

# TECHNICAL PROGRAM AND ACTIVITIES

## 33rd Annual International **NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE**



**Indian Wells, California  
July 15-19, 1996**



**IEEE**

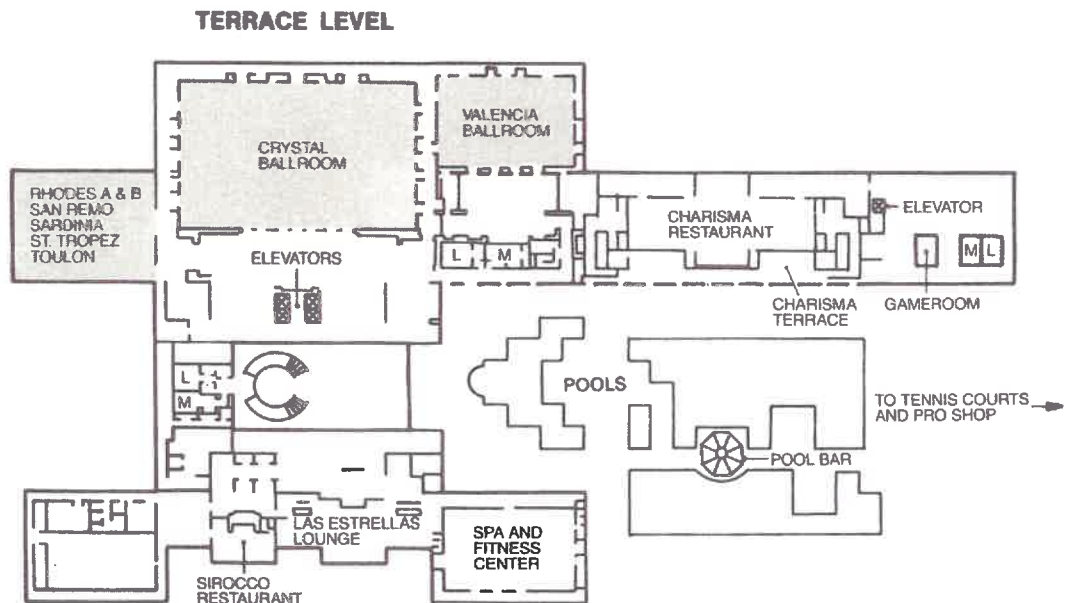
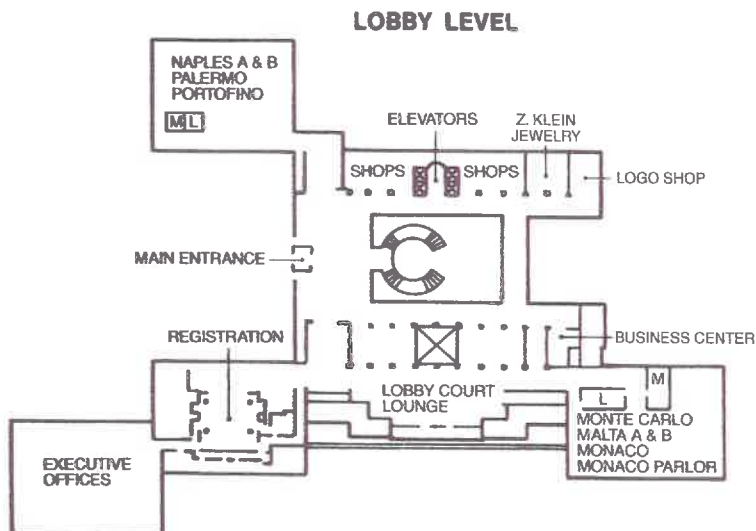
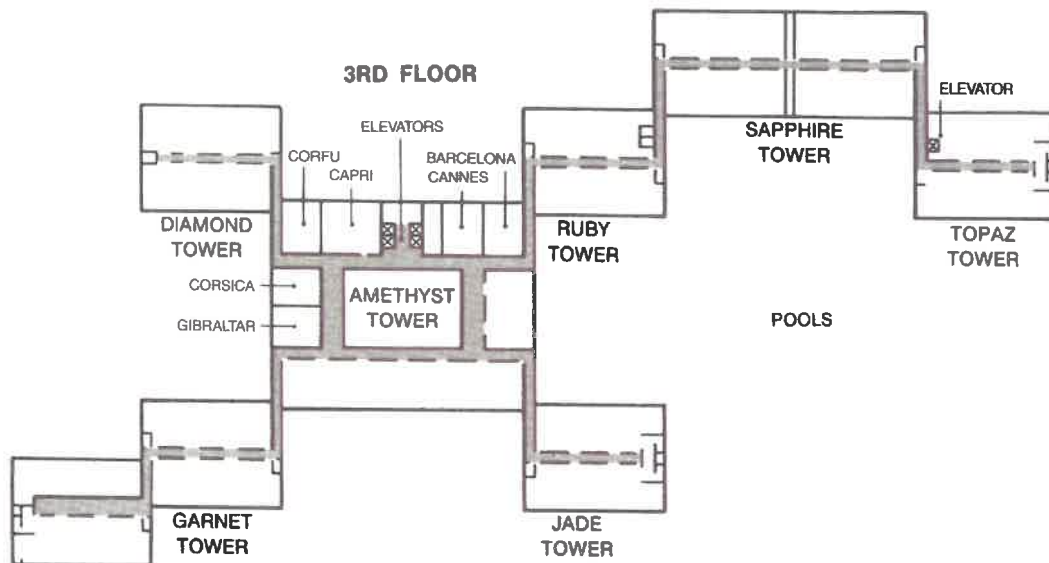
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NSREC '96 - INDIAN WELLS, CA



# Renaissance Esmeralda Resort





# Schedule

Time	Monday July 15	Tuesday July 16	Wednesday July 17	Thursday July 18	Friday July 19
7:30	[7:30] Continental Breakfast	[7:30] Continental Breakfast	[7:30] Continental Breakfast		
8:15	[8:15] <b>Short Course:</b> Introduction Ronald L. Pease Crystal Ballroom	[8:15] <b>Conference Opening</b> Awards Presentations Crystal Ballroom	[8:15] <b>Invited Paper:</b> <b>Galileo at Jupiter</b> Robert Mitchell	[7:45] Continental Breakfast	[7:45] Continental Breakfast
8:30	[8:30] <b>Spacecraft Anomalies and Future Trends</b> James C. Ritter			[8:30] <b>Session G:</b> Radiation Effects in Photonic Materials and Systems	[8:30] <b>Invited Paper:</b> <b>Thriving in the Desert: The Story of the Coachella Valley</b> Morgan Levine
8:45		[8:45] <b>Session A:</b> Basic Mechanisms of Radiation Effects			
9:00			[9:15] <b>Session E:</b> Non-Destructive Single-Event Effects		
10:00	[10:00] Break		[10:05] Break	[9:50] Break	[9:30] <b>Radiation Effects Data Workshop</b> Poster Presentations Valencia Ballroom
11:00	[10:30] <b>Total Dose Response of Bipolar Microcircuits</b> David W. Emily	[10:20] Break [10:45] <b>Session B:</b> Isolation Technologies	[10:30] <b>Session E (cont.)</b>	[10:15] <b>Session H:</b> Radiation Effects in Devices and Integrated Circuits	
12:00	[12:00] Lunch	[12:05] Lunch	[11:45] Lunch	[11:35] Lunch	[12:00] End of Conference
1:00					
2:00	[1:15] <b>Catastrophic Single-Event Effects in the Natural Space Environment</b> Kenneth F. Galloway and Gregory H. Johnson	[1:30] <b>Session C:</b> Dosimetry	[1:15] <b>Session F:</b> Single-Event Device Effects	[1:00] <b>Invited Paper:</b> <b>Space and Desert Storm</b> General Donald Kutyna (Retired)	
3:00	[2:45] Break		[2:20] <b>Poster Session</b> Poster Presentations Valencia Ballroom	[2:00] <b>Session I:</b> Hardness Assurance and Testing Techniques	
4:00	[3:15] <b>Design Issues for Radiation Tolerant Microcircuits for Space</b> David R. Alexander	[3:20] Break [3:45] <b>Session D:</b> Spacecraft Environments and Effects		[3:35] Break	
5:00	[4:45] <b>Wrap-up</b> [5:00] Exam (only for students requesting CEU credit) [5:30] End of Short Course	[5:05] End of Session	[5:00] End of Session	[4:00-5:30] Radiation Effects Committee Open Meeting Crystal Ballroom	
6:00					
7:00	[7:00-10:00] Conference Registration and Reception <b>California Dreamin' Beach Party</b> Crystal Ballroom and Poolside	[7:00-10:00] Industrial Exhibit Reception Crystal Ballroom	[6:30-10:30] Conference Social <b>An Evening with the Phantom</b> Crystal Ballroom		
8:00					

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# Chairman's Invitation



## Conference Committee

### General Chairman

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### Guest Editor

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### Industrial Exhibits

**Bill Bartholet**  
Boeing Defense & Space  
Group  
(206) 773-9268

## Dear Colleague,

You are cordially invited to attend the **33rd Annual International Nuclear and Space Radiation Effects Conference (NSREC)** to be held at the Renaissance Esmeralda Resort in **Indian Wells, California, July 15-19, 1996**. Indian Wells was chosen as the site for this year's IEEE-sponsored meeting for its outstanding conference facilities and local conference support amenities.

The 1996 conference will begin on Monday, July 15, with a one-day radiation effects "Short Course." Short Course Chairman Ron Pease has assembled a series of lectures on Challenges for 21st Century Space Systems that will address potential problems with future space system microelectronics. Session topics include (1) spacecraft anomalies and future trends, (2) total dose response of bipolar microcircuits, (3) catastrophic single-event effects in the natural space environment, and (4) design issues for radiation tolerant microcircuits for space.

The 1996 NSREC Technical Program Chairman, Ron Schrimpf, has assembled an outstanding technical program that will be of interest to everyone wanting to know more about radiation damage to electronics and its prevention. The technical program, held Tuesday, July 16, through Friday, July 19, will consist of contributed oral and poster papers as well as a data workshop. There are also several invited talks planned into the program that will be of general interest to you and your companions.

The research papers presented at NSREC have been carefully evaluated by session chairmen, technical reviewers, authors, and editors to ensure that only new and significant material is accepted for presentation. Technical excellence in publication is then reflected in the *IEEE Transactions on Nuclear Science*.

At the Industrial Exhibit, representatives from semiconductor vendors, wafer manufacturers, testing facilities, and equipment manufacturers will be available to discuss their latest products and technology developments. A brochure, included with registration packets, will provide preview information on all of the exhibitors.

We are arranging 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](mailto:nsrec.brochure@ieee.org)". If you would like to submit a late-news paper, the current Call-for-Papers is available from "[nsrec.call@ieee.org](mailto:nsrec.call@ieee.org)". Upon receipt of your message, the IEEE computer will forward the most current information to you automatically. For World Wide Web users, the above material is available in graphical format at "<http://www.ieee.org/nps/nsrec/nsrec.html>". Our Web Page will be updated with the latest information as it becomes available.

The Multi-Government and Industry commitment of the many engineers and scientists, all volunteers who have donated their time and effort to the conference, make the NSREC the most prominent international symposium on radiation effects. Plan to join this international forum for networking and informal discussions to gather information pertinent to your needs.

I'm looking forward to meeting you at the 1996 IEEE-NSREC in Indian Wells, California!

**Charles J. Utrias**  
*General Chairman*

# Short Course Program

## RADIATION EFFECTS CHALLENGES FOR 21<sup>ST</sup> CENTURY SPACE SYSTEMS

### CRYSTAL BALLROOM

MONDAY, JULY 15

8:15 AM – 5:30 PM

7:30 AM	REGISTRATION/CONTINENTAL BREAKFAST
8:15 AM	SHORT COURSE INTRODUCTION Ronald L. Pease <i>RLP Research, Inc.</i>
8:30 AM	<b>SPACECRAFT ANOMALIES AND FUTURE TRENDS</b> James C. Ritter <i>Naval Research Laboratory</i>
10:00 AM	BREAK
10:30 AM	<b>TOTAL DOSE RESPONSE OF BIPOLAR MICROCIRCUITS</b> David W. Emily <i>Naval Surface Warfare Center, Crane Division</i>
12:00 PM	LUNCH
1:15 PM	<b>CATASTROPHIC SINGLE-EVENT EFFECTS IN THE NATURAL SPACE ENVIRONMENT</b> Kenneth F. Galloway and Gregory H. Johnson <i>The University of Arizona</i>
2:45 PM	BREAK
3:15 PM	<b>DESIGN ISSUES FOR RADIATION TOLERANT MICROCIRCUITS FOR SPACE</b> David R. Alexander <i>Mission Research Corporation</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 1996 NSREC Short Course is **Radiation Effects Challenges for 21<sup>st</sup> Century Space Systems**. The course will start with a discussion of anomalies in present day space systems and how they relate to the effects of the various space radiation environments on microelectronics. Specific examples will be given to illustrate how space radiation damage can cause system failures from accumulated dose, single particle strikes, and displacement damage in microelectronic and photonic devices. The procedures that have been employed for identifying and fixing these problems, as well as approaches for minimizing their occurrence, will be presented. The focus will then switch to trends in space systems, covering both government and commercial programs. The emphasis will be on the use of new technologies and commercial off-the-shelf parts, resulting from the increased requirements on performance and the lowering of margins to reduce costs. The discussion of system trends will set the stage for the introduction of new challenges raised by recent data on the low dose rate sensitivity of bipolar linear devices and catastrophic effects in MOS and bipolar technologies from heavy ions. Although both of these topics have been mentioned in previous short courses, they have not been addressed in depth. Having presented these challenges, the final topic will address a potential solution in the form of a cost effective approach to the development and implementation of radiation tolerant microcircuits using commercial process technologies.

Ronald L. Pease of RLP Research is the 1996 Short Course Chairman. The course is divided into four segments. Instructors for this year's short course are James C. Ritter of the Naval Research Laboratory, David W. Emily of the Naval Surface Warfare Center, Crane Division, Kenneth F. Galloway and Gregory H. Johnson of the University of Arizona, and David R. Alexander of Mission Research 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

**Ronald L. Pease** received his B. S. degree in physics from Indiana University in 1965 and pursued graduate studies in physics at the University of Washington, Seattle the following year. He joined NAD Crane (now NSWC-Crane) in 1966, where he performed radiation testing of missile components and headed the DNA Bipolar Program. From 1977-1979 he was with the BDM Corporation in Albuquerque, NM. In 1979 he joined Mission Research Corporation in Albuquerque where he was Manager of the Microelectronics Division. At MRC he was principal investigator on several hardening and hardness assurance programs. In 1993 he formed his own company, RLP Research, where he is now a technical advisor and radiation effects analyst. Mr. Pease has been involved in the NSREC for many years, having served in a number of positions. He has over 40 publications and has won several outstanding and meritorious paper awards at the NSREC.





## SPACECRAFT ANOMALIES AND FUTURE TRENDS

James C. Ritter

*Naval Research Laboratory*

James C. Ritter will discuss the various types of effects which produce anomalies in space systems, giving historical and other examples of such anomalies. He will describe how system engineers search for the cause of the aberrant behavior of the system, and the accompanying phenomena which often provide valuable clues to the cause. Because the causes of many anomalies are never determined, it is difficult to accumulate comprehensive statistics on the distribution of causes of anomalies or failures in satellites. He will describe how anomalies are handled through on-orbit corrections or reprogramming, and how they are handled for future generations of the same space system. The second subject covered in this talk will be trends in future space systems, and how those trends will be affected by radiation effects in microelectronic and photonic devices and systems. The future holds new types of systems such as cellular telephones and data transfer systems and, equally importantly, greatly increasing numbers of satellites.



**James C. Ritter** is head of the Radiation Effects Branch at the Naval Research Laboratory where he has worked since 1962. For ten years at NRL he pursued basic research in nuclear physics. In 1971 he began performing and directing research in radiation effects in microelectronics. He has worked on the radiation hardening of satellite systems and has participated in revising the Joints Chiefs of Staff Guidelines for hardening satellites. He has been Program Manager or Principal Investigator on a number of space experiments such as the Microelectronics and Photonics Test Bed and the Combined Release and Radiation Effects Satellite Microelectronics Experiment. He currently directs an extensive research program in radiation effects in semiconductor and superconductor devices and materials. Mr. Ritter was an instructor for the 1989 NSREC Short Course.

## SPACECRAFT ANOMALIES AND FUTURE TRENDS

### Anomalies

- Introduction
- Types of anomalies
- Examples of anomalies and their results
- Causes of anomalies
- Determining the cause
- Preventing anomalies and solutions
- Publishing the results

### Future trends

- New types of DoD and NASA space systems
- Projected increases in numbers and types of commercial spacecraft
- New technologies and radiation effects challenges
- Use of COTS in future spacecraft
- COTS advantages and disadvantages

### Conclusions and summary





## TOTAL DOSE RESPONSE OF BIPOLAR MICROCIRCUITS

David W. Emily

*Naval Surface Warfare Center, Crane Division*

David W. Emily will discuss total dose effects in bipolar microcircuits, with emphasis on the recently discovered low dose rate sensitivity of many linear devices. Because past short courses have focused on CMOS microcircuits, the session will begin with fundamentals of bipolar transistor operation and present basic processing and device design details, contrasting the difference between vertical, lateral, and substrate transistors. Basic total dose effects in bipolar transistors and digital and linear integrated circuits will be presented as an introduction to the important low dose rate sensitivity in linear circuits. The remainder of the session will be devoted to a discussion of the response of bipolar linear transistors and microcircuits as a function of dose rate and irradiation temperature. Recent theories to explain the dose rate mechanism will be presented along with implications for hardness assurance.



**David W. Emily** received his B. S. degree with honors in electrical engineering from Purdue University in 1976. He has been employed by the Naval Surface Warfare Center, Crane Division since 1973. Initial assignments included reliability assessment and failure analysis of microelectronics. He has been involved in radiation effects research and testing since 1980. Responsibilities have included radiation hardness assurance evaluation of strategic missile components, development and testing of advanced technologies, and research into radiation effects on bipolar and BiCMOS processes. He currently manages the Technology Development Branch which supports the research, development, and testing of radiation hardened microelectronics. Mr. Emily is active with NSREC and has served as official reviewer, session chairman, and finance chairman. He has authored several papers in radiation effects, including the 1983 outstanding conference paper.

## TOTAL DOSE RESPONSE OF BIPOLAR MICROCIRCUITS

### Introduction

- Bipolar integrated circuits in modern space systems

### Fundamentals of bipolar transistor operation

#### Bipolar transistor structures

- Vertical, lateral, and substrate devices

#### Transistor total dose effects

- Substrate, sidewall, and surface inversion
- Gain degradation

#### Integrated circuit response

- Digital
- Analog
- Low-rate introduction

#### Low-rate effects

- Circuit response data
  - Bias effects
  - Temperature effects
  - Anneal effects
- Transistor response data
  - Bias effects
  - Temperature effects
  - Anneal effects
- Modeling
- SEM irradiation
- Basic mechanisms theories
- Hardness assurance test method development
  - High-temperature irradiation
  - Post-irradiation anneal
  - Over-test

### Future trends and conclusions



## CATASTROPHIC SINGLE-EVENT EFFECTS IN THE NATURAL SPACE RADIATION ENVIRONMENT

Kenneth F. Galloway and Gregory H. Johnson  
*The University of Arizona*

Kenneth F. Galloway and Gregory H. Johnson will cover catastrophic single particle effects in semiconductor devices and microcircuits. The session will begin with an introduction to the space particle environment and the interaction of energetic particles with devices and circuits. The remainder of the session will be divided according to the various catastrophic effects: burnout, gate rupture, dielectric rupture, and latchup. Although many of these effects have been discussed briefly in previous short courses, none have been addressed in depth. For each of these effects the status of the experimental data will be presented, followed by a discussion of modeling to understand the physical mechanisms. Based on the understanding of mechanisms, techniques for reducing susceptibility will be presented. The session will conclude with a summary of the important features of each effect as it relates to space applications.



**Kenneth F. Galloway** is currently serving as a Professor and as Department Head of Electrical and Computer Engineering at the University of Arizona. Prior to joining the University of Arizona, Dr. Galloway held appointments at Indiana University (1966-72), the Naval Weapons Support Center (1972-74), the University of Maryland (1980-86), and the National Bureau of Standards (1974-86). He joined the University of Arizona in 1986. Dr. Galloway's research interests include solid-state devices and semiconductor technology. He has authored or co-authored more than 100 technical publications. He was elected an IEEE Fellow in 1986 for "Contributions to the study of radiation effects in microelectronics." He received the Medal of Honor from the University of Montpellier II. He has served in many capacities with the NSREC and the RESG, including the positions of 1985 general conference chairman and chairman of the RESG. Dr. Galloway received the B. A. degree from Vanderbilt University in 1962 and the Ph. D. degree from the University of South Carolina in 1966.

## CATASTROPHIC SINGLE-EVENT EFFECTS IN THE NATURAL SPACE RADIATION ENVIRONMENT

### Introduction

- Energetic particles in the space radiation environment
- Interaction of energetic particles and device materials

### Catastrophic single-event effects

- Single-event burnout
- Single-event gate rupture
- Single-event dielectric rupture
- Single-event latchup

### Summary and conclusions



**Gregory H. Johnson** received the B. S., M. S., and Ph. D. degrees in Electrical Engineering from the University of Arizona in 1988, 1990, and 1992, respectively. He held a National Research Council Post-Doctoral Fellowship at the USAF Phillips Laboratory for two years following his graduate studies. Dr. Johnson is currently a Research Assistant Professor at the University of Arizona, where his research interests include radiation effects on microelectronics, microelectronic device physics, and long-term aging effects on microelectronic device reliability. Gregory has presented several papers at previous NSRECs, including the Outstanding Conference Paper in 1991.



## DESIGN ISSUES FOR RADIATION TOLERANT MICROCIRCUITS FOR SPACE

David R. Alexander

*Mission Research Corporation*

David R. Alexander will present design-related issues for space applications of radiation tolerant microcircuits. The session will begin with a discussion of a general methodology for assessing the impact of different design approaches on the radiation hardness of integrated circuits. A typical microcircuit will be partitioned into its principal functional blocks, and the primary failure mechanisms associated with each functional block will be identified. Both heavy ion and total dose ionizing radiation effects will be addressed. Several electrical and layout design alternatives for each functional block will be evaluated for their contribution to radiation tolerance. The general approach will be illustrated for digital CMOS microcircuits, but suggestions for applications to other integrated circuit types will also be given. The presentation will conclude with an application of the methodology to two types of radiation tolerant microcircuits.



**David R. Alexander** received his B. S. in Electrical Engineering from the U. S. Air Force Academy in 1968 and his M. S. in Electrical Engineering from the University of New Mexico in 1973. From 1968 to 1973 he was an Air Force officer assigned to the Air Force Weapons Laboratory in Albuquerque, New Mexico. In 1973, he joined the BDM Corporation and was the principal investigator for several programs in radiation response modeling of microcircuits. In 1980, he became a member of the technical staff at Sandia National Laboratories. He is currently with Mission Research Corporation and has been the Division Manager of MRC's Microelectronics Division since 1993. At MRC, he has been responsible for applying computer-aided design and modeling practices to microcircuits. Mr. Alexander has been active in the NSREC for several years and has served in several positions. He has numerous technical publications and was a recipient of the Distinguished Poster Paper Award in 1988.

## DESIGN ISSUES FOR RADIATION TOLERANT MICROCIRCUITS IN SPACE

### General approach to evaluation of design hardening

- Partitioning the microcircuit into functional blocks
- Identifying radiation response mechanisms
- Evaluating radiation tolerant design approaches

### Partitioning of digital CMOS microcircuit design for hardness evaluation

- Input/output functions
  - Identifying dominant failure mechanisms
  - Evaluating design alternatives
  - Considering testing issues
- Combinational functions
- Sequential functions/state machines
- Data bus functions
- Memory functions

### Applying design evaluation methodology to other circuit types

- Analog
- Mixed signal

### Demonstration of radiation tolerance enhancement through design



# 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 Crystal Ballroom at the Renaissance Esmeralda Resort. Oral papers will be 12 minutes in length with 3 additional minutes reserved for questions. The Technical Sessions and chairpersons are:

- **Basic Mechanisms of Radiation Effects**  
*Bill Warren, Sandia National Laboratories*
- **Isolation Technologies**  
*Nadim Haddad, Loral Federal Systems*
- **Dosimetry**  
*Bob Block, Rensselaer Polytechnic Institute*
- **Spacecraft Environments and Effects**  
*Janet Barth, NASA Goddard Space Flight Center*
- **Non-Destructive Single-Event Effects**  
*Eugene Normand, Boeing Defense and Space Group*
- **Single-Event Device Effects**  
*Jeff Titus, Naval Surface Warfare Center, Crane Division*  
*Jean-Marie Palau, Université de Montpellier*
- **Radiation Effects in Photonic Materials and Systems**  
*Chuck Barnes, Jet Propulsion Laboratory*  
*Jean-Claude Boudenot, Thomson-CSF*
- **Radiation Effects in Devices and Integrated Circuits**  
*Mike Xapsos, Naval Research Laboratory*
- **Hardness Assurance and Testing Techniques**  
*Mike Maher, National Semiconductor*

### Poster Session

Papers that are most appropriate for visual presentation will be displayed from 12:00 PM Tuesday through Thursday evening in the Valencia Ballroom. Authors will be available to discuss their posters from 2:20 PM to 5:00 PM on Thursday. The poster chairman is *Lew Cohn, Defense Nuclear Agency*.

### 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 Valencia Ballroom from 9:30 AM to 12:00 PM on Friday. 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 12:00 PM Friday. The workshop chairman is *Scott Tyson, Mission Research Corporation*.

## INVITED SPEAKERS

The 1996 NSREC is pleased to feature three invited talks. Robert Mitchell will present *Galileo at Jupiter*, General Donald Kutyna (Retired) will present *Space and Desert Storm*, and Morgan Levine will present *Thriving in the Desert: The Story of the Coachella Valley*.

## 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 3, 1996. Please submit late-news summaries, using the 4-page summary and 35-word abstract format, to the Technical Program Chairman, Ronald D. Schrimpf, The University of Arizona, Dept. of Electrical and Computer Engineering, Bldg. 104, 1230 E. Speedway, Tucson, AZ 85721, (520) 621-4116. In your summary, please make a case that your presentation will be newsworthy.



7:30 AM REGISTRATION AND CONTINENTAL BREAKFAST  
Renaissance Esmeralda Resort, Crystal Ballroom

8:15 AM OPENING REMARKS  
CRYSTAL BALLROOM *Charles J. Utrias, Conference General Chairman*  
*Marty R. Shaneyfelt, Local Arrangements Chairman*

8:30 AM AWARDS PRESENTATION  
*Peter S. Winokur, Steering Group Chairman*

8:40 AM TECHNICAL SESSION OPENING REMARKS  
*Ronald D. Schrimpf, Technical Program Chairman*

## SESSION A BASIC MECHANISMS OF RADIATION EFFECTS

8:45 AM Session Introduction  
*Chairman: Bill Warren, Sandia National Laboratories*

A-1  
8:50 AM **Radiation-Induced Interface Traps in Hardened MOS Transistors: An Improved Charge-Pumping Study**  
*C. Chabrier, J. L. Autran, O. Flament, P. Paillet, and J. L. Leray, CEA; J. C. Boudenot, Thomson-CSF*

Three-level and multifrequency charge pumping techniques, combined with isochronal anneals, have been used to investigate the generation and the evolution of interface traps in irradiated MOS transistors manufactured in a radiation-hardened technology.

A-2  
9:05 AM **The Determination of Si-SiO<sub>2</sub> Interface Trap Density in Four-Terminal VDMOSFETs Using Charge Pumping**  
*S. C. Witczak, K. F. Galloway, J. R. Brews, and R. D. Schrimpf, University of Arizona; J. L. Titus, NSWC-Crane; G. Prevost, Thomson-CSF*

The utility of charge pumping to measure Si-SiO<sub>2</sub> interface trap density in irradiated four-terminal VDMOSFETs is demonstrated. When the device is properly biased, charge-pumping current can be modeled with conventional charge-pumping theory.

A-3  
9:20 AM **Influence of the Oxygen Content in Silicon on the Radiation Induced Si/SiO<sub>2</sub> Interface Traps**  
*A. Paccagnella, M. Ceschia, and R. Carlesso, Università di Padova; P. Belluti, IRST; G. F. Dalla Betta, G. Verzellesi, and G. Soncini, Università di Trento; and P. G. Fuochi, CNR-FRAE*

Ionizing radiation induces different interface trap densities in MOS devices fabricated on wafers with different oxygen content, as shown by I-V and charge pumping measurements of p- and n-MOSFETs, likely due to interface mechanical stress.

A-4  
9:35 AM **Radiation-Induced Charge Trapping in Bipolar Base Oxides**  
*D. M. Fleetwood and L. C. Riewe, Sandia National Laboratories; S. C. Witczak and R. D. Schrimpf, University of Arizona*

Capacitance-voltage and thermally-stimulated-current methods are used to investigate radiation induced charge trapping in bipolar base oxides. Results are compared with models of oxide and interface trap charge buildup at low electric fields.



- A-5**  
9:50 AM **The Effect of Deposition Conditions on the Radiation Tolerance of BPSG Films**  
*R. Fuller, H. Evans, C. Gamlen, B. Czagas, M. Morrison, and R. Lowry, Harris Semiconductor; P. Lenahan and C. Frye, Penn State University*

A study has been conducted of the effects of deposition conditions on the radiation hardness of Borophosphosilicate Glass (BPSG). Two stoichiometrically similar films can differ greatly in radiation tolerance depending on the deposition conditions.

- A-6**  
10:05 AM **A New Model for the Generation–Recombination Process in Silicon Depletion Regions after Irradiation**  
*S. Watts, A. Holmes–Siedle, J. Matheson, and A. Mohammadzadeh, Brunel University; R. Pace, University of South Australia*

It is proposed that defect levels in a semiconductor may interact to cause a much higher generation or recombination rate to account for the magnitude of the generation currents occurring in silicon depletion regions after neutron irradiation.

## POSTER PAPERS

- PA-1** **Modeling the Field and Thermal Dependence of Radiation–Induced Charge Annealing in MOS Devices**  
*V. V. Emelianov, O. V. Meshurov, and V. N. Ulimov, Scientific Instruments Research Institute; A. V. Sogoyan, Specialized Electronic Systems; V. S. Pershenkov, Moscow Engineering Physics Institute*

Modeling the field and thermal dependence of radiation–induced charge reversible annealing, based on the assumption that the energy level of defects in the oxide is located within the Si forbidden gap, is described and verified.

- PA-2** **A Model of the Near–Interface Variable Bandgap and Nature of Border Traps in MOS Oxides**  
*V. S. Pershenkov, S. V. Cherepko, V. V. Abramov, A. V. Shalnov, and V. I. Rusanovsky, Moscow Engineering Physics Institute*

The mechanism of the charge exchange of radiation–induced defects in the oxide and substrate is discussed, taking into account the variable SiO<sub>2</sub> bandgap width in the interfacial region between the Si and the SiO<sub>2</sub>.

- PA-3** **The Conception of Two–Level AD Centers in Irradiated MOS Structures**  
*V. S. Pershenkov, S. V. Cherepko, and V. V. Belyakov, Moscow Engineering Physics Institute; V. N. Ulimov, Scientific Instruments Research Institute; A. V. Sogoyan, Specialized Electronic Systems*

The conception of two–level acceptor–donor (AD) centers is introduced. The generation and annihilation mechanisms of the AD centers are discussed. The correlation between these centers and interface traps is experimentally verified.

- PA-4** **Anomalous Temperature Dependencies of Electric Parameters in Irradiated MOS Devices**  
*G. I. Zebrev, V. V. Emelianov, R. G. Useinov, and V. N. Ulimov, Scientific Instruments Research Institute; V. N. Bezborodov, "Cyclon" Institute*

It was experimentally found that midgap voltage and subthreshold slope have anomalous reproducible dependencies on measurement temperature in irradiated MOS devices. It is suggested that the effects are caused by rechargeable oxide traps near the interface.





**PA-5 Breakdown Properties of Irradiated MOS Capacitors**

*A. Paccagnella and E. Formigoni, Università di Padova; G. Ghidini and D. Drera, SGS-Thomson; P. G. Fuochi, CNR-FRAE*

The breakdown characteristics of both thin and thick oxide MOS capacitors are modified by electron irradiation, due to variation of the oxide trapping properties, as shown by breakdown field, charge-to-breakdown, and Fowler-Nordheim injection measurements.

**PA-6 Time Resolved Annealing Studies of Single Neutron Irradiated Avalanche Photodiodes**

*M. Dai, F. Buchinger, and J. K. P. Lee, McGill University; H. Dautet, EG&G Optoelectronics Division*

Fast-neutron induced APD counting rate variations were monitored, showing rapid forward annealing process, occasionally followed by temporary reverse annealing. Stepwise counting rate changes suggest creation, annihilation and configuration switching of individual charge-generating defects.

**PA-7 Nuclear Radiation Displacement Damage Prediction in Gallium Arsenide through Low Temperature Photoluminescence Measurements**

*S. M. Khanna, Defence Research Establishment; A. Houdayer, Université de Montréal; A. Jorio, C. Carlone, and M. Parenteau, Université de Sherbrooke; J. W. Gerdes, Jr., Aberdeen Proving Ground*

We compare the radiation damage constant associated with the photoluminescence intensity, the introduction rate of the gallium vacancy and NIEL values for various particles at different energies. Our results question the use of gamma irradiation as a standard.

10:20 AM BREAK

**SESSION B ISOLATION TECHNOLOGIES**

10:45 AM Session Introduction

*Chairman: Nadim Haddad, Loral Federal Systems*

**B-1 Over-Coordinated Oxygen Centers in SIMOX and Thermal Oxides**

10:50 AM *W. L. Warren, K. Vanheusden, J. R. Schwank, D. M. Fleetwood, M. R. Shaneyfelt, and P. S. Winokur, Sandia National Laboratories; R. A. B. Devine, France Télécom/CNET*

H-induced positive oxide charge is very different from radiation-induced oxygen vacancy hole traps ( $E'$  centers) in  $\text{SiO}_2$ . We propose that overcoordinated O centers are responsible for this charge, which is EPR inactive.

**B-2 Electron Trapping in Buried Oxides During Irradiation From 40 to 300 Kelvin**

11:05 AM *R. E. Stahlbush, Naval Research Laboratory*

Electron traps in annealed buried oxides depend on conditions such as the thickness and annealing temperature that affect the oxygen deficiency. Two electron traps are observed; the deeper one is filled by room temperature irradiation.

**B-3 Development of Radiation Hardened Thin BOX SIMOX Silicon-on-Insulator Substrates for Advanced Electronics**

11:20 AM *L. P. Allen, M. L. Alles, and R. P. Dolan, Ibis Technology Corporation; H. L. Hughes and P. J. McMarr, Naval Research Laboratory; R. K. Lawrence, ARACOR*

Radiation hardness of 120 nm buried oxide SIMOX devices is reported. A TBOX process with supplemental oxygen dose and hardening has been shown to reduce the  $\Delta V_{TB}$  to  $\sim 2V$  at 1 MRad total dose.



- B-4**  
11:35 AM **Dependence of Radiation Induced Buried Oxide Charge on Silicon-on-Insulator Fabrication Technology**  
*R. K. Lawrence, ARACOR; B. J. Mrstik and H. L. Hughes, Naval Research Laboratory; P. J. McMarr, SFA*

Various SOI technologies have been irradiated. For low density SOI it has been observed that the total number of charges trapped in the BOX saturates at approximately  $1.1 \times 10^{13} \text{ cm}^{-2}$ , independent of BOX thickness or fabrication technique.

- B-5**  
11:50 AM **Two-Dimensional Simulation of Total Dose Effects on NMOSFETs with Lateral Parasitic Transistors Using the TRAPPOX Finite Elements Code**  
*C. Brisset, V. Ferlet-Cavrois, O. Musseau, and J. L. Leray, CEA; R. Escoffier and A. Michez, Centre d'Electronique de Montpellier*

Charge trapping and lateral leakage currents in NMOSFETs have been determined by 2D finite element simulations. Results verify the location of leakage current paths in LOCOS edges and open the way for more efficient device hardening.

## POSTER PAPER

- PB-1**  
**CMOS/SOS RAM Transient Radiation Upset and "Inversion" Effect Investigation**  
*A. Y. Nikiforov and I. V. Poljakov, Specialized Electronic Systems*

The CMOS/SOS RAM transient upset and inversion effect were investigated with pulsed laser, pulsed voltage, and low-intensity light simulators. It was found that the inversion is caused by cell photocurrents concurrent with power supply voltage drop transfer to the output.

12:05 PM LUNCH

- SESSION C**  
1:30 PM **DOSIMETRY**  
Session Introduction  
*Chairman: Bob Block, Rensselaer Polytechnic Institute*

- C-1**  
1:35 PM **Gamma Ray and X-Ray Imaging Device**  
*S. Kronenberg, US Army CECOM; G. J. Brucker, G. Gentner, and E. Bechtel, Consultants*

This study describes a device capable of imaging a gamma ray source with very high angular resolution and a  $4\pi$  solid angle of acceptance. The ionization chamber or scintillation counter sensors operate for intensities ranging from microrads per hour up to high levels.

- C-2**  
1:50 PM **A Dose Rate Independent pMOS Dosimeter for Space Applications**  
*J. R. Schwank, S. B. Roeske, D. E. Beutler, D. J. Moreno, and M. R. Shaneyfelt, Sandia National Laboratories*

A dual-dielectric pMOS dosimeter recently designed at Sandia exhibits little or no fade of its output characteristics at dose rates from 0.002 to 50 rad(Si)/s. This dosimeter is ideal for low dose rate space applications.



- C-3**  
2:05 PM **Stacked p-FET Dosimeter for the STRV-2 MWIR Detector: A Joint US-UK Project**  
*M. Buehler, Jet Propulsion Laboratory; A. Holmes-Siedle, Radiation Experiments and Monitors (REM); C. Caines, Defence Research Agency; C. Carmichael and D. Martin, Halcyon Microelectronics*
- A stacked p-FET dosimeter consisting of a RADMON mother chip with three p-FETs and multiplexer and an attached RADFET has been developed for the STRV-2/MWIR detector. Calibration of the dosimeter indicates that the RADFET is about 20 times more sensitive to radiation than the RADMON.
- C-4**  
2:20 PM **p-FET Derived Proton-Beam Dose-Depth Curves**  
*M. Buehler, Jet Propulsion Laboratory; C. Carmichael and D. Martin, Halcyon Microelectronics; J. Siebers, Loma Linda Medical Center*
- An array of four p-FETs was used to obtain a dose-depth curve for the 100 MeV proton beam at the Loma Linda Proton Therapy Facility. The p-FET dosimetry compares extremely well with ionization chamber results and tends to resolve the peak and distal edge region more sharply.
- C-5**  
2:35 PM **Tests of the Prototype of the ESA Standard Radiation Environment Monitor at the Proton Irradiation Facility**  
*W. Hajdas, N. Schlumpf, and A. Zehnder, PSI Paul Scherrer Institut; L. Adams, E. Daly, and B. Nickson, ESA-ESTEC*
- A prototype of the ESA Standard Radiation Environment Monitor was constructed and tested at the PSI Proton Irradiation Facility. The response function of the detector was measured at proton energies between 30 and 300 MeV and angles from 0° to 180°.
- C-6**  
2:50 PM **Enhanced Radiation Shielding by Space-Charge Fields in Insulating Slabs**  
*A. R. Frederickson, USAF Phillips Laboratory; S. Woolf, ARCON Corp.*
- Space-charge and the resulting electric fields accumulate in good insulators during irradiation, resulting in electric fields that can alter the trajectory of high energy electrons and provide enhanced shielding effectiveness. We investigate this effect with high energy electron irradiation (0.7 to 2 MeV) of planar polymethylmethacrylate shields.
- C-7**  
3:05 PM **Effects of Material and/or Structure on Shielding of Electronic Devices**  
*R. Mangeret, T. Carrière, and J. Beaucour, Matra Marconi Space; T. M. Jordan, Experimental & Mathematical Physics Consultants*
- This paper considers both the role of materials on the shielding efficiency and the effect of the structure of the shield. The NOVICE code was used to explore optimization of multilayer, multimaterial structures.

## POSTER PAPERS

- PC-1** **Dose Rate and Flux of Proton Beams Using Differentially Filtered Diamond Detectors**  
*D. C. Judy, J. Blackburn, G. Merkel, and R. M. Fleetwood, Army Research Laboratory; D. M. Weidenheimer, B. Jenkins, S. G. Gorbics, and N. R. Pereira, Berkeley Research Associates*
- A spectrometer employing differentially filtered diamond photoconducting detectors has been employed to analyze the temporal and energy distribution of an intense pulsed proton beam. The results are compared to electromagnetic, calorimetric and radiachromic depth dose measurements.





**PC-2 MOSFET Micro–Macro Dosimetry**

*A. B. Rosenfeld, G. I. Kaplan, M. G. Carolan, and B. J. Allen, University of Wollongong; R. Maughan, M. Yudelev, and C. Kota, Wayne State University*

Simultaneous measurements of charge collection in drain and source p–n junctions and charge build-up in the thick SiO<sub>2</sub> of a MOSFET were performed in a mixed high–low LET radiation field. The applications for micro and macro dosimetry in Boron Neutron Capture Therapy are discussed.

**PC-3 Simulation of Spacecraft Secondary Particle Emissions & Their Energy Deposition in CCD X–Ray Detectors**

*C. S. Dyer, P. R. Truscott, H. E. Evans, and C. L. Peerless, Defence Research Agency*

A radiation transport suite has been used to simulate gamma-ray emissions produced in the XMM spacecraft by interactions of cosmic rays and solar protons. Their energy deposition in CCD detectors is a significant source of background.

**PC-4 Space Applications of the MITS Electron–Photon Monte Carlo Transport Code System**

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

The MITS code system is verified against 3D experimental data and used in adjoint mode to simulate point deposition due to the electron environment in a geometrically complex GPS subsystem.

**PC-5 PRISM—A Tool for Modeling Proton Energy Deposition in Semiconductor Materials**

*M. K. Oldfield and C. I. Underwood, University of Surrey*

This paper presents a description of, and test results from, a new software modeling tool: PRISM (Protons in Semiconductor Materials). The model simulates proton energy deposition in complex 3D sensitive volumes of semiconductor material.

3:20 PM BREAK

**SESSION D SPACECRAFT ENVIRONMENTS AND EFFECTS**

3:45 PM Session Introduction

*Chairwoman: Janet Barth, NASA Goddard Space Flight Center*

**D-1 Single Event Upset at Ground Level**

3:50 PM *E. Normand, Boeing Defense & Space Group*

Ground level upsets have been observed in computer systems containing large amounts of RAM memory and, based on measured data from the WNR neutron beam, they are consistent with the atmospheric neutrons as the major cause of the upsets.

**D-2 Measurements of the Radiation Environment from CREDO–II on STRV & APEX**

4:05 PM

*C. S. Dyer, C. J. Watson, C. L. Peerless, and A. J. Sims, Defence Research Agency; J. Barth, NASA/GSFC*

The Cosmic Radiation Environment and Dosimetry experiments have now been operational in complementary orbits onboard the APEX and STRV satellites since the summer of 1994, enabling extensive comparisons with the standard environment models.



**D-3**  
4:20 PM **New Techniques for Predicting Solar Proton Fluence Levels**  
*M. A. Xapsos, Naval Research Laboratory; G. P. Summers, Naval Research Laboratory and University of Maryland Baltimore County; P. Shapiro, SFA; E. A. Burke, Consultant*

Methods used in extreme value statistics and in compound Poisson process theory are applied to predict the level of solar proton fluences. A database updated to include events up to July 1994 is used.

**D-4**  
4:35 PM **Method for Predicting Anomaly Rate by Spontaneous Pulsing of Insulators Inside Spacecraft**  
*A. R. Frederickson, USAF Phillips Laboratory*

High energy electrons can generate spacecharge-caused electric fields and high voltages inside spacecraft. A new guideline for estimating the frequency of electrostatic discharge pulsing is presented, based on CRRES data.

**D-5**  
4:50 PM **Probability Factors Governing ESD Effects in Geosynchronous Orbit**  
*G. L. Wrenn and R. J. K. Smith, DRA Farnborough*

Case studies of classic distributions of anomalies experienced by operational satellites, due to surface charging (MARECS-A) and internal charging (DRA-8), yield probability factors in respect to solar cycle, season, local time, and geomagnetic activity.

## POSTER PAPERS

**PD-1** **Ground Verification of In-Orbit Anomalies in the Double Probe Electric Field Experiment on Freja**  
*B. Johlander and R. Harboe-Sorensen, ESA/ESTEC; G. Olsson and L. Bylander, Royal Institute of Technology*

System-level proton irradiation as a tool to debug low cost experiment design and component selection shows excellent agreement with in-orbit anomalies. The procedures used and experimental results are reported.

**PD-2** **Shielding Considerations for Satellite Microelectronics**  
*W. C. Fan, C. R. Drumm, S. B. Roeske, and G. J. Scrivner, Sandia National Laboratories*

Shielding for space microelectronics can reduce the dose to an acceptable level. A layered shielding design that is at least fifty percent more effective than a standard, single-material shield is proposed.

**PD-3** **Integrated Environmental Monitoring System for Spacecraft—On-Orbit Results**  
*A. Bogorad, C. Bowman, J. Beck, R. Herschitz, and I. Cohen, Lockheed Martin Astro Space; M. Buehler, Jet Propulsion Laboratory*

Measurements of surface charging, internal charging, and total dose radiation from a GEO orbit are presented. Sensor data correlate well with NASCAP predictions and particle counts from other spacecraft.

5:05 PM **End of Session D**



7:30 AM REGISTRATION AND CONTINENTAL BREAKFAST  
Renaissance Esmeralda Resort, Crystal Ballroom

**INVITED PAPER Galileo at Jupiter**

8:15 AM Robert Mitchell, Jet Propulsion Laboratory

This presentation provides a travelogue of the journey of the Galileo Spacecraft, beginning with its launch in October, 1989, and proceeding through the rather circuitous path to Jupiter, with descriptions of both problems and successes along the way. The results available from both the atmospheric probe mission and the orbiter since the December 7th arrival at Jupiter are shown, and a preview of things to come in the year and a half remaining in the orbital mission is presented.

**Robert Mitchell** is a graduate of the University of Arkansas, and has been at the Jet Propulsion Laboratory for over thirty years. His career started as a trajectory and maneuver analyst for the Mariner '67 Project to Venus. He had similar roles on Mariner '69 to Mars, Mariner '71 (which was the first Mars orbiter), and Viking, the 1975 mission that landed two vehicles on the Martian surface. He has served as Navigation Team Leader for the second half of the Viking mission, Mission Design Manager for the Galileo Project, and Mission Design Section Manager. He is currently Science and Sequence Manager for the Galileo Project.

**SESSION E NON-DESTRUCTIVE SINGLE-EVENT EFFECTS**

9:15 AM Session Introduction

*Chairman: Eugene Normand, Boeing Defense and Space Group*

**E-1 Impact of Technology Trends on SEU in CMOS SRAMs**

9:20 AM *P. E. Dodd, F. W. Sexton, G. L. Hash, B. L. Draper, A. J. Farino, and R. S. Flores, Sandia National Laboratories*

Upset mechanisms and the sensitivity of SEU to technology scaling and design parameters are studied using three-dimensional mixed-level simulation of CMOS SRAMs.

**E-2 Non-Destructive Measurement for CMOS Devices Using Charge Collection Techniques**

9:35 AM *L. Edmonds, G. Swift, and A. Johnston, Jet Propulsion Laboratory*

Results of an experiment providing initial validation of the use of charge collection spectroscopy to measure the overlayer and epitaxial thickness and substrate diffusion length are given for two CMOS SRAM test devices.

**E-3 Single Event Upset Cross Sections at Various Data Rates**

9:50 AM *R. A. Reed and C. J. Dale, Naval Research Laboratory; M. A. Carts and P. W. Marshall, Naval Research Laboratory and SFA; M. La Macchia, Motorola*

We present data which shows that SEU cross section varies linearly with frequency, and investigate SEU cross section behavior as noise margin decreases, which shows that the bit transition region is most susceptible to SEU.

10:05 AM BREAK





- E-4**  
10:30 AM **S.E.U. Experiments on an Artificial Neural Network Implemented by Means of a Transputer**  
*R. Velazco, A. Assoum, and Ph. Cheynet, LSR/IMAG; R. Ecoffet, CNES; M. Olmos, Universitat Politècnica de Catalunya*
- The SEU sensitivity of an Artificial Neural Network intended to be used in space to detect "protonic whistlers" is investigated. A hardware implementation, associating a Transputer to a dedicated neural processor is presented. Experimental results (ground tests and SEU simulations) show the robustness of this implementation.
- E-5**  
10:45 AM **Space Radiation Measurements and Predictions for the IDT 3081 32-Bit RISC  $\mu$ P in the CEMOS VII Process**  
*W. J. Stapor and P. T. McDonald, Naval Research Laboratory*
- High-energy heavy ion SEE measurements were performed on the IDT 3081 RISC micro-processor at the TASCC facility. Results are compared with SEE measurements from other beams and calculated space rates.
- E-6**  
11:00 AM **Analysis of Multiple Bit Upsets (MBU) in a CMOS SRAM**  
*O. Musseau, F. Gardic, and P. Roche, CEA; T. Corbière, Matra MHS; R. Reed, S. Buchner, P. McDonald, J. Melinger, L. Tran, and A. B. Campbell, Naval Research Laboratory*
- MBUs have been studied in a 256k SRAM with heavy ions, at normal and grazing angles, and with a pulsed laser. In both cases they result from strong modification of charge collection mechanisms.
- E-7**  
11:15 AM **Cross Section Measurements and Upset Rate Calculations**  
*E. Petersen, Consultant*
- This paper discusses the impact of the heavy ion upset cross section curve being determined by intra-cell gain variations rather than by cell to cell variations of critical charge as previously assumed.
- E-8**  
11:30 AM **Charge-Collection Characteristics of GaAs MESFETs Fabricated with a Low-Temperature Grown GaAs Buffer Layer: Computer Simulation**  
*D. McMorro, J. S. Melinger, and A. B. Campbell, Naval Research Laboratory; W. R. Curtice, W. R. Curtice Consulting; S. Buchner and A. R. Knudson, SFA*
- Two-dimensional device simulations of GaAs MESFETs fabricated with a low-temperature grown GaAs (LT GaAs) buffer layer reveal a sensitive dependence of the charge-collection characteristics on various structural and operational parameters.

## POSTER PAPERS

- PE-1** **Evaluation of Soft-Error Hardness of DRAMs under Quasi-Heavy Ion Irradiation Using He Single Ion Microprobe Technique**  
*T. Matsukawa, T. Tani, S. Mori, M. Koh, B. Shigeta, K. Igarashi, and I. Ohdomari, Waseda University*
- Soft-error immunity of DRAMs is evaluated by using a single ion microprobe. By irradiating particular sites on the DRAM with He ions, threshold LET and susceptibility to multi-bit errors are estimated.
- PE-2** **Comparison of Beam Blanking SEM and Heavy Ion SEU Tests on NASDA's 64KBit SRAMs**  
*A. Pesce, J. Aoki, T. Hada, N. Nemoto, T. Akutsu, and S. Matsuda, NASDA; T. Igarashi and S. Baba, RYOEI Technica*
- Beam Blanking SEM (BBSEM) was successfully used to measure and to map soft error sites on 64kbit memory cells. A linear relation between BBSEM beam current and heavy ion LET has been found.



**PE-3 Charge Collection in GaAs MESFET Circuits Using a High Energy Microbeam**

*A. Campbell, T. Weatherford, S. Buchner, A. Knudson, and P. McDonald, Naval Research Laboratory; B. Fischer, S. Metzger, and M. Schlögl, GSI*

Measurements of charge collection in test circuits typical of modern GaAs MESFET technology have been performed using the GSI ion microbeam (150 MeV argon). Results show variations in charge collection within transistor elements.

**PE-4 Space Radiation Measurements and Predictions for the Samsung 64 Mb DRAM**

*W. J. Stapor and P. T. McDonald, Naval Research Laboratory; T. Cousins and T. Jones, Defence Research Establishment of Ottawa; S. Andersen and K. Chao, Seagr Engineering; J. D. Kinnison and B. G. Carkhuff, Johns Hopkins Applied Physics Laboratory*

High-energy heavy-ion SEE measurements were performed on 3.3V Samsung 64 Mb CMOS DRAMs. The results indicate that emerging DRAM technologies may be quite suitable for some space missions.

**PE-5 Direct Processes in the Energy Deposition of Protons in Silicon**

*J. Barak and J. Levinson, Soreq NRC; M. Victoria, CRPP; W. Hajdas, Paul Scherrer Institute*

The low-energy part of proton-induced SBD spectra have a higher number of counts than expected from p+Si reactions. It is shown to be mainly due to direct ionization by the protons. This process may cause SEU in devices with low critical charge.

**PE-6 One Parameter Model Calculations for Predicting Proton Induced Upset**

*P. Calvel and C. Barillot, Alcatel Espace; R. Ecoffet, CNES; S. Duzellier, CERT/ONERA*

This paper presents a one-parameter empirical model for proton induced Single Event Upset (SEU). This model is based on heavy-ion data, and will improve the previous 'two-parameter' Bendel model. Application to various parts is presented.

**PE-7 Modeling the Heavy Ion Cross-Section for Single Event Upset with Track Structure Effects: The HICUP-TS Model**

*L. W. Connell and F. W. Sexton, Sandia National Laboratories; P. J. McDaniel, Phillips Laboratory; A. K. Prinja, University of New Mexico*

Whereas HICUP modeled the heavy ion strike as a line source of charge, HICUP-TS accounts for the spatial distribution of electron-hole-pairs by using a  $1/r^k$  profile. The model compares well with experimental data.

11:45 AM LUNCH

**SESSION F SINGLE-EVENT DEVICE EFFECTS**

1:15 PM Session Introduction

*Chairmen: Jeff Titus, Naval Surface Warfare Center, Crane Division  
Jean-Marie Palau, Université de Montpellier*

**F-1 Influence of Ion Beam Energy on SEGR Failure Thresholds of Vertical Power MOSFETs**

1:20 PM

*J. L. Titus, NSWC-Crane; C. F. Wheatley, Consultant; M. Allenspach, R. D. Schrimpf, J. R. Brews, and K. F. Galloway, University of Arizona; D. I. Burton, Harris Semiconductor; R. L. Pease, RLP Research*

For the first time, experimental observations and numerical simulations show that the impact energy of the test ion influences the single-event gate rupture (SEGR) failure thresholds of vertical power MOSFETs.



- F-2**  
1:35 PM **A Physical Interpretation for the Single-Event-Gate-Rupture Cross-Section of N-Channel Power MOSFETs**  
*G. H. Johnson, K. F. Galloway, R. D. Schrimpf, M. Allenspach, and C. Dachs, University of Arizona; J. L. Titus, NSWC-Crane; C. F. Wheatley, Consultant*

The single-event-gate-rupture cross-section is measured as a function of drain-source and gate-source bias for n-channel power MOSFETs. The experimental techniques are explained, and the results are interpreted with the help of two-dimensional computer modeling.

- F-3**  
1:50 AM **First Observations of Power MOSFET Burnout with High Energy Neutrons**  
*D. L. Oberg, J. L. Wert, E. Normand, and P. P. Majewski, Boeing Defense & Space Group; S. A. Wender, Los Alamos National Laboratory*

Single event burnout was seen in power MOSFETs when exposed to high energy neutrons from the Weapons Neutron Research beam. Devices with rated voltage >400 volts exhibited SEBO at substantially less than the rated voltage.

- F-4**  
2:05 PM **SEB and SEGR in N-Channel Power MOSFETs**  
*M. Allenspach, C. Dachs, G. H. Johnson, R. D. Schrimpf, J. R. Brews, and K. F. Galloway, University of Arizona; E. Lorfèvre and J. M. Palau, Université Montpellier*

For particular bias conditions, it is shown that a device can fail due to either single-event gate rupture (SEGR) or single-event burnout (SEB). The likelihood of triggering SEGR is shown to be dependent on the ion impact position.

## POSTER PAPERS

- PF-1** **Radiation Effect Characterization and Test Methods of Single-Chip and Multi-Chip Stacked 16Mbit DRAMs**  
*K. A. LaBel and M. M. Gates, NASA/GSFC; H. S. Kim, Jackson & Tull; P. Marshall, Consultant; J. Kinnison and B. Carkhuff, Applied Physics Laboratory*

This paper presents radiation effects characterization of spaceflight-candidate 16Mbit DRAMs. This includes heavy ion, proton, and Co60 irradiations on single-chip devices, as well as proton irradiation of a stacked DRAM module.

- PF-2** **The Risk of Utilizing SEE Sensitive COTS Digital Signal Processor (DSP) Devices in Space**  
*R. Koga, K. B. Crawford, S. J. Hansel, W. R. Crain, and S. H. Penzin, The Aerospace Corporation*

SEE sensitive DSPs may be utilized in some space-borne systems, in which the number of DSPs is limited. An SEE tolerant system, with a limited risk factor, may be built after thorough ground testing for SEE.

- PF-3** **Single Event Effects in Pulse Width Modulator Controllers**  
*S. H. Penzin, W. R. Crain, K. B. Crawford, S. J. Hansel, J. F. Kirshman, and R. Koga, The Aerospace Corporation*

SEE testing was performed on pulse width modulation (PWM) controllers, which are commonly used in switched mode power supply systems. Two types of single event upset (SEU) were observed that relate to different sections of the device design which involve a Set-Reset flip/flop.

- PF-4** **Single Event Transients in Linear Devices**  
*D. K. Nichols, J. R. Coss, T. Miyahira, and H. R. Schwartz, Jet Propulsion Laboratory*

This paper presents a display of heavy-ion-induced single event transients for linear devices. The transients have serious vital signs: a low LET threshold, high voltage amplitudes and microseconds pulse duration.



**PF-5 Quantitative Estimation of Generation Rates of Si/SiO<sub>2</sub> Interface Defects by MeV He Single Ion Irradiation**

*M. Koh, B. Shigeta, K. Igarashi, T. Matsukawa, T. Tanii, S. Mori, and I. Ohdomari, Waseda University*

Generation rates of oxide trapped holes and interface states in both n-channel and p-channel MOSFETs from CMOS4007 parts by MeV He single-ion irradiation have been investigated quantitatively.

2:20 PM – 5:00 PM  
VALENCIA BALLROOM

**POSTER SESSION**

*Chairman: Lew Cohn, Defense Nuclear Agency*



Authors will be present during this session to answer questions. Posters will be displayed for individual viewing from Tuesday afternoon to Thursday evening (5:00 PM) of the conference. Abstracts for posters are listed in this brochure under the oral sessions with which they are associated.





7:45 AM REGISTRATION AND CONTINENTAL BREAKFAST  
Renaissance Esmeralda Resort, Crystal Ballroom

**SESSION G RADIATION EFFECTS IN PHOTONIC MATERIALS AND SYSTEMS**

8:30 AM Session Introduction

Chairmen: *Chuck Barnes, Jet Propulsion Laboratory*  
*Jean-Claude Boudenot, Thomson-CSF*

**G-1 Proton/Electron Irradiation of Silicon and GaAs/Ge Solar Cells up to High Fluences and a New Coverglass Development**

8:35 AM

*R. L. Crabb and A. P. Robben, ESA/ESTEC*

Plans to launch global communication satellites into high-radiation orbits by 1998 have prompted an experimental evaluation of silicon and GaAs/Ge solar cells to high proton/electron fluences. Coverglass hardening requirements are discussed and the evaluation of a new cerium stabilized coverglass is presented.

**G-2 Anomalous Degradation of Silicon Solar Cells Subjected to High-Fluence Irradiation**

8:50 AM

*T. Ohshima, Y. Morita, and I. Nashiyama, Japan Atomic Energy Research Institute;*  
*O. Kawasaki, T. Hisamatsu, and S. Matsuda, National Space Development Agency of Japan;*  
*T. Nakao and Y. Wakow, Advanced Engineering Services*

Anomalous degradation in the electrical performance of silicon solar cells due to high-fluence irradiation of electrons and protons is investigated. A model which reproduces the anomalous degradation phenomenon is introduced.

**G-3 X-Ray Sensing with Charge Coupled Devices (CCDs) and the Impact of Space Protons**

9:05 AM

*A. Holmes-Siedle and S. J. Watts, Brunel University; A. D. Holland, University of Leicester*

New CCD technology for X-ray astronomy is studied for the impact of space protons. Extensive experiments and modeling are described and methods for in-flight prediction are proposed.

**G-4 Spectral Response of a Laser Diode to Pulsed Irradiation: Comparison with Electrical Excitation**

9:20 AM

*J. Baggio, J. M. Rainsant, C. D'hose, J. L. Leray, P. Lalande, and O. Musseau, CEA*

The analysis of the spectral response of a laser diode shows comparable effects under both electrical and transient radiation excitations. These effects are mostly determined by the transient bias current of the laser diode.

**G-5 Gamma Radiation Tests of Potential Optical Fibre Candidates for Fibroscopy**

9:35 AM

*O. Deparis and M. Decréton, SCK•CEN; P. Mégret and M. Blondel, Faculté Polytechnique de Mons*

Conventional high-OH and new low-OH low-Cl fibres were  $\gamma$ -irradiated in two steps up to 1.5 MGy. From *in situ* radiation-induced attenuation measurements, the latter was found to better meet the requirements for fibroscopy.



## POSTER PAPERS

### PG-1 **Degradation and Recovery of $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ Photodiodes by 1-MeV Fast Neutrons**

*H. Ohyama and K. Hayama, Kumamoto National College of Technology; J. Vanhellemont, IMEC; Y. Takami, Rikkyo University; S. Kohiki, Nagaoka University of Technology; H. Sunaga, Takasaki JAERI*

The degradation of  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  p-i-n photodiodes by 1-MeV fast neutron irradiation and their recovery by subsequent isochronal annealing are investigated and compared with results obtained after 1-MeV electron irradiation.

### PG-2 **The Effects of High Energy Proton and Alpha Particle Radiations on GaAs Quantum Well Infrared Photodetectors (QWIPs)**

*S. M. Khanna, Defence Research Establishment; H. C. Liu, P. H. Wilson, and M. Buchanan, Institute of Microstructural Sciences*

GaAs quantum well infrared photodetectors are ideal for remote-sensing due to their wide wavelength coverage and monolithic two-dimensional array development. High energy proton and alpha particle irradiations indicate their suitability for space applications.

### PG-3 **Low Fluence Neutron Irradiation Effects on Dark Current Distributions in CCDs**

*R. Gaillard, D. Thouvenot, P. Trochet, O. Riant, F. Desnoyers, G. Poirault, and D. Peyre, Nucleides SA*

Dark current variation distributions of two CCD types irradiated with neutrons have been measured, and defect annealing analyzed. Dark current distribution for single interaction allows prediction. Both bulk and interface defects contribute to dark current increases in non-MPP mode.

### PG-4 **Electron Induced Depolarization of a Tellurium Dioxide Modulator**

*E. W. Taylor, J. E. Winter, and A. D. Sanchez, AFMC Phillips Laboratory*

The first observation of electron induced transient depolarization of light propagating in a tellurium dioxide acousto-optic Bragg-modulator is reported. Polarization changes due to electron induced heating effects were analyzed using Stokes formalism.

9:50 AM BREAK

## SESSION H **RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS**

10:15 AM Session Introduction

*Chairman: Mike Xapsos, Naval Research Laboratory*

### H-1 **Mechanisms of Ionizing-Radiation-Induced Gain Degradation in Lateral PNP BJTs**

10:20 AM

*D. M. Schmidt, A. Wu, and R. D. Schrimpf, University of Arizona; D. M. Fleetwood, Sandia National Laboratories; R. L. Pease, RLP Research; W. E. Combs, NSWC-Crane*

The physical mechanisms responsible for gain degradation in lateral PNP bipolar transistors are examined experimentally and through simulation. The effect of increased surface recombination velocity at the base surface is moderated by positive oxide charge.



**H-2**  
10:35 AM **Enhanced Total Dose Damage in Junction Field Effect Transistors and Related Linear Integrated Circuits**

*O. Flament, J. L. Autran, J. L. Leray, and O. Musseau, CEA; R. Truche and E. Orsier, CEA/DTA/LETI*

Enhanced damage for total dose radiation of JFETs is revealed by high temperature and/or low dose rate irradiations. This effect, consistent with previous data on devices processed with field oxides, must be considered for low dose rate effects on linear ICs.

**H-3**  
10:50 AM **Analysis of Bipolar Linear Circuit Response Mechanisms for High and Low Dose Rate Total Dose Irradiations**

*H. Barnaby, Mission Research Corporation; P. Cole and P. Baker, NSW-Crane; R. Pease, RLP Research*

A methodology is presented for the identification of circuit total dose response mechanisms in bipolar linear microcircuits irradiated at high and low dose rates. This includes circuit simulations using SPICE and selective irradiations of portions of the circuit using a scanning electron microscope.

**H-4**  
11:05 AM **Enhanced Damage in Bipolar Devices at Low Dose Rates: Effects at Very Low Dose Rates**

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

The effect of very low dose rates and equivalence of high-temperature irradiation are investigated for several device types that are sensitive to enhanced low dose-rate damage. New results are included at 0.001 rad(Si)/s.

**H-5**  
11:20 AM **Performance of Commercial Analog Processes for Spaceborne Applications**

*G. K. Lum, D. K. Kinell, R. J. May, and L. E. Robinette, Lockheed Martin Missiles & Space*

Total dose hardness of commercial CMOS processes, evaluated at dose rates of 50, 18, 1.8, and 0.175 rad(Si)/s showed leakages ten times greater at the lowest rate. Impact on spaceborne designs will be discussed.

**POSTER PAPERS**

**PH-1** **Dose Rate and Total Dose 1/f Performance of GaAs Heterojunction Bipolar Transistors**

*D. M. Hiemstra, SPAR Environmental Systems*

GaAs heterojunction bipolar transistor 1/f noise performance is demonstrated to be unaffected by dose rate and total dose. This is believed to be due to shielding provided by the N<sup>+</sup> collector from the GaAs substrate.

**PH-2** **Radiation Response of P-I-P Diodes on Diamond Substrates of Various Types**

*A. Denisenko, W. R. Fahrner, and R. Job, University of Hagen; U. Strähle, Ministry of Defense; H. Henschel, Fraunhofer Institute*

P-i-p diodes fabricated on natural and synthetic diamond films are subjected to  $\gamma$ , e<sup>-</sup>, and neutron exposure. Radiation-induced defects are studied by fitting theoretical models of thermionic carrier injection in insulators to experimental I-V curves.



**PH-3 Degradation and Recovery of Proton Irradiated Si<sub>1-x</sub>Ge<sub>x</sub> Epitaxial Devices**

*H. Ohyama and K. Hayama, Kumamoto National College of Technology; J. Vanhellemont, J. Poortmans, and M. Caymax, IMEC; Y. Takami, Rikkyo University; H. Sunaga and I. Nashiyama, Takasaki JAERI; Y. Uwatoko, Saitama University*

Si<sub>1-x</sub>Ge<sub>x</sub> epitaxial diodes and HBTs are irradiated with protons and compared to previous results for electron- and neutron-irradiated devices.

**PH-4 CMOS Inverter Design—Hardened to the Total Dose Effect**

*F. M. Roche and L. Salager, Université Montpellier II/CNRS*

A design-based correction is presented which incorporates a degradation property to improve the total dose rad-tolerance of a logic inverter implemented in a CMOS/bulk technology.

**PH-5 Transient Laser Simulation Tests Adequacy: Shadowing and High Intensity Effects Analysis**

*A. Y. Nikiforov and P. K. Skorobogatov, Specialized Electronic Systems*

Dose-rate effects in a specialized CMOS test structure are investigated using a laser. Results are compared to software simulations.

**PH-6 Radiation and Postirradiation Functional Upsets in CMOS SRAM**

*A. I. Chumakov and A. V. Yanenko, Specialized Electronic Systems*

CMOS SRAM functional upsets are investigated as a function of total dose, dose rate, and annealing time. Localized and conventional X-rays, LINAC, and Sr-90 (Y-90) irradiations were performed.

**PH-7 Radiation Response of Advanced Commercial SRAMs**

*A. J. Lelis, S. R. Murrill, and T. R. Oldham, U. S. Army Research Laboratory*

Total-dose tests have been performed on an advanced commercial 4M SRAM which uses thin-film p-channel transistors in a 6T cell design. These results are compared with results obtained on the 4T-2R cell used in earlier generations of SRAMs.

11:35 AM LUNCH





## INVITED PAPER

1:00 PM

### SPACE AND DESERT STORM

*General Donald Kutyna, U. S. Air Force (Retired)*

The war in Iraq was the first major conflict in which America's space forces played a significant role in supporting its warfighters on the land, over the seas, and in the air. General Don Kutyna, U. S. Air Force (Retired) was commander of those space forces during the conflict. His presentation will outline how space forces were employed, the differences they made, their shortcomings and lessons learned, and improvements to be sought in the future.

**General Donald Kutyna** holds degrees from the U. S. Military Academy, the Massachusetts Institute of Technology, and the Industrial College of the Armed Forces, and is a command pilot with more than 4,500 flying hours in 26 different fighters and bombers. He managed the Department of Defense Space Shuttle Program and was responsible for development, acquisition, and launch support for all Air Force expendable launch vehicles, including the Titan IV. General Kutyna served on the presidential commission to investigate the Space Shuttle Challenger accident. He has served as commander of Air Force Space Command and commander in chief of NORAD and the U. S. Space Command. Among his many honors, General Kutyna has received the General Thomas D. White United States Air Force Space Trophy, given to the individual who has made the most outstanding contribution to the nation's progress in space, and the Air Force Association's Schriever Award, recognizing outstanding contributions to the nation's military space program. He is currently Loral Corporation's Vice President for Advanced Space Systems.

## SESSION I

2:00 PM

### HARDNESS ASSURANCE AND TESTING TECHNIQUES

#### Session Introduction

*Chairman: Mike Maher, National Semiconductor*

#### I-1

2:05 PM

#### Life-Cycle Cost Trade Studies for Hardness Assurance

*D. G. Millward, Millward Research*

Trade studies have been conducted to illustrate that for certain military systems, earlier strategies for hardness assurance can result in higher life-cycle costs than non-standard approaches. A sample problem is included to illustrate the results.

#### I-2

2:20 PM

#### Fundamental Limits of Radiation Hardness in Gate Oxide Arrays

*M. A. Xapsos, Naval Research Laboratory*

Variations in processing during manufacturing and in dose deposition during irradiation limit the overall radiation hardness of modern gate oxide arrays. These factors are quantitatively discussed, and compared to data.

#### I-3

2:35 PM

#### Hardness Assurance Techniques for COTS Devices

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

Hardness assurance (HA) techniques and total dose radiation characterization data for COTS devices from various manufacturers are presented. Test results show that Method 1019.4 is not always valid for COTS devices in space applications.

#### I-4

2:50 PM

#### Accelerated Tests for Bounding the Low Dose Rate Radiation Response of Lateral PNP Bipolar Junction Transistors

*S. C. Witczak, R. D. Schrimpf, K. F. Galloway, and D. M. Schmidt, University of Arizona; D. M. Fleetwood, Sandia National Laboratories; R. L. Pease, RLP Research; W. E. Combs, NSWC-Crane; J.S. Suehle, NIST*

Low dose rate gain degradation of lateral pnp bipolar transistors can be simulated by accelerated irradiations performed at approximately 135°C. Degradation enhancement is explained by temperature-dependent radiation-induced interface trap formation above the transistor's base.



- I-5**  
3:05 PM **Total Dose Effects and Hardness Assurance for Optocouplers**  
*B. G. Rax, C. I. Lee, A. H. Johnston, and C. E. Barnes, Jet Propulsion Laboratory*
- Recent test data on optocouplers showed that significant degradation occurred at 10 krad(Si). This paper investigates the failure mechanisms as well as hardness assurance methods.

- I-6**  
3:20 PM **The Use of Conversion Model for CMOS IC Prediction in Space Environments**  
*I. N. Shvetzov-Shilovsky, V. V. Belyakov, S. V. Cherepko, V. S. Pershenkov, and M. Y. Popov, Moscow Engineering Physics Institute; A. I. Chumakov, Specialized Electronic Systems; V. V. Emelyanov, Scientific Instruments Research Institute*
- A model for total-dose-sensitive MOSFET parameters is developed. In annealing time, this model is a linear function of one variable, providing robust parameter fitting. The model is used for IC prediction in space environments.

## POSTER PAPERS

- PI-1** **Effects of Process Variations on Device Performance and Degradation**  
*M. Satagopan, M. P. Pagey, B. L. Bhuvu, and S. E. Kerns, Vanderbilt University*
- An approach for simulating the effect of process variations on the susceptibility of MOS devices to radiation has been developed. This approach supports the combination of theoretical and experimental results from published research in a single, unified analysis platform.
- PI-2** **Gate-Level Modeling for Leakage Current Failure Induced by Total Dose for the Generation of Worst-Case Test Vectors**  
*A. A. Abou-Auf, U. S. Army Research Laboratory*
- A novel gate-level model has been developed for the automatic generation of worst-case test vectors for leakage current failure induced in CMOS devices by total dose.
- PI-3** **Elevated Temperature Irradiation of Bipolar Linear Microcircuits**  
*R. L. Pease, RLP Research; M. Gehlhausen, NSWC-Crane*
- Conventional bipolar linear microcircuits were irradiated at high dose rate, elevated temperature and the results compared to low dose rate, room temperature response. Elevated temperature enhanced degradation, but not as much as at low dose rates.
- PI-4** **Post-Irradiation Degradation of Input Bias Current on Commercial Linear Bipolar Integrated Circuits**  
*P. L. Cole, D. Emily, W. E. Combs, and M. A. Gehlhausen, NSWC-Crane; R. L. Pease, RLP Research*
- Input bias current of selected commercial bipolar linear circuits increases significantly after Co-60 irradiation on a scale of hours to weeks. Transistors were isolated and gain degradation was correlated with circuit response. Possible mechanisms are discussed.
- PI-5** **Low Dose Rate Proton Irradiation of Quartz Crystal Resonators**  
*R. Koga, M. D. Looper, and S. D. Pinkerton, The Aerospace Corporation; P. Cash and D. Emmons, Datum Inc.; W. J. Stapor and P. T. McDonald, Naval Research Laboratory*
- Quartz crystal resonators were systematically irradiated with 65 MeV protons to characterize low dose radiation-induced degradation.

3:35 PM **End of Session I**

4:00 PM **Open Meeting**



7:45 AM REGISTRATION AND CONTINENTAL BREAKFAST  
Renaissance Esmeralda Resort, Crystal Ballroom

INVITED PAPER **Thriving in the Desert: The Story of the Coachella Valley**  
8:30 AM *Morgan Levine*

The Coachella Valley contains a unique combination of natural desert and manmade features. This talk and slide presentation will describe the local desert environment, the plants and animals that inhabit the valley, where all the water to supply the population (and golf courses) comes from, and the earthquake risk in the valley. In addition, the history and culture of the local Cahuilla Indians will be described, including how they became the most successful Indian tribe in the United States.

Also known as "Wind in Her Hair," **Morgan Levine** is originally from the Linne Indian Tribe. She earned her "Indian" name because she has spent most of her life in the San Geronio Pass, the third windiest pass in the world. For the past twenty years, she has ranched in the Coachella Valley. When she's not busy leading jeep and hiking tours, Morgan works with the Cahuilla Indians, Coachella Valley Archeological Society, and numerous other environmental groups in education about the cultural and natural resources of the Coachella Valley. She is an award-winning speaker and an expert on local Native American cultures, ethnobotany, and historical facts regarding the area.

9:30 AM – 12:00 PM  
VALENCIA BALLROOM

**RADIATION EFFECTS DATA WORKSHOP**  
*Chairman: Scott Tyson, Mission Research Corporation*



Authors will be present at posters to answer questions during this session. Workshop posters will be displayed for individual viewing from Tuesday afternoon until the end of the conference at noon on Friday.

**W-1 Dose Rate and Total Dose Noise Performance of a Commercial Off the Shelf Dielectrically Isolated Operational Amplifier During Irradiation**  
*D. M. Hiemstra, SPAR Environmental Systems*

The noise performance in a dose rate environment of a dielectrically isolated FET operational amplifier at the onset of irradiation and with respect to total dose is presented. Comparison to previously reported results is made.

**W-2 Radiation Effects in Analog CMOS Analog-to-Digital Converters**  
*T. L. Turflinger, M. V. Davey, and J. P. Bings, NSWC-Crane*

Analog CMOS circuitry is becoming common in the marketplace. Two commercial ADCs are tested in the total dose and dose rate environments. Test results and applicability to system use are discussed.

**W-3 Total Ionizing Dose (TID) Evaluation Results of Low Dose Rate Testing for NASA Programs**  
*A. K. Sharma, NASA/GSFC; K. Sahu and S. Brashears, Unisys*

This paper summarizes the evaluation results of total ionizing dose (TID) low dose rate testing (0.01 to 0.15 rads/sec) in support of NASA programs using parts such as EEPROMs, ADCs and DACs, op amps, voltage comparators and references, and DC-DC Converters.



**W-4 Current Single Event Effect Test Results for Candidate Spacecraft Electronics**

*K. A. LaBel, A. K. Moran, D. K. Hawkins, A. B. Sanders, and E. G. Stassinopoulos, NASA/GSFC; C. M. Seidleck, Hughes/ST Systems Corporation; H. S. Kim and J. E. Forney, Jackson & Tull; P. Marshall, Naval Research Laboratory/SFA; C. Dale, Naval Research Laboratory; J. Kinnison and B. Carkhuff, Applied Physics Laboratory*

We present both proton and heavy ion single event effect (SEE) ground test results for candidate spacecraft electronics. A variety of digital and analog devices were tested, including EEPROMs, DRAMs, and DC-DC Converters.

**W-5 A Compendium of Recent Total Dose Data on Bipolar Linear Microcircuits**

*R. L. Pease, RLP Research; W. E. Combs, NSWC-Crane; A. Johnston, Jet Propulsion Laboratory; T. Carriere, Matra Marconi Space; S. McClure, Hughes Space and Communications*

Many conventional bipolar linear microcircuits used in space systems have shown a dose-rate sensitivity to total-dose degradation. Dose-rate data taken by several agencies have been combined and presented in terms of sensitive parameter shifts at a fixed dose and dose-rate enhancement factor.

**W-6 Dose Rate Effects of a Bipolar A/D Converter**

*G. U. Youk, University of Florida*

The total ionizing dose rate tests of the AD574 were performed at the dose rate of 2 to 10 rad (Si)/s. The results clearly show increasing failure rate as dose rate increases. Unlike modern bipolar technology, no sign of the reverse trend at low dose rate was found for the AD574.

**W-7 The Total Dose Response of NPN Transistors with Different Package Types to Various Irradiation Conditions**

*S. Dowling, Cranfield University*

Devices with two different geometries were made from single wafers, in four different packages. The effects of temperature, shielding, and dose rate during irradiation were evaluated, for total doses of 25 to 200 Gy.

**W-8 "RADON-5E" Portable Pulsed Laser Simulator: Description, Qualification Technique and Results, Dosimetry Procedure**

*A. Y. Nikiforov, O. B. Mavritsky, A. N. Egorov, V. S. Figurov, V. A. Telets, P. K. Skorobogatov, and S. A. Polevich, Specialized Electronic Systems*

The RADON-5E portable laser simulator is described. The measurement procedure and qualification technique are discussed and qualification test results are presented. The dosimetry procedure is developed and calibration curves for several ICs are measured in flash X-ray tests.

**W-9 The Effects of Ionizing Radiation on the Honeywell HTMOS High Temperature Linear CMOS Technology**

*D. Larsen, P. Welling, and W. Tsacoyeanes, Draper Laboratory*

LINAC test results for the Honeywell HTMOS, high temperature, 10V, linear IC technology demonstrated device survival at  $5 \times 10^{11}$  rads(Si)/s with recovery times below 10  $\mu$ s. Co-60 tests demonstrated functionality up to 1MRad(Si), though a few manufacturer's specifications were exceeded.





**W-10 Total Dose Radiation Hard 0.5  $\mu\text{m}$  SOI CMOS Transistors and 256K SRAMs**

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

The total dose radiation performance of 0.5  $\mu\text{m}$  non-fully depleted CMOS transistors and 256K SRAMs fabricated in SIMOX is discussed. The address access time of the SRAM varied from 15 ns at 3.6 V to 19 ns at 2.75 V.

**W-11 Update of Single Event Failure in Power MOSFETs**

*D. K. Nichols, J. R. Coss, and T. Miyahira, Jet Propulsion Laboratory; J. Titus, NSW-Crane; D. Oberg, J. Wert, and P. Majewski, Boeing*

This paper presents an update of the first 1994 compendium of single event test data for power MOSFETs. It provides failure thresholds from burnout or gate rupture for some 40 devices of six manufacturers.

**W-12 Single Event Effect Proton and Heavy Ion Test Results for Ethernet Local Area Network Commercial Devices**

*C. Poivey, P. Garnier, and T. Carrière, Matra Marconi Space; J. Nagel, DASA*

We present proton and heavy ion single event effect (SEE) ground test results for candidate spacecraft commercial electronics. Device types are IEEE802.3 (ETHERNET) Local Area Network (LAN) controllers, repeaters, and transceivers.

**W-13 The Heavy Ion Irradiation Facility at CYCLONE—A Dedicated SEE Beam Line**

*G. Berger and G. Ryckewaert, Université Catholique de Louvain; R. Harboe-Sorensen and L. Adams, ESA/ESTEC*

The CYCлотron of LOuvain la NEuve (CYCLONE) produces ion beams for SEE studies. This paper describes the present facility, improvements to be installed, and some SEU data taken at both BNL and UCL.

**W-14 Opportunities for Single Event and Other Radiation Effects Testing and Research at the Indiana University Cyclotron Facility**

*C. C. Foster, S. L. Casey, P. Miesle, N. Sifri, and A. H. Skees, Indiana University Cyclotron Facility; K. M. Murray, KM Sciences*

The beam line end station and associated instrumentation used at the Indiana University Cyclotron Facility for radiation effects research and testing with up to 200 MeV protons are described, as are plans for future enhancements.

**W-15 Heavy Ion Evaluation of GaAs Microwave Devices**

*C. Barillot, A. Bensoussan, F. Brasseur, and P. Calvel, Alcatel Espace*

Four GaAs processes were evaluated under heavy ion testing in order to estimate their sensitivity to Single Event Burnout. Different biases were applied. Burnout was observed at the higher voltages, but the hardness of these four processes appears suitable for nominal space applications.

**W-16 Solar Cell Degradation Observed by the Advanced Photovoltaic and Electronics Experiments (APEX) Satellite**

*K. P. Ray, E. G. Mullen, and D. A. Guidice, Phillips Laboratory; D. E. Delorey, Boston College; D. C. Marvin, The Aerospace Corporation; H. B. Curtis and M. F. Piszczor, NASA Lewis Research Center*

Solar cell data from the Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) experiment flown onboard the APEX satellite is presented. Comparisons between different array materials and correlations with the space radiation environment are made.

12:00 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 Crystal Ballroom D, E, and F, which is adjacent to the Valencia Ballroom. The exhibit will be open from noon to 5:00 PM on Tuesday, July 16, and again that evening from 7:00 PM to 10:00 PM. During the Tuesday evening session, refreshments will be provided for attendees and their guests. The exhibits will be open again during the continental breakfast on Wednesday morning, July 17. The exhibits will close at 10:30 AM following the mid-morning break. Companies wanting additional information regarding exhibits should contact Bill Bartholet at (206) 773-9268 or send E-mail to nsrec96@asic.ds.boeing.com. Late registration for exhibit booth space will be accepted.

## PRE-REGISTERED EXHIBITORS

**Actel Corporation**  
**Boeing Defense & Space Group**  
**GEC Plessey Semiconductors**  
**Harris Semiconductor**  
**Honeywell Solid State Electronics Center**  
**J. L. Shepherd & Associates**  
**Loral Federal Systems-Manassas**  
**Space Electronics Inc.**  
**SiBond, L. L. C.**  
**Temic**  
**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 adjacent to the Crystal Ballroom to reserve a room for a side meeting. Arrangements for audiovisual equipment, refreshments, etc., should be identified so they can be relayed to the Renaissance Esmeralda Resort. Requesters are personally responsible for settling accounts for such items during the conference. Contact ETC Services, Inc. at (303) 770-2055 or send an e-mail message to ETCSVC@aol.com to make meeting reservations in advance.

## MESSAGES

**(619) 773-4444**  
**Fax: (619) 346-9308**

A message board will be located in the lobby area outside the Crystal Ballroom for all incoming messages during the Short Course and Technical Sessions. Faxes can be received through the resort. Costs associated with faxes are the responsibility of the attendee.

## CONTINENTAL BREAKFAST & COFFEE BREAKS

The 1996 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 and newspapers will be provided for each resort guest with their wake-up call.

## RADIATION EFFECTS COMMITTEE OPEN MEETING

The IEEE Radiation Effects Committee will hold its Open Meeting in the Crystal Ballroom from 4:00 PM to 5:30 PM on Thursday, July 18. 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 Committee. There will be a special election for Secretary of the RESG to complete the remaining year of a three-year term. Finally, a Nominating Committee will be elected to choose candidates for next year's Steering Committee ballot. Nominations will be taken from the floor. All NPSS members are eligible to vote. Refreshments will be provided.



## Steering Group

### *Chairman*

**Peter S. Winokur**  
Sandia National Laboratories

### *Executive Vice-Chairman*

**Klaus G. Kerris**  
Army Research Laboratory

### *Secretary*

**Mary K. D'Ordine**  
Raytheon Company

### *Treasurer*

**Walter M. Shedd**  
Phillips Laboratory

### *Senior Member-at-Large*

**David W. Emily**  
Naval Surface Warfare Center

### *Member-at-Large*

**James P. Frank**  
Honeywell, Inc.

### *Junior Member-at-Large*

**Kenneth A. LaBel**  
NASA/GSFC

### *Past Chairman*

**Kenneth F. Galloway**  
The University of Arizona

### *Vice-Chairman, Publications*

**Daniel M. Fleetwood**  
Sandia National Laboratories

### *Vice-Chairman, Publicity*

**Kenneth K. Hunt**  
Mission Research Corporation

### *Special Publications Assignment*

**Paul V. Dressendorfer**  
Sandia National Laboratories

### *RADECS Liaison*

**Philippe M. Calvel**  
Alcatel Espace

### *Vice-Chairman, 1995 NSREC*

**Dale G. Platteter**  
Naval Surface Warfare Center

### *Vice-Chairman, 1997 NSREC*

**Dennis B. Brown**  
Naval Research Laboratory

### *Vice-Chairman, 1998 NSREC*

**James R. Schwank**  
Sandia National Laboratories

### *AdCom Members:*

**Mayrant Simons**  
Research Triangle Institute

**Burr C. Passenheim**  
Full Circle Research, Inc.

**James R. Coss**  
Jet Propulsion Laboratory

**James P. Spratt**  
Full Circle Research, Inc.

## News from the Radiation Effects Steering Group (RESG)

The RESG welcomes Ken LaBel of the NASA Goddard Space Flight Center (GSFC) as its newly elected Member-At-Large. In addition, the Chairman has appointed Ken Hunt of Mission Research Corporation as Vice-Chairman of Publicity, Philippe Calvel of Alcatel Espace as RADECS Liaison, and Jim Schwank of Sandia National Laboratories as the 1998 Nuclear and Space Radiation Effects Conference (NSREC) General Chairman. The RESG is pleased to announce that beginning in 1996, NASA GSFC will become an official sponsor of the NSREC, joining DNA, Phillips Laboratory, Sandia, and JPL.

At its Fall Meeting in Indian Wells, the RESG reviewed the 1995-1998 NSRECs. The 1995 NSREC was, by any metric, a great success. Despite declining attendance, it ran financially in the "black" and maintained a strong international flavor. The conference was attended by 397 engineers and scientists from 17 countries, with 71 international registrants. At the Technical Sessions, 116 papers were presented in oral and poster format. Most papers presented at the conference were published in the December Issue of the IEEE Transactions on Nuclear Science (TNS). We are indebted to Guest Editors Ron Schrimpf (U. of Arizona), Art Campbell (Naval Research Laboratory), and Lloyd Massengill (Vanderbilt University) who worked tirelessly with reviewers and authors to produce this high-quality journal. A Radiation Effects Data Workshop, chaired by Ken LaBel, was also held during the conference. Seventeen data-intensive papers were published in late November in the 1995 IEEE Radiation Effects Data Workshop Record, available from the IEEE Service Center. Great job Ken!

Chuck Utrias, General Chairman of the 1996 NSREC, reviewed final plans for the upcoming Indian Wells Conference. Many details of the 1996 NSREC are contained in this program booklet. In addition, Dennis Brown, General Chairman of the 1997 NSREC, discussed preliminary plans for his conference which will be held in Snowmass Village (at Aspen), Colorado on July 21-25, 1997. Dennis is joined by Allan Johnston as Technical Program Chairman, Teresa Farris as Local Arrangements Chairwoman, and Joe Benedetto as Finance Chairman.

We have clearly entered the information age. The role of the World Wide Web in IEEE is expanding exponentially. Look for IEEE Spectrum, Table of Contents of IEEE journals, and even Conference Proceedings on the Web. The NSREC now has its own home page on the Web at <http://www.ieee.org/nps/nsrec/nsrec.html>. Aside from the conference brochure, this is the best place to get information about this year's conference, including information about the Palm Springs area. Try it out! Our thanks to Dale Platteter, who is our very own webmeister. In addition, the NSREC Call for Papers is available from IEEE e-mail by sending any message to [nsrec.call@ieee.org](mailto:nsrec.call@ieee.org).

We are pleased to distribute two important publications to 1996 NSREC attendees. The first is the April '96 Special Issue of TNS on "Single Event Effects and the Space Radiation Environment." This issue, nearly eighteen months in preparation, was co-edited by Dan Fleetwood of Sandia and Remi Gaillard of Nucleides SA, France. It contains approximately 30 articles on recent progress in understanding single-event effects on electronics and photonics, as well as in understanding the near-earth space radiation environment. The second publication is the Proceedings from RADECS'95, which was held in Arcachon, France last Fall. Approximately 100 papers, on topics ranging from basic mechanisms of radiation effects to flight-test data, are included in its pages. Approximately 50 of these papers were published in a June '96 Special Issue of TNS.

On a final note, I must point out that only one-half of attendees at this Conference belong to IEEE, and considerably fewer are members of our sponsoring IEEE Society, Nuclear and Plasma Sciences (NPSS). Membership in IEEE has many benefits, including reduced registration fees at this and other IEEE conferences. IEEE/NPSS membership allows one to vote in IEEE elections and is a requirement for holding key elected and/or appointed REC positions that shape the future of this Conference. If you are not a member of IEEE and NPSS, I urge you to drop by our IEEE membership desk in the registration area and join up. We need your active participation to maintain the NSREC as the premier radiation-effects conference in the U. S. As always, 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*

# Awards

## 1995 NSREC AWARDS

For the 1995 Conference, awards were determined by a combination of popular vote and awards committee balloting. In addition to the traditional Outstanding and Meritorious Paper Awards, the new awards process also acknowledges best conference presentations in the oral, poster, and data workshop sessions.

### Outstanding Paper Award

#### **Effects of Interface Traps and Border Traps on MOS Postirradiation Annealing Response**

*D. M. Fleetwood, W. L. Warren, J. R. Schwank, P. S. Winokur, M. R. Shaneyfelt, and L. C. Riewe*

### Meritorious Paper Awards

#### **Hardness Assurance Issues for Lateral PNP Bipolar Junction Transistors**

*R. D. Schrimpf, R. J. Graves, D. M. Schmidt, D. M. Fleetwood, R. L. Pease, W. E. Combs, and M. DeLaus*

#### **Single-Event Gate Rupture in Power MOSFETs: Prediction of Breakdown Biases and Evaluation of Oxide Thickness Dependence**

*M. Allenspach, I. Mouret, J. L. Titus, C. F. Wheatley, Jr., R. L. Pease, J. R. Brews, R. D. Schrimpf, and K. F. Galloway*

#### **Enhanced Damage in Linear Bipolar Integrated Circuits at Low Dose Rate**

*A. H. Johnston, B. G. Rax, and C. I. Lee*

### Outstanding Oral Presentations

#### **Hardness Assurance Issues for Lateral PNP Bipolar Junction Transistors**

*R. D. Schrimpf, R. J. Graves, D. M. Schmidt, D. M. Fleetwood, R. L. Pease, W. E. Combs, and M. DeLaus*

#### **Single-Event Gate Rupture in Power MOSFETs: Prediction of Breakdown Biases and Evaluation of Oxide Thickness Dependence**

*M. Allenspach, I. Mouret, J. L. Titus, C. F. Wheatley, Jr., R. L. Pease, J. R. Brews, R. D. Schrimpf, and K. F. Galloway*

### Outstanding Poster Presentation

#### **Impact of Oxide Thickness on SEGR Failure in Vertical Power MOSFETs: Development of a Semi-empirical Expression**

*J. L. Titus, C. F. Wheatley, Jr., D. I. Burton, I. Mouret, M. Allenspach, J. R. Brews, R. D. Schrimpf, K. F. Galloway, and R. L. Pease*

### Outstanding Data Workshop Presentation

#### **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, C. M. Seidleck, H. S. Kim, J. Forney, and C. Dale*

## IEEE FELLOWS

One member of the radiation effects community was elected to the grade of IEEE Fellow on January 1, 1996.

### **Nelson S. Saks**

*Naval Research Laboratory*

A certificate will be presented to Mr. Saks during the conference opening on Tuesday, July 16.



# Registration and Travel

## CONFERENCE REGISTRATION

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

To pre-register, complete the Conference registration form enclosed in this booklet. Please note that the registration fees are higher if payment is received after June 12, 1996.

Mail the Conference registration form with your remittance to ETC Services, Inc. Faxed registrations will be accepted with credit card payment. The registration form, **with payment**, should be mailed to arrive no later than 7 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 "1996 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 Crystal Ballroom on the following schedule:

Sunday, July 14	4:00 PM – 9:00 PM
Monday, July 15	7:30 AM – 5:00 PM
	6:30 PM – 9:30 PM
Tuesday, July 16	7:30 AM – 5:00 PM
Wednesday, July 17	7:30 AM – 3:00 PM
Thursday, July 18	7:45 AM – 3:00 PM
Friday, July 19	7:45 AM – 10:00 AM

## RESORT RESERVATIONS

**Renaissance Esmeralda Resort**  
**44-400 Indian Wells Lane**  
**Indian Wells, California 92210-9971**  
**(619) 773-4444**  
**Fax: (619) 836-1285**

The 1996 IEEE NSREC will be held at the 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 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 NSREC daily room rate for either single or double occupancy is \$89 plus tax. Roll-aways are also available upon request at \$15 each. In addition, a block of rooms is available at the prevailing Government rate plus tax for U. S. government attendees. The rate is available only for U. S. Government civilian or military personal **with proof of Government employment and travel orders**. All reservations must be guaranteed and accompanied by a first night deposit, required 14 days after a reservation is made. The deposit is refundable if cancellation is received by the resort 72 hours prior to the arrival date. Check-in time is 3:00 PM. The Health and Fitness Center Admissions fee will be waived for all attendees.

**The cut-off for room reservations is June 12, 1996. After June 12, 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 INDIAN WELLS

The newly expanded and remodeled terminal at the Palm Springs Regional Airport truly accommodates the needs of recreational and business travelers. Air service is currently available from numerous U. S. cities. The Palm Springs Regional Airport is located approximately 15 miles from the Renaissance Esmeralda Resort. Additional flights are offered at the nearby Ontario and Los Angeles International Airports and John Wayne/Orange County Airport.

*You can help the NSREC control costs by having your travel agent include the conference discount codes when making reservations with American, Southwest, or Hertz. Note that it is not necessary to use the conference negotiated rates to have your travel agent include the reference number.*

### Airline Discount

American Airlines (our primary carrier), and Southwest Airlines, in cooperation with the IEEE NSREC, are offering special discounts to the conference.

**American Airlines (primary carrier):** Rates are based on American's published round-trip fares within the United States and Canada.

- Travel dates are between July 11 and July 22, 1996. Destinations are Palm Springs Regional Airport, Los Angeles International Airport, Ontario International Airport, and John Wayne/Orange County Airport.
- A 5% discount off any American published fare in effect when tickets are purchased, subject to all applicable restrictions.
- A 10% discount off applicable unrestricted one-way fares in effect when tickets are purchased seven days in advance.

To take advantage of this discount, call American, or have your travel agent call, at (800) 433-1790 for reservations. **Reference AN#7776AC.**

**Southwest Airlines:** Southwest Airlines is offering a 10% discount off Southwest's low everyday "unrestricted" fares and a 5% discount off many of Southwest's even lower "restricted" fares. Discounts are valid for tickets purchased by July 5, 1996. For Southwest Airline reservations call the special group number (800) 433-5368 and provide **Identifier Code #M9886.**

### Rental Car Discount

**Hertz** has been selected as the Official Rental Car Agency for the 1996 NSREC. Special discounted rental car rates will apply one week before and one week after the conference. For reservations and information call Hertz at (800) 654-2240 and mention **Reference CV#5168.**

Car/Class	Daily Rates	Weekly Rates (5-7 days)
Compact 2-Door/4-Door	37.99/40.99	156.99/171.99
Midsize	43.99	179.99
Full Size 2-Door/4-Door	46.99/49.99	201.99/209.99

All rates include free mileage. Rates do not include tax, optional coverages, or gas refueling charges. Return car to same rental location or additional charges may apply. Rental locations are Palm Springs Regional Airport, Los Angeles International Airport, Ontario International Airport, and John Wayne/Orange County Airport. Other car classes are available.

### Transportation from Palm Springs Airport

The Transportation Department of the Renaissance Esmeralda Resort is available to provide transportation to conference attendees staying at the resort at a special rate of \$17 each way. Simply copy, complete, and send or fax the Transportation Form on the next page to the Renaissance Esmeralda Resort so that it arrives a minimum of one week prior to your arrival. The transportation charges will be billed to the guest's room account. Taxi service is approximately \$35 per person each way.



**RENAISSANCE ESMERALDA RESORT**  
**ATTN: TRANSPORTATION DEPARTMENT**

The Transportation Department of the Renaissance Esmeralda Resort is available to provide transportation to conference attendees staying at the resort to and from the **Palm Springs Airport only**.

One-Way Trip: \$17 (IEEE NSREC)  
Round Trip: \$34 (IEEE NSREC)

Please photocopy and complete the following information and send or fax to the address or fax number below, attention Transportation Department, a minimum of one week prior to arrival. Transportation charges will be billed to guest's room account.

NOTE: PLEASE HAVE ALL BAGGAGE IDENTIFIABLE WITH NAME TAGS.

TRANSPORTATION INFORMATION

Guest Name: \_\_\_\_\_

Phone # (Home): \_\_\_\_\_ (Office): \_\_\_\_\_

Arrival Date: \_\_\_\_\_ Departure Date: \_\_\_\_\_

Airline: \_\_\_\_\_ Airline: \_\_\_\_\_

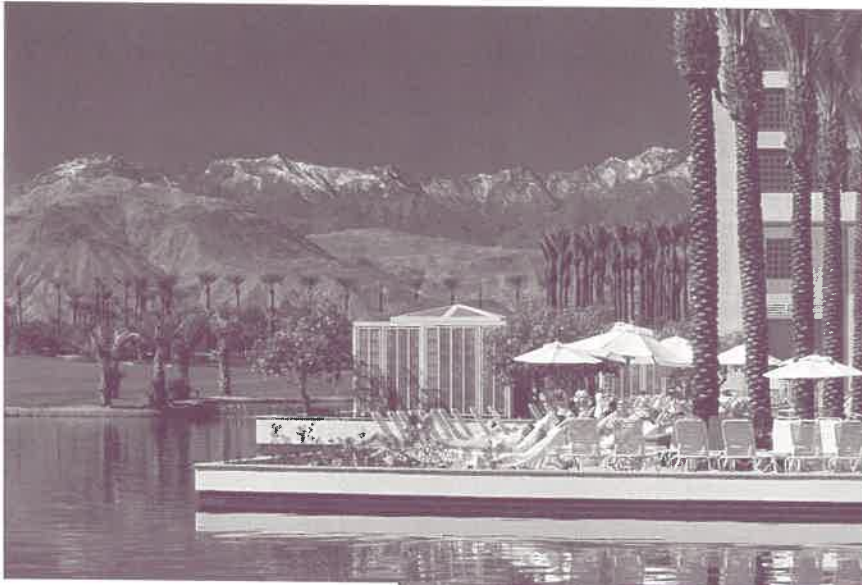
Flight #: \_\_\_\_\_ Flight #: \_\_\_\_\_

Arrival Time: \_\_\_\_\_ Departure Time: \_\_\_\_\_

Depart Resort: \_\_\_\_\_

If we may be of any further assistance, please do not hesitate to contact Gerry McLaughlin at (619) 773-4444 ext. 2336 or fax to (619) 836-1271.

Renaissance Esmeralda Resort  
44-400 Indian Wells Lane  
Indian Wells, CA 92210-9971  
**FAX: (619) 346-9308**





# 1996 IEEE NSRE Conference and Short Course Registration Form

Name \_\_\_\_\_  
Last Name First Name Middle Initial

Name to appear on badge \_\_\_\_\_

Company/Agency \_\_\_\_\_

Mailing Address \_\_\_\_\_  
\_\_\_\_\_

City \_\_\_\_\_

State \_\_\_\_\_ Zip Code \_\_\_\_\_

Country \_\_\_\_\_

Telephone Number \_\_\_\_\_

FAX Number \_\_\_\_\_

E-mail Address \_\_\_\_\_

## IEEE MEMBERSHIP

☐ I am an IEEE Member. \_\_\_\_\_  
Membership Number

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

**Nonmembers must register at the nonmember rate**, but if you join during the conference, you will receive a complimentary half-year membership in IEEE and in the IEEE Nuclear and Plasma Sciences Society.

## CANCELLATIONS

A \$25 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after July 1, 1996, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference.

Mail or FAX 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 FEES

(Late fee REQUIRED if payment received after June 12, 1996)

	Early	Late	
<b>IEEE Member</b>			
Short Course	\$225	\$250	\$ _____
Technical Sessions	\$275	\$350	\$ _____

<b>Non-IEEE Member</b>			
Short Course	\$275	\$300	\$ _____
Technical Sessions	\$375	\$450	\$ _____

<b>Full-Time Students who are IEEE Members</b>			
Short Course	\$100	\$100	\$ _____
Technical Sessions	\$100	\$100	\$ _____

Total Amount Enclosed for Registration:	\$ _____
Add 5% if Credit Card Payment:	\$ _____
<b>TOTAL AMOUNT ENCLOSED:</b>	\$ _____

## PAYMENT OF FEES

☐ Enclosed is a check or money order in **U.S. DOLLARS ONLY**, drawn on or payable through a U.S. bank.  
Payable To: **1996 IEEE NSREC**

☐ Charge Registration Fees plus 5% to my Credit Card using one of the following Credit Cards:

☐ American Express ☐ Master Card ☐ Visa

Card No. \_\_\_\_\_

Expiration Date \_\_\_\_\_

Cardholder  
Signature \_\_\_\_\_

If your company or agency is going to pay by check at a later date, please do not complete the credit card portion of this form.



# 1996 IEEE NSREC Activities Registration Form

Conference Participant \_\_\_\_\_

Company/Agency \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_

State \_\_\_\_\_ Zip Code \_\_\_\_\_

Country \_\_\_\_\_

Telephone Number \_\_\_\_\_

FAX Number \_\_\_\_\_

Accompanying  
Persons: \_\_\_\_\_  
Name

Please list ages  
for children under  
age 21 only. \_\_\_\_\_  
Name Age

\_\_\_\_\_  
Name Age

\_\_\_\_\_  
Name Age

## CHILD CARE INFORMATION

Child care will be provided only during "An Evening with the Phantom." This will be available at no charge for those who pre-register their children by June 12, 1996 (names and ages must be included on this registration form). If you do not pre-register, we cannot guarantee there will be space for your child. For those who wish to arrange for child care at other times during the conference, contact the resort's concierge desk for licensed and bonded child care referrals.

## CANCELLATIONS

To encourage advanced registration for conference activities, we will refund all activity fees for conference attendees and/or their family members who for any reason are unable to attend the conference. To receive your refund if your plans change after this form is submitted, **you must** notify ETC Services by FAX at (303) 741-5890 (do not FAX changes after Thursday, July 11) or notify the conference registration desk when picking up your registration materials (**but no later than 24 hours before the scheduled activity**).

Mail or FAX this form and your remittance to:

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

## ACTIVITY FEES

Late fee **REQUIRED** if payment received after June 12, 1996. We strongly encourage early registration; note that the number of tickets available for each event is limited. Children must be accompanied by an adult during all tours and social events.

	Early	Late	Number Attending	Total Cost
<b>California Dreamin' Beach Party: Monday, July 15</b>				
Adult	\$0	\$0	_____	\$_____
Child (Ages 0-11)	\$0	\$0	_____	\$_____
<b>Lunch with a Psychic...Ask LaVeta! Tuesday, July 16</b>				
Adult	\$22	\$25	_____	\$_____
Child (Ages 0-11)	\$22	\$25	_____	\$_____
<b>An Evening with the Phantom: Wednesday, July 17</b>				
Adult	\$27	\$32	_____	\$_____
Child (Ages 0-11)	\$18	\$22	_____	\$_____
Child Care (Ages 0-12)	\$0	\$0	_____	\$_____
<b>The Living Desert: Thursday, July 18</b>				
Adult	\$11	\$14	_____	\$_____
Child (Ages 3-11)	\$6	\$8	_____	\$_____
Child (Under 3)	\$0	\$0	_____	\$_____

Total Amount Enclosed for Activities:	\$ _____
Add 5% if Credit Card Payment:	\$ _____
<b>TOTAL AMOUNT ENCLOSED:</b>	\$ _____

## PAYMENT OF FEES

☐ Enclosed is a check or money order in **U.S. DOLLARS ONLY**, drawn on or payable through a U.S. bank.  
Payable To: **1996 IEEE NSREC**

☐ Charge Registration Fees plus 5% to my Credit Card using one of the following Credit Cards:

☐ American Express ☐ Master Card ☐ Visa

Card No. \_\_\_\_\_

Expiration Date \_\_\_\_\_

Cardholder  
Signature \_\_\_\_\_





# Social Program

The 1996 NSREC Committee will provide a program that gives you and your companions a taste of the culture, beauty, and entertainment found in the Coachella Valley area. We strongly encourage early registration for the social events; note that the number of tickets available for each event is limited. **Late fees apply if payment is received after June 12, 1996.** Children must be accompanied by an adult during all tours and social events.

*All conference participants and companions who register and pay by June 12 for the Lunch with a Psychic, An Evening with the Phantom, or The Living Desert will be entered in a drawing for a free "spa sampler" at the Renaissance Esmeralda Resort Health Spa. The spa sampler includes a half-hour massage, a half-hour facial, a manicure, and a pedicure.*

**Monday, July 15**  
7:00 PM – 10:00 PM  
**California Dreamin'  
Beach Party**  
*Conference Reception*

Conference attendees and their families are invited to join in the fun at the California Dreamin' Beach Party located at the Renaissance Esmeralda Resort's pool from 7:00 PM to 10:00 PM. Complimentary beach food, fun, and music will be available to all. Enjoy practicing your golf putts, racing Cigarette Radio Controlled Boats, sand volleyball, hula-hoop contests, basketball, and more! The kids will love the sandy beach play area. Don't miss the opportunity to renew old friendships and start new ones. The registration desk will be open during the conference reception, 6:30 PM – 9:30 PM, outside the Crystal Ballroom.

**Tuesday, July 16**  
11:00 AM – 2:00 PM  
**Lunch with a Psychic  
Ask LaVeta!**  
*Companion Event*

LaVeta Dillman, professional psychic, will teach you how to use your own intuitiveness for personal growth. Enjoy a leisurely lunch followed by LaVeta's entertaining presentation where she will give you the confidence to believe in your own intuitions. Voluntary audience participation will allow her to personally interact with you and answer questions specific to your areas of interest. LaVeta brings out the best in everyone. Join us for a motivational and enlightening afternoon you won't soon forget. Buses depart from the resort's front lobby at 11:00 AM and return at 2:00 PM. Adults/Children (Ages 0–11): \$22 (Early)/\$25 (Late).

For 25 years **LaVeta Dillman** has provided psychic counseling to corporations, social organizations, police departments, and individuals, including a number of well-known celebrities. A registered nurse for 37 years, LaVeta developed her psychic intuitions around the age of 40. Now a professional psychic, LaVeta dispenses psychic advice over the airwaves weekdays via *Ask LaVeta*, and hosts *Living the Spirit*, a Sunday morning motivational show. She also occupies much of her time hosting motivational classes, speaking engagements, and personal-growth seminars.



**Wednesday, July 17**  
6:30 PM – 10:30 PM  
**An Evening with  
the Phantom**  
*Conference Social*

Join us for an exquisite evening of fine cuisine and entertainment featuring musical selections from Andrew Lloyd Weber's "Phantom of the Opera" Broadway musical. You and your guests will be a part of the phantom's lair and opera house, experiencing the dramatic music that attributes to this musical's worldwide fame. After the dinner and performance, delight in a lively band and dance floor music. This exciting night will be one to remember! The festivities will take place at the resort's Crystal Ballroom from 6:30 PM – 10:30 PM. Complimenting this evening of drama and fun will be a child care program providing food, entertainment, and games for the enjoyment of our younger guests who do not wish to attend "An Evening with the Phantom." **To ensure an appropriate child to adult ratio, advance registration will be required for the child care program. If you do not make reservations for the child care program by June 12, we cannot guarantee there will be space for your child.** Adults : \$27 (Early)/\$32 (Late), Children (Ages 0–11, An Evening with the Phantom): \$18 (Early)/\$22 (Late), and Child Care Program (Ages 0–12): \$0.



**Thursday, July 18**  
**7:45 AM – 11:00 AM**

**Explore the Living Desert**

*Companion Event*

The Living Desert Wildlife and Botanical Park is like a zoo, only better. Besides the magnificent cats and howling wolves, you'll also view breathtaking gardens as you journey through 1,200 acres of the desert's intricate and fragile ecosystem. Visit Eagle Canyon and encounter mountain lions, golden eagles, bobcats, foxes, javelinas, Mexican wolves, and more. Acclaimed as one of the most successful zoological parks in the country, the Living Desert is home to nearly 400 fascinating desert animals. The lush botanical gardens represent 10 different desert ecosystems, and over 5 miles of hiking trails are offered on its 1,000 acre adjacent preserve. Buses will depart from the main entrance of the Renaissance Esmeralda Resort at 7:45 AM. Your ticket will admit you to the Living Desert for you to explore at your leisure. Food and beverages are available at the park's café and the gift shop offers unique Living Desert souvenir items. Shuttle buses will be available for return to the resort at 10:00, 10:30, and 11:00 AM. Adults: \$11 (Early)/\$14 (Late), Children (ages 3–11): \$6 (Early)/\$8 (Late). Children under 3 years old are free.



Arabian Oryx – "Unicorn of the Desert" Photograph © The Living Desert

**CHILD CARE**

Excluding Wednesday night's child care program (see Conference Social above), no child care will be provided by the conference. Please contact the resort's concierge desk at (619) 773-4444 for licensed and bonded child care referrals.

# Resort Activities

**Golf** The resort is situated on the Indian Wells Golf Resort, which is comprised of two 18 hole championship golf courses designed by Ted Robinson. The cost for NSREC attendees staying at the Renaissance Esmeralda Resort is \$37.00 for Monday through Thursday, and \$47.00 Friday through Sunday. In addition, for those wishing to play golf after 3:00 PM ("Twilight Play"), the cost is \$30.00 for any day of the week. Rates include: green fees for 18 holes, shared cart, and range balls. There is a one time golf club storage fee at the resort of \$5.00/stay. To make golf reservations, call the Esmeralda at (619) 773-4444 and ask for the reservation department. The reservation department will confirm that you are a guest at the resort and will make your golf reservations for you.

**Tennis** Seven courts are available for play (two of these are lit for night play). Rate: \$5.00/person/court hour. Tennis lessons are available for an additional fee. Call (619) 836-1270 to book court times or for additional information.

**Health Spa and Fitness Center** The resort health spa and fitness center includes: Nautilus equipment, Lifecycle, Liferower, Stairmaster, Precor Treadmill, and an aerobic room. Spa services include massages, facials, manicures, pedicures, and make-up applications. Daily admission to the spa is complimentary for attendees staying at the Renaissance Esmeralda Resort. Cost of spa treatments and services can be obtained by contacting the spa personnel directly.



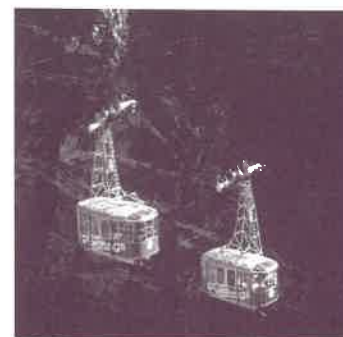
# Coachella Valley Area

## GENERAL INFORMATION

Indian Wells is one of the seven cities in the Coachella Valley that comprise the Palm Springs Desert Resorts Communities. The Palm Springs Desert Resorts is the home of the Aerial Tramway, Desert Museum, Indian Canyons, Oasis Waterpark, Moorten's Botanical Garden, Palm Springs Suns baseball team, Palm Springs International Film Festival, and more. Visitors revel in its gourmet restaurants, sidewalk cafes, shopping, culture, 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 fascinating 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. For free literature on the Palm Springs Desert Resort Communities, please call the Convention and Visitors Bureau at (800) 967-3767.

### Palm Springs Aerial Tramway

Experience the breathtaking panorama as you soar high above the rugged San Jacinto Mountains. Passengers travel 2.5 miles from Valley Station (2,643 feet) in Chino Canyon to Mountain Station (8,516 feet) at the edge of Long Valley and back again. Mountain Station features an Alpine buffet restaurant, cocktail lounge, gift and apparel shop, picnic area and movie theater. Both stations have observation decks to offer spectacular views of Palm Springs and the surrounding areas. Picnic areas and food are available. This area is also popular with hikers, offering 54 miles of trails in the San Jacinto Wilderness Park. (619) 325-1391.



Photograph by Arthur Coleman

### Galleries in Palm Springs

The numerous fine art galleries throughout Palm Springs encourage browsing and special recognition of noted artists. Below are just a couple you might like to explore:

*Adagio Galleries*, southwest and Latino art from the west coast. (619) 320-2230.  
*Heusso Gallery*, whimsical art for the young at heart. (619) 322-8957.

### La Quinta Sculpture Park

Stroll through the paved trails of this 20-acre park admiring both the sculptures and breathtaking views of the surrounding mountains. The beautiful 3-acre lake is enhanced with floating statues as well. Golf carts are available for rental. (619) 564-6464.

### Date Gardens

Don't leave the desert without trying the popular "date shakes". The Coachella Valley is the "Date Capital of the World," with worldwide shipping. Palm groves have thrived here since the 1800s. Nearby ranches on Highway 111 that are open to visitors include the Indian Wells Date Gardens in Palm Desert and the Oasis Date Gardens in Thermal. Shields Date Gardens in Indio presents a continuous slide program on the history of dates.

### General Patton Memorial Museum

This museum contains memorabilia from World War II and other eras of American military history and includes displays of tanks and artillery. A 26-minute video highlights the general's life and career. The development of Southern California's water system and 11 desert training camp sites are indicated on a relief map. 30 miles east off I-10 at Chiriaco Summit. (619) 227-3483.

### Palm Springs Suns Professional Baseball

In its second season, the Double A Minor League team will play in town from July 12-20 at Palm Springs Stadium. Advance tickets: (619) 323-7867.

### Moorten's Botanical Garden

Walk the trails of this internationally famous living museum to view its 3,000 varieties of giant cacti, trees, birds, succulents, and flowers. A nursery is open to visitors as well at this "Desertland" Historical Landmark. (619) 327-6555.





## Shopping

*Palm Canyon Drive* (Palm Springs), glamorous boulevard rich in a diverse artistic culture.  
*El Paseo Drive* (Palm Desert), known as "Rodeo Drive of the Desert" offers designer boutiques, art galleries and novelty shops – a unique shopping experience.  
*Desert Fashion Plaza* (Palm Springs), specializes in haute couture from the likes of Gucci, I. Magnin and Saks.  
*Desert Hills Factory Outlet Stores* (Cabazon), Adolfo II, Guess?, Esprit, OshKosh, Corning/Revere, Anne Klein, etc.  
*Palm Desert Town Center* (Palm Desert), four major department stores and many small boutiques and specialty shops.

## Oasis Waterpark

The Palm Springs Oasis Waterpark is a deluxe, family-oriented water playground with a wave pool, 13 waterslides, river, spa, beach volleyball and an outdoor pavilion. Body or board surf the wave pool, inner tube the "Whitewater" river or dare to free-fall down the 70-foot "Scorpion" slide. "Creature Fantasy" is fun time for the small children with giant fun critters. There's plenty of shade, beach food, and rental "hideaway" cabanas available. Lockers and dressing rooms are on site. (619) 325-7873.



Photograph by Arthur Coleman

## Camelot Park Family Entertainment Center

Camelot Park is a playground for the entire family. Enjoy any one of the three 18-hole miniature golf courses, a batting cage, go carts, bumper boats, and a games pavilion. Camelot Park is located in Cathedral City. (619) 321-9893.

## Idyllwild

Travel the scenic Palms-to-Pines Highway to cool off in the mountain community of Idyllwild. This Alpine town is nestled in a pine forest, a refreshing change from the desert landscape. Wander through the quaint town and discover the specialty shops featuring antiques and hand-crafted items, galleries, and restaurants.

## Temecula Valley

Known as the "Napa Valley of the South", Temecula Valley is one of Southern California's best kept secrets. The valley boasts 3,000 acres of premier grapes grown annually, producing up to 140,000 cases of wine. Wines include award-winning Chardonnay, Sauvignon Blanc, Chenin Blanc, and Cabernet Sauvignon. As you travel through the picturesque scenery of the valley you will pass internationally famous wineries such as Callaway and Thornton (specializing in "Methode Champenoise"), to name a few.

## Southern California Attractions

Extend your stay and take advantage of your close proximity to Southern California's many attractions. Visit Disneyland, Knott's Berry Farm, Universal Studios, the San Diego Zoo, Sea World, and the sunny Southern California beaches. The Palm Springs Desert Resorts are located within a two-hour drive of Los Angeles, Orange County and San Diego.

## WEATHER AND CLOTHING

Typical July temperatures in the Coachella Valley range from 73°F to 108°F. The average humidity is 24%, easing the discomfort of the high temperatures. The recommended clothing is casual, short-sleeve shirts, and don't forget your swimsuit! Additionally, a hat and sun block are strongly suggested during the day. A few of the city's more exclusive restaurants require a coat and tie for gentlemen, but most welcome casual attire. Temperatures are lower at the top of the Palm Springs Aerial Tramway and the Alpine community of Idyllwild.



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## 1997 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE Short Course and Radiation Effects Data Workshop



**July 21-25, 1997**  
**Snowmass Conference Center**  
**Snowmass Village, Colorado**

The 1997 IEEE International Conference on Nuclear and Space Radiation Effects will be held July 21-25 in Snowmass Village, Colorado at the Snowmass Conference Center. 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 21, a Radiation Effects Data Workshop, and an Industrial Exhibit. The technical program includes oral and poster sessions. 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:

### **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, guidelines, and hardness assurance methodology
- Radiation exposure facilities

**New technologies and developments of interest to the radiation effects community**

## PAPER SUMMARY DEADLINE: FEBRUARY 5, 1997



## Procedure for Submitting Summaries:

Authors must conform to the following requirements:

1. Submit 12 copies of (a) an abstract no longer than 35 words attached to (b) an informative summary (appropriate for a 12-minute presentation). 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.
2. The summary should be no less than two nor more than four pages in length, including figures and tables. *All figures and tables must be large enough to be clearly read.* Note that this is more than an abstract, but *do not exceed four pages.*
3. Type your summary using 11 point or greater type on either U. S. Standard, 8.5 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 and company affiliations of the authors, and company address (city and state). Underline the name of the author presenting the paper.
4. Obtain all corporate, sponsor, and government approvals and releases necessary for presenting your paper at an open-attendance international meeting.
5. Include a cover letter giving (a) the names, complete addresses, and telephone and FAX numbers of all authors, and (b) the session that you prefer for presentation (if you have a preference). *Authors are also encouraged to state their preference for an oral or poster presentation in the conference, or a poster at the data workshop.* However, the final category of all papers will be determined by the Technical Program Committee, which is responsible for selecting final papers from initial submissions.

Papers accepted for oral or poster presentation at the Conference will be eligible for publication in the Conference issue of the *IEEE Transactions on Nuclear Science* (December 1997), based on a separate submission of a complete paper, and subject to an independent review after the Conference. Further information will be sent to prospective authors upon acceptance of their NSREC summary. It is not necessary to be an IEEE member to present a paper or attend the NSREC. However, we encourage IEEE membership of all NSREC participants.

**Radiation Effects Data Workshop:** The Radiation Effects Data Workshop is a forum for papers on radiation effects data on electronic devices and systems. Workshop papers are intended to provide radiation response data to scientists and engineers who use electronic devices in a radiation environment, and for designers of radiation-hardened systems. Papers describing new simulation or radiation facilities are also welcomed. The procedure for submitting a summary to the Workshop is identical to the procedure for submitting NSREC summaries. Radiation Effects Data Workshop papers will be published in a Workshop Proceedings and are not candidates for publication in the Conference issue of the *IEEE Transactions on Nuclear Science*.

**Snowmass Village:** NSREC is returning to Snowmass! Snowmass is located 200 miles from Denver and Colorado Springs. Enjoy a scenic 3 hour drive or fly directly into the Aspen Pitkin County Airport. Airport shuttle service is available along with shuttle service throughout Snowmass. The conference will be held at the Snowmass Conference Center, a 35,400 sq. ft. facility. For those of you who attended NSREC in 1987, you will remember the Center is one of the finest conference facilities in the Rocky Mountains.

Few places in the world can rival the natural beauty and cultural atmosphere found in the Snowmass/Aspen area. A seemingly endless variety of events, dining, and entertainment affords you the opportunity to enjoy different activities and cuisine. Snowmass Village Mall has over 50 shops and restaurants and is reminiscent of a European village. The historic mining town of Aspen tempts you with over 100 restaurants and a myriad of boutiques and galleries.

At an elevation of 8300 feet, hiking trails abound. Trails begin at Snowmass Village and will lead hikers from novice to expert into the high country. The famous Maroon Bells of the Rockies are located 15 miles from Snowmass and are a photographer's paradise. True to the Old West, horseback rides, western BBQs, hayrides, and a local rodeo are available to the conference attendees. The Aspen Music Festival will be running during the conference.

Selected properties in the area include the Silvertree Hotel, adjacent to the Conference Center. The Silvertree offers three restaurants and a nightclub, along with 16 shops at the Silvertree Plaza. The Wildwood Hotel is located next door to the Center, offering a pool and hot tub nestled amongst the aspens. The Mt. Chalet extends the warmth and comfort of a mountain ski lodge, while the Stonebridge Inn's newly remodeled lobby, restaurant, and lounge will be a welcome spot to greet fellow attendees. Both Mt. Chalet and Stonebridge Inn are a short walk from the Center. All properties have mini-refrigerators and coffee makers in the rooms and will extend conference rates from July 17-27, 1997. More extensive information can be found at the Aspen/Snowmass site on the World Wide Web (<http://www.aspenonline.com/aspenonline/>).

**See you at Snowmass!**

**Summaries (12 copies) must be received by February 5, 1997.**

Address them to:

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Photograph courtesy of Snowmass Resort Association

# **Renaissance Esmeralda Resort**

**44-400 Indian Wells Lane  
Indian Wells, California 92210-9971  
(619) 773-4444  
Fax: (619) 346-9308**





### Directions From the Palm Springs Airport

The Renaissance Esmeralda Resort is located approximately 15 miles from the Palm Springs Airport. From the airport please turn left onto El Cielo, then left on Ramon Road. Take Interstate 10 East to the Washington exit and exit right onto Washington. Turn right 3 miles later on Highway 111. Travel two miles to Indian Wells Lane. The Esmeralda is on the right side.

### Directions From Los Angeles International Airport

Exit airport, take Century Blvd. to Interstate 105 East. Exit onto Interstate 605 North. Go to Interstate 10 East. Take I-10 East past the Palm Springs turnoff and continue 25 minutes to the Washington exit. Turn right on Washington and go 3 miles to Highway 111. Turn right and travel two miles to Indian Wells Lane. The Esmeralda is on the right side.

