

43rd
ANNUAL
INTERNATIONAL
NUCLEAR & SPACE
RADIATION
EFFECTS
CONFERENCE



NSREC 2006
Ponte Vedra Beach

July 17 ~ 21, 2006
Sawgrass Marriott Resort & Spa, Florida

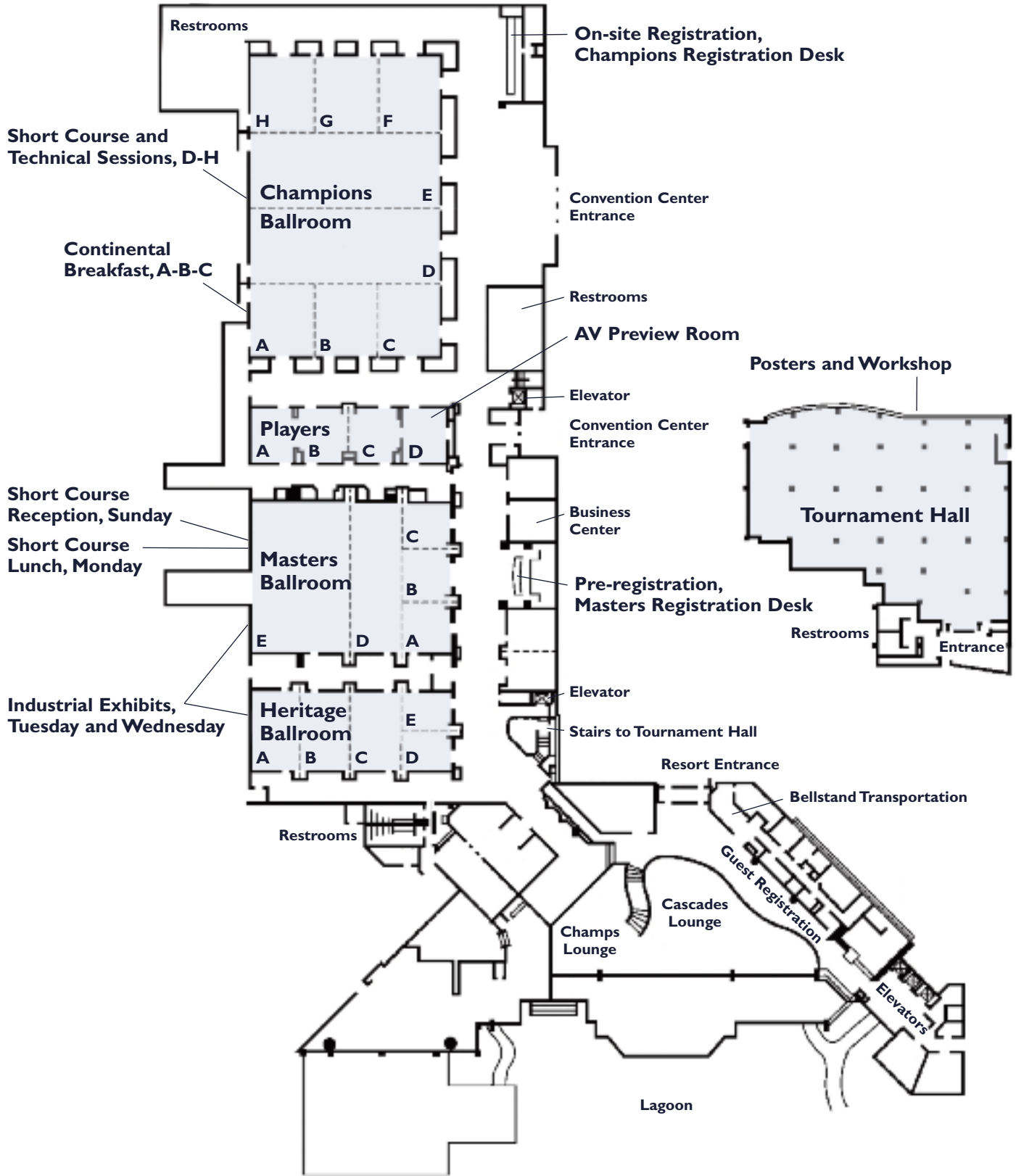


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IEEE/NPSS
Radiation Effects Committee

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Defense Threat Reduction Agency
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and Packaging Program

Conference Facilities

Sawgrass Marriott Resort & Spa



Schedule

Time	Monday July 17	Tuesday July 18	Wednesday July 19	Thursday July 20	Friday July 21
7:30	[7:30] Continental Breakfast, Champions Ballrooms A-C	[7:30] Continental Breakfast, Champions Ballrooms A-C	[7:30] Continental Breakfast, Champions Ballrooms A-C	[7:30] Continental Breakfast, Champions Ballrooms A-C	[7:30] Continental Breakfast, Champions Ballrooms A-C
8:00	[8:00] Short Course Introduction Dr. Robert Reed Champions Ballrooms D-H				
8:15	[8:15] Part 1 – Modeling the Space Radiation Environment Dr. Mike Xapsos	[8:15] Conference Opening Champions Ballrooms D-H	[8:15] Announcements [8:20] Session E Single-Event Effects: Devices and Integrated Circuits Champions Ballrooms D-H	[8:15] Invited Talk Reinventing CMOS to Stay on Moore's Law Dr. Theodore Dellin Champions Ballrooms D-H	[8:15] Invited Talk Gravity Probe B: Testing Einstein at the Limits of Engineering Dr. William J. Bencze Champions Ballrooms D-H
8:30					
9:00		[8:55] Session A Hardness Assurance			
9:30				[9:15] Announcements [9:20] Session G Basic Mechanism of Radiation Effects	[9:15] Data Workshop Tournament Hall
10:00	[9:45] Break, Champions Ballrooms A-C	[9:45] Break, Masters and Heritage Ballrooms	[9:55] Break, Masters and Heritage Ballrooms	[9:55] Break, Champions Ballrooms A-C	
10:30	[10:15] Part 2 – Space Radiation Transport Models Dr. Giovanni Santin	[10:15] Session B Radiation Effects in Devices and Integrated Circuits	[10:25] Session E (continued)	[10:25] Session G (continued)	
11:00			[10:55] Session F Space and Terrestrial Environments		
11:30					
12:00	[11:45] Short Course Luncheon, Masters Ballroom	[11:50] Lunch	[12:00] Lunch	[12:10] Lunch	[11:45] End of Conference
12:30					
1:00	[1:00] Part 3 – Device Modeling of Single Event Effects Prof. Mark E. Law	[1:20] Session C Single-Event Effects: Mechanisms and Modeling	[1:30] Invited Talk Hurricane Emergency Preparedness and Restoration Response James R. Timberlake	[1:40] Session H Dosimetry and Facilities	
1:30					
2:00					
2:30	[2:30] Break, Champions Ballrooms A-C	[2:40] Break, Masters and Heritage Ballrooms	[2:35] Poster Session Tournament Hall		
3:00	[3:00] Part 4 – Circuit Modeling of Single Event Effects Jeff Black and Dr. Tim Holman	[3:10] Session C (continued)		[3:00] Break, Champions Ballrooms A-C	
3:30				[3:30] Session I Photonic Devices and Integrated Circuits	
4:00		[4:10] Session D Hardness by Design			
4:30	[4:30] Wrap-up			[4:35] End of Session	
5:00	[4:45] Exam (for students requesting CEU credit only)				
5:30	[5:15] End of Short Course	[5:15] End of Session	[5:05] End of Session		[5:15 to 6:30] Radiation Effects Committee Open Meeting, Champions Ballrooms D-H
6:00		[6:00 to 10:00] Industrial Exhibits Reception 6:00 Cocktails 7:00 Buffet Heritage and Masters Ballrooms	[6:00 to 10:00] Conference Social A Taste of Florida Dinner and Entertainment 6:00 Cocktails 6:45 Dinner		
6:30					
7:00					

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Chairman's Invitation



NSREC 2006
Ponte Vedra Beach



*"Welcome to Ponte Vedra Beach!
Many thanks to the volunteers,
authors, exhibitors, and attendees
who have made the IEEE NSREC
a "must attend" for those working
in the field of radiation effects."*

Janet Barth
General Chairman

On behalf of the IEEE Nuclear and Plasma Sciences Society Radiation Effects Committee, I invite you to attend the 43rd annual IEEE Nuclear and Space Radiation Effects Conference (NSREC). This year's conference will be held at the Sawgrass Marriott Resort and Spa in Ponte Vedra Beach, Florida, July 17-21, 2006. We will continue the tradition of previous NSRE Conferences by offering an outstanding technical program, a one-day Short Course preceding the technical program, a Radiation Effects Data Workshop, and an Industrial Exhibit. Engineers, scientists, managers, and other interested parties from around the world will attend. Some highlights of the Conference are given below; complete details are provided in this booklet. Additional information on the conference is available on the Web at www.nsrec.com.

The Technical Program Chairman, Gary Lum (Lockheed Martin), and his program committee, have assembled an excellent set of contributed papers that are arranged into nine sessions of oral and poster papers, and a Radiation Effects Data Workshop. The Workshop consists of papers emphasizing radiation effects data on electronic devices and systems and descriptions of new simulation and radiation test facilities. In addition, there are three outstanding invited talks of general interest to both conference attendees and their companions.

Robert Reed (Vanderbilt University) has organized this year's Short Course with a theme of "Modeling the Space Radiation Environment and Effects on Microelectronic Devices and Circuits". The 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. The Short Course will start with Monday morning sessions devoted to the methods used to predict the Space Radiation Environment and Modeling the Basic Interactions of Radiation with Matter. The two talks in the afternoon will focus on Single Event Effects (SEE) modeling, the use of Technology Computer Aided Design (TCAD) tools and modeling Single Event Effects in Integrated Circuits. Attendees can earn Continuing Education Credits at the conclusion of the Short Course.

This year's Industrial Exhibit, organized by Richard Elmhurst (Honeywell), will facilitate one-on-one discussions between conference attendees and exhibitors on the latest developments in radiation-hardened and radiation-tolerant electronic devices, radiation analysis and testing services, and radiation test 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 radiation effects and to become better acquainted. Nick van Vonno (Intersil), this year's Local Arrangements Chairman, has put together an outstanding social program. The Wednesday evening social showcases Florida's varied food and culture. Attendees are invited to experience the sights, sounds, and tastes of Florida in an indoor setting at the Sawgrass Marriott Resort. While parents are dining and dancing, children can attend a parallel function at the hotel that will feature poolside games and "dive-in" movies. We strongly encourage you to register as soon as possible for the social events since some are limited in the numbers we can accommodate.

The Sawgrass Marriott Resort and Spa is a full service resort that includes the Marriott Beach Club a short distance away on the Atlantic Ocean. Guests who are registered at the Marriott also have access to the famous Sawgrass golf courses. Ponte Vedra Beach is located between Jacksonville and St. Augustine amid expansive beaches and salt-water marshes. The area is blessed with abundant natural parks with excellent bird watching and fishing. St. Augustine is the oldest continuously occupied city in the United States and features an authentic Spanish fort, the Castillo San Marcos. Within easy driving distance there are three outlet malls, Adventure Landing and Shipwreck Island Water Park, and Jacksonville Beach. The Orlando attractions and Cape Canaveral and the Kennedy Space Center are within driving distance and are great options for attendees and their families before or after the conference.

We are very excited about this year's conference and look forward to seeing you in Ponte Vedra Beach.

Short Course Program

MODELING THE SPACE RADIATION ENVIRONMENT AND EFFECTS ON MICROELECTRONIC DEVICES AND CIRCUITS

CHAMPIONS BALLROOMS D-H - MONDAY, JULY 17

- 7:30 AM **REGISTRATION/CONTINENTAL BREAKFAST**
- 8:00 AM **SHORT COURSE INTRODUCTION**
Dr. Robert Reed *Vanderbilt University*
- 8:15 AM **PART 1 – MODELING THE SPACE RADIATION ENVIRONMENT**
Dr. Mike Xapsos *NASA Goddard Space Flight Center*
- 9:45 AM **BREAK (CHAMPIONS BALLROOMS A-C)**
- 10:15 AM **PART 2 – SPACE RADIATION TRANSPORT MODELS**
Dr. Giovanni Santin *ESA/ESTEC*
- 11:45 AM **SHORT COURSE LUNCHEON (MASTERS BALLROOM)**
- 1:00 PM **PART 3 – DEVICE MODELING OF SINGLE EVENT EFFECTS**
Prof. Mark E. Law *University of Florida*
- 2:30 PM **BREAK (CHAMPIONS BALLROOMS A-C)**
- 3:00 PM **PART 4 – CIRCUIT MODELING OF SINGLE EVENT EFFECTS**
Jeff Black and Dr. Tim Holman *Vanderbilt University Institute for Space and Defense Electronics*
- 4:30 PM **WRAP-UP**
- 4:45 PM **EXAM (only for students requesting CEU credit)**
- 5:15 PM **END OF SHORT COURSE**

NOTE: All short course attendees will receive a special CD-ROM containing the complete notes from all previous NSREC short courses (1980-2006). The notes will be electronically searchable and will include all figures and text.

Short Course

COURSE DESCRIPTION

This one-day Short Course will provide a detailed discussion of the methods used by radiation effects engineers to model the space radiation environment and some of its effects on modern devices and circuits. The remarkable advances in modern device technology offers specific challenges for high-fidelity radiation effects modeling. These include the need for improved modeling of the variability of the space radiation environment, the transport of the environment through spacecraft structures and chip packaging, and detailed single event effects modeling at the device and circuit level.

Four talks on different aspects of the problem will be presented. The first talk will be given by Mike Xapsos, NASA expert in radiation environment modeling, and will focus on methods used to predict the space radiation environment. The second talk of the morning, given by Giovanni Santin, ESA expert in radiation transport, will focus on modeling the basic interactions of radiation with matter. The afternoon session will provide two talks focused on Single Event Effects (SEE) modeling. The first one will focus on the use of Technology Computer Aided Design (TCAD) tools, and will be given by Mark Law, leader in TCAD tool development. Jeff Black, Senior Engineer at the Institute for Space and Defense Electronics, will present the last talk of the day on modeling SEEs in integrated circuits.

Each attendee will receive a complimentary CD-ROM that contains an archive of IEEE Nuclear and Space Radiation Effects Conference (NSREC) Short Course Notebooks (1980-2006). This collection covers 27 years of one-day tutorial courses, presented yearly at NSREC. It serves as a valuable reference for students, engineers, and scientists.

CONTINUING EDUCATION UNITS (CEUs)

For those interested in Continuing Education Units (CEUs), 0.6 CEUs, endorsed by the IEEE and the International Association for Continuing Education and Training (IACET) will be available. The IEEE is an authorized CEU sponsor member of the IACET. IEEE guidelines for CEU credit will be followed. To qualify for CEU credit a person must be a registered attendee of the Short Course and must pass a written examination with a score of 75% or better. The examination will be given after the last segment of the Short Course. It will be open book, consisting of approximately 20 multiple-choice questions covering the material presented in the Short Course. A certificate of completion will be mailed to all students who request and qualify for it.

SHORT COURSE CHAIRMAN



*Dr. Robert Reed
Short Course Chairman*

Robert A. Reed received his M.S. and Ph.D. degrees in Physics from Clemson University in 1993 and 1994. After completion of his Ph.D. he 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 Goddard Space Flight Center where he supported NASA space flight and research programs. He is currently a Research Associate Professor at Vanderbilt University. His radiation effects research activities included topics such as single event effects and displacement damage basic mechanisms and on-orbit performance analysis and prediction techniques. He has authored over 70 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 involved in the NSREC community since 1992 serving as 2004 Finance Chairman, 2002 Poster Session Chairman, and 2000 Short Course Instructor.

Short Course Monday



Mike Xapsos is a research physicist in the Radiation Effects and Analysis Group at NASA Goddard Space Flight Center where he oversees its work on the space radiation environment. This involves developing models of the environment and using models and tools to determine radiation requirements for NASA missions. He is the Project Scientist for the Space Environment Testbeds (SET) Project and the Radiation Lead for the Solar Dynamics Observatory (SDO) Mission. Prior to joining NASA in 2001 he worked in the Radiation Effects Branch at the Naval Research Laboratory, where he also researched problems in device radiation physics. He holds a Bachelor's degree in physics and chemistry from Canisius College and a PhD degree in physics from the University of Notre Dame. He has held the position of Guest Editor for the IEEE Transactions on Nuclear Science, Technical Program Chairman for the IEEE Nuclear and Space Radiation Effects Conference, and is currently General Chairman for the Single Event Effects Symposium. He has published over 75 technical papers and holds one US patent.

MODELING THE SPACE RADIATION ENVIRONMENT

Dr. Mike Xapsos

NASA Goddard Space Flight Center

Dr. Mike Xapsos, NASA Goddard Space Flight Center, will discuss recent developments in modeling the trapped particle, galactic cosmic ray and solar particle radiation environments. The metrics for describing effects these radiations have on electronic devices and circuits will be introduced. This includes ionizing dose, displacement damage dose and linear energy transfer (LET). A substantial portion of the course will be devoted to the recent application of models for characterization of radiation environments. The origins of the methods will be described leading up to the environment applications. Comparisons with traditional models will be shown. Example results for different phases of the solar cycle and for missions ranging from low earth orbit out to interplanetary space will be presented.

Introduction

The Solar Activity Cycle

The Earth's Trapped Radiation Environment

- The Magnetosphere and Trapped Particle Motion
- Trapped Proton Models
 - AP-8
 - Recent Developments
- Trapped Electron Models
 - AE-8
 - Recent Developments

Galactic Cosmic Rays

- Background
- Models

Solar Particle Events

- Solar Proton Models
 - Distribution of Event Magnitudes
 - Cumulative Fluences
 - Worst Case Events
 - Self-Organized Criticality
- Solar Heavy Ion Models

Future Challenges

Short Course Monday



Giovanni Santin is an analyst in the Space Environments and Effects Analysis section at the European Space Agency (ESA / ESTEC) on loan from RHEA Tech Ltd for the support to ESA programmes. He is a specialist in radiation transport codes for Monte-Carlo simulations.

His current research interests are in development and use of radiation environment models, radiation effects modeling for manned and unmanned missions, radiation analysis engineering tools and radiation monitors.

He holds a Bachelor's degree in physics and a PhD degree in physics from the University of Trieste, Italy. Prior to joining ESA with RHEA in 2002 he worked on experimental particle physics at CERN for the University of Geneva and on medical physics at the University of Lausanne. In addition to his research in space environment, he is involved in medical physics research, mainly in developments for PET and SPECT and in dosimetry for radiation therapy.

SPACE RADIATION TRANSPORT MODELS

Dr. Giovanni Santin

ESA / ESTEC and Rhea System SA

Dr. Giovanni Santin, ESA / ESTEC, will provide a review of the physical interactions of the space radiation environment with matter and models used to compute the environment local to the microelectronic circuit. The first portion will be devoted to defining the important physical processes that must be included when modeling the transport of space radiation environment through spacecraft materials. Then he will provide an overview of the current techniques and tools that are available for transport modeling. The last portion will focus on the application and validation of GEANT4 for use in transport model of the space environment with an emphasis on effects on microelectronic devices.

Introduction

Space Radiation Transport: Physics

- Radiation Types
- In the Spacecraft / In the Devices
- Electromagnetic Interactions
- Nuclear Interactions
- Interplay of Processes

Transport Techniques

- Analytical / Monte Carlo
- Single Particle / Collective Effects
- Forward / Reverse
- Look-Up Tables / Sectoring

In Depth: Monte Carlo Techniques

- General Concepts
- Geometry / Physics
- Output: Tallies and Variance Reduction

Radiation Transport Tools

- History
- Present
- Future

Physics Validation for Space Environment Analyses

- The Case of GEANT4
- Basic Processes / Complex Set-Ups
- Nuclear Interaction Models
- Impact on Effects on Microelectronic Devices

Summary

Short Course Monday



Mark Law is a professor and chair of Electrical and Computer Engineering at the University of Florida. He received the B.S. Cpr.E. degree from Iowa State University in 1982 and the Ph.D. degree from Stanford University in 1988. His current research interests are in integrated circuit process modeling, characterization, and device modeling. Dr. Law was named a National Science Foundation Presidential Faculty Fellow in 1992, College of Engineering Teacher of the Year in 1996-97, and a UF Research Fellow in 1998. He was editor-in-chief of the IEEE Journal on Technology Computer Aided Design. He is currently the vice-president for technical activities of the IEEE Electron Device Society. He chaired the 1997 Simulation of Semiconductor Process and Devices Meeting, the 1999 and 2002 silicon front-end processing symposium of the Materials Research Society, the 2005 Ultra-Shallow Junctions workshop and chaired the 2000 International Electron Devices Meeting. He was named an IEEE Fellow in 1998 for his contributions to integrated circuit process modeling and simulation.

DEVICE MODELING OF SINGLE EVENT EFFECTS

Prof. Mark E. Law

University of Florida

Prof. Mark E. Law, University of Florida, will discuss using device and process simulation tools effectively to model single event upset behaviors. Modeling single event upset provides many challenges to TCAD tools. In this course, practical pitfalls will be described and techniques will be discussed to avoid these problems. Several issues can create problems. First, numerical approximations must be understood and controlled by the user. Second, the device geometry, doping, and materials need to be set up correctly. Third, physical transport models have specific limitations for application to single event simulations. Most TCAD models have been tuned to MOS device transport, and may not be appropriate for bulk charge removal in a single event case. A complex simulation example illustrating these points will be presented to help illustrate good practice.

Introduction to TCAD

- Model Hierarchy
- Common Classes of TCAD Tools

Numerical Approximations

- Time Discretization
- Spatial Discretization
- Current Flow Solutions

Physical Approximations

- Process Flow
 - Garbage In-Garbage Out
 - Junctions
 - Materials
 - Strain
- Device Approximations
 - Mobility
 - Quantum Effects
 - Energy and Temperature

Simulation Example

- Process Simulation - Structure and Issues
- Device Simulation
 - DC Tuning and Verification
 - SEU Simulation

Conclusions

Short Course Monday



Jeffrey D. 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 his MSEE at the University of New Mexico in 1991. He is currently pursuing his PhD at Vanderbilt University. Jeff's areas of specialty and interest are single event effects and mitigation approaches. Prior to joining ISDE in 2004, Jeff worked for Mission Research Corporation, now ATK Mission Research, in Albuquerque, NM. Jeff is just completing his three year term as Secretary of the Radiation Effects Steering Group. He has enjoyed serving the NSREC community in various positions.



Dr. W. Timothy Holman is a member of the Institute for Space and Defense Electronics and a research associate professor in the Department of Electrical and Computer Engineering at Vanderbilt University. His current research is focused on radiation effects in analog and mixed-signal circuits, and the design of radiation-hardened mixed-signal circuits in CMOS and BiCMOS technologies. In addition to his research, Dr. Holman has developed new methods for video-based delivery of educational material that are used to produce archival CD-ROM copies of the NSREC short course for attendees each year.

CIRCUIT MODELING OF SINGLE EVENT EFFECTS

Jeff Black and Dr. Tim Holman

Vanderbilt University Institute for Space and Defense Electronics

Jeff Black and Dr. Tim Holman, Vanderbilt University Institute for Space and Defense Electronics, will discuss the various tools currently available for simulating single event effects at the circuit level. Circuit level simulation can be performed more efficiently than TCAD simulation at a cost of reduced simulation fidelity. This course will provide an understanding of the circuit simulation fidelity and how to make use of the results in design and analysis tasks using modern technology. They will provide an overview of single event effects mechanisms with emphasis on the circuit structures responsible for charge generation. They will also provide a classification of circuit simulation tools and describe the simulation challenges and potential pitfalls. The bulk of the course will cover the tools available for circuit simulation, defining the circuits and stimulus inputs, setting up the simulations, and analyzing the results. An example of single event effects simulation will be shown on each class of circuit simulator.

Introduction

Fundamental Single Event Effects Overview

- Single Event Effects Mechanisms
- Single Event Effects Structures
- Circuit Simulation Responses
- Payoffs/Pitfalls of Circuit Modeling and Simulation

Transistor Level SEE Modeling and Simulation

- Available Tools and Capabilities
- Circuit Model Requirements
- Defining the Inputs
- Simulation Approaches and Results
- Example

Mixed-Mode SEE Modeling and Simulation

- Available Tools and Capabilities
- Breaking Up the Problem
- Simulation Approaches and Results
- Example

Behavioral Level SEE Modeling and Simulation

- Available Tools and Capabilities
- System Models
- Defining the Inputs
- Simulation Approaches and Results
- Example
- Summary

Summary

Technical Program

TECHNICAL INFORMATION



"The NSREC 2006 technical program committee has assembled an exemplary program of contributed papers describing the latest developments in nuclear and space radiation effects and captivating invited talks. I invite everyone to come and participate in this international program; to learn and discuss recent radiation effects developments with old and new technical colleagues."

Gary Lum, Lockheed Martin Space Systems Co., Technical Program Chairman

The NSREC technical program will consist of contributed oral and poster papers, three invited papers, and a 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:

- **Basic Mechanisms of Radiation Effects**
Chair: Andrea Cester, University of Padova, Padova, Italy
- **Dosimetry and Facilities**
Chair: Barbara Von Przewoski, Indiana University Cyclotron Facility, Bloomington, IN
- **Hardness Assurance**
Chair: Jerry L. Gorelick, Boeing Satellite Systems, Los Angeles, CA
- **Hardness By Design**
Chair: Bharat Bhuvu, Vanderbilt University, Nashville, TN
- **Photonic Devices and Integrated Circuits**
Chair: Kyle B. Miller, Ball Aerospace, Boulder, CO
- **Radiation Effects in Devices and Integrated Circuits**
Chair: James R. Schwank, Sandia National Laboratories, Albuquerque, NM
- **Single-Event Effects: Devices and Integrated Circuits**
Chair: John M. Baker, Lockheed Martin Space Systems Company, Sunnyvale, CA
- **Single-Event Effects: Mechanisms and Modeling**
Chair: Jacques Baggio, CEA, Bruyeres-le-Chatel, France
- **Space and Terrestrial Environments**
Chair: Joseph E. Mazur, The Aerospace Corporation, Chantilly, VA

POSTER SESSION

Papers that are most effectively presented visually with group discussion will be displayed as posters from 12:00 PM Tuesday, July 18 through 11:45 AM Friday, July 21. Authors will be available to discuss their work during the Poster Session Wednesday, July 19. The Poster Session Chair is Hugh J. Barnaby, Arizona State University, Tempe, Arizona.

RADIATION EFFECTS DATA WORKSHOP

Papers in the data 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 from 12:00 PM Tuesday, July 18, through 11:45 AM Friday, July 21. Authors will be available to discuss their work during the Data Workshop Session Friday, July 21 in Tournament Hall. A copy of the Workshop Record will be mailed to all registered attendees after the conference. The data workshop chair is David M. Hiemstra, MDA, Brampton, Ontario, Canada.

INVITED SPEAKERS

Dr. Theodore Dellin, Chief Scientist Emeritus of the Microsystems Center of Sandia National Laboratories, Albuquerque, NM; James R. Timberlake, Lead Power Quality Engineer at Progress Energy Corporation, Orlando, FL; Dr. William J. Bencze, Senior Research Engineer and Deputy Program Manager of Gravity Probe B Relativity Mission, Stanford University, Palo Alto, CA.

LATE-NEWS PAPERS

A limited number of late news papers will be accepted and included in the Poster Session and the Radiation Effects Data Workshop. The deadline for submission is June 2, 2006. Detailed instructions for submitting a late-news summary to the technical program committee are available on the NSREC website at www.nsrec.com.

Technical Program Tuesday

CHAMPIONS BALLROOMS D-H

8:15 AM

OPENING REMARKS

Janet Barth, NASA Goddard Space Flight Center, General Chairwoman

8:20 AM

AWARDS PRESENTATION

Ron Schrimpf, Vanderbilt University, Radiation Effects Steering Group Committee

8:50 AM

TECHNICAL SESSION OPENING REMARKS

Gary Lum, Lockheed Martin Space Systems Co., Technical Program Chairman

SESSION A

8:55 AM

HARDNESS ASSURANCE

SESSION INTRODUCTION

Chair: Jerry L. Gorelick, Boeing Satellite Systems

A-1
9:00 AM

Effects of Angle of Incidence on Proton-Induced Single-Event Latchup

J.R. Schwank, M.R. Shaneyfelt, J.A. Felix, P.E. Dodd, Sandia National Laboratories; J. Baggio, V. Ferlet-Cavrois, P. Paillet, S. Girard, CEA; G.K. Lum, Lockheed Martin Space Systems; E. Blackmore, TRIUMF

The effect of proton angle of incidence on single-event latchup hardness is investigated at room and elevated temperature. Angle of incidence can greatly impact proton SEL sensitivity. Possible mechanisms and hardness assurance implications are discussed

A-2
9:15 AM

Implications of Characterization Temperature on Hardness Assurance Qualification

M.R. Shaneyfelt, J.R. Schwank, P.E. Dodd, J.A. Felix, Sandia National Laboratories

Devices were irradiated at room temperature and electrically characterized post irradiation as a function of temperature. Some devices exhibited significantly more parametric degradation when characterized at temperature extremes. Hardness assurance implications are discussed.

A-3
9:30 AM

Real Time Rail Span Measurement Technique

P.R. Fleming, B.L. Bhuva, A.D. Tipton, Vanderbilt University

Rail span collapse is the dominant failure mechanism of CMOS circuits for dose rate exposures. A circuit that measures rail span and provides designers with critical margin of failure information is proposed.

POSTER PAPERS

PA-1

A Statistical Technique to Measure the Proportion of MBUs in SEE Testing

A. Chugg, M. Moutrie, R. Jones, A. Burnell, MBDA UK Limited

Neutron SEE data for memories shows that the distribution of MBU's is a geometrical progression. We demonstrate that this permits the proportion of MBU's to be calculated from the variance of the errors per read-cycle.

9:45 – 10:15 AM
MASTERS AND HERITAGE
BALLROOMS

BREAK

Technical Program Tuesday

SESSION B 10:15 AM **RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS** SESSION INTRODUCTION

Chair: James R. Schwank, Sandia National Laboratories

B-1 10:20 AM **Total Ionizing Dose Effects on Triple-Gate FETs**

M. Gaillardin, S. Cristoloveanu, IMEP-ENSERG; P. Paillet, CEA-DIF; V. Ferlet-Cavrois, CEA-DIF; O. Faynot, C. Jahan, CEA-LETI

Total ionizing dose effects are investigated for the first time on scaled triple-gate SOI transistors. Their radiation behavior is studied in devices with various geometries and hardness assurance implications are discussed.

B-2 10:35 AM **An Investigation of Dose Enhancement and Source Dependent Effects in 200 GHz SiGe HBTs**

A.K. Sutton, A.P. Gnana Prakash, B. Jun, E. Zao, R.M. Diestelhorst, G. Espinel, J.D. Cressler, Georgia Institute of Technology; M.A. Carts, A.M. Phan, Muniz Engineering; P.W. Marshall, Consultant to NRL; R.L. Ladbury, C.J. Marshall, NASA/GSFC; R.A. Reed, R.D. Schrimpf, D.M. Fleetwood, Vanderbilt University

Variations in the total dose tolerance of the emitter-base spacer and shallow trench isolation in 200 GHz SiGe HBTs are investigated using multiple radiation sources and dose rates. Significant differences are consistently observed.

B-3 10:50 AM **The Effects of Irradiation Temperature on the Proton Response of SiGe HBTs**

A.P. Gnana Prakash, A.K. Sutton, R.M. Diestelhorst, G. Espinel, J. Andrews, B. Jun, J.D. Cressler, Georgia Institute of Technology; P.W. Marshall, Consultant to NASA/GSFC; C.J. Marshall, NASA/GSFC

We compare the effects of 63 MeV protons on first-generation and third-generation SiGe HBTs irradiated at liquid nitrogen temperature (77°K) and at room temperature (300°K).

B-4 11:05 AM **Radiation and Bias Effects in Fully-Depleted and Partially-Depleted SiGe HBTs Fabricated on CMOS-Compatible SOI**

M. Bellini, B. Jun, T. Chen, J.D. Cressler, Georgia Institute of Technology; P.W. Marshall, Consultant to NASA/GSFC; D. Chen, R.D. Schrimpf, D.M. Fleetwood, Vanderbilt University; J. Cai, IBM Thomas J. Watson Research Center

Total ionizing dose effects in fully-depleted and partially-depleted SiGe HBT-on-SOI transistors are compared at room and at cryogenic temperatures. Collector and substrate bias affect the two-dimensional nature of current flow and avalanche multiplication across temperature.

B-5 11:20 AM **Radiation Response and Variability of Advanced Commercial Foundry Technologies**

J.A. Felix, P.E. Dodd, M.R. Shaneyfelt, J.R. Schwank, Sandia National Laboratories

The radiation hardness of nominally identical SRAMs fabricated in five commercial foundries is examined. Large variations in single-event latchup and total dose response are observed. Qualification and hardened-by-design integrated circuit implications are discussed.

Technical Program Tuesday

- B-6** **Impact of Heavy-Ion Strikes in Nanocrystal Non-volatile Memory Cell Array**
11:35 AM *A. Cester, A. Gasperin, A. Paccagnella, University of Padova; C. Gerardi, V. Ancarani, STMicroelectronics*

We present new results on heavy-ion irradiation of nanocrystal non-volatile prototype memory manufactured with chemical vapor deposition process. Despite the increase of tunnel oxide leakage current, small variations of memory cell retention time are measured.

POSTER PAPERS

- PB-1** **Temperature-Dependence of Gate-Induced Drain Leakage in X-Ray Irradiated 130 nm CMOS Devices**
B. Jun, R.M. Diestelhorst, M. Bellini, G. Espinel, A.P. Gnana Prakash, J.D. Cressler, Georgia Institute of Technology; D. Chen, R.D. Schrimpf, D.M. Fleetwood, Vanderbilt University

Gate-Induced Drain Leakage (GIDL) characteristics in 130 nm CMOS technology are investigated, using x-ray irradiation and operating temperature as variables. Radiation-induced traps strongly enhance off-state GIDL at 300°K, and cooling strongly suppresses radiation-induced GIDL.

- PB-2** **Proton Tolerance of SiGe Precision Voltage References for Extreme Temperature Range Electronics**
L. Najafzadeh, M. Bellini, G.A. Espinel, A.P. Gnana Prakash, J.D. Cressler, Georgia Institute of Technology; P.W. Marshall, Consultant to NASA/GSFC; C.J. Marshall, NASA/GSFC

We investigate the effects of proton irradiation on the performance of SiGe BiCMOS voltage references intended for extreme environment operational conditions and show that degradation due to proton irradiation is minor at cryogenic temperatures.

- PB-3** **SEE and TID Characterization of an Advanced Commercial 2Gbit NAND Flash Nonvolatile Memory**
T.R. Oldham, QSS Group, Inc/NASA/GSFC; R.L. Ladbury, K.A. LaBel, NASA/GSFC; M. Friendlich, H.S. Kim, M. D. Berg, T.L. Irwin, Muniz Engineering

An advanced commercial 2 Gbit NAND flash memory (90 nm technology, one bit/cell) has been characterized for TID and heavy ion SEE. Results are similar in some ways to previous flash results, but we also detected a new failure mode.

- PB-4** **Modeling Total-Dose Effects of a Low-Dropout Voltage Regulator**
V. Ramachandran, B. Narasimham, R.D. Schrimpf, W.T. Holman, D.M. Fleetwood, Vanderbilt University; A.F. Witulski, Institute for Space and Defense Electronics; R.L. Pease, RLP Research ; G. Dunham, J. Seiler, D. Platteter, NAVSEA Crane

Total ionizing dose effects in a low-dropout voltage regulator are examined based on experimental data and circuit simulations. Degradation in bandgap and op-amp circuit blocks in simulations emulates post-irradiation trends observed experimentally.

Technical Program Tuesday

PB-5 Analysis of Circuit Effect on the Total-Dose Response of a Linear Bipolar Comparator

M.F. Bernard, L. Dusseau, J. Boch, F. Saigne, J.-R. Vaille, CEM2 - UMR CNRS 5507, Universite Montpellier II; R.D. Schrimpf, Department of Electrical Engineering and Computer Science, Vanderbilt University; E. Lorfevre, Centre National d'Etudes Spatiales; J.-P. David, CERT/ONERA

Experimental results for devices irradiated biased and grounded exhibit two different total-dose responses that are characteristic of the circuit. A circuitry failure mechanism and layout elements are identified to justify this bias effect.

11:50 AM – 1:20 PM LUNCH

SESSION C SINGLE-EVENT EFFECTS: MECHANISMS AND MODELING

1:20 PM SESSION INTRODUCTION

Chair: Jacques Baggio, CEA

C-1 Statistical Analysis of the Charge Collected in SOI and Bulk Devices under Heavy Ion and Proton Irradiation

1:25 PM

V. Ferlet-Cavrois, P. Paillet, J. Baggio, D. Lambert, O. Faynot, C. Jahan, L. Tosti, CEA; J.R. Schwank, G. Vizkelethy, M.R. Shaneyfelt, Sandia National Laboratories; E.W. Blackmore, TRIUMF

A wide distribution of collected charge is measured on SOI and bulk devices under proton and heavy ion irradiation. The device geometry is shown to have a significant influence on the transistor response.

C-2 Digital Single Event Transient Pulse Generation and Propagation in Fast Bulk CMOS ICs

1:40 PM

M. Turowski, A. Raman, CFD Research Corporation (CFDRC); D. Mavis, P. Eaton, Microelectronics Research and Development Corporation (Micro-RDC)

Fully coupled mixed-mode simulation, as opposed to decoupled mixed-level modeling, is able to accurately predict generation and propagation of digital single event transient (SET) pulses in fast CMOS ICs and obtain agreement with measured data.

C-3 Charge Collection and Sharing in a 130nm CMOS Technology

1:55 PM

O.A. Amusan, L.W. Massengill, B.L. Bhuvu, P.R. Fleming, M.L. Alles, A.L. Sternberg, R.D. Schrimpf, Vanderbilt University; A.F. Witulski, J.D. Black, Institute for Space and Defense Electronics

Charge sharing between adjacent devices can lead to increased SEU vulnerability. Simulations are used to identify and quantify the effects of various mechanisms on charge sharing between multiple nodes. Mitigation layout guidelines are presented.

C-4 Multiple-Bit Upset in 130nm CMOS Technology

2:10 PM

A.D. Tipton, J.A. Pellish, R.A. Reed, R.D. Schrimpf, R.A. Weller, M.H. Mendenhall, Vanderbilt University; A.K. Sutton, R. Diestelhorst, G. Espinel, J.D. Cressler, Georgia Institute of Technology; P.W. Marshall, Consultant to NASA/GSFC; G. Vizkelethy, Sandia National Laboratories

A calculation of multiple-bit upset (MBU) cross section is presented for a 130nm CMOS technology. We show MBU increases with angle and the contribution of MBU to single-event upset can be significant.

Technical Program Tuesday

- C-5**
2:25 PM **Analysis of 45-nm Multi-Gate Transistors Behavior under Heavy Ion Irradiation by 3-D Device Simulation**
K. Castellani-Coulie, D. Munteanu, L2MP-University of Provence; J.-L. Aufran, L2MP-University of Provence, IUF; V. Ferlet-Cavrois, P. Paillet, J. Baggio, CEA/DAM/DIF
- The sensitivity to heavy ions of three 45-nm multi-gate transistors is evaluated by 3-D simulation. An in depth investigation of main internal parameters is performed to study the electrical response of the different device architectures.
- 2:40 – 3:10 PM
MASTERS AND
HERITAGE BALLROOMS **BREAK**
- C-6**
3:10 PM **A Physical Explanation of Very Low Cross Sections Near the Threshold LET: the Rutherford Diffusion**
F. Wrobel, P. Iacconi, University of Nice-Sophia Antipolis; G. Hubert, EADS-CCR
- We performed Monte-Carlo simulations based on both RPP and ambipolar diffusion models. Very low cross sections experimentally obtained near the threshold LET are attributed to the Rutherford diffusion which produce secondary ions with higher LET.
- C-7**
3:25 PM **SEU Error Signature Analysis of Gbit/s SiGe Logic Circuits Using a Pulsed Laser Microprobe**
A.K. Sutton, R. Krithivasan, J.D. Cressler, Georgia Institute of Technology; P.W. Marshall, Consultant to NRL; C. Seidleck, M.A. Carts, Muniz Engineering; S. Buchner, QSS Group Inc.; R.L. Ladbury, C.J. Marshall, NASA/GSFC; S. Currie, B. Randall, K. Fritz, B. Gilbert, The Mayo Foundation; R.A. Reed, Vanderbilt University; G. Niu, Auburn University; D. McMorrow, Naval Research Laboratory
- Analysis of error signatures of multi-Gbps bit error rate testing is employed to infer SEE sensitivity of circuits in first-generation SiGe technology. Strike locations, circuit architecture, and bias conditions are compared.
- C-8**
3:40 PM **The Effect of Negative Feedback on Single-Event Transient Propagation in Digital Circuits**
B. Narasimham, B.L. Bhuva, W. Holman, R.D. Schrimpf, L.W. Massengill, Vanderbilt University; A. Witulski, Institute for Space and Defense Electronics
- A Miller feedback mechanism that affects the minimum pulse width needed for SET propagation is identified. This effect increases the critical charge required for propagation by 30%, thereby reducing the estimated error rate.
- C-9**
3:55 PM **Secondary Effects of Single Ions on Floating Gate Memory Cells**
G. Cellere, A. Paccagnella, DEI, Padova University; A. Visconti, M. Bonanomi, STMicroelectronics; A. Brianza
- A programmed Floating Gate (FG) hit by a heavy ion experiences large charge loss. In most modern technologies even a FG not direct hit can experience degradation of the stored information, with peculiar characteristics.

Technical Program Tuesday

POSTER PAPERS

PC-1 Substrate Engineering and Charge Collection Mitigation in Deep Trench Isolation Devices

J.A. Pellish, R.A. Reed, M.L. Alles, R.D. Schrimpf, R.A. Weller, M.H. Mendenhall, E.J. Montes, Vanderbilt University; M. Varadharajaperumal, G. Niu, Auburn University; A.K. Sutton, R. Diestelhorst, G. Espinel, R. Krithivasan, J.P. Comeau, J.D. Cressler, Georgia Institute of Technology; G. Vizkelethy, Sandia National Laboratories; P.W. Marshall, Consultant to NASA/GSFC

Diffusive charge collection from events outside the trench can increase the SEU cross section in deep trench isolation technologies. Microbeam test data and device simulations demonstrate how this can be mitigated through substrate engineering techniques.

PC-2 Single Event Upset Mechanisms for Low Energy Deposition Events in Silicon Germanium HBTs

E.J. Montes, R.A. Reed, J.A. Pellish, M.L. Alles, R.D. Schrimpf, R.A. Weller, Vanderbilt University; M. Varadharajaperumal, G. Niu, Auburn University; A.K. Sutton, R. Diestelhorst, G. Espinel, R. Krithivasan, J.P. Comeau, J.D. Cressler, Georgia Institute of Technology; P.W. Marshall, Consultant to NASA/GSFC; G. Vizkelethy, Sandia National Lab

Circuits fabricated using SiGe HBTs demonstrate SEU cross-section trends that differ from the standard RPP model. Microbeam measurements and TCAD simulations identify the important charge collection mechanisms that dominate the broad beam SEU response.

PC-3 Estimation of the Crosstalk Pulse Caused by Single Event Hits for Deep Submicron CMOS Technologies

A. Balasubramanian, A.L. Sternberg, B.L. Bhuvu, L.W. Massengill, Vanderbilt University

With technology scaling an SET pulse affects multiple logic paths instead of the single hit path due to crosstalk effects. Factors affecting crosstalk pulse due to an SEU are analyzed for advanced technologies including 65nm.

PC-4 Comparison of Single Photon Laser and MeV Ion Induced Single Event Transients in High-Speed Si Devices

J.S. Laird, A.H. Johnston, Jet Propulsion Laboratory, California Institute of Technology; S. Onoda, T. Hirao, H. Itoh, Japan Atomic Energy Agency

We illustrate some inherent differences between Single Event Transients generated by a bandgap picosecond laser and MeV heavy ions by comparing transient currents collected with an ion microbeam and a picosecond laser with varying track waists.

PC-5 Modeling Ionizing Radiation in 65nm Silicon-on-Insulator Semiconductor Devices with a Double Current Pulse

A.J. KleinOsowski, IBM Austin Research Laboratory; P. Oldiges, R.Q. Williams, IBM Systems and Technology Group; P.M. Solomon, IBM Watson Research Laboratory

We describe a technique for modeling ionizing radiation in a partially-depleted SOI MOSFET device. We use two current pulses, one connected between the drain and body of the device, and the other connected between the body and source of the device.

Technical Program Tuesday

PC-6 Multi-Error Propagation Mechanisms Clarified in CMOSFET SRAM Devices under Quasi-Mono Energetic Neutron Irradiation

E. Ibe, H. Yamaguchi, Production Engineering Research Laboratory, Hitachi, Ltd; S.S. Chung, S.J. Wen, Cisco Systems; Y. Yahagi, H. Kameyama, Renesas Technology Corp., Kodaira; S. Yamamoto, Renesas Technology Corp., Itami

Multi-cell upset (MCU) of 130nm SRAM under neutron tests shows Idd stepwise increases with MCU multiplicity, but is recovered by re-writing. MCU modes differ drastically between data patterns of all zeros, ones and checkerboard.

PC-7 Boxes: An Engineering Methodology for Calculating Soft Error Rates in SOI Integrated Circuits

D.E. Fulkerson, D.K. Nelson, Honeywell DSES Plymouth

Memory and logic error rates are predicted by breaking each transistor into theoretical "boxes" with differing sensitivities to ionizing radiation. Theory agrees well with experimental vertical ion strikes. Boxes also predict more subtle upset mechanisms.

PC-8 Simple Calculations of Proton SEU Cross Sections from Heavy Ion Cross Sections

J. Barak, Soreq NRC

Simple expressions, based on proton and Si interactions, are proposed for calculating proton induced SEU cross sections from heavy ion cross sections in devices with sub-micron sensitive volumes. Calculations for modern devices yield good agreement with the experiments.

PC-9 Current leakage evolution in partially gate ruptured power MOSFETs

L. Scheick, L. Edmonds, Y. Chen, L. Selva, Jet Propulsion Laboratory, California Institute of Technology

Single-event gate ruptures that result in low-level leakages (<10 mA) are investigated in comparison to larger leakage ranges. The structural features and reliability effects of different-order magnitude breaks are also investigated.

PC-10 Anomalous Charge Collection in Silicon Carbide Schottky Barrier Diodes and Resulting Permanent Damage and Single-Event Burnout

S. Kuboyama, C. Kamezawa, N. Ikeda, Japan Aerospace Exploration Agency; T. Hirao, Japan Atomic Energy Agency; H. Ohyama, Kumamoto National College of Technology

It was demonstrated the Silicon Carbide Schottky barrier diodes exhibited anomalous charge collection with heavy ion irradiation. Consequently, the permanent damage and Single-Event Burnout was observed. The model for the mechanism is proposed.

PC-11 Erratic Behavior of Radiation Induced Leakage Current in Floating Gate Memories

G. Cellere, DEI, Padova University; A. Paccagnella, INFN, Sezione di Padova; A. Visconti, M. Bonanomi, FTM-Advanced R&D, STMicroelectronics

Tracks of defects left by single ions impacting on thin (10nm) SiO₂ layers give rise to Radiation Induced Leakage Current (RILC). RILC has an erratic behavior similar to that of SILC, but with peculiar characteristics.

Technical Program Tuesday

SESSION D **HARDNESS BY DESIGN**

4:10 PM

SESSION INTRODUCTION

Chair: Bharat Bhuvu, Vanderbilt University

D-1
4:15 PM

A Radiation Hardened by Design Register File with Lightweight Error Detection and Correction

K.C. Mohr, L.T. Clark, Arizona State University

A 0.13 μ m RHBD 32x36b register file with error detection and correction capability is presented. The EDAC scheme supports fine granularity (byte) writes, with low area and latency overhead, suitable for small, fast memories including caches.

D-2
4:30 PM

SET Tolerant Latch Using Cascode-Voltage Switch Logic Gates

M.C. Casey, B.L. Bhuvu, L.W. Massengill, Vanderbilt; J.D. Black, ISDE

A new latch design using Cascode-Voltage Switch Logic gates is evaluated for single event environments. The design shows potential for excellent SE tolerance for charge collection on single and multiple nodes.

D-3
4:45 PM

An Area and Power Efficient Radiation Hardened Flip-Flop Circuit

J.E. Knudsen, L.T. Clark, Arizona State University

A RHBD flip-flop with high SEE immunity is described. Circuit size and power are reduced by combination of a temporal latch master and DICE slave. Measured TID, heavy ion and power results are presented.

D-4
5:00 PM

Application of RHBD Techniques to SEU Hardening of Third-Generation SiGe HBT Logic Circuits

R. Krithivasan, M. Nayeem, A.K. Sutton, W.-M. L. Kuo, B.M. Haugerud, L. Najafizadeh, J.D. Cressler, Georgia Tech; P.W. Marshall, NRL Consultant; M.A. Carls, Muniz Engineering; C.J. Marshall, NASA/GSFC; G. Niu, Auburn Univ.; R.A. Reed, Vanderbilt; B.A. Randall, C.A. Burfield, Mayo Clinic; B. Gilbert, Analog Devices

We investigate the application of RHBD techniques to the SEU-hardening of digital logic circuits in third-generation, 200 GHz SiGe HBT technology. Broad-beam heavy ion SEU data are presented and discussed.

POSTER PAPERS

PD-1

An SEU-Robust Configurable Logic Block for the Implementation of a Radiation-Tolerant FPGA

S. Bonacini, CERN, European Organization for Nuclear Research, and INPG, Institut National Polytechnique de Grenoble; K. Kloukinas, F. Faccio, A. Marchioro, CERN

A user-configurable logic block suitable for the implementation of a radiation-tolerant FPGA was designed in a CMOS-0.25 μ m technology. Heavy-ion beam testing demonstrated the SEU robustness of the circuit up to an LET of 80 MeV-cm²/mg.

Technical Program Tuesday

PD-2 Reducing Soft Error Rate in Logic Circuits Through Approximate Logic Functions

B. Sierawski, ISDE; B.L. Bhuvu, L.W. Massengill, Vanderbilt University

A RHBD approach is described that uses logical masking to reduce the single-event error rate of a given circuit. Area, speed, and power penalty are user-controlled and traded off for different threat mitigation levels.

PD-3 Optimization for SEU/SET Immunity on 0.15 μm Fully Depleted CMOS/SOI Digital Logic Devices

A. Makihara, HIREC; M. Midorikawa, H. Shindou, S. Kuboyama, JAXA; T. Hirao, JAEA; S. Onoda, T. Ohki, Y. Takahashi, Nihon University

The logic cells for 0.15 μm Fully Depleted CMOS/SOI commercial process were optimized for SEU/SET immunity up to LET of 64 MeV-cm²/mg. It was demonstrated that the process was suitable for space applications with a light penalty.

5:15 PM END OF TUESDAY SESSIONS

Technical Program Wednesday

CHAMPIONS BALLROOMS D-H
8:15 – 8:20 AM

ANNOUNCEMENTS

SESSION E
8:20 AM **SINGLE-EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS**
SESSION INTRODUCTION

Chair: John M. Baker, Lockheed Martin Space Systems Company

E-1
8:25 AM **Single-Event Transients in Voltage Regulators**

A.H. Johnston, T.F. Miyahira, F. Irom, J.S. Laird, Jet Propulsion Laboratory, California Institute of Technology

Single-event transients from heavy ions are evaluated for linear voltage regulators. Internal shutdown can be triggered for one device type that causes the device to shut down for about one second before recovery occurs

E-2
8:40 AM **Digital Single Event Transient Trends with Technology Node Scaling**

J.M. Benedetto, ATK Mission Research; P. Eaton, D. Mavis, Micro-RDC; M. Gadlage, T. Turflinger, NAVSEA Crane

We have measured the single-event-transient (SET) width over three CMOS technology nodes (0.25, 0.18 and 0.13 μm) using an identically scaled programmable-delay temporal-latch technique. The SET width is shown to increase substantially at lower operating voltages.

E-3
8:55 AM **Digital Device Error Rate Trends in Advanced CMOS Technologies**

M.J. Gadlage, T. Turflinger, NAVSEA Crane; P.H. Eaton, Micro-RDC; J.M. Benedetto, ATK Mission Research; V. Zhu, Texas Instruments

Data are presented from D Flip-Flop test chips in four technology nodes ranging from 250 nm down to 65 nm. Threshold LETs, saturated cross sections and error rates are compared as the feature sizes shrink.

E-4
9:10 AM **Propagating SET Characterization Technique for Digital CMOS Libraries**

M. Baze, J. Wert, J. Clement, M. Hubert, Boeing Phantom Works; A. Witulski, VU/ISDE; D. McMorrow, Naval Research Laboratory

A circuit architecture based on simple logic gates is described which uses small chip areas and low speed testing to characterize SETs for digital applications. Utility of this architecture is demonstrated with heavy ion data.

E-5
9:25 AM **Alpha-Induced Multiple Cell Upsets in Standard and Radiation Hardened SRAMs Manufactured in a 65nm CMOS Technology**

G. Gasiot, P. Roche, STMicroelectronics

Accelerated alpha SER measurements are carried out on regular and radiation hardened SRAMs in a 65nm CMOS technology. Results are compared to previous experimental radiation data in 130nm and 90nm. A formula is proposed to discriminate Multiple Cell Upsets.

E-6
9:40 AM **Limiting SEU Cross-Sections of Deep Submicron SOI SRAMs**

M.S. Liu, H.Y. Liu, D. Nelson, N. Brewster, Honeywell; H.L. Hughes, Naval Research Lab

This paper discusses proton and heavy ion induced single event upsets in radiation hardened 0.15 micron SOI SRAMs. Non-conventional "double-hit" mechanisms are used to explain test results.

Technical Program Wednesday

9:55 – 10:25 AM
MASTERS AND
HERITAGE BALLROOMS

BREAK

E-7
10:25 AM

Monte-Carlo Simulation of Proton Upsets in Xilinx Virtex-II FPGA Using a Position Dependent Qcrit with PROPSET

C.C. Foster, Foster Consulting Services, LLC; P.M. O'Neill, C.K. Kouba, Avionics Systems Division/EV5, NASA-JSC

Proton upsets predicted by the software code, PROPSET, for Xilinx Virtex-II FPGA are presented. PROPSET uses heavy-ion upset data to determine the upset energy threshold at each position within the device's sensitive volume.

E-8
10:40 AM

Proton-Induced Single Event Upset in 6T SOI SRAMs

H. Liu, M.S. Liu, Honeywell; H.L. Hughes, Naval Research Laboratory

This paper presents a method to estimate the limiting proton-induced upset cross section for 6T SOI SRAM cells based on simple parameters. It also discusses the relation between proton and heavy ion upset cross sections.

POSTER PAPERS

PE-1

Investigation of Macro- and Micro-Models for Prediction of SET-Induced Instability in Linear Voltage Regulators

P.C. Adell, Vanderbilt University; A.F. Witulski, R.D. Schrimpf, Vanderbilt University (ISDE); V. Pouget, IXL- Bordeaux University; R. Marec, P. Calvel, ALCATEL ALENIA Space; F. Bezerra, CNES, French Space Agency

SET-induced oscillations were measured on a stable linear-regulator based on the LM124 op-amp. Simulations showed that oscillations are triggered by a change of current-path inside the LM124 micro-model input stage, validated by laser testing.

PE-2

Single-Event-Upset Critical Charge Measurements and Modeling of 65nm Silicon-on-Insulator Latches and Memory Cells

D.F. Heidel, K.P. Rodbell, P. Oldiges, M.S. Gordon, H.H.K. Tang, C. Plettner, IBM Research Division; E.H. Cannon, IBM Systems & Technology Group

Experimental and modeling results are presented on the critical charge required to upset exploratory 65nm silicon-on-insulator (SOI) circuits. Using a mono-energetic, collimated beam of particles, the charge deposition was modulated and modeled.

PE-3

Microdose Induced Data Loss on Floating Gate Memories: Experimental Data and Physical Models

J. Patterson, D. Nguyen, S. Guertin, Jet Propulsion Laboratory, California Institute of Tech

FLASHs were irradiated with heavy ions and data loss is observed. A fraction of the lost data is retrievable after sufficient annealing. The data is correlated with physical models which infer microdose as the primary mechanism.

PE-4

Radiation Characterization of a Hardened 0.22 μm Anti-Fuse Field Programmable Gate Array

R.J. Nejad, Welkin Associates LTD; P.A. Rickey, K. Konadu, W.J. Stapor, P.T. McDonald, Stapor Associates Inc; W. Heidergott, General Dynamics C4 Systems

We present comprehensive application-realistic radiation effects measurements for Actel RTSX-SU series FPGAs utilizing high energy heavy ions and protons, and a measurement methodology and test structure applicable to many flight designs.

Technical Program Wednesday

PE-5 Single-Event Sensitivity and Hardening of a Pipelined Analog-to-Digital Converter

A.L. Sternberg, L.W. Massengill, Vanderbilt; M. Hale, B. Blalock, University of Tennessee

Circuit simulations are used to determine the single-event response of a pipelined analog-to-digital converter. Sensitive cross-sections are calculated. Sensitive areas were identified and hardened, resulting in a reduction in the sensitive cross-section.

PE-6 Analysis of Single Events Effects on Monolithic PLL Systems

H.H. Chung, W. Chen, B. Bakkaloglu, H.J. Barnaby, B. Vermeire, S. Kiaei, Arizona State

Impact of single event effects on locking behavior of a monolithic PLL system designed in a 0.13 μ m CMOS process is analyzed by varying loop bandwidths and single-event pulse widths with a time-domain PLL model.

PE-7 Light Particle-Induced Single Event Degradation in SDRAMs

J.P. David, T. Nuns, ONERA; F. Bezerra, E. Lorfèvre, CNES

SDRAMs have been exposed to protons, neutrons, and alpha particles. Numerous cells exhibit large data retention degradation that are attributed to single interactions. The physical process leading to the degradation is discussed.

PE-8 Hybrid Fault Detection Technique: A Case Study on Virtex-II Pro's PowerPC 405

P. Bernardi, L. Sterpone, M. Violante, Politecnico di Torino, Dip. Automatica e Informatica; L. Entrena, C. Lopez-Ongil, M. Portela-Garcia, Universidad Carlos III de Madrid

We present an application of a hybrid fault detection technique for the PowerPC 405 processor cores embedded in the Xilinx Virtex-II Pro FPGAs. Experimental results obtained by fault-injection campaigns are presented that confirm its effectiveness.

PE-9 Single Event-Induced Error Propagation through Nominally-Off Transmission Gates

J.M. Hutson, V. Ramachandran, B.L. Bhuvu, R.D. Schrimpf, O.A. Amusan, Vanderbilt University; X. Zhu, Texas Instruments Incorporated

A radiation-induced mechanism for false latching through CMOS transmission gates is presented and examined via circuit simulations on a 65nm CMOS process.

PE-10 Single-Event Upset and Scaling Trends in New Generation of the Commercial SOI PowerPC Microprocessors

F. Irom, F. Farmanesh, Jet Propulsion Laboratory, California Institute of Technology; C.K. Kouba, Johnson Space Center

Heavy-ion induced SEUs are measured for new generation SOI PowerPCs. SEU sensitivity decreases with reduced core voltage up to a point which the trend reverses. This suggests improvement in SEU for scaled devices may be limited.

PE-11 An Analysis of Single Event Upset Dependencies of High Frequency and Architectural Implementations within Actel RTAX2000S FPGAs

M. Berg, H. Kim, A. Phan, T. Irwin, M. Friendlich, J. Howard, MEI Technologies Inc; J.J. Wang, Actel Corp.; R.L. Ladbury, K.A. LaBel, NASA/GSFC; S. Buchner, QSS Corp.

To investigate frequency and architectural effects on SEU cross sections within the RTAX2000S device, a novel approach to high speed testing is implemented. Testing was performed at variable speeds ranging from 15MHz - 150MHz.

Technical Program Wednesday

SESSION F SPACE AND TERRESTRIAL ENVIRONMENTS

10:55 AM SESSION INTRODUCTION

Chair: Joseph E. Mazur, The Aerospace Corporation

F-1 **Quantifying the Double-Sided Neutron SEU Threat, from Low (Thermal) Energy and High (> 10 MeV) Energy Neutrons**

11:00 AM

E. Normand, Boeing Phantom Works; K. Vranish, A. Sheets, M. Stitt, Smiths Aerospace & Defense Systems Inc; R. Kim, SAVE Incorporated

We quantify the SEU rate induced by neutrons in current devices, from low energy (thermal) and high energy neutrons. New measured SEU cross sections from both kinds of neutrons in SRAMs, DRAMs and microprocessors are included.

F-2 **Neutron-Induced Single Event Effects Testing Across a Wide Range of Energies and Facilities and Implications for Standards**

11:15 AM

C. Dyer, A. Hands, K. Hunter, A. Frydland, P. Truscott, Space Division, QinetiQ

Neutron test data on SEE for a wide range of SRAMs, facilities (monoenergetic and continuum) and energies (thermal to 800 MeV) are compared and implications are examined for rates in various environments and for associated standards.

F-3 **Interaction of Charged Spacecraft with Electric Propulsion Plasma Plume: On Orbit Data and Ground Test Results**

11:30 AM

J. Likar, A.L. Bogorad, T. Malko, N. Goodzeit, Lockheed Martin Commercial Space Systems; J. Galofaro, NASA; M. Mandell, SAIC

On-orbit observations and ground tests demonstrate interaction between charged spacecraft and electrothermal thruster-generated plasma. On-orbit measurements and test results are presented for plasma diagnostics and solar array performance during long-term exposure of flight solar panel.

F-4 **Electrostatic Discharge Induced Momentum Impulse from Charged Spacecraft Surfaces**

11:45 AM

A.L. Bogorad, J. Likar, R. Herschitz, C. Voorhees, Lockheed Martin Commercial Space Sys.

Electron beam measurements have demonstrated that ESD imparts significant impulse to the discharging surface. Impulse was shown to scale with ESD current amplitude and appears to be an electrical, rather than mechanical, interaction.

POSTER PAPER

PF-1 **The Cosmic Ray Telescope for the Effects of Radiation (CRaTER) Investigation for the Lunar Reconnaissance Orbiter**

J.E. Mazur, J.B. Blake, M.D. Looper, The Aerospace Corporation; H. Spence, E.L. Kepko, Boston University; J. Kasper, Massachusetts Institute of Technology; L. Townsend, Y. Charara, University of Tennessee

We describe an investigation to measure linear energy transfer spectra in lunar orbit. The measurements and improvements to radiation transport models will address the effects of the lunar radiation environment on human and technological systems.

12:00 – 1:30 PM LUNCH

Technical Program Wednesday

INVITED TALK

1:30 – 2:30 PM

CHAMPIONS BALLROOMS D-H



Hurricane Emergency Preparedness and Restoration Response

*James R. Timberlake, CPQ, CEM, Lead Power Quality Engineer,
Progress Energy Corporation, Orlando, FL*

Presentation will focus around the 2004 and 2005 hurricane responses. Timberlake will present a brief overview of the storm response planning process, including possible responses to all types of disasters, such as ice storms, hurricanes, and terrorism. The successes and lessons learned from the 2004 season will be discussed.

Cases of our latest development in storm responses will be shown. In 2005 a 100% self-contained staging site was developed and implemented. This method of staging and logistics places our resources at ground zero where they are most effective. A discussion of the successes of the ability to build a tent city at the site in an eight hour time frame will be presented. This staging site includes everything a work crew needs in order to be successful away from home. Sleeping quarters, mobile showers, laundry services, nursing staff, full service commissary, communications systems, and mail call from home.

James Timberlake began his professional career when he graduated from the University of Central Florida with a Bachelor of Science degree in electrical engineering. He was then employed by Florida Power Corporation. James has an extensive background in the electric utility business. His experiences span 20 years and include all facets of distribution engineering and construction, bargaining unit employee supervision, and management of a large group work environment. He is a Certified Energy Manager (CEM), and a Certified Power Quality Specialist (CPQ).

Most recently, James is working in the role of Lead Power Quality Engineer at Progress Energy, Florida. In this role he is responsible for identifying and providing solutions to solve power quality issues that affects “Key” customers within the service territory.

During emergency response events James is responsible for system level staging and logistics. In this role he assists in directing the planning, procurement, and mobilization of all resources necessary to support restoration activities within the company as well as off system or out of state responses. During the 2004 hurricane season, James Timberlake was instrumental in supporting an unprecedented response to five major hurricanes (Bonnie, Charlie, Francis, Ivan, and Jeanne) in the state of Florida. In the 2005 hurricane season he directed the off system staging and logistics response to Hurricane Rita in Texas. In this event Progress Energy responded off system with more than 400 resources to a 100% self contained staging site in eastern Texas.

POSTER SESSION

2:35 – 5:05 PM

TOURNAMENT HALL

INTRODUCTION



Hugh Barnaby, Arizona State University

5:05 PM

END OF WEDNESDAY SESSIONS

Technical Program Thursday

INVITED TALK

8:15 – 9:15 AM

CHAMPIONS BALLROOMS D-H



Reinventing CMOS to Stay on Moore's Law

Dr. Theodore Dellin, Chief Scientist Emeritus of the Microsystems Center, Sandia National Laboratories, Albuquerque, NM

Moore's Law describes the fact that ICs get exponentially faster, better and cheaper over time. Moore's Law is, of course, not a fundamental law of nature. As Gordon Moore himself observed, "No exponential is forever ..." Today, the scaling-down of IC technologies, which fuels Moore's Law, is running up against fundamental physical and material limitations that threaten the ability to sustain the historic rates of IC improvements.

However, as Gordon Moore went on to say "... but forever can be delayed." To sustain Moore's law now requires reinventing the CMOS IC by replacing the historic materials and planar MOS transistor structures that were the backbone of the industry in the last century. We'll start with a simple model of what drives IC performance and power. Then we'll consider the major challenges of increasing power and worsening performance-robbing parasitics. We'll describe the current state of reinventing CMOS to overcome these challenges. We'll look at what has worked well (Cu, strained Si), what has proved difficult (low k intermetallic dielectrics) and the profound changes that will be needed in the very near future (metal gate transistor with high k dielectric, fully depleted Silicon Oxide Insulator or multi-gate). The talk will conclude with some possible future scenarios for Moore's Law and some brief remarks on what this all means for niche applications, like rad-hard ICs.

Dr. Theodore (Ted) Dellin has 25 years experience in microelectronics and microsystems. Most importantly for the purposes of this talk, he has helped develop the commercial industry's International Technology Roadmap for Semiconductors (ITRS), leading the reliability section for almost a decade. Among other things, Dr. Dellin is the Chief Scientist Emeritus of Sandia National Laboratories' Microsystems Center, a member of Sematech's Reliability Technical Advisory Board and a past chair of the IEEE Nonvolatile Memory Workshop.

Dr. Dellin also focuses on the serious challenge of meeting the training needs of people working in micro technologies. With his wife, Arlene, he has developed quicker and easier ways to keep up with the advancing technology and has written the **21st Century Semiconductor Technology Handbook**. He founded and continues to teach at Sandia's in-house Microsystems University, has given numerous tutorials at technical conferences and has provided short courses in devices, technology and reliability for organizations in the U.S. and Europe through his company, Quick Start Micro Training LLC.

A copy of the slides presented will be available after the conference at www.quickstartmicro.com.

Technical Program Thursday

CHAMPIONS BALLROOMS D-H
9:15 – 9:20 AM

ANNOUNCEMENTS

SESSION G
9:20 AM

BASIC MECHANISM OF RADIATION EFFECTS

SESSION INTRODUCTION

Chair: Andrea Cester, University of Padova

G-1
9:25 AM

A Framework for Understanding Displacement Damage Mechanisms in Irradiated Silicon Devices

J.R. Srouf, J.W. Palko, The Aerospace Corporation

A framework is presented for understanding carrier generation and recombination mechanisms. Measurements, simulations, and analyses support the conclusion that correlation of displacement damage effects with NIEL is due to the dominant influence of defect subclusters.

G-2
9:40 AM

Atomic-Scale Mechanism for Dopant-Type Dependent Damage in Si at Low NIEL

M.J. Beck, L. Tsetseris, M. Caussanel, R.D. Schrimpf, D.M. Fleetwood, S.T. Pantelides, Vanderbilt University

Analysis of quantum-mechanical calculations demonstrates that Si Frenkel Pair stability is charge-state dependent. We show that Frenkel Pair recombination after electron capture explains lower, experimentally observed damage rates in low-energy irradiated p-Si versus n-Si.

9:55 – 10:25 AM
CHAMPIONS BALLROOMS A-C

BREAK

G-3
10:25 AM

Characterization of the Radiation Response of 0.13 μ m n-Channel MOSFETs

I.S. Esqueda, H.J. Barnaby, M. McLain, K. Holbert, Arizona State University; M. Baze, Boeing Phantom Works; B.L. Bhuvu, L.W. Massengill, J.D. Black, R.D. Schrimpf, Vanderbilt

The results of total ionizing dose radiation experiments on 0.13 μ m n-channel MOSFET transistors with various gate geometries are presented. Enlarged edge devices (dog-bone designs) are shown to be ineffective at mitigating radiation damage.

G-4
10:40 AM

Effects of Water on the Aging and Radiation Response of MOS Devices

I.G. Batyrev, M.P. Rodgers, D.M. Fleetwood, R.D. Schrimpf, S.T. Pantelides, Vanderbilt

The reactions of water in SiO₂ are investigated using a hierarchy of calculations in conjunction with controlled-moisture experiments. The critical role of water in MOS aging and radiation response is elucidated and confirmed.

G-5
10:55 AM

Effects of Switched-bias Annealing on Charge Trapping in HfO₂ Gate Dielectrics

X.J. Zhou, D.M. Fleetwood, L. Tsetseris, R.D. Schrimpf, S.T. Pantelides, Vanderbilt Univ.

We have investigated the switched-bias annealing response of MOS capacitors with high-k dielectrics after irradiation or constant-voltage stress. Reversible oxide and interface trap charge densities are found to depend strongly on annealing bias and temperature.

Technical Program Thursday

- G-6**
11:10 AM **Differences Between Charge Trapping States in Irradiated Nano-crystalline HfO₂ and Non-crystalline Hf Silicates**
G. Lucovsky, S. Lee, H. Seo, L.B. Fleming, M. Ulrich, D.E. Aspnes, North Carolina State University; R.D. Schrimpf, D.M. Fleetwood, Vanderbilt University; J.A. Felix, Sandia National Laboratories; J. Luning, Stanford Synchrotron Radiation Laboratory

The paper provides an explanation for qualitative differences between radiation-induced charge trapping states in nano-crystalline HfO₂ and non-crystalline Hf silicate alloys in high-k; gate stacks by combining electrical measurements with spectroscopic studies and theory.

- G-7**
11:25 AM **Nature of Interface Defect Buildup in Gated Bipolar Devices Under Low Dose Rate Irradiation**
X.J. Chen, H.J. Barnaby, Arizona State University; R.D. Schrimpf, D.M. Fleetwood, Vanderbilt University; R.L. Pease, RLP Research; D.G. Platteter, NAVSEA Crane

Interface trap build-up in gated bipolar devices under low dose rate TID exposure was observed through charge pumping experiments. Results suggest that interface trap formation is a combination of fast Pb centers and slow border traps.

- G-8**
11:40 AM **Physical Model for the Low Dose Rate Effect in Bipolar Devices**
J. Boch, F. Saigne, J.-R. Vaillat, L. Dusseau, Universite Montpellier II; R.D. Schrimpf, Vanderbilt University; E. Lorfèvre, CNES

A physical model of the dose rate effect in BJTs is proposed, based on competition between trapping and recombination of radiation-induced carriers in the oxide. The influences of oxide quality and irradiation temperature are investigated.

- G-9**
11:55 AM **Proton and Heavy Ion Irradiation Effects on AlGaIn/GaN HFET Devices**
G. Sonia, F. Brunner, R. Lossy, M. Mai, E. Richter, J. Schmidt, U. Zeimer, L. Wang, M. Weyers, J. Wurfl, G. Trankle, Ferdinand-Braun-Institut fuer Hoechstfrequenztechnik; A. Denker, J. Opitz-Coutureau, Ionenstrahllabor, Hahn-Meitner-Institut; G. Pensl, Institut fuer Angewandte Physik

Operation of AlGaIn/GaN HFETs in space was stimulated by irradiation with protons and heavy ions. High energy (68 MeV) has no impact on device performance. High fluences at lower energy (2 MeV) result in degradation.

POSTER PAPERS

- PG-1**
Fast Estimation of Clusters Produced by Protons
C. Inguibert, T. Nuns, ONERA; G. Rolland, CNES

Defects can produce non-uniform degradation in some component parameters. Analysis requires a knowledge of the size and the nature of the defects. We propose to calculate the probability of cluster formation on cross section interaction integration.

- PG-2**
New Partition Factor Calculations for Evaluating the Damage of Low Energy Ions in Silicon
A. Akkerman, J. Barak, Soreq NRC

Updated results of Lindhard partition factor of low energy (< 500 keV) Si ions in silicon for non-ionizing energy loss (NIEL) and damage calculations were obtained using Monte Carlo simulations. The new values are significantly larger than previous results.

Technical Program Thursday

PG-3 Impact of Heavy-Ion Strikes on Minimum-Size MOSFETs with Ultra-Thin Gate Oxide

S. Gerardin, M. Bagatin, A. Cester, A. Paccagnella, DEI - Padova University; B. Kaczer, IMEC; A. Candelori, INFN Padova

We present new original experimental results on the effects produced by one or two heavy-ion strikes on minimum-size MOSFETs manufactured in a 0.1 μ m CMOS technology.

PG-4 Damage Equivalence of Heavy Ions in Silicon Bipolar Junction Transistors

E. Bielejec, G. Vizkelethy, D.B. King, Sandia National Laboratories; N.R. Kolb, KTech Corp.

Results of displacement damage correlation between neutrons, light ions (protons) and heavy ions in bipolar junction transistors will be presented. Gain degradation as the function of fluence was measured. The gain degradation due to heavy ion irradiation followed the Messenger-Spratt equation, while some deviation was found for light ions.

12:10 – 1:40 PM LUNCH

SESSION H DOSIMETRY AND FACILITIES

1:40 PM SESSION INTRODUCTION

Chair: Barbara Von Przewoski, Indiana University Cyclotron Facility

H-1 Limiting Factors in Low-Dose Applications of FGMOS Dosimeters

1:45 PM *P. McNulty, K. Poole, J. Reneau, K. Freeman, M. Crissler, Clemson University; D. Strobel, M. Fennell, R. Perez, Space Micro; M. Randall, L. Call, Cancer Centers of the Carolinas*

Accurate dosimetry for ionizing radiation using FGMOS transistors over a wide range of doses is improved by careful part selection, large numbers of transistors, mapping radiation sensitivity across the array, analysis of temperature dependence.

H-2 Microdosimetric GEANT4 and FLUKA Monte-Carlo Simulations and Measurements of Heavy Ion Irradiation of Silicon and Tissue

2:00 PM *P. Beck, S. Rollet, ARC Seibersdorf Research; M. Wind, F. Bock, ARC Seibersdorf Research, Vienna University of Technology; M. Latocha, ARC Seibersdorf Research, Institute of Nuclear Physics Polish Academy of Sciences; H. Bock, Vienna University of Technology, Atomic Institute*

We describe microdosimetric measurements and simulations with GEANT4 and FLUKA Monte-Carlo codes in silicon and tissue. Analyses of deposited energy in sensitive volumes of some micrometers were carried out after exposure to heavy ion radiation.

H-3 Determination of the Deposited Energy in a Silicon Volume by n-Si Nuclear Interaction Using 14 MeV Neutron Source

2:15 PM *H. Chabane, J. R. Vaille, P. Garcia, L. Dusseau, J. Boch, F. Saigne, CEM2 University Montpellier II; B. Barelaud, J.L. Decossas, XLIM University Limoges; F. Wrobel, LPES University Nice-Sophia Antipolis; Y. Calzavara, CEA Valduc*

The aim of this work is to validate the results of a Monte Carlo nuclear physics code used to determine the deposited energy in a silicon volume. Silicon sensor was exposed to 14 MeV neutrons.

Technical Program Thursday

- H-4**
2:30 PM **Simultaneous Evaluation of TID and Displacement Damage Dose Using a Single OSL Sensor**
P. Garcia, J.-R. Vaillie, D. Benoit, H. Chabane, J. Boch, B. Sagnes, F. Saigne, L. Dusseau, Universite Montpellier II; G. Berger, Catholic University of Louvain-la-Neuve; K. Idri, Centre Val d'Aurelle; E. Lorfevre, F. Bezerra, Centre National d'Etudes Spatiales

The possibility to evaluate simultaneously the total ionizing dose and the displacement damage dose using a single OSL integrated sensor is demonstrated. Results obtained during the real time monitoring of a proton beam are presented.

- H-5**
2:45 PM **Application of Imaging Systems to Characterization of Single-Event Effects in High-Energy Neutron Environments**
Z. Torok, S. Platt, University of Central Lancashire

We characterize the SEE-inducing properties of high-energy neutron beams, including the spatial distribution of induced charge. Detector characteristics are evaluated and comparison made between neutron beams at LANSCE and TRIUMF accelerator facilities.

POSTER PAPERS

- PH-1**
High-Vacuum Gamma Irradiation Facilities for Synergistic Effects Testing on Optoelectronic Components and Materials
*A.F. Fernandez, B. Brichard, H. Ooms, F. Berghmans, SCK*CEN, Belgian Nuclear Research Center*

An irradiation chamber combining high vacuum and thermal cycling with different gamma dose rates has been qualified. The vacuum irradiation module operates in the high-vacuum regime (10^{-5} mbar) even in the presence of moderate outgassing from polymer materials.

- PH-2**
Transient Currents Generated by Heavy Ions with Hundreds of MeV
S. Onoda, T. Hirao, H. Itoh, JAEA; J.S. Laird, Jet Propulsion Laboratory, California Institute of Technology

A transient current imaging system has been developed for collimated irradiations using an AVF Cyclotron. The system has been used to measure the very high-energy dependence of Single Event Transients in Si optoelectronics and a comparison made with quasi 3D TCAD simulation.

- PH-3**
Enhanced Low Dose Rate Sensitivity in MOSFETs
S.J. Kim, D.H. Ko, K.W. Min, KAIST; J. Seon, Satrec Initiative Co. Ltd.; Y.H. Shin, New Medical Technology Co. Ltd.

We report the dose rate dependence for REM RADFET of space dosimeter and Fairchild power MOSFET. The MOSFETs consistently show ELDRS at a series of laboratory experiments with various conditions.

Technical Program Thursday

PH-4 Silicon Microdosimetry in Heterogeneous Materials: Simulation and Experiment

A. Wroe, A. Rosenfeld, I. Cornelius, University of Wollongong; D. Prokopovich, M. Reinhard, Australian Nuclear Science and Technology Organization; R. Schulte, V. Bashkirov, Loma Linda University Medical Center

Microdosimetry spectra obtained experimentally utilizing an SOI microdosimeter within biological materials, will be used to provide information on secondary radiation spectra at tissue boundaries. Comparative GEANT4 simulations of the experimental conditions will also be shown.

PH-5 Detailed Comparison of Monte Carlo and Sector-Shielding Analyses for Space Applications

R. Lindberg, E. Daly, P. Nieminen, ESA/ESTEC; G. Santin, ESA/ESTEC and RHEA System SA

Predictions of total ionizing dose made using full 3-D Monte Carlo and simplified sector-shielding techniques for simple and complex geometries in a space environment are compared and differences between them analyzed in detail.

3:00 – 3:30 PM

CHAMPIONS BALLROOMS A-C

BREAK

SESSION I PHOTONIC DEVICES AND INTEGRATED CIRCUITS

3:30 PM SESSION INTRODUCTION

Chair: Kyle B. Miller, Ball Aerospace

I-1 Neutron, Gamma-Ray and Pulsed X-Ray Radiation-Induced Effects on Multimode Silica-Based Optical Fibers

3:35 PM

S. Girard, J. Baggio, J. Bisutti, CEA DIF

We study the mechanisms induced by pulsed X-rays (~1 MeV), gamma-rays (~1 MeV) and 14 MeV neutrons in graded-index optical fibers through spectral measurements (300-1100 nm) of their radiation-induced attenuation.

I-2 CCD Radiation Testing at Low Temperatures Using a Laboratory Alpha Particle Source

3:50 PM

G.R. Hopkinson, Sira Technology Ltd; A. Mohammadzadeh, ESA, ESTEC

The performance of large area CCDs was measured after alpha particle irradiation at -135°C. CTE damage was a factor ~1.3 higher than after annealing to room temperature or room temperature irradiation.

I-3 Electron-Induced Displacement Damage Effects in CCDs

4:05 PM

H.N. Becker, T. Elliott, J.W. Alexander, Jet Propulsion Laboratory, California Institute of Technology

We compare differences in parametric degradation for CCDs irradiated to the same displacement damage dose with 10-MeV and 50-MeV electrons. Charge transfer efficiency degradation was observed to not scale with NIEL for small signals.

Technical Program Thursday

I-4
4:20 PM **Important Factors Relevant to Proton Testing of Shielded Space Solar Cells**

S.R. Messenger, J.R. Lorentzen, SFA, Inc.; E.A. Burke, Consultant; R.J. Walters, J.H. Warner, US Naval Research Laboratory; T.L. Morton, Ohio Aerospace Institute; G.P. Summers, University of Maryland Baltimore County

To simulate proton irradiation effects on space solar cells, ground irradiations are typically performed using normally incident, monoenergetic protons. It is shown that this method greatly overestimates the effects that are seen in space conditions.

POSTER PAPERS

PI-1 **The Influence of High-Energy Lithium Ion Irradiation on Electrical Characteristics of Si and GaAs Solar Cells**

J.B. Ramani, M.C. Radhakrishna, Department of Physics, Bangalore University; A. Agrawal, Power Systems Group, ISRO Satellite Centre; S.A. Khan, Inter University Accelerator Center

Space-grade Si and GaAs solar cells were irradiated by 15 & 40 MeV Li ions. I-V curves (AM0 condition) reveal that the effect of high-energy Li ion irradiation has produced similar effects as that of proton irradiation.

PI-2 **Displacement Damage Effects on Time-Resolved Gain and Bandwidth of a Low Breakdown Voltage Si Avalanche Photodiode**

J.S. Laird, H.N. Becker, A.H. Johnston, Jet Propulsion Laboratory, California Institute of Technology; S. Onoda, T. Hirao, H. Itoh, Japan Atomic Energy Agency

Displacement damage effects on dark current and time-resolved device gain have been investigated in a high-bandwidth gain product Si Avalanche Photodiode. Spatially resolved impulse response measurements were made with a focused picosecond laser.

4:35 PM **END OF THURSDAY SESSIONS**

5:15 – 6:30 PM **RADIATION EFFECTS COMMITTEE OPEN MEETING**
CHAMPIONS BALLROOMS D-H

Technical Program Friday

INVITED TALK

8:15 – 9:15 AM

CHAMPIONS BALLROOMS D-H



Gravity Probe B: Testing Einstein at the Limits of Engineering

Dr. William J. Bencze, Senior Research Engineer and Deputy Program Manager, Gravity Probe B Relativity Mission, Stanford University, Palo Alto, CA

Gravity Probe B, a NASA-sponsored astrophysics satellite developed at Stanford University and the Lockheed Martin corporation, was successfully launched on 20 April 2004 from Vandenberg AFB to test some fundamental predictions of Einstein's general theory of relativity: the geodetic and frame-dragging effects. The concept of the experiment is deceptively simple: place a perfect gyroscope in orbit, isolate it from all classical disturbance torques, and measure the spin axis drift caused only by the warping and twisting of space due to the gravitational mass of the Earth. Making this simple concept a reality has proven to be confoundingly difficult and has resulted in arguably the most sophisticated scientific satellite developed to date. This talk will examine the predictions of Einstein's theory of general relativity, describe the design of the spacecraft and the science instrumentation at its core, discuss many of the novel technologies developed and engineering breakthroughs required to build the instrument, and take a look at some early performance data from on-orbit operations.

Dr. William Bencze received his Bachelors degree in Electrical Engineering from Stanford University in 1989, followed by a PhD in 1996 with a specialization in precision instrumentation and automatic control systems. On Gravity Probe B he developed the electrostatic suspension systems now in operation on orbit, served as the overall electronics systems manager for the Gravity Probe B spacecraft prior to launch. Dr. Bencze is now a Senior Research Engineer and the Deputy Program Manager at Gravity Probe B. His professional interests include hybrid and nonlinear control systems, gravitational and inertial reference systems, analog electronics design, and precision instrumentation systems for space borne and terrestrial high reliability applications.

DATA WORKSHOP

9:15 – 11:45 AM

TOURNAMENT HALL

INTRODUCTION



Chair: David M. Hiemstra, MDA

W-1

Guide to the IEEE Radiation Effects Data Workshop

D.M. Hiemstra, MDA

Radiation Effects Data Workshop Records from 1992-2005 have been reviewed and tables prepared which facilitate the search for radiation response data by part number, type or effect.

Technical Program Friday

- W-2** **Compendium of Total Ionizing Dose Results and Displacement Damage Results for Candidate Spacecraft Electronics for NASA**
D.J. Cochran, S.D. Kniffin, C. Poivey, M.V. O'Bryan, M. Berg, H.S. Kim, A.M. Dung-Phan, M.A. Carts, J.D. Forney, T. Irwin, C.M. Seidleck, M. Friendlich, MEI Technologies, Inc.; S.P. Buchner, T.R. Oldham, QSS Group Inc.; K.A. LaBel, R.L. Ladbury, A.B. Sanders, D.K. Hawkins, S.R. Cox, D. Petrick, W. Powell, J. Karsh, NASA/GSFC

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** **Compendia of Radiation Test Results of Integrated Circuit**
P. Layton, C. Gilbert, E. Patnaude, L. Longden, G. Williamson, C. Sloan, Maxwell Technologies

TID and SEE data was taken to qualify and evaluate IC devices for radiation susceptibility in the natural space environment. A summary of the test data is presented and discussed.

- W-4** **Compendium of Single Event Effects Results for Candidate Spacecraft Electronics for NASA**

M.V. O'Bryan, C. Poivey, S.D. Kniffin, J.W. Howard Jr., M. Berg, H.S. Kim, A.M. Dung-Phan, M.A. Carts, J.D. Forney, T. Irwin, C.M. Seidleck, M. Friendlich, MEI Technologies, Inc.; K.A. LaBel, R.L. Ladbury, A.B. Sanders, C.J. Marshall, D.K. Hawkins, S.R. Cox, D. Petrick, W. Powell, and J. Karsh, NASA/GSFC; S.P. Buchner, T.R. Oldham, QSS Group Inc.; P.W. Marshall, Consultant to NASA/GSFC; M.P. Baze, The Boeing Company; W. Estes, Jackson & Tull Chartered Engineers

Vulnerability of a variety of candidate spacecraft electronics to proton and heavy ion induced single event effects is studied. Devices tested include digital, linear bipolar, and hybrid devices.

- W-5** **200-MeV Proton Test Results on COTS-Based Electronic Hardware for NASA-JSC Spaceflight Projects**

C. Kouba, P. O'Neill, C. Bailey, NASA-Johnson Space Center; K. Nguyen, Jacobs Sverdrup Engineering, NASA-Johnson Space Center

High-energy proton test results on numerous commercial electronic devices are presented. These devices were evaluated in 2005 as candidates for several flight hardware experiments for use onboard the Space Shuttle and International Space Station.

- W-6** **Results of Single-Event Effects Measurements Conducted at the Jet Propulsion Laboratory**

F. Irom, T. F. Miyahira, Jet Propulsion Laboratory, California Institute of Technology

This paper reports single-event effects results for a variety of microelectronic devices that includes ADC, supervisory circuit, FIFO and a Viterbi decoder. The data was collected to evaluate these devices for possible use in NASA spacecrafts.

Technical Program Friday

- W-7 Single Event Effects of New High Speed Analog to Digital Converters, Digital to Analog Converters, Hybrid MUXDAC Devices, and Voltage Converters**
A.L. Bogorad, A.J. Esteban, J.J. Likar, S. Moyer, R. Herschitz, Lockheed Martin Commercial Space Systems
- SEE testing of new devices revealed unexpected behavior that has serious implications to spacecraft design. Previously unreported SET, SEFI, and clock upsets underscore the importance of testing in worst-case operating conditions representative of device applications.
- W-8 Total Ionizing Dose Effects in Bipolar Technology and High Voltage Transistors**
R.M. Chevez, B.G. Rax, A.H. Johnston, Jet Propulsion Laboratory, California Institute of Technology
- Total Ionizing Dose test results in bipolar IC's showed bias dependency. Integrated Circuits tested under unbiased conditions exhibited greater parametric degradation and failures compared to biased devices. However, biased high voltage transistors exhibited parametric degradation.
- W-9 The Effects of Proton Irradiation on 90nm Strained Silicon CMOS on SOI Devices**
A. Appaswamy, B. Jun, R.M. Diestelhorst, G. Espinel, A.P. G. Prakash, J.D. Cressler, Georgia Institute of Technology; P.W. Marshall, Consultant to NASA/GSFC; C.J. Marshall, NASA/GSFC; Q. Liang, G. Freeman, IBM Microelectronics, East Fishkill
- The effects of 63 MeV protons on 90nm strained-silicon CMOS-on-SOI devices are investigated for the first time, and compared to unstrained-SOI devices. No significant degradation is observed up to a total equivalent dose of 600 krad(Si).
- W-10 Effects of Radiation on Commercial Power Devices**
L. Scheick, R. Chavez, L. Selva, H.N. Becker, JPL
- The results of various tests on power device are presented. Commercial power devices with voltage blocking ratings over 400V are very susceptible to both dose and single event effects.
- W-11 Proton Tolerance of InAs Based HEMT and DHBT Devices**
S.M. Currie, N.E. Harff, R.G. Pittelkow, B.K. Gilbert, E.S. Daniel, Mayo Clinic; P.W. Marshall, Consultant to NASA/GSFC; J. Bergman, B. Brar, J.B. Hacker, Rockwell Scientific Company; A. Gutierrez, C. Monier, Northrup Grumman Space Technology
- We present measurements of proton induced degradation in emerging low power high performance InAs based devices, including InAs/AlSb HEMTs and In_{0.86}Ga_{0.14}As base 6.0 Å lattice constant DHBT devices.
- W-12 Measurements of Radiation Effects on Optoelectronics**
T.F. Miyahira, A.H. Johnston, F. Irom, Jet Propulsion Laboratory, California Institute of Technology
- This paper reports radiation test results for variety of optoelectronic devices that includes LEDs, optocouplers, and phototransistors. The data was collected to evaluate these devices for possible use in NASA spacecrafts.

Technical Program Friday

W-13 Proton Radiation Effects in High Power LED for Optical Wireless Links for Intra-Satellite Communications (OWLS)

J.J. Jimenez, Instituto Nacional de Tecnica Aeroespacial (INTA); R. Tamayo, M. Alvarez, J.A. Dominguez, I. Arruego, J.M. Oter, J. Sanchez, H. Guerrero, INTA

LEDs of different technologies suitable for OWLS were irradiated with 30, 52 and 60 MeV and up to 2.8×10^{12} p/cm² (in 5 steps). Electrical and optoelectronic parameters have been characterized during the test.

W-14 Total Dose and Dose Rate Response of Low Dropout Voltage Regulators

R.L. Pease, RLP Research; G. Dunham, J. Seiler, NAVSEA Crane

The total dose response of three bipolar low dropout voltage regulators is presented for a variety of irradiation test conditions including high and low dose rate. These parts will be flown in a space experiment to compare ground test results with degradation in space.

W-15 Total Ionizing Dose Testing of a RadHard-by-Design FET Driver in a 0.35 μ m Triple Well Process

M. Hartwell, K. Ryan, S. Netherton, P. Milliken, Aeroflex

TID testing performed on a RadHard-by-Design FET driver on a 0.35 μ m triple well process demonstrated radiation hardness >300krad(Si). Triple well isolation provides superior performance, multiple and negative power supplies capabilities for robust mixed-signal ASICs.

W-16 Radiation Effects in a Floating Gate Device Irradiated Under Bias

J.-J. Wang, N. Charest, B. Cronquist, Actel Corp.; G. Kunganesum, University of Toronto

The floating-gate device in a 0.22 μ m Flash-based FPGA was irradiated by X-ray. The radiation-induced threshold-voltage shift depends on the control-gate bias during irradiation. A physical explanation and a semi-empirical model are presented.

W-17 Single Event Upset Characterization of the Virtex-4 Field Programmable Gate Array Using Proton Irradiation

D.M. Hiemstra, F. Chayab, Z. Mohammed, MDA

Proton induced SEU cross-sections of functional blocks and the SRAM which stores the logic configuration of the Virtex-4 FPGA are presented. Upset rates in the space radiation environment are estimated.

W-18 Single Event Effects Test Results for the Actel ProASIC Plus Field Programmable Gate Array

G.R. Allen, G.M. Swift, Jet Propulsion Laboratory, California Institute of Technology

This work describes radiation testing of Actel's ProASIC Plus FPGA. The Device Under Test (DUT) was a ProASIC Plus APA300-PQ208 nonvolatile, field reprogrammable device which is based on a 0.22 μ m flash-based LVCMOS technology.

W-19 Single Event Upsets in Xilinx Virtex-4 FPGA Devices

J. George, R. Koga, The Aerospace Corporation; G. Swift, G. Allen, Jet Propulsion Laboratory; C. Carmichael, C.W. Tseng, Xilinx, Inc.

We present SEU sensitivities for Xilinx Virtex-4 LX60 FPGA devices in heavy ions similar to earlier generations. Upsets were identified separately for all functional blocks of the device including new clock dividers and DSP blocks.

Technical Program Friday

- W-20 Upset Characterization of the PowerPC405 Hard-Core Processor Embedded in the Xilinx Virtex-IIpro Field Programmable Gate Array**
G.M. Swift, G.R. Allen, F. Farmanesh, Jet Propulsion Laboratory, California Institute of Technology; D.J. Petrick, NASA/GSFC; F. Chayab, MDA Corporation; J.S. George, The Aerospace Corp.

Heavy-ion and proton SEU results for the 1.5V, 130 nm Virtex-II Pro PPC405 core show consistency, via available models, and fit with earlier processor work. Pseudo-static and dynamic methodologies yield insight into duty-cycle and frequency dependences.

- W-21 Radiation Tests on 2Gb NAND Flash Memories**
D.N. Nguyen, S.M. Guertin, J.D. Patterson, Jet Propulsion Laboratory, California Institute of Technology

SEE and TID tests of 2Gbits flash memories are reported. In-situ and biased irradiations characterized the total dose response of the memories. Failures were catalogued as SEU read errors, write errors and SEFI failures.

- W-22 Radiation Characteristics of a 0.11 μ m Modified Commercial CMOS Process**
C. Poivey, H. Kim, J. Forney, A. Phan, MEI Technologies; K.A. LaBel, NASA/GSFC; M.A. Vilchis, R.K. Saigusa, R. Finlinson, A. Sukharov, V. Hornback, J. Song, J. Tung, M.R. Mirabedini, LSI Logic

We present radiation data, total ionizing dose and single event effects, on the LSI Logic 0.11 μ m commercial process and two modified versions of this process. Modified versions include a buried layer to guarantee single latchup immunity

- W-23 Radiation Performance of a 1 Gbit DDR SDRAM Fabricated in the 90nm Technology Node**
R.L. Ladbury, K.A. LaBel, NASA/Goddard Space Flight Center; M. Berg, H. Kim, M. Friendlich, NASA/GSFC/Muniz Engineering, Inc.; R.A. Reed, Institute for Space and Defense Electronics, Vanderbilt University

We present SEE and TID data for a 1 Gbit DDR SDRAM fabricated in 90nm CMOS technology. We also compare performance of current and past generations of devices by the same manufacturer.

- W-24 SEE and TID Results for a RadHard-by-Design 16Mbit SRAM with Embedded EDAC**
C. Hafer, J. Mabra, D. Slocum, A. Jordan, T. Farris, Aeroflex

RadHard-by-Design has been advanced by embedding EDAC into a 16Mbit SRAM to SEU harden the memory cells. Conventional RadHard-by-Design techniques are used for the non-memory circuitry. Hardness results are presented.

- W-25 Single Event Effects Sensitivity of the Q Series Advanced CMOS Technology**
R. Koga, J. George, P. Yu, S. Crain, K. Crawford, M. Zakrzewski, The Aerospace Corp.

Heavy ion induced SEEs for the Quiet Series FACT devices are presented. SETs take place in devices with memory elements as well as in gates. These devices are tolerant to SEEs at low LET values.

Technical Program Friday

W-26 Single Event Transients (SETs) Induced in the RH108 Operational Amplifier in Analog Circuits by Heavy Ion and Pulse-Laser Testing Methodologies

R.M. Chevez, L.Z. Scheick, T.F. Miyahira, J.S. Laird, A.H. Johnston, Jet Propulsion Laboratory, California Institute of Technology

Heavy ion testing method has been correlated with laser scanning in the RH108 SET sensitivity using different configurations. This correlation is confirmed by comparing transient types and plots of transient voltage amplitude versus pulse duration.

W-27 Evaluation of Worst-Case Test Conditions for SEE on Power MOSFETs

S. Liu, M. Boden, H. Cao, E. Sanchez, International Rectifier Corp.; J. Titus, NAVSEA Crane

Extensive SEE tests were performed on 600V and 250V power MOSFETs with different ions, beam energies, Bragg Peak positions, drain/source biases. Results show no worst-case test condition for SEB but is for SEGR.

W-28 Determination of High Energy Neutron Voltage Stress Margins for High Voltage IGBT and Diode Pairs from Two Manufacturers using Energetic Particle Induced Charge Spectroscopy, EPICS

R. Edwards, J. Woodhouse, Goodrich Engine Control Systems

Use of high voltage [$>200V$] IGBT electronic drives is increasing. To avoid destructive SEB in the atmospheric neutron radiation environment, 50% derating is recommended. EPICS is used to determine voltage stress margins for two manufacturers.

W-29 The Use of the Compensated Contoured Double Scatterer in the Radiation Test Beamline at the Francis H. Burr Proton Therapy Center

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

The compensated contoured double scatterer is a beam spreading system that was developed for clinical proton therapy applications. Application of this system to radiation test beams at the Francis Burr Proton Therapy Center is described.

W-30 Berkeley Accelerator Space Effects (BASE) Light Ion Facility Upgrade

M.B. Johnson, T.L. Gimpel, M.A. McMahan, W.S. Tiffany, Lawrence Berkeley National Laboratory

The BASE Light Ion Facility upgrades have been completed. All proton beams are now delivered to Cave 4A. New control software, a larger diameter beam window, and improved quality assurance measures have been added.

W-31 Correlating Geometry and Shielding Effects on Accelerated Soft Errors in 90nm SRAM Using Spallation Neutron Beams

X. Zhu, R. Baumann, Texas Instruments; B. Takala, Los Alamos National Lab; D. Dohmann, Teradyne; L. Martinez, Texas instruments

Accelerated soft error data in embedded SRAM in an advanced CMOS DSP are used to determine the impact of geometry and shielding effects on the accuracy of extrapolated product failure rates due to terrestrial neutrons.

11:45 AM END OF CONFERENCE

RESG NEWS



The forty-third annual Nuclear and Space Radiation Effects Conference (NSREC) will be held at the Sawgrass Marriott Resort and Spa, located along the Atlantic Coast in Ponte Vedra Beach, Florida. Sawgrass has a spectacular setting, with 15 acres of lagoons, moss-draped oaks, and fragrant magnolias. The site will please those who love beaches, historical sites, and shopping. It also is home to the Tournament Players Club Stadium Golf Course, which hosts The Players Championship every March. Janet Barth and her 2006 conference committee have put together a strong technical program, as well as social events that will provide frequent opportunities for discussing radiation effects with friends, old and new.



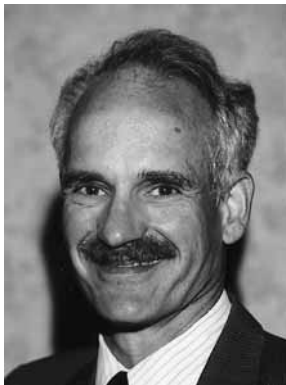
Ronald D. Schrimpf
Chairman

Lloyd Massengill of Vanderbilt University is the 2007 Conference General Chair; he has chosen the Hilton Hawaiian Village Hotel in Honolulu, Hawaii as the conference site. This will be the first visit of NSREC to Hawaii, so start thinking about submitting a paper!

Paul Dodd of Sandia National Labs will chair the 2008 Conference, which will be held at the J. W. Marriott Resort in Tucson, Arizona. This is a brand new resort located in the mountains west of Tucson, with incredible views and an environmentally sensitive design.

The amount of lead time required to plan a conference has increased and it currently takes more than three years to plan each NSREC. Mark Hopkins of The Aerospace Corporation is presently considering sites for the 2009 conference. He will host the spring RESG meeting in Quebec City, Canada.

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 instruction can be found at <http://www.nsrec.com/editmsg.htm>.



Tim Oldham
Executive Vice Chairman

During the fall RESG meeting in Ponte Vedra Beach, Steve Buchner of QSS Group/NASA Goddard was selected as Assistant Guest Editor for the December issue of the *IEEE Transactions on Nuclear Science*. We're very pleased that Steve has agreed to perform this important job.

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.

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 \$20. 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 \$60 (print) or \$40 (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 \$60 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 *2006 IEEE Radiation Effects Data Workshop Record* and one issue of the *IEEE Transactions on Nuclear Science* will be mailed to each NSREC technical session attendee.

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

You are invited to attend the IEEE Radiation Effects Committee's Annual Open Meeting on Thursday, July 20, from 5:15 – 6:30 PM in the Champions Ballrooms D-H. All conference attendees and spouses are encouraged to attend. We will discuss the 2006 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

2005 OUTSTANDING CONFERENCE PAPER AWARD

Effects of Particle Energy on Proton and Neutron-Induced Single-Event Latchup

*J. R. Schwank, P. E. Dodd, J. A. Felix, F. W. Sexton, G. L. Hash, M. R. Shaneyfelt,
Sandia National Laboratories; J. Baggio, V. Ferlet-Cavrois, P. Paillet, Damien Lambert,
CEA/DIF; E. Blackmore, TRIUMF*

2005 DATA WORKSHOP PAPER AWARDS

Radiation Belt Modeling for Spacecraft Design: Model Comparisons for Common Orbits

J.-M. Lauenstein, Muñiz Engineering, Inc.; J. L. Barth, NASA/GSFC

IEEE FELLOWS

One distinguished member of the radiation effects community was elected to the grade of IEEE Fellow on January 1, 2006.

Dr. Edward Petersen

Consultant, Jeffersonton, VA, USA

Edward's citation reads, "for contributions to upset rate calculations for microelectronics in space environments."

2005 NPSS MERIT AWARD

Peter Winokur

Sandia National Laboratories

The NPSS Merit Award recognizes outstanding technical contributions to the fields of Nuclear and Plasma Sciences. Peter's citation reads "For contributions to the development of radiation hardened microelectronics and radiation hardness assurance test methods."

Awards

2005 RADIATION EFFECTS AWARD

The 2005 Radiation Effects Award was presented to Professor Jean Gasiot from the Université Montpellier, France, during the opening ceremonies of the 2005 conference. Professor Gasiot's citation reads "for technical contributions and leadership that have enhanced the understanding of radiation effects in semiconductor devices, for strong contributions to the European radiation effects community, and for promoting radiation effects education."

2006 RADIATION EFFECTS AWARD

The winner of the 2006 Radiation Effects Award will be announced Tuesday morning, July 18.

2007 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2007 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 2007 IEEE NSREC at Waikiki, in Honolulu, Hawaii in July 2007. 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 Véronique Ferlet-Cavrois, Member-at-Large for the Radiation Effects Steering Group. Véronique be reached at 33-169-26-4265, veronique.ferlet@cea.fr.

Conference Information

The 2006 IEEE NSREC will be held at the Sawgrass Marriott Resort and Spa. Nestled along Florida's Atlantic coast in picturesque Ponte Vedra Beach on 15 acres, the Resort offers 508 guest rooms and villas, seven restaurants and two lounges, three swimming pools, 11 nearby tennis courts and five championship golf courses nearby.



ROOMS FOR SIDE MEETINGS

Several meeting rooms are available for use by any registered conference attendee at the Sawgrass Marriott 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@qwest.net to make side meeting reservations before the conference. To make a side meeting reservation during the conference, see the NSREC Registration Desk staff.

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.

MESSAGES

904-285-7777
ASK FOR THE NSREC
REGISTRATION DESK
FAX: 904-285-0906

A message board will be located in the lobby just outside the conference room for all incoming messages 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 a fee for incoming guest faxes.

CONTINENTAL BREAKFAST AND COFFEE BREAKS

The 2006 IEEE NSREC will provide continental style breakfasts and refreshments at breaks during the NSREC Short Course and Technical Sessions. Breakfast every day will begin at 7:30 AM for *conference registered attendees only*.

BUSINESS CENTER

The Sawgrass Marriott Resort and Spa has a Business Center located in the Convention Center on the Lobby Level. The Business Center is open 24 hours (with room key access) and staffed during normal business hours. Services available are: outgoing fax machine, computer stations with internet access, laptop internet access outlets, and printers. 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 16, 2006.**

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

720-733-2003
FAX: 720-733-2046
ETCSERVICES@QWEST.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 "2006 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 Champions Registration Desk. For everyone who has pre-registered, your packets can be picked up at the Masters Registration Desk. The following is the schedule for registration:

ON-SITE REGISTRATION HOURS

Sunday, July 16	5:00 PM – 9:00 PM
Monday, July 17	7:30 AM – 4:00 PM 6:00 PM – 9:00 PM
Tuesday, July 18	7:30 AM – 5:30 PM
Wednesday, July 19	7:30 AM – 3:00 PM
Thursday, July 20	7:30 AM – 3:00 PM
Friday, July 21	7:30 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 16, 2006 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@qwest.net.

Registration and Travel

HOTEL RESERVATIONS AND INFORMATION

SAWGRASS MARRIOTT RESORT AND SPA

1000 PGA TOUR BLVD
PONTE VEDRA BEACH,
FLORIDA
32082
USA

904-285-7777
FAX: 904-285-0906



The 2006 IEEE NSREC will be held at the Sawgrass Marriott Resort and Spa in Ponte Vedra Beach. Sawgrass is also a showcase of Florida's natural treasures, with 15 acres of lagoons, moss-draped oaks, and fragrant magnolias. Dining choices include seven restaurants and two lounges that offer everything from fresh seafood and steaks to casual dining with a tropical

twist. Your guest room is a soothing retreat after taking advantage of their pristine ocean beach, three swimming pools, 11 nearby tennis courts, and their award-winning children's program. Surrounded by five championship golf courses, Sawgrass is truly a golfer's paradise, and just minutes away from their ocean Beach Club. The hotel rooms offer coffeemaker, iron/board, cable TV, hair dryer, high-speed internet access and mini-bar. Villa Suites, with fully equipped kitchens, lend themselves well to families and offer all the amenities of the popular hotel rooms. The new Spa opened in late 2005 and offers a wide range of spa treatments, along with a private pool. Basic Spa facilities are available at the rate of \$25 per day; treatments are at an additional fee. Check with the Spa for appointments and rate details. The hotel has its own 24-hour fitness center located in the main building of the resort. It is offered to NSREC attendees on a complimentary basis.

The group rate for a standard room is \$119.00 + 9% tax for single and double occupancy (please refer to the **IEEE NSREC Block of Rooms**). Additional adults are \$20.00 + tax per person. Children 18 years of age and younger are free when sharing a room with their parents. One-bedroom villas (complete with full kitchen & living room) are available on a "space available" basis @ \$149.00 + 9% tax per night. A second adjoining bedroom can be added at the regular room rate. In line with the current government per diem guidelines, a limited number of rooms are available at the prevailing government rate plus 25%, or \$107.50 + 9% tax, single/double occupancy (please refer to the **IEEE NSREC GOV Block of Rooms**).

MAKING RESERVATIONS

All rooms must be guaranteed with a credit card or deposited by check. The cut-off for IEEE NSREC reservations is **June 16, 2006**. After the cut-off date, room accommodations will be confirmed on a space available basis and the room rate will be higher!

Reservations can be made by calling the Sawgrass Marriott directly at 904-285-7777 or 800-457-4653 – provide the full conference name, IEEE NSREC, in order to make reservations at our special rates. Alternatively, reservations can be made on-line at the NSREC web site (www.nsrec.com), by clicking on the link to the Sawgrass Marriott hotel registration web site. This will take you directly to the IEEE NSREC block of rooms where the special "rate code" has already been entered. You must simply enter the dates needed for your reservation and then follow the prompts.

Negotiated group rate: <http://marriott.com/property/propertypage/jaxsw?groupCode=insinsa&app=resvlink>

Government rate: <http://marriott.com/property/propertypage/jaxsw?groupCode=inginga&app=resvlink>

Note: Reservations for the villas and suites require a call directly to the hotel for availability and booking, tel: 904-285-7777.

Registration and Travel

AIRPORT AND TRANSPORTATION INFORMATION

The Jacksonville International Airport is located north of Jacksonville and is 37 miles from the Sawgrass Resort. Please see below for driving directions. Taxi service is \$50.00 one-way from the Airport.

Note: In most cases, the airfares into Orlando are MUCH lower than they are into Jacksonville. A shuttle service is not available from Orlando but if you rent a car, the drive is about 2 1/2 - 3 hours, depending on traffic and how you drive.

AIRPORT SHUTTLE

Carey Transportation in Jacksonville has arranged a special IEEE NSREC rate for the conference of \$35.00 each way for reservations made three days in advance. The shuttle will run at the top of each hour for reservations made in advance. When leaving the baggage claim area, proceed to the Ground Transportation Booth and ask for your Carey Chauffeur. For more information and to make reservations, contact Carey (24-hours a day) at 1-800-829-7433 and mention program code "IEEE." The Carey Service Desk is located in the lobby of the hotel and can assist you with any ground transportation needs at extension 7880.

DRIVING DIRECTIONS

From Jacksonville International Airport: Take Interstate 95 South. Exit at State Road 202 (Exit 344, J. Turner Butler Boulevard). Follow SR202 East to A1A; turn right onto A1A and follow south 3.5 miles to PGA Tour Boulevard. Turn right on PGA Tour Boulevard. The Sawgrass Marriott Resort and Spa will be on the left.

From the south (Orlando): Take Interstate 4 North from the Orlando area to Interstate 95. Follow I-95 North to State Road 202 (Exit 344, J. Turner Butler Boulevard). Follow SR202 East to A1A; turn right onto A1A and follow south 3.5 miles to PGA Tour Boulevard. Turn right on PGA Tour Boulevard. The Sawgrass Marriott Resort and Spa will be on the left.

From the west: Take Interstate 10 to Interstate 95 and follow I-95 South. Exit at State Road 202 (Exit 344, J. Turner Butler Boulevard). Follow SR202 East to A1A; turn right onto A1A and follow south 3.5 miles to PGA Tour Boulevard. Turn right on PGA Tour Boulevard. The Sawgrass Marriott Resort and Spa will be on the left.

DRIVING NOTE

Please note that rental car agencies may furnish directions to the Marriott property using State Road 9A. This route is not recommended due to possible construction delays.

PARKING

Self-parking is complimentary for NSREC hotel guests at the Sawgrass Marriott. Valet parking is \$15.00 per day, chargeable to your room account.

Registration and Travel

RENTAL CAR DISCOUNT HERTZ

HERTZ NUMBER
CV #03S20001 IEEE NSREC

As the hotel site is well outside Jacksonville, we suggest a rental car, if possible. Public transportation is sporadic and many attractions are not within walking distance. The Sawgrass Marriott does operate a shuttle to their oceanfront beach club; using this is recommended due to limited parking at that facility. In addition, there is a shopping center directly across from the hotel that can be accessed on foot.

Hertz has been selected as the official car rental agency for the 2006 NSREC and will be offering discounted rates for conference attendees. For reservations and information, call Hertz at 800-654-2240 and mention CV #03S20001 or use the Hertz website at www.hertz.com. The special conference rates will be available from July 11, 2006, to July 27, 2006, and will be valid for pick-up and return at any Florida Hertz location. Note also that Hertz has a rental office conveniently located on the Sawgrass Marriott property.

Class	Car type	Daily (per day)	Weekend (per day)	Weekly (5 - 7 days)
A	Economy	\$30.99	\$28.99	\$125.99
B	Compact 2/4-door	\$33.99	\$29.99	\$134.99
C	Midsized	\$34.99	\$31.99	\$157.99
D	Special sporty	\$36.99	\$31.99	\$162.99
F	Fullsize 4-door	\$39.99	\$35.99	\$179.99
G	Premium	\$44.99	\$49.99	\$211.99
I	Towncar	\$60.99	\$60.99	\$298.99
L	4WD/AWD SUV	\$52.99	\$49.99	\$249.99
R	Minivan 2WD	\$44.99	\$49.99	\$249.99
U	Convertible	\$52.99	\$49.99	\$249.99

The above rates are subject to availability so advance reservations are recommended. 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.

Industrial Exhibits



Richard Elmhurst
Industrial Exhibits Chairman

The 2006 exhibits will be held July 18-19 at the Sawgrass Marriott Resort, Masters and Heritage Ballrooms, in Ponte Vedra, Florida. We are looking forward to a very well attended conference with an excellent traffic flow through the exhibit areas; the exhibit halls are adjacent to the main convention ballroom. To encourage foot traffic, we are planning catered functions including the Tuesday evening reception in the exhibit area. **NOTE: Children under 16 must be accompanied by an adult in the Exhibits.**

For additional information, contact:

Richard Elmhurst Phone: 727-539-3209
Honeywell Space Systems Fax: 727-539-2598
Email: richard.f.elmhurst@honeywell.com

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

Booth Spaces: \$2,200 per 8' x 10' area. Included in this cost is:

- A link to your company's web page on the NSREC exhibitor page
- One (1) complimentary conference registration per 8' x 10' space rented
- Two (2) complimentary exhibitor badges granted to the exhibit area for booth staffers (additional exhibitor badges \$100 each)
- Exhibitor Reception July 18, 2006

EXHIBIT HALL HOURS

Set-Up:	Monday, July 17	4:00 PM - 7:00 PM
	Tuesday, July 18	7:00 AM - 8:45 AM
	All booths must be in place by 8:45 AM, Tuesday.	
Show Hours:	Tuesday, July 18	9:00 AM - 5:00 PM
		9:45 AM - 10:15 AM (conference break)
		2:40 PM - 3:10 PM (conference break)
		6:00 PM - 10:00 PM (exhibitor reception)
		<i>6:00 PM cocktails, 7:00 PM buffet</i>
	Wednesday, July 19	9:00 AM - 1:00 PM
		9:55 AM - 10:25 AM (conference break)
Tear-down:	Wednesday, July 13	1:00 PM - 4:00 PM

EXHIBITORS

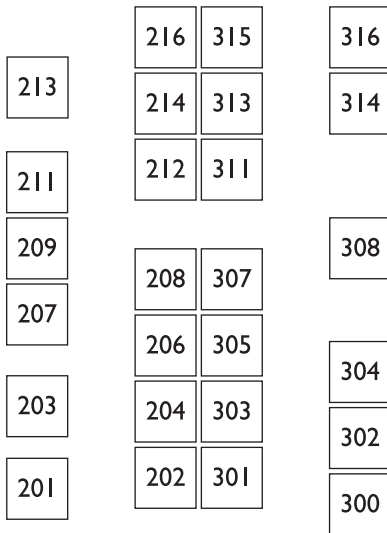
Please check our web site (www.nsrec.com) for a current listing of companies exhibiting at 2006 NSREC.

Industrial Exhibits

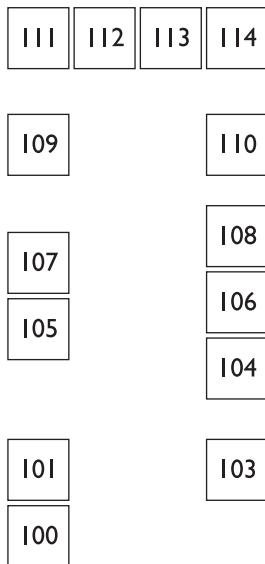
EXHIBITORS

NSREC Industrial Exhibits

Masters Ballroom



Heritage Ballroom



Company	Internet Site	Booth #
3D Plus - USA	www.3d-plus.com	314
Actel Corporation	www.actel.com	305, 307
Aeroflex Colorado Springs	www.aeroflex.com/radhard	202, 204
ATK Mission Research Microelectronics Division	www.atk.com	301
Atmel	www.atmel.com	302, 304
BAE Systems	www.na.baesystems.com	303
Boeing Solid State Electronics Development	www.boeing.com/ssed	104
Crane Aerospace & Electronics	www.cranae.com	315
Cyclotron Institute, Texas A& M	www.cyclotron.tamu.edu/ref	107
Defense Microelectronics Activity (DMEA)	www.dmea.osd.mil	300
Honeywell Solid State Electronics Center	www.myspaceparts.com	203
ICS Radiation Technologies	www.icsrad.com	112
Idaho Accelerator Center	www.iac.isu.edu	110
International Rectifier	http://hirel.irf.com	308
Intersil Corporation	www.intersil.com	211
J.L. Shepherd & Associates	www.jlshepherd.com	216
Lawrence Berkeley National Lab - 88" Cyclotron	http://user88.lbl.gov	106
Maxwell Technologies	www.maxwell.com	316
MicroSemi Corporation	www.microsemi.com	209
Modular Devices Inc.	www.mdipower.com	311
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2006 IEEE NSREC Technical Sessions and Short Course Registration Form



Name _____
Last Name First Name Middle Initial

Name to appear on badge _____

Company/Agency _____

Mailing Address _____

City _____

State _____ Zip Code _____

Country _____

Telephone Number _____

Fax Number _____

E-mail Address _____

IEEE MEMBERSHIP

I am an IEEE Member. _____
Membership Number

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 16, 2006 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.

Mail or Fax this form and your remittance (payable to 2006 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 16, 2006.

	<u>Early</u>	<u>Late</u>	
IEEE Member			
Short Course **	\$230	\$280	\$ _____
Technical Sessions	\$400	\$480	\$ _____
Non-IEEE Member			
Short Course **	\$290	\$345	\$ _____
Technical Sessions	\$500	\$600	\$ _____
Full-Time Students who are IEEE Members *			
Short Course **	\$115	\$280	\$ _____
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: **2006 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 the full-time student IEEE rate, you must provide your IEEE number on this form.

** All short course attendees will receive a special CD-ROM containing the complete notes from all previous NSREC short courses (1980-2006). The notes will be electronically searchable and will include all figures and text.

2006 IEEE NSREC Activities Registration Form



Conference Participant _____

Company/Agency _____

Address _____

City _____

State _____ Zip Code _____

Country _____

Telephone Number _____

Fax Number _____

Accompanying Persons _____
Name

Please list ages for children under age 21 only

Name Age

Name Age

Name Age

Mail or Fax this form and your remittance
(payable to 2006 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 16, 2006. We strongly encourage early registration; note that the number of tickets available after pre-registration for each event is limited. Children must be accompanied by an adult during all tours and social events.

	<u>Early</u>	<u>Late</u>	<u>Number Attending</u>	<u>Total Cost</u>
Short Course Reception: Sunday, July 16				
Adult	\$0	\$0	_____	
St. Augustine Tour or Alligator Farm: Tuesday, July 18				
Adult	\$25	\$30	_____	\$_____
Child (age 4-12)	\$20	\$25	_____	\$_____
Child (age 0-3)	\$0	\$0	_____	
Industrial Exhibits Reception: Tuesday, July 18				
Adult/child	\$0	\$0	_____	
Child (age 0-12)	\$0	\$0	_____	
A Taste of Florida Dinner and Entertainment: Wednesday, July 19				
Adult/child	\$35	\$45	_____	\$_____
Child (age 0-3)	\$0	\$0	_____	
Pool Party (age 4-12)	\$20	\$25	_____	\$_____
Family Ancestors and Lunch: Thursday, July 20				
Adult/child	\$25	\$30	_____	\$_____

TOTAL AMOUNT ENCLOSED: \$_____

CANCELLATIONS

To encourage advanced registration for conference social activities, we will refund all activity fees for conference attendees and/or their companions who for any reason are unable to attend the conference. If your plans change after this form is submitted and you would like to request a refund, you must notify ETC Services by email at etcservices@qwest.net or FAX at 720-733-2046 no later than July 7 or notify the conference registration desk when picking up your registration materials (**but no later than 24 hours before the scheduled activity**).

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: **2006 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

PONTE VEDRA BEACH, FLORIDA



"Welcome to sunny Florida! We wish you an enjoyable stay."

*Nick van Vonno, Intersil
Local Arrangements Chairman*

The 2006 Nuclear and Space Radiation Effects Conference will be held at the Sawgrass Marriott in Ponte Vedra Beach, Florida, a beachfront community located on the Atlantic Ocean just outside Jacksonville.

Jacksonville and the beaches are fabulous Florida at its best with a dash of Southern charm added. From expansive beaches and endless saltwater marshes to a modern downtown, exciting shopping and championship golf courses, there are activities to please everyone.

Ponte Vedra Beach features beautiful beaches, world-class tennis, and professional golf. The natural beauty of this area has been carefully preserved, with miles of freshwater streams and lagoons, twisted live oaks and hammocks of wild palmettos. Jacksonville is a city adorned with fountains, parks and plazas, with neighborhoods lined with hundred-year old oak trees draped with Spanish moss. Jacksonville Beach is a few miles North of Ponte Vedra Beach and offers beach facilities, shopping and fine dining. St. Augustine is just a short drive away, and offers many attractions including Fort San Marcos, built to defend this oldest city in the United States against would-be invaders. Guided tours on buses and trams and scenic boat tours are a great way to see St. Augustine. To the North of Jacksonville is Amelia Island, with downtown Fernandina Beach offering antique shopping and fine dining. The Jacksonville area features numerous Florida state parks, including Guana State Park, the Timucuan Preserve and the Fort George historical site. The parks offer opportunities for hiking, fishing, water sports and bird watching. Other Florida attractions such as the Kennedy Space Center, the Orlando attractions and the Port Canaveral cruise ship terminal are only a couple of hours drive away.



Photo: courtesy of the Sawgrass Marriott.

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

**SUNDAY, JULY 16
5:00 PM TO 7:00 PM
SHORT COURSE
RECEPTION**

Please join us for light refreshments in the Masters 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 18
9:30 AM TO 3:30 PM
ST. AUGUSTINE CITY TOUR
OR
ALLIGATOR FARM VISIT



Attendees have two events to choose from – visiting St. Augustine or the Alligator Farm Zoological Park on this tour. The tour will meet at the Sawgrass Marriott at 9:30 AM for departure to St. Augustine, arriving by 10:15 AM. Those wishing to visit the Alligator Farm remain on the bus and will arrive at 10:30 AM. **NOTE:** Admission to the alligator Farm is **NOT** included in the tour. Costs are \$12.58 for adults and \$6.98 for children, 5 - 11 years. Strollers can be taken on the bus.

St. Augustine

St. Augustine, the nation's oldest city, also holds the distinction of being one of the nation's most charming. Because of North Florida's year-round mild climate, the area's delightful historic district, with its cobblestone streets and its quaint cafes, bars, unique shops and bed-and-breakfast inns, comes alive with locals and tourists setting out on foot to explore landmarks such as the Castillo de San Marcos National Monument. St. Augustine and the Castillo serve as outstanding reminders of the power of the Spanish empire in the New World. If you have a passion for antiques, hand crafted gifts, blown glass, arts and crafts, fine arts, gifts or handmade chocolates, St. Augustine is the hot shopping spot for you! Relax as you stroll along historic downtown streets and shop in the eclectic stores located there. Visit the Lightner Museum with its distinctive Spanish Renaissance styling, then stop to take in a meal in one of many fine restaurants.

Alligator Farm Zoological Park

The Park features alligators, crocodiles, wading birds and exotic animals. A snack bar is available. Buses will depart the Park at 12:15 PM and arrive back at St. Augustine at 12:30 PM, allowing time to meet the other attendees for lunch there.

The bus departs St. Augustine at 2:45 PM and will arrive back at the Marriott at 3:30 PM.

Please remember to bring sunscreen, comfortable walking shoes, and water!

TUESDAY, JULY 18
6:00 PM TO 10:00 PM
INDUSTRIAL EXHIBITS
RECEPTION

6:00 PM COCKTAILS
7:00 PM BUFFET

A reception will be hosted by the NSREC exhibitors in the Heritage and Masters Ballrooms. Along with meeting representatives from leading companies in the radiation-hardening industry, enjoy complimentary food and drinks for NSREC attendees and their guests. **NOTE: Children under 16 must be accompanied by an adult in the Exhibits.**



Social Program

**WEDNESDAY, JULY 19
6:00 PM TO 10:00 PM
A TASTE OF FLORIDA
DINNER AND
ENTERTAINMENT**

**6:00 PM COCKTAILS
6:45 PM DINNER**



Welcome to 'A Taste of Florida'! Our Wednesday night social will bring the many aspects of Florida to life for you to experience, from Miami's South Beach to the Everglades. It will be held on the Sawgrass Marriott property in Champion Ballrooms D - H.

Nothing says 'Florida' like pink flamingoes! Standing seven feet tall with wings spread, they welcome you to this exciting function. Once inside, you will start your tour of the Sunshine State in outrageous South Beach. You will then move south to Key West, followed by a stop in the Florida Everglades. You will end your tour in exciting Daytona Beach.

Your meal will be served buffet style (open from 6:45 to 8:15 PM) and will feature cuisine typical of four theme areas, including Keys seafood salad, South Beach bonito gratin, Daytona BBQ and Apalachicola clams, mussels and oysters, plus a great array of side dishes and desserts.

Entertainment will be by Florida's own Ocean Waves beginning at 7:00 PM. This five-piece band has been thrilling audiences for years with their unique blend of island-style music from the Caribbean, soulful R&B, beach music, Reggae and Jazz, all incorporating Latin rhythms and an enormous amount of excitement, energy and professionalism. These guys don't wear long beards and they don't wear cheap sunglasses!

Children 4-12 have two events to choose from. They may attend the Wednesday social with their parents or choose a parallel "Pool Party" function. The Pool Party runs from 6:00 - 10:00 PM and is chaperoned by the Marriott's professional recreation staff. It consists of a variety of poolside fun and games including the sunken treasure hunt, arts and crafts, noodle races and the famous Sawgrass "Dive-in Movie." Dinner will be served. NOTE: Children cannot go back and forth between the two events. Please see the Activity Registration page for costs.

Welcome to Florida... and don't forget your sunscreen! Attendance to this event is restricted to attendees and their immediate family members. We encourage you to sign up early, as we expect this to be a sellout.

Social Program

**THURSDAY, JULY 20
11:30 AM TO 2:00 PM
LUNCH AT THE
SAWGRASS MARRIOTT:**

**THE FIVE Ws OF
GENEALOGY:
WHO, WHAT, WHEN,
WHERE AND WHY**



Have you ever wanted to find out more about your ancestors? Have you seen articles on researching your family through genealogy but were you concerned about difficult searches and hours spent digging through dusty libraries? Come join us for an exciting function with lunch in a beautiful Florida setting. After lunch, there will be a talk by Ann Mohr Osisek of Orlando, Florida, a professional genealogist, President of the Florida State Genealogical Society and Past President of the Central Florida Genealogical Society, with years of experience in this fascinating field. Ann is a member of the National Genealogical Society and the Association of Professional Genealogists, serving as Secretary of the FL Chapter of APG. Ms. Mohr Osisek will show you how to get started researching your family history and how to use the Internet for your research. As an added attraction we have arranged for a display of family memorabilia, showing typical genealogical research literature, memorabilia and images that will bring your ancestors to life! This display will be courtesy of our own Sue van Vonno, who is an experienced genealogist herself and who will be available for discussions on her favorite activity as well. Be prepared, there is no telling what your research will turn up!

This function will be held on the Sawgrass Marriott property. Lunch will be served at 11:30 AM, followed by the talk from 12:45 to 1:30 PM and a discussion period afterwards.

AEROBICS

Get a healthy start on your day with Dave Bushmire, our own certified aerobics instructor. These sessions will take place at 6:30 AM on Tuesday, Wednesday and Thursday in the Island Green Pavilion Room.

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 at 720-733-2046 no later than July 7, 2006.

Local Activities

PONTE VEDRA BEACH SHOPPING

The Sawgrass Village shopping center is conveniently located across the feeder road to the Marriott property. It can be easily reached on foot or via the Marriott shuttle and provides a wide range of resources, including a grocery store, pharmacy, several restaurants, upscale boutique clothing stores and a liquor store. There are also numerous shopping centers off A1A, both north and south of the Marriott property.

THE JACKSONVILLE BEACHES

Jacksonville Beach is ten minutes North of the Sawgrass Marriott property and features a boardwalk, ocean pier and public beach. There is a selection of restaurants and beach shops for fun shopping and dining. The restored downtown area is an attractive destination.

ST. AUGUSTINE

The oldest continuously occupied city in the United States, St. Augustine is filled with modern and ancient treasures. The city still shows considerable influence from the Europeans that settled here centuries ago.

Guided tours on buses and trams are the best way to experience this fascinating city, with stops at all the major points of interest including Castillo San

Marcos, an authentic and very large Spanish fort in an excellent state of preservation. St. Augustine is surrounded by water and a boat tour is an excellent alternative for seeing the town. The downtown area features several museums including the Lightner. Enjoy wandering through the museum's setting – the former Hotel Alcazar, built in 1887 in the Spanish Renaissance style by railroad magnate Henry M. Flagler. The Lightner features cut glass, Victorian art glass, costumes, furnishings and mechanical musical instruments from the Gilded Age. There is abundant shopping on Saint George Street and a broad range of lunch and dinner opportunities. Public parking is available in several lots for a nominal fee; this is highly recommended, as street parking is difficult to find. There is a large parking lot adjacent to the trolley station on A1A, just across from Castillo San Marcos.



Castillo San Marcos. Photo: courtesy of the Sawgrass Marriott.

STATE PARKS

The Northeast Florida state parks provide outstanding ecotourism opportunities. At Big Talbot Island, Little Talbot Island and the Fort George site, north of Jacksonville Beach, you will find hiking, great biking trails, a bird sanctuary and excellent fishing. Near these sites is Kingsley Plantation, offering a glance back to the antebellum South. The plantation has been carefully restored and offers visitors a true sense of the struggles and drama of those times. Other nearby state parks include Anastasia State Park, Guana State Park and Faver Dykes State Park, all south of Jacksonville.

Local Activities

OUTLET MALLS

There are three major outlet malls within easy driving distance of the Sawgrass Marriott. St. Augustine Outlet Mall (<http://www.staugustineoutlets.com>) is on State Road 16, two miles Northwest of St. Augustine, and features 85 stores. Belz Factory Outlet World (<http://www.belz.com>) is located near the St. Augustine Outlet Mall, at Exit 318 off Interstate 95 South of Jacksonville; this is the exit for State Road 16, so both malls can be easily accessed in one trip. Belz Factory Outlet World features some 50 stores. The Avenues Mall (<http://www.simon.com/mall/default.aspx?ID=124>) is located at the intersection of US 1 (Phillips Highway) and Interstate 95 (exit 339 off I-95), 15 minutes south of downtown Jacksonville. The Avenues Mall has five department stores and more than 20 exclusive stores.

ADVENTURE LANDING

Adventure Landing and Shipwreck Island Water Park in Jacksonville Beach is the largest family entertainment center in northeast Florida and is located five minutes West of Jacksonville Beach on Beach Boulevard. The premier summertime attraction is Shipwreck Island Water Park, featuring the Little St. Johns River, Typhoon Lagoon – a half million-gallon wave pool – and three water slides. Adventure Landing also features Speedway Go-Karts, Adventure Golf, Laser Tag and many other fun activities.

AMELIA ISLAND AND FERNANDINA BEACH

Fernandina Beach is on Amelia Island, some 35 miles North of Ponte Vedra Beach. Shop for antiques or stop in for lunch or dinner at one of the area's many restaurants, featuring Southern specialties such as fried green tomatoes. Other sights include the history museum and the 1839 lighthouse that is still operational. Amelia Island itself offers coastal live oak hammocks and spectacular ocean views with abundant wildlife. Fort Clinch State Park provides visitors a unique look at the daily life of Civil War soldiers and their families.

CHAMPIONSHIP GOLF COURSES

Golfing and Florida are interchangeable when talking about sporting activity. As the second-largest golf resort in the United States and the home of the world-famous TPC at Sawgrass Stadium Course, the Sawgrass Marriott Resort and Spa has a reputation for unsurpassed golf, with a mixture of play that is pleasurable for both the proficient golfer and high handicapper. With Ponte Vedra Beach home to several of the world's most challenging courses, NSREC 2006 will offer both the serious and the not so serious golfer a challenge that he or she will not forget.



Photo: courtesy of the Sawgrass Marriott.

Courses available to NSREC attendees and their guests will include the TPC Valley*, Oak Bridge*, Sawgrass*, and Marsh Landing*, as well as a number of public courses within a short drive of the Resort, including the Royal St. Augustine and "King and Bear" at World Golf Village.

(*You must be a registered guest at the Sawgrass Marriott to play the resort's managed TPC courses. The only exception will be an informal pre-conference golf outing on July 15th. Any registered NSREC 2006 attendee or guest may play the Valley Course on the 15th. For information contact Doug Barth at barth7394@comcast.net.)

Local Activities

WORLD GOLF VILLAGE

Visitors to the World Golf Hall of Fame will experience the fascinating tale of golf's history and its development from the cradle in Scotland through its growth to the far reaches of the world. The World Golf Hall of Fame is conveniently located 20 minutes south of Jacksonville and 8 miles north of historic St. Augustine, off Interstate-95 at exit 323, International Golf Parkway.

DOWNTOWN JACKSONVILLE



Enjoy a visit to any one of Downtown's many unique attractions, including museums, theatre, and an array of festivals, concerts, shows and exhibitions. With over 90 restaurants, downtown is definitely a dining destination. It's also a cultural center, with over 17 art galleries, museums, theatres and performing arts venues. The Museum of Science and History features rotating exhibits, educational programs and, of course, a planetarium. Check out the Art Loft Explorium at the Jacksonville Museum of Modern Art, located on Hemming Plaza. This colorful space features 16 stimulating learning stations where children and adults can experience modern and contemporary art.

ORLANDO ATTRACTIONS

Orlando, Florida is the theme park capital of the world. Walt Disney World covers over 47 square miles and has four major theme parks, Magic Kingdom Park, Epcot, Disney - MGM Studios and Disney's Animal Kingdom Theme Park. There are two water parks, Disney's Blizzard Beach and Disney's Typhoon Lagoon. You can also choose from two nighttime entertainment complexes, Downtown Disney West Side, or Pleasure Island.

Universal's theme parks have developed into a first rate destination with two theme parks, Universal Studios Theme Park and Universal's Islands of Adventure.

For years children have been chanting "Shamu, Shamu, Shamu" at the very mention of Sea World. Well, the killer whales are still there, along with polar bears, birds of all shapes and sizes and some amazingly friendly dolphins.

Aside from the major theme parks Orlando features a number of smaller parks that offer a great day out for people of all ages. Typically these parks have shorter lines and the whole experience is a little more laid back.

CAPE CANAVERAL AND THE KENNEDY SPACE CENTER

Since the dawn of space flight, John F. Kennedy Space Center has been at the forefront of America's adventure in space. From here, NASA has launched its astronauts and spacecraft on missions to Earth orbit, the moon and the universe beyond.

To access Kennedy Space Center off I-95, take Exit #215 (SR 50). Turn left (east) onto SR 50 and follow to SR 405. Turn right (east) on SR 405 and travel 11 miles. The KSC Visitor Complex will be on your right. The complex is open every day of the year, except December 25 and launch days. Hours are from 9:00 AM to 5:30 PM. The KSC bus tour lasts 2 to 2 1/2 hours. Tours start at 10:00 AM and run every 15 minutes.

WEATHER AND CLOTHING

The average high in July is 91°F (32.7°C), while the low is 72°F (22.2°C). The humidity can be high, with afternoon rain a common occurrence; you'll note that many planned Conference functions are indoors. The beach will be an attractive alternative, with an average surf temperature of 83°F (28.3°C), so be sure to pack your bathing suit! While you're packing, throw in some sunscreen; it is all too easy to get burned, especially if you are not used to our subtropical climate.

2006 Conference Committee



General Chair
Janet Barth
NASA Goddard Space
Flight Center
301-286-5966
Fax: 301-286-5475
janet.l.barth@nasa.gov



Technical Program
Gary Lum
Lockheed Martin Space
Systems Co.
408-756-0120
Fax: 408-734-2005
gary.lum@lmco.com



Local Arrangements
Nick van Vonno
Intersil
321-724-7546
Fax: 321-729-1024
nvanvonn@intersil.com



Short Course
Robert Reed
Vanderbilt University
615-343-2702
Fax: 615-343-9559
robert.reed@vanderbilt.edu



Publicity
Teresa Farris
Aeroflex Colorado Springs
719-594-8035
Fax: 719-594-8468
teresa.farris@aeroflex.com



Industrial Exhibits
Richard Elmhurst
Honeywell Space Systems
727-539-3209
Fax: 727-539-2598
richard.f.elmhurst@
honeywell.com



Awards
Paul Dodd
Sandia National
Laboratories
505-844-1447
Fax: 505-844-2991
pedodd@sandia.gov



Finance
Dale McMorrow
Naval Research Laboratory
202-767-5469
Fax: 202-404-7194
mcmorrow@ccs.nrl.navy.mil



Guest Editor
Philippe Paillet
CEA, France
33 1 69 26 50 89
Fax: 33 1 69 26 70 53
philippe.paillet@cea.fr



Associate Guest Editor
Jim Felix
Sandia National
Laboratories
505-844-6132
Fax: 505-844-2991
jafelix@sandia.gov



Assistant Guest Editor
Steve Buchner
QSS Group/NASA/GSFC
301-286-5019
Fax: 301-268-4699
sbuchner@
pop500.gsfc.nasa.gov

Official Reviewers

Jacques Baggio, *CEA*

John Baker, *Lockheed Martin Space Systems*

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Radiation Effects Steering Group

Chairman

Ronald D. Schrimpf
Vanderbilt University
Electrical Eng. and Comp. Science
P.O. Box 1608, Station B
Nashville, TN 37235
615-343-0507 fax: 615-343-0601
ron.schrimpf@vanderbilt.edu
(Term expires: 7/06)

Past Chairman

Dale G. Platteter
NAVSEA Crane
Code 605, Building 3334
300 Highway 361
Crane, IN 47522-5001
812-854-1206 fax: 812-854-1751
platt@ieee.org
(Term expires: 7/06)

Junior Member-at-Large

Wayne Abare
Harris GCSD
2530 Rocky Point Road
Malabar, FL 32950
321-729-7224 fax: 321-727-6007
wabare@harris.com
(Term expires: 7/07)

Special Publications Assignment

Paul V. Dressendorfer
Sandia National Laboratories
MS 1413 / Department 1141
P.O. Box 5800
Albuquerque, NM 87185-1413
505-844-5373 fax: 505-844-5470
dressepv@sandia.gov

Vice-Chairman, 2008 Conference

Paul E. Dodd
Sandia National Laboratories
PO Box 5800
MS 1083
Albuquerque, NM 87185-1083
505-844-1447 fax: 505-844-2991
pedodd@sandia.gov

NPSS AdCom Member

Allan H. Johnston
Jet Propulsion Laboratory
MS 303-220
4800 Oak Grove Drive
Pasadena, CA 91109
818-354-6425 fax: 818-393-4559
allan.h.johnston@jpl.nasa.gov
(Term expires: 12/07)

Executive Vice-Chairman

Timothy R. Oldham
NASA Goddard
Code 561.4
Building 22, Room 048
Greenbelt, MD 20771
301-286-5489 fax: 301-286-4699
toldham@pop500.gsfc.nasa.gov
(Term expires: 7/06)

Senior Member-at-Large

Steven L. Clark
Air Force Research Lab
3550 Aberdeen Ave., SE
Kirtland AFB, NM 87117-7556
505-846-6067 fax: 505-853-2205
steven.clark@kirtland.af.mil
(Term expires: 7/06)

Vice-Chairman, Publications

Marty Shaneyfelt
Sandia National Laboratories
P.O. Box 5800, MS-1083
Albuquerque, NM 87185-1083
505-844-6137 fax: 505-844-2991
shaneymr@sandia.gov
(Term expires: 7/06)

Vice-Chairman, 2006 Conference

Janet L. Barth
NASA/GSFC
Code 561
Building 23, Room E303
Greenbelt, MD 20771
301-286-5966 fax: 301-286-5475
janet.l.barth@nasa.gov

Vice-Chairman, 2009 Conference

Mark Hopkins
The Aerospace Corp
PO Box 80360
ACP/507
Albuquerque, NM 87198
505-872-6201 fax: 505-872-6213
Mark.a.hopkins@aero.org

NPSS AdCom Member

Dan Fleetwood
Vanderbilt University
PO Box 92, Stn B EECS Dept
Nashville, TN 37235
615-322-2498 fax: 615-343-6702
Dan.fleetwood@vanderbilt.edu
(Term expires: 12/07)

Secretary

Jeffrey D. Black
Vanderbilt University/ISDE
2014 Broadway, Suite 200
Nashville, TN 37203
615-322-3758 fax: 615-343-9550
jeffrey.d.black@vanderbilt.edu
(Term expires: 7/06)

Member-at-Large

Véronique Ferlet-Cavrois
CEA
BP12 SEIM
91680 Bruyeres-le-Chatel France
33-169-26-4265 fax: 33-169-26-7053
veronique.ferlet@cea.fr
(Term expires: 7/07)

Vice-Chairman, Publicity

Teresa Farris
Aeroflex Colorado Springs
4350 Centennial Blvd.
Colorado Springs, CO 80907-3486
719-594-8035 fax: 719-594-8486
teresa.farris@aeroflex.com
(Term expires: 7/06)

Vice-Chairman, 2007 Conference

Lloyd W. Massengill
Vanderbilt University
Electrical Eng. & Comp. Science
Box 1683, Station B
Nashville, TN 37235
615-343-6677 fax: 615-343-6614
lloyd.w.massengill@vanderbilt.edu

NPSS AdCom Member

Joseph M. Benedetto
ATK Mission Research Corporation
5017 North 30th Street
Colorado Springs, CO 80919
719-633-2344 x177 fax: 719-532-1926
benedetto@mrcmicroe.com
(Term expires: 12/06)

RADECS Liaison

Robert Ecoffet
DTS/AQ/EQE/ER
CNES - Toulouse Space Center
18 Avenue Edouard Belin
31401 Toulouse Cedex 4, France
33.5.61.28.17.96 fax: 33.5.61.27.47.32
robert.ecoffet@cnes.fr
(Term expires: 7/06)

ANNOUNCEMENT and FIRST CALL FOR PAPERS



2007 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE Short Course and Radiation Effects Data Workshop

July 23 - 27, 2007
Hilton Hawaiian Village
Honolulu, Hawaii

www.nsrec.com

Sponsored By

IEEE/NPSS Radiation Effects Committee

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The 2007 IEEE International Conference on Nuclear and Space Radiation Effects will be held July 23 - 27 in Honolulu, Hawaii at the Hilton Hawaiian Village. The Conference features a technical program consisting of eight to ten sessions of contributed papers describing the latest observations in radiation effects, an up-to-date Short Course on radiation effects offered on July 23, 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 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 2, 2007

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 using 11 point or greater type on either U.S. Standard, 8.5 inch (21.6 cm) x 11 inch (27.9 cm), or A4, 21 cm x 29.7 cm, white paper, with 1 inch (2.5 cm) margins on all four sides, and single-column format.
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) 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 2, 2007

Detailed submission and
formatting instructions
will be available after
January 2, 2007
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 2007), 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*.

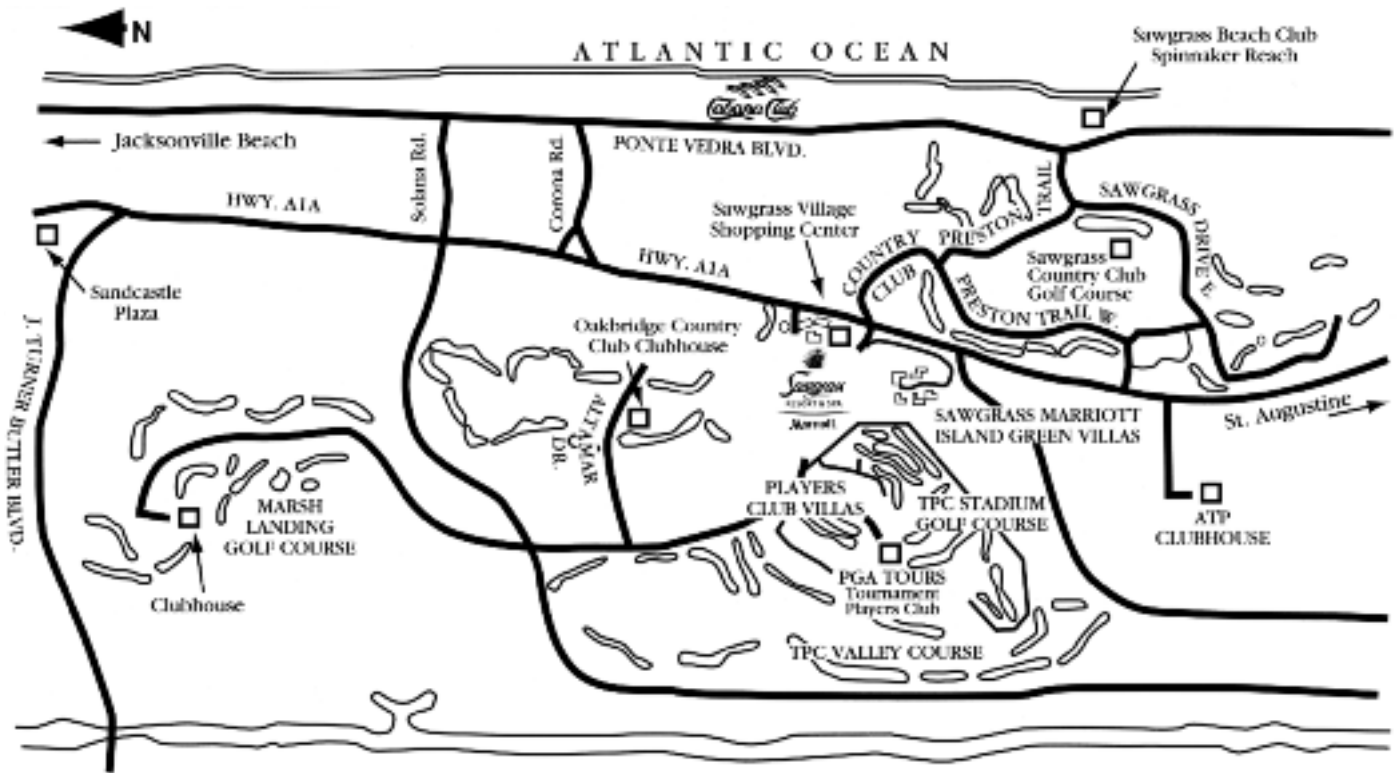
WAIKIKI, HAWAII

NSREC 2007 will be held at the Hilton Hawaiian Village Beach Resort on amazing Waikiki Beach, Honolulu, on the island of Oahu, Hawaii. The resort spans 22 acres, offering the widest stretch of beach on Waikiki, a beachfront lagoon, waterfalls, five pools, gardens, an exquisite art collection, exotic wildlife, a full-service spa, and nightly entertainment. There are more than 20 restaurants and lounges on site and the Village also boasts more than 90 shops. Beyond the Village property is Waikiki – synonymous with vitality – where there is a fascinating blend of eastern, western, and Polynesian cultures. The greater city of Honolulu stretches out further, from Diamond Head to Pearl Harbor. The rest of the island of Oahu, also known as

“The Gathering Place,” offers something for everyone, from the majestic cliffs of the Ko’olau Mountains (mauka) to the crystal-blue waters of the Pacific Ocean (makai). Conference attendees can enjoy pristine beaches with turquoise waters for snorkeling and swimming, razor-edged mountains and lush rainforests for hiking (with no snakes!), famous north shore beaches for world-class surfing, museums and botanical gardens for touring, and of course “battleship row.” For more information on Oahu and the rest of the Hawaiian islands, visit www.aloha-hawaii.com.



Ponte Vedra Beach



The Marriott Beach Club – shuttle service is available from Sawgrass to the Beach Club – please check at the bell desk.



St. Augustine – the oldest city in the U.S. is 20 miles from Sawgrass.



Jacksonville – a city on water – is 18 miles from Sawgrass.



Driving Directions

From Jacksonville International Airport:

Take Interstate 95 south.
Exit at State Road 202 (Exit 344, J. Turner Butler Boulevard).
Follow SR202 East to A1A; turn right onto A1A and follow south 3.5 miles to PGA Tour Boulevard.
Turn right on PGA Tour Boulevard. The Sawgrass Marriott Resort & Spa will be on the left.

From the south (Orlando):

Take Interstate 4 north from the Orlando area to Interstate 95.
Follow I-95 North to State Road 202 (Exit 344, J. Turner Butler Boulevard).
Follow SR202 East to A1A; turn right onto A1A and follow south 3.5 miles to PGA Tour Boulevard.
Turn right on PGA Tour Boulevard. The Sawgrass Marriott Resort & Spa will be on the left.

From the west:

Take Interstate 10 to Interstate 95 and follow I-95 south.
Exit at State Road 202 (Exit 344, J. Turner Butler Boulevard).
Follow SR202 East to A1A; turn right onto A1A and follow south 3.5 miles to PGA Tour Boulevard.
Turn right on PGA Tour Boulevard. The Sawgrass Marriott Resort & Spa will be on the left.

Please note that rental car agencies may furnish directions to the Marriott property using State Road 9A. This route is not recommended due to possible construction delays.