



40th ANNUAL INTERNATIONAL NUCLEAR & SPACE RADIATION EFFECTS CONFERENCE

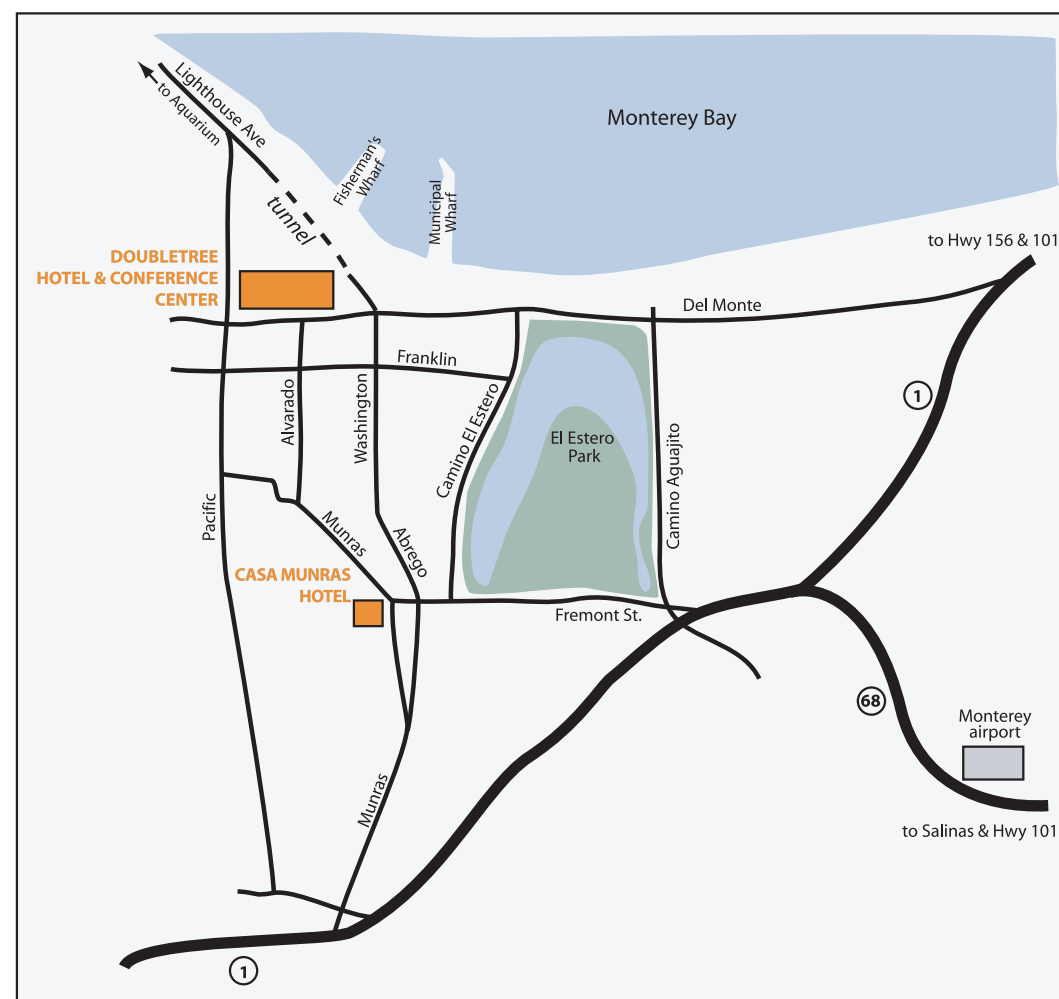
July 21 - 25, 2003
DoubleTree Hotel and Monterey Conference Center
Monterey, California

www.nsrec.com



Sponsored by
IEEE NPSS Radiation Effects Committee

Supported by
Defense Threat Reduction Agency
Sandia National Laboratories
Air Force Research Laboratory
NASA Electronic Parts & Packaging Program



From Monterey airport (or Highway 68 from Salinas):

Merge with Highway 1, South
Immediately get into the right lane
Take Monterey exit (Fremont Street)
Turn right on Camino Aguajito
Continue, and turn left on Del Monte at traffic signal
Get into left lane, continue to Downtown Exit
(left turn signal before tunnel)
Proceed on Del Monte for about 1 1/2 blocks
Hotel is on the right

From Highway 156/Highway 1

Continue on Highway 1, South to Monterey exit,
turn left on Fremont
(see above for rest of route)



From San Francisco or San Jose (1 1/2 to 2 hours)

Take 101 South, continuing past Gilroy
(Note that traffic can be quite heavy south of San Jose because of a long-term road construction project)
Take the exit to Highway 156 towards Monterey
Continue on 156 to Highway 1
Take Highway 1 South to Monterey
(see detailed map on front inside cover for further directions.)

From Los Angeles (6 hours)

Option 1:
Take US 5 north and go west on Highway 152 to Gilroy
From Gilroy go South on US 101
Take the exit to Highway 1
Take Highway 1 South to Monterey
(see detailed map on front inside cover for further directions.)

Option 2:
Take US 101 north to Salinas
Take Highway 68 toward Monterey
(see detailed map on front inside cover for further directions.)

From Monterey airport (or Highway 68 from Salinas):

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From Highway 156/Highway 1

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(see above for rest of route)

Schedule

Time	Monday July 21	Tuesday July 22	Wednesday July 23	Thursday July 24	Friday July 25
7:30	[7:30] Continental Breakfast DeAnza Foyer	[7:30] Continental Breakfast DeAnza Foyer	[7:30] Continental Breakfast DeAnza Foyer	[7:30] Continental Breakfast DeAnza Foyer	[7:30] Continental Breakfast DeAnza Foyer
8:15	[8:15] Short Course Introduction Joseph Benedetto Steinbeck Forum	[8:15] Conference Opening Serra Grand Ballroom II	[8:15] Invited Talk Use of Technology in the Exploration of Monterey Bay Dr. Marcia K. McNutt Serra Grand Ballroom II	[8:15] Invited Talk The Future of Electronics: Micro, Nano, or Molecular? Prof. Mark S. Lundstrom Serra Grand Ballroom II	[8:15] Invited Talk Living and Working in Space Carl Walz Serra Grand Ballroom II
8:30	[8:30] CMOS Scaling and Process History, Design Principles and Hardening by Design Methodologies Ronald Lacoe				
9:00		[8:55] Session A Devices and Integrated Circuits			
9:30			[9:15] Session D Atmospheric and Terrestrial Radiation Effects	[9:15] Session G Spacecraft Environments and Effects	[9:15] Data Workshop DeAnza Ballroom
10:00	[10:00] Break DeAnza Foyer	[10:00] Break DeAnza Foyer	[10:05] Break Serra Grand Ballroom I	[10:05] Break DeAnza Foyer	
10:30	[10:30] Radiation Response and Reliability of Oxides Used in Advanced Processes Alessandro Paccagnella	[10:30] Session A (continued)	[10:35] Session E Single Event Effects, Devices and Integrated Circuits	[10:35] Session H Hardness Assurance	
11:00					
11:30					
12:00	[12:00] Short Course Lunch DeAnza Ballroom	[12:00] Lunch Note: Industrial Exhibits Open 11:45	[12:10] Lunch Note: Industrial Exhibits Close 3:30	[11:55] Lunch	[11:45] End of Conference
12:30					
1:00					
1:30	[1:15] How Device Scaling Affects Single Event Effects Sensitivity Timothy R. Oldham	[1:30] Session B Basic Mechanisms	[1:30] Session F Single Event Effects, Mechanisms and Modeling	[1:30] Session I Dosimetry and Facilities	
2:00					
2:30					
3:00	[2:45] Break DeAnza Foyer	[3:05] Break Serra Grand Ballroom I		[2:35] Poster Session DeAnza Ballroom	
3:30	[3:15] Radiation Effects in SiGe HBT BiCMOS Technology John Cressler		[3:20] End of Session		
4:00		[3:35] Session C Photonic Devices and Integrated Circuits			
4:30					
5:00	[4:45] Wrap-up				
5:30	[5:00] Exam (for students requesting CEU credit only)	[5:10] End of Session		[5:00] End of Session	
6:00	[5:30] End of Short Course			[5:15 to 6:45] Radiation Effects Committee Open Meeting Serra Grand Ballroom II	
6:30					
7:00		[7:00 to 10:00] Industrial Exhibits Reception Serra Ballrooms	[7:00 to 11:00] Conference Social The Monterey Bay Aquarium		

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Chairman's Invitation



NSREC 2003
M O N T E R E Y



"On behalf of the 2003 Conference Committee, I invite you to join us in picturesque Monterey to mark the 40th anniversary of the NSREC. The committee has worked very hard to live up to the strong tradition that makes this one of the key technical conferences on radiation effects in electronic devices, circuits, systems and materials."

Allan Johnston
General Chairman

On behalf of the NPSS Radiation Effects Committee, it is my pleasure to invite you to attend the 40th Annual International Conference on Nuclear and Space Radiation Effects (NSREC) to be held July 21-25, 2003 at the DoubleTree Hotel and City of Monterey Conference Center in Monterey, California. As with previous NSRE Conferences, the 2003 Conference will feature:

- an outstanding Technical Program
- a one-day Short Course that will precede the Technical Program
- a Radiation Effects Data Workshop, integrated into the Technical Program
- an Industrial Exhibit, with participation from many organizations

To commemorate the 40th Anniversary, a special issue of the Transactions on Nuclear Science will be distributed to all attendees. The special issue will contain reviewed papers that summarize key technical findings presented at the conference over its history, with a contemporary interpretation of the results. Joe Srour (Northrop Grumman Space Technology) is the editor of the special issue.

The Technical Program Chairman, Paul Dodd (Sandia National Laboratories) and his program committee have selected an outstanding set of contributed papers, organized into nine sessions of oral and poster presentations for the Technical Sessions. High-quality data-oriented papers were selected for poster presentation in the Radiation Effects Data Workshop. There will also be invited talks of a more general nature that should be of interest to attendees and their families.

The Poster Session, organized by Marty Shaneyfelt (Sandia National Laboratories) and the Radiation Effects Data Workshop, organized by Jerry Wert (Boeing Phantom Works) will be held adjacent to each other in the DoubleTree Hotel.

The theme of this year's Short Course, organized by Joe Benedetto (MRC) is *Radiation Effects in Advanced Commercial Technologies: How Device Scaling Has Affected the Selection of Spaceborne Electronics*. The Short Course will be presented Monday, July 21st, and includes sections on hardness by design, radiation and reliability issues for oxides in advanced devices, the impact of device scaling on single-event effects, and radiation effects on advanced bipolar devices.

This year's Industrial Exhibit, organized by Howard Bogrow (Xilinx) begins Tuesday with a reception in the evening and continues through Wednesday. The Exhibit features the latest information on radiation-resistant electronics, test equipment and facilities, hardware, and software simulation products and services.

The DoubleTree Hotel is located in downtown Monterey, a few steps away from the pier in Monterey Bay where seals, otters and other marine life abound. Monterey is one of the most popular vacation destinations in California. Nearby activities include kayaking, hiking, fishing, golf, wine tasting and even auto racing. The Local Arrangements Chairman, Mark Hopkins (Aerospace Corporation), has planned several social events for attendees and family members, including a shopping trip and luncheon in nearby Carmel and a visit to a local winery. The highlight of the social program is an evening at the world-renowned Monterey Aquarium, which will be open only to conference attendees and families. This will provide a relaxing environment for social interaction, as well as the opportunity to see the aquarium without the large crowds that are present during a typical day in peak season.

Your 2003 Conference Committee has worked hard to plan the technical and social aspects of this year's NSREC. We look forward to seeing you in Monterey.

Short Course Program

RADIATION EFFECTS IN ADVANCED COMMERCIAL TECHNOLOGIES: HOW DEVICE SCALING HAS AFFECTED THE SELECTION OF SPACEBORNE ELECTRONICS

STEINBECK FORUM - MONDAY, JULY 21

- 7:30 AM **REGISTRATION/CONTINENTAL BREAKFAST**
- 8:15 AM **SHORT COURSE INTRODUCTION**
Joseph Benedetto
MRC Microelectronics
- 8:30 AM **CMOS SCALING, DESIGN PRINCIPLES AND
HARDENING-BY-DESIGN METHODOLOGIES**
Ronald Lacoce
The Aerospace Corporation
- 10:00 AM **BREAK (DEANZA FOYER)**
- 10:30 AM **RADIATION RESPONSE AND RELIABILITY OF OXIDES
USED IN ADVANCED PROCESSES**
Alessandro Paccagnella
University of Padova
- 12:00 PM **SHORT COURSE LUNCHEON**
- 1:15 PM **HOW DEVICE SCALING AFFECTS SINGLE EVENT
EFFECTS SENSITIVITY**
Timothy R. Oldham
NASA GSFC/QSS Group, Inc.
- 2:45 PM **BREAK (DEANZA FOYER)**
- 3:15 PM **RADIATION EFFECTS IN SiGe HBT BICMOS TECHNOLOGY**
John Cressler
Georgia Tech
- 4:45 PM **WRAP-UP**
- 5:00 PM **EXAM** (only for students requesting CEU credit)
- 5:30 PM **END OF SHORT COURSE**

Short Course

COURSE DESCRIPTION

Recent changes in commercial semiconductor processing have lead to an enhanced level of intrinsic radiation hardness of electronic devices designed and manufactured for the consumer or industrial market. It is now fairly common to find the same SRAM, DRAM or Flash memory device types found in a desktop PC or cell phone also being used for a LEO or GEO satellite system. While advanced semiconductor processing has opened up the door for the use of commercial components in space, it has also brought up a number of new issues and concerns, including the introduction of new materials, device structures and radiation-induced degradation modes.

The 2003 NSREC Short Course, "Radiation Effects in Advanced Commercial Technologies: How Device Scaling Has Affected the Selection of Spaceborne Electronics," is intended to provide the necessary information to allow participants to better understand the numerous changes which have arisen with advanced component fabrication technologies and how these changes impact the radiation response and reliability of spaceborne electronics.

The morning will begin with a description of advanced CMOS processes, including process history, scaling and proven design hardness techniques. There is a tremendous opportunity to use commercial fabrication facilities not only for the production of radiation tolerant components but also for the study of new basic mechanisms and materials. During the second short course presentation we will focus on the challenges and opportunities involved with the new ultra-thin oxides from a radiation and reliability viewpoint.

After lunch the third presentation will discuss single event effects in advanced CMOS technology, which have been heavily influenced by changes in device design and scaling. The fourth presentation will discuss total dose and single event effects in advanced bipolar devices, where scaling has also had a major effect on the way that advanced devices are affected by radiation.

Joseph Benedetto of MRC Microelectronics, the 2003 NSREC Short Course Chairman, has assembled a highly qualified team of experts to address these topics. Sufficient background will be provided in each section to allow newcomers to understand the basics, and the discussion will proceed to include some of the latest results and technologies. Thus the short course will be beneficial both to those new to the field of radiation effects and to experienced engineers and scientists.

CONTINUING EDUCATION UNITS (CEUs)

As in previous short courses, 0.6 CEUs endorsed by the IEEE and the International Association for Continuing Education and Training (IACET) will be available to qualified students. The IEEE is an authorized CEU sponsor member of the IACET. IEEE guidelines for offering CEU credit will be followed. Thus, 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 greater. The examination will be given immediately after the last segment of the Short Course, will be open book, and will consist 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

SHORT COURSE CHAIRMAN



Joseph Benedetto
Short Course Chairman

Joseph M. Benedetto received his B.S. in Physics from the State University of New York and his M.S.E.E. and Ph.D. degrees from the University of Maryland. Dr. Benedetto began his career in radiation effects over 20 years ago as a Graduate Research Fellow at the National Bureau of Standards. From 1983 to 1995 he performed basic and applied research for the US Army Research Laboratory. Between 1995 and 2002, Dr. Benedetto served as Standard Product Technology Manager for Aeroflex UPMC and beginning in 2003, he joined Mission Research Corporation Microelectronics Division as the Director of Radiation Effects Engineering.

During the past several years Dr. Benedetto has been very active in developing new methods for hardening commercial foundries and qualifying commercial integrated circuits for spaceborne applications. Dr. Benedetto has been very active in the radiation effects community, serving in various conference roles (Finance Chairman, Local Arrangements Chairman and Short Course Chairman) and was recently elected to the IEEE Nuclear and Plasma Sciences ADCOM. He has published over 75 articles in a wide variety of publications, including IEEE Spectrum, IEEE Transactions on Nuclear Science and the Journal of Applied Physics. To date he has been awarded two US Patents and has several more patents pending related to hardening spacecraft electronics.

Dr. Benedetto is a Senior Member of the IEEE, Member of the IEEE Nuclear and Plasma Sciences Society and Sigma Pi Sigma.



Ronald Laco received his B.S., M.S., and Ph.D. in Physics from the University of California, Los Angeles in 1974, 1977, and 1983, respectively. He attended graduate school as a Hughes Aircraft Fellow and worked at the Hughes Research Laboratory in Malibu, California while earning his Ph.D. degree. After receiving his Ph.D., Dr. Laco was a joint NSF/CNRS Fellow at the University of Paris-South from 1984-1986, where he worked on reduced-dimensional systems and organic superconductivity. Dr. Laco joined The Aerospace Corporation in 1987 as a Member of the Technical Staff and is currently the Manager of the Microelectronics Reliability and Radiation Effects Section of the Microelectronics Technology Department. He is responsible for research in the areas of microelectronics reliability and radiation hardness for microelectronics that will be employed in Air Force space programs. Recently, Dr. Laco has published extensively on the use of commercial microelectronics processes for fabricating radiation-hardened components for space. Dr. Laco has published over one hundred papers, and was the recipient of the 1997 IEEE International Reliability Physics Symposium's Best Paper Award, the 1997 NSREC Meritorious Paper Award and the 1998 NSREC Outstanding Paper Award.

CMOS SCALING, DESIGN PRINCIPLES AND HARDENING-BY-DESIGN METHODOLOGIES

Ronald Laco

The Aerospace Corporation

Ronald Laco will describe relevant changes in CMOS processing over the last 20 years with respect to utilizing CMOS components in stressing radiation environments. He will first provide an overview of CMOS processing and associated scaling, and the impact of this scaling on various performance parameters. This will lead into a discussion on the recent trends in the effects of radiation on advanced commercial CMOS processes, and why this has created an opportunity for using these processes unmodified, with the necessary hardness built into the component by use of only design techniques. The specific techniques for the application of this "Hardened-By-Design" (HBD) approach will be described in detail. Finally, issues associated with the reliability and qualification of components fabricated using the HBD approach will be discussed.

Introduction

Overview of CMOS Scaling

- Power/Performance/Functionality
- Technology Evolution
- Future Technology Challenges

Hardness-By-Design (HBD) – Why Now?

- Overview of HBD
- Total-Dose Hardness Trends in Advanced Commercial CMOS Technologies

Hardness-By-Design – Approach

- Meeting Total-Dose Requirements
- Meeting SEU Requirements
- Meeting SEL Requirements

Reliability and Qualification Issues

Conclusion



Alessandro Paccagnella received the Laurea degree in Physics cum Laude in 1983 from the University of Padova, Italy. Then his academic career developed at the Universities of Modena, Trento, Cagliari, and Padova, where he is currently Full Professor of Electronics. In the past he studied different aspects of physics, technology, and reliability of III-V devices and he spent some research periods at the University of California, San Diego, and at the IBM T.J. Watson Research Center, Yorktown Heights, NY. At present, he coordinates the research activity of a group at the University of Padova working on CMOS devices and technology, with a particular attention to ionizing radiation effects on ultra-thin gate oxides, floating gate memory cells, silicon microstrip detectors, power MOSFETs, and programmable logic devices. Alessandro Paccagnella has coauthored more than 220 scientific papers, and about 130 of them have been published on international journals. He has co-authored works, which received awards at ESREF 1992, ESREF 1998, NSREC 1999 and ESSDERC 2000. He is a member of the IEEE NPSS and EDS societies and of the Association RADECS.

RADIATION RESPONSE AND RELIABILITY OF OXIDES USED IN ADVANCED PROCESSES

Alessandro Paccagnella

University of Padova

After starting with a short review of the radiation effects in thick oxides, Alessandro Paccagnella will examine how thin gate oxides react to radiation damage. In the first step in this direction he will examine the behavior of 10-nm oxides used as tunnel dielectric in non-volatile memory cells, presenting evidence of simultaneous leakage current and charge trapping. By thinning the oxide layer radiation induced leakage current and radiation-induced breakdown will then appear as the reliability challenge relevant to radiation damage, replacing charge trapping. Synergetic effects of radiation damage and electrical stresses have been recently investigated and will be presented along with emerging issues on new replacement materials for silicon oxide.

Introduction

- Technology Trends in CMOS

A Short Summary of Radiation Damage in Thick Oxides: A Well Assessed Picture

- Charge Trapping
- Interface State Generation
- Breakdown

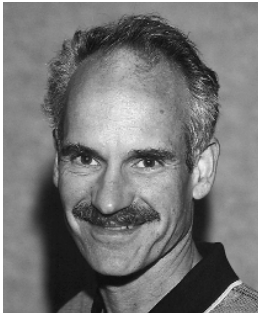
Thinning the Gate Oxide: 10-nm Oxides (Tunnel Oxides in Flash Memories)

- Charge Trapping and Distribution
- Trapped Charge Removal through Electrical Stresses
- Leakage Currents after Irradiation

Gate Oxides in Contemporary CMOS Technologies

- Radiation Induced Charge Trapping: Is It Still an Issue?
- Radiation Induced Leakage Current (RILC)
- Radiation Induced Soft Breakdown (RSB)
- Single Event Gate Rupture (SEGR)
- Radiation and Electrical Stresses
- Alternative Gate Dielectrics: First Radiation Studies

Conclusion



Timothy R. Oldham received his B.S. from Michigan State University (1969), his M.S. from American University (1975), and his Ph. D. from Catholic University of America (1982), all in Physics. He started as a summer student, and worked at the Army Research Laboratory and its predecessors, for more than 34 years, on a variety of radiation and electronics reliability research problems. Recently, he has joined the Radiation Effects and Analysis Group at the NASA Goddard Space Flight Center, as a contractor with QSS Group, Inc. He has been elected Fellow of the IEEE for his technical contributions, which are documented in more than 30 journal articles, plus a book and a book chapter. Most of this work was first presented at this conference. He has served as Technical Program Chairman for the NSREC (1990), as General Conference Chairman (1994), as Awards Chairman (2001), and as an Editor for the conference issue of the Transactions on Nuclear Science (TNS) (1997-1999). Recently, he was one of three editors for the special TNS issue commemorating this 40th NSREC.

HOW DEVICE SCALING AFFECTS SINGLE EVENT EFFECTS SENSITIVITY

Timothy R. Oldham

NASA GSFC/QSS Group, Inc.

The very existence of Single Event Effects (SEE) is a consequence of scaling. Long-time NSREC attendees can remember when there were no SEE, because device sizes had not been scaled down enough for a single particle to have any detectable effect. Timothy Oldham will review how scaling has led to SEE, and how scaling will most likely affect SEE in the near future. He will review the basic mechanisms of charge deposition and collection, and device and circuit effects. He will give particular emphasis to steps the commercial semiconductor industry is taking to harden COTS technology against alpha particles, which are a major driver in the commercial sector.

Introduction

- Background—Scaling and the Limits of Scaling
- Basic Definitions and Concepts

Basic Mechanisms

- Charge Deposition—Track Structure Effects
- Charge Collection
- Recombination
- Funneling

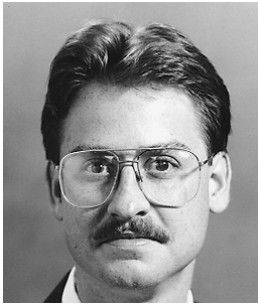
Device and Circuit Effects

- Upset
 - DRAMs
 - SRAMS
 - Commercial Industry Hardening
- Latch-Up
- Snap-Back
- Burn-Out
- Gate Rupture
- Stuck Bits
 - Micro-Dose—Gate, Field Oxides
 - Micro-Damage—Track Formation
- Transients
- Hard/Soft Breakdown

Software Solutions

- Error Correction
- Built-In Self Test (BIST)

Conclusion



John D. Cressler received the B.S. degree in physics from the Georgia Institute of Technology, Atlanta, GA in 1984, and the M.S. and Ph.D. degrees in applied physics from Columbia University, New York, NY in 1987 and 1990. From 1984 to 1992 he was on the research staff at the IBM Thomas J. Watson Research Center in Yorktown Heights, NY. In 1992 he left IBM Research to join the faculty at Auburn University, Auburn, AL, where he served until 2002. In 2002 he joined the faculty at Georgia Tech, where he is currently Professor of Electrical and Computer Engineering. Dr. Cressler has published over 250 technical papers related to his research. He is the author of the book (with Guofu Niu) Silicon-Germanium Heterojunction Bipolar Transistors, Artech House, 2002. He has served on the following journals and conference committees: *IEEE Journal of Solid-State Circuits*, *IEEE Transactions on Nuclear Science*, *IEEE International Solid-State Circuits Conference*, *IEEE Bipolar/BiCMOS Circuits and Technology Meeting*, *IEEE International Electron Devices Meeting*, and *IEEE Nuclear and Space Radiation Effects Conference*. He also serves on the *IEEE Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems*, *IEEE European Workshop on Low-Temperature Electronics*, and *IEEE International SiGe Technology and Device Meeting* committees. Dr. Cressler was elected an IEEE Fellow in 2001 for "contributions to the understanding and optimization of silicon and silicon-germanium bipolar transistors."

RADIATION EFFECTS IN SiGe HBT BICMOSTECHNOLOGY

John Cressler

Georgia Tech

The final 2003 IEEE NSREC Short Course section will be taught by John Cressler of Georgia Tech. His section will focus on advanced Si-based bipolar technology for space applications, primarily in the form of SiGe HBT technology. After an introduction to SiGe strained layer epitaxy, and its use in SiGe HBT design, Dr. Cressler will present a detailed assessment of the impact of radiation on SiGe HBTs and circuits, including dc and ac degradation mechanisms, proton energy and gamma dose rate effects, scaling issues, single event upset, and future directions for the technology.

Introduction

SiGe HBT BiCMOS Technology

- Motivation
- SiGe Strained Layer Epitaxy
- The SiGe HBT
- Performance Capabilities
- Some History and Performance Trends

The Effects of Radiation on SiGe HBTs

- Transistor dc Response
- Spatial Location of the Damage
- Transistor ac Response
- Si vs SiGe and Structural Aspects
- Proton Energy Effects
- Low-Dose-Rate Gamma Sensitivity
- Broadband Noise
- Low-Frequency Noise
- Comparison to GaAs

Technology Scaling Issues

- SiGe HBT Scaling
- Si CMOS Scaling

Circuit-Level Tolerance

- The Importance of Transistor Bias
- Bandgap Reference Circuits
- Voltage Controlled Oscillators
- RF Passives

Single Event Upset

- Experimental SEU Results
- Transistor Equivalent Circuit
- Simulation Methodology
- Charge Collection Characteristics
- Circuit Architecture Dependence
- Ion Microbeam Results

Conclusion

Technical Program

TECHNICAL INFORMATION



"The NSREC 2003 technical program will serve as an outstanding venue for presenting the latest research on nuclear and space radiation effects. Oral, poster, and Data Workshop sessions will afford numerous opportunities for valuable technical exchanges between authors and attendees."

Paul Dodd,
Sandia National Laboratories,
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 three minutes for questions. The Technical Sessions and chairpersons are:

- **Devices and Integrated Circuits**
Chairs: Guofu Niu, Auburn University, and Raoul Velazco, TIMA Laboratory
- **Basic Mechanisms**
Chair: Philippe Paillet, CEA
- **Photonic Devices and Integrated Circuits**
Chair: Robert Walters, Naval Research Laboratory
- **Atmospheric and Terrestrial Radiation Effects**
Chair: Robert Baumann, Texas Instruments
- **Single-Event Effects, Devices and Integrated Circuits**
Chair: Leif Scheick, Jet Propulsion Laboratory
- **Single-Event Effects, Mechanisms and Modeling**
Chair: Nicholas Boruta, Lockheed Martin Space Systems
- **Spacecraft Environments and Effects**
Chair: Lawrence Townsend, University of Tennessee
- **Hardness Assurance**
Chair: Christian Poivey, NASA Goddard Space Flight Center
- **Dosimetry and Facilities**
Chair: Carlos Castaneda, University of California, Davis

POSTER SESSION

Papers that are most effectively presented visually with group discussion will be displayed from 12:00 PM Tuesday, July 22 through 11:45 AM Friday, July 25. Authors will be available to discuss their work during the Poster Session Thursday, July 24. The poster chair is Marty Shaneyfelt, Sandia National Laboratories.

RADIATION EFFECTS DATA WORKSHOP

Papers in the workshop are intended to provide radiation response data to scientists and engineers who use electronic devices in a radiation environment, and to designers of radiation-hardened systems. Workshop posters can be viewed from 12:00 PM Tuesday, July 22 through 11:45 AM Friday, July 25. Authors will be available to discuss their work during the Data Workshop Session Friday, July 25. A copy of the Workshop Record will be mailed to all registered attendees after the conference. The workshop chair is Jerry Wert, The Boeing Company.

INVITED SPEAKERS

Three invited speakers will give stimulating and entertaining presentations during the conference. Dr. Marcia McNutt, President and CEO of the Monterey Bay Aquarium Research Institute, will give an exciting talk on the use of technology to explore Monterey Bay. Professor Mark Lundstrom of Purdue University will give us a preview of the possible futures of electronics. Carl Walz, NASA astronaut, will captivate us with his experiences of living and working in space.

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 submitting late-news papers is May 30, 2003. 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

8:15 AM **OPENING REMARKS**
SERRA GRAND BALLROOM II *Allan Johnston, Jet Propulsion Laboratory*

8:20 AM **AWARDS PRESENTATION**
Dale Platteter, Radiation Effects Steering Group Chairman

8:50 AM **TECHNICAL SESSION OPENING REMARKS**
Paul Dodd, Sandia National Laboratories

SESSION A DEVICES AND INTEGRATED CIRCUITS

8:55 AM **SESSION INTRODUCTION**
Chairs: Guofu Niu, Auburn University, and Raoul Velazco, TIMA Laboratory

A-1 **Substrate Removal and BOX Thinning Effects on Total Dose Response of FDSOI**
9:00 AM *P. Gouker, J. Burns, P. Wyatt, K. Warner, E. Austin, MIT Lincoln Laboratory; R. Milanowski, Dynamics Research Corporation*

We studied total dose radiation effects in submicron FDSOI nFETs on conventional SOI wafers, after substrate removal, and after BOX thinning. A significant enhancement in radiation tolerance is observed after substrate removal and BOX thinning.

A-2 **Developing Passivation Layers for Reducing Enhanced Low-Dose-Rate Sensitivity in Linear Bipolar Devices**
9:15 AM *Marty R. Shaneyfelt, James R. Schwank, Paul E. Dodd, Leonard C. Riewe, Sandia National Laboratories; Ronald L. Pease, RLP Research; Michael C. Maher, Sunny Gupta, National Semiconductor Corporation*

Final chip passivation layers are evaluated to identify films that will not degrade the total dose hardness of bipolar technologies. Possible correlations between mechanical stress induced by the passivation layers and radiation degradation are discussed.

A-3 **Proton-Irradiation Effects on AlGaIn/GaN High Electron Mobility Transistors**
9:30 AM *Xinwen Hu, Aditya P. Karmarkar, Daniel M. Fleetwood, Ronald D. Schrimpf, Robert D. Geil, Robert A. Weller, Vanderbilt University; Brad D. White, Mykola Bataiev, Leonard J. Brillson, Ohio State University; Umesh K. Mishra, University of California at Santa Barbara*

AlGaIn/GaN High Electron Mobility Transistors were irradiated with 1.8-MeV protons for fluences between $3 \times 10^{11} \text{ cm}^{-2}$ and $3 \times 10^{15} \text{ cm}^{-2}$. The devices are very radiation tolerant exhibiting little degradation at fluences up to $1 \times 10^{14} \text{ cm}^{-2}$.

A-4 **Super-Radiation Hard Particle Tracking at the CERN SLHC**
9:45 AM *M. Rahman, R. Bates, W. Cunningham, F. Doherty, A. Gouldwell, L. Haddad, M. Horn, J. Melone, C. Parkes, P. Roy, V. O'Shea, K. M. Smith, V. Wright, University of Glasgow; J. Vaitkus, University of Vilnius*

The proposed upgrade of the CERN LHC to ten times brighter luminosity poses severe challenges to semiconductor trackers. We investigate a silicon '3D' detector design for LHCb/Velo and semiconductors alternative to silicon.

Technical Program Tuesday

10:00 - 10:30 AM
DEANZA FOYER

BREAK

A-5
10:30 AM

The Impact of Gamma Irradiation on SiGe HBTs Operating at Cryogenic Temperatures

*John D. Cressler, Ramkumar Krithivasan, Akil Sutton, Georgia Tech;
John Seiler, Jeff Krieg, Steve Clark, NAVSEA Crane; Alvin Joseph, IBM Microelectronics*

The effects of gamma irradiation on the characteristics of SiGe HBTs operating in the cryogenic environment are reported. Exposure to 1 Mrad total dose at 77K produces significantly less degradation than exposure at 300K.

A-6
10:45 AM

Proton Tolerance of Third-Generation, 0.12 μm 185 GHz SiGe HBTs

*Yuan Lu, John D. Cressler, Ramkumar Krithivasan, Georgia Institute of Technology;
Ying Li, Auburn University; Robert A. Reed, Paul W. Marshall, NASA-GSFC;
Greg Freeman, David Ahlgren, IBM Microelectronics*

The impact of proton irradiation on the dc and ac characteristics of a third-generation, 185 GHz SiGe HBT technology is presented. Comparisons with prior technology generations are used to investigate the damage mechanisms.

A-7
11:00 AM

Using Proton Irradiation to Probe the Origins of Low-Frequency Noise Variations in SiGe HBTs

*Zhenrong Jin, John D. Cressler, Georgia Institute of Technology;
Jarle A. Johansen, University of Tromsø; Robert A. Reed, NASA GSFC;
Paul W. Marshall, Consultant to NASA GSFC; Alvin J. Joseph, IBM Microelectronics*

Proton irradiation is used to probe the physical origins of low-frequency noise variation in SiGe HBTs. After irradiation the noise level degradation is negligible, but the noise variation decreases and depends on geometry and bias.

A-8
11:15 AM

Impact of Proton Irradiation on the Static and Dynamic Characteristics of High-Voltage 4H-SiC JBS Switching Diodes

*Zhiyun Luo, John R. Williams, Auburn University; Tianbing Chen, John D. Cressler, Georgia Institute of Technology; David C. Sheridan, IBM Microelectronics;
Robert A. Reed, Paul W. Marshall, NASA-GSFC*

The effects of proton irradiation on the static and dynamic performance of 4H-SiC JBS diodes are investigated. Degradation in series resistance, as well as improvements of leakage current and blocking voltage after irradiation were observed.

A-9
11:30 AM

Comparison of Ionizing Radiation Effects in 0.18 and 0.25 micron CMOS Technologies for Analog Applications

Valerio Re, Massimo Manghisoni, University of Bergamo; Lodovico Ratti, Valeria Speziali, Gianluca Traversi, University of Pavia; Andrea Candelori, University of Padova

We present a comparative study of ionizing radiation effects in 0.18 and 0.25 micron CMOS transistors, with the goal of evaluating the impact of device scaling on the design of low-noise rad-hard analog circuits.

Technical Program Tuesday

A-10
11:45 AM

Proton Tolerance of Multiple-Threshold Voltage and Multiple-Breakdown Voltage CMOS Device Design Points in a 0.18 μm System-on-a-Chip CMOS Technology

Ying Li, Jun Pan, Guofu Niu, Michael J. Palmer, Auburn University; John D. Cressler, Yuan Lu, Georgia Institute of Technology; Robert A. Reed, NASA-GSFC; Paul W. Marshall, Consultant to NASA-GSFC; Christopher Polar, Jackson and Tull Chartered Engineers; Alvin J. Joseph, IBM Microelectronics

This paper presents the first investigation of the proton radiation response of the dc and RF performance of the multiple CMOS device design points in a 0.18 μm system-on-a-chip CMOS technology.

POSTER PAPERS

PA-1

Bulk Damage Caused by Single Protons in SDRAMs

Satoshi Kuboyama, Hiroyuki Shindou, Yasushi Deguchi, Sumio Matsuda, NASDA; Toshio Hirao, JAERI

We describe experimental data for a new failure mode that has a cross-section larger than SEU in 256 Mbit SDRAMs. The failure mode is attributable to the bulk damage caused by single protons.

PA-2

Neutron and Electron Irradiation Effects in InGaP/GaAs Single Heterojunction Bipolar Transistors

Soujanya Vuppala, S. Subramanian, Oregon State University; Peter Zwicknagl, Infineon Technologies

Neutron and electron irradiation effects in InGaP/GaAs HBTs are investigated. The devices show considerable degradation of current gain and increase in $V_{CE,offset}$ under neutron irradiation, but are quite robust under electron irradiation.

PA-3

Response of Piezoresistive MEMS Accelerometers and Pressure Transducers to High Gamma Dose Rates

Keith E. Holbert, James A. Nessel, Arizona State University; Steven S. McCready, A. Sharif Heger, Thomas H. Harlow, Los Alamos National Laboratory

We present results from exposing piezoresistive MEMS sensors to Mrads of gamma irradiation. Further, we analyze the failure mechanisms for the pressure transducer and accelerometer studied.

PA-4

Total Dose Degradation of Optical MEMS Mirrors

T. F. Miyahira, H. D. Becker, S. S. McClure, L. D. Edmonds, A. H. Johnston, Jet Propulsion Laboratory

We present the first radiation test results of optical MEMS devices. Tests were performed on two very different deformable MEMS micromirror arrays. Test results are discussed with respect to the different device constructions.

Technical Program Tuesday

PA-5 Utilizing Asynchronous Logic for Performance Improvement in Space Applications

David J. Barnhart, United States Air Force Academy; Paul W. Duggan, Bruce W. Suter, Air Force Research Laboratory; Kenneth S. Stevens, Intel Corp.

Asynchronous logic is used in the design of prototype Fast Fourier Transform processors for space applications to increase throughput and efficiency. Total dose characterization reveals the potential for strategic applications.

PA-6 Total Dose and Single Event Effects in DC/DC Converter Control Circuitry

P. C. Adell, R. D. Schrimpf, J. Boch, W. T. Holman, J. Stacey, A. Sternberg, K. F. Galloway, Vanderbilt University; P. Ribero, TRAD Test & Radiation

Total-dose and single-event effects in the linear control circuitry of DC/DC power-converters are examined. Catastrophic failure induced by error-amplifier total-dose irradiation is compared for two modes of operation.

PA-7 Improvement of the Electric Characteristics of Low-k Dielectric HOSP Material by Gamma Irradiation

Tien-Ko Wang, Cheng-Hong Jiang, Kuei-Shu Chang-Liao, National Tsing Hua University

A Co-60 gamma irradiation of ~0.4 Mrad can improve the electrical characteristics of the low-k dielectric material HOSP; combined with a post-sputter sintering of 60 min at 300 °C, the associated copper diffusion problem can be suppressed.

PA-8 SPICE Modeling of Neutron Radiation Effects in Bipolar Junction Transistors

Yanqing Deng, Michael S. Shur, Rensselaer Polytechnic Institute; Tor A. Fjeldly, Trond Ytterdal, Norwegian University of Science and Technology

Neutron total dose and transient radiation effects (including annealing effects) in bipolar junction transistors are modeled and implemented in SPICE. The model compares favorably with experimental results.

12:00 - 1:30 PM LUNCH

SESSION B BASIC MECHANISMS 1:30 PM SESSION INTRODUCTION *Chair: Philippe Paillet, CEA*

B-I Probing Proton Damage in SOI CMOS Technology By Using Lateral Bipolar Action

Ying Li, Guofu Niu, Auburn University; John D. Cressler, Georgia Institute of Technology; Jagdish Patel, Mohammad M. Mojarradi, Jet Propulsion Laboratory; Mike Liu, Honeywell Solid State Electronics Center; Robert A. Reed, NASA-GSFC; Paul W. Marshall, Consultant to NASA-GSFC; Benjamin J. Blalock, University of Tennessee

We investigate proton damage in SOI CMOS using lateral bipolar operational modes. The impact of interface states and oxide charge can be more clearly observed using lateral bipolar action than by using FET operational characteristics.

Technical Program Tuesday

B-2
1:50 PM **Charge Separation Techniques for Irradiated Pseudo-MOS SOI Transistors**
Bongim Jun, Ronald Schrimpf, Daniel Fleetwood, Vanderbilt University; Sorin Cristoloveanu, ENSERG

The concentrations of radiation-induced oxide-trap charge and interface-trap charge in the buried oxide of pseudo-MOS SOI transistors are separated using the midgap-current technique and dual-transistor analysis. Charge densities obtained from the two methods are compared.

B-3
2:05 PM **Effects of Electric Field on Radiation-Induced Dopant Deactivation by Hydrogen**
S. N. Rashkeev, D. M. Fleetwood, R. D. Schrimpf, S. T. Pantelides, Vanderbilt University

We show that radiation-induced dopant depassivation is due primarily to direct neutralization by H^+ . The strong electric field dependence is due to the interplay between H^+ diffusion and drift in the depletion region.

B-4
2:20 PM **A Mechanism for Radiation Dose-Rate Sensitivity of Bipolar Transistors**
Harold P. Hjalmarson, Steven C. Witzak, Marty S. Shaneyfelt, James R. Schwank, Charles E. Hembree, Thomas R. Mattsson, Sandia National Labs; Ronald L. Pease, RLP Research; Arthur H. Edwards, Air Force Research Labs

A mechanism for enhanced low dose rate sensitivity (ELDRS) is described. In this mechanism, bimolecular reactions dominate the kinetics at high dose rates thereby causing a sub-linear dependence on total dose.

B-5
2:35 PM **Radiation-Induced Charge Trapping in Thin $Al_2O_3/SiO_xN_y/Si(100)$ Gate Dielectric Stacks**
J. A. Felix, D. M. Fleetwood, R. D. Schrimpf, Vanderbilt University; M. R. Shaneyfelt, J. R. Schwank, P. E. Dodd, Sandia National Laboratories; E. P. Gusev, C. D'Emic, IBM

We have investigated the total-dose response of Al_2O_3 on silicon-oxynitride capacitors. The midgap-voltage shifts scale similarly with thickness, but are slightly larger, than those of high-quality thermal SiO_2 of equivalent electrical thickness.

B-6
2:50 PM **Bistability of Oxygen Vacancies Revisited: First Principles Calculations of E' Centers in Crystalline and Amorphous SiO_2 Using Large Unit Cells**
Arthur H. Edwards, A. C. Pineda, Air Force Research Laboratory; Peter A. Schultz, H. P. Hjalmarson, Sandia National Laboratories; P. Sushko, A. Shluger, University College of London

We present density functional calculations on oxygen vacancies in crystalline and amorphous SiO_2 . We found no cases in which the puckered configuration would persist when neutralized. We present an alternative model for charge cycling.

Technical Program Tuesday

POSTER PAPERS

PB-1 NIEL for Heavy Ions: An Analytical Approach

Scott Messenger, SFA, Inc.; Ed Burke, Consultant; Mike Xapsos, NASA GSFC; Geoff Summers, Rob Walters, NRL; Insoo Jun, JPL; Tom Jordan, EMPC

For the first time, we describe an analytical model for calculating NIEL for heavy ions based upon screened Coulomb potentials. The model applies to any incident ion on any target material in the Coulombic limit.

PB-2 Proton Nonionizing Energy Loss (NIEL) for Device Applications

Insoo Jun, Jet Propulsion Laboratory; Mike Xapsos, NASA/GSFC; Scott Messenger, Edward Burke, SFA, Inc.; Robert Walters, Geoff Summers, Naval Research Laboratory; Thomas Jordan, EMPC

The proton induced NIEL for representative device materials is presented for the energy range between the displacement thresholds of materials to 1000 MeV. All interaction mechanisms (Coulomb and nuclear elastic/inelastic) are fully accounted for.

PB-3 Contactless Ultra-Fast Laser Probing of Radiation-Induced Leakage Current in Ultra-Thin Oxides

R. Pasternak, A. Chatterjee, Y. V. Shirokaya, B. K. Choi, Z. Marka, J. K. Miller, Y. Jiang, R. G. Albridge, S. N. Rashkeev, S. T. Pantelides, R. D. Schrimpf, D. M. Fleetwood, N. H. Tolk, Vanderbilt University

Laser-induced second-harmonic signals measuring leakage currents in a variable-thickness oxide structure (1.0-6.5 nm) are substantially enhanced by X-ray irradiation. The mechanisms responsible for radiation-induced leakage current through thin oxides are discussed.

PB-4 Electrical and Spectral Properties of 1.8 MeV Proton Irradiated AlGaIn/GaN HEMT Structures as a Function of Proton Fluence

B. D. White, M. Bataiev, S. A. Ringel, L. J. Brillson, The Ohio State University; X. Hu, D. M. Fleetwood, R. D. Schrimpf, S. T. Pantelides, Vanderbilt University; W. J. Schaff, Cornell University

We have examined electrical and optical properties of HEMT structures as a function of 1.8 MeV proton fluence. Physical mechanisms of the transistor electrical degradation are proposed based on materials characterization and spectral results.

PB-5 Radiation Hardness of Czochralski Silicon Studied by 10 MeV and 20 MeV Protons

Eija Tuominen, Jaakko Härkönen, Esa Tuovinen, Katri Lassila-Perini, Panja Luukka, Petteri Mehtälä, Saara Nummela, Jukka Nysten, Alessio Zibellini, Helsinki Institute of Physics; Zheng Li, Brookhaven National Lab; Paula Heikkilä, Victor Ovchinnikov, Marko Yli-Koski, Helsinki University of Technology; Pauli Laitinen, Iiro Riihimäki, Ari Virtanen, University of Jyväskylä

We processed pin-diodes on Czochralski, Float Zone and diffusion oxygenated Float Zone silicon and irradiated them with 10 and 20 MeV protons. We found Czochralski Silicon to be extremely radiation hard compared to other materials.

Technical Program Tuesday

PB-6 The Role of Nanoclusters in Reducing Hole Trapping in Implanted Oxides

Bernard Mrstik, Harold Hughes, Naval Research Laboratory; Pascale Gouker, MIT Lincoln Laboratory; Reed Lawrence, Pat McMarr, SFA, Inc.

We find that the reduced hole trapping observed in oxides implanted with Si is due to the formation of Si nanoclusters. The nanoclusters appear to reduce hole trapping by interfering with hydrogen transport during irradiation.

3:05 - 3:35 PM
SERRA GRAND BALLROOM I

BREAK

SESSION C PHOTONIC DEVICES AND INTEGRATED CIRCUITS

3:35 PM SESSION INTRODUCTION

Chair: Robert Walters, Naval Research Laboratory

C-1 Proton-Induced Secondary Particle Environments for Space-Based Infrared Sensors

3:40 PM

J. C. Pickel, PR&T, Inc.; R. A. Reed, NASA/GSFC; P. W. Marshall, Consultant-NASA/GSFC; T. M. Jordan, EMP Consultants; G. Gee, B. Fodness, SGT, Inc.; M. McKelvey, R. McMurray, K. Enrico, C. McCreight, NASA/ARC

We present measurements of proton-induced secondary particle environments in the vicinity of an infrared focal plane. Secondary particles were detected with an infrared detector array and results are analyzed for implications to space-based infrared sensors.

C-2 Comparison of CCD Damage Due to 10 and 60 MeV Protons

3:55 PM

G. R. Hopkinson, Sira Electro-optics Ltd; A. Mohammadzadeh, ESA-ESTEC

Dark current and CTI data are presented for four CCD device types after 10 and 60 MeV proton irradiation. Comparison of the damage at the two energies allows testing of the validity of NIEL scaling.

C-3 Proton-Induced Transients and Charge Collection Mechanisms in a LWIR HgCdTe Focal Plane Array

4:10 PM

Paul W. Marshall, GSFC Consultant; John E. Hubbs, Douglas C. Arrington, AFRL/Ball Aerospace; Rodolfo A. Ramos, AFRL; George Gee, SGT, Inc.; Jim C. Pickel, PR&T, Inc.; Robert A. Reed, Cheryl J. Marshall, NASA GSFC

We compare measurements and modeling of 30 and 63 MeV proton-induced transients in a HgCdTe LWIR infrared focal plane assembly operating at 40 K. Charge collection modeling describes diffusion of carriers to multiple pixels.

C-4 Comparison of the Effects of 51-MeV Protons on Differing Silicon Avalanche Photodiode Structures

4:25 PM

Heidi N. Becker, Tetsuo F. Miyahira, Allan H. Johnston, Jet Propulsion Laboratory

Different silicon avalanche photodiode structures are compared for the effects of 51-MeV protons on dark current and responsivity. Large differences in depletion widths coincided with differences in sensitivity to dark current increases and responsivity degradation.

Technical Program Tuesday

- C-5**
4:40 PM **Effects of 2-MeV Proton Irradiation on Operating Wavelength and Leakage Current of Vertical Cavity Surface Emitting Lasers**
Aditya Kalavagunta, University of Arizona; Mark A Neifeld, University of Arizona; Ron Schrimpf, Bo Choi, Vanderbilt University

The threshold current, leakage current, and operating wavelength of high-speed vertical cavity surface emitting lasers (VCSELs) are shown to increase with proton fluence. The degradation results from an increase in resistivity due to mobility degradation and carrier removal.

- C-6**
4:55 PM **Annealing Displacement Damage in GaAs LEDs: Another Galileo Success Story**
Gary Swift, Gregory C. Levanas, J. Martin Ratliff, Allan H. Johnston, JPL/Caltech

A recent failure of Galileo's magnetic recorder was identified as LED degradation. Annealing the culprit OP133s proved successful and the irreplaceable data was recovered. Test data and modeling results calibrate an understanding of this incident.

POSTER PAPERS

- PC-1**
Neutron Irradiation Effects in GaN-Based Blue LEDs
ChyShiun Li, S. Subramanian, Oregon State University

Neutron irradiation effects on the electrical and optical properties of commercial GaN-InGaN double heterojunction LEDs are investigated. No significant degradation in electrical properties is seen while optical properties show considerable degradation.

- PC-2**
Irradiation Induced Degradation of High Speed Response of Si P-I-N Photodiodes
J. S. Laird, T. Hirao, S. Onoda, H. Mori, T. Kamiya, Japan Atomic Energy Research Institute; T. Ohyama, Kumamoto National College of Technology

High-speed photodiodes are an important component of optical links used in space. We examine MeV electron degradation of 1.5 GHz Si pin structures using CV-IV and pulsed laser. A model for the degradation is presented.

- PC-3**
Single-Event Dark Current Spikes Induced in CCDs by High Energy Neutrons
Andrew Michael Chugg, Rodri Jones, MBDA UK Limited; James Armstrong, Douglas King, BAE Systems

This paper presents an analysis of dark signal non-uniformity induced in a charge coupled device by 90 MeV neutrons. Random Telegraph Signal switching between multiple levels was seen for some dark current spikes.

Technical Program Tuesday

PC-4 Modeling of Proton-Induced CCD Degradation in the Chandra X-Ray Observatory

D. H. Lo, J. R. Srour, Northrop Grumman Space Technology

Modeling results are presented for proton-induced degradation of CCDs used on Chandra. Observed on-orbit changes are accounted for with a proton spectrum that is a factor of $\sim 10^5$ less than that incident on the spacecraft.

PC-5 Performances of the Hydrogen-Loading Technique as Radiation-Hardening Method for Optical Fibers

Benoît Brichard, Alberto Fernandez Fernandez, Francis Berghmans, Marco van Uffelen, Hans Ooms, Paul Brogermans, SCKCEN

Hydrogen processing of glasses is a convenient tool for reducing the radiation sensitivity of optical fibers. We have evaluated the performances of this method in fission reactor and cobalt-60 irradiation conditions.

5:10 PM END OF TUESDAY SESSIONS

Technical Program Wednesday

INVITED TALK
8:15 - 9:15 AM
SERRA GRAND BALLROOM II

Use of Technology in the Exploration of Monterey Bay

Dr. Marcia K. McNutt, Monterey Bay Aquarium Research Institute

The Monterey Bay Aquarium Research Institute (MBARI) was founded in 1987 by David Packard. The institute's main focus is on designing and building new tethered and autonomous underwater vehicles and in situ sensor packages for increasing the spatial and temporal sampling of the ocean and its inhabitants. MBARI is located in Moss Landing, California, where its two research ships and remotely operated vehicles are berthed, giving them immediate access to Monterey Bay. MBARI also maintains moorings offshore, equipped with ocean-monitoring instruments, as well as two moorings in the equatorial Pacific that are part of the NOAA Tropical Atmosphere Ocean array. In this talk, Dr. McNutt will describe the institute's use of technological innovation to explore Monterey Bay.

Marcia McNutt is the President and Chief Executive Officer of the Monterey Bay Aquarium Research Institute. She was born and raised in Minneapolis, Minnesota, and in 1973, she received a BA degree in Physics, summa cum laude, Phi Beta Kappa, from Colorado College in Colorado Springs. With the help of a National Science Foundation Graduate Fellowship, she next studied geophysics at Scripps Institution of Oceanography in La Jolla, California, where she earned a PhD in Earth Sciences in 1978. After a brief appointment as a sabbatical replacement at the University of Minnesota, she spent the next three years working on the problem of earthquake prediction at the US Geological Survey in Menlo Park, California, before joining the faculty at MIT in Cambridge, Massachusetts, in 1982. Dr. McNutt spent the next 15 years at MIT, where she was appointed the Griswold Professor of Geophysics. While at MIT, she also served as Director of the Joint Program in Oceanography and Applied Ocean Science and Engineering, a cooperative graduate educational program between MIT and the Woods Hole Oceanographic Institution. In 1988, she won the Macelwane Award from the American Geophysical Union, presented for outstanding research by a young scientist. Dr. McNutt is the President of the American Geophysical Union, and lives in Salinas, California with her three daughters and her husband, Ian Young, a sea captain.

SESSION D
9:15 AM

ATMOSPHERIC AND TERRESTRIAL RADIATION EFFECTS **SESSION INTRODUCTION**

Chair: Robert Baumann, Texas Instruments

D-I
9:20 AM

Solar Particle Enhancements of Single Event Effect Rates at Aircraft Altitudes

C. S. Dyer, F. Lei, S. N. Clucas, QinetiQ

Data from spaceborne detectors and ground-level neutron monitors, together with radiation transport codes, are applied to calculate the SEE environments due to large solar particle events. Calculations are validated against data from Concorde.

Technical Program Wednesday

D-2
9:35 AM **Comparisons of Soft Error Rate for SRAMs in Commercial SOI and Bulk below the 130 nm Technology Node**

Philippe Roche, Gilles Gasiot, STMicroelectronics; Keith Forbes, Vincent O'Sullivan, Motorola; Veronique Ferlet, CEA-DAM

This paper presents experimental ASER on SOI and bulk SRAMs for the 250, 130 and 90 nm technologies. Monte Carlo simulations are used to model the key parameters for cosmic and terrestrial SER towards the 65 nm node.

D-3
9:50 AM **Contribution of SiO₂ in Neutron-Induced SEU in SRAM**

Frederic Wrobel, Philibert Iacconi, University of Nice; Jean-Marie Palau, University of Montpellier; Marie-Catherine Calvet, EADS-LV

We considered an Si/SiO₂ sample and simulated neutron-induced SEU. A dedicated subroutine gives recoil energies in the 5-150 MeV incident energy range. We show the SiO₂ layer increases the SER by about several tens of percent.

POSTER PAPERS

PD-1 **Terrestrial Thermal Neutrons**

John Dirk, Martin Nelson, James F. Ziegler, United States Naval Academy; Alan Thompson, National Institute for Standards and Technology; T. H. Zabel, IBM Research

The terrestrial thermal neutron flux (remnants of cosmic ray cascades) has been accurately measured in 42 locations. Maximum variations of only 2x are observed for unshielded sites, but the variations are contrary to theoretical predictions.

PD-2 **Soft Error Rate Increase for New Generations of SRAMs**

Thomas Granlund, Bo Granbom, Saab Avionics AB; Nils Olsson, Systems Technology Swedish Defence Research Agency

We report on enhanced susceptibility for neutron-induced soft errors from accelerated testing of Static Random Access Memories (SRAMs), performed at Los Alamos National Laboratory. This enhancement is per bit of memory.

10:05 – 10:35 AM
SERRA GRAND BALLROOM I

BREAK

SESSION E
10:35 AM **SINGLE-EVENT EFFECTS, DEVICES AND INTEGRATED CIRCUITS**
SESSION INTRODUCTION

Chair: Leif Scheick, Jet Propulsion Laboratory

E-1
10:40 AM **Modeling Single-Event Transient Propagation in a Complex Digital Device**

Ken Clark, US Naval Research Laboratory

A methodology to determine the effect of SETs on complex digital devices has been developed. This methodology is based on the SET state-transition model and was validated by radiation testing of a complex digital device.

Technical Program Wednesday

E-2
10:55 AM **Investigation of Single-Event Transients in Voltage-Controlled Oscillators**
Wenjian Chen, Hugh Barnaby, University of Arizona; Vincent Pouget, Pascal Fouillat, Yann Deval, Dean Lewis, University Bordeaux 1

The responses of voltage-controlled oscillators to single-event transients are investigated. Laser testing and simulations indicate that ion strikes on critical transistors may cause temporary distortions in the oscillating output which are frequency dependent.

E-3
11:10 AM **Identification and Classification of Single Event Upsets in the Configuration Memory of SRAM based FPGAs**
Marco Ceschia, Alessandro Paccagnella, Damiano Bortolato, Paolo Zambolin, Università di Padova; Massimo Violante, Matteo Sonza Reorda, Paolo Bernardi, Maurizio Rebaudengo, Politecnico di Torino; Marco Bellato, Andrea Candelori, Istituto Nazionale di Fisica Nucleare

SRAM based FPGA has been tested under heavy ion irradiation. Single event upsets in the configuration memory have been identified and classified to develop a fault injection model that simulates the effects of SEUs on implemented designs.

E-4
11:25 AM **Single Event Effects in SOI CMOS 4M SRAM Fabricated in Unibond**
Michael Liu, Walter Heikkila, Keith Goelke, Dany Anthony, Allan Hurst, Gary Kirchner, Honeywell SSEC; William Jenkins, Harold Hughes, Naval Research Laboratory; Souvik Mitra, Dimitris Ioannou, George Mason University

Single event upsets in 4M SRAM fabricated in Unibond substrates are measured and discussed. Critical charge calculated from heavy ion data is compared with SPICE simulation. Improved SEU performance with beta reduction will be reported.

E-5
11:40 AM **Impact of Data Cache Memory on the SEU Induced Error Rate of Microprocessors**
Fabien Faure, Raoul Velazco, Joan Albert Gimeno Rovira, TIMA-CMP; Massimo Violante, Maurizio Rebaudengo, Matteo Sonza Reorda, Politecnico di Torino

Cache memories included in most complex processors constitute a significant contribution to the global SEU induced error rate. Three different approaches allowing the study of this contribution by fault injection are investigated in this paper.

E-6
11:55 AM **Single-Event Upset in Advanced Commercial PowerPC Microprocessors**
Farokh Irom, Farhad F. Farmanesh, Gary M. Swift, Allan H. Johnston, Jet Propulsion Laboratory

Single-event upset from heavy ions is measured for advanced commercial microprocessors, comparing upset sensitivity in registers and d-cache for several generations of devices. Multiple-bit upsets and asymmetry in register upset cross sections are also discussed.

Technical Program Wednesday

POSTER PAPERS

PE-1 Accurate Single Event Transient Analysis via Zero-Delay Logic Simulation

Massimo Violante, Politecnico di Torino

We describe an approach for analyzing single event transients in combinational circuits. The approach analyzes SETs via zero-delay simulation with the same accuracy of timed simulators, but with a speed-up of 3 orders of magnitude.

PE-2 Applicability of Circuit Macromodeling to Analog Single-Event Transient Analysis

Younes Boulghassoul, Lloyd W. Massengill, Vanderbilt University

This work evaluates the applicability of vendor-supplied analog circuit macromodels to single-event transient (SET) analyses. Our findings demonstrate that macromodeling is effective for system-level SET propagation, but not for details on SET initiation.

PE-3 An SEU Hardening Approach for High-Speed SiGe HBT Digital Logic

Ramkumar Krithivasan, John D. Cressler, Georgia Institute of Technology; Guofu Niu, Auburn University; Steve M. Currie, Karl E. Fritz, Pamela A. Riggs, Barbara A. Randall, Barry Gilbert, Mayo Foundation; Robert Reed, Paul Marshall, NASA GSFC

A new circuit-level SEU hardening approach for SiGe HBT digital logic is introduced and analyzed. The new circuit exhibits sufficient SEU tolerance, low layout complexity, and modest power consumption, making it suitable for space applications.

PE-4 Single-Event Effects in 0.18 μm CMOS Commercial Processes

Akiko Makihara, Hiroaki Asai, Yasuo Sakaide, Yoshihisa Tsuchiya, Toshifumi Arimitsu, High-Reliability Components Corporation; Yoshiya Iide, Hiroyuki Shindou, Satoshi Kuboyama, Sumio Matsuda, National Space Development Agency of Japan

We evaluated SEEs in sample circuits fabricated at TSMC and Fujitsu with their 0.18 μm CMOS commercial processes. The samples were designed with hardness-by-design methodology. The results indicate effective hardening design associated with SEEs.

PE-5 SEU Mitigation for Half-Latches in Xilinx Virtex FPGAs

Paul Graham, Michael Caffrey, Los Alamos National Laboratory; Michael Wirthlin, D. Eric Johnson, Nathan Rollins, Brigham Young University

We introduce the half-latch single-event upset issue found in Xilinx Virtex FPGAs and describe methods for mitigating the effects of half-latch SEUs. One mitigation method's effectiveness is then illustrated through experimental data.

PE-6 Validation of an FPGA Fault Simulator

Michael J. Wirthlin, Eric Johnson, Nathan Rollins, Brigham Young University; Paul Graham, Michael Caffrey, Los Alamos National Laboratory

This work describes the radiation testing for validating a fault simulation tool used to study the behavior of FPGA circuits in the presence of configuration memory upsets.

Technical Program Wednesday

PE-7 Single Event Effects and Mitigation in Commercial 0.15 μm Antifuse-Based FPGA

*Jih-Jong Wang, Brian Cronquist, John McCollum, Solomon Wolday, Actel Corporation;
Rich Katz, NASA/Goddard; Igor Kleyner, Orbital Science Corporation*

The single event effects of 0.15 μm antifuse FPGA were investigated by beam test and computer simulation. Single event upsets of user flip-flop, clock, control logic, and embedded SRAM are identified and mitigation methods are proposed.

12:10 – 1:30 PM LUNCH

SESSION F SINGLE-EVENT EFFECTS, MECHANISMS AND MODELING **1:30 PM SESSION INTRODUCTION**

Chair: Nicholas Boruta, Lockheed Martin Space Systems

F-1 Modeling Proton Strikes in SiO_2 Using the Columnar Recombination Coefficient Obtained from SEGR Analyses **1:35 PM**

*Randall Milanowski, Dynamics Research Corporation;
Nicholas Boruta, Lockheed Martin Space Systems*

We have applied two-dimensional numerical simulation in a study of proton strikes in SiO_2 . Agreement with data is obtained if the recombination coefficient is taken from recent SEGR analyses rather than Langevin's formula.

F-2 Statistical Model for Radiation Induced Wear-Out of Ultra-Thin Gate Oxides After Exposure to Heavy Ion Irradiation **1:50 PM**

*Andrea Cester, Salvatore Cimino, Enrique Miranda, Alessandro Paccagnella,
Università di Padova; Gabriella Ghidini, ST Microelectronics;
Andrea Candelori, Istituto Nazionale di Fisica Nucleare*

The accelerated wear-out of irradiated and electrically stressed ultra-thin gate oxides is described by an original model of the breakdown occurrence. A method to extrapolate results to low voltage applications is proposed.

F-3 Data Retention After Heavy Ion Exposure of Floating Gate Memories: Analysis and Simulation **2:05 PM**

*Luca Larcher, Università di Modena; Giorgio Cellere, Alessandro Paccagnella,
Università di Padova; Andrea Chimenton, Università di Ferrara;
Andrea Candelori, INFN; Alberto Modelli, ST Microelectronics*

Irradiated floating gates present large tails in distributions of threshold voltages during data retention experiments. A model which statistically accounts for gate oxide currents due to phonon and trap assisted tunneling closely describes experimental data.

Technical Program Wednesday

F-4
2:20 PM **Broad-Beam and Ion Microprobe Studies of Single-Event Upsets in High Speed 0.18 μm Silicon-Germanium Heterojunction Bipolar Transistors and Circuits**

Robert Reed, Kenneth LaBel, NASA/GSFC; Paul Marshall, Consultant to NASA/GSFC; Jim Pickel, PR&T; Martin Carts, Raytheon/NASA/GSFC; Guofu Niu, Auburn University; Karl Fritz, Pam Riggs, Jason Prairie, Barbara Randall, Barry Gilbert, Mayo Foundation; Gyorgy Vizkelethy, Paul Dodd, Sandia National Laboratories; Tim Irwin, J&T/NASA/GSFC; John Cressler, Ramkumar Krithivasan, Georgia Institute of Technology

Combining broad-beam circuit level SEU response with ion microprobe tests on single silicon germanium heterojunction bipolar transistors allows for a better understanding of the charge collection mechanisms responsible for SEU response of SiGe HBT technology.

F-5
2:35 PM **3D Simulation of Heavy-Ion Induced Charge Collection in SiGe HBTs**

Muthubalan Varadharajaperumal, Guofu Niu, Auburn University; Ramkumar Krithivasan, John D. Cressler, Georgia Institute of Technology; Robert A. Reed, Paul W. Marshall, NASA-GSFC; Gyorgy Vizkelethy, Paul E. Dodd, Sandia National Labs; Alvin J. Joseph, IBM Microelectronics

This paper presents the first 3D simulation of heavy-ion induced charge collection in SiGe HBTs, together with microbeam testing data. The sensitive area of charge collection for each terminal is identified.

F-6
2:50 PM **Three-Dimensional Mapping of Single Event Effects Using Two Photon Absorption**

Dale McMorro, Joseph S. Melinger, Naval Research Laboratory; William T. Lotshaw, SFA, Inc.; Stephen Buchner, QSS Group, Inc.; Younes Boulghassoul, Lloyd W. Massengill, Vanderbilt University; Ron L. Pease, RLP Research

Carrier generation based on sub-bandgap two-photon absorption is used to perform three-dimensional mapping of the single event transient response of the LM124 operational amplifier.

F-7
3:05 PM **Charge Collection by Capacitive Influence Through Isolation Oxides**

V. Ferlet-Cavrois, J. Baggio, C. D'Hose, A. Torres, P. Paillet, O. Flament, CEA; J. R. Schwank, G. Vizkelethy, Sandia National Laboratories

This paper analyzes the collected charge in ion irradiated MOS structures. The charge generated in the substrate induces a parasitic displacement current and charge collection. This has important implications for circuit reliability in radiation environments.

Technical Program Wednesday

POSTER PAPERS

PF-1 **A Single Event Latchup Suppression Technique**

*J. P. Spratt, R. E. Leadon, Full Circle Research, Inc.; J. C. Pickel, PR&T Consulting;
R. C. Lacoe, S. C. Moss, S. D. LaLumondiere, Aerospace Corp.*

Results are presented on a technique using displacement damage from energetic ions to suppress SEL in CMOS. Ions implanted through the back of a thinned chip degrade parasitics causing latchup without degrading functionality or parametrics.

PF-2 **Single Event Transients in High-Speed InP/InGaAs Avalanche Photodiodes**

*J. S. Laird, T. Hirao, S. Onoda, T. Kamiya, Japan Atomic Energy Research Institute;
H. Ohyama, Kumamoto National College of Technology*

Heavy ions incident on InGaAs/InP Avalanche Photodiodes induce Single Event Transients (SET) that degrade optical link Bit-Error-Rates. Using a focused 18-MeV O beam, we examine charge collection mechanisms leading to SET's in an InP/InGaAs APD.

PF-3 **Enhanced Avalanche Multiplication Factor and Single-Event Burnout**

Satoshi Kuboyama, Naomi Ikeda, Sumio Matsuda, NASDA; Toshio Hirao, JAERI

We describe experimental data for single-event burnout of bipolar junction transistors and the results of analysis using device simulators. The analysis indicates the enhanced impact ionization rate in the ion track plays an essential role.

PF-4 **Comparison of NMOS and PMOS Transistor Sensitivity to SEU in SRAMs Studied by Device Simulation**

*Karine Castellani-Coulié, Bruno Sagnes, Frederic Saigné, Jean-Marie Palau,
Université Montpellier II; Marie-Catherine Calvet, EADS-LV; Paul E. Dodd,
Frederick Sexton, Sandia National Laboratories*

The off-NMOS and off-PMOS transistors SEU sensitivities are studied in a 0.6 μm SRAM. In some cases the off-PMOS sensitivity is shown to be similar to the off-NMOS one. This could affect the SEU rate calculation.

PF-5 **LET Spectrum of Proton Energy Levels from 50 to 500 MeV and their Effectiveness for Single Event Effects Characterization of Microelectronics**

David M. Hiemstra, MDRobotics; Ewart W. Blackmore, TRIUMF

Effective LET spectrum of heavy nuclear recoils produced by proton interactions in silicon for various proton energies are calculated. The effectiveness of each proton energy level for single event effects screening of microelectronics is evaluated.

PF-6 **Neutron-Induced Pion Production in Silicon-Based Circuits**

*J. D. Kinnison, Richard Maurer, David R. Roth, Johns Hopkins Applied Physics Laboratory;
Peter J. McNulty, Clemson University; Wagih G. Abdel-Kader, South Carolina State University*

Pion-production events result in slightly more SEE events for devices with relatively large sensitive volumes and low thresholds for upset but dramatically fewer events for the same sensitive volume when the threshold is high.

3:20 PM END OF WEDNESDAY SESSIONS

Technical Program Thursday

INVITED TALK
8:15 - 9:15 AM
SERRA GRAND BALLROOM II

The Future of Electronics: Micro, Nano, or Molecular?

Prof. Mark S. Lundstrom, Purdue University

As the recent report of silicon MOSFETs with 6 nm channel lengths demonstrates, progress in silicon technology continues at a breath-taking pace. There is, however, a growing consensus that the end of device scaling is only a decade or so away. As silicon technology accelerates toward its limits, rapid progress in unconventional electronics is also occurring. In this talk, Mark Lundstrom will examine the limits of silicon technology, discuss some recent scientific breakthroughs in molecular electronics, and explore the possibilities of turning this exciting science into new technologies.

Mark Lundstrom is the Scifres Distinguished Professor of Electrical and Computer Engineering at Purdue University where his teaching and research center on the physics, technology, and simulation of nanoscale electronic devices. He is the director of the NSF-funded Network for Computational Nanotechnology and serves on the leadership councils of the NASA-funded Institute for Nanoelectronics and Computing and the MARCO/DARPA Focus Center for Materials, Structures, and Devices. His research and teaching have been recognized by several awards – most recently the IEEE Cleo Brunetti Award, which he shared with his colleague Supriyo Datta for their contributions to the physics and simulation of nanoscale electronics devices.

SESSION G
9:15 AM

SPACECRAFT ENVIRONMENTS AND EFFECTS **SESSION INTRODUCTION**

Chair: Lawrence Townsend, University of Tennessee

G-1
9:20 AM

The ESA Standard Radiation Environment Monitor Programme - First Results from PROBA-I and Integral

A. Mohammadzadeh, P. Nieminen, E. Daly, P. Vuilleumier, European Space Agency; P. Bühler, C. Eggel, W. Hajdas, N. Schlumpf, A. Zehnder, Paul Scherrer Institute; J. Schneider, Contraves Space; R. Fear, Mullard Space Science Laboratory

The main characteristics of the ESA Standard Radiation Environment Monitor (SREM) are outlined. First SREM results from PROBA-I and Integral spacecraft are presented.

G-2
9:35 AM

A Model of Geostationary Electron Environment: POLE

D. Boscher, S. Bourdarie, ONERA/DESP; R. Friedel, LANL/NIS-2

We analyzed 25 years of electron radiation belt measurements from the geostationary LANL satellites. A model reproducing the solar cycle, valid from 30 keV up to 2.5 MeV, was derived. It is compared to AE8.

G-3
9:50 AM

Measurement of Conductivity and Charge Storage in Insulators Related to Spacecraft Charging

A. R. Frederickson, Caltech Jet Propulsion Lab; J. R. Dennison, Utah State University

Novel methods have been developed to measure conductivity and charge storage in thin film insulating spacecraft materials. For a variety of such samples these values differ by up to 10^4 from current standard values.

Technical Program Thursday

POSTER PAPERS

PG-1 Grazing Angle Proton Scattering: Effects on Chandra and XMM-Newton X-Ray Telescopes

B. K. Dichter, Air Force Research Laboratory; S. Woolf, Arcon Corporation

We describe grazing-angle proton scattering from solid surfaces. Results are applied to the damage to a focal plane instrument on Chandra X-Ray telescope. We show that the previous calculations under-predicted the damaging flux.

PG-2 Neutron Energy Spectra from 200 MeV Proton Interaction with Spacecraft Materials

Richard H. Maurer, James D. Kinnison, David R. Roth, Johns Hopkins Applied Physics Laboratory; John F. Dicello, Johns Hopkins Medical Institutions

We report on refined and detailed energy spectra results of neutron production greater than 10 MeV from collisions of 200 MeV protons with combinations of aluminum, graphite and polyethylene.

PG-3 Prediction of Energetic Solar Particle Event Dose-Time Profiles Using Artificial Neural Networks

Jennifer L. Hoff, Lawrence W. Townsend, J. Wesley Hines, University of Tennessee

A set of artificial neural networks has been developed which is capable of forecasting dose-time profiles for energetic solar particle events based on doses obtained during the early stages of the event.

PG-4 Total Dose Orbital Data by Dosimeter Onboard Tsubasa (MDS-I) Satellite

Yugo Kimoto, Hideki Koshiishi, Haruhisa Matsumoto, Tateo Goka, National Space Development Agency of Japan

This paper describes the total dose measurement device for spacecraft and the flight result. The total dose that is acquired in this experiment does not correspond with the SHIELDOSE-II model result for some shield thickness.

10:05 – 10:35 AM
DEANZA FOYER

BREAK

SESSION H HARDNESS ASSURANCE

10:35 AM SESSION INTRODUCTION

Chair: Christian Poivey, NASA Goddard Space Flight Center

H-I Total Dose Hardness Assurance Testing Using Laboratory Radiation Sources

10:40 AM

*Philippe Paillet, Veronique Ferlet-Cavrois, Olivier Flament, CEA;
James R. Schwank, Marty R. Shaneyfelt, Sandia National Laboratories*

SOI transistors were irradiated using high-energy protons, and electrons. The radiation-induced back-gate threshold voltage shift was used to determine the optimum laboratory source for simulating the space radiation environment.

Technical Program Thursday

H-2
10:55 AM **Bias Dependence of Fully Depleted Transistors to Total Dose Irradiation**
O. Flament, A. Torres, CEA

We investigate the worst case bias of fully depleted transistors under X-ray irradiation. The coupling between front and back gates and the latch triggered by floating body effects are evaluated as a function of dose.

H-3
11:10 AM **ELDRS in Space: An Updated and Expanded Analysis of the Bipolar ELDRS Experiment on MPTB**
*T. L. Turflinger, W. M. Schemichel, J. F. Krieg, J. L. Titus, NAVSEA Crane;
A. B. Campbell, M. Reeves, NRL; P. W. Marshall, Consultant; R. L. Pease, RLP Research*

MPTB experiment A4 established ELDRS degradation in space. Data are updated through orbit 3719, dosimetry corrected, and new analysis explores displacement damage and the rate of degradation as a function of dose rate.

H-4
11:25 AM **Impact of Mechanical Stress on Total-Dose Effects in Bipolar Transistors**
*J. Boch, R. Cizmarik, R. D. Schrimpf, D. M. Fleetwood, Vanderbilt University;
F. Saigné, Université Reims-Champagne-Ardennes*

Experiments conducted at high and low dose rates show that the total-dose response of bipolar linear ICs is strongly influenced by mechanical stress. The role of mechanical stress on enhanced-low-dose-rate-sensitivity is discussed.

H-5
11:40 AM **SEE Characterization of Vertical DMOSFETs: An Updated Test Protocol**
Jeffrey L. Titus, NAVSEA Crane Div.; C. Frank Wheatley, Private Consultant

Power MOSFET SEE test protocols are inadequate and do not represent worse-case conditions. We present updated test protocols, suggest new approaches to describe SEE, and provide models to predict worse-case test energies.

POSTER PAPERS

PH-1
Performance Impact of Single-Event Effects in Classical Analog-to-Digital Converter Architectures
*Vincent Pouget, Dean Lewis, Pascal Fouillat, Dominique Dallet, IXL Laboratory;
Fabien Faure, Paul Peronnard, Raoul Velazco, TIMA Laboratory*

An original methodology is presented for characterizing SEE impact on ADC performance parameters. Events produced by a pulsed laser and heavy ions are analyzed with an ADC testing dedicated software coupled with the THESIC+ tester.

PH-2
Heavy-Ion Single Event Effects Testing of Lead-On-Chip Assembled High-Density Memories
*R. Harboe-Sørensen, European Space Agency/ESTEC;
F.-X. Guerre, J.-G. Loquet, C. Tizon, Hirex Engineering*

This paper summarizes steps taken by ESA in order to address heavy ion SEE testing of lead-on-chip assembled high-density memories. In particular sample preparation techniques, test approaches, test facilities and test analyses will be addressed.

Technical Program Thursday

PH-3 Using a System-Level, Bit-Error-Rate Model to Predict On-Orbit Performance

Michael A. Cosgrove, Eastman Kodak Company

Component SEU rates are used to model and predict system BER performance in trade studies and specification verification analyses. Simplifying trade studies involving component cost, delivery-time reductions, and part substitution effects are important benefits.

11:55 AM – 1:30 PM LUNCH

SESSION I DOSIMETRY AND FACILITIES

1:30 PM SESSION INTRODUCTION

Chair: Carlos Castaneda, University of California, Davis

I-1 Radiation Effects on an Optically Stimulated Luminescence Based Dosimeter for Space Applications

1:35 PM

J-R. Vaillé, S. Ducret, K. Idri, L. Dusseau, University of Montpellier; F. Saigné, University of Reims; S. Matias, Oncogard Ales; R. Germanicus, R. Ecoffet, CNES

The loss of sensitivity induced by the displacement damage effect on the Optically Stimulated Luminescent dosimeter is investigated. A new architecture is proposed and successfully tested to harden the sensor at the system level.

I-2 Correlation of Neutron Dosimetry Using a Silicon Equivalent Proportional Counter Microdosimeter and SRAM SEU Cross Sections for Eight Neutron Energy Spectra

1:50 PM

Brad Gersey, Richard Wilkins, Harold Huff, Ramesh C. Dwivedi, Prairie View A&M University; Bruce Takala, John O'Donnell, Steve A. Wender, Los Alamos National Laboratory; Robert C. Singleterry, Jr, NASA Langley Research Center

A silicon equivalent proportional counter microdosimeter and 4 Mb SRAM were exposed to eight progressively hardened neutron energy spectra at the LANSCE ICE House facility. Resulting dosimetric results were correlated to SEU cross sections.

I-3 Neutron Dosimetry with Planar Silicon p-I-n Diodes

2:05 PM

Anatoly Rosenfeld, Michael Learch, Iwan Cornelius, University of Wollongong; Mark Yudelev, Wayne State University; V. Perevertailo, SPA Detector/BIT; Oleg Zinets, Igor Anokhin, Institute for Nuclear Research; Patrick Griffin, Sandia National Laboratories; Mark Reinhard, D.Alexiev, ANSTO

New NIEL sensors based on silicon planar p-I-n diodes of different geometry have been investigated and their response to fast neutron fields are compared with bulk diodes.

I-4 LET Dependence of Charge Collection Properties of Silicon Microdosimeters

2:20 PM

Iwan M. Cornelius, Anatoly B. Rosenfeld, University of Wollongong; Rainer Siegle, David D. Cohen, Australian Nuclear Science and Technology Organisation

Charge collection images of silicon microdosimeters were measured with a heavy ion microprobe. Monte Carlo simulations of charge deposition were used to formulate charge collection efficiency images for a number of ion species.

Technical Program Thursday

POSTER PAPERS

PI-1 **A Compact Portable Setup for in situ Solar Cell Degradation Studies**

A. Filevich, C. J. Bruno, J. Fernández Vázquez, M. J. L. Tamasi, M. G. Martínez Bogado, J. C. Plá, J. Duran, J. Schuff, A. Burlon, P. Stoliar, D. Minsky, A. J. Kreiner, Departamento de Física, CNEA; M. Alurralde, I. Prario, Departamento de Materiales, CNEA; R. Mayer, Grupo Neutrones y Reactores, CNEA

We describe a new setup for in-situ study of solar cell degradation for in-air proton and electron irradiations. We applied it to compare the equivalent proton dose between the JPL method and a new one.

PI-2 **Electron Dose Distribution Within Aluminum Spherical Shell Structures**

Philippe Calvel, Olivier Mion, Catherine Barillot, Ronan Marec, Alcatel Space; Robert Ecoffet, CNES

We analyze the accuracy of ray tracing deposited dose calculation method for electron environment. Dose enhancement is observed within multiple spherical shell shielding. Recommendation is given, and a new ray tracing technique is presented.

PI-3 **Criteria for the Selection of Dosimetry Cross Sections**

Patrick J. Griffin, Sandia National Laboratories

This paper defines a process for selecting dosimetry-quality cross sections. The selection depends upon screening high quality evaluations with quantified uncertainties and benchmarking to reference neutron fields. This procedure is illustrated for the $^{23}\text{Na}(n,\gamma)^{24}\text{Na}$ reaction.

PI-4 **Neutron Contribution to $\text{CaF}_2\text{:Mn}$ Thermoluminescent Dosimeter Response in Mixed (n/ γ) Field Environments**

K. R. DePriest, P. J. Griffin, Sandia National Laboratories

$\text{CaF}_2\text{:Mn}$ TLD's are used as photon dosimeters in mixed field environments. A model of a TLD-400 chip was used to determine the neutron contribution to the response of a $\text{CaF}_2\text{:Mn}$ TLD in Sandia reactor environments.

PI-5 **Microdose Analysis of Ion Strikes on SRAM Cells**

Leif Scheick, JPL/NASA

The effect of ion radiation on SRAM microstructures is analyzed. The voltage at which a cell cannot hold a programmed state changes with microdose. SPICE simulations and physical analyses support experimental data.

PI-6 **GEANT4 Simulations of Silicon Microdosimetry Measurements in Fast Neutron Therapy**

Iwan Cornelius, Anatoly Rosenfeld, University of Wollongong; Peter Bradley, Zarlink Semiconductor

Silicon microdosimetry measurements in Fast Neutron Therapy were modeled using the GEANT4 Monte Carlo toolkit. The model was used to investigate the importance of neutron interactions in the non tissue equivalent sensitive volume.

Technical Program Thursday

POSTER SESSION

2:35 – 5:00 PM
DEANZA BALLROOM

INTRODUCTION



Chair: Marty Shaneyfelt, Sandia National Laboratories

5:00 PM

END THURSDAY SESSIONS

5:15 - 6:45 PM
SERRA GRAND BALLROOM II

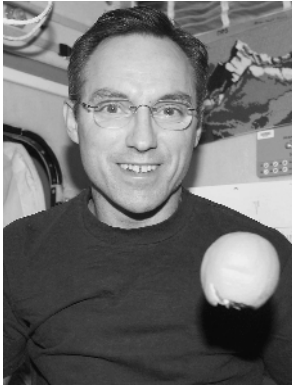
RADIATION EFFECTS COMMITTEE OPEN MEETING

Technical Program Friday

INVITED TALK

8:15 - 9:15 AM

SERRA GRAND BALLROOM II



Living and Working in Space

Carl Walz, NASA Astronaut

Carl Walz, U.S. Air Force officer and career astronaut, will describe his experiences on the most recent team to work aboard the International Space Station (ISS). He will discuss his intensive training in Russia and the U.S., the mission itself and the recovery process after more than 4 months in space. We will have a unique opportunity to learn the latest status of the Station and the growing understanding of man's place in space.

Colonel Walz began his Air Force career as a nuclear research officer responsible for analysis of radioactive samples from the Atomic Energy Detection System. He took his first step toward being an astronaut by graduating as a Distinguished Graduate Flight Test Engineer from the USAF Test Pilot School, after which he served as a Flight Test Engineer working on a variety of F-16C airframe avionics and armament development programs.

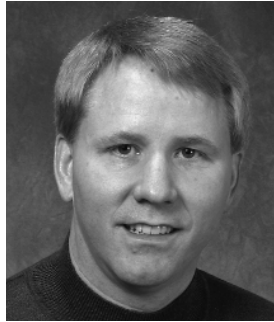
Selected by NASA in January 1990, Colonel Walz is a veteran of four space flights and logged over 34 days in space by 1996. In 1993 he served as a mission specialist on STS-51, where he was one of a five-member crew that deployed the U.S. Advanced Communications Technology Satellite and the Shuttle Pallet Satellite with NASA and German scientific experiments aboard. During this mission he participated in his first spacewalk, spending seven hours evaluating tools for the Hubble Space Telescope servicing mission. His second flight opportunity was in 1994 as the Orbiter flight engineer on STS-65. The crew of seven flew the second International Microgravity Laboratory spacelab module and conducted more than 80 experiments focusing on materials and life sciences research in microgravity. In 1996 he was a mission specialist on STS-79 where the six-member crew aboard Atlantis docked with the Russian MIR station, delivered food, water, U.S. scientific experiments and Russian equipment and exchanged NASA long duration crewmembers.

In 1998 Colonel Walz began training in both the U.S. and Russia for his latest mission of living and working aboard the International Space Station. On December 7, 2001 he arrived aboard STS-108 Endeavour as part of the Expedition-4 crew of three (one Russian cosmonaut and two American astronauts) that stayed on the station for approximately four months. They performed flight tests of the station hardware, conducted internal and external maintenance tasks and several spacewalks, and developed the capability of the station to support the addition of science experiments. He returned to earth in early May.

Technical Program Friday

DATA WORKSHOP
9:15 AM – 11:45 AM
DEANZA BALLROOM

INTRODUCTION



Chair: Jerry Wert, The Boeing Company

W-1 Continuing Evaluation of Bipolar Linear Devices for Total Dose Bias Dependency and ELDRS Effects

*S. S. McClure, C. C. Yui, B. G. Rax, M. D. Wiedeman, Jet Propulsion Laboratory;
J. L. Gorelick, Boeing Satellite Systems*

We present results of continuing efforts to evaluate total dose bias dependency and ELDRS effects in bipolar linear microcircuits. Several devices were evaluated, each exhibiting moderate to significant bias and/or dose rate dependency.

W-2 Performance Degradation of High Precision, 16-Bit Analog-to-Digital Converters

Phil Layton, Gale Williamson, Ed Patnaude, Larry Longden, Chad Thibodeau, Boris Kazak, Clancy Sloan, Maxwell Technologies

16-bit A/D converters were evaluated for performance and linearity degradation due to the total dose induced voltage shifts in the voltage reference. Test data and analysis of three A/D converters is presented.

W-3 Analysis of Radiation Effects in Space for Terrestrial Solar Cells on MDS-1

*Taishi Sumita, Mitsuru Imaizumi, Shirou Kawakita, Sumio Matsuda, Saburo Kuwajima, National Space Development Agency of Japan;
Takeshi Ohshima, Tomihiro Kamiya, Japan Atomic Energy Research Institute*

An analysis of solar cell degradation flight data from MDS-1 has been performed using the displacement damage dose methodology developed by NRL. We report both these flight and ground test data for six terrestrial cells.

W-4 Total Dose, Single Event Effect and Radiation Induced Single Cell Failures in Advanced Flash Memories

Duc Nguyen, Leif Scheick, JPL/NASA

We compare radiation effects on the highest density multi-level cell NOR and single-level cell NAND flash memories to the previous generations. Total ionization dose (TID) test results show unexpected failure modes.

Technical Program Friday

W-5 Recent Radiation Test Results at JPL

Bruce E. Pritchard, Bernard G. Rax, Steven S. McClure, NASA-Jet Propulsion Lab

This paper documents recent TID test results (including proton damage and ELDRS) obtained by JPL. Unusual test results, such as abnormally low or high failure levels or unusual failure or response mechanisms, are emphasized.

W-6 Degradation of Commercially Available DAC ICs in Mixed-Radiation Environment

S. Aghara, W. S. Charlton, University of Texas Austin; R. J. Fink, M. R. Samadi, J. A. Ochoa, J. R. Porter, Texas A&M University; B. Bhuva, Vanderbilt University

Experiments were performed at several fluence levels in a mixed-radiation environment (fast neutrons and gamma rays) to better understand the electrical performance of digital to analog converters under irradiation. Procedures, facilities and results are presented.

W-7 Total Dose Results for the AD9225RH Analog-to-Digital Converter

John P. Bings, Matt Gadlage, Steven D. Clark, NAVSEA Crane Division; Jim Sheehy, Dan Morgan, Robert Steinbach, Mission Research Corp.; Christopher Carney, Dan Kelley, Analog Devices Inc.; Hassan Kaakani, Honeywell Solid State Electronics; Clyde Elliott, USASMD

This paper presents total dose test results for the AD9225RH. The AD9225RH is a radiation hardened 12 Bit, 25-MSPS ADC manufactured by Honeywell Inc. based on the Analog Devices Inc. commercial AD9225 ADC.

W-8 Update of Integrated Circuit SEE Responses: 2001-2002

J. R. Coss, Retired

This tenth biennial update presents heavy ion and proton SEE data from various test groups over the past two years. Proton displacement damage data is also presented.

W-9 Total Ionizing Dose Results and Displacement Damage Results for Candidate Spacecraft Electronics for NASA

Donna J. Cochran, QSS Inc.; Kenneth A. LaBel, Robert A. Reed, Cheryl J. Marshall, Donald K. Hawkins, Anthony B. Sanders, Stephen R. Cox, NASA/GSFC; Ray L. Ladbury, Scott D. Kniffin, Christopher Palor, Orbital Sciences Corporation; Christian Poivey, SGT; Martha V. O'Bryan, Martin A. Carts, Raytheon Information Technology & Scientific Services; James W. Howard, Jr., Jackson & Tull Chartered Enterprises; Stephen P. Buchner, Tim Irwin, Zoran Kahrlic, QSS, Inc.; John P. Bings, John Seiler, NAVSEA CRANE; Paul W. Marshall, Consultant; Hak S. Kim, James D. Forney, Jackson & Tull Chartered Engineers

We present data on the vulnerability of a variety of candidate spacecraft electronics to total ionizing dose and displacement damage. Devices tested include optoelectronics, digital, analog, and hybrid devices, among others.

Technical Program Friday

W-10 Single Event Effects Results for Candidate Spacecraft Electronics for NASA

Martha V. O'Bryan, Christina M. Seidleck, Martin A. Carts, Raytheon ITSS; Kenneth A. LaBel, Robert A. Reed, Cheryl J. Marshall, Donald K. Hawkins, Anthony B. Sanders, Stephen R. Cox, NASA/GSFC; Ray L. Ladbury, Scott D. Kniffin, Christopher Palor, Orbital Sciences Corporation; James W. Howard Jr., Hak S. Kim, James D. Forney, J & T Chartered Engineers; Christian Poivey, SGT; Stephen P. Buchner, Tim Irwin, Zoran Kahrlic, QSS; Paul W. Marshall, Consultant; Jeffrey Titus, NAVSEA Crane

We present data on the vulnerability of a variety of candidate spacecraft electronics to proton and heavy ion induced single event effects. Devices tested include optoelectronics, digital, analog, linear bipolar, and hybrid devices, among others.

W-11 Variability in Measured SEE Sensitivity Associated with Design Iterations

R. Koga, S. Crain, P. Yu, K Crawford, V. Tran, The Aerospace Corporation

SEE sensitivity variability emerges in microcircuit design iterations. It encompasses various types of SEE for recently fabricated microcircuits.

W-12 SEE Sensitivity Trends in Non-Hardened High Density SRAMs with Sub-Micron Feature Sizes

R. Koga, K. Crawford, P. Yu, S. Crain, V. Tran, The Aerospace Corporation

The range of SEE sensitivity in non-hardened high-density SRAMs is large. Within this range, we have observed a tendency toward reduced SEU and SEFI sensitivities, as well as various cell structures, and high latchup cross-sections.

W-13 Susceptibility of Ultracapacitors to Proton and Gamma Irradiation

S. Shojah-Ardalan, R. Wilkins, M. Reed, Z. Ahmed, Center for Applied Radiation Research; H. U. Machado, B. A. Syed, NASA Johnson Space Center; S. McClure, B. Rax, L. Scheick, M. Weideman, C. Yui, Jet Propulsion Laboratory

Ultracapacitors are promising components for energy storage, power backup and delivery systems. Our study examines the possible effects associated with gamma and proton irradiation in selected samples up to 1200 Farad.

W-14 SEU Mitigation of Xilinx Virtex II FPGAs for Critical Flight Applications

Candice C. Yui, Gary M. Swift, JPL/Caltech; Carl Carmichael, Xilinx, Inc.

The speed, I/O count, and reconfigurability of SRAM-based FPGAs make them attractive for flight applications. However, critical designs require effective upset mitigation. Measurements of the effectiveness of configuration control and TMR during heavy-ion irradiation are reported.

W-15 Single Event Effects Test Results of 512M SDRAMs

Tilan E. Langley, Ty Morris, SEAKR Engineering, Inc.; Rocky Koga, The Aerospace Corporation

Single event effects tests results for new 512M SDRAMs are reported in this paper. Effects characterized during testing include upset, latchup, SEFI and microlatch measurements.

Technical Program Friday

W-16 In-Flight Observations of Long-Term Single Event Effect Performance on Orbview-2 and Xray Timing Explorer Solid State Recorders

Christian Poivey, SGT-Inc; Janet L. Barth, Kenneth A. LaBel, Harvey Safren, NASA-GSFC; George Gee, SFT-Inc.

We present multi-year SEU flight data on Solid State Recorder (SSR) memories for two NASA missions. Actual SEU rates are compared to the predicted rates based on ground test data and environment predictions.

W-17 Single Event Upset Characterization of a Personal Computer Micro-Controller System-on-a-Chip using Proton Irradiation

David M. Hiemstra, Simon Yu, Marius Pop, MDRobotics

Experimental single event upset characterization of a personal computer micro-controller system-on-a-chip using proton irradiation is presented. Results are compared with previous tests on other x86 microprocessors.

W-18 Catastrophic SEE in High-Voltage Power MOSFETs

L. E. Selva, L. Z. Scheick, S. S. McClure, T. F. Miyahira, S. M. Guertin, S. K. Shah, F. D. Patterson, D. N. Nguyen, F. F. Farmanesh, F. Irom, G. M. Swift, Jet Propulsion Laboratory

SEE tests of high-voltage power MOSFETs from several manufacturers indicate long-range ions are worst case scenario for inducing SEGR/SEB. In situ measurements show SET in oxide can trigger SEGR and in epitaxial can elicit SEB.

W-19 Characterization of SET Response of the LM124A, the LM111, and the LM6144

Mark W Savage, Tom Turflinger, Jeff L. Titus, NAVSEA Crane; Ron L. Pease, RLP Research, Inc.; Christian F. Poivey, NASA/GSFC

We present a paper that characterizes the single event transient response of the LM124, LM111, and LM6144 in a heavy ion environment. In the paper both the test methods used and the data are presented.

W-20 Correlation Between Proton and Heavy-Ion SEUs in Commercial Memory Devices

Kenichi Chiba, Isamu Nashiyama, Hiroaki Asai, Kenji Sugimoto, Norio Nemoto, HIREC; Yoshiya Iide, Hiroyuki Shindo, Naomi Ikeda, Satoshi Kuboyama, Sumio Matsuda, NASDA

Proton and heavy-ion SEU tests are performed on commercial 4Mbit-SRAMs, 64Mbit-DRAMs and EEPROMs. Correlation between proton and heavy-ion SEUs is examined and an empirical equation has been derived between proton SEU cross-section and heavy-ion threshold-LET.

W-21 Single Event Effects Testing of the Linfinity SG1525A Pulse Width Modulator Controller

James W. Howard Jr., James D. Forney, Jackson and Tull; Martin A. Carts, Raytheon ITSS; Kenneth A. LaBel, NASA GSFC; Timothy L. Irwin, QSS Group, Inc.

The Linfinity SG1525A pulse width modulator controller was investigated for single event effects. While no latchup events were observed, a temporal overlap of the outputs, that could be destructive, was observed for all LETs used.

Technical Program Friday

W-22 Single Event Effects Test Results for Space Programs

*Super Nguyen, Brian Steffan, Eric Normandy, Paul Storassli, Maria-Isabel Soto, Raytheon;
Rocky Koga, Aerospace*

This paper summarizes the test results of the single event effects (SEE) testing with heavy ions and proton on mostly high speed state of the art devices intended for use in space applications.

W-23 The Proton Irradiation Program at the Northeast Proton Therapy Center

E. W. Cascio, J. M. Sisterson, J. Flanz, M. S. Wagner, Northeast Proton Therapy Center

The Harvard Cyclotron Laboratory (HCL) was closed on 1 July 2002. The successful transfer of the research and radiation effects testing program from HCL to the Northeast Proton Therapy Center is described.

W-24 Proton Beam of Variable Energy - the New Tool for Investigation of Radiation Effects at PNPI Synchrocyclotron

*Nikolai Abrossimov, Eugeni Ivanov, Yuri Mironov, German Riabov, Michael Tverskoy,
Petersburg Nuclear Physics Institute*

The new variable energy (200-1000 MeV) proton beam line at 1 GeV PNPI synchrocyclotron is presented along with beams available earlier. It is shown that calculated and experimental beam parameters are in good agreement.

W-25 Improved Capabilities for Proton and Neutron Irradiations at TRIUMF

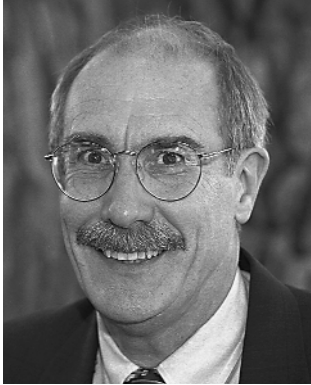
E. W. Blackmore, TRIUMF

Improvements at TRIUMF now permit higher fluence irradiations to 10^{14} protons/cm² over the energy range 20-500 MeV. High-energy neutrons are available from the 500 MeV, 150 μ A beam dump with fluxes similar to LANSCE.

11:45 PM END OF CONFERENCE



This year, NSREC celebrates its 40th anniversary conference in Monterey. The Radiation Effects Steering Group (RESG) chose Monterey because of its excellent location and outstanding technical facilities. We found the “environment” in Monterey to be very peaceful and relaxing, a good choice for NSREC. The DoubleTree Hotel, located near Fisherman’s Wharf on Monterey Bay, is surrounded by an historic old-town area. A small microbrewery is located next to the hotel. The Wednesday evening social will be held at the Monterey Aquarium. And this year, please bring a sweater, as Monterey’s average daily **maximum** temperature is 68°F in July.



Dale G. Platteter
Chairman

Allan Johnston from Jet Propulsion Laboratory and his 2003 Conference Committee are planning to observe the 40th anniversary with a special June issue of the *Transactions on Nuclear Science*, summarizing the significant technical findings of the radiation effects community over the past 40 years. If all goes according to schedule, the special issue will be available for NSREC attendees in July.

As far as future NSREC’s are concerned, the 2004 Conference is scheduled for 19-23 July 2004 at the Renaissance Waverly Hotel in Atlanta, Georgia. Dan Fleetwood of Vanderbilt University, Conference General Chairman, has been working for over two years on the details of this meeting.

Fred Sexton from Sandia National Laboratories, 2005 Conference General Chairman, visited several potential NSREC sites this fall. You will be pleased to know that we signed a contract for 2005 with the Sheraton Hotel and Towers in downtown Seattle, Washington.

Janet Barth of NASA Goddard Space Flight Center was appointed as 2006 Conference General Chair. Janet is excited about serving our community in this new capacity.

The results of the 2003 RESG elections are official. We welcome Tim Oldham from NASA Goddard Space Flight Center as RESG vice-chairman, and Susan Crain from Aerospace Corporation as RESG Secretary. In January, the RESG appointed Ron Pease of RLP Research as Member-at-Large.

RESG, with help from Tim Holman of Vanderbilt University, has published a video of the 2002 Radiation Effects Short Course on CDROM. We did this as a promotional tool to attract new members to NPSS. If you join IEEE/NPSS in Monterey, you will receive a copy of this CD.

We recently published the “NSREC Fact Book” summarizing 40 years of NSREC tradition. It is available on the web at <http://www.nsrec.com/facts03.pdf>. The book contains some vital statistics on each conference, including best paper awards.

Please visit our web site at www.nsrec.com for the most up-to-date conference information, on-line NSREC registration materials, author preprint requests, publishing schedules, web links to our exhibitors, and more.

We promise to keep you very busy this week. Best of all, we will provide quality opportunities for technical exchange with the authors and volunteers who make NSREC happen. Their names are listed on every page of this brochure. Be sure to thank them.



Ronald D. Schrimpf
Executive Vice Chairman

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 \$143. NPSS membership is \$10. NPSS members receive a free subscription to *NPSS News* and have an opportunity to purchase a subscription to the *IEEE Transactions on Nuclear Science* (electronic or print) for an additional \$20.

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 25% 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 1989) from an on-line web-based database. What are you waiting for? Apply for membership at <http://www.ieee.org> or talk to Vern Price at 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 \$850 (only \$20 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 \$150 (\$75 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 1980-2002* is available on CD-ROM for \$200 (\$160 IEEE members). To obtain individual copies of this CD, please visit the IEEE *on-line Catalog and Store* at <http://shop.ieee.org/store> or contact IEEE Service Center at 732-981-1393. Ask for IEEE product order code EC146.

A complimentary copy of the 2003 *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 24, from 5:15 – 6:45 PM in the Serra Grand Ballroom II. All conference attendees and spouses are encouraged to attend. We will discuss the 2003 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

2002 OUTSTANDING CONFERENCE PAPER AWARD

Impact of Passivation Layers on Enhanced Low-Dose-Rate Sensitivity and Preirradiation Elevated Temperature Stress Effects in Bipolar Linear ICs

M. R. Shaneyfelt, J. R. Schwank, G. L. Hash, P. E. Dodd, C. A. Reber, S. C. Witzczak, L. C. Riewe, H. P. Hjalmarson, J. C. Banks, B. L. Doyle and J. A. Knapp of Sandia National Laboratories, R. L. Pease of RLP Research, M.C. Maher of National Semiconductor Corporation, and D. M. Fleetwood of Vanderbilt University

2002 MERITORIOUS CONFERENCE PAPER AWARDS

Charge Collection in SOI Capacitors and Circuits and Its Effect on SEU Hardness

J. R. Schwank, P. E. Dodd, M. R. Shaneyfelt, G. Vizkelethy, B. L. Draper, T. A. Hill, D. S. Walsh, G. L. Hash, B. L. Doyle and F. D. McDaniel of Sandia National Laboratories

Unified Model of Hole Trapping, I/f Noise, and Thermally Stimulated Current in MOS Devices

D. M. Fleetwood, H. D. Xiong, Z. Y. Lu, C. J. Nicklaw, J. A. Felix, R. D. Schrimpf and S. T. Pantelides of Vanderbilt University

Physical Model for Enhanced Interface-Trap Formation at Low Dose Rates

S. N. Rashkeev, C. R. Cirba, D. M. Fleetwood, R. D. Schrimpf and S. T. Pantelides of Vanderbilt University, S. C. Witzczak of Sandia National Laboratories, and A. Michez of Centre d'Electronique et de Microelectronique de Montpellier

2002 DATA WORKSHOP PAPER AWARDS

Radiation Effects Predicted, Observed, and Compared for Spacecraft Systems

B. E. Pritchard, G. M. Swift and A. H. Johnston of Jet Propulsion Laboratory, California Institute of Technology

Current Single Event Effects and Radiation Damage Results for Candidate Spacecraft Electronics

M. V. O'Bryan, C. M. Seidleck and M. A. Carts of Raytheon Information Technology & Scientific Services, K. A. LaBel, D. K. Hawkins, A. B. Sanders, R. A. Reed, C. J. Marshall and S. R. Cox of NASA Goddard Space Flight Center, R. L. Ladbury, S. D. Kniffin, M. R. Jones, C. D. Palor and J. A. Sciarini of Orbital Sciences Corporation, C. Poivey of Stinger Ghaffarian Technologies, Inc., J. W. Howard Jr., H. S. Kim and J. D. Forney of Jackson & Tull Chartered Engineers, S. P. Buchner, T. L. Irwin and Z. A. Kahrlic of QSS Group, Inc., J. P. Bings, J. L. Titus, S. D. Clark and T. L. Turflinger of NAVSEA Crane - Surface Warfare Center Division, and P. W. Marshall, Consultant

Awards

2002 RADIATION EFFECTS AWARD

The 2002 Radiation Effects Award was presented to Dr. Kenneth Galloway, Dean of Engineering, Vanderbilt University, during the opening ceremonies of the 2002 conference. Dr. Galloway received this year's award with a citation for technical contributions and leadership that have enhanced the understanding of radiation effects in semiconductor devices, for meritorious service to the radiation effects community, and for promoting radiation effects education.

2003 RADIATION EFFECTS AWARD

The winner of the 2003 Radiation Effects Award will be announced Tuesday morning, July 22.

2004 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2004 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 2004 IEEE NSREC at Atlanta, Georgia in July 2004. 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 Ron Pease, Member-at-Large for the Radiation Effects Steering Group. Ron can be reached at 505-565-0548, rpease@mrsmicroe.com.

Industrial Exhibits



"This year's conference and exhibits promise to be very special, something that you won't want to miss."

Howard Bogrow
Industrial Exhibits Chairman

The 2003 exhibit will be held at the Monterey Conference Center, Serra Grand Ballroom I, Monterey, California on July 22 and 23, 2003. We are looking forward to another well-attended conference and excellent traffic through the exhibit booth area. As you'll see in the enclosed floorplan, the exhibits are next door to the technical sessions. Also, for your convenience, a stage will be set up with public address capability for vendor-sponsored raffles during the exhibit hours.

For additional information, contact:

Howard Bogrow
Xilinx, Inc.
10647 W. Irma Lane
Peoria, AZ 85382

Phone: 623-376-8692
Fax: 623-572-2855
Email: howard@xilinx.com

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

Booth Spaces: \$2,000 per 10' 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 10 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 22, 2003

As of this writing, several booth spaces are available but as in past years, the exhibit area is filling quickly.

EXHIBIT HALL HOURS

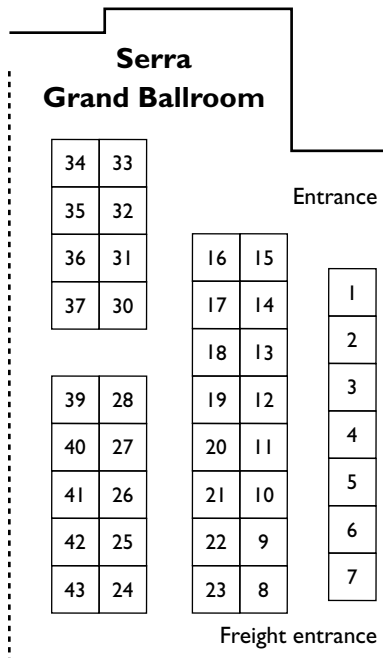
Set-Up:	Monday, July 21	12:00 PM through
	Tuesday, July 22	11:45 AM
Show Hours:	Tuesday, July 22	11:45 AM - 4:30 PM
		3:05 PM - 3:35 PM (conference break)
		7:00 PM - 10:00 PM (exhibitor reception)
	Wednesday, July 23	9:30 AM - 3:30 PM
		10:05 AM - 10:35 AM (conference break)
Tear-down:	Wednesday, July 23	3:30 PM through
	Thursday, July 24	10:00 AM

Industrial Exhibits

EXHIBITORS

Please check our web site (www.nsrec.com) for a current listing of companies exhibiting at 2003 NSREC.

NSREC Industrial Exhibit



Company	Internet Site	Booth(s) #
Actel	www.actel.com	20, 21
Aeroflex UTM	www.utmc.com	31, 32
Atmel	www.atmel.com	3, 4
Babcock	www.babcockinc.com	37
BAE Systems	www.iewe.na.baesystems.com	13
Boeing Rad Effects Lab	www.boeing.com/assocproducts/radiationlab/data	7
Brookhaven	http://tvdg10.phy.bnl.gov/index.html	6
Crane Interpoint	www.interpoint.com	40
Defense Microelectronics Activity	www.dmea.osd.mil	28
DPA Components International	www.dpalabs.com	18
EMPC	www.empc.com	26
Honeywell SSEC	www.myspaceparts.com	19
Integrated Systems Engineering	www.ise.com	41
International Rectifier	hirel.irf.com	15
Intersil	www.intersil.com	27
JD Instruments	www.jdinstruments.net	1
J.L. Shepherd Associates / ICS Radiation Technology	www.jlshepherd.com	2
Maxwell Technologies Inc.	www.maxwell.com	11, 12
Modular Devices	www.mdipower.com	25
MRC Microelectronics	www.mrcmicroe.com	17
NASA Applied Radiation	www.pvamu.edu/carr	8
NASA Goddard Space Flight Center	lws.gsfc.nasa.gov	36
NASA Marshall Space Flight Center	see.msfc.nasa.gov	34, 35
Northrop Grumman	www.northropgrumman.com	10
Peregrine Semiconductor	www.peregrine-semi.com	14
Sandia National Labs	www.sandia.gov	16
Seakr Engineering	www.seakr.com	30
Silvaco	www.silvaco.com	5
Synplicity	www.synplicity.com	23
Texas A&M Cyclotron	http://cyclotron.tamu.edu/ref/	24
US Semiconductor Corp.		39
Vanderbilt University (ISDE)	www.vuse.vanderbilt.edu	22
White Sands Missile Range	www.wsmr.army.mil	9
Xilinx	www.xilinx.com	33

Conference Information

The 2003 IEEE NSREC will be held at the DoubleTree Monterey Hotel and the adjoining Monterey Conference Center. They are located in the heart of Monterey, nestled between Monterey Historic Park, Fisherman's Wharf and the charming downtown area. Since so much to see is within walking distance, we suggest that you not rent a car and thus save yourself the garage parking expense. Restaurants in the hotel are the California Grill and Peter B's Brew Pub, but dozens of other eateries are within walking distance.



Photograph courtesy of DoubleTree Hotel

ROOMS FOR SIDE MEETINGS

Several meeting rooms are available for use by NSREC attendees during the conference week at the DoubleTree Monterey. Contact ETC Services at 720-733-2003 or send an e-mail message to etcservices@qwest.net to make meeting reservations in advance of the conference.

To make a meeting room reservation during the conference, see the NSREC registration desk. All audiovisual equipment and refreshments must be coordinated through the hotel and are the responsibility of the attendee.

MESSAGES

831-655-3005
FAX: 831-372-0620

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 for a fee, 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.

CONTINENTAL BREAKFAST AND COFFEE BREAKS

The 2003 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 DoubleTree Monterey has a Business Center located on the second floor. Normal hours of operation are 8:00 AM – 5:00 PM, Monday through Friday; however, there is 24-hour access for hotel guests with a room key. Services available include outgoing fax machine, two computer stations with Internet access, one laptop Internet access outlet and two printers. Costs associated with the Business Center services must be put on a valid credit card. Photocopies can be made in the Sales Office (next door) during their office hours of 7:30 AM – 5:30 PM, Monday through Friday.

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 20, 2003.

**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. Faxed registrations will be accepted with credit card payment. 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. 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 "2003 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 REGISTRATION HOURS

On-site registration for the Conference will be located in the Portola Room next to the DoubleTree Monterey Hotel's front desk. The following is the schedule for on-site registration:

Sunday, July 20	5:00 PM – 9:00 PM
Monday, July 21	7:30 AM – 4:00 PM 6:00 PM – 9:00 PM
Tuesday, July 22	7:30 AM – 5:30 PM
Wednesday, July 23	7:30 AM – 3:00 PM
Thursday, July 24	7:30 AM – 3:00 PM
Friday, July 25	7:30 AM – 10:00 AM

REGISTRATION CANCELLATION POLICY

A \$25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 20, 2003 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

DOUBLETREE MONTEREY HOTEL

**TWO PORTOLA PLAZA
MONTEREY, CA 93940**

831-649-4511

TOLL-FREE: 800-222-8733

FAX: 831-649-3109

With an open, airy lobby, you are immediately greeted by smiling faces and the famous DoubleTree cookies when you check into our host hotel. All sleeping rooms here offer either one king or two double beds, a data port, 2-line phones, desk, TV, iron/board, hairdryer and keycard locks.

Room rates are at \$159.00 single or double occupancy under the IEEE NSREC block of rooms. For additional adults in the room, add \$20 per person. Children under 18 years of age and sharing a room with an adult are free. In line with the current convention hotel government per diem guidelines, a limited number of rooms are available at the prevailing government rate plus 25%. The cut-off for IEEE NSREC reservations is **June 17, 2003**.

EARLY CHECK-OUT FEE

The DoubleTree Monterey Hotel has an **EARLY CHECK-OUT FEE** of \$50.00 if you depart earlier than your reservation states. At check-in, you will be asked to verify your departure date so be sure to check this carefully.

CASA MUNRAS GARDEN HOTEL

**700 MUNRAS AVENUE
MONTEREY, CA 93490**

831-375-2411

**TOLL-FREE WITHIN
CALIFORNIA: 800-222-2446**

**TOLL-FREE OUTSIDE
CALIFORNIA: 800-222-2558**

FAX: 831-649-0267

Because the DoubleTree cannot accommodate our entire group, a second hotel is available that will give you a totally different experience from our "host" hotel. Only a few blocks from the conference, CASA MUNRAS GARDEN HOTEL is a charming one and two story property with walkways through gardens and a very tranquil atmosphere. Here the parking is free — a definite plus. It is located at the opposite end of Alvarado and Calle Principal (the main streets) from the DoubleTree so when taking that short walk to the hotel each day, you can window shop or discover new restaurants in town. There is one restaurant/lounge within the hotel, a garden swimming pool and a guest laundry service.

Room rates are at \$139.00 for a queen bed, \$149.00 for a king bed, and \$159 for two double beds. Ask for the IEEE NSREC block of rooms. A limited number of rooms are offered at the prevailing government rate. **CALL EARLY** for reservations!! This hotel will have to cut back our block of rooms two months before the conference but they will continue to hold some rooms after that date until our final cut-off date, **June 17, 2003**.

MAKING RESERVATIONS AT DOUBLETREE AND CASA MUNRAS GARDEN

All room rates are subject to a 10.05% state and local tax. All rooms must be guaranteed with a credit card or deposit by check. The cut-off for IEEE NSREC reservations is **June 17, 2003**. After the cut-off date, room accommodations will be confirmed on a space available basis and the room rate will be higher! **EARLY RESERVATIONS ARE A MUST SINCE THIS IS HIGH SEASON IN MONTEREY!!!**

Registration and Travel

AIRPORT AND TRANSPORTATION INFORMATION

The Monterey Peninsula Airport is located just four miles (or a ten minute drive) from the DoubleTree Monterey Hotel. Taxi service is about \$10.00 one way although the rate is subject to change. Since taxi service is inexpensive, there is no “airport shuttle” service.

In addition to the Monterey Airport, some attendees may opt to fly into San Jose International Airport (60 miles away) or San Francisco International Airport (120 miles away.) The Monterey-Salinas Airbus (Website: www.montereyairbus.com) provides several daily trips to and from both San Francisco and San Jose Airports. The drop off and pickup points for this service in Monterey is the Monterey Transit Plaza which is within walking distance (several blocks) of both the DoubleTree and Casa Munras Hotels.

DRIVING DIRECTIONS

From San Francisco International Airport, follow the airport exit signs to the U.S. 101 South ramp towards San Jose. Once on U.S. 101, you will travel approximately 85 miles. Take the CA 156 West/Monterey Peninsula Exit off U.S. 101. Continue on CA 156 for approximately 6 miles. Follow the signs to CA 1 South. Take CA 1 South approximately 12 miles and then use the Del Monte Avenue Exit towards Pacific Grove. Continue on Del Monte Avenue for about 2 miles. Stay in the left lane of Del Monte Avenue as the road splits in two directions (if you find yourself going through a tunnel you have gone the wrong way!!). Turn right onto Portola Plaza/Alvarado Street. The DoubleTree Hotel is directly to your left and hotel parking is on your right. For planning purposes, you should allow two hours for this trip.

From San Jose International Airport, follow the airport exit signs onto Airport Parkway. Turn right on Old Bayshore Highway and proceed approximately 1/2 mile to the U.S. 101 South on-ramp. Once on U.S. 101, you will travel approximately 52 miles. Take the CA 156 West/Monterey Peninsula Exit off U.S. 101. Continue on CA 156 for approximately 6 miles. Follow the signs to CA 1 South. Take CA 1 South approximately 12 miles and then use the Del Monte Avenue Exit towards Pacific Grove. Continue on Del Monte Avenue for about 2 miles. Stay in the left lane of Del Monte Avenue as the road splits in two directions (if you find yourself going through a tunnel you have gone the wrong way!!). Turn right onto Portola Plaza/Alvarado Street. The DoubleTree Hotel is directly to your left and hotel parking is on your right. For planning purposes, you should allow one and 1/2 hours for this trip.

From Monterey Peninsula Airport, follow the airport exit signs onto Olmsted Road. Turn right onto CA 68 West. Continue on CA 68 for about one mile and then take the CA 1 South/CA 68 West ramp. Proceed on CA 1 South/CA 68 West about 1/2 mile to the Camino Aguajito exit towards Naval School. Continue on Camino Aguajito about 1/2 mile and then turn left on Del Monte Avenue. Proceed on Del Monte Avenue for approximately 1/2 mile. Stay in the left lane of Del Monte Avenue as the road splits in two directions (if you find yourself going through a tunnel you have gone the wrong way!!). Turn right onto Portola Plaza/Alvarado Street. The DoubleTree Hotel is directly to your left and hotel parking is on your right.

PARKING

Parking is available in a covered garage next to the DoubleTree Monterey at a fee. For registered hotel guests, there is a special NSREC discount of \$5.00 per day off the prevailing self-parking rates. The current prevailing rate is \$13 per day for self-parking and \$15.00 per day for valet parking, each with in and out privileges.

One block away are two public parking garages. The East Custom House Garage is located on Washington Street between Franklin and Del Monte. Here, there is no

Registration and Travel

attendant but rather this location has a payment box where you insert your bills. The West Custom House Garage is located on Tyler Street between Franklin and Del Monte. This location has an attendant that you pay. The fee in both garages is a one-time charge of \$5.00 each time you park; there are no in and out privileges.

For Casa Munras Garden Hotel guests, we suggest that you leave your car in their free parking lot and walk three blocks to the DoubleTree.

RENTAL CAR DISCOUNT 800-331-1600

AWD NUMBER A606096

Avis has been selected as the official rental car agency for the 2003 NSREC and is offering discounted rates for conference attendees. For reservations and information, call Avis at 800-331-1600 and mention AWD Number A606096, or go to the Avis web-site at www.avis.com. The special conference rates below are available from July 14 through August 01, 2003. However, should a lower qualifying rate become available, Avis will provide a 5% discount off that rate. These rates are valid in the following airports: Monterey Peninsula Airport, San Jose International Airport, San Francisco International Airport.

Class	Car type	Daily (per day)	Weekend (per day)	Weekly
A	sub-compact	\$42.99	\$27.99	\$179.99
B	compact	\$52.99	\$30.99	\$189.99
C	intermediate	\$58.99	\$33.99	\$209.99
D	fullsize 2-dr	\$60.99	\$36.99	\$219.99
E	fullsize 4-dr	\$63.99	\$38.99	\$224.99
G	premium	\$66.99	\$43.99	\$254.99
H	luxury	\$88.99	\$73.99	\$344.99
V	minivan	\$68.99	\$85.99	\$319.99
W	sport utility	\$68.99	\$85.99	\$319.99
K	convertible	\$68.99	\$85.99	\$319.99

Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges. Renter must meet Avis' age, driver and credit requirements.

The rates above are guaranteed. Return to the same renting location or additional surcharges may apply. Weekend daily rates are available from noon Thursday to 11:59 PM on Monday. All rates include unlimited free mileage.

AIRLINE DISCOUNT 800-633-8825

I.D. CODE 510SH

United Airlines is the official airline for the 2003 NSREC and is offering special fares available on United and United Express.

- Travel dates are between July 17-28, 2003.
- Destinations are Monterey, CA, San Francisco, CA and San Jose, CA.
- Discounts are from the United States, Canada and Puerto Rico.
- A 5% discount off any published fare, including First Class.
- A 10% discount off applicable BUA or like fares in effect when tickets are purchased 7 days in advance, the reservations are made in "M" class of service.
- A 15% discount off applicable BUA or "M" class of service purchased 30 days in advance.
- These discounts are valid provided all rules and restrictions are met. These discounts are not combinable with other discounts or promotions.

NOTE: The discount is available for the conference attendee, family member or traveling companions.

2003 IEEE NSREC and Short Course Registration Form



NSREC 2003
MONTEREY

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 20, 2003 cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.

Mail or Fax this form and your remittance
(payable to 2003 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 20, 2003.

	<u>Early</u>	<u>Late</u>	
IEEE Member			
Short Course	\$230	\$280	\$ _____
Technical Sessions	\$340	\$410	\$ _____
Non-IEEE Member			
Short Course	\$290	\$345	\$ _____
Technical Sessions	\$425	\$510	\$ _____
Full-Time Students who are IEEE Members *			
Short Course	\$105	\$280	\$ _____
Technical Sessions	\$105	\$410	\$ _____

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: **2003 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.

2003 IEEE NSREC Activities Registration Form



NSREC 2003
MONTEREY

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

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 15 or notify the conference registration desk when picking up your registration materials (**but no later than 24 hours before the scheduled activity**).

* Attendance at Wednesday's social is limited to immediate family members.

Mail or Fax this form and your remittance
(payable to 2003 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 20, 2003. **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.

	Early	Late	Number Attending	Total Cost
Short Course Reception: Sunday, July 20				
Adult/child	\$0	\$0	_____	_____
Carmel-by-the-Sea Lunch/Shopping: Tuesday, July 22				
Adult	\$25	\$30	_____	\$_____
Child (age 0-10)	\$10	\$15	_____	\$_____
Industrial Exhibits Reception: Tuesday, July 22				
Adult/child	\$0	\$0	_____	_____
Monterey Bay Aquarium: Wed., July 23*(see note below)				
Adult	\$38	\$48	_____	\$_____
Child (age 4-12)	\$20	\$23	_____	\$_____
Child (age 0-3)	\$0	\$0	_____	\$_____
Chateau Julien Winery Tour/Lunch: Thursday, July 24				
Adult/child	\$30	\$35	_____	\$_____

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: **2003 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

Located on the rugged California coastline, the Monterey Peninsula is truly nature's wonderland. One of the most beautiful meetings of land and sea in the world, the peninsula has unparalleled natural beauty. Combined with this beauty are a host of attractions that make Monterey a



Photograph courtesy of Monterey County Convention & Visitors Bureau

tourist mecca. The 2003 NSREC Committee has made arrangements for everyone to enjoy some of the highlights of Monterey Peninsula with the planned social events. We strongly encourage you to register as early as possible for the social events, as we are limited in the number of people that can be accommodated. While last minute accommodations are possible, transportation, restaurant and tour guide preparations are necessary to guarantee the arrangements.

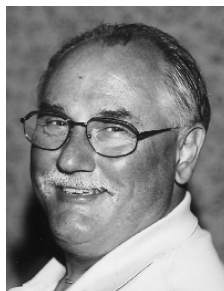
Children must be accompanied by an adult during all tours and social events.

SUNDAY, JULY 20 6:00 TO 9:00 PM SHORT COURSE RECEPTION

Please join us for refreshments in the De Anza Ballrooms from 6:00 to 9:00 PM. The registration desk (in the Portola Room which is near the hotel registration desk) will be open from 5:00 to 9:00 PM.

MONDAY, JULY 21 EVENING

There are no scheduled NSREC events for Monday evening. Please take this time to visit the many sights of Monterey and enjoy the fine restaurants. Please feel free to ask anyone on the conference committee or the DoubleTree Hotel concierge for a recommendation.



"We hope you will take the time to enjoy some of the truly unique attractions on the Monterey Peninsula by participating in this year's social program."

*Mark Hopkins
Local Arrangements Chairman*



*Miriam Johnston
Conference Hostess*

Social Program

**TUESDAY, JULY 22
11:00 AM TO 4:00 PM
CARMEL-BY-THE-SEA AND
LUNCH AT CASANOVA'S**

Known throughout the world for its pristine beach, charming shops and fairy-tale cottage-type architecture, Carmel-by-the-Sea is situated in an unusual setting of scenic beauty. The village, with its secluded alleyways and courtyards, is a beehive of activity that includes many fine inns and hotels, over 80 art galleries, and hundreds of boutiques, small cafés, and gourmet restaurants.



Photograph courtesy of Monterey County Convention & Visitors Bureau

Buses will depart the DoubleTree Hotel at 11:00 AM for the 30-minute trip to Carmel-By-The-Sea. First stop will be Carmel's most romantic restaurant Casanova's where NSREC companions will lunch. After dining, the companions will have ample time to wander through the village to visit the many shops or visit the beach to "catch some rays." Buses will leave Carmel promptly at 3:30 PM for the return to the hotel. This is a casual event, shorts/slacks are appropriate and good walking shoes are recommended. Strollers can be placed on the bus.

**TUESDAY, JULY 22
7:00 TO 10:00 PM
INDUSTRIAL EXHIBITS
RECEPTION**

A reception will be hosted by the NSREC exhibitors in the Serra Ballrooms. Along with meeting the leading companies of the radiation-hardening industry, there will be complementary food and drink for NSREC attendees and their guests. Dress is casual.

**WEDNESDAY, JULY 23
7:00 TO 11:00 PM
THE MONTEREY BAY
AQUARIUM
CONFERENCE SOCIAL**

The Monterey Bay Aquarium is world renowned for its unique and spectacular displays of marine wildlife. Its award winning exhibits include the many habitats associated with the Monterey Bay National Marine Sanctuary. The habitat exhibits include a kelp forest, reefs, the sandy sea floor, estuaries and sloughs, the rocky shoreline and the open waters.



Photograph courtesy of Monterey County Convention & Visitors Bureau

Please join us Wednesday evening for a private party at the aquarium that includes cocktails and a buffet dinner. We recommend you take the 35-minute stroll from the DoubleTree Hotel past Fisherman's Wharf along the edge of the bay where you can see sea lions and otters relaxing on rocks. On the stroll you will come upon Cannery Row with many shops that you may wish to stop and visit, before finally coming to the aquarium. Limited shuttle busing will also be available from the DoubleTree Hotel directly to the aquarium starting at 6:15 PM and following thereafter. There will be staffers at the aquarium directing you to the Hovden Way entrance.

The aquarium will open at 7:00 PM beginning with cocktails in the Outer Bay Wing and we then proceed to dinner at 7:30 PM. It is a strolling dinner through the aquarium and you will have ample time to walk around the various exhibits, as well as visit with friends and colleagues. Attendance at this event is limited to immediate family members.

Buses will run continuously between the hotel and aquarium with the last bus leaving the aquarium at 11:00 PM. Dress is casual and strollers can be placed on the bus.

Social Program

**THURSDAY, JULY 24
11:00 AM TO 4:00 PM
LUNCH AT TARPY'S AND
CHATEAU JULIEN WINERY**

Monterey County's long growing season and marine influences present a perfect climate for growing grapes. It is home to more grape acreage than Napa Valley and boasts many award-winning wines. The Chateau Julien Wine Estate spans over 246 acres in a protected canyon of the Santa Lucia Mountain Range. The location of the canyon provides variations in elevation and sun exposure, allowing the growth of several different varietals. The winery's beautiful Chateau and Chai are nestled amongst vineyard plantings, gardens and cobblestone pathways on the sixteen-acre estate.



Photograph courtesy of Monterey County Convention & Visitors Bureau

Buses will depart the DoubleTree Hotel at 11:00 AM for the short trip to Tarpy's Roadhouse where NSREC companions will dine on the restaurant's American Country Cuisine. After lunch and after another short bus ride, the companions will arrive at the Chateau Julien Wine Estate. At the estate, a tour of the grounds will be given, including a wine tasting. There will be ample time for the guests to relax on the grounds and consider the purchase of a few bottles of wine to take home.

The buses will depart for the DoubleTree Hotel at 3:30 PM, arriving at approximately 4:00 PM.

AEROBICS

Get up and at 'em with an aerobic morning wake-up with Dave Bushmire, our own certified aerobics instructor. These lively sessions will be held on Tuesday, Wednesday and Thursday mornings at 6:30 AM in the Ironwood II room on the DoubleTree's third floor. What a great way to start the day!!

ACTIVITIES CANCELLATION POLICY

To encourage advance registration for conference social activities, NSREC will refund all activity fees for conference attendees and/or their companions who for any reason are unable to attend the conference. If your plans change after your activities registration form is submitted, request a refund by notifying ETC Services by fax at 720-733-2046 but no later than July 15, 2003.

Local Activities

GENERAL INFORMATION

Please note that the information provided in this section is courtesy of the Monterey County Convention and Visitors Bureau

Since the 1880s, visitors have been enjoying the spectacular beauty of the Central Coast. Located 345 miles north of Los Angeles and 125 miles south of San Francisco, Monterey County's dramatic ocean scenery, pristine pine forests, and historic communities continue to beckon adventure-seekers, seafarers, artists, writers and vacationers.

Long before Europeans arrived, native peoples of the Esselen, Ohlone and Salinan tribes lived here. They relied on the abundance of the sea and thrived. Juan Rodriguez Cabrillo was the first European to discover Monterey Bay. While high seas prevented him from landing, he nonetheless claimed the land for Spain in 1542. Sebastian Vizcaino was the first European to set foot on the Peninsula, in 1602. He called it "Monterey" after Count de Monte Rey, a viceroy of New Spain. He named the valley for his patron saint, Our Lady of Carmel. Though Vizcaino urged the Spanish to colonize the area, it took half a century before they proceeded to populate Alta (upper) California.



Photograph courtesy of Monterey County Convention & Visitors Bureau

Father Junipero Serra, a Franciscan priest proclaimed the area the military and ecclesiastical capital of Alta (upper) California. General

Gaspar de Portola immediately began to build the first of four California presidios while Father Serra selected a site near the mouth of the Carmel River to construct the second of California's 21 missions. The missions were the center of early Californian life, until 1822 when Mexico declared its independence from Spain. Monterey became the capital of Alta California and huge ranchos were established.

In 1846, Commodore John Drake Sloat of the US Navy took Monterey without a fight, and Monterey became the center of California politics. Three years later, the Constitutional Convention met in Colton Hall and six weeks later they had laid the foundations for the 31st state. On October 13, 1849, Monterey became California's first capital.

PATH OF HISTORY

Today, the early history of Monterey is preserved in a number of Mexican adobes. The adobes of Monterey are nestled in quiet gardens, almost invisible at times, save for the plaques identifying them, and the only way to see them properly is on foot. The Path of History is one of the great bargains on the Peninsula. This self-guided, two-mile tour of Old Monterey — marked by yellow tiles set in the sidewalk — explores adobes, gardens and sites of interest. Maps are available for individuals and groups. Free guided tours depart daily from the Cooper Museum and from the Maritime Museum at the Custom House Plaza.

Local Activities

PEBBLE BEACH

At the southern tip of the peninsula, due west of Monterey and north of Carmel-by-the-Sea is Pebble Beach. A gated community in the beautiful Del Monte Forest, it is home to seven world-class golf courses and the 17-mile drive. On this spectacular drive, you will see shoreline birds such as snowy egrets and blue herons as well as sea lions and small leopard seals basking on the rocks.

CARMEL-BY-THE-SEA

Carmel lies just off California Highway 1, five miles south of Monterey. The soft white sands of Carmel Beach attract tourists from around the world. Above the beach, the quaint town of Carmel is a combination of art galleries, fine restaurants and unique boutiques. (See the social program for a companion's event in this locale.)

BIG SUR



Point Lobo, just four miles south of Carmel is the northern gateway to Big Sur. The unspoiled meadows, forests and beaches of Point Lobo showcase the central coast's unparalleled natural beauty. Spectacular views of the coastline make a drive down California Highway 1 a "must do" for any visitor to Monterey. Visitors can stop and enjoy the scenery from numerous turn-outs.

*Photograph courtesy of Monterey County
Convention & Visitors Bureau*

ELKHORN SLOUGH

Located up the coast from the Monterey Peninsula, the Elkhorn Slough National Estuarine Reserve is home to hundreds of species of birds and marine wildlife. The main channel winds seven miles inland, feeding some 2,500 acres of rich marsh and tidal flats. A visitor center offers interpretive displays and miles of well-maintained trails. Open Wednesday through Sunday 9:00 AM - 5:00 PM. Private pontoon boat tours are also available.

NATIONAL STEINBECK CENTER & STEINBECK HOUSE

For fans of the 1962 Nobel Prize winner for Literature, John Steinbeck, there are two sights of interest, just a short drive from Monterey in historic old town Salinas: the National Steinbeck Center and the Steinbeck House. The Steinbeck Center has interactive exhibits and museum that allow you to explore the places and experiences of John Steinbeck's world. The Steinbeck House is the birthplace and boyhood home of John Steinbeck and is now operated as a luncheon restaurant. An entrance fee is required for the Steinbeck Center.

Local Activities

CANNERY ROW



This historic waterfront district in Monterey was once the heart of a thriving sardine-packing industry. Now a tourist's shopping paradise, you can still see signs of the former bustling industry in the various warehouse that now contain shops selling souvenirs, restaurants and galleries. Cannery Row is also home to the world-famous Monterey Bay Aquarium, itself housed in a former cannery. (See the social program describing the conference social at this facility.)

*Photograph courtesy of Monterey County
Convention & Visitors Bureau*

FISHERMAN'S WHARF

Old Fisherman's Wharf is just a short walk from the conference hotel. This is a great place to take in the sights, sounds and smells of Monterey. Stroll down the wharf with a cup of hot clam chowder or stop by one of the restaurants featuring fresh seafood. Because it is located next to Wharf 2 that is the heart of the area's thriving fishing industry, you can usually watch the working trawlers unloading the catch of the day. If you are feeling adventurous, you can take to the waters with a glass bottom boat tour or deep-sea fishing trip.

THE MARITIME MUSEUM OF MONTEREY AND STANTON CENTER

Monterey's maritime past comes alive at the Maritime Museum located across from Fisherman's Wharf. This museum showcases Monterey's seafaring heritage explaining the role this harbor played in early California history and as a home to the U.S. Navy.

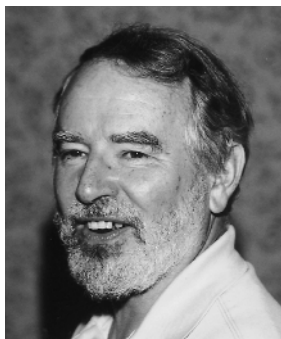
CARMEL MISSION

Located in Carmel-by-the-Sea, the Carmel Mission Basilica has some of the most significant religious artifacts in California. Founded by Father Serra, the mission was built in 1770 and visitors can get a taste of mission life as it was back then. An on-site museum houses California's first library as well as a collection of tools and equipment used by the Spaniards and Native Americans. The \$2 adult and \$1 child museum entrance donation is to restore the mission. The grounds and mission are free.

WEATHER AND CLOTHING

The weather in Monterey County varies significantly depending on the time of day and area visited. The coast is consistently mild, with an average maximum temperature in July of 68 degrees F and an average minimum temperature of 51 degrees F. Dressing in layers is advised. Light- to medium-weight clothing is appropriate. It is a good idea to bring a jacket and raincoat.

2003 Conference Committee



General Chair
Allan Johnston
Jet Propulsion Laboratory
818-354-6425
Fax: 818-393-4559
allan.h.johnston@jpl.nasa.gov



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



Local Arrangements
Mark Hopkins
The Aerospace Corporation
505-872-6201
Fax: 505-872-6211
mark.a.hopkins@aero.org



Short Course
Joe Benedetto
Mission Research Corporation
719-633-2344
Fax: 719-532-1926
benedetto@mrcmicroe.com



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



Finance
Kay Jobe
Boeing Satellite Systems
310-416-3705
Fax: 310-364-5143
kay-carol.m.jobe@boeing.com



Awards
Gordon Hopkinson
SIRA Electro-Optics Ltd. (UK)
44 20 8467-2636
Fax: 44 20 8467-6515
gordon_hopkinson@sirao.co.uk



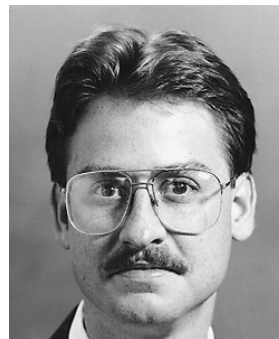
Industrial Exhibits
Howard Bogrow
Xilinx
623-376-8692
Fax: 623-572-2855
howard@xilinx.com



Guest Editor
Jim Kinnison
JHU/APL
240-228-6169
Fax: 240-228-6696
jim.kinnison@jhuapl.edu



Associate Guest Editor
Lew Cohn
DTRA
703-325-1156
Fax: 703-325-2959
lewis.cohn@dtra.mil



Assistant Guest Editor
John Cressler
Georgia Tech
404-894-5161
Fax: 404-894-4641
cressler@ece.gatech.edu

Official Reviewers

David Alexander, *Mission Research Corporation*

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Pascal Fouillat, *IXL-ENSERB*

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Eugene Normand, *Boeing*

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Mayrant Simons, *Research Triangle Institute*

Daniel Stephens, *Pacific Northwest National Laboratory*

Mani Subramanian, *Oregon State University*

Geoff Summers, *Naval Research Laboratory*

Gary Swift, *Jet Propulsion Laboratory*

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Jeffrey Titus, *NAVSEA Crane*

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Radiation Effects Steering Group

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: 7/03)

Past Chairman

Klaus G. Kerris
Retired
2701 Shanandale Drive
Silver Spring, MD 20904-1633
301-572-7535
kerris@erols.com
(Term expires: 7/03)

Junior Member-at-Large

Gary K. Lum
Lockheed Martin
Orgn. L4, Bldg. 157
1111 Lockheed Martin Way
Sunnyvale, CA 94088
408-756-0120 fax: 408-743-2005
gary.lum@lmco.com
(Term expires: 7/05)

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, 2004 Conference

Daniel M. Fleetwood
Vanderbilt University
Electrical Eng. & Comp. Science
P.O. Box 92, Station B
Nashville, TN 37235
615-343-2485 fax: 615-343-6702
dan.fleetwood@vanderbilt.edu

NPSS AdCom Member

Kenneth F. Galloway
Vanderbilt University
School of Engineering
P.O. Box 1826, Sta. B
Nashville, TN 37235
615-322-0720 fax: 615-343-8006
kenneth.f.galloway@vanderbilt.edu
(Term expires: 12/03)

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: 7/03)

Executive Vice-Chairman

Ronald D. Schrimpff
Vanderbilt University
Electrical Eng. and Comp. Science
P.O. Box 1608, Station B
Nashville, TN 37235
615-343-0507 fax: 615-343-0601
ron.schrimpff@vanderbilt.edu
(Term expires: 7/03)

Senior Member-at-Large

David M. Hiemstra
MD Robotics
9445 Airport Road
Brampton, ON L6S 4J3
Canada
905-790-2800 x4733 fax: 905-790-4400
dhiemstr@mdrobotics.ca
(Term expires: 7/03)

Vice-Chairman, Publications

Nick W. van Vonno
Intersil Corporation
Mail Stop 51-191
P.O. Box 883
Melbourne, FL 32902-0883
321-724-7546 fax: 321-729-1118
nvanvonn@intersil.com
(Term expires: 7/03)

Vice-Chairman, 2002 Conference

Kenneth K. Hunt
Air Force Research Laboratory
Building 891
3550 Aberdeen Ave. SE
Kirtland AFB, NM 87117-5576
505-846-4959 fax: 505-853-2205
ken.hunt@kirtland.af.mil

Vice-Chairman, 2005 Conference

Fred W. Sexton
Sandia National Laboratories
MS 1081 / Department 1762
P.O. Box 5800
Albuquerque, NM 87185-1081
505-844-3927 fax: 505-844-2991
sextonfw@sandia.gov

NPSS AdCom Member

Dennis B. Brown
National Reconnaissance Office
AS&T Div.
14675 Lee Rd.
Chantilly, VA 20151
703-808-5290 fax: 703-808-2646
dbbrown@ccf.nrl.navy.mil
(Term expires: 12/05)

Secretary

James R. Schwank
Sandia National Laboratories
MS 1083
P.O. Box 5800
Albuquerque, NM 87185-1083
505-844-8376 fax: 505-844-2991
schwankjr@sandia.gov
(Term expires: 7/03)

Member-at-Large

Ronald L. Pease
RLP Research
8 Songbird Lane
Los Lunas, NM 87031
505-565-0548
rpease@mrcmicroe.com
(Term expires: 7/04)

Vice-Chairman, Publicity

Teresa Farris
Aeroflex UTM
4350 Centennial Blvd.
Colorado Springs, CO 80907-3486
719-594-8035 fax: 719-594-8486
teresa.farris@aeroflex.com
(Term expires: 7/03)

Vice-Chairman, 2003 Conference

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

Vice-Chairman, 2006 Conference

Janet L. Barth
NASA / GSFC
Code 561.4
Building 22, Room 046
Greenbelt, MD 20771
301-286-8046 fax: 301-286-4699
janet.l.barth@nasa.gov

NPSS AdCom Member

Joseph M. Benedetto
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)

Notes

ANNOUNCEMENT and FIRST CALL FOR PAPERS



2004 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE Short Course and Radiation Effects Data Workshop

**July 19 - 23, 2004
Renaissance Waverly Hotel
Atlanta, Georgia**

www.nsrec.com

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*Dan Fleetwood
Vanderbilt University
615-322-1507*

Technical Program

*Jim Pickel
PRT, Inc.
760-451-2256*

Local Arrangements

*Jim Kinnison
Johns Hopkins/APL
240-228-6169*

Short Course

*Joe Srouf
Northrop Grumman Space Technology
310-813-4569*

Publicity

*Teresa Farris
Aeroflex UTMIC
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Finance

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NASA/GSFC
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Awards

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Industrial Exhibits

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DTRA
703-325-1156*

The 2004 IEEE International Nuclear and Space Radiation Effects Conference will be held July 19 - 23 in Atlanta, Georgia at the Renaissance Waverly Hotel. 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 offered on July 19, 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
- SOI and SOS Technologies
- 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 Temperature Effects
- Single-Event Effects
- Novel Device Structures, such as MEMS

Space, Atmospheric, and Terrestrial Radiation Effects

- Characterization and Modeling of Radiation Environments
- Space Weather Effects
- Spacecraft Charging

Hardness Assurance Technology and Testing

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

Commercial Space Systems

New Developments of Interest to the Radiation Effects Community

PAPER SUMMARY DEADLINE: FEBRUARY 6, 2004

PROCEDURE FOR SUBMITTING SUMMARIES

Authors must conform to the following requirements:

1. Electronically submit a single Adobe Acrobat file 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 a 12-minute oral or poster presentation). 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.
2. 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. Type 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. Please include title, names and company affiliations of the authors, and company address (city and state). Underline the name of the author presenting the paper.
4. Obtain all corporate, sponsor, and government approvals and releases necessary for presenting your paper at an open-attendance international meeting.
5. Include a cover letter giving (a) the names, complete addresses, telephone and FAX numbers, and e-mail addresses of all authors, and (b) the session that you prefer for presentation (if you have a preference). A complete list of session names will be available at www.nsrec.com. *Authors are also encouraged to state their preference for an oral or poster presentation in the conference, or a poster at the data workshop.* However, the final category of all papers will be determined by the Technical Program Committee, which is responsible for selecting final papers from initial submissions.

**Summaries must be received by
February 6, 2004**

**Detailed submission and
formatting instructions
will be available after
October 1, 2003
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 2004), 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 strongly 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.

ATLANTA, GEORGIA

World-class restaurants, festive nightlife, five major league sports teams and an abundance of cultural attractions and events help make Atlanta the center for entertainment in the South. Its diverse restaurants feature cuisine from around the globe prepared by world-renowned chefs. Buckhead, Midtown and Virginia-Highlands are among the most popular neighborhoods for Atlanta nightlife. From Atlanta's role in the Civil War to the celebration of the 1996 Centennial Olympic Games, Atlanta's historical attractions promise a visit filled with education and entertainment. Atlanta's convenience for travel, wide range of attractions, and southern hospitality make it enjoyable for tourists year-round. For more information on all Atlanta has to offer, visit the Atlanta Convention and Visitors Bureau's Web site at www.atlanta.net.



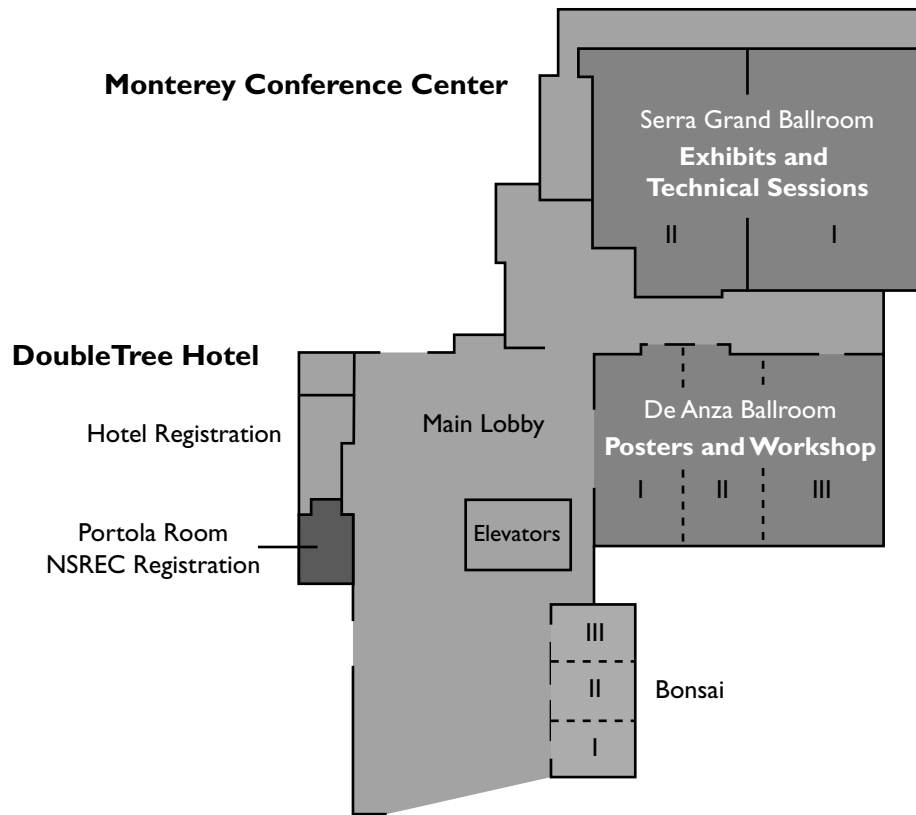
Photograph courtesy of Renaissance Waverly Hotel

Notes

Conference Facilities

Monterey Conference Center DoubleTree Hotel

LEVEL ONE



LEVEL THREE

