

TECHNICAL PROGRAM AND ACTIVITIES

32nd Annual International

NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE



**Madison, Wisconsin
July 17-21, 1995**



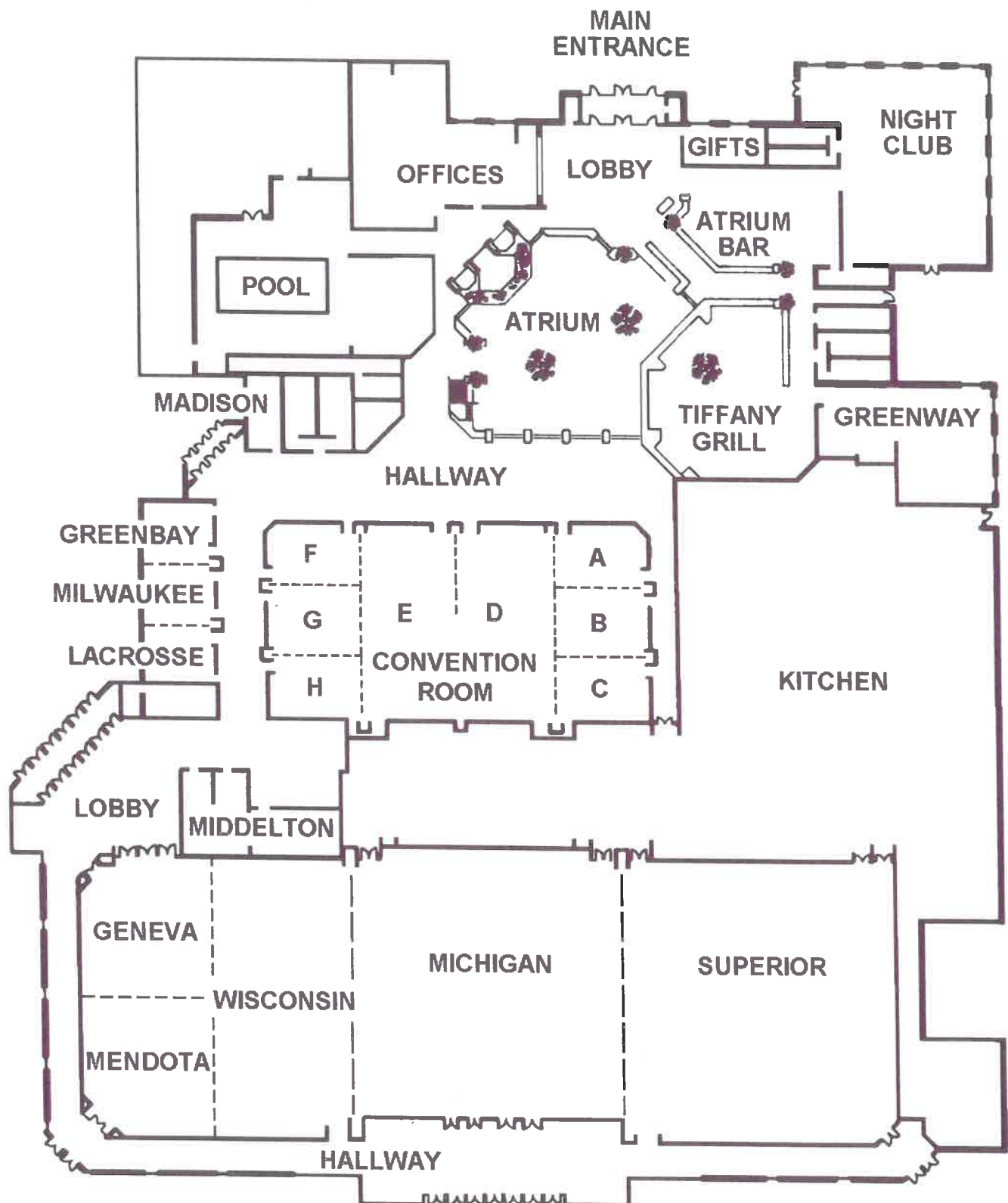
IEEE

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Holiday Inn Madison West



Schedule

Time	Monday July 17	Tuesday July 18	Wednesday July 19	Thursday July 20	Friday July 21
7:30	Continental Breakfast	Continental Breakfast	Continental Breakfast	Continental Breakfast	Continental Breakfast
8:15	Short Course: Introduction James R. Schwank Michigan Room	Conference Opening Awards Presentations Michigan Room	Invited Paper: The Hubble Telescope and the Shoemaker-Levy Comet Collision with Jupiter Stephen P. Maran	Invited Paper: Proton Radiotherapy – A New Technique or an Old Saw Paul M. DeLuca University of Wisconsin	Invited Paper: The Ellipso Global Communications Satellite System: The Concept and the Orbits Matthew J. Schor Mobile Communication Holdings Inc.
8:30	[8:30] Single-Event Effects Qualification William J. Stapor				
8:45		[8:45] Session A: Radiation Effects in Devices and ICs			
9:00			[9:15] Session D: Non- Destructive Single-Event Effects	[9:15] Session F: Destructive Single-Event Effects	[9:15] Session I: Radiation Effects on Photonic Materials and Systems
10:00	[10:00] Break	[9:50] Break	[9:50] Break	[9:50] Break	[9:50] Break
11:00	[10:30] A First-Principles Approach to Total-Dose Hardness Assurance Daniel M. Fleetwood	[10:20] Session A (cont.)	[10:20] Session D (cont.)	[10:20] Session F (cont.)	[10:20] Session I (cont.)
12:00	[12:00] Lunch	[11:20] Session B: Hardness Assur- ance and Testing Techniques	[11:35] Lunch	[10:50] Session G: Space Single-Event Effects	[10:50] Session J: Isolation Technologies
1:00		[11:55] Lunch		[11:55] Lunch	[12:10] End of Conference
2:00	[1:15] Advanced Test Methodologies Nick van Vonno	[1:15] Session B (cont.)	[1:15] Session E: Radiation Metrology and Facilities	[1:15] Session G (cont.)	
3:00	[2:45] Break	[2:00] Session C: Basic Mechanisms of Radiation Effects	[2:20] Radiation Effects Data Workshop Poster Presentations Wisconsin Room	[1:30] Session H: Spacecraft Environments and Effects	
4:00	[3:15] Qualification from the Buyer's Perspective Lee Mendoza	[2:50] Break		[2:50] Poster Session Poster Presentations Geneva Room	
5:00	[4:45] Wrap-up	[3:20] Session C (cont.)	[4:00] End of Session		
6:00	[5:00] Exam (only for students requesting CEU credit)	[4:35] End of Session			
7:00	[5:30] End of Short Course		[5:00-10:00] Conference Social Vilas Zoo (Board buses at Holiday Inn)	[5:00] End of Session	
8:00	[7:00-9:30] Conference Registration and Reception Convention Room	[7:00-10:00] Industrial Exhibit Reception Convention Room		[5:30-7:00] Radiation Effects Committee Open Meeting Michigan Room	

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Chairman's Invitation



Conference Committee

General Chairman

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Naval Surface Warfare Center
(812) 854-1808

Technical Program

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Ronald D. Schrimpf
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(520) 621-4116

Dear Colleague,

You are cordially invited to attend the **32nd Annual International Nuclear and Space Radiation Effects Conference (NSREC)** that will be held at the convention and trade center of the Holiday Inn Madison West, in **Madison, Wisconsin, July 17-21, 1995**. Madison was chosen as the site for this year's IEEE-sponsored meeting for several reasons: perfect weather in July, several freshwater lakes nearby, home of the University of Wisconsin and State Capitol, but mostly for its outstanding conference facilities.

The 1995 conference begins on Monday, July 17, with a radiation effects "Short Course." Dr. Jim Schwank has assembled a series of lectures focused on *Advanced Qualification Techniques, A Practical Guide to Radiation Testing of Electronics*. The recent closing of several rad-hard semiconductor process lines has made the design, procurement, and radiation testing of spacecraft electronics a difficult task. Designers are now often forced to use commercial off-the-shelf electronics and nonhardened processes, requiring significant changes to their traditional radiation testing/qualification procedures. This year's Short Course addresses those radiation testing techniques that guarantee only the most rad-tolerant parts are used in our spacecraft and systems.

Our Technical Program Chairman, Dr. Peter McNulty, has put together an outstanding program that will interest everyone who wants to learn about radiation damage to electronics and how to prevent it. The technical program, held Tuesday, July 18, through Friday, July 21, will consist of contributed oral and poster papers and a data workshop. You will also find several invited talks of general interest to your entire family.

The quality of research presented at NSREC gets better each year. As always, our session chairmen, technical reviewers, authors, and editors make sure that "only the best" make it through the selection process. We pride ourselves on technical excellence in publication, as reflected in the *IEEE Transactions on Nuclear Science*.

You will be pleased with the Industrial Exhibit scheduled for Tuesday evening and Wednesday morning. Representatives from semiconductor vendors, wafer manufacturers, testing facilities, and equipment manufacturers will be available to explain their latest products and developments. Come prepared to collect catalogues, business cards, and literature.

We have recently arranged for "electronic retrieval" of the latest NSREC material via electronic mail and the World Wide Web. A copy of this brochure (text only) can be obtained by sending a blank E-mail message to "nsrec.brochure@ieee.org". If you would like to submit a paper, the current Call-for-Papers is available at "nsrec.call@ieee.org". Upon receipt of your message, the IEEE computer will forward the most current information to you automatically. We plan to keep these two E-mail addresses permanently and continue to provide this service for years to come. For World Wide Web users, the above material is available in graphical format at "<http://www.ieee.org/nps/nsrec/nsrec.html>".

As you page through the conference brochure, please take time to recognize the many engineers and scientists (all volunteers) who have donated their time to make this meeting one of the most prominent international symposia on radiation effects. If you haven't realized it yet, these people make NSREC special.

I'm looking forward to meeting you in Madison!

Dale G. Platteter
General Chairman

Short Course Program

ADVANCED QUALIFICATION TECHNIQUES: A PRACTICAL GUIDE FOR RADIATION TESTING OF ELECTRONICS

MONDAY, JULY 17

8:15 AM - 5:30 PM

MICHIGAN ROOM

7:30 AM	REGISTRATION/CONTINENTAL BREAKFAST
8:15 AM	SHORT COURSE INTRODUCTION James R. Schwank <i>Sandia National Laboratories</i>
8:30 AM	SINGLE-EVENT EFFECTS QUALIFICATION William J. Stapor <i>Naval Research Laboratory</i>
10:00 AM	BREAK
10:30 AM	A FIRST-PRINCIPLES APPROACH TO TOTAL-DOSE HARDNESS ASSURANCE Daniel M. Fleetwood <i>Sandia National Laboratories</i>
12:00 PM	LUNCH
1:15 PM	ADVANCED TEST METHODOLOGIES Nick van Vonno <i>Harris Corporation</i>
2:45 PM	BREAK
3:15 PM	QUALIFICATION FROM THE BUYER'S PERSPECTIVE Lee Mendoza <i>The Aerospace Corp.</i>
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

The theme of the 1995 NSREC Short Course is **Advanced Qualification Techniques: A Practical Guide for Radiation Testing of Electronics** for radiation-hardened and commercial devices in space systems. The Short Course is intended to be a practical guideline, giving students the background and know-how to test and qualify present-day and future electronic devices using reliable, cost-effective techniques. The development of hardness assurance and qualification testing techniques is a rapidly evolving area. As more emphasis is placed on the use of commercial devices in military systems and the margin between device capability and system requirements becomes increasingly less, knowledge of practical and reliable testing and qualification techniques and their implementation becomes increasingly more important. This year's Short Course addresses those radiation testing techniques which guarantee that only the most rad-tolerant parts are used in our spacecraft and systems. This timely theme should be of interest to attendees from a wide spectrum of backgrounds, from those interested in the mechanisms of radiation effects to users and buyers of electronic components and systems.

James R. Schwank of Sandia National Laboratories is the 1995 Short Course Chairman. The course is divided into four segments. Instructors for this year's Short Course are William J. Stapor of the Naval Research Laboratory, Daniel M. Fleetwood of Sandia National Laboratories, Nick van Vonno of Harris Corporation, and Lee Mendoza of The Aerospace Corporation. Each Short Course segment will be followed by a short question-and-answer period.

Continuing Education Units (CEUs)

This year, 0.6 CEUs endorsed by the IEEE and the International Association for Continuing Education and Training (IACET) will be made available to qualified students. The IEEE is an Authorized CEU Sponsor member of the IACET. IEEE guidelines for offering CEU credit will be followed. To qualify, a student must be a registered attendee of the Short Course and pass a written exam with a score of 75% or greater. The exam will be given immediately following the last segment of the Short Course (5:00 PM), will be open book, and will consist of approximately 20 multiple-choice questions covering the presented material. No CEU credit will be offered to students who have not taken and passed the written exam. A certificate of completion will be mailed to all qualified students.

Short Course Chairman

James R. Schwank received his B.S., M.S., and Ph.D. degrees in electrical engineering at the University of California at Los Angeles in 1970, 1974, and 1978, respectively. He joined Sandia National Laboratories in 1979 where he is a senior member of the technical staff. At Sandia, he has been involved in numerous studies investigating the mechanisms of radiation effects in semiconductor devices, in developing techniques for improving the radiation hardness of MOS devices, and in hardness assurance activities. Dr. Schwank has served the NSREC as short course instructor, publicity chairman, session chairman, and reviewer; and the Hardened Electronics and Radiation Technology (HEART) Conference as technical program chairman, guest editor, associate guest editor, and session chairman. He has won six outstanding or meritorious conference paper awards and has authored more than 65 papers on radiation effects in electronic devices. Dr. Schwank is a Fellow of the IEEE.



SINGLE-EVENT EFFECTS QUALIFICATION

William J. Stapor

Naval Research Laboratory

William J. Stapor will emphasize techniques for qualifying electronic devices and integrated circuits for single event effects. It will start with an overview of the space environment and how it relates to single event effects. Cosmic particles and trapped particles in the earth's radiation belts can cause soft-error upset and hard errors in an integrated circuit. Students will learn about what ground-based measurement sources are available for simulating Single-Event Effects (SEE), their uses, and their limitations. Students will next learn about methods for predicting SEE. This is an area of considerable importance due to the complexity of today's devices and the variability in radiation environments. Hardness assurance test methods presently available will be discussed. This segment will end with a discussion of problems and trends for future SEE testing.



William J. Stapor has a B.S. in physics from William and Mary, Williamsburg, Virginia, and M.S. and Ph.D. degrees in nuclear physics from The Catholic University of America, Washington, D. C. He initially worked in the photonuclear physics community making high-energy electron-scattering measurements of nuclear charge distributions. He has worked in the radiation effects area for over eleven years at the Naval Research Laboratory, Washington, D.C., in the Radiation Dynamics Section of the Radiation Effects Branch, specializing in single event effects in microelectronics. Dr. Stapor is presently the Defense Nuclear Agency Program Advisory Reviewer for the single event task area. He has chaired the last two Single Event Symposia held every two years in the Los Angeles area. He performs basic research and development as well as practical engineering consulting to the spacecraft community. Dr. Stapor has authored or co-authored over 45 publications.

SINGLE-EVENT EFFECTS QUALIFICATION

Introduction

- SEE Definition
- Concept of Cross Section

Single-Event Effects and Total-Dose Space Environment

Ground-Based Measurements

- Accelerators and Ions
 - Protons
 - Heavy Ions
- Procedures to Collect Data at the Accelerator
- Laboratory Simulators and Tools
 - ^{252}Cf
 - Pulsed Lasers
 - Microbeams
- Procedures to Collect Data in the Laboratory Using Simulator Tools

Prediction of SEE Rates

- Methodologies
- Commercial Modeling Codes (CREME, Space Radiation, etc.)
- Problems with the Predictions (Realism, Environment, Statistics, etc.)
- Issues in Single-Event Rates
 - Discrete Devices, Components, Circuits, Systems
 - Level of SEE Rate Tolerance
 - SEE Hardening and/or Mitigation

Hardness Assurance Test Methods

- Mil- and ASTM Standards
- SEP Test Guide
- ^{252}Cf Guideline Document

Future Trends

- Increased Device and System Complexity
- Dynamic and Static Operation
- Better Environmental Models
- Meaningful Ground Data
- Meaningful Space Data

Conclusions and Summary

A FIRST-PRINCIPLES APPROACH TO TOTAL-DOSE HARDNESS ASSURANCE

Daniel M. Fleetwood

Sandia National Laboratories

Daniel M. Fleetwood will emphasize total-dose hardness assurance techniques for qualifying electronic devices and integrated circuits. It will start with a description of several radiation environments with varying total-dose requirements. The student will then learn of laboratory radiation sources used to simulate and test for total-dose effects. Students will learn of time-dependent effects and device response and failure modes. This knowledge is essential in order to correlate laboratory measurements to system requirements. Present-day test methods will be discussed. This segment will end with an overview of possible non-destructive tests and future trends for hardness assurance testing.



Daniel M. Fleetwood received his B.S., M.S., and Ph.D. degrees in physics from Purdue University in 1980, 1981, and 1984, respectively. There, he received the Lark-Horovitz Award for his work on $1/f$ noise in metals. Dan joined Sandia National Laboratories' Advanced Microelectronics Development Department in 1984 and moved to the Radiation Technology and Assurance Department in 1986. He was named a Distinguished Member of the Technical Staff in 1990. He has authored more than 110 papers on radiation effects and $1/f$ noise in microelectronics and has received seven outstanding or meritorious conference paper awards. Dan has served the IEEE NSREC as guest editor, poster session chairman, session chairman, and technical program chairman. He presently is vice-chairman for publications and technical program on the radiation effects steering group. Dan is a senior member of IEEE and a member of The American Physical Society, Phi Beta Kappa, Phi Kappa Phi, and Sigma Pi Sigma.

A FIRST-PRINCIPLES APPROACH TO TOTAL-DOSE HARDNESS ASSURANCE

Introduction

Design Margin and Safety Factors

Focus

Sources and Environments

MOS Testing Issues

- Defects in MOS
- Dose-Rate Effects
- Technical Basis for MIL-STD 883D, Test Method 1019.4
 - Time Dependent Effects
 - Constraints on Low-Dose-Rate Hardness Assurance
 - "Rebound" Testing
- Test Method 1019.4
 - Main Flow
 - Comparison to BS 22900
- Overstress Requirement in Test Method 1019.4
 - Switched-Bias Effects
 - pMOS Transistors
 - Interface-Trap Annealing
 - Latent Interface Traps
- IC Data
- Relaxing Rebound Test Requirements
- Less Conservative Oxide-Charge Tests
- Weapon Applications
 - Issues
 - 10-keV X-ray Irradiation
 - Possible Test Methods
- Synopsis of MOS Test Methods
- Effects of Burn-in
- If Parts Fail

Testing Issues for Bipolar Devices

QML

Non-Destructive Testing

Conclusions and Future Trends

ADVANCED TEST METHODOLOGIES

Nick van Vonno
Harris Corporation

Nick van Vonno's presentation is divided into two sections. The first section is an overview of traditional approaches to qualification testing. In addition to issues such as wafer level testing and screening for latchup and burnout, students will also learn of the special case of testing and qualifying cryogenic electronics. The second section is on advanced approaches to electronics qualification testing. In this section, students will learn of advanced approaches that can result in substantial savings in cost and time in qualification testing, including the qualified manufacturers list (QML) methodology. The difficult issue of how to qualify VLSI components will also be covered. This segment will end with a discussion of future trends for hardness assurance testing and the impact of commercial off-the-shelf (COTS) mandates.



Nick van Vonno received his B.S. degree in electrical engineering from the University of Florida in 1966. Upon graduation, he joined Radiation, Incorporated (now Harris Corporation). After initial assignments in reliability engineering, he moved to process development and device engineering with participation in both bipolar and CMOS projects. Later responsibilities were in the design, development, and production of hardened analog components on a variety of strategic programs. Specific areas of interest included mixed-signal design, cryogenic CMOS process development, and SOI technology. Mr. van Vonno has been active in NSREC affairs. He served as session chairman of Isolation Technologies and Poster sessions and was guest editor for the 1992 conference and awards chairman in 1994. He has authored over 20 technical publications in the field of hardened component design and processing and is a senior member of IEEE.

ADVANCED TEST METHODOLOGIES

Traditional Approaches

- **Total Dose Testing**
 - Wafer Level Testing
 - Test Transistor Correlation; Scaling Effects
 - Package Level Testing
 - Dose Rate Effects and Limitations
- **Dose Rate Testing**
 - Latchup and Burnout Screening
 - Wafer Level Testing and Limitations
- **SEE Testing**
 - Screening/Qualification Methods
- **In-Orbit Verification**
- **Special Case: Cryogenics**
 - Qualification Plans and Device Physics
 - Production and Qualification Testing
 - Total Dose Testing
 - Dose Rate Testing
 - SEE Testing
- **Summary: Limitations of Traditional Approaches**
 - Impact of VLSI and Higher Complexity
 - Impact of ASIC Methods

Advanced Approaches

- **Introduction to QML**
 - Types of QML Certification
 - QML Methodology
 - SPC Applications
 - European Standards
- **Testing VLSI Components**
 - Standard Products
 - ASSP's
 - ASIC's
- **Future Trends in Hardness Assurance Testing**
 - Impact of COTS Mandates

QUALIFICATION FROM THE BUYER'S PERSPECTIVE

Lee Mendoza

The Aerospace Corporation

Lee Mendoza will cover qualification of electronics from the buyer's perspective. This perspective presents different problems from that of the device engineer or manufacturer. The student will first learn how to choose parts to meet system requirements. This can often be a difficult problem considering the wide variety of available parts and test methods for qualification. Due to their lower costs, commercial devices are seeing increased use in military and space systems. Students will learn of tradeoffs between commercial and radiation-hardened devices. This segment will end with several case histories of real system failures caused by radiation-induced part degradation.



Lee Mendoza received his B.S. degree in applied mathematics and physics from the University of Wisconsin - Milwaukee in 1978 and his M.S. in physics from the University of California at Los Angeles in 1980. He has been employed by The Aerospace Corporation since 1980, currently as the lead project engineer for the Early Warning Systems Program Technology Office. Mr. Mendoza has provided systems engineering and integration support in on-board processing systems and technologies for the Boost Surveillance and Tracking System (BSTS), Advanced Warning System (AWS), and Follow-on Early Warning System (FEWS) programs. In the technology office, he has had a strong role in the development of 32-bit radiation-hardened processors and memories. He has also been very active in the Qualified Manufacturers List (QML) program as an auditor at QML Validation reviews.

QUALIFICATION FROM THE BUYER'S PERSPECTIVE

Choosing Parts to Meet System Requirements

- **Understanding the System Requirements**
 - Performance
 - Radiation
 - Military Standards
- **Parts Availability**
- **Determining Radiation Capability**
 - Manufacturer's Data
 - Databases
 - Testing
- **Qualification Approaches**
 - QML
 - Monitored Line
 - Do It Yourself
- **Radiation Testing**
 - Test Guidelines
 - Who Can and Should do Radiation Testing?
 - What Testing Should be Performed?
 - Potential Pitfalls

Commercial Devices

- **What Are Commercial Devices?**
 - How Hard Are They?
 - What Does the Future Hold?
- **Tradeoffs Between Commercial and Radiation-Hardened Parts**
 - Performance
 - Margins
 - Variability
 - Cost
- **Implementation Using Commercial Devices**
 - Shielding
 - System Approaches

Case Histories

Technical Program

TECHNICAL INFORMATION

The technical program will consist of contributed oral and poster papers, three distinguished invited talks, and a radiation effects data workshop. All oral sessions will be held in the Michigan Room at the Holiday Inn Madison West. Oral papers will be 12 minutes in length with 3 additional minutes reserved for questions. The technical sessions and chairpersons are:

- **Radiation Effects in Devices and ICs**
Gary Lum, Lockheed Martin Corporation
- **Hardness Assurance and Testing Techniques**
David Alexander, Mission Research Corporation
- **Basic Mechanisms of Radiation Effects**
Art Edwards, University of North Carolina Charlotte; Jean-Luc Leray, CEA
- **Non-Destructive Single-Event Effects**
Robert Ecoffet, CNES; Deb Newberry, CDI
- **Radiation Metrology and Facilities**
Patrick Griffin, Sandia National Laboratories
- **Destructive Single-Event Effects**
James Kinnison, Johns Hopkins Applied Physics Laboratory
- **Space Single-Event Effects**
E.G. Stassinopoulos, NASA Goddard
- **Spacecraft Environments and Effects**
Jason Wilkenfeld, S-Cubed
- **Radiation Effects on Photonic Materials and Systems**
Cheryl Dale, Naval Research Laboratory; Gordon Hopkinson, Sira, Ltd.
- **Isolation Technologies**
Robert Pugh, Phillips Laboratory

Radiation Effects Data Workshop

These 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. Workshop papers will be presented in a separate session (poster format) in the Wisconsin Room from 2:20 PM to 4:00 PM on Wednesday. All conference registrants will be mailed a copy of the Workshop Proceedings (which will be an archival IEEE publication) following the conference. Workshop papers will be available for viewing from 12:00 PM Tuesday through Friday morning. The workshop chairman is *Kenneth LaBel, NASA, Goddard SFC.*

Poster Session

Papers that are most appropriate for visual presentation will be displayed from 12:00 PM Tuesday through Friday morning in the Geneva Room. Authors will be available to discuss their poster from 2:50 PM to 5:00 PM on Thursday. The poster chairman is *Fred Sexton, Sandia National Laboratories.*

INVITED SPEAKERS

The 1995 NSREC is pleased to feature three invited talks. Stephen P. Maran will present *The Hubble Telescope and the Shoemaker-Levy Comet Collision with Jupiter*, Paul M. DeLuca, Jr. will present *Proton Radiotherapy - A New Technique or an Old Saw*, and Matthew Schor will present *The Ellipso Global Communications Satellite System: The Concept and the Orbits.*

LATE-NEWS PAPERS

A few late-news papers will be accepted and will be presented in the poster session. The deadline for submission of late-news papers is June 1, 1995. Please submit late-news summaries, using the 4-page summary and 35-word abstract format, to the Technical Program Chairman, Peter J. McNulty, Clemson University, 117 Kinard Laboratory of Physics, Department of Physics and Astronomy, Clemson, SC 29634-1911; (803) 656-3419. In your summary, please make a case that your presentation will be newsworthy.



- 7:30 AM **REGISTRATION**
Holiday Inn Madison West, Trade Center Lobby
Continental Breakfast
- 8:15 AM **OPENING REMARKS**
MICHIGAN ROOM *Dale G. Platteter, Conference General Chairman*
 Ken Hunt, Local Arrangements Chairman
- 8:30 AM **AWARDS PRESENTATION**
 Peter S. Winokur, Steering Group Chairman
- 8:40 AM **TECHNICAL SESSION OPENING REMARKS**
 Peter J. McNulty, Technical Program Chairman
- SESSION A** **RADIATION EFFECTS IN DEVICES AND ICs**
- 8:45 AM **Session Introduction**
 Chairman: Gary Lum, Lockheed Martin Corporation
- A-1** **Comparison of Ionizing Radiation-Induced Gain Degradation in**
8:50 AM **Lateral, Substrate, and Vertical PNP BJTs**
 D. M. Schmidt, R. J. Graves, R. D. Schrimpf, University of Arizona; D. M. Fleetwood, Sandia National Laboratories; R. N. Nowlin, Phillips Laboratory; W. E. Combs, Naval Surface Warfare Center

Substrate and lateral PNP devices exhibit higher radiation-induced gain degradation than vertical PNPs, and a strong dose-rate dependence of gain degradation. The gain degradation is due to increased base current and decreased collector current.
- A-2** **Degradation of Si_{1-x}Ge_x Epitaxial Heterojunction Bipolar**
9:05 AM **Transistors by 1-MeV Fast Neutrons**
 H. Ohyama, K. Hayama, Kumamoto National College of Technology; J. Vanhellemont, J. Poortmans, M. Caymax, IMEC; Y. Takami, Rikkyo University; H. Sunaga, Japan Atomic Energy Research Institute

The degradation of Si_{1-x}Ge_x based HBTs by 1-MeV fast neutrons is investigated and attributed to the formation of deep levels in the base and collector involving deactivation of dopant atoms.
- A-3** **Radiation Tolerance of High-Performance SiGe HBTs Grown by**
9:20 AM **UHV/CVD**
 J. A. Babcock, J. D. Cressler, L. S. Bhamidipati, R. C. Jaeger, Auburn University; S. D. Clark, Naval Surface Warfare Center; D. L. Harame, IBM

Radiation tolerance and low-frequency noise characteristics of high-performance SiGe HBTs, grown by UHV/CVD and optimized for 77 K, have been investigated. Results at both 300 K and 77 K indicate that this SiGe technology is inherently radiation tolerant.
- A-4** **Ionizing Radiation-Induced Asymmetries of the Retention**
9:35 AM **Characteristics of Ferroelectric Thin Films**
 R. A. Moore, J. M. Benedetto, Army Research Laboratory

This work reveals that ionizing radiation can produce a retention asymmetry in FE thin films at dose levels lower than a concomitant decrease in retained polarization.
- 9:50 AM **BREAK**



- A-5**
10:20 AM **Charge Collection in GaAs MESFETs Fabricated in Semi-Insulating Substrates**
J. R. Schwank, F. W. Sexton, Sandia National Laboratories; T. R. Weatherford, D. McMorrow, A. R. Knudson, Naval Research Laboratory

Charge collection in GaAs MESFETs fabricated in semi insulating substrates following laser or heavy-ion strikes shows evidence for bipolar-gain which enhances the collected charge and the sensitivity of these devices to single-event upset.

- A-6**
10:35 AM **A Low-Cost Highly Reliable SEU-Tolerant SRAM: Prototype and Test Results**
T. Calin, F. Vargas, M. Nicolaidis, TIMA/INPG Laboratory; R. Velazco, LGI/IMAG Laboratory

A new technique is presented to achieve SEU tolerance in CMOS static RAM circuits. The technique uses Transient Current Detection (TCD) to localize the effected memory cell and a parity bit per word to perform error correction.

- A-7**
10:50 AM **Plastic Packaging and Burn-in Effects on Ionizing Dose Response in CMOS Microcircuits**
S. Clark, J. Bings, Naval Surface Warfare Center; M. Maher, National Semiconductor; M. Williams, D. Alexander, Mission Research Corporation; R. Pease, RLP Research, Inc.

This paper describes the results of an experiment to identify any significant variations in total ionizing dose response in CMOS microcircuits which can be related to ceramic and plastic packaging.

- A-8**
11:05 AM **Silicon Carbide FETs for High Temperature Nuclear Applications**
C. J. Scozzie, J. Blackburn, J. M. McGarrity, W. M. Delancey, Army Research Laboratory

The irradiation of 6H-SiC depletion-mode junction field-effect transistors (JFETs) at 25°C and 300°C in a 250 kW nuclear reactor is reported. In-situ measurements of device performance are presented for accumulated fluences up to 5×10^{15} n/cm².

SESSION B **HARDNESS ASSURANCE AND TESTING TECHNIQUES**

- 11:20 AM **Session Introduction**
Chairman: David Alexander, Mission Research Corporation

- B-1**
11:25 AM **Enhanced Damage in Linear Bipolar Integrated Circuits at Low Dose Rate**
A. H. Johnston, B. G. Rax, C. I. Lee, Jet Propulsion Laboratory

Ionization damage is investigated in linear circuits at dose rates as low as 0.002 rad(Si)/s, extending earlier work to devices with complex input stages. Variations in the response of devices from different vendors are also investigated.

- B-2**
11:40 AM **Hardness Assurance Issues for Lateral PNP Bipolar Junction Transistors**
R. J. Graves, D. M. Schmidt, R. D. Schrimpf, University of Arizona; D. M. Fleetwood, Sandia National Laboratories; R. N. Nowlin, Phillips Laboratory; W. E. Combs, Naval Surface Warfare Center; R. L. Pease, RLP Research, Inc.; M. DeLaus, Analog Devices, Inc.

The dose-rate dependence of gain degradation in lateral PNP transistors is even more serious than that previously reported for NPN BJTs. Hardness assurance issues associated with high-temperature irradiation and annealing are discussed.

- 11:55 AM **LUNCH**



B-3
1:15 PM **Radiation Evaluation of an Advanced 64 Mb, 3.3 V DRAM and Insights into the Effects of Scaling on Radiation Hardness**

D. C. Shaw, G. M. Swift, D. J. Padgett, A. H. Johnston, Jet Propulsion Laboratory

Total ionizing dose radiation evaluations of a 64 Mb DRAM are presented. The effects of scaling on radiation hardness are studied utilizing test structures and 16 Mb DRAMs with varying feature sizes from the same line.

B-4
1:30 PM **Hardness Assurance and Testing Techniques for High Resolution (12- to 16-bit) Analog-to-Digital Converters**

C. I. Lee, B. G. Rax, A. H. Johnston, Jet Propulsion Laboratory

This paper discusses hardness assurance techniques to test and evaluate total dose radiation degradation of high-resolution A/D converters. A new 16-bit converter with internal calibration is compared with older designs using more conventional architectures.

B-5
1:45 PM **Circuit Hardening Level Above 100 Mrad: Demonstration and Verification**

O. Flament, J. L. Leray, O. Musseau, A. Vitez, A. Quemeneur, M. Raffaelli, CEA; E. Orsier, R. Truche, CEA/DTA/LETI

Results on a hardened technology for high-energy physics and nuclear plant applications are presented. Ionizing dose and temperature responses indicate that such a technology can fulfill the high reliability and hardness required in these environments.

SESSION C
BASIC MECHANISMS OF RADIATION EFFECTS

2:00 PM **Session Introduction**

*Chairman: Art Edwards, University of North Carolina Charlotte
Jean-Luc Leray, CEA*

C-1
2:05 PM **Relaxation of Si-SiO₂ Interfacial Stress in Bipolar Screen Oxides Due to Ionizing Radiation**

S. C. Witzak, K. F. Galloway, R. D. Schrimpf, University of Arizona; W. Wong-Ng, J. S. Suehle, National Institute of Standards and Technology; M. DeLaus, Analog Devices, Inc.

Repeated cycles of irradiations and anneal relieve Si-SiO₂ interfacial stress while increasing radiation sensitivity in bipolar junction transistors. The results support the view that decreasing Si compressive stress degrades the radiation hardness of Si-SiO₂ structures.

C-2
2:20 PM **Effects of Interface Traps and Border Traps on MOS Postirradiation Annealing Response**

D. M. Fleetwood, L. C. Riewe, W. L. Warren, M. R. Shaneyfelt, P. S. Winokur, J. R. Schwank, Sandia National Laboratories

Threshold-voltage and charge-pumping measurements are combined to separate the contributions of interface and border traps to the postirradiation annealing response of soft oxides. The possible roles of oxygen vacancies and hydrogen are explored.

C-3
2:35 PM **Charge Trapping and Leakage in Buried Thermal Oxides**

R. E. Stahlbush, Naval Research Laboratory; G. A. Brown, Texas Instruments

The effects of annealing temperature and oxide thickness on charge trapping and leakage in buried oxides have been studied. Samples are polysilicon on thermal oxide (25 to 400 nm) and were annealed at 1100°C to 1325°C.

2:50 PM **BREAK**

- C-4**
3:20 PM **The Effect of a Post Oxidation Anneal on the VUV Radiation Hardness of the Si/SiO₂ System**
M. Clement, J. M. M. de Nijs, A. van Veen, A. Schut, P. Balk, Delft University of Technology
- Post oxidation anneal of MOS systems not only increases the hole trap density but also the interface state generation rate. The latter effect is by removing electrically inactive traps for radiation-induced H species or excitons.
- C-5**
3:35 PM **Evidence that Type Inversion in N-type High-Resistivity Silicon Diodes is Due to a Radiation-Induced Deep Acceptor**
J. Matheson, M. Robbins, S. Watts, Brunel University
- DLTS measurements and defect kinetics considerations lead to a phosphorus removal rate that is 30 times lower than had been assumed. A device model, including a deep acceptor, is used to explain type inversion.
- C-6**
3:50 PM **Radiation-Induced Defects in Chemical-Mechanical Polished MOS Oxides**
M. R. Shaneyfelt, W. L. Warren, D. L. Hetherington, P. S. Winokur, Sandia National Laboratories
- Significantly larger densities of P_{b1} centers are observed in irradiated chemical-mechanical polished oxides as opposed to unpolished oxides. This suggests that the polishing process alters the SiO₂-Si interface.
- C-7**
4:05 PM **Microscopic Nature of Defect Centers in Doped Oxides**
W. L. Warren, M. R. Shaneyfelt, D. M. Fleetwood, P. S. Winokur, Sandia National Laboratories
- An electron paramagnetic resonance study has been carried out on phosphorus and boron doped oxide films on Si. The principal defects are oxygen-related centers with B or P in the near vicinity.
- C-8**
4:20 PM **Implications for the Structure of a Radiation Damage Center in Thermally Grown Gate and SIMOX Buried Oxides**
J. F. Conley, P. M. Lenahan, Penn State University
- We report the first observation of a hydrogen-complexed EP (E'₈) center. Comparing EP/H and E'₇/H electron spin resonance spectra, we provide the first strong evidence that EP (E'₈) centers do not have a delocalized structure.
- 4:35 PM **End of Session C**



7:30 AM **REGISTRATION**
Holiday Inn Madison West, Trade Center Lobby
Continental Breakfast

INVITED PAPER **The Hubble Telescope and the Shoemaker-Levy Comet Collision with Jupiter**
8:15 AM *Stephen P. Maran, NASA Goddard SFC*

The July 1994 impacts of the massive fragments of Comet Shoemaker-Levy 9 were monitored in visual and ultraviolet light and also spectroscopically by the Hubble Space Telescope with remarkable results. Other key Hubble findings about the solar system, including the first view of the surface of the moon Titan, which may have hydrocarbon oceans, and the discovery of oxygen on Europa, will be described. No talk on Hubble would be complete without a description of its ongoing search for supermassive black holes and the determination of the extragalactic distance scale and, thereby, the age of the universe.

Stephen P. Maran is a Senior Staff Scientist in the Laboratory for Astronomy and Solar Physics at the NASA-Goddard Space Flight Center in Greenbelt, Maryland, and the Press Officer of the American Astronomical Society. An investigator of stars, nebulae, and comets, he is currently working on the Hubble Space Telescope, the ASTRO-2 mission of the Space Shuttle Endeavor, and other NASA projects in astronomy and space science and was a 1991 recipient of the NASA Medal for Exceptional Achievement. Dr. Maran is the host of the NASA satellite TV program, "Space Astronomy Update," and is a regular guest on the syndicated radio talk show, "Capitol Conversation." He is the author of over 300 scientific papers and popular articles written since 1963, including many contributions to SMITHSONIAN, NATURAL HISTORY, SCIENTIFIC AMERICAN, and other periodicals. Since 1981, he has been a Harlow Shapley Lecturer for the American Astronomical Society, speaking on astronomy and space science at colleges and universities around the United States. He is a member of three commissions of the International Astronomical Union (dealing respectively with radio astronomy, comets, and astronomy from satellites) and is a Fellow of the American Association for the Advancement of Science. He is the editor-in-chief of THE ASTRONOMY AND ASTROPHYSICS ENCYCLOPEDIA, published in October, 1991, by Van Nostrand Reinhold and the Cambridge University Press, and has written or edited seven other books since 1964, including, in 1981, "A Meeting with the Universe" (coedited with Dr. Bevan French), which has sold over 130,000 copies through the U.S. Government Printing Office and major commercial bookstore chains. Dr. Maran received the B.S. in Physics at Brooklyn College of the City University of New York in 1959 and earned the M.A. (1961) and Ph.D. (1964) in Astronomy from the University of Michigan.

SESSION D NON-DESTRUCTIVE SINGLE-EVENT EFFECTS

9:15 AM **Session Introduction**
Chairman: Robert Ecoffet, CNES; Deb Newberry, CDI

D-1 A Comparison of Single-Event Results from Lower Energy and Higher Energy Ion Beams

9:20 AM *W. J. Stapor, A. Knudson, Naval Research Laboratory; J. D. Kinnison, B. G. Carkhuff, Applied Physics Laboratory; H. Dussault, Rome Laboratory*

Track simulations, charge-collection measurements, and integrated circuit cross-section measurements are compared between lower energy beams commonly used at the Brookhaven National Laboratory Tandem Accelerator and higher energy beams produced at the Chalk River Nuclear Laboratory.



- D-2**
9:35 AM **High Energy Heavy-Ion-Induced Charge Transport Across Multiple Junctions**
H. Dussault, Rome Laboratory; J. W. Howard, Jr., R. C. Block, Rensselaer Polytechnic Institute; W. J. Stapor, Naval Research Laboratory; A. R. Knudson, SFA, Inc.; M. R. Pinto, AT&T Bell Laboratories

High-energy heavy-ion experiments and numerical simulations show that two junctions bridged by an ion track respond in a coupled manner.
- 9:50 AM BREAK
- D-3**
10:20 AM **Pulsed-Laser-Induced SEU and Charge-Collection Measurements as a Function of Optical Penetration Depth**
D. McMorrow, J. S. Melinger, N. Thantu, A. B. Campbell, Naval Research Laboratory; A. R. Knudson, S. Buchner, T. R. Weatherford, L. H. Tran, SFA, Inc.

A comprehensive investigation into the effects of laser penetration depth on the SEU threshold and charge-collection characteristics of a variety of GaAs and Si parts is presented.
- D-4**
10:35 AM **Critical Charge Concepts for High-Density SRAMs**
P. E. Dodd, F. W. Sexton, Sandia National Laboratories

Three-dimensional simulations indicate that more charge may be collected at sensitive nodes from strikes that do not cause upset than from strikes that do, challenging critical charge concepts that rely on total collected charge.
- D-5**
10:50 AM **Evaluation of the Upset Risk in CMOS SRAM through Full Three-Dimensional Simulation**
Y. Moreau, J. Gasiot, Centre D'Electronique de Montpellier; S. Duzellier, CERT/ONERA

Three-dimensional device simulations, based on a description of a full 1 μm epitaxial CMOS inverter, and experimental results are reported for evaluation of single and multiple bit error risk.
- D-6**
11:05 AM **Elimination of Charge-Enhancement Effects in GaAs FETs with an LT GaAs Buffer Layer**
D. McMorrow, J. S. Melinger, A. B. Campbell, Naval Research Laboratory; T. R. Weatherford, A. R. Knudson, S. Buchner, Lan Hu Tran, SFA, Inc.; W. R. Curtice, W. R. Curtice Consulting

The use of a low-temperature grown GaAs buffer layer in GaAs FETs is shown via computer simulation and experimental measurement to reduce ion-induced charge collection by two to three orders of magnitude.
- D-7**
11:20 AM **Particle-Induced Mitigation of SEU Sensitivity in High Data Rate GaAs HIGFET Technologies**
P. W. Marshall, SFA, Inc.; C. J. Dale, Naval Research Laboratory; M. La Macchia, Motorola, Inc.

Proton and heavy-ion data on two GaAs HIGFET logic families - one source coupled (SCFL) and the other complementary (C-HIGFET) - show the importance of dynamic testing and develop a new technique for mitigating SEU sensitivity.
- 11:35 AM LUNCH



SESSION E RADIATION METROLOGY AND FACILITIES

1:15 PM

Session Introduction

Chairman: Patrick Griffin, Sandia National Laboratories

E-1

1:20 PM

MOSFET Dosimeters: The Role of the Capsulation on the Dosimetric Characteristics in Mixed Gamma-Neutron and Megavoltage X-ray Fields

A. B. Rosenfeld, M. G. Carolan, University of Wollongong; B. J. Allen, St. George Hospital Cancer Care Centre; V. I. Khivrich, Institute for Nuclear Research

Limitations and advantages of MOSFET dosimeters with thick oxide for gamma dosimetry in mixed gamma-neutron fields are investigated. LiF epoxy covers can be used to avoid thermal neutron contributions to response.

E-2

1:35 PM

Adjoint Electron-Photon Transport Monte Carlo Calculations with ITS

L. J. Lorence, R. P. Kensek, J. A. Halbleib, Sandia National Laboratories; J. E. Morel, Los Alamos National Laboratory

A general adjoint coupled electron-photon Monte Carlo code for solving the Boltzmann-Fokker-Planck equation has recently been created. The applicability of the new code to radiation-interaction problems of the type found in space environments is demonstrated.

E-3

1:50 PM

Potential Enhancement of Warm X-ray Dose from a Reflexing Bremsstrahlung

T. W. L. Sanford, J. A. Halbleib, Sandia National Laboratories; G. Cooperstein, B. V. Weber, Naval Research Laboratory

The potential for generating intense bursts of warm x-rays using electron reflexing diodes on pulsed-power accelerators is evaluated with the TIGER Monte Carlo code and applied to two suggested Jupiter diode configurations.

E-4

2:05 PM

Radiation Response of FAMOS Transistor Arrays

D. R. Roth, P. J. McNulty, L. R. Craig, M. W. Savage, R. A. Reed, W. J. Beauvais, Clemson University; K. A. LaBel, NASA/Goddard SFC

A procedure is described for characterizing the radiation response of EPROMs using erase time which has potential applications to microdosimetry and the study of radiation damage to oxides.

2:20 - 4:00 PM
WISCONSIN ROOM

RADIATION EFFECTS DATA WORKSHOP

Chairman: Kenneth LaBel, NASA Goddard SFC

Authors will be present at posters to answer questions during this session. Workshop posters will remain up for individual viewing from Tuesday - Friday of the conference.

W-1

Trends in Device SEE Susceptibility from Heavy Ions

D. K. Nichols, J. R. Coss, K. P. McCarty, H. R. Schwartz, G. M. Swift, R. K. Watson, Jet Propulsion Laboratory; R. Koga, W. R. Crain, K. B. Crawford, S. J. Hansel, The Aerospace Corporation

A sixth set of heavy-ion single-event effects (SEE) test data has been collected since the last IEEE publications. SEE trends are indicated for several functional classes of ICs.

W-2 Single-Event Effect Proton and Heavy-Ion Test Results in Support of Candidate NASA Programs

K. A. LaBel, A. K. Moran, D. K. Hawkins, A. B. Sanders, E. G. Stassinopoulos, R. K. Barry, NASA/Goddard SFC; C. M. Seidleck, Hughes/ST Systems Corp.; H. S. Kim, Jackson and Tull Chartered Engineers, Inc.; J. Forney, SAIC; P. Marshall, SFA, Inc; C. Dale, Naval Research Laboratory

We present proton and heavy-ion single-event effect (SEE) ground test results for candidate spacecraft electronics. The variety of analog and digital devices tested includes ADCs, DC-DC converters, DRAMs, linear devices, and a microprocessor.

W-3 Single-Event Upset and Latchup Measurements in Avionics Devices using the WNR Neutron Beam

E. Normand, J. L. Wert, P.P. Majewski, W. B. Bartholet, D. L. Oberg, Boeing; M. Shoga, Hughes Aircraft; G. Woffinden, Amdahl Corp.; S. A. Wender, Los Alamos National Laboratory

The SEU upset rates for ARINC 429 receivers tested in the WNR atmospheric neutron beam agree with rates in memories, and neutron-induced latchup was measured in LCA 100 k and 200 k gate arrays.

W-4 Anti-fuse/FPGA Reliability in the Heavy-Ion Environment

R. B. Katz, NASA/Goddard SFC; G. M. Swift, Jet Propulsion Lab/CIT; R. L. Barto, INTELSAT

Direct evidence of dielectric anti-fuse failure as a result of heavy-ion irradiation has been obtained. Models, experimental data, and new analysis techniques are used to investigate the failure mechanism. New FPGA anomalies are uncovered.

W-5 Confirmation of Calculated Error Rates in an ASIC Chip using a Pulsed Laser

S. Buchner, SFA, Inc.; M. Baze, W. Bartholet, Boeing; J. Melinger, D. McMorrow, Naval Research Laboratory

Calculated error rates for SEUs propagating through an ASIC agreed with error rates measured with a pulsed laser.

W-6 An Experimental Method for the Analysis of Latching of Heavy-Ion Induced Transients

R. Johansson, P. Liden, P. Dahlgren, Chalmers University of Technology

This paper presents an experimental method for investigating the impact of particle-induced transients in combinational logic in CMOS circuits.

W-7 Heavy Ion, Proton, and Co-60 Radiation Evaluation of 16 MBit DRAM Memories for Space Application

R. Harboe-Sorensen, S. Fraenkel, ESA/ESTEC; R. Muller, T. U. Braunschweig

This paper presents the results of a heavy-ion, proton and Co-60 radiation evaluation program carried out on 15 commercially available 16 Mbit DRAMs representing eight manufacturers.

W-8 Radiation Effects in MICREL MIC4427 MOSFET Drivers

M. D. Skipper, K. Atkins, G. R. Hopkinson, Sira, Ltd.; K. A. LaBel, NASA/Goddard SFC

Results of Co-60 total dose and heavy-ion latchup testing indicate that the MIC4427 is suitable for use as a CCD clock driver in low-dose-rate space environments, up to a total dose of >50 krad(Si).

- W-9 Total-Dose and Heavy-Ion Evaluation of UC1806 Pulse Width Modulator from Unitrode**
J. P. Bensoussan, C. Barillot, P. Calvel, ALCATEL ESPACE; P. Poirot, Consultant
- A pulse width modulator, in BiCMOS technology, was evaluated for both total-dose and heavy-ion effects. Heavy-ion testing was performed in both static and dynamic modes.
- W-10 Radiation Evaluation of the 80C186 16-Bit Microprocessor Utilizing a Novel Technique for In-Situ Electrical Biasing and Characterization**
D. C. Shaw, C. I. Lee, Jet Propulsion Laboratory
- Functional dynamic tests for the 80C186 16-bit microprocessor from two manufacturers show failure levels that differ by more than a factor of ten.
- W-11 Total-Dose Characterization of the PACE SOS 1750A Microprocessor Chipset**
M. Regula, O. Pedersen, Daimler-Benz Aerospace AG; R. R. Konegen, Performance Semiconductor Corporation
- Total-dose characterization of Performance's CMOS 1750A microprocessor chipset built using both Westinghouse's standard SOS and radiation-hardened SOS processes and various wafers, including Sarnoff epi-layer on Aerorad 54416 sapphire wafers, is presented.
- W-12 Rad-Hard Successive Detection Microwave Logarithmic Amplifiers Employing GaAs Monolithic Chips using Heterojunction Bipolar Transistors**
L. Silverman, G. Kuchner, AEL Industries, Inc.; M. Jupina, Villanova University; P. Enquist, Research Triangle Institute
- A successive detection monolithic logarithmic amplifier was subjected to Co-60 radiation at 1 rad/s to a total-dose of 10^6 rad(Si). Only small changes in the bias point, linearity and output power compression point occurred.
- W-13 Low Noise and High Tolerance to Radiation Effects of Complementary Bipolar SOI IC Technology**
A. H. Pawlikiewicz, A. L. Bishop, R. C. Jerome, United Technologies Microelectronics Center
- The $1/f$ noise performance of an advanced complementary bipolar SOI process, ACUTE, is presented as a function of a total dose, device geometry and polarity as well as bias condition during irradiation.
- W-14 Radiation Hardness of a Commercial High-Temperature CMOS Process**
K. Neumeier, L. Hofter, S. Seitz, Fraunhofer-Institut für Festkörpertechnologie; H. P. Bruemmer, Consultant
- A commercial 2 μ m CMOS process was modified for high temperature applications. The major modifications were BESOI-substrate and trench isolation. A test chip, including logic and analog circuits, was irradiated up to 200 krad(Si).
- W-15 Investigation of Dose-Rate Effects on CMOS Submicron Technologies**
T. Corbiere, MATRA MHS; J. L. Venturin, CNES
- This study evaluates the dose-rate effects on circuits representative of the MATRA MHS state-of-the-art CMOS technology used for space parts manufacturing and provides recommendations for characterizing future new CMOS technologies.



W-16 CRRES Electron Omnidirectional Flux Models and CRRESELE Utility

D. H. Brautigam, J. T. Bell, Phillips Laboratory

This paper presents CRRES models of outer zone electron omnidirectional fluxes for a range of magnetosphere conditions. The software utility CRRESELE is used to estimate electron fluences measured for a specified orbit.

W-17 PL-GEOSpace: Three-Dimensional Visualization of the Dynamic Space Environment

G. P. Ginet, Phillips Laboratory; R. Biasca, Northeastern University; M. Tautz, Radex, Inc.

A description will be given of the PL-GEOSpace code constructed to facilitate assessment of the space hazards by bringing together many environmental models under the umbrella of a user-friendly and graphics-intensive master program.

W-18 Cold X-ray Simulation Capabilities at Phoenix

E. Nolting, L. Miles, J. Miller, V. Kenyon, III, W. Spicer, Jr., J. Draper, C. Parsons, F. Warnock, Naval Surface Warfare Center; A. Fisher, G. Peterson, Naval Research Laboratory; M. Krishnan, R. Prasad, G. Rondeau, Science Research Laboratory, Inc.; J. Fockler, P. Spence, P. Corcoran, Titan Pulse Sciences, Incorporated; J. Sethian, N. Pereira, Berkeley Research Associates, Inc.; R. Smith, Advanced Technology and Research

This paper describes the innovative techniques used in the development of the Phoenix radiation effects simulator as the DoD's premier multi-kilojoule cold x-ray source.

W-19 Large-Area Electron Beam Mode on Casino

J. D. Miller, J. Rosario, R. F. Schneider, E. E. Nolting, R. A. Stark, V. L. Kenyon, Naval Surface Warfare Center; J. D. Sethian, Berkeley Research Associates, Inc.; K. T. Nguyen, Mission Research Corporation

A low-current-density ($500\text{--}1000 \text{ \AA}/\text{cm}^2$), large-volume (12" diameter by 12" long) electron beam capability to simulate soft X-ray environments for three-dimensional, cryogenically cooled objects is described.

4:00 PM End of Data Workshop



7:30 AM **REGISTRATION**
Holiday Inn Madison West, Trade Center Lobby
Continental Breakfast

INVITED PAPER Proton Radiotherapy - A New Technique or an Old Saw

8:15 AM *Paul M. DeLuca, Jr., University of Wisconsin*

In the late 1940's, Robert R. Wilson, in a seminal paper, outlined all the important aspects of the application of high-energy protons to the treatment of cancer. In the intervening decades, hundreds of individuals were treated; but no substantive effort to expand this technique to the greater population of patients was initiated. The convergence of high-performance computational resources, advanced 3-D imaging techniques, and distributed processing accelerator control facilities has now made proton therapy a promising possibility. Several aspects that are relevant and necessary to the success of proton cancer therapy will be discussed.

Paul M. DeLuca, Jr., is a Professor and Chairman of the Department of Medical Physics at the University of Wisconsin. He received his B.S. in Physics and Mathematics from LeMoyne College, Syracuse, NY, in 1966 and his Ph.D. in Nuclear Physics from the University of Notre Dame. He has published extensively on Dosimetry and Microdosimetry for use at medical radiation facilities. He has recently been active in characterizing the proton beams at Loma Linda University for use in cancer therapy.

SESSION F DESTRUCTIVE SINGLE-EVENT EFFECTS

9:15 AM **Session Introduction**

Chairman: James Kinnison, Johns Hopkins Applied Physics Laboratory

F-1 Effects of Ion Damage on IBICC- and SEU-Imaging

9:20 AM *F. W. Sexton, K. M. Horn, B. L. Doyle, M. R. Shaneyfelt, T. L. Meisenheimer, Sandia National Laboratories*

Ion-beam damage arising from microbeam techniques is addressed. IBICC imaging is degraded by both displacement and ionizing dose damage. Regions exposed to microbeams can become sensitive to upset with increasing dose accumulated during SEU imaging.

F-2 Simulation-Aided Hardening of N-Channel Power MOSFETs to Prevent Single-Event Burnout

9:35 AM *C. Dachs, J. M. Palau, J. Gasiot, Universite Montpellier II; F. Roubaud, Universite Antilles Guyane; P. Tastet, CNES*

A two-dimensional MEDICI simulator is used to investigate hardening solutions. Not only are carrier lifetimes reduced, base enlargement, and emitter doping decrease effects verified, but also simple p+ plug geometrical modifications are proposed and validated by simulation.

9:50 AM **Break**

F-3 Correlation of Picosecond Laser-Induced Latchup and Energetic Particle-Induced Latchup in CMOS Test Structures

10:20 AM *S. C. Moss, S. D. LaLumondiere, J. R. Scarpulla, K. P. MacWilliams, W. R. Crain, R. Koga, The Aerospace Corporation*

We show that there is an excellent linear correlation between latchup thresholds measured using picosecond laser pulses and energetic particles in CMOS structures designed for latchup characterization.



F-4
10:35 AM **Computer Simulated Predictions of SEGR Structural Dependence in Power MOSFETs**

M. Allenspach, I. Mouret, J. R. Brews, R. D. Schrimpf, K. F. Galloway, University of Arizona; J. L. Titus, Naval Surface Warfare Center; C. F. Wheatley, Jr., Consultant; R. L. Pease, RLP Research, Inc.

The dependence of SEGR sensitivity in VDMOS power transistors on oxide thickness was investigated through 2-D simulation and verified experimentally. Increasing the oxide thickness is an effective hardening technique for SEGR.

SESSION G
SPACE SINGLE-EVENT EFFECTS

10:50 AM Session Introduction

Chairman: E.G. Stassinopoulos, NASA Goddard

G-1
10:55 AM **Single Event Upset Rates on 1 M and 256 k Memories: CRUX Experiment on APEX**

J. Adolphsen, UNISYS; E.G. Stassinopoulos, J. Barth, K. A. LaBel, NASA/Goddard SFC; C. M. Seidleck, Hughes/ ST Systems Corp.

Variations in single-event upset rate due to altitude, L-shell parameter, and physical locations of devices from the CRUX and CREDO experiments on APEX are compared to results from the CRRES, SAMPEX, and TOMS satellites.

G-2
11:10 AM **Measurement of the Radiation Environment from LEO to GTO Using the CREAM and CREDO Experiments**

C. S. Dyer, A. J. Sims, P. R. Truscott, C. Peerless, C. Watson, Defence Research Agency

The Cosmic Radiation Environment and Dosimetry experiment on STRV-1a is monitoring the radiation environment in GTO and in conjunction with similar detectors in LEO affords coverage of the whole magnetosphere.

G-3
11:25 AM **Influence of Solar Cycle on Spot-1, -2, -3 Upset Rates**

R. Ecoffet, M. Prieur, M. F. Del Castillo, CNES; S. Duzellier, D. Falguere, CERT/ONERA

Upset data from SPOT computer memories, covering a complete solar cycle, are compared with predictions for galactic and solar cosmic rays. The most critical periods are the transitions between phases of the cycle.

G-4
11:40 AM **SEU Results from the Advanced Photovoltaic and Electronics Experiments (APEX) Satellite**

E. G. Mullen, K. P. Ray, Phillips Laboratory; R. Koga, The Aerospace Corporation

A solid state tape recorder of the APEX satellite recorded SEUs in its memory chips. SEU rates and locations are compared to in-situ particle measurements, ground testing of the same devices, and radiation model data.

11:55 AM LUNCH

G-5
1:15 PM **SEE Rate Calculations using the Effective Flux Approach**

E. Petersen, Consultant

This paper explains the inconsistencies reported between effective flux calculations and integral rectangular parallelepiped calculations. The two types of calculation yield consistent results when the effective flux calculation is performed allowing for the appropriate geometry.



SESSION H SPACECRAFT ENVIRONMENTS AND EFFECTS

1:30 PM

Session Introduction

Chairman: Jason Wilkenfeld, S-Cubed

H-1

1:35 PM

"Super Storms" from 1932 to 1993 and How They Relate to New Radiation Belts

J. T. Bell, M. S. Gussenhoven, E. G. Mullen, Phillips Laboratory; R. Hilmer, Boston University

Magnetic indices from 1932 to 1993 were used to select major magnetic storm periods. The storms were related to high-energy particle measurements to determine when and how often new radiation belts can form.

H-2

1:50 PM

Variations and Dynamics of MeV Electrons over a Solar Cycle as Measured by the DMSP J4 Detector

E. G. Mullen, M. S. Gussenhoven, Phillips Laboratory; E. Holeman, Boston College

Variations and dynamics of 2 to >5 MeV electrons over a complete solar cycle period from 1983 through 1994 are presented. Results will be related to periods of deep dielectric charging anomalies in space systems.

H-3

2:05 PM

The Low Altitude Edge of the Inner Radiation Belt: Dose Models from the APEX Satellite

M. S. Gussenhoven, E. G. Mullen, D. A. Hardy, P. Severance, Phillips Laboratory; D. Madden, E. Holeman, D. Delorey, Boston College; F. Hanser, Panametrics, Inc.

Dosimeter data from the APEX satellite in a 350 by 2500 km, 70°-inclination orbit are used to produce preliminary high-resolution dose models of the steep gradient edges of the inner belt.

H-4

2:20 PM

Evaluation of Space Radiation Modeling Uncertainties using LDEF Satellite Measurements

T. W. Armstrong, B. L. Colborn, Science Applications International Corporation; T. A. Parnell, J. W. Watts, Jr., B. A. Harmon, NASA Marshall Space Flight Center; E. V. Benton, E. R. Benton, University of San Francisco

Predictions to compare with dose, activation, and LET measurements made on the LDEF satellite have been made to evaluate the accuracy of current space radiation models for low-earth orbit applications.

H-5

2:35 PM

A New Solar Flare Particle Environment Model and Multiple-bit Single-Event Upset Rates

W. A. Kolasinski, T. J. Lie, The Aerospace Corporation

This paper proposes a new model for the solar flare particle environment, estimates multiple-bit SEU rates for an SRAM in that environment, and examines the effectiveness of shielding in reducing SEU rates.

2:50 PM - 5:00 PM

GENEVA ROOM

POSTER SESSION

Chairman: Fred Sexton, Sandia National Laboratories

Authors will be present during this session to answer questions. Posters will remain up for individual viewing from Tuesday - Friday of the conference.

PA: RADIATION EFFECTS IN DEVICES AND ICs

PA-1

Dose Rate Effects on MOS and Bipolar Circuits

J. Beaucour, T. Carriere, A. Gach, MATRA Marconi Space; B. Johlander, L. Adams, ESA/ESTEC

Total-dose testing of nine different part types of the major technological families were carried out in order to study dose-rate effects and annealing conditions. Practical implications for the ESA/SCC22900 test method are deduced.



PA-2 Dose-Rate Dependent 1/f Noise Performance of a GaAs Operational Amplifier

D. M. Hiemstra, SPAR Environmental Systems

Dose-rate dependent 1/f noise performance of a custom GaAs MESFET op-amp is presented. The noise degradation is believed to be due to electron trapping in deep levels, enhanced by backgating. Possible improvements are suggested.

PA-3 Radiation-Induced Degradation in Power MOSFETs

P. Mialhe, E. Bendada, M. de la Bardonnie, Universite de Perpignan; J. P. Charles, A. Hoffmann, Supelec

An innovative method for device characterization is proposed to qualify the radiation response of power MOSFETs.

PA-4 In-situ Measurements of Resistivity and Charge-Collection Efficiency on a Silicon Surface-Barrier Detector under Neutron Irradiation

I. Kanno, K. Kamitani, S. Kanazawa, I. Kimura, Kyoto University

In-situ measurements of resistivity and charge-collection efficiency of a silicon surface-barrier detector using fission fragments were performed under neutron irradiation. Even under 10^{12} n/cm² of neutron fluence, the charge-collection efficiency decreased.

PA-5 Simulating Total-Dose and Dose-Rate Effects on Digital Microelectronics Timing Delays Using VHDL

C. P. Brothers, R. D. Pugh, Phillips Laboratory

This paper describes a fast timing simulator based on VHSIC Hardware Description Language (VHDL) for simulating the timing of digital microelectronics in pre-irradiation, total-dose, and dose-rate radiation environments.

PA-6 A Fast, Low-Power CMOS Amplifier on SOI for Sensor Applications in a Radiation Environment of up to 20 Mrad

P. Aspell, F. Faccio, P. Jarron, E. H. M. Heijne, CERN; G. Borel, Thomson TCS

The design of a 480 mW, 17-ns rise time CMOS current mode amplifier in an SOI radiation-hard technology is presented. The amplifier performance is studied after 0, 10, and 20 Mrads of ionizing irradiation.

PA-7 A New Efficient Algorithmic-Based SEU Tolerant System Architecture

Y. Blaquiére, Université du Québec à Montréal; G. Gagne, Y. Savaria, C. Evequoz, École Polytechnique de Montréal

A new ABFT architecture is proposed to tolerate several SEU with low overheads. It memorizes operands on a stack upon error detection and corrects errors by recomputing.

PB: HARDNESS ASSURANCE AND TESTING TECHNIQUES

PB-1 Use of MOS Structures for Investigation of Low-Dose-Rate Effect in Bipolar Transistors

V. V. Belyakov, V. S. Pershenkov, A. V. Shalnov, I. N. Shvetzov-Shilovski, Moscow Engineering & Physics Institute

The use of conventional MOS transistors in bipolar mode for investigation of surface peripheral recombination current in bipolar transistors is presented. A physical mechanism for bipolar low-dose-rate response is proposed.

PB-2 Effect of Rapid Thermal Annealing on Radiation Hardening of MOS Devices

O. Flament, J. L. Leray, CEA; E. Orsier, J. L. Pelloie, R. Truche, CEA

The influence of RTA treatment on MOS radiation hardness is compared with classical furnace treatment. Dose response is more dependent on time-related properties of the oxide such as the viscous flow than on maximum temperature.

PC: BASIC MECHANISMS OF RADIATION EFFECTS

PC-1 Effect of Electron Traps on Reversibility of Annealing

V. S. Pershenkov, V. V. Belyakov, S. V. Cherepko, Moscow Engineering & Physics Institute; A. Y. Nikiforov, Specialized Electronics Systems; V. N. Ulimov, V. V. Emelianov, Research Institute of Scientific Instruments

The kinetics of rechargeable radiation-induced trap buildup are investigated. Experimental evidence is provided to show that the switching reversible annealing following irradiation is caused by filling and detrapping of the oxide shallow electron traps.

PC-2 Effects of Forming Gas, Nitrogen, and Vacuum Anneals on Interface and Oxide Traps in X-ray Irradiated MOS Transistors

M. P. Pagey, R. J. Milanowski, K. T. Henegar, B. L. Bhuva, L. W. Massengill, S. E. Kerns, Vanderbilt University

The effects of radiation-intensive lithography and three different anneal treatments on nMOS hot-carrier vulnerability have been studied. Nitrogen anneal was found to be most effective in annealing the radiation-induced damage.

PC-3 Field-Oxide Edge Leakage in N₂O Oxynitride Transistors Following Irradiation

R. B. Klein, SFA, Inc.; N. S. Saks, Naval Research Laboratory; Y. Okada, P. J. Torbin, Motorola

The post-irradiation source-to-drain edge leakage in transistors with N₂O oxynitride and SiO₂ gate insulators is compared. The increased edge leakage in oxynitride arises from reduced charge compensation in the oxynitride FET.

PC-4 Trap Precursor Formation in Si-SiO₂ Induced by High Temperature Annealing in Hydrogen

S. N. Kuznetsov, V. A. Gurtov, Petrozavodsk University

The Si-SiO₂ interface states and the trapped oxide charges generated by X-ray irradiation are examined for MOS capacitors with a postoxidation anneal in molecular hydrogen over a temperature range of 800 - 1300 K.

PC-5 Irradiation Effects on Ge-H, Al-H and Other H-Related Point Defects in Cultured Quartz Crystals

H. Bahadur, National Physical Laboratory

Irradiation effects on Ge, Al, and other H-related point defects in quartz were investigated. Irradiation at 77 K in prior 300 K-irradiated Ge-doped samples showed a novel defect center absorbing at 3400 cm⁻¹.

PC-6 Influence of Doping by Germanium on Defect Creation in Silicon

L. I. Khirunenko, V. I. Shakhovtsov, V. V. Shumov, V. I. Yashnik, Academy of Sciences

Doping with germanium decreases the formation of radiation defects in Si. Germanium atoms are apparently annihilation centers of primary radiation defects in Si.

PD: NON-DESTRUCTIVE SINGLE-EVENT EFFECTS

PD-1 SEE Results using High-Energy Ions

S. Duzellier, D. Falguere, CERT/ONERA; R. Ecoffet, CNES; J. Buisson, CEA

Tests on submicron SRAMs and DRAMs using two accelerators, one low-energy, the other high energy, show that low-energy data overestimate the sensitivity for modern devices with small sensitive volumes and low LET thresholds.

PD-2 Ion-Induced Charge Collection and SEU Sensitivity for Emitter Coupled Logic Devices

R. Koga, W. R. Crain, S. J. Hansel, K. B. Crawford, J. F. Kirshman, The Aerospace Corporation

Selected Emitter Coupled Logic (ECL) devices have been used to investigate their vulnerability to single-event effects. Explanations for the high sensitivity to single-event upset for both SRAMs and Flip-Flops are provided.

PD-3 Single Event Upsets in Gallium Arsenide Pseudo-Complementary MESFET Logic

D. J. Fouts, K. Wolfe, S. Van Dyk, U.S. Naval Postgraduate School; T. Weatherford, SFA, Inc.; D. McMorrow, A. B. Campbell, Naval Research Laboratory

Measurements of the SEU sensitivity of GaAs Pseudo-Complementary MESFET Logic are described. This new type of high-speed, low-power logic provides improved tolerance to SEUs with existing fabrication processes over traditional circuit designs.

PD-4 Comparison of Charge-Collection Measurements in Silicon and InGaAs Irradiated by Energetic Protons and Neutrons

E. Normand, D. L. Oberg, J. L. Wert, P. P. Majewski, Boeing; G. A. Woffinden, Amdahl, S. Satoh, K. Sasaki, Fujitsu; M. G. Tverskoy, V. V. Miroshkin, Petersburg Nuclear Physics Institute; N. Goleminov, Moscow Engineering & Physics Institute; S. Wender, A. Gavron, Los Alamos National Laboratory

A variety of charge-collection measurements by energetic protons and neutrons have been measured and compared. These include deposition in small silicon junctions, large volume American and Russian silicon surface barrier detectors, and InGaAs photodiodes.

PD-5 Effects of Geometry on the Proton SEU Dependence on Angle of Incidence

R. A. Reed, P. J. McNulty, Clemson University

Simulations of proton-induced spallation reactions show that the shape of the sensitive volume determines the variation of SEU cross section with angle of incidence. The simulation results are consistent with published experimental measurements on surface barrier detectors.

PD-6 Dependence on Angle of Incidence for Neutron-Induced SEU

K. G. Kindall, D. R. Roth, P. J. McNulty, R. A. Reed, Clemson University

The charge-collection spectra measured in a bipolar memory device with a well-defined sensitive volume exposed to Pu/Be neutrons exhibits a strong dependence on angle of incidence.

PD-7 Some Aspects of Application of the Two-Parameter SEU Model

V. V. Miroshkin, M. G. Tverskoy, Petersburg Nuclear Physics Institute

Influence of the projectile type, pion production in nucleon-nucleon interactions, and angle of incidence on SEU cross section for the INTEL 2164A microcircuit within a framework of the two-parameter model is investigated.



PD-8 Application of a Diffusion Model to SEE Cross Sections of Modern Devices

E. C. Smith, Consultant; E.G. Stassinopoulos, K. LaBel, NASA Goddard Space Flight Center; G. Brucker, Consultant; C. M. Seidlick, Hughes/ST Systems Corp.

A model for SEE cross sections based on the theory proposed by Kirkpatrick in 1979 appears to explain discontinuities in measured cross-section data.

PD-9 SEU Fault Tolerance in Artificial Neural Networks

R. Velazco, A. Assoum, N. E. Radi, LGI/IMAG; R. Ecoffet, CNES; X. Botey, Universitat Politecnica de Catalunya

This paper investigates the SEU sensitivity of three digital integrated circuits designed to implement artificial neural networks (ANN). Results prove that ANN have an intrinsic fault tolerance against errors produced by heavy particles.

PE: RADIATION METROLOGY AND FACILITIES

PE-1 An Exact Treatment of Self-Shielding and Covers in Neutron Spectrum Determinations

P. J. Griffin, J. G. Kelly, Sandia National Laboratories

This paper provides an exact methodology for treating dosimeter self-shielding and the scattering effects in sensor covers. The difference with conventional approaches is on the order of 10%.

PE-2 Characterization and Qualification of a Neutron Irradiation Environment for Neutron Hardness Assurance Testing of Electronic Devices

J. S. Bennion, Idaho State University; G. M. Sandquist, University of Utah; J. G. Kelly, P. J. Griffin, Sandia National Laboratories; P. S. Sheehan, B. L. Saxey, TRW, Inc.

The neutron environment of a facility designed for hardness assurance testing of electronic parts is characterized by a DoD certified neutron source.

PE-3 Analytic Approximation for Charge Deposition Profile by 0.1 to 100 MeV Electrons in Thick Slabs

A. R. Frederickson, Phillips Laboratory; E. A. Beidl, MIT

An analytic approximation is developed for current penetration and charge deposition with normal incidence high-energy electrons. Adjustable parameters are evaluated to fit the approximation to tabulated ITS Monte Carlo and experimental electron-deposition data.

PF: DESTRUCTIVE SINGLE-EVENT EFFECTS

PF-1 Implications of Single-Event Characterization of DC-DC Converters and a Solid State Power Switch

K. A. LaBel, R. K. Barry, K. Castell, NASA/Goddard SFC; H. Kim, Jackson and Tull Chartered Engineers, Inc.; C. M. Seidlick, Hughes/ST Systems Corp.

As part of NASA/GSFC's efforts in supporting spaceflight qualification for multiple programs, single-event effect (SEE) characterization of various DC-DC power converters, as well as solid state power switches (SSPS), was undertaken.

PF-2 Impact of Oxide Thickness on SEGR: Development of a Semi-Empirical Expression

J. L. Titus, Naval Surface Warfare Center; C. F. Wheatley, Consultant; D. I. Burton, Harris Semiconductor; M. Allenspach, J. Brews, R. Schrimpf, K. Galloway, I. Mouret, University of Arizona; R. L. Pease, RLP Research, Inc.

The impact of gate oxide thickness on SEGR is experimentally determined using specially fabricated power MOSFETs having identical structures, except the gate oxide thickness. From these data, a semi-empirical expression is developed and demonstrated.

PG: SPACE SINGLE-EVENT EFFECTS

PG-1 IBM Thinkpad Radiation Testing and Recovery During EUROMIR Missions

M. Martignano, R. Harboe-Sorensen, ESA/ESTEC

During the EUROMIR '94 flight, an SEU experiment was conducted to evaluate the suitability of a commercial notebook computer, the IBM ThinkPad 750C, for flight usage.

PG-2 The CESR Multi-Mission Radiation Monitor

M. Boer, J. Naya, J. P. Chabaud, CESR; R. Ecoffet, A. Baiget, M. Labrunee, CNES; P. Calvel, P. Reveret, Alcatel Espace

A radiation monitor has been designed for the spectroscopy of high-energy electrons and protons in the space environment, as well as SEU, with very good resolution.

PG-3 Effects of Target Fragmentation on Evaluation of LET Spectra from Space Radiation in Low-Earth Orbit (LEO) Environment: Impact on SEU Predictions

J. L. Shinn, F. A. Cucinotta, J. W. Wilson, NASA Langley Research Center; G. D. Badhwar, P. M. O'Neill, NASA Johnson Space Center; F. F. Badavi, Christopher Newport University

Linear energy transfer (LET) spectra behind aluminum shielding in low-earth orbit (LEO) space radiation environment are calculated using the HZETRN/BRYNTRN computer code. Contributions from target fragmentation are shown to affect SEU predictions significantly.

PG-4 Further Development of the Heavy Ion Cross Section for Single Event Upset Model (HICUP): Upset Rate Prediction

L. W. Connell, F. W. Sexton, A. K. Prinja, Sandia National Laboratories

The upset rate integral for HICUP is compared to the standard chord length method. Both methods are shown to be equivalent, but HICUP provides a more logical framework for packaging the upset parameters.

PH: SPACECRAFT ENVIRONMENTS AND EFFECTS

PH-1 A New Solar Flare Heavy-Ion Model and its Implementation through MACREE, an Improved Modeling Tool to Calculate Single-Event Effect Rates in Space

P. P. Majewski, E. Normand, D. L. Oberg, Boeing

A new solar flare heavy-ion model has been developed to support Space Station SEE evaluations. It shows good agreement with previous flare data and is implemented via an improved version of the CREME code.

PH-2 Integrated Environmental Monitoring System for Spacecraft

A. Bogorad, C. Bowman, A. Dennis, J. Beck, D. Lang, R. Herschitz, Lockheed Martin

A space environmental monitoring system that measures surface charging potential, internal charging flux, and total dose is described. This system, weighing one pound and requiring 0.5 W of power, was integrated on Martin Marietta's spacecraft.



PI: RADIATION EFFECTS ON PHOTONIC MATERIALS AND SYSTEMS

PI-1 Radiation Hardness of Optical Link Components

B. Dinkespiler, M. Jevaud, E. Monnier, C. Olivetto, S. Tisserant, Centre de Physique des Particules de Marseille; J. Collot, J. Y. Hostachy, P. de Saintignon, Institut des Sciences Nucleaires; J. P. Coulon, Laboratoire de L'Accelerateur Lineaire; E. Albertson, L. O. Eek, B. Lund-Jensen, J. Soderqvist, J. Wahlgren, Royal Institute of Technology

A study of radiation hardness (up to 5×10^{14} neutrons (1 MeV)/cm² and 1.5 Mrad) at 293 K and 89 K of LEDs (GaAs, InP) and multimode optical fibers in analog optical links, intended for use in a high-energy-physics experiment, is presented.

PI-2 Alpha Particle Simulation of Space Radiation Damage Effects in Semiconductor Devices

C. W. Colerico, H. B. Serreze, Spire Corporation; S. R. Messenger, SFA, Inc.; M. A. Xapsos, Naval Research Laboratory; E. A. Burke, Consultant

We describe a method to simulate effects of space radiation damage to semiconductor devices. By combining analytic and numerical techniques to data obtained from alpha exposures, device response to other radiation types can be predicted.

PI-3 Particle Dependence of the Gallium Vacancy Production in Irradiated n-Type Gallium Arsenide

S. M. Khanna, Defence Research Establishment Ottawa; A. Jorio, C. Carlone, M. Parenteau, Universite de Sherbrooke; A. Houdayer, Universite de Montreal; J. W. Gerdes, Jr., Aberdeen Proving Ground

The relative introduction rate of the gallium vacancy in n-type GaAs irradiated with Co-60, 7 MeV electrons, 14 MeV and 1 MeV neutrons, protons (0.6 to 200 MeV), and a variety of heavy ions has been determined.

PJ: ISOLATION TECHNOLOGIES

PJ-1 Radiation Hardness of the SOI3HD Technology for LHC Applications

A. Mekkaoui, P. Delpeirre, Centre de Physique des Particules de Marseille

New results are presented on the hardness of Thomson SOI3HD, an SOI rad-hard CMOS process, to protons (up to 23 Mrad(Si)) and neutrons (up to 6×10^{14} n/cm²).

PJ-2 Test CMOS/SOS RAM for Transient Radiation Upset Comparative Research and Failure Analysis

A. Y. Nikiforov, I. V. Poljakov, Specialized Electronic Systems

A test CMOS/SOS 512x8 with eight types of memory cells was designed and tested at high dose rates. The developed cell was found to be upset-free up to 2×10^{12} rad(Si)/s.

PJ-3 Characterization of a Fully Resonant, 1-MHz, 25-Watt, DC/DC Converter Fabricated in a Rad-Hard BCDMOS Technology

J. L. Titus, M. A. Gehlhausen, Naval Surface Warfare Center; J. C. Desko, Jr., T. T. Nguyen, K. E. Hollenbach, M. A. Shibib, D. J. Roberts, AT&T Bell Labs

AT&T's BCDMOS rad-hard process has been characterized, and a fully resonant 1-MHz, 25-Watt, DC/DC Converter has been demonstrated in total dose, dose rate, neutrons, and heavy ions.

5:00 PM End of Poster Session

5:30 PM Open Meeting
Michigan Room

7:30 AM **REGISTRATION**
Holiday Inn Madison West, Trade Center Lobby
Continental Breakfast

INVITED PAPER **The Ellipso Global Communications Satellite System: The Concept and the Orbits**

8:15 AM

Matthew J. Schor, Mobile Communications Holdings, Inc.

The Ellipso system design achieves low cost by minimizing the number of satellites necessary to cover the populated regions of the Earth. The minimum cost objective drives the optimum orbital altitude to levels within the Earth's Van Allen radiation belts. The radiation environments in the desired orbits are well characterized and primarily affect the solar arrays as well as the spacecraft electronics. Ellipso incorporates numerous approaches that mitigate the radiation effects and allows the construction of a global communications satellite system with unprecedented low operating costs.

Matthew J. Schor is the Lead Engineer for Spacecraft Systems at Mobile Communications Holdings, Inc., the developer of the Ellipso™ global communication satellite system. He is responsible for the design and development of Ellipso's innovative and lightweight communication satellite. Before his involvement with MCHI, Mr. Schor founded Eagle Eye Technologies, Inc., to develop miniaturized communication systems for low-earth orbiting satellite-based data transfer; was a Senior Spacecraft Engineer at W.J. Schafer Associates, Inc., supporting the Clementine lunar mapping and asteroid flyby mission, and was a Spacecraft Engineer at Defense Systems Inc., responsible for thermal design and radiation effects analysis for SDI's small satellites. Mr. Schor received a Fellowship from the U.S. Department of Energy under which he received an M.S. in Nuclear Engineering from MIT; received an MBA from the George Washington University, with specialization in Management of Technology; and holds a B.S. in Nuclear Engineering from the University of Virginia.

SESSION I **RADIATION EFFECTS ON PHOTONIC MATERIALS AND SYSTEMS**

9:15 AM

Session Introduction

Chairman: Cheryl Dale, Naval Research Laboratory; Gordon Hopkinson, Sira, Ltd.

I-1

9:20 AM

Effects of Electron Beam Irradiation on Transient Photoluminescence Measurements of GaAs and AlGaAs Double Heterostructures

S. C. Moss, L. F. Halle, D. C. Marvin, The Aerospace Corporation

We extract lifetime damage coefficients from transient photoluminescence measurements of carrier lifetime in III-V double heterostructures irradiated with energetic electrons. Advanced solar cells made from such materials degrade when exposed to the space radiation environment.

I-2

9:35 AM

Radiation Hardness and Defect Analysis of an X-ray Charge Coupled Device Detector

N. Meidinger, L. Struder, Max-Planck-Institut; H. Soltau, C. V. Zanthier, KETEK GmbH

Experimental analysis of the radiation hardness of a deep-depletion Charge Coupled Device for X-ray spectroscopy in ESA's cornerstone XMM satellite mission is reported. A theoretical model for predictions and solid state defect analysis is discussed.

9:50 AM

BREAK

I-3

10:20 AM

Radiation-Hardened Silicon-on-Insulator Photodiodes

N. M. Kalkhoran, F. Namavar, Spire Corporation; E. Burke, Consultant

N-on-P photodiodes were fabricated on bulk silicon and on silicon-on-insulator substrates produced using the SIMOX process. Although the optical quantum efficiencies were comparable, the SIMOX SOI photodiodes showed superior radiation hardness.



I-4
10:35 AM **Further Measurements of Random Telegraph Signals in Proton-Irradiated CCDs**

I. H. Hopkins, SIRA/UCL Postgraduate Centre; G. R. Hopkinson, Sira, Ltd

The probability/proton for creation of a defect showing TRS behavior is proportional to the elastic NIEL. A model is proposed, based on the reorientation of the PV center in a high electric field.

SESSION J
10:50 AM **ISOLATION TECHNOLOGIES**

Session Introduction

Chairman: Robert Pugh, Phillips Laboratory

J-1
10:55 AM **Trapping-Detrapping Properties of Irradiated Ultra-Thin SIMOX Buried Oxides**

P. Paillet, J.-L. Leray, J.-L. Autran, CEA; B. Aspar, LETI; A.-J. Auberton-Herve, SOITEC

Electron and hole trapping and detrapping have been investigated in new SIMOX buried oxides of different thicknesses (80 to 400 nm) after X-ray irradiation. Isochronal annealing and thermally stimulated current (TSC) results are presented.

J-2
11:10 AM **Charge Trapping Versus Buried Oxide Thickness for SIMOX Structures**

R. K. Lawrence, ARACOR; D. E. Ioannou, George Mason University; H. L. Hughes, B. Mrstik, Naval Research Laboratory; P. J. McMarr, SFA, Inc.

Charge trapping versus buried oxide thickness on various SIMOX buried oxides has been compared. A knee has been observed in the voltage shift versus buried oxide thickness relationship for low applied electric fields during irradiation.

J-3
11:25 AM **The Effect of Power Supply Voltage Scaling on Total-Dose Radiation Effects in Fully-Depleted MOS Transistors**

S. T. Liu, Honeywell; W. C. Jenkins, Naval Research Laboratory

The radiation-induced front channel threshold-voltage shift of fully-depleted MOSFETs is investigated as a function of power supply voltage from 5.5 to 1.2 V. The change in V_{th} decreases more slowly than the change in V_{DD} .

J-4
11:40 AM **Radiation Response of a High Performance Analog Bipolar Technology with Vertical NPN and PNP Polysilicon Emitter Transistors**

I. R. C. Post, R. C. Jerome, A. L. Bishop, United Technologies Microelectronics Center; W. E. Combs, Naval Surface Warfare Center

The radiation response of current gain and base/collector junction breakdown voltage for both npn and pnp polysilicon emitter bipolar transistors is investigated, along with the effect of processing parameters, critical dimensions, and design rules.

J-5
11:55 AM **SEU in SOI/GAA SRAMs**

P. Francis, G. Berger, J.-P. Colinge, Catholic University of Louvain

The SEU hardness of a 1 k GAA (Gate All Around) SRAM is demonstrated for low voltage applications.

12:10 PM **End of Conference**

Conference Information

INDUSTRIAL EXHIBIT

This year's Industrial Exhibit will feature the leading suppliers of radiation-hardened products, related materials, and services. The exhibit will be held in the Convention Room, which is adjacent to the atrium. The exhibit will be open from noon to 5:00 PM on Tuesday, July 18, and again that evening from 7:00 PM to 10:00 PM. The Tuesday evening session will also feature an exhibitor-hosted reception for attendees and their guests. The exhibits will open again on Wednesday morning, July 19, from 8:00 AM to 10:30 AM. Companies wanting additional information regarding exhibits should contact Twila D. Gamble or Teresa Farris at (719) 594-8035 or send E-mail to farris@utmc.utc.com. Late registration for exhibit booth space will be accepted.

PRE-REGISTERED EXHIBITORS

Actel Corporation
Boeing Radiation Effects Laboratory
Boeing Semiconductor Design Engineering
GEC Plessey Semiconductors
Harris Semiconductor
Honeywell Solid State Electronics Center
Ibis Technology Corporation
J.L. Shepherd & Associates
Loral Federal Systems Manassas
SiBOND, L.L.C.
SOITEC USA Inc.
Thomson Components & Tubes Corporation
Union Carbide Crystal Products
United Technologies Microelectronics Center

ROOMS FOR SIDE MEETINGS

Several meeting rooms are available for use by NSREC attendees during the conference week. Please contact the conference registration desk outside the Geneva Room to reserve a room for a side meeting. Arrangements for audiovisual equipment, refreshments, etc., should be identified so they can be relayed to the Holiday Inn. Requesters are personally responsible for settling accounts for such items during the conference. Contact Ken Hunt (Local Arrangements Chairman) at (505) 768-7626 to make advance meeting reservations.

MESSAGES

(608) 831-2000

Fax: (608) 831-2040

A message board will be located in the Holiday Inn in the lobby area outside the Geneva Room for all incoming messages during the Short Course and technical sessions. Faxes can be received through the hotel. Costs associated with faxes are the responsibility of the attendee.

RADIATION EFFECTS COMMITTEE OPEN MEETING

The IEEE Radiation Effects Committee will hold its Open Meeting in the Michigan Room from 5:30 PM to 7:00 PM on Thursday, July 20. All conference attendees are encouraged to attend the Open Meeting to discuss this 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 NPSS members present are eligible to vote. Refreshments will be provided.



Steering Group

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Peter S. Winokur
Sandia National Laboratories

Executive Vice-Chairman

Klaus G. Kerris
Army Research Laboratory

Secretary

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Army Research Laboratory

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Charles J. Utrias
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Vice Chairman, 1997 NSREC

Dennis B. Brown
Naval Research Laboratory

Special Publications Assignment

Paul V. Dressendorfer
Sandia National Laboratories

AdCom Members;

Deb M. Newberry
Computing Devices
International

Mayrant Simons
Research Triangle Institute

Burr C. Passenheim
Full Circle Research

James R. Coss
Jet Propulsion Laboratory

James P. Spratt
Full Circle Research

News from the Radiation Effects Steering Group (RESG)

The RESG met in Madison, WI, on November 8-9, 1994, at the site of the 1995 NSREC. Tim Oldham summarized the Tucson conference. Total registration for the conference was 433, which represents a decline of only 6 percent from 1993. The conference continues to have a strong international flavor with 74 registrants (17%) from countries other than the United States. There were 203 papers submitted to the conference with 141 accepted for presentation. Of these papers, 113 were accepted for publication in the December issue of the Transactions on Nuclear Science (TNS) which was mailed out in late December. Credit is due to the Editors (Ed Boesch, Ron Schrimpf, and Art Campbell), the reviewers, and the authors for making this process work without sacrificing the timeliness or quality of the December issue. In addition, the Radiation Effects Data (RED) Workshop Record (containing 17 papers) was mailed out in November, which achieves the stated intent of getting the data out to the community as quickly as possible. Our thanks to Dave Emily, the RED Workshop Chairman, for a job well done. Dale Platteter then reviewed final plans for the upcoming Madison conference. Many details of the 1995 NSREC are contained in this program booklet. In addition, Chuck Utrias discussed preliminary plans for his conference which will be held at the Stouffer Esmeralda Resort in Palm Springs, CA, July 15-19, 1996. Dennis Brown has accepted the RESG's invitation to serve as the 1997 NSREC General Chairman.

In its role of providing guidance and oversight of the activities of the Radiation Effects Committee (REC), the RESG is addressing the following issues.

1. The RESG supports increased use of electronic distribution for conducting business. In the future, look for electronic registration and, eventually, electronic submission of summaries.
2. An April 1996 special issue of the IEEE TNS on "Single-Event Effects and the Space Radiation Environment" will be co-edited by Dan Fleetwood of Sandia and Remi Gaillard of Nucleides SA, France.
3. Guideline documents for Guest Editor and Publicity have been completed, and an initial draft of the guideline document for Local Arrangements Chairman is in review.
4. Some changes have been proposed to Article II - Fields of Interest of the REC Constitution. These revisions were advertised in the Spring NPSS Newsletter and will be adopted unless 30 voting members of the REC object.
5. There is a continuing discussion regarding the future of the NSREC in light of cutbacks and reduced budgets in the field of radiation effects. The RESG feels these issues will largely be driven by the quantity and quality of technical papers submitted to the conference each year.
6. Dr. Lloyd Massengill of Vanderbilt has accepted the position of Assistant Guest Editor, beginning with the 1995 December issue of TNS.
7. A RADECS liaison position has been created to strengthen interaction and coordination between NSREC and RADECS. Philippe Calvel will serve in this position for a two-year term, beginning this summer.

The committee is dedicated to sustaining NSREC as a high-quality technical conference that offers attendees many opportunities for technical interchange, both formal and informal. We believe that the NSREC has been an important and valuable event for the radiation effects community and continues to be the premier radiation effects conference in the U.S. We welcome your input and suggestions—it is your conference and we want to properly serve your needs.

Peter S. Winokur
Chairman

Klaus G. Kerris
Executive Vice Chairman



1994 OUTSTANDING PAPER AWARD

Proton-Induced Charge Transfer Degradation in CCDs for Near-Room Temperature Applications

I. H. Hopkins, G. R. Hopkinson, and B. Johlander

1994 MERITORIOUS PAPER AWARDS

Effects of Burn-In on Radiation Hardness

M. R. Shaneyfelt, D. M. Fleetwood, J. R. Schwank, T. L. Meisenheimer, and P. S. Winokur

Physical Mechanisms Contributing to Enhanced Bipolar Gain Degradation at Low Dose Rates

D. M. Fleetwood, S. L. Kosier, R. N. Nowlin, R. D. Schrimpf, R. A. Reber, Jr., M. Delaus, P. S. Winokur, A. Wei, W. E. Combs, and R. L. Pease

Analysis of Neutron Damage in High-Temperature Silicon Carbide JFETs

F. B. McLean, J. M. McGarrity, C. J. Scozzie, C. W. Tipton, and W. M. DeLancey

IEEE FELLOWS

Two members of the radiation effects community were elected to the grade of IEEE Fellow on January 1, 1995. Certificates will be presented to them during the conference opening on Tuesday, July 18.

Paul V. Dressendorfer

Sandia National Laboratories

James C. Pickel

Maxwell Labs

IEEE MEMBERSHIP

There will be an IEEE membership desk in the registration area to make it easy for you to become an IEEE member. A representative will be available during registration hours to answer questions and explain the benefits of IEEE membership. If you join at the conference, you will receive a credit of \$27 towards your new half-year IEEE membership and a complimentary initial half-year membership in the IEEE Nuclear & Plasma Sciences Society. **Please note that, if you are currently not a member of the IEEE, you must register for the conference at the nonmember rate.**

CONTINENTAL BREAKFAST & COFFEE BREAKS

The 1995 NSREC will provide continental breakfast and refreshments at breaks during the Short Course and the Technical Sessions for registered short course and technical attendees only. Complimentary coffee is available for all hotel guests in the atrium bar area. A reasonably priced "all-you-can-eat" full breakfast is available at the Tiffany Grill, also located in the hotel atrium.

Registration and Travel

CONFERENCE REGISTRATION

ETC Services, Inc.
7731 South Cove Circle
Littleton, CO 80122
(303) 770-2055
Fax: (303) 741-5890

To preregister, complete the Conference registration form enclosed in this booklet. Please note that the registration fees are higher for all registrations received after June 15, 1995.

Mail the Conference registration form with your remittance to ETC Services, Inc. Fax registrations will be accepted with credit card payment. Registrations should be mailed at least 10 days prior to the Conference, or arrangements should be made to hand carry fees for on-site registration. Telephone registrations will not be accepted.

Registration fees should be made payable to the "1995 IEEE NSREC" and must be in U. S. funds only. Advance payment of registration and activity fees should be by one of the following: (1) check made out in U. S. dollars and drawn on a domestically located bank, (2) U. S. Money Order, or (3) Mastercard, VISA, or American Express credit card. An additional 5% charge will be added to the registration and activity fees for credit card payments.

On-site registration for the Conference will be conducted outside the Geneva Room of the Holiday Inn Trade Center on the following schedule:

Sunday, July 16	6:00 PM - 9:00 PM
Monday, July 17	7:30 AM - 5:00 PM
	6:30 PM - 9:30 PM
Tuesday, July 18	7:30 AM - 5:00 PM
Wednesday, July 19	7:30 AM - 3:00 PM
Thursday, July 20	7:30 AM - 3:00 PM
Friday, July 21	7:30 AM - 10:00 AM

HOTEL RESERVATIONS

Holiday Inn Madison West
1313 John Q. Hammons Dr.
Middleton, WI 53562
(608) 831-2000
Fax: (608) 831-2040

The 1995 IEEE Nuclear and Space Radiation Effects Conference will be held at the Holiday Inn Madison West in Madison, Wisconsin. The Holiday Inn Madison West is a hotel, convention, and trade center with meeting space for 2000 people located near the major shopping and dining area of suburban Madison. The hotel features a ten-story garden atrium and waterfall, a well-equipped exercise room, an indoor pool, sauna, and whirlpool. NSREC will have access to the entire hotel and meeting space during the conference period, providing an excellent environment for technical interactions and discussions. The conference has reserved 250 rooms; 100 are available at the prevailing Government rate (\$59) plus tax **with proof of Government employment**, and 150 are available at \$79 (including tax).

Alternate Hotels

Budgetel Inn • 8102 Excelsior Dr. • Madison, WI 53717
(608) 831-7711 • Fax: (608) 831-1942

The Budgetel Inn is located approximately one-half mile from the Holiday Inn, has a large domed pool, and offers a free continental breakfast. A conference rate of \$55 (including tax) is guaranteed for 80 rooms.

Best Western WestTowne Suites • 650 Grand Canyon Dr. • Madison, WI 53719
(608) 833-4200 • Fax: (608) 833-5614

The Best Western WestTowne Suites is an easy two-mile drive from the Holiday Inn. It offers a full breakfast and a drink and snacks in the evening to all guests. A conference rate of \$66 (including tax) is guaranteed for 50 suites.

Radisson Inn Madison • 517 Grand Canyon Dr. • Madison, WI 53719
(608) 833-0100 • Fax: (608) 833-6543

The Radisson is next to the Best Western WestTowne Suites. A conference rate of \$66 (including tax) is guaranteed for 80 rooms. Use of a nearby health club is offered to all guests for a minimal charge.

The cut-off for room reservations is June 15, 1995. After June 15, room accommodations will be confirmed on a space-available basis only; and the conference rate cannot be guaranteed. Be sure to reference "The IEEE NSREC" when you call to make reservations. No hotel registration form is provided in this brochure.



TRANSPORTATION TO MADISON

The Dane County Regional Airport in Madison is served by American, Delta, Midwest Express, Northwest, TWA, United Airlines, and USAir and is located 15 miles from the Conference and backup hotels.

You can also fly to the Conference through Milwaukee (80 miles away), Chicago (150 miles away), or Minneapolis (280 miles away). You may find this more economical and an enjoyable way to see more of the Upper Midwest during a leisurely drive to and from the Conference.

Airline Discount

UNITED AIRLINES, in cooperation with the IEEE Nuclear and Space Radiation Effects Conference, is offering a special rate to Dane County Airport in Madison. These rates are based on United's published round-trip fares within the United States.

- Travel dates are between July 14 and July 25, 1995. Destination is Madison only. United offers eight flights between Chicago and Madison daily.
- A 5% discount off any United or United Express published fare in effect when tickets are purchased, subject to all applicable restrictions.
- A 10% discount off applicable BUA fares in effect when tickets are purchased seven days in advance.

To take advantage of this discount, follow these simple steps: Call United, or have your travel agent call, at (800) 521-4041 for reservations 7:00 AM - 1:00 AM EST - Daily. **Reference ID#578EC.**

Madison Ground Transportation

All major automobile rental agencies are represented at the airport. The Holiday Inn and Radisson Inn have limited free shuttle service available, but arriving travelers should call ahead to arrange for the shuttle to be at the airport. Taxi service is approximately \$15 per person each way. Limousine service is available through Black Tie Limousine (608-222-0202) at \$40 per trip (maximum 3 people) or \$50 per trip (maximum 6 people).

Directions from the Madison Airport

The Conference and backup hotels are located approximately 15 miles from the Dane County Regional Airport. At the first traffic light after exiting the airport, turn right onto Packers Avenue. Take Packers north 1/4 mile to Northport Drive, which angles off to the left (north-west). Follow Northport for two miles to the light at county Highway M. Turn left on M and follow it west for seven miles to the light at West Beltline Highway (US 12). Turn left (south) and follow US 12 to all the hotels.

Holiday Inn: 1 mile on US 12 to Greenway Exit.

Budgetel: 1.5 miles on US 12 to Old Sauk Road Exit.

Radisson & Best Western: 3 miles on US 12 to Gammon Road Exit.

To reach the Radisson or Best Western from the Gammon Road exit, turn left under US 12 to the first stoplight at Odana Road. Turn right and proceed for two blocks to the second intersection at Grand Canyon Road. Turn right on Grand Canyon. The Radisson is on your left; and a short distance further, the Best Western is on your right.

Maps of Madison and the hotel area are included at the end of this brochure for your assistance.

1995 IEEE NSRE Conference and Short Course Registration Form

*Last Name, First Name, Middle Initial

*Company or Agency

*Preferred Mailing Address

Mail Stop

*City, State, Zip Code, Country

*Telephone Number

FAX Number

E-mail/Internet Address

IEEE Member Number

Name as it will appear on badge (if different from above)

Accompanying Persons:

Name

Please list ages
for children under
age 21 only

Name

Age

Name

Age

Name

Age

REGISTRATION FEES:

(Late fee REQUIRED if received after June 15, 1995)

	IEEE Member		Non-IEEE Member		
	Early	Late	Early	Late	
Short Course	\$200	\$225	\$225	\$250	\$ _____
Technical Sessions	\$250	\$325	\$325	\$400	\$ _____

Full-Time Students: **

Short Course	\$50	\$ _____
Technical Sessions	\$80	\$ _____

REGISTRATION TOTAL:

\$ _____

* As you want it to appear in the Conference List of Attendees.

** To qualify for reduced conference rates, you must be a full-time Student and an IEEE member.

Mail or FAX both pages of this form and your remittance to:

ETC Services, Inc.
7731 South Cove Circle
Littleton, CO 80122
Telephone: (303) 770-2055
FAX: (303) 741-5890

REGISTRATION FOR CONFERENCE ACTIVITIES

Cost Number Total
Attending Cost

Conference Reception July 17

Adult: \$0 _____

Child: \$0 _____

Child Care: \$0 _____

City and Garden Tour July 18

Adult: \$20 _____ \$ _____

Child: \$10 _____ \$ _____

State Street Shopping July 19

Adult: \$5 _____ \$ _____

Child: \$5 _____ \$ _____

Conference Social Henry Vilas Zoo July 19

Adult: \$25 _____ \$ _____

Child: \$10 _____ \$ _____

House on the Rock July 20

Adult: \$25 _____ \$ _____

Child: \$15 _____ \$ _____

ACTIVITIES TOTAL:

_____ \$ _____

(Notes: Child rates are for ages 3-11. Children must be accompanied by an adult during all tours and social events.)

Total Amount Enclosed for Registration: \$ _____

Total Amount Enclosed for Activities: \$ _____

Add 5% if Credit Card Payment: \$ _____

TOTAL AMOUNT ENCLOSED: \$ _____

Payment: (See instructions on reverse side)

☐ Enclosed is check or money order in U.S. DOLLARS ONLY.
Payable To: **1995 IEEE NSREC**

☐ Payment by Credit Card

CREDIT CARD PAYMENT:

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!

☐ Charge Registration Fees plus 5% to my:

☐ American Express ☐ Master Card ☐ Visa

Card No. _____ Exp.Date _____

Cardholder Signature _____

INSTRUCTIONS FOR PAYMENT OF FEES

Registration fees should be made payable to the 1995 IEEE NSREC and must be in **U.S. funds only**. Advance payment of registration and activity fees should be by check made out in U.S. dollars and drawn on a domestic bank, by U.S. Money Order, or by one of the following credit cards: American Express, Master Card, or Visa.

Payment for fees at the conference must be in U.S. funds and by check drawn on a U.S. bank, cash, traveler's checks, or by one of the following credit cards: American Express, Master Card, or Visa. An additional 5% charge will be added to the registration and activity fees for credit card payment.

CANCELLATIONS:

A \$25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration and activity fees requested after July 3, 1995, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.

CHILD CARE INFORMATION

Child Care will be provided for the Monday night Conference and Registration Reception only. This will be available at the Holiday Inn at no charge for those who preregister their children (including their ages) on the registration form. For those who wish to arrange for child care at other times during the conference, information on local services will be available at the registration desk.

Social Program

The 1995 NSREC Committee will provide a program that gives you and your companions a taste of the city as well as the country around Madison. We strongly encourage early registration for the social events. Note that child rates are for ages 3-11. Children must be accompanied by an adult during all tours and social events.

Sunday, July 16 **Short Course Reception**

A welcome reception will be held Sunday evening for all Short Course attendees. Registration begins Sunday evening and is open during the Reception, 6:00 PM - 9:00 PM, Geneva Room.

Monday, July 17 **Conference and** **Registration Reception**

A complimentary reception will be held for all conference attendees and their companions in the Holiday Inn Conference Center adjacent to the atrium. The ethnic diversity of the Madison area will be emphasized at the conference reception. This reception will welcome attendees to Madison with food and music of the area. Don't miss the opportunity to renew old friendships and start new ones. The registration desk will be open during the conference reception, 7:00 PM - 9:30 PM, Convention Room.

Tuesday, July 18 **City and Garden Tour** *Companion Event*

There is no better way for your companions to start their week in Madison than to take an informative and entertaining tour of the city. You will begin the day with a bus tour of the downtown and university, learning about the history and culture of the area. Ask your guide about shopping, entertainment, or restaurants. The grandeur of the recently refurbished State Capitol will amaze you during a guided walking tour of that landmark. Lunch will be served in the lush setting of the Olbrich Botanical Gardens and Conservatory, and a luncheon speaker will tell you more about this unique area of the country. Located near downtown Madison on the shores of Lake Monona, Olbrich Gardens features 14 acres of outdoor specialty gardens, including the rose, herb, butterfly, perennial, rock, and All-America annual gardens. The Conservatory is a sunny, 50-foot-high glass pyramid housing a diverse tropical collection of ferns, palms, and flowering plants growing in a naturalized setting, complete with 25-foot waterfall. After ample time for a stroll of the Gardens, the buses will return you refreshed and ready to see more of Madison and Wisconsin. Buses will depart from the main entrance of the Holiday Inn at 9:00 AM and return to the Holiday Inn at 3:00 PM. Adults \$20, Children \$10.

Wednesday, July 19 **State Street Shopping** *Companion Event*

This is a convenient and inexpensive way to spend some time exploring the center of activity in downtown Madison. We will provide bus transportation to and from the State Street area where you can shop (window or serious), visit museums, or just enjoy a leisurely lunch. Depart from the main entrance of the Holiday Inn at a civilized hour (10:00 AM) and return to the Holiday Inn at 2:00 PM, in plenty of time to freshen up for the conference social at the zoo. Adults/Children \$5.

Wednesday, July 19 **Conference Social** **"This Place is a Zoo!"**

Good old-fashioned fun at the zoo will be the theme for this year's conference social. Attendees and guests will board buses at the Holiday Inn starting at 5:00 PM to travel the short distance to the Vilas Zoo. The zoo is a medium-size facility with a surprisingly large assortment of animals and birds, big and small. The spacious surrounding park and sandy beach are located on the shore of Lake Wingra. Volleyball will be set up to satisfy the competitive urge, and animal handlers and jugglers will circulate to entertain during even the most serious technical discussions. A giant tent will seat all of our group for a sumptuous dinner and make-your-own sundae bar. We will be entertained by the Torpedoes, who will knock your bobby socks off with a 50s-60s show. The band will continue to provide Oldies tunes after dinner for those who want to rock the night away, or you can spend some more time strolling the zoo grounds. Buses will shuttle guests back to the hotel from 7:30 PM to 10:00 PM. Adults \$25, Children \$10.

Thursday, July 20
House on the Rock
Companion Event

The House on the Rock is one of Wisconsin's most fascinating and well-known attractions. Mere words cannot describe this incredible place. House on the Rock is a combination of a one-of-a-kind house built atop a 60-foot column of rock, connected to what is now a 40-acre complex of displays, exhibits, and gardens. You will be overwhelmed by the intricate collections of the antique and the unique, all the slightly-wacky life work of Alex Jordan. Buses will depart from the main entrance of the Holiday Inn at 9:15 AM and take you to the House near Spring Green. Your ticket will admit you to the House itself and the complex of interconnected showrooms and exhibits to explore at your leisure. You can purchase lunch at any of the three eating facilities conveniently located throughout the complex and visit a variety of gift and specialty shops at the end of the self-guided tour. **Due to the architectural design of the House, wheelchairs are not able to reach the main house. However, the majority of the tour is accessible by wheelchair. Strollers are not allowed on the tour; baby carriers are recommended.** Reboard the buses at 3:30 PM for the trip back to Madison. 9:15 AM - 4:30 PM. Adults \$25, Children \$15.



CHILD CARE

Child care will be provided for the Monday night Conference and Registration Reception only. This will be available at the Holiday Inn at no charge for those who preregister their children (including their ages) on the registration form. For those who wish to arrange for child care at other times during the conference, information on local services will be available at the registration desk.

Madison Area

GENERAL INFORMATION

Arts and entertainment, ethnic traditions, urban sophistication, and youthful spirit await you in Madison. This progressive, cosmopolitan city is home to a world-class university; the seat of state government; and an electric atmosphere that energizes any visitor's stay. Named Money Magazine's **"2nd Best Place To Live In America"** last year, Madison is also one of this country's best places to visit!

Known for its beauty and small-town friendliness, Madison boasts a one-of-a-kind Midwestern isthmus stretching between Lake Mendota and Lake Monona. The majestic State Capitol stands prominently in the heart of the isthmus. The University of Wisconsin-Madison campus is a short stroll away down State Street, which is lined with a collection of restaurants, specialty shops, bookstores, cafes, galleries, museums, and boutiques.

The 1995 conference will be held just a few miles west of downtown Madison. West Madison and the "bedroom community" of Middleton are truly the growth areas of Madison. New housing areas, office complexes, and shopping centers abound. Rolling hills border the area, and Wisconsin's famed dairy farms are just a few minutes' drive away.

New Glarus Mineral Point

These two small communities, a short 20-mile drive from your hotel, are examples of the many towns around Madison that attract visitors to a unique blend of crafts, antiques, and displays centered around the diverse European ethnic cultures represented throughout southern Wisconsin. New Glarus is known as "America's Little Switzerland." Original and replica buildings provide authentic settings to view Swiss pioneer life. Mineral Point was settled by Cornish miners during the region's "lead rush" of 1830. Miners lived in crude dugouts called "badger holes," thus leading to Wisconsin's nickname, "the Badger State."

Little Norway

An outstanding and unique collection of Norse antiques has been assembled in this homestead of an early Norwegian settler. The museum is nestled in a tiny wooded valley among the foothills of Blue Mounds. The original cabins, built in 1856, have been preserved and are furnished with the arts and crafts of the pioneer. The "Norway Building," built in Norway for Chicago's Columbian Exposition of 1893, is a fine example of ancient Norse church architecture. This building contains an impressive and colorful collection of folk objects from both Scandinavia and America.

Cave of the Mounds

Explore the natural treasure and wonderful fun of these magnificent caverns, with their jewel-like stalactites and stalagmites that were created millions of years ago by the earth's natural processes. A long-buried treasure, the Cave was discovered in 1939 when a quarry blast revealed the entrance to this sparkling, underground fairyland. A tour of the Cave, viewing the spectacular shimmering water pools, is an awe-inspiring, entertaining, and educational experience for the whole family.

Taliesin

Frank Lloyd Wright's Wisconsin home is considered by many to be his greatest architectural achievement. Built in 1911 on the brow of a hill overlooking the Wisconsin River, this remarkable building was Wright's home, workshop, laboratory, and retreat for nearly 50 years. From his Taliesin studio, he created works of architecture that changed the way America lived and worked. You can take one or more of the guided tours of Taliesin and several other Wright-designed buildings on the 600-acre property near Spring Green. Interior tours of the Taliesin residence are also available by reservation.

Circus World Museum

The Circus World Museum in Baraboo, one hour's drive from Madison, is the original winter quarters of the Ringling Bros. Circus. Step back into the golden days of the American circus with live big-top circus performances, magic shows, daily circus parades, demonstrations of historic circus operations, concerts, and exhibits, including the world's largest collection of antique circus parade wagons. **We recommend you visit after July 21, when the wagons will be back from their annual train trip to Milwaukee.**

Wisconsin Dells

This town, an hour north of Madison, is one of the most spectacular locations along the Wisconsin River and one of the state's premier vacation destinations. Named after the nearby seven-mile stretch of the river containing magnificent geologic formations carved from the Cambrian sandstone, Wisconsin Dells is a true family resort. You can take a leisurely boat tour or an action-packed trip on the "ducks"—WW II amphibious vehicles that go from land to water and back again with ease. Nowhere else in Wisconsin will you find such a wide variety of amusements to enjoy. There are midway rides, stage shows, outdoor performances, specialty shops, nightly entertainment, water parks (the world's largest), and miniature golf courses throughout town. You can even enjoy greyhound racing or Indian casino gambling nearby.

**TRAVEL
LITERATURE**

For free Wisconsin travel literature, please call the Wisconsin Division of Tourism (toll free, 24 hours) at 1-800-432-8747. Ask for the "Wisconsin Auto Tours Brochure." This brochure describes 24 road adventures with over 800 Wisconsin area attractions.

**WEATHER AND
CLOTHING**

Summertime can be one of the most pleasant seasons in Madison, consisting of pleasant temperatures and moderate humidity. High temperatures will range between 75°F to 85°F. Lows will be in the 60's. Be prepared for the occasional summer shower.

SPECIAL EVENTS

Several annual events are being held in the Wisconsin area, immediately before and after the conference. Come early and stay late!

The Great Circus Parade

Milwaukee, Wisconsin, Sunday, July 16, 2:00 PM. This free event, held on the streets of downtown Milwaukee, is the largest circus parade anywhere. Ringling Brothers and Barnum & Bailey Circus comes to town with over one hundred antique circus wagons, direct from their Circus World Museum. Accompanied by bands, brightly-colored costumed circus performers, and live exotic animals, this annual event is a must for the entire family. Call (414) 273-7877 for more information.

**Experimental Aircraft
Annual Fly-in**

Oshkosh, Wisconsin, July 27- August 2. The sky "comes alive" each year when over 2,500 experimental aircraft descend on Wittman Regional Airport. This is the ultimate dream for any aviation enthusiast. See the daily afternoon air show of homebuilts, antiques, classics, World War II era military warbirds, contemporaries, rotorcraft, seaplanes, and ultralights. Special half-price admission for pre-convention day, Wednesday, July 26th. Call (414) 426-4800 for more information.

1995 Conference Committee



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Lockheed Martin

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SFA, Inc.

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Applied Physics Laboratory

F. Barry McLean
Army Research Laboratory

George Messenger
Messenger & Associates

Isabelle Mouret
University of Arizona

Olivier Musseau
CEA

Karl Neumeier
Fraunhofer-Institute fur
Festkorpertechnologie

Eugene Normand
Boeing

Dennis Oberg
Boeing

Timothy Oldham
Army Research Laboratory

Philippe Paillet
CEA

Jean-Marie Palau
CEM, Universite Montpellier II

Burr Passenheim
Full Circle Research

Ron Pease
RLP Research

Jim Pickel
S-Cubed

Martin Ratliff
Jet Propulsion Laboratory

David Roth
Clemson University

Marty Shaneyfelt
Sandia National Laboratories

Munir Shoga
Hughes Aircraft

John Silver
United Technologies
Microelectronics Center

Eddy Simoen
IMEC

Mary Helen Sparks
Aberdeen Proving Ground

James Spratt
Full Circle Research, Inc.

Edward Taylor
Phillips Laboratory

Dennis Thompson
Eastman Kodak Company

David Vehar
Sandia National Laboratories

William Warren
Sandia National Laboratories

Steven Watts
Brunel University

Wes Will
Boeing

John Williams
University of Arizona

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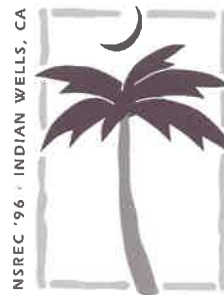
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ANNOUNCEMENT and FIRST CALL FOR PAPERS



1996 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE Short Course and Radiation Effects Data Workshop

July 15-19, 1996
Stouffer Renaissance Esmeralda Resort
Indian Wells, California



Sponsored By

IEEE/NPSS Radiation Effects
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The 1996 IEEE International Conference on Nuclear and Space Radiation Effects will be held July 15-19 in Indian Wells, California, at the Stouffer Renaissance Esmeralda Resort. The Conference features a technical program consisting of eight to ten sessions of contributed papers describing the latest observations in radiation effects, an up-to-date Short Course on radiation effects offered on July 15, a Radiation Effects Data Workshop, and an Industrial Exhibit. The technical program includes a strong poster session. In order to allow maximum participation by attendees, no parallel sessions will be scheduled.

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 (but not limited to):

Basic mechanisms of radiation effects in electronic materials and devices

- Ionizing radiation effects
- Materials and device effects
- Displacement damage
- Single-event charge collection phenomena
- Radiation transport, energy deposition, and dosimetry
- Processing-induced radiation effects

Radiation effects on electronic and photonic devices and circuits

- MOS, bipolar, and III-V technologies
- SOI and SOS technologies
- Optical and optoelectronic sensors and transmitters
- Methods for hardened design and manufacturing
- Modeling of devices, circuits, and systems
- Particle detectors and associated electronics for high-energy accelerators
- Cryogenic temperature effects
- Novel device structures

Space radiation effects

- Single-event phenomena in devices and circuits
- Modeling of space radiation environments
- Spacecraft charging

Hardness assurance technology and testing

- Testing techniques and guidelines
- Radiation exposure facilities

New technologies and developments of interest to the radiation effects community

PAPER SUMMARY DEADLINE: FEBRUARY 2, 1996

Procedure for Submitting Papers: Authors must conform to the following requirements:

1. Submit 12 copies of (a) a factual abstract no longer than 35 words attached to (b) an informative summary (appropriate for a 10- to 15-minute presentation) no less than two nor more than four pages in length, including figures and references. The summary must furnish sufficient details to permit a meaningful review and clearly indicate (a) the purpose of your work, (b) significant results, and (c) how your work advances the state of the art. Note that this is more than an abstract, but do not exceed four pages.
2. Obtain all corporate, sponsor, and government approvals and releases necessary for presenting your paper at an open-attendance international meeting.
3. Type your summary using 11 point or greater type on either U. S. Standard, 8-1/2 in. (21.6 cm) x 11 in. (27.9 cm), or A4, 21 cm x 29.7 cm, white paper, with 1 in. (2.5 cm) margins on all four sides. Please include title, names of the authors, company affiliation, and company address (city and state). Underline the name of the author presenting the paper.
4. Include a cover letter giving (a) the names, complete addresses, and telephone and FAX numbers of all authors; (b) your preference for oral, poster, or workshop presentation; and (c) the session that you prefer for presentation (if you have a preference).

Each paper presented at the Conference also becomes a candidate for publication in the Conference (December 1996) issue of the IEEE Transactions on Nuclear Science. This is a separate submission and is subject to a completely independent review. Radiation Effects Data Workshop papers will be published in a Workshop Proceedings and are not eligible for publication in the IEEE Transactions on Nuclear Science. It is not necessary to be an IEEE member to present a paper or attend the NSREC. However, we encourage IEEE membership of all NSREC participants.

Radiation Effects Data Workshop: The Radiation Effects Data Workshop is a forum for papers on radiation effects data on electronic devices and systems. Workshop papers are intended to provide radiation response data to scientists and engineers who use electronic devices in a radiation environment, and for designers of radiation-hardened systems. Papers describing new simulation or radiation facilities are also welcomed. The procedure for submitting a summary to the Workshop is identical to the procedure for submitting NSREC summaries.

Indian Wells: The Conference will be held at the Stouffer Renaissance Esmeralda Resort located at the base of the Santa Rosa Mountains in Indian Wells. Indian Wells is one of the seven cities in the Coachella Valley that comprise the Palm Springs Desert Resorts Communities. The Stouffer Renaissance Esmeralda Resort is inspired by the dazzling beauty of classic resorts in the Mediterranean. The AAA Four Diamond/Mobil Four Star award-winning resort, with its surrounding golf courses, lush green foliage, and dramatic, angular architecture, evokes the image of an emerald stone. The resort features seven tennis courts, three outdoor heated swimming pools, two whirlpools, a health spa and fitness center, and a business center. The resort provides excellent Conference space and an outstanding environment for technical interactions and discussions.

The Palm Springs Desert Resorts are the home of the Aerial Tramway, Desert Museum, Indian Canyons, Oasis Water Resort, Moorten's Botanical Garden, Palm Springs Angels baseball team, Palm Springs International Film Festival, and more. Visitors revel in its gourmet restaurants, sidewalk cafes, shopping malls, and cultural and special events. The resort community has long been considered the "Golf Capital of the World" and the "Playground of the Presidents." In such glamorous roles, it attracts nearly two million visitors a year and holds fascination and enlightening history and stories. There are more golf courses per square mile than any other place in the world, 10,000 pools, 600 tennis courts, world-class sporting events, fine dining, cultural activities, unique shopping, and so much more.

The Palm Springs Desert Resorts are located within a two-hour drive of Los Angeles, Orange County, and San Diego. This proximity to Southern California's golden triangle enables Conference attendees and their guests to visit the many attractions in the area including Disneyland, Knott's Berry Farm, Universal Studios, the San Diego Zoo, Sea World, and the sunny Southern California beaches. The valley is served by numerous major airlines at the Palm Springs Regional Airport. Palm Springs is also located within easy driving distance of the Los Angeles, Ontario, Orange County, and San Diego International Airports.

**Summaries (12 copies) must be received by February 2, 1996.
Address them to:**

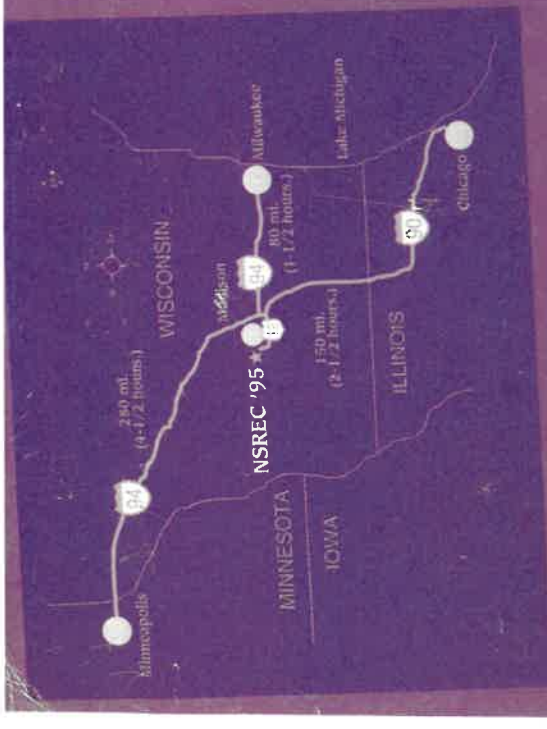
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