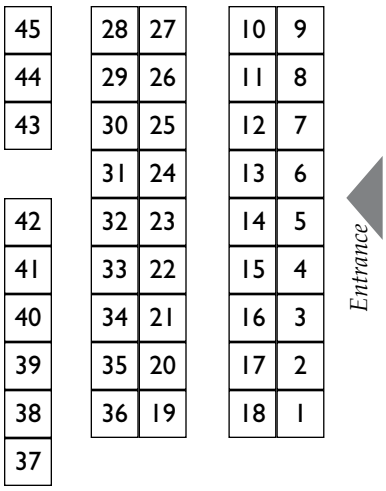
EXHIBITORS

Please check our web site (**www.nsrec.com**) for a current listing of companies exhibiting at 2008 NSREC.

Industrial Exhibits

NSREC INDUSTRIAL EXHIBITS

TUCSON BALLROOM



Company	Internet Site	Booth #
3D Plus - USA	www.3d-plus.com	41
Actel Corporation	www.actel.com	35, 36
Aeroflex Colorado Springs	www.aeroflex.com/radhard	44, 45
American Semiconductor	www.americansemi.com	33
Atmel	www.atmel.com	1, 2
BAE Systems	www.eis.na.baesystems.com	11
Boeing	www.boeing.com/SSED	14
Crane Aerospace & Electronics	www.craneae.com	27
Custom Test Systems	www.customtestsystems.net	16
Cyclotron Institute, Texas A & M University	cyclotron.tamu.edu/ref	32
Defense Microelectronics Activity (DMEA)	www.dmea.osd.mil	29
Honeywell	www.honeywell.com	21
International Rectifier	hirel.irf.com	6
Intersil Corporation	www.intersil.com	23
JD Instruments	jdinstruments.net	39
J. L. Shepherd & Associates	www.jlsheperd.com	28
Lawrence Berkeley	user88.lbl.gov	15
Maxwell Technologies	www.maxwell.com	26
Micropac Industries, Inc.	www.micropac.com	19
Micro-RDC	www.micro-rdc.com	10
Modular Devices Inc.	www.mdipower.com	22
NASA - NEPP	nepp.nasa.gov	5
National Reconnaissance Office	dii.westfield.net	7
National Semiconductor	www.national.com	31
New Mexico Tech /METTOP	www.emrte.nmt.edu	37
Northrop Grumman Corporation	www.northropgrumman.com	12
Nu-Trek	www.nu-trek.com	38
Peregrine Semiconductor Corp.	www.psemi.com	3
Radiation Assured Devices	www.radiationassureddevices.com	43
Raytheon Missile Systems	www.raytheon.com	17
Sandia National Laboratories	www.sandia.gov	9
Silvaco International	www.silvaco.com	8
Space Micro	www.spacemicro.com	20
Synopsys	www.synopsys.com	25
Synplicity	www.synplicity.com	34
Teledyne	www.teledynemicrotech.com	30
Texas Instruments	www.ti.com	42
Ultracomm	www.ultracomm-inc.com	40
Vanderbilt University - Institute for Space and Defense Electronics	www.isde.vanderbilt.edu	4
Viasic, Inc.	www.viasic.com	13
White Sands	www.wsmr.army.mil/capabilities/datts/testing/lab_fac/nucleareffectsfac.html	24
Xilinx	www.xilinx.com	18

2008 IEEE NSREC Technical Sessions and Short Course Registration Form

NSREC 2008 Tucson Arizona

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

☐ I am not a Member, but I wish to join the IEEE.

Non-members must register at the non-member rate.

CANCELLATIONS

A $25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 13, 2008 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.

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

ETC Services, Inc.
2254 Emerald Drive
Castle Rock, CO 80104

720-733-2003 **Fax: 720-733-2046**

REGISTRATION FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 13, 2008.

	Early	Late	
IEEE Member *			
Short Course	$250	$300	$_____
Technical Sessions	$400	$480	$_____
Non-IEEE Member			
Short Course	$315	$375	$_____
Technical Sessions	$500	$600	$_____
Full-Time Students who are IEEE Members *			
Short Course	$115	$300	$_____
Technical Sessions	$115	$480	$_____

TOTAL AMOUNT ENCLOSED: $_____

PAYMENT OF FEES

☐ Enclosed is a check or money order 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. _____ Expiration 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.

2008 IEEE NSREC
Activities Registration Form

NSREC 2008 Tucson Arizona

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*

_____
Name *Age*

CANCELLATIONS

To encourage advanced registration for conference social activities, we will refund all activity fees for conference attendees and/or their companions who for any reason are unable to attend the conference. If your plans change after this form is submitted and you would like to request a refund, you must notify ETC Services by email at etcservices@qwestoffice.net or FAX at 720-733-2046 no later than July 3 or notify the conference registration desk when picking up your registration materials (**but no later than 24 hours before the scheduled activity**).

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

ETC Services, Inc.
2254 Emerald Drive
Castle Rock, CO 80104

720-733-2003 **Fax: 720-733-2046**

ACTIVITY FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 13, 2008. 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.

	Early	Late	Number Attending	Total Cost
Tubac and San Xavier del Bac: *Tuesday, July 15*				
Adult	$24	$30	_____	$_____
Child (age 4-12)	$15	$20	_____	$_____
Child (age 0-3)	$0	$0	_____	
Industrial Exhibits Reception: *Tuesday, July 15*				
Adult/child	$0	$0	_____	
Pima Air & Space Museum: *Wednesday, July 16*				
Adult	$35	$45	_____	$_____
Child (age 4-12)	$15	$25	_____	$_____
Child (age 0-3)	$0	$0	_____	
Arizona-Sonoran Desert Museum: *Thursday, July 17*				
Adult	$35	$42	_____	$_____
Child (age 4-17)	$22	$27	_____	$_____
Child (age 0-3)	$0	$0	_____	
Stargazing: *Thursday, July 17*				
Adult/child	$5	$5	_____	$_____

TOTAL AMOUNT ENCLOSED: $_____

PAYMENT OF FEES

☐ Enclosed is a check or money order 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. _____ Expiration Date _____

Printed Name _____

Address _____

Address _____

Signature _____

Social Program

TUCSON, ARIZONA

"Welcome to the Old Pueblo! We hope that you enjoy the social program and the many unique attractions in Tucson and Arizona."

Bill Heidergott, General Dynamics, Local Arrangements Chairman

Cradled in the Tucson Mountains, the 575-room JW Marriott Starr Pass Resort & Spa is the newest Tucson resort to open in 18 years. Rich in culture, history and natural beauty, this area called Starr Pass is simply amazing. Featuring a 20,000 square foot spa, 27 holes of golf, seven dining options, and 88,000 square feet of indoor and outdoor event space, this Tucson resort encompasses everything you could need or want. No other Tucson resort compares. A fun-filled waterpark, including a lazy river and 100' waterslide, has recently opened as an exciting complement to the Marriott's adult, children and spa pools.

The Hashani Spa at Starr Pass offers a host of unique treatments that combine the latest beauty and health technology with ancient healing techniques in a luxurious, pampering environment. A spiral staircase leads guests to the three-level, 20,000 square foot retreat, complete with separate lounges for men and women. On the second level, you'll find the Pilates studio, cardiovascular circuit and weight-training equipment, and dramatic floor-to-ceiling views of the valley. There's a movement studio, private spa pool, whirlpools, and steam rooms. The many spa services range from classic massage to treatments that incorporate desert botanicals and draw their inspiration from century-old healing practices. Don't miss the al fresco dining and a fresh, creative meal at the Spa's café, Blossom.

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

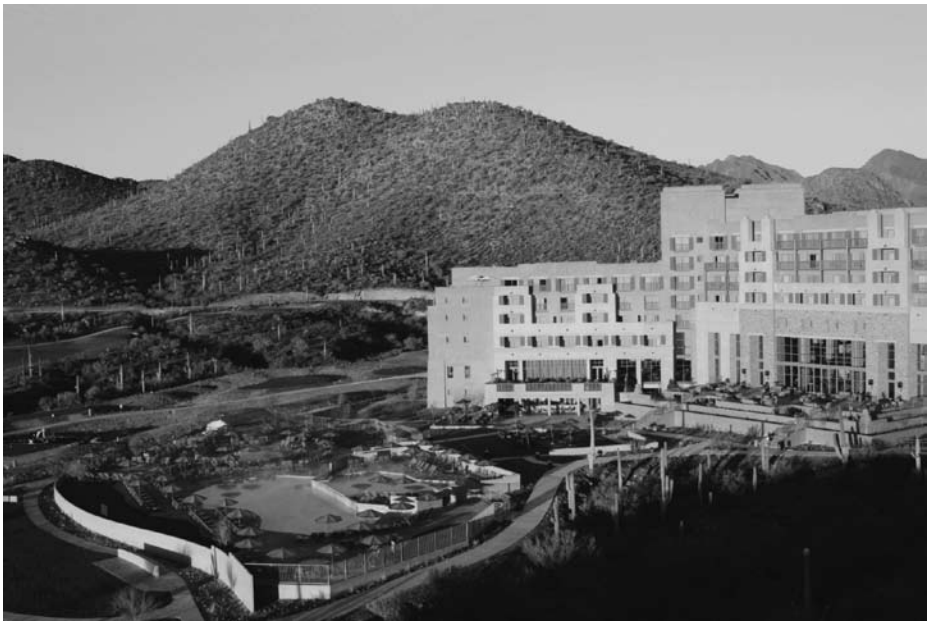


Photo: courtesy of JW Marriott Starr Pass Resort

SUNDAY, JULY 13
5:00 PM TO 7:00 PM
SHORT COURSE RECEPTION

Please join us for light refreshments in the Tucson Ballroom from 5:00 PM to 7:00 PM. The registration desk will be open from 5:00 PM to 9:00 PM. This will be a good time to meet old friends and renew old acquaintances!

Social Program

TUESDAY, JULY 15
9:00 AM TO 3:30 PM
TUBAC AND
SAN XAVIER DEL BAC

The early Spanish missionaries built adobe chapels and missions throughout Mexico, which at that time, included Arizona. Several fine architectural examples can be visited but the best of them is Mission San Xavier del Bac, located very close to Tucson. Fondly referred to as the "White Dove of the Desert," this active Franciscan mission is considered to be the finest example of Mission architecture in the U.S. You'll have a chance to visit this mission on the way to Tubac.

Photo: courtesy of Tucson Visitors Bureau

The Presidio San Ignacio de Tubac was founded in June of 1752, after a major battle with the Pima Indians. The fifty cavalrymen garrisoned at this remote military post were stationed there to prevent further rebellion, protect colonists and the mission, and further explore the Southwest. Today, working artist studios surround the grounds that once served as the home for the military garrison. Scenic high-desert vistas surround Tubac and the slightly higher altitude provides a cooler climate than in Tucson. This positively affects the economy of more than 90 businesses that are housed among the charming, meandering streets. Art galleries, artist studios and gift shops include such items as silk screened fabrics, copper fountains, paintings, sculpture, pottery, etchings, basketry, complex beading, ethnic art and much more. Numerous restaurants offer varied and delicious cuisine for lunch, on your own.

You may also choose to explore the ruins of the Spanish Colonial fort including archaeological finds. The Visitor's Center at the Presidio offers historic exhibits tracing Tubac's past from the days of the Apache raids to Arizona's statehood. This excursion includes transportation, self-guided tour of San Xavier del Bac, and time to explore (sightsee, shop, dine, etc.) in Tubac. It does not include the nominal entry fee to the Presidio (approximately $3.00). Strollers can be put in the luggage compartment of the motorcoach. Please remember to wear comfortable walking shoes and light, summer clothes. And bring your water. Buses depart from Starr Circle.

TUESDAY, JULY 15
6:00 PM TO 10:00 PM
INDUSTRIAL EXHIBITS
RECEPTION

6:00 PM COCKTAILS
7:00 PM BUFFET

A Tuesday night reception will be hosted by the NSREC exhibitors. Along with meeting representatives from leading companies in the radiation-hardening industry, NSREC attendees and their guests can enjoy complimentary food and drinks. Visit the exhibits and any registered technical attendee can participate in the booth raffles. **NOTE: Children under 16 must be accompanied by an adult in the Exhibits.**

Social Program

WEDNESDAY, JULY 16
5:30 TO 10:30 PM
PIMA AIR & SPACE MUSEUM

Photo: courtesy of Pima Air & Space Museum

Photo: courtesy of Pima Air & Space Museum

This year's NSREC social will be held at the Pima Air & Space Museum, one of the largest aviation museums in the world. The Museum collection includes more than 275 aircraft and spacecraft from around the globe, including many rare and one-of-a-kind aircraft and more than 125,000 artifacts.

Buses will begin departing from Starr Circle at the JW Marriott on Wednesday at 5:30 PM. Upon arrival at the Air & Space Museum, tour guides will board the buses to provide an approximately twenty minute introduction to the facility and tour of the outside aircraft and exhibits. From giant B-52's to the rare and unusual, such as the "Super Guppy" transport plane, you'll see virtually every aircraft used in the Korean War and Vietnam, including a collection of MiG jet fighters, as well as modern combat aircraft still in use by today's military. "Airliner Row" displays airliners from around the globe as well as many noteworthy commercial and civil aviation aircraft.

Photo: courtesy of Pima Air & Space Museum

On completion of the outside exhibits tour, we will disembark in the area of Hangar 1, location of the event reception. Hangar 1 features a full-scale replica of the Wright Flyer, the first aircraft to achieve successful powered flight, as well as numerous vintage and modern aircraft, both civil aviation and military. The Spirit of Freedom Hangar houses the more rare and important aircraft in the Museum's collection, including the Lockheed SR-71 "Blackbird", the only remaining Martin PBM-5A "Mariner", and the very rare North American F-107. Hangar 1 also has several hands-on activities for children, including a cockpit they can climb into and work the flight controls, and a Control Tower where they can turn on runway lights and listen to radio transmissions.

Hors d'oeuvres and refreshments will be served while we have the opportunity to explore the museum exhibits. The 390th Memorial Museum features a beautifully restored B17G 'Flying Fortress' named "I'll Be Around"; the 390th Museum is dedicated to preserving the rich heritage of the aircrews, ground crews, staff and commanders of the 390th Bombardment Group. A limited number of trams will be available for those interested in specific outside exhibits. Docents will be available in all hangar location to provide descriptive information and answer questions.

Music and dinner will be held in Hanger 4 with the opportunity to socialize and dance afterwards. This hangar features many World War II exhibits, including the centerpiece, a beautifully restored B-29 Superfortress.

Buses will begin returning to the JW Marriott at 9:00 PM, with the last bus departing at 10:00 PM. Strollers can be taken on the bus and the museum is "stroller and wheelchair friendly." A limited number of wheelchairs and strollers are available at the museum free of charge (on a first come – first served basis). Dress is casual, activities are both indoors and outside during early evening sun; comfortable walking shoes are recommended. There are no restrictions on photography – bring your camera.

Social Program

THURSDAY, JULY 17
6:45 AM TO 11:45 AM
ARIZONA-SONORA DESERT MUSEUM

Photo: courtesy of Elaine Bean

In the heart of the Sonoran Desert, the Arizona-Sonora Desert Museum is a world-renowned zoo, natural history museum and botanical garden…all in one place. For half of a century, this museum has fascinated visitors with its exhibits of live animals, recreating the desert so realistically that you find yourself eye-to-eye with mountain lions, prairie dogs, Gila monsters and more. Within the museum grounds, you'll see over 300 animal species and 1200 kinds of plants. There are almost two miles of paths traversing 21 acres of beautiful desert.

On arrival, docents will provide a get-acquainted tour of the facility before you venture off to explore on your own.

In order to have the best opportunity to see the live animals in this almost-natural habitat, this tour will depart the hotel early in the day, before the sun becomes too hot.

Excursion includes transportation, admission to the museum, docent-guided tour and a box breakfast to enjoy on the way to the museum! Strollers and wheel chairs are available at the museum free of charge (first come-first served basis). Find these at the entrance. Strollers can be placed in the luggage compartment of the motorcoach. Please remember to wear comfortable walking shoes and light, summer clothes although there is an outside chance you might need a very light wrap in the early morning hours. Buses depart from Starr Circle.

THURSDAY, JULY 17
9:30 PM TO 11:30 PM
ARIZONA STARGAZING

There is no better place than southern Arizona to view the wonders of the night sky. Many people have never looked through a telescope or some have not even seen dark, evening skies littered with stars. The experience will be a very memorable one for you!

State-of-the-art telescopes provide a window to the universe and bring otherwise invisible celestial objects into plain view with incredible detail. Unfortunately, there will be an almost-full moon on this night so you won't be able to see the galaxies beyond our own Milky Way, but the astronomers believe that you should be able to clearly see: our Moon, Jupiter and its four moons, the Hercules Star cluster (the best globular cluster in the sky), Albierio (colorful double star), and the Dumbell and Ring nebulas (gas clouds in space.)

Stargazing will take place on the hotel grounds. The Tucson Amateur Astronomy Association services this special event and their astronomers will be available to answer questions, point you in the right direction, and explain the mysteries of this night's skies. Due to the length of daylight during this time of year, this event will not be able to begin until 9:30 PM.

AEROBICS

Get a healthy start on your day with Dave Bushmire, our own certified aerobics instructor. These sessions will take place outside on the Ania Terrace at 6:30 - 7:30 AM, Tuesday, Wednesday, and Thursday.

ACTIVITIES CANCELLATION POLICY

To encourage advance registration for conference social activities, NSREC will refund all activity fees for conference attendees and companions who for any reason are unable to attend the conference. If your plans change after your activities registration form is submitted, simply request a refund by notifying ETC Services by fax or e-mail no later than July 3, 2008. Fax: 720-733-2046. E-mail: **etcservices@qwestoffice.net**.

Local Activities

GENERAL INFORMATION

The city of Tucson is 2,389 feet above sea level and covers nearly five-hundred square miles. The landscape is varied and includes flowering desert, rolling hills, winding dry riverbeds, rugged canyons and pine-topped peaks, all beneath a clear, blue sky. Scenery on the sixty-minute drive from downtown Tucson to the top of the highest mountain peak, Mt. Lemmon (9,157 ft), is like what you'd see on a trip from Mexico to Canada. The spectacular skyline features the Rincon, Santa Catalina, Tucson, Santa Rita, and Tortolita mountain ranges. Tucson was formally founded in 1775, about the time the nation's forefathers were signing the Declaration of Independence. Locally, the city is still called the Old Pueblo for the adobe fortress or "presidio" that marked its early borders. Over the past three centuries, Tucson has grown from a Native American farming community, to Spanish outpost, to dusty frontier town, to bustling territorial days' railroad hub, to today's Southwestern metropolis of a million people.

KARTCHNER CAVERNS STATE PARK

One of the great natural wonders of the western United States; it's believed that no human had ever seen this huge living cave prior to its discovery in the 1970s by two Tucson cave enthusiasts. This is remarkable because it is a "wet" or "living" cave, meaning the calcite formations are still growing. The Rotunda/Throne Room Tour is available year-round, leaving every twenty minutes; the approximate one-half mile tour lasts one and a half hours. On this tour you will discover the role water has played in the creation of Kartchner Caverns. You will see some of the tiniest, most delicate formations found in the cave, as well as the largest column in Arizona. This tour includes an up-close look at the variety of formations and colors that makes this cave one of the top ten in the world. Unfortunately, the Big Room Tour is not available at the time of the conference. All tours are guided by a trained tour guide; reservations are strongly recommended and can be made by calling: 520-586-CAVE. The cave averages 68 °F and 98% humidity year round. All cave trails are barrier-free. Due to wet surfaces and changes in grades, strollers and walkers are not allowed on the tours. **www.pr.state.az.us/Parks/parkhtml/kartchner.html**

Photo: courtesy of Tucson Visitors Bureau

Local Activities

KITT PEAK NATIONAL OBSERVATORY

Photo: courtesy of Tucson Visitors Bureau

Kitt Peak National Observatory (KPNO), part of the National Optical Astronomy Observatory (NOAO), supports the most diverse collection of astronomical observatories on earth for nighttime optical and infrared astronomy and daytime study of the sun. Founded in 1958, KPNO, located 56 miles southwest of Tucson, is home to twenty-four optical and two radio telescopes representing eight astronomical research institutions. The Kitt Peak National Observatory Visitor Center is open to the public daily from 9:00 AM to 3:45 PM; guided tours are offered daily at 10:00 AM, 11:30 AM, and 1:30 PM. **www.noao.edu/kpno/**

DEGRAZIA GALLERY / EXHIBIT

Photo: courtesy of Tucson Visitors Bureau

The work of renowned Tucson artist, the late Ted DeGrazia, portrays Native Americans of the Sonoran Desert in all aspects of daily life. He designed, built, and lived at the chapel and art gallery complex. This eclectic, rustic chapel is covered with the artist's murals. The nearby gallery houses many of DeGrazia's personal favorites. A new exhibition of sketches by the artist includes more than 50 black-and-white drawings of daily life he witnessed during his frequent trips to Mexico.

GOLF

The Tucson climate and outstanding courses make Tucson a favorite golf destination. Get an early tee time to avoid the heat and experience designs by Robert Trent Jones Jr., Tom Fazio, Tom Weiskopf and Jack Nicklaus at reduced summer rates.

Photo: courtesy of Tucson Visitors Bureau

SHOPPING

There are many fine shopping opportunities in Tucson and Southern Arizona, from bustling contemporary malls to south-of-the-border souvenir stands, with quaint plazas, specialty boutiques, antique stores, and artisan galleries. The Tucson area is one of the country's major centers of Native American culture, with many shops specializing in indigenous works of art. The more than 100 eclectic boutiques, galleries, and restaurants of the Fourth Avenue Shopping District and Old Town Artisans, numerous malls in the Tucson area, and convenient day trips to Tubac, Nogales, and Tombstone provide ample opportunity for shopping activity.

Local Activities

TOMBSTONE

Photo: courtesy of Tucson Visitors Bureau

"The town too tough to die" has charming architecture, quaint wooden sidewalks, and many original buildings. Tombstone was perhaps the most renowned of Arizona's old mining camps. The days of lawlessness and violence that nearly led to martial law and military troops in Tombstone, climaxed with the infamous Earp-Clanton battle, fought near the rear entrance of the O.K. Corral, on October 26, 1881. Over the course of seven years the mines produced millions of dollars in silver and gold before rising underground waters forced suspension of operations. Truly a historic American landmark, Tombstone is America's best example of our 1880 western heritage, which is well preserved with original 1880's buildings and artifacts featured in numerous museums. Just outside of town is the original Boothill Graveyard, containing about 250 grave markers, many with gunslinger's interesting epitaphs. See daily re-enactments of the shoot-out staged at the real O.K. Corral, and other live action, and tour the Crystal Palace Saloon, Big Nose Kate's Saloon, and Bird Cage Theatre. **www.cityoftombstone.com**

OLD TUCSON STUDIOS

Photo: courtesy of Tucson Visitors Bureau

A working movie set originally built for the 1939 Western epic *Arizona*, the theme park is a re-creation of an 1880's frontier town with period townsfolk. Old Tucson Studios, an active film set whose credits include some of Hollywood's biggest westerns, features film and television shoots throughout the year along with a full array of daily live entertainment and attractions including high-flying stunt shows, blazing gunfights and rip-roaring saloon musicals. Enjoy trail rides, historic studio tours, unique shopping, rides for the whole family, and the famous Reno locomotive. The Old West comes alive through the efforts of entertainers and tour guides; you won't find more rugged gunslingers or more beautiful dance-hall girls anywhere in the West!

TITAN MISSILE MUSEUM

The world's only ballistic missile museum, the former Titan II missile silo belonged to the 571st Strategic Missile Squadron of the 390th Strategic Missile Wing. Tours include a six-story view of the Titan II missile in its silo, a visit to the underground launch control center, and a simulated missile launch. Walking shoes are required, no heels please, food and beverages, except bottled water, are prohibited.

Photo: courtesy of Tucson Visitors Bureau

WEATHER AND CLOTHING

Tucson averages a high of 99 °F (37 °C) and a low of 74 °F (23 °C) during the month of July. Average rainfall in Tucson is 11.7 inches, 4.6 of which typically falls during the monsoon season of July and August. Scheduling and planning of local activities should include consideration of the daytime temperatures, including appropriate clothing and drinking plenty of water if you will be outside for an extended period of time.

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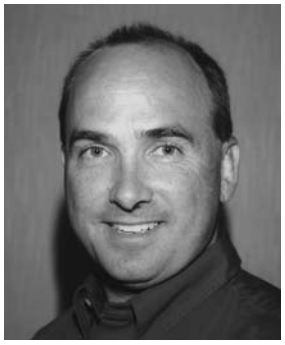

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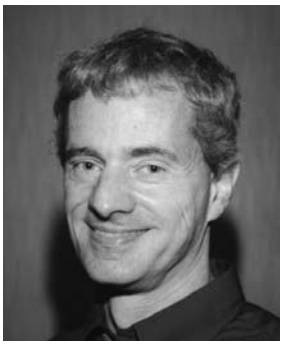

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ANNOUNCEMENT and FIRST CALL FOR PAPERS

2009 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE

Short Course and Radiation Effects Data Workshop

July 20 - 24, 2009
Hilton Québec
Québec City, Québec, Canada

www.nsrec.com

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The 2009 IEEE Nuclear and Space Radiation Effects Conference will be held July 20 - 24 in Québec City, Canada at the Hilton Québec. 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 20, a Radiation Effects Data Workshop, and an Industrial Exhibit. The Technical program includes oral and poster sessions.

Papers describing 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
- Ionizing Radiation Effects
- Materials and Device Effects
- Displacement Damage
- Single-Event Charge Collection Phenomena and Mechanisms
- Radiation Transport, Energy Deposition and Dosimetry
- Processing-Induced Radiation Effects

Radiation Effects on Electronic and Photonic Devices and Circuits
- 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
- Cryogenic or High Temperature Effects
- Single-Event 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
- Soft Error Rates (SER)

Hardness Assurance Technology and Testing
- Testing Techniques, Guidelines and Hardness Assurance Methodology
- Radiation Exposure Facilities
- Dosimetry

New Developments of Interest to the Radiation Effects Community

PAPER SUMMARY DEADLINE: FEBRUARY 6, 2009

PROCEDURE FOR SUBMITTING SUMMARIES

Authors must conform to the following requirements:

1. Prepare a single Adobe Acrobat file (maximum 5 pages) consisting of (a) an abstract no longer than 35 words on the first page, followed by (b) an informative **two to four page summary** describing results appropriate for 12-minute oral or a poster presentation. On the first page, please include 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.
2. 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 (one additional page is allowed for the 35-word abstract). *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.**
3. Prepare your summary in single-column format, using 11 point or greater font size, formatted for either U.S. Standard (8.5 x 11 inch) or A4 (21 x 29.7 cm) page layout, with 1 inch (2.5 cm) margins on all four sides.
4. Obtain all corporate, sponsor, and government approvals and releases necessary for presenting your paper at an open-attendance international meeting.
5. Summary submission consists of an Author Information Form and a PDF-format copy of the four-page summary. Submission is electronic only, through **www.nsrec.com**. Details on the submission process may be found at **www.nsrec.com**. *Authors are requested to state their preference for presentation (oral, poster, or data workshop poster) and for session.* However, the final category of all papers will be determined by the Technical Program Committee, which is responsible for selecting final papers from initial submissions.

Summaries must be received by February 6, 2009

Detailed submission and formatting instructions will be available after January 4, 2009 at www.nsrec.com

Papers accepted for oral or poster presentation at the technical program will be eligible for publication in the Conference issue of the *IEEE Transactions on Nuclear Science* (December 2008), based on a separate submission of a complete paper, and subject to an independent review after the Conference. 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 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*.

QUÉBEC CITY, QUÉBEC, CANADA

Photo: Courtesy of Hilton Québec

NSREC 2009 will be held at the Québec City Convention Centre in Québec City, Québec, Canada. The conference hotel will be the Hilton Québec which is connected by indoor walkways to the convention centre and a concourse of shops. All rooms feature a spectacular view of the city. Québec City is the capital of the Canadian province of Québec. Québec City's Old Town is the only North American fortified city north of Mexico whose walls still exist, and was declared a World Heritage Site by UNESCO in 1985 as the "Historic District of Old Québec." It is also one of the oldest cities in North America. Québec City is internationally known for its Summer Festival, Winter Carnival and the Château Frontenac, a historic hotel which dominates the city skyline. The chief of Parliament, the National Assembly of Québec, the National Museum of Fine Arts and the Museum of Civilization are found within or near Québec City's Old Town. Among the tourist attractions near the city are Montmorency Falls, the Basilica of Sainte-Anne-de-Beaupré in the town of Sainte-Anne-de-Beaupré, and the Île d'Orléans. Conference attendees and companions will enjoy this historic city's European nature, culture, and fine food. For more information on Québec City, visit **www.quebecregion.com**; for additional information on the Hilton Québec City, visit **www.hiltonquebec.com**.

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NSREC 2008 Tucson Arizona

DIRECTIONS FROM TUCSON AIRPORT TO JW MARRIOTT STARR PASS RESORT & SPA

Tucson is undergoing major Interstate freeway construction through 2010. Therefore we are providing two sets of directions. Average travel time is 20 minutes. ROUTE A uses the Interstate, which may have major delays. ROUTE B uses main city streets.

ROUTE A
> North on Tucson Blvd.
> Left on Valencia Rd.
> Right onto I-19 Freeway north
> Exit at Starr Pass Blvd./22nd St.
> From ramp, left on Starr Pass Blvd.
> Starr Pass Blvd. ends at hotel

ROUTE B
> North on Tucson Blvd.
> Left on Valencia Rd.
> Right on Campbell Ave.
> Left on 22nd Street, which becomes Starr Pass Blvd.
> Starr Pass Blvd. ends at hotel