Association RADECS

www.radecs.org

Radecs 2009

www.radecs2009.com

10th European Conference on Radiation Effects on Components and Systems

Conference Program RADECS 2009

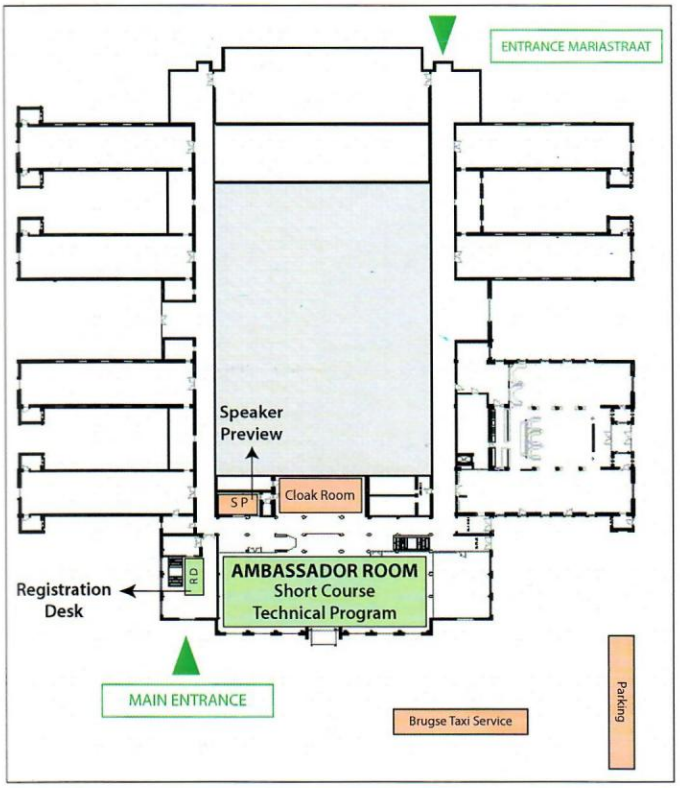
14 - 18 September, 2009

Bruges - Belgium

Conference Venue

Oud Sint-Jan Conference Center
Mariastraat 38 or parking via Zonnekemeers
8000 Brugge
Belgium
www.oudsintjan.eu

Level 0



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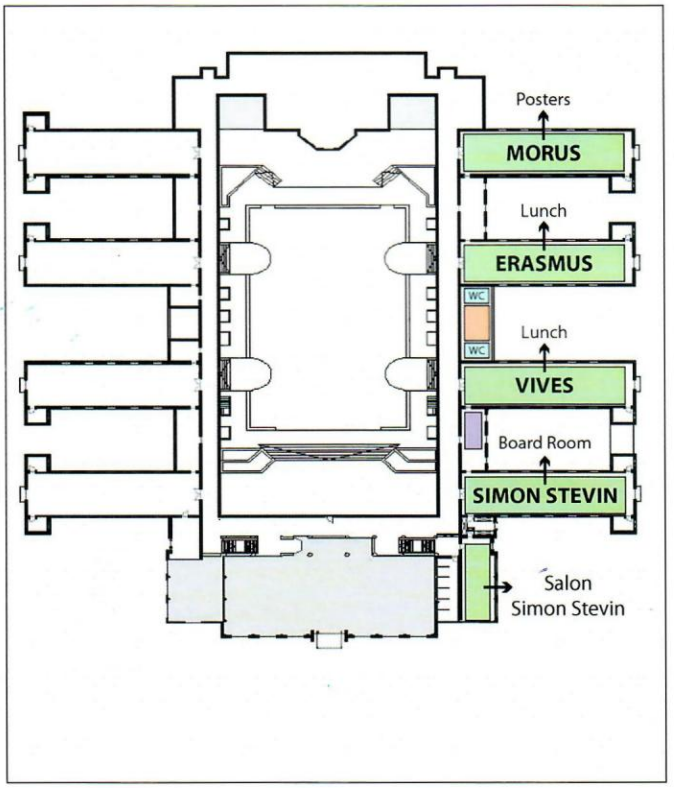

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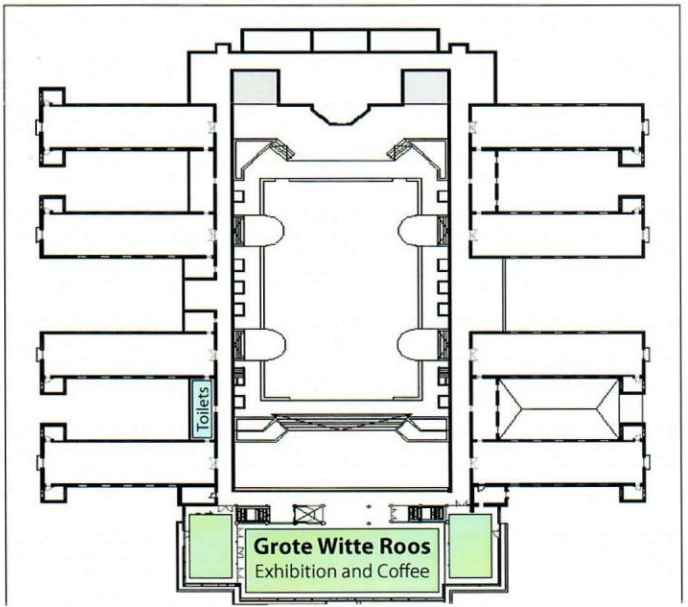

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Program at a Glance

Time	Monday September 14	Tuesday September 15	Wednesday September 16	Thursday September 17	Friday September 18
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8.40	**Short Course 1**		**Session C:** SEE - Mechanisms and Modeling I		
9.00				**Session E:** Hardness Assurance	
9.10		**Session A:** Devices, Integrated Circuits and MEMS I			
9.15					Invited Lecture 4
9.30					
9.45			Invited Lecture 2	Invited Lecture 3	
9.55	Coffee Break				**Session I:** Technology and Design Hardening
10.00					
10.15	**Short Course 2 & 3**				
10.30		Coffee Break	Coffee Break	Coffee Break	
10.45					
10.55				**Session F:** Terrestrial and Radiation Environments	
11.00		**Session A:** Devices, Integrated Circuits and MEMS II	**Session C:** SEE - Mechanisms and Modeling II		Conference Closing
11.15					
11.30					Light Lunch
11.45					
12.00	Lunch	Lunch	Lunch	Lunch	Bus to IMEC
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14.00					
14.15					
14.30					
14.45			Coffee Break	Coffee Break	
15.00		Coffee Break			
15.10				**Session H:** Dosimetry and Facilities	
15.15			Poster Papers & Data Workshop & Late News		
15.30	Coffee Break	Invited Lecture 1			
15.45					
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16.30					
16.45					
17.00					
17.15					
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17.45					
18.00					
19.00	Reception Town Hall			Belgian Evening	

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Chairman's Invitation

Benoît Brichard
RADECS 2009
General
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On behalf of the RADECS association (Radiation and its Effects on Components and Systems), I am pleased to invite you to attend the 10th RADECS conference to be held September 14-18 in Bruges, Belgium. This year is an important milestone for the RADECS community corresponding to the 10th edition of the biennial conference meeting and, herewith, the 20th anniversary of the RADECS association. The conference is organized in strong partnership between SCK•CEN, Thales Alenia Space Etca and IMEC. Following the tradition the conference will feature a high-quality technical program including a data workshop, a one-day short course and an industrial exhibition. RADECS is a key meeting for scientists and engineers dealing with radiation effects in electronic devices and undoubtedly the event not to be missed in Europe regarding such a topic. We welcome you to be part of this forum.

The RADECS meeting will start on Monday, September 14, with the traditional one-day Short Course organized by Sylvain Girard from CEA. This year the focus will be on current simulation techniques available to model radiation environments and their related radiation-induced effects. Such subject becomes more and more important with the reality of the downscaling of electronics and the associated necessity to develop appropriate tools to better understand and predict radiation-induced degradations in electronics. The short course presenters have prepared a useful key notebook for future references and I am convinced that you will take great benefit attending this short course.

The Technical Program Chair, Cor Claeys from IMEC, and his technical committee have assembled a rich set of varied contributed papers reporting the latest advance on radiation effects in electronic and photonic materials, devices and systems. The program is spread over 10 oral sessions from Tuesday, September 15 to Friday, September 18 and one poster session including a Data Workshop as well as the Late News contributions.

Teresa Farris (Aeroflex) and Christian Chatry (TRAD) succeeded in building a nice panel of 23 exhibitors for the industrial exhibition. Leading companies involved in electronic, photonic, space and nuclear applications will exhibit their latest cutting-edge technologies and services to users concerned by radiation. A Welcome Reception for participants and their guests is organized on Tuesday evening.

Our local organizer Medicongress has assembled an interesting social program and tour. They will take care of us for the time of the conference. Feel free to contact them if you have inquiries. I also invite you to attend the Belgian Evening on Thursday evening, which is the perfect time to meet old friends but also to make new ones too! Bruges is a marvellous place with a medieval flavour and a large historical heritage certified by Unesco. I am confident that you will enjoy discovering this beautiful city.

The conference committee and I are delighted to welcome you.
Enjoy your stay!

Short Course Program
Monday, September 14, 2009

TOWARDS MODELING OF RADIATION EFFECTS IN NANO-SCALE SYSTEMS

08.40 **SHORT COURSE INTRODUCTION**
S. Girard (CEA, France)

08.50 **Session I: Basics of Radiation Effects in Electronic Devices**
A. Paccagnella & S. Gerardin (Univ. Padova, Italy)

09.55 COFFEE BREAK

10.20 **Session II: Evolution of the Radiation Environments**
J. Barth (NASA/ Goddard Space Flight Center, USA)

11.15 **Session III: Experimental Tools to Simulate Radiation Environments / Radiation Effects**
G. Berger (UCL, Belgium) & V. Pouget (CNRS – IMS Lab, France)

12.10 LUNCH

13.40 **Session IV: Radiation Transport Models and Software**
P. Truscott (Qinetiq Aerospace Division, UK)

14.35 **Session V: Monte-Carlo Simulation of Single-Event Effects**
R.A. Weller, R.D. Schrimpf, R.A. Reed, M.H. Mendenhall, K.M. Warren, B.D. Sierawski, L.W. Massengill (Institute for Space & Defense Electronics, Vanderbilt Univ., USA)

15.30 COFFEE BREAK

15.55 **Session VI: Simulation of Radiation Effects at the Atomic Scale: Theory and Examples of Applications**
N. Richard (CEA, France)

16.50 **Session VII: Future Challenges in Radiation Effects**
P.E. Dodd, M.R. Shaneyfelt, J.R. Schwank, and J.A. Felix (Sandia National Laboratories Albuquerque, USA)

17.30 CLOSING REMARKS

19.00 RECEPTION AT THE TOWN HALL OFFERED BY THE MAYOR OF BRUGES

Short Course Introduction

Course Description

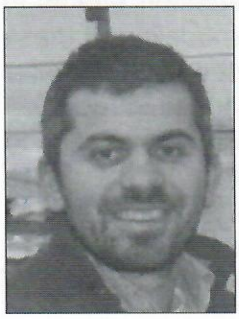
A one-day short course will be held at the beginning of the RADECS Conference, on September 14, in Bruges, Belgium.

The Short Course will review the evolutions of radiation environments, related effects on electronics and the future challenges for the radiation effect community. The short course will be composed of seven oral presentations of 45 minutes each. In the morning, the first three courses will focus on the description of radiative environments and on the experimental facilities, theoretical models and softwares allowing to estimate the vulnerability of electronic or optoelectronic components. Three courses will address the description of radiation effects in electronic devices and circuits with a special emphasis on the modeling of these effects from the atomic scale to the components. Finally, the last course will offer the attendees the opportunity to discuss about the future challenges in radiation effects. This tutorial short course will offer an opportunity for newcomers to familiarize with radiation effects, and for experts to review their knowledge and to focus on unexplored areas. A short course notebook will also be provided to each attendee as a companion to the oral presentations of the instructors, and also to serve as a useful reference for members of the radiation effects community.

Sylvain Girard (CEA)

Received the M. Sc. in 2000, and a Ph.D. in Optics and Optoelectronics Engineering in 2003, both from the University of Saint-Etienne, France. He joined the Commissariat à l'Energie Atomique (CEA DAM) in 2004 as a Research Engineer in charge of studies related to radiation-induced effects on optoelectronic and electronic devices. He is directly in charge of studies on the vulnerability of optical components, and more particularly fiber optics and glasses for the future Laser Mégajoule. Sylvain has authored or co-authored more than 45 papers published in international journals and more than 60 conference presentations. He took several positions within the organizing committee of the RADECS conferences: in 2006 as Session Chair and in 2007 as Guest Editor for the Conference Proceedings. He also served in the organizing committees of other workshops and conferences, including the Symposium "SiO_2 and Advanced Dielectrics" (2006, 2008), and the first International Symposium on Reliability of Optoelectronics for Space (in 2009). He currently serves as Associated Editor for IEEE Transactions on Nuclear Science. Sylvain is a Member of the IEEE and NPSS.

Short Course 1



Basics of Radiation Effects in Electronic Devices

Alessandro PACCAGNELLA and Simone GERARDIN
Università di Padova

Summary - Exposure of microelectronic devices and circuits to ionizing radiation can lead to two broad classes of effects. Total ionizing dose (TID) effects are related to the progressive degradation of insulating layers, leading to parametric drifts and possible failure. Single event effects (SEE) are due to charge deposited by strongly ionizing particles and collected by sensitive circuit nodes, and may cause both transient and permanent effects. The main quantities describing the interaction of ionizing radiation with electronic chips will be introduced in this presentation.

Afterwards, the basic mechanisms underlying TID effects will be reviewed, focusing on the build-up of trapped charge and generation of defects in insulating layers. For Bipolar devices, the impact of radiation dose (ELDRS) will be described. TID effects have been strongly mitigated in CMOS circuits by thinning of the gate oxide, causing degradation of the lateral isolation to become the most prominent phenomenon. The SEE classification will be presented, along with the main parameters characterizing this class of phenomena. The fundamental physical aspects of the charge deposition and collection process will be presented. SRAM will be the component chosen to illustrate the different aspects related to SEEs that can be experimentally observed.

Biographies - Alessandro Paccagnella is Full Professor of Electronics at the University of Padova, where he coordinates the research activity of the RREACT team at the Department of Information Engineering. He has worked on the effects induced by ionizing radiation in semiconductor detectors and devices, starting from silicon detectors for high energy physics to CMOS devices and circuits, co-authoring more than 300 scientific papers. At present, his interests are focused on synergetic effects between ionizing radiation and electrical stresses in decananometer transistors, non-volatile memories, and programmable logic devices such as FPGAs. He has coauthored papers that received awards at NSREC and RADECS conferences.

Simone Gerardin received the Laurea degree (summa cum laude) in Electronics Engineering in 2003, and a Ph.D. in Electronics and Telecommunications Engineering in 2007, both from the University of Padova, Italy. He is currently a research assistant at the same university. His activity is focused on soft and hard errors induced by ionizing radiation in advanced CMOS technologies, and on their interplay with device aging and ESD. Simone has authored or co-authored more than 20 papers published on international journals and more than 40 conference presentations, including two best student papers. In 2005 he received the Phelps Continuing Education Grant from the NPSS.

Short Course 2

Evolution of the Radiation Environments

Janet BARTH
NASA/Goddard Space Flight Center

Summary - This Session of the Short Course will focus on the sources of the radiation environments and the drivers that produce variations. The presentation will include the discovery and definition of the radiation environments from both scientific and engineering points of view. The availability of descriptions of the radiation environment that are useful for engineering applications is dependent on our knowledge of the environment, the availability of appropriate data for modelling, and funds for modelling and validation. Modelling efforts are also driven by the emergence of new, critical radiation effects and mechanism issues as the radiation sensitivity of technologies change. The Session will also provide background information and serve as an introduction for Session 3, "Radiation Transport Models and Software". The complex space radiation environments consist of 1) particles trapped by planetary magnetospheres in "belts", including protons, electrons, and heavier ions 2) transient particles which include protons and heavy ions of all of the elements of the periodic table, and 3) primary and secondary particles in the atmospheres of planets. Variations depend on location in space and on the year in the solar cycle, both somewhat predictable. However, large variations that depend on events on the Sun are not predictable with reasonable certainty. We will see that since the early 1960's efforts to understand the radiation environment and its variations often went hand in hand with requirements generated by the mission goals of our agencies. Session 1 will also discuss the requirements for descriptions of the radiation environment that can meet the needs of system designers and operators through all phases of the life cycle of spacecraft development and operation. For example, statistically based specification or "climate" models are used for the design phase, which includes system design and mission planning; the operation phase requires "forecasting" models for protecting the systems investment, for mission planning, and for personnel scheduling; and "nowcasting" the environment is used to resolve anomalies so risk can be reassessed for both the operating systems and for other systems that are in development.

Biography - Since 1976 Ms. Janet Barth has worked at NASA/Goddard Space Flight Center (GSFC). She started her career working in the area of radiation environments and effects research and as a lead radiation hardness assurance engineer for NASA flight projects. She was a member of the team that developed NASA's systems engineering approach to radiation hardness assurance for emerging technologies. Starting in 2000, Ms. Barth worked on the development of NASA's Living With a Star (LWS) Program as a member of the science preformulation/ proposal team and the LWS Program Science Architecture Team, and later as the Project Manager for the LWS Space Environment Testbed. In 2002 she became the Associate Head of GSFC's Flight Data Systems and Radiation Effects Branch and in 2005 she was appointed as the Branch Head. The Branch develops flight qualified Command and Data Handling avionics systems for spacecraft and instruments and supports spacecraft integration. The Branch is also responsible for radiation hardening of spacecraft and instrument systems and for leading research on the characterization of space radiation environments and its effects on space flight electronics components. Ms. Barth is actively involved with the IEEE Nuclear and Radiation Effects Conference (NSREC); teaching the Short Course in 1997, as the Guest Editor of the Transactions on Nuclear Science from 1998-2000, the Technical Program Chairwoman in 2001, and the General Conference Chairwoman in 2006. She is a regular participant in the Radiation and its Effects on Components and Systems (RADECS) Conference and has served as a session co-chair and as the NSREC liaison to the RADECS Conference Technical Committee in 2001. She is a member of the RADECS Association and the IEEE Nuclear and Plasma Sciences Society Advisory Committee. Ms. Barth is a Senior Member of the IEEE.

Short Course 3

Experimental Tools to Simulate Radiation Environments / Radiation Effects

Guy BERGER and Vincent POUGET
Université catholique de Louvain and CNRS – IMS Lab

Summary - Despite good understanding of device behaviors and evolution of their parameters, harsh environment utilizations need a complete characterization using specific tools. Irradiation facilities are widely used for this purpose using heavy ions, protons and neutrons beams for Single Event Effect (SEE) and Cobalt 60 sources for Total Ionizing Dose (TiD) testing. Additional tools like the lasers are also very useful. This course will describe the different available tools which are used for device testing. We will focus on important parameters and give test methods guidelines. Practical aspects will be emphasized and new challenges will be addressed. Laser testing for single-event effects consists in focusing short laser pulses in the active semiconductor region of a device in order to reproduce the transient localized particle-induced ionization of the material. The spatial resolution and the absence of cumulated dose are some of the main benefits of this technique, which has proven to be very useful for parts screening and detailed analysis of most types of single events.
This part of the course will present the principles and experimental details of the pulsed laser technique for SEE testing. We will review the main parameters that must be considered and several case studies will illustrate the current capabilities and limitations of the technique in its classical form and its two-photon version. Guidelines will be proposed that summarize the best practices for SEE laser testing of modern devices.

Biographies - Guy Berger got his MSEE degree from Université catholique de Louvain. He joined the Cyclotron Research Laboratory (CRC) in 1988, where he started to work in the heavy ion sources field. He started the activities of device testing around the different CRC beam lines in 1992. He is now in charge of the different irradiation facilities (HIF, LIF, NIF and GIF) using K120 cyclotron and Cobalt 60 source at Louvain la Neuve.

Vincent Pouget got his Master degree in Physics in 1997 and his PhD in Instrumentation and Measurement in 2000 from the University of Bordeaux. He joined the CNRS in 2003 as a full-time research scientist at the IXL laboratory, now the IMS lab. He works in the Laser Testing & Analysis team within the Nanoelectronics group. He's in charge of the ATLAS laser testing facility and his research interests include single-event effects, failure analysis, and dependability issues in nanoelectronics.

Short Course 4

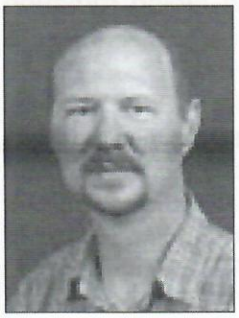
Radiation Transport Models and Software

Pete TRUSCOTT
QinetiQ Aerospace Division

Summary - The interactions of radiation with materials can give rise to significant changes to the radiation environment experienced by spaceborne components and instruments compared to the environment outside of the spacecraft. As well as attenuating particle fluxes, these interactions can produce secondary radiation which may have yet further (and in some cases greater) influence on microelectronics and sensors. Today's radiation transport simulation software, such as Geant4, MCNPX and FLUKA, can treat a very wide range of particle species, particle energies (from in excess of 100GeV/nuc down to a few keV and even to thermal energies for neutrons) at physical scales from the dimensions of planetary atmospheres down to deep sub-micron scales of microelectronics. Such tools have undergone significant evolution over the past twenty years as a result of the changing requirements as well as to take advantage of developments in low-cost, high-performance computers. This section of the short course will review the underlying physical interactions of space radiation with materials, the models and techniques which may be employed to treat these processes, and the evolution of the models and software over the past two decades from those which originally treated a limited range of processes and particles (e.g. HETC, ITS3), to the comprehensive and versatile models we see today. The driving forces for this evolution will be examined, and current and future challenges facing radiation transport simulation will also be discussed.

Biography - Pete Truscott received his BSc in physics from the University of Bristol in 1985, and joined the Radiation Environment, Effects and Protection Group in what was then the Royal Aircraft Establishment (now QinetiQ), Farnborough. His initial work included the development and application of energetic particle simulation models (such as HETC, MORSE, MCNP, and EGS) to shielding analysis for spacecraft, and in particular, the development of new models to study induced radioactive background in gamma-ray detectors during spaceflight. Between 1991 and 1998, Pete was the Technical Manager for the CREAM radiation monitor experiment, which saw ten flights on Space Shuttle and Mir Space Station. Some of the results from these flights were incorporated into a thesis, and in 1997, Pete received his PhD from the University of London for his work on the analysis of induced radioactivity in spaceborne BGO detectors. Since 1998 and at the instigation of ESA, Pete has been leading work at QinetiQ to help develop and apply the object-oriented radiation toolkit (Geant4) to space missions. Since then, Pete's work has simultaneously soared and plunged in altitude, as his research has included the study through simulation of microdosimetry effects in semiconductors at aircraft altitude and the penetration of particle accelerator beams through concrete shields, to the development of models to simulate and mitigate the Martian and Jovian radiation environments. He is currently Technical Leader for environments and effects simulation, and is managing a number of projects developing Geant4 and Geant4-related tools for UK MOD and ESA.
Although radiation effects on 21st Century monolithic technologies absorbs much of his time during daylight hours, outside of working hours, Pete has been known to maintain an interest (as an amateur) in the opposite extreme of lithic technology ... i.e. prehistoric archaeology.

Short Course 5



Monte Carlo Simulation of Single Event Effects

R.A. WELLER, R.D. SCHRIMPF, R.A. REED, M.H. MENDENHALL, K.M. WARREN, B.D. SIERAWSKI, L.W. MASSENGILL
Institute for Space & Defense Electronics /Vanderbilt University

Summary - This short course describes an approach for simulating single-event effects in electronics, based on the synthesis of first-principles nanoscale physics with higher-level models of microelectronic device and system response. As microelectronic technologies become smaller, faster, and denser, it becomes important to understand the detailed mechanisms responsible for single-event effects in order to predict the event rate accurately. The circuit response depends on the amount of charge collected by sensitive nodes and the rate at which the charge is collected. The presence of high-Z metallization layers, like tungsten or copper, or materials with very large neutron cross sections, like Boron-10, may strongly impact the single-event error rate. Also, circuits designed to be immune to charge collection at a single circuit node may still be vulnerable to upset caused by charge collection at multiple nodes. Single-event effects analysis and simulation are typically based on average particle strikes, described by the stopping power, or linear energy transfer (LET), of the incident particle. Although LET is frequently a useful concept, particularly in larger devices, the amount of energy deposited in a sensitive device volume in a particular event, as well as the spatial and temporal distribution of the deposited energy, may vary significantly even when considering a group of particles having the same mass and incident energy. Thus, the response of a circuit to an average event may not produce an accurate picture of how a circuit will respond in a real radiation environment. In particular, the results will be very misleading when a significant portion of the single-event effects are initiated by nuclear reactions. In this short course, we will describe a Monte Carlo approach for estimating the distribution of single event effects based on a combination of detailed modeling of discrete radiation events and Technology Computer Aided Design (TCAD) and other device and circuit simulation techniques to compute the subsequent motion of charge. The results of these simulations show that event-to-event variation may have a significant impact when predicting the single-event error rate in advanced spacecraft electronics. Specific criteria for supplementing established RPP-based single event analysis with Monte Carlo computations will be discussed.

Biographies - The authors are affiliated with the Institute for Space and Defense Electronics at Vanderbilt University. ISDE works on applications of Vanderbilt's radiation-effects research to practical problems. One of the current areas of emphasis is development of physically-based simulation tools for calculating single-event rates in electronics.

There are nine professors associated with ISDE, in addition to fifteen engineers. The authors have been active in the IEEE Nuclear and Space Radiation Effects Conference, serving in roles that include General Chairman, Technical Program Chairman, Short Course Chairman, and Guest Editor. Ron Schrimpf serves as the liaison between RADECS and the IEEE Nuclear and Plasma Sciences Society.

Short Course 6

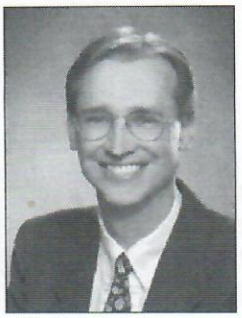
Simulation of Radiation Effects at the Atomic Scale: Theory and Examples of Applications

Nicolas RICHARD
CEA DAM DIF

Summary - This short course reviews the status of research in quantum modelling and simulation of radiation effects in materials at the atomic scale. We will first present the theoretical framework of the Density Functional Theory (DFT) which allows to perform ground state ab initio simulations. We will show how this method brings new insights for the analysis of consequences of radiation effects on materials, in particular for the study of the properties of point defects, which can be modified or even directly created by radiation. To understand the effects of radiation, it is also important to model accurately the material response to an excitation. This course will describe the different methodologies used to address this problem. We will show that these methods allow the access to the electronic and optical properties and it becomes then possible to couple theoretical and experimental spectroscopy. A link will also be made with multiscale modeling by discussing the use of other atomic scale methods as classical molecular dynamics or Kinetic Monte Carlo in which accurate data given by the ab initio level can be transfer allowing larger system size and time scale simulations. Examples, mostly on oxides and semiconductors for microelectronics and optoelectronics will be given all along the course.

Biography - Nicolas Richard received his PhD degree in 2001 from Marne-la-Vallée University, France, in theoretical chemistry and computer science. After a post-doctoral position at the European Center of Atomic and Molecular Calculations (CECAM), Lyon-France, he joined the "Commissariat à l'Energie Atomique" (CEA) in Bruyères-le-Châtel in 2002 as a research engineer. Since then, he works on atomistic computer simulations for microelectronic and optoelectronic hardening. Dr Nicolas Richard has published 15 papers for the last ten years and has served as a reviewer for different publications. He was implied in the organization of different conferences and symposium as the MRS Spring Meeting 2007 or the SiO_2 Symposium 2008 and served the radiation effects community as co-editor for the proceedings for the RADECS 2007 conference.

Short Course 7



Future Challenges in Radiation Effects

Paul E. DODD
Sandia National Laboratories

Summary - Advances in microelectronics performance and density continue to be fueled by the engine of Moore's Law. Although lately this engine appears to running out of steam, recent developments in advanced technologies have brought about a number of challenges and opportunities for their use in radiation environments. For example, while many advanced CMOS technologies have generally shown improving total dose tolerance, single-event effects continue to be a serious concern for highly scaled technologies. In this short course, we will examine the impact of recent developments and the challenges they present to the radiation effects community. Topics to be covered will include the impact of technology scaling on radiation response, including recent work on single-event transients in high-speed digital circuits and evidence for single-event effects caused by proton direct ionization. We will discuss hardening and mitigation techniques for nanometer-scale technologies. Recent developments leading to hardness assurance challenges will be covered. Finally, although the future is notoriously hard to predict, we will discuss radiation effects challenges that may loom in the future as the electronics industry looks beyond Moore's Law to alternative technologies to augment or replace traditional CMOS devices.

Biography - Paul E. Dodd (S'90–M'97–SM'01) received his B.S., M.S., and Ph.D. degrees in Electrical Engineering from Purdue University in 1988, 1989, and 1993, respectively. He joined Sandia National Laboratories in 1993, where he is Team Leader of the Radiation Physics, Technology, and Assurance Department. He is involved in the development of Sandia's radiation-hardened bulk and SOI CMOS technologies, the computer simulation of radiation effects on microelectronics, and hardness assurance activities for Sandia systems. Paul has served the radiation effects community as General Chairman, Technical Program Chairman, Short Course Chairman, Short Course Instructor, Awards Chairman, Session Chairman, and Publicity Chairman for the IEEE Nuclear and Space Radiation Effects Conference (NSREC). He has also served on the technical program committees of the IEEE International Electron Devices Meeting and the IEEE International Reliability Physics Symposium (IRPS), and has been a Short Course Instructor for the IEEE SOI Conference, the IEEE IRPS, and the Hardened Electronics and Radiation Technology (HEART) Conference. He has authored or co-authored more than 100 publications and short courses, including 8 NSREC Outstanding Conference Papers. Paul was the recipient of the 2001 IEEE NPSS Early Achievement Award. He is a Senior Member of the IEEE, and a member of the NPSS and the EDS.

Invited Talks

C. Remmerie (Thales Alenia Space, Belgium)

For this RADECS 2009, Invited Talks will be given by Medical Doctor Volker DAMANN (ESA), Professor Dominique LAMBERT (FUNDP), Mr. Jean-Paul POCHOLLE (TRT) and Mrs. Sibylla GOEGEBUER (Sint-Jan-Hospitaalmuseum). The subjects, approaching various domains: scientific, technical and cultural, will promise to be fascinating.
It will be a great pleasure for me to introduce all these speakers during this week and I am sure that you will be delighted and captivated by their presentations.

Invited Talks are integrated in the technical program and will address the following subjects:

V.R. Damann (ESA, The Netherlands)

Human Factors – Factor Humans
A journey to the International Space Station – from a space-medicine perspective

Tuesday, September 15 – 15.20 hrs

The presenter will take the audience on a virtual journey to the International Space Station and back to earth. Along their way and linked to several mission milestones the audience will learn about living and working in space, risk assessment and risk mitigation strategies in the medical domain and will get to know the medical team and their tasks and responsibilities in the efforts to enable mankind to explore space. The selection and medical support activities will be explained, as well as the impact of environmental factors on the astronaut's health. Considering the ISS as a platform for future human space exploration, thoughts about the evolution of space-medicine will be brought forward.

The speaker:
Volker Damann graduated from the medical school in Marburg in 1985 and began his specialization in Nuclear Medicine and Radiology at the Marburg university clinic and in private practice. He joined the German Aerospace Research Establishment (DLR) in 1989 and became a flight surgeon after training at the Aviation Medical Institute of the German Airforce in Fuerstenfeldbruck and NASA Johnson Space Centre. In his career as flight surgeon he supported nine Space Shuttle missions and several missions to the Russian MIR station. He joined ESA at the European Astronaut Centre in Cologne in 1995 and was appointed Head of the Crew Medical Support Office in 1998. Since then the medical team established a robust medical infrastructure at the EAC in Cologne with a diverse blend of technical and medical specialists to support long-duration spaceflights.

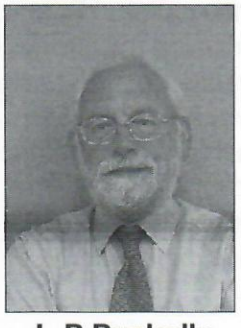
D. Lambert (Faculté Notre Dame de la Paix, Belgium)

Georges Lemaître - The Man Who Invented the Big Band Theory

Wednesday, September 16 – 09.45 hrs

We want to describe the life and the work of Georges Lemaître (1894-1966). Using original archives, we follow step by step the history, which lead to the "Primeval Atom Hypothesis", considered as the prehistory of the Big Bang theory. The talk shows also that Lemaître was not only a cosmologist but also a specialist in computer science, programming, pedagogy of mathematics. We will emphasize his major contribution to the study of cosmic rays and to the famous "3-body problem" in classical mechanics.

The speaker:
PhD in Physics and PhD in Philosophy (U.C.L.) Professor of Logic, Theoretical Physics, History and Philosophy of Sciences in Namur (F.U.N.D.P.) and Luxembourg (Uni.Lu) . Member of the "Académie Royale de Belgique" (Classe des Sciences) and of the "International Academy of philosophy of Sciences. Author of books: "Un atome d'univers. La vie et l'oeuvre de Georges Lemaître" (Bruxelles, Racine, 2000), "L'itinéraire spirituel de Georges Lemaître" (Bruxelles, Lessius, 2007 et "Comment les pattes viennent au serpent. Essai sur l'étonnante plasticité du vivant" (avec René Rezsohazy, Paris, Flammarion, 2005).



J.-P Pocholle (Thales Research & Technology, France)

Cold Atoms, Atom chips and Sensor Applications

Thursday, September 17 – 09.45 hrs

By combining laser beams and magnetic fields, atoms can be cooled down to very low temperatures. As a result, atoms can be treated as waves and in recent years ultra-cold atomic gases have been successfully employed to perform high-precision measurements with interferometric methods. Such new quantum devices based on manipulations of atoms on microchips hold great promise for applications in the field of integrated inertial navigation sensors (gyroscopes, accelerometers, gravity gradiometers and precision time).
In this survey, special attention is given to describe basic tools governing coherent atom optics and an overview of the rapidly evolving field of magnetic microchips traps are discussed to investigate the potential of integrated matter-wave based sensors.

The speaker:
Jean-Paul Pocholle is Scientist Senior Expert in the Physics Department of THALES Research & Technology Fr.
He has been responsible for the Laser and Nonlinear Optics Laboratory. His research interests include laser physics and non linear optics, plasma physics, quantum physics, propagation in optical fibers and waveguides, optoelectronics, sensors (laser gyro, hydrophone ...). He is the author or co-author of over 100 journal articles and several tens of patents.
He was the recipient of the "Fabry-de Gramont" Award of the Société Française d'Optique. He is a Fellow of the Optical Society of America and he was member of the "Comité National de la Recherche Scientifique".

This special Invited Talk will be given in remembrance of our colleague, Jean-Claude BOUDENOT. Given by one colleague from Thales Research and Technology, Jean-Paul POCHOLLE will follow the same quest of advance topics.

S. Goegebuer (Sint-Jan-Hospitaal-museum, Belgium)

The History of the Memling in Sint-Jan-Hospital Museum in Bruges: A Survey

Friday, September 18 – 09.15 hrs

The speaker will describe the history of the Memling in Sint-Jan-Hospital Museum from the 12th until the 15th century. A survey of the six Hans Memling panels, exhibited in the museum, will be included.

The speaker:
Sibylla Goegebuer studied art history and archaeology at the University of Ghent, as well as Museum Management at the 'Hoger Architectuurinstituut Sint-Lucas' in Ghent. Sibylla Goegebuer currently is assistant director of the Memling in Sint-Jan-Hospital Museum and coordinates a number of exhibitions, such as Kantlijnen – The face of lace in 2008 and actually Moving Archives – Foundlings (28 November 2009 – 29 August 2010).

Technical Program RADECS 2009 Introduction

Cor Claeys (IMEC)

The RADECS 2009 Technical Program Committee succeeded in putting together an exciting scientific program. Keynote, invited and contributed papers will review the state-of-the-art and give insight in new developments in the field. The meeting will create the right forum with ample opportunities for technical discussions and networking with colleagues and international experts. We are counting on your participation to make this 10th edition another successful meeting.

Technical Program

Session A: Devices, Integrated Circuits and MEMS
Chairs: J. Boch (Univ. Montpellier) & P. Leroux (KHK/SCK•CEN)

Session B: Single Event Effects: Devices and Integrated Circuits
Chairs: R. Harboe-Sørensen (ESA-ESTEC) & O. Flament (CEA)

Session C: Single Event Effects: Mechanisms and Modeling
Chairs: S. Kuboyama, (JAXA) & R. Marec (Thales Alenia Space)

Session D: Basic Mechanisms
Chairs: E. Simoen (IMEC) & D. Fleetwood (Vanderbilt Univ.)

Session E: Hardness Assurance
Chairs: C. Poivey (ESA-ESTEC) & K. LaBel (NASA)

Session F: Terrestrial and Radiation Environments
Chairs: D. Heynderickx (DH Consultancy) & M. Xapsos (NASA)

Session G: Photonics
Chairs: A. Gusarov (SCK•CEN) & J. Kuhnhenn (Fraunhofer INT)

Session H: Dosimetry and Facilities
Chairs: G. Berger (UCL) & W. Hajdas (PSI)

Session I: Technology and Design Hardening
Chairs: F. Faccio (CERN) & B. Bhuva (Vanderbilt Univ.)

Poster Session

The Poster Session will be held on Wednesday, September 16, from 15.15 until 17.30 hrs.
The Poster chairs are R. Velazco (CNRS) and P. Adell (JPL/NASA).

Radiation Effects Data Workshop

The Data Workshop will be held at the same time as the Poster Session.
S. Duzellier (ONERA) and S. McClure (JPL/NASA) are the Data Workshop session chairs.

Late News Papers

A limited number of late news papers will be accepted and included in the Poster Session and Radiation Effects Data Workshop. The late news chairs are V. Ferlet-Cavrois (ESA) and S. Armstrong (Vanderbilt Univ.).

Technical Program
Tuesday, September 15, 2009

08.30 **Conference Opening**
Welcome by P. Calvell, RADECS Association President
Introduction by C. Legrain, General Secretary of SCK•CEN
Opening Remarks by B. Brichard, General Chairman
Opening Technical Program by C. Claeys, Technical Chairman

Session A - Devices, Integrated Circuits and MEMS I

09.10 Session Introduction
Chairs: J. Boch (Univ. Montpellier) & P. Leroux (KHK/SCK•CEN)

A-1 **Modeling of Ionizing Radiation-Induced Degradation in Multiple Gate Field Effect Transistors**

09.15 *I.S. Esqueda[1], H.J. Barnaby[1], F.E. Mamouni[2], R.D. Schrimpf[2]*
[1]Arizona Univ.; [2]Vanderbilt Univ.

The radiation response of advanced non-planar multiple gate field effect transistors (MuGFETs) has been shown to have a strong dependence on width (W_d).

A-2 **Total-Dose Effects Caused by High-Energy Neutrons and γ-Rays in Multiple-Gate FETs**

09.30 *V. Kilchytska[1], J. Alvarado[1], N. Collaert[2], R. Rooyakers[2], O. Militaru[1], G. Berger[1], D. Flandre[1]*
[1]Université Catholique de Louvain; [2]InterUniversity Microelectronics Center (IMEC)

We investigate the effects of high-energy neutrons and γ-rays on MuGFETs with different geometries. It is revealed that short-channel FinFETs can become extremely sensitive to the total-dose effect, caused either by γ-rays or high-energy neutrons.

A-3 **Influence of Back-Gate Bias and Process Conditions on the Gamma-Degradation of the Transconductance of MuGFETs**

09.45 *S. Put[1,2,3], E. Simoen[1], N. Collaert[1], C. Claeys[1,2], M. Van Uffelen[3], P. Leroux[3,4]*
[1]IMEC; [2]KU Leuven; [3]SCK•CEN; [4]Katholieke Hogeschool Kempen

The radiation-induced variation of the transconductance in the subthreshold region is studied for different back-gate voltages and for different kinds of SOI MuGFETs: devices with and without Selective Epitaxial Growth (SEG) and 45° rotated transistors.

A-4 **Effects of Moisture on Radiation-Induced Degradation in CMOS SOI Transistors**

10.00 *M.R. Shaneyfelt, J.R. Schwank, P.E. Dodd, T.A. Hill, S.M. Dalton, S.E. Swanson*
Sandia National Laboratories

The effects of moisture on radiation-induced charge buildup in oxides of a 0.35 µm SOI technology are explored. The results are compared to previously published results on MOS technologies fabricated in the 1980s.

A-5 **Radiation Effects in SiGe p-MODFETs Grown on Silicon-On-Sapphire Substrates**

10.15 *A. Madan[1], J.J. Mo[2], R. Arora[4], S.D. Phillips[2], J.D. Cressler[2], P.W. Marshall[3], R.D. Schrimpf[4], S.J. Koester[5]*
[1]Georgia Tech; [2]Georgia Institute of Technology; [3]Consultant to NASA-GSFC; [4]Vanderbilt Univ.; [5]IBM

The radiation response of strained SiGe p-MODFETs is investigated for the first time. It is observed that the drain current, transconductance, and 1/f noise of the devices improve marginally following proton exposure.

Session A - Devices, Integrated Circuits and MEMS II

A-6 **Impact of Neutron Irradiation on Oxidized High-Resistivity Silicon Substrates with and without a Trap-Rich Passivation Layer**

11.00 *C. Roda Neve[1], V. Kilchytska[1], J. Alvarado[1], D. Lederer[2], O. Militaru[1], D. Flandre[1], J.-P. Raskin[1]*
[1]Université Catholique de Louvain; [2]Farran Technology Ltd

We investigate the influence of high-energy neutrons on oxidized HR Si-substrates. RF losses are strongly reduced in the case of thin-oxide, while substrates with a polysilicon passivation layer are almost insensitive to the neutron irradiation.

A-7 **Charge Collection Properties and Front-End Performance of Heavily Irradiated DNW MAPS**

11.15 *L. Ratti[1,3], M. Dellagiovanna[1], M. Manghisoni[2,3], G. Traversi[2,3], V. Re[2,3], S. Bettarini[4,5], F. Morsani[5], G. Rizzo[4,5]*
[1]Università degli Studi di Pavia; [2]Università degli Studi di Bergamo; [3]INFN Sezione di Pavia; [4]Università degli Studi di Pisa; [5]INFN Sezione di Pisa

The effects of relatively high doses of γ-rays, beyond 1 Mrad, on deep N-well CMOS MAPS are studied based on the electrical characterization of front-end electronics and on sensor tests with laser and radiation sources.

A-8 **The Effect of Proton and Gamma Radiation on Different Type of Temperature Sensors**

11.30 *M. González-Guerrero, M.T. Álvarez, J.J. Jiménez, J. Sánchez-Páramo, H. Guerrero*
Instituto Nacional de Técnica Aeroespacial

In a study performed to test the effects of proton and gamma radiation on different temperature sensors, Pt RTDs and thermocouples result negligibly sensitive, though IC-based Ad590 and, especially, TMP36, modify significantly their readout signals.

A-9 **TID and Displacement Damage Effects in Vertical and Lateral Power MOSFETs for Integrated DC-DC Converters**

11.45 *F. Faccio[1], B. Allongue[1], G. Blanchot[1], C. Fuentes[1,2], S. Michelis[1,3], S. Orlandi[1]*
[1]CERN; [2]UTFSM; [3]EPFL

The radiation tolerance of vertical and lateral power MOSFETs in different technologies is studied in view of developing fully integrated DC-DC converters. The decrease in Ron induced by displacement damage limits their application at very large hadron fluence.

Poster Papers

PA-1 **Using Oxide-Trap Charge-Pumping Method in Radiation Reliability Analysis of Short Lightly Doped Drain Transistor**

B. Djezzar, H. Tahi
Centre de Développement des Technologies Avancées (CDTA)

A thorough investigation of the possibility of application of Oxide-Trap Charge-Pumping OTCP extraction method to evaluate the radiation-induced traps in short LDD-transistors is conducted. We have successfully demonstrated that the OTCP is able not only to determine all kind of traps induced by radiation in narrow LDD-transistors but also in short LDD-transistors.

PA-2 **Modelling of γ-Radiation Effects in Bipolar Transistors with VHDL-AMS**

W. De Cock[1], H. Versmissen[2], P. Leroux[2], M. Van Uffelen[1]
[1]SCK•CEN; [2]Katholieke Hogeschool Kempen

A VHDL-AMS Gummel-Poon bipolar transistor model is proposed using dose dependent model parameters. The model was tested and evaluated on two commercially available devices showing

PA-3 **Effects of Proton and Ion Beam Irradiation on Titanium Dioxide Memristors**
M. Vujisic[1], K. Stankovic[2], P. Osmokrovic[1]
[1]University of Belgrade; [2]Institute of Nuclear Sciences 'Vinča'

Effects of titanium dioxide memristor exposure to proton and ion beams are investigated. Simulations of particle transport suggest that radiation response of the memristor depends on the thickness of the conducting oxygen-deficient layer.

PA-4 **A MEMS Dosimeter Comprised of Diamond for Very High Neutron Fluence**
J.L. Davidson[1], W.P. Kang[1], P.K. Basu[1], A.G. Holmes-Siedle[2], K.F. Galloway[1]
[1]Vanderbilt Univ.; [2]REM Oxford Ltd

The construct and modeled performance of a bilayer cantilever beam type device which can serve as a dosimeter for very high neutron fluence environments such as nuclear or fusion applications are described.

PA-5 **Current-Voltage Characterization of SHI Irradiated Silicon Bipolar Power Transistor**
C.M. Dinesh[1], Ramani[1], M.C. Radhakrishna[1], K.V. Madhu[1], B. Jayashree[2], S.A. Khan[3], D. Kanjilal[3]
[1]Bangalore Univ.; [2]APS College for Arts and Science; [3]Inter University Accelerator Centre

60 MeV boron ion energy transfer in Si power BJTs for the interface charge state density is studied. LET, total ionizing dose and total displacement damage dose are correlated with the observed post-irradiated electrical characteristics.

12.00 LUNCH

Session B – SEE - Devices and Integrated Circuits I

13.40 Session Introduction
Chairs: R. Harboe-Sørensen (ESA-ESTEC) & O. Flament (CEA)

B-1 **Total Dose Effects on the Propagation of Single Event Transients in a CMOS Inverter String**
13.45 *S. Buchner[1], M. Sibley[2], P. Eaton[2], D. Mavis[2], D. McMorrow[3]*
[1]NASA-GSFC; [2]Micro-RDC; [3]Naval Research Laboratory

A pulsed laser has been used to reveal how the propagation of single event transients in a string of inverters is affected by exposure to total ionizing dose radiation.

B-2 **Large SET Broadening in a Fully-Depleted SOI Technology - Mitigation with Body Contacts**
14.00 *V. Ferlet-Cavrois[1], D. Kobayashi[2], D. McMorrow[3], J.R. Schwank[4], H. Ikeda[2], M. Gaillardin[1], O. Flament[1], K. Hirose[2]*
[1]CEA; [2]ISAS/JAXA; [3]Naval Research Laboratory; [4]Sandia National Laboratories

Large SET broadening effects are shown in fully-depleted SOI inverter chains using laser irradiation. These broadening effects are due to significant floating-body effects in single transistors. Designing with body contacts can efficiently suppress these effects.

B-3 **Analysis of SET Propagation in Flash-based FPGAs by means of Electrical Pulse Injection**
14.15 *N. Battezzati[1], L. Sterpone[1], V. Ferlet-Cavrois[2]*
[1]Politecnico di Torino; [2]CEA

A technique based on electrical pulse injection for the analysis of SETs propagation within logic resources of Flash-based FPGAs is developed. Experimental results provide detailed characterization of basic gates and realistic routing and logic paths.

B-4 **Estimation of Heavy-Ion LET Thresholds in Advanced SOI IC Technologies from Two-Photon Absorption Laser Measurements**

14.30 *J.R. Schwank[1], M.R. Shaneyfelt[1], D. McMorrow[2], V. Ferlet-Cavrois[3], D.F. Heidel[4], P.W. Marshall[5], J.A. Pellish[6], K.A. LaBel[6], K.P. Rodbell[4], M. Hakey[7], P.E. Dodd[1], S.E. Swanson[1], S.M. Dalton[1]*
[1]Sandia National Laboratories; [2]Naval Research Laboratory; [3]CEA; [4]IBM T.J. Watson Research Center; [5]NASA consultant; [6]NASA Goddard Spaceflight Center, [7]IBM System & Technology Group

The laser energy thresholds for SEU for SOI SRAMs were empirically correlated to heavy-ion LET thresholds for Sandia's 0.35-µm SOI technology. The use of this relationship to estimate LET thresholds in other technologies is discussed.

B-5 **Layout-Aware Multi-Cell Upsets Effects Analysis on TMR circuits implemented on SRAM-based FPGAs**

14.45 *L. Sterpone[1], M. Violante[1], A. Bocquillon[2], F. Miller[2], N. Buard[2], A. Manuzzato[3], S. Gerardin[3], A. Paccagnella[3]*
[1]Politecnico di Torino; [2]EADS Innovation Works; [3]Università di Padova

We developed a tool combining the layout information obtained from laser screening of a device with an algorithm for estimating multi-cell upsets effects on TMR circuits implemented on SRAM-based FPGAs. Detailed experimental results are provided.

15.00 COFFEE BREAK

INVITED LECTURE

15.20 **Human Space Flight - The Astronaut Constraints**
V.R. Damann (ESA)

Session B – SEE - Devices and Integrated Circuits II

B-6 **The Role of the Charge Generated During Heavy Ion Irradiation in the Gate Damage of Medium Voltage Power MOSFET**

16.00 *G. Busatto[1], G. Currò[2], F. Iannuzzo[1], A. Porzio[1], A. Sanseverino[1], F. Velardi[1]*
[1]University of Cassino; [2]STMicroelectronics

An experimental study aimed to identify the test conditions at which latent damages are created is presented for different ion species with different energy losses both in the oxide and in the silicon.

B-7 **Investigation of Single Event Burnout Sensitive Depth in Power MOSFETS**

16.15 *F. Darracq[1], V. Pouget[1], D. Lewis[1], P. Fouillat[1], E. Lorfevre[2], R. Ecoffet[2], F. Bezerra[2]*
[1]IMS; [2]CNES

The depth of the Single-event burnout sensitive volume of power MOSFETs is investigated using TCAD simulation and laser testing approaches. Simulations of ion tracks stopping at different depths are confronted to laser experiment results.

B-8 **Annealing of Heavy-Ion Induced Floating Gate Errors: LET and Technology Dependence**

16.30 *M. Bagatin[1], S. Gerardin[1], G. Cellere[1], A. Paccagnella[1], A. Visconti[2], S. Beltrami[2], M. Bonanomi[2], R. Harboe-Sørensen[3]*
[1]Università di Padova; [2]Numonyx; [3]ESA-ESTEC

We discuss the annealing of Floating Gate errors in Flash memories after heavy-ion irradiation. Comparing the behavior of different technologies, we examine the annealing dependence on the particle LET and energy, and cell feature size.

B-9 **Single Event Gate Rupture in 130-nm CMOS Transistor Arrays Subjected to X-ray Irradiation**
16.45 *M. Silvestri[1,2], S. Gerardin[1,2], F. Faccio[3], A. Paccagnella[1,2]*
[1]Università di Padova; [2]INFN; [3]CERN

We present new experimental results on heavy ion-induced gate rupture on deep submicron CMOS transistor arrays.

B-10 **In Flight Observation of Proton Induced Destructive Single Event Phenomena**
17.00 *F. Bezerra[1], E. Lorfevre[1], R. Ecoffet[1], D. Peyre[2], C. Binois[2], S. Duzellier[3], T. Nuns[3], M. Mélotte[4], P. Calvel[5], R. Marec[5], N. Chatry[6], W. Falo[6]*
[1]Centre National d'Etudes Spatiales; [2]EADS-ASTRIUM SPACE; [3]ONERA; [4]Thales Alenia Space-ETCA; [5]Thales Alenia Space; [6]TRAD

CARMEN2/MEX Experience Module aboard JASON2 satellite is dedicated to the study of the effects of space radiation environment on various electronic devices. Since June 2008, many Single Event Latchup and Burnout have been observed, mainly in the South Atlantic Anomaly area.

Poster Papers

PB-1 **Single Event Effects on CVSL and CMOS Exclusive-OR (EX-OR) Circuits**
H. Hatano
Shizuoka Institute of Science and Technology

Single event transient (SET) effects on cascade voltage switch logic (CVSL) exclusive-OR (EX-OR) circuits were investigated using SPICE. SET tolerance was compared to conventional CMOS EX-OR circuits, showing that CVSL is harder than CMOS.

PB-2 **Two-Photon Absorption (TPA) Backside Pulsed Laser Tests in the LM324**
I. López-Calle, F.J. Franco, J.G. Izquierdo, J.A. Agapito
Universidad Complutense de Madrid (UCM)

Experiments to obtain XY scans on the surface of an amplifier at different depths and energy values were performed at the UCM, the results of which are shown and discussed in this paper.

PB-3 **Physical Evidence for the Electrical Signature of SEGR on Thin Vertical Oxides**
R.K. Lawrence, J.A. Zimmerman, J.F. Ross
BAE Systems

Analysis techniques provide the physical evidence for the electrical signature used for SEGR detection in thin vertical oxides. Oxide rupture location is identified.

PB-4 **Investigation of Neutron and Proton SEU Cross-Sections on SRAMs between a few MeV and 50 MeV**
D. Lambert, F. Desnoyers, D. Thouvenot
EADS Nuclétudes

This work focuses on the difference between neutron and proton SEU cross-sections on SRAMs between a few MeV and 50 MeV where the cross-sections cannot be considered similar. Experiments and simulations are presented.

PB-5 **An Approach to Single Event Testing of SDRAMs**

P.C. Adell[1], L. Edmonds[1], R. McPeak[2], L. Scheick[1], S.S. McClure[1]
[1]Jet Propulsion Laboratory; [2]Consultant

A testing approach based on error-pattern identification with a graphical mapping and color-coding of the full SDRAM during single-event characterization is proposed. Results about unique SEFI modes and the role of temperature are discussed.

PB-6 **A CMOS Integrated System for SEE-Induced Transients Acquisition**

S. Bota, J.L. Merino, B. Alorda, J. Verd, G. Torrens, J. Segura
Universitat de les Illes Balears

We present the design and operation of a circuit design that captures the effect of ionizing particles on sensitive CMOS IC internal nodes. The circuit has been designed and fabricated on a 130nm technology. Preliminary experimental results and detailed simulations are provided to demonstrate the feasibility of the system implemented.

17.30 WELCOME RECEPTION IN THE INDUSTRIAL EXHIBITION AREA "Grote Witte Roos"

Technical Program
Wednesday, September 16, 2009

Session C – SEE - Mechanisms and Modeling I

08.40 Session Introduction
Chairs: S. Kuboyama (JAXA) & R. Marec (Thales Alenia Space)

C-1 Gate Bias Dependence of Single Event Charge Collection in AlSb/InAs HEMTs

08.45 *S. DasGupta[1], D. McMorrow[2], R. A. Reed[1], R. D. Schrimpf[1], J. Brad Boos[2]*
[1]Vanderbilt Univ.; [2]Naval Research Laboratory

The relationship between Single Event charge collection and gate bias for AlSb/InAs HEMTs is analyzed. Spatial correlation between excess channel carriers and the horizontal field is shown to be the key factor.

C-2 Development of a New Methodology to Model the Synergistic Effects between TID and ASETs

09.00 *N.J.-H. Roche[1], L. Dusseau[1], J. Boch[1], Y. Gonzalez Velo[1], J.-R. Vaillé[1], F. Saigné[1], G. Auriel[2], B. Azais[2], S.P. Buchner[3], R. Marec[4], P. Calvel[4], F. Bezerra[5]*
[1]Université Montpellier II; [2]DGA; [3]NASA Goddard Space Flight Center; [4]Thales Alenia Space; [5]CNES

A high level model is developed using circuit analysis to predict the synergy effect observed on a three stages operational amplifier. This model makes possible to explain and to predict the ASETs propagation in circuitry.

C-3 MUSCA SEP³ Contributions to Investigate the Direct Ionization Proton Upset in 65nm Technology for Space and Atmospheric Applications

09.15 *G. Hubert[1], S. Duzellier[1], C. Inguimbert[1], F. Bezerra[2], R. Ecoffet[2]*
[1]ONERA; [2]CNES

This paper presents the MUlti-SCAles Single Event Phenomena Predictive Platform. MUSCA SEP³ is used to investigate the upset induced by the direct ionization of proton in 65nm technology and evaluates the operational SER consequences.

C-4 Collected Charge Analysis for a New Advanced Transient Model by TCAD Simulation in 90nm Technology

09.30 *L. Artola[1], G. Hubert[1], F. Bezerra[2], S. Duzellier[1], K. Castellani-Coulié[3]*
[1]ONERA; [2]CNES; [3]IM2NP

TCAD simulations of 90nm CMOS bulk technology has been performed to investigate which technologies parameters impact collection charge for Single Event Effects. This work proposes an updated collection model I(t).

INVITED LECTURE

09.45 **Georges Lemaître: The Man who Invented the Big Bang Theory**
D. Lambert (FUNDP)

10.30 COFFEE BREAK

Session C – SEE - Mechanisms and Modeling II

C-5 Single Event Upset and Multiple Cell Upset Modeling in Commercial Bulk CMOS 65nm SRAMs

11.00 *S. Uznanski[1], G. Gasiot[1], P. Roche[1], J.-L. Autran[2]*
[1]STMicroelectronics; [2]IM2NP

Heavy-ion experimental characterizations of three commercial bulk 65nm SRAM bitcells were carried out and compared to simulated values obtained using a proprietary Monte-Carlo simulation code. The contributions of Single Event Upsets and Multiple Cell Upsets are discussed.

C-6 Analysis of the Single Event Effects of a 90nm CMOS Phase-Locked Loop

11.15 *A.V. Kauppila[1], T.D. Loveless[1], G.L.Vaughn[2], B.L. Bhuva[3], L.W. Massengill[3], W.T. Holman[3]*
[1]Vanderbilt Univ.; [2]University of Alabama at Birmingham; [3]Institute for Space and Defense Electronics/ Vanderbilt Univ.

A novel approach towards comparing single-event (SE) vulnerability of various components at the function level for a phase-locked loop (PLL) is presented.

C-7 TCAD Mixed-Mode Simulation of Bitflip with Pulsed Laser

11.30 *F.R. Palomo, J.M. Mogollón, J. Nápoles, M.A. Aguirre*
University of Sevilla

Simulation of pulsed laser SEE in a AMIS05 flip-flop through an adaptation of Sentaurus TCAD mixed-mode to works with the pair generation rate for Single Photon Absorption. The experimental verification of model predictions shows good agreement in the bitflip threshold energy.

C-8 Enabling Mixed-Mode Analysis of Nano-Scale SiGe BiCMOS Technologies in Extreme Environments

11.45 *M. Turowski, A. Raman, A. Fedoseyev*
CFD Research Corporation

The latest developments combining 3D physics of nano-scale devices, mixed-mode coupling with Cadence Spectre, interface to Geant4 radiation models, and extreme temperature modeling, enable simulations of radiation effects in modern mixed-signal systems which match experiments.

Poster Papers

PC-1 Layout-Oriented Simulation of Non-Destructive Single Event Effects in CMOS IC Blocks

E. Do[1], V. Liberali[1], A. Stabile[1], C. Calligaro[2]
[1]University of Milano; [2]RedCat Devices

This paper presents a tool based on a two dimensional charge collection simulation to study nondestructive single event effects in CMOS blocks. A map can be obtained, showing the sensitivity to SET and SEU, to identify critical parts of the circuit and to compare different layout solutions.

PC-2 Efficient Single Event Upset Simulations of a Tolerant PD SOI CMOS D Flip-Flop

J. Alvarado[1], V. Kilchytska[1], G. Berger[2], D. Flandre[1]
[1]Université Catholique de Louvain; [2]CRC

SEU modeling in Partially-Depleted SOI CMOS circuits by Spice simulations is presented. Good agreement with mixed-mode simulation is observed at different conditions. High LETs are necessary to observe a transient upset in the D flip-flop.

PC-3 **3D Simulation of Charge Collection and MNU in SEU Hardened Storage Cells**

L. Liu, Y. Zhao, S. Yue
Beijing Microelectronics Technology Institute

Three-dimensional simulation is used to explore the basic charge-collection mechanisms in MOSEFT. Then the problem of multiple-node upset in DICE is studied .The results show the transient floating node and charge lateral diffusion are the key reasons for MNU.

PC-4 **Methodology of Soft Error Rate Computation in Modern Microelectronics**

G.I. Zebrev[1], I.O. Ishutin[1], R.G. Useinov[2], V.S. Anashin[3]
[1]Moscow Engineering Physics Institute; [2]Research Institute of Scientific Instruments; [3]Scientific Research Institute of Space Instrument Engineering

We have proposed test methodology based on successive experimental determination of angular cross-section dependence followed be averaging over full solid angle. Equivalence between phenomenological and chord-length distribution averaging for soft error rate computation is revealed.

PC-5 **Analysis of Current Components in Single Event Transient**

L. Zheng, C. Shuming, L. Bin, L. Biwei, Z.. Zhenyun
National University of Defense Technology

Using 3D mixed-mode simulation, parasitic bipolar conduction in an inverter chain is studied. Negative and positive components of source current are related to bipolar amplification and diffusion of carriers respectively.

PC-6 **A Monte Carlo-Based Control Signal Generator for Single Event Effect (SEE) Fault Injection**

H. Zheng, L. Fan, S. Yue, L. Liu
Beijing Microelectronics Technology Institute

In this paper a single event effect (SEE) fault injection control signal generator based on Monte Carlo method is proposed. Fault control signal generated by the traditional SEE fault injection emulation method for VLSI does not take the speciality of the space environment and the electrical characteristics of the circuit into account.

PC-7 **Effect of Multiple Injections on the SEEs in SRAM Cell**

G. Toure[1,2], J.-M. Portal[1], G. Hubert[2], K. Castellani-Coulié[1], A. Lesea[3]
[1]IM2NP-UMR CNRS 6242 / IMT; [2]ONERA-DESP; [3]Xilinx

This paper presents a new approach to analyze nanometres SRAM response to SEE attributed to proton-Silicon interactions. It couples the MUlti SCAles Single-Event Phenomena Predictive Platform (MUSCA SEP3) with SPICE modelling to study multi-injections phenomena.

PC-8 **Fast SER Evaluation of Embedded RAMs in Fault Emulation Systems**

M. Portela-García, C. López-Ongil, M. García-Valderas, E. San Millán, L. Entrena
Universidad Carlos III de Madrid

Embedded RAMs have traditionally been a problem for transient fault injection systems based on emulation. A solution is proposed for checking the robustness of complex digital circuits against single events with hardware emulation. A new memory model accelerates emulation campaigns giving fault injection rates around 50 kfaults per second.

12.00 LUNCH

Session D – Basic Mechanisms

13.40 Session Introduction

Chairs: E. Simoen (IMEC) & D. Fleetwood (Vanderbilt Univ.)

D-1 **"Effective NIEL" in Silicon: Calculation Using Molecular Dynamic Simulation Results**

13.45 *C. Inguimbert[1], P. Arnolda[1], T. Nuns[1], G. Rolland[2]*
[1]ONERA-DESP; [2]CNES

Molecular dynamic studies demonstrate that, under suitable conditions, low energy transfer below the atomic displacement threshold (Td) can enhance damage production.

D-2 **Angular and Strain Dependence of Heavy-Ions Induced Degradation in SOI FinFETs**

14.00 *A. Griffoni[1], S. Gerardin[1], A. Ruzza[1], G. Meneghesso[1], A. Paccagnella[1], E. Simoen[2], C. Claeys[2]*
[1]Università di Padova; [2]IMEC

We studied the short- and long-term effects of heavy-ion strikes on SOI FinFET devices manufactured in a sub 32-nm CMOS process. We analyzed the dependence on the channel strain, incidence angle, and channel type.

D-3 **Effects of Halo Doping and Si Capping Layer Thickness on Total-Dose Effects in Ge p-MOSFETs**

14.15 *R. Arora[1], J. Mitard[2,3], E. Simoen[2], E.X. Zhang[1], D.M. Fleetwood[1], B.K. Choi[1], R.D. Schrimpf[1], K.F. Galloway[1], S.R. Kulkarni[4], M. Meuris[2], C. Claeys[2,3]*
[1]Vanderbilt Univ.; [2]IMEC; [3]University of Leuven; [4]University of KIEL

The total-dose response of Ge p-MOSFETs is reported. Radiation-induced fall in on-off current ratio increases with halo doping density. Increasing the number of Si monolayers at the interface reduces total-dose sensitivity.

D-4 **A Deep Level Transient Spectroscopy Study of Electron and Proton Irradiated p^+n GaAs Diodes**

14.30 *J.H. Warner[1], S.R. Messenger[1], R.J. Walters[1], S.A. Ringel[2], M.R. Brenner[2]*
[1]Naval Research Laboratory; [2]Ohio State Univ.

Defects produced by 0.6, 1, and 5 MeV electrons are compared with those produced by 2 MeV proton irradiations in p^+n GaAs diodes using Deep Level Transient Spectroscopy (DLTS). A new defect emerges as the electron energy is increased.

Poster Papers

PD-1 **Comparison of γ and β-ray Irradiation Effects in Sol-Gel Ge-Doped SiO2**

A. Alessi[1], S. Agnello[1], F. M. Gelardi[1], D. G. Sporea[2], C. Oproiu[2], B. Brichard[3]
[1]University of Palermo; [2]National Institute for Lasers, Plasma and Radiation Physics; [3]SCK•CEN

We report an experimental comparison of γ and β-ray effects in Ge doped sol-gel silica. No relevant differences between the induced Ge-related defects have been observed but for paramagnetic defects arising from H reaction.

PD-2 **The Conversion Model of Low Dose Rate Effect in Bipolar Transistors**

V.S. Pershenkov[1], D.V. Savchenkov[1], A.S. Bakerenkov[1], V.N. Ulimov[2], A.Y. Nikiforov[3], A.I. Chumakov[3]
[1]Moscow Engineering Physics Institute; [2]Research Institute of Scientific Instruments; [3]Specialized Electronic Systems

A physical model based on the assumption that conversion of shallow and deep oxide traps to interface traps leads to an S-shaped dependence of excess base current of bipolar transistor versus dose rate is presented.

PD-3 Semi-Empirical LET Descriptions of Heavy Ions Used in the European Component Irradiation Facilities

A. Javanainen[1], W.H. Trzaska[1,2], R. Harboe-Sørensen[3], A. Virtanen[1], G. Berger[4], W. Hajdas[5]
[1]University of Jyväskylä; [2]Helsinki Institute of Physics; [3]The European Space Agency; [4]The Cyclotron Research Centre; [5]Paul Scherrer Institut

Semi-empirical fitting based on classical Bohr theory has been applied to the experimental LET data of RADEF heavy ion cocktail. The implementation of parameterized LET descriptions in the European Component Irradiation Facilities is presented.

PD-4 Single Event Transients in Scaled CMOS Operational Amplifiers

O.J. Chukwuma, J.O. Attia
Prairie View A&M Univ.

SETs in CMOS op amps were investigated using time-domain and new frequency domain techniques. As the feature size of the op amps decreased, the peak voltage and FWHM product decreased, and the 3-dB frequency increased.

14.45 COFFEE BREAK

15.15 **Poster Papers:** *Chairs: R. Velazco (CNRS) & P. Adell (JPL/NASA)*
Data Workshop: *Chairs: S. Duzellier (ONERA) & S. McClure (JPL/NASA)*
Late News: *Chairs: V. Ferlet (ESA) & S. Armstrong (Vanderbilt Univ.)*

DATA WORKSHOP

DW-1 Low Dose Rate Test Results of National Semiconductors ELDRS-free Bipolar Comparators LM111 and LM119

K. Kruckmeyer, L. McGee, B. Brown, L. Miller
National Semiconductor

Low dose rate and high dose rate data and drift calculations are presented for National Semiconductors "ELDRS-free" bipolar comparators, LM111 and LM119, and compared to older versions of the products.

DW-2 Characterization of New Radiation Hardened Bipolar Operational Amplifiers

G. Chaumont[1], B. Cornanguer[1], P. Briand[1], C. Prugne[1], F. Malou[2]
[1]STMicroelectronics; [2]CNES

New operational amplifiers developed by STMicroelectronics have been ELDRS and heavy ions characterized. This paper presents the TID results at high and low dose rates and SEE test results.

DW-3 Low Dose Rate Testing on Commercial Micropower Single Supply Rail-to-Rail Instrumentation Amplifiers

M. Álvarez, J.A. Domínguez, C. Hernando, C.P. Fernández, I. Arruego
Laboratorio de Optoelectrónica (ACUI)

Instrumentation amplifiers suitable for low Earth orbit space missions were irradiated at low dose rate with gamma particles by INTA. The aim of this work is to analyze the enhanced of low dose rate sensitivity in devices based on bipolar technology, which are sensitive to it.

DW-4 **Total Ionizing Dose and Single Event Effects Test Results of a Radiation Hardness-By-Design Library for 0.15um Fully Depleted SOI-ASIC**

A. Makihara[1], T. Ebihara[1], T. Yokose[1], Y. Tsuchiya[1], Y. Miyazaki[1], Y. Satoh[2], H. Shindou [2], S. Kuboyama[2]
[1]High-Reliability Engineering & Components Corporation; [2]Japan Aerospace Exploration Agency

This paper describes Total Ionizing Dose and Single Event Effects test results of a Radiation hardness-By Design Library for 0.15m Fully Depleted CMOS/SOI-ASIC at a commercial foundry. Reasonable data was obtained to improve the library.

DW-5 **ATMEL ATF280E Rad Hard SRAM Based Reprogrammable FPGA SEE Test Results**

G. Mantelet, M. Briet, G. Rouxel, S. Hachad, B. Bancelin, D. de saint Roman
Atmel

The paper presents the new ATMEL rad-hard SRAM based reprogrammable FPGA design choices as well as the SEE (Single Event Effect) test results to illustrate the capability of this product to be used in space.

DW-6 **Comparison of TID Response and SEE Characterization of Single and Multi Level High Density NAND Flash Memories**

F. Irom[1], D.N. Nguyen[1], R. Harboe-Sørensen[2], A. Virtanen[3]
[1]Jet Propulsion Laboratory; [2]European Space Agency; [3]University of Jyväskylä

We report SEE and TID response for 8Gb NAND flash memory. This part appears to be less susceptible to SEE compared to older generations of flash memories. The charge pump survived up to 600 krads.

DW-7 **Radiation Studies on the UMC 180 nm CMOS Process at GSI**

S. Löchner, H. Deppe
GSI Helmholtzzentrum für Schwerionenforschung GmbH

GRISU test ASICs were irradiated with different heavy ions, fluences up to 10^{12} ions/cm^2 and with a LET between 1 and 60MeV cm^2/mg. Cross section for SEU/SET were measured during the tests. Furthermore TID measurements were applied. Results on degradation and annealing are reported.

DW-8 **SEU Data and Fault Tolerance Analysis of a LEON 3FT Processor**

A. Jordan, C. Hafer, J. Mabra, S. Griffith, J. Nagy, M. Lahey, D. Harris
Aeroflex

Single-bit per word error protection is implemented on this LEON 3 fault tolerant processor. SEU data is reviewed and fault analysis is examined based on processor operation and operation environment.

LATE NEWS

LN-1 **Effect of the Ion Mass and Energy on the Response of SOI Transistors to the Ion Deposited Charge by Direct Ionization**

M. Raine[1], V. Ferlet-Cavrois[1], M.Gaillardin[1], J.-E. Sauvestre[1], O. Flament[1], A. Bournel[2], V. Aubry-Fortuna[2]
[1]CEA; [2]Université Paris Sud

Experimental results showing different responses for SOI transistors under heavy ion irradiation are analyzed using Geant4 and Synopsys Sentaurus device simulations. The transistor response is shown to strongly depend on the ion mass and energy.

LN-2 Background Estimation in MXGS Apparatus on International Space Station

B. Alpat[1], M. Menichelli[1], D. Caraffini[2], M. Petasecca[2], F. Renz[2]
[1]INFN Sezione di Perugia; [2]MAPRAD

This paper describes a study of background estimation in Modular X- and Gamma ray Sensor (MXGS) onboard ESA's Atmosphere-Space Interactions Monitor (ASIM) mission, using Geant4 simulations and Spenvis packages for particle flux generations.

LN-3 Cobalt-60, Proton and Electron Irradiation of a Radiation-Hardened Active Pixel Sensor

D. Hervé[1], M. Beaumel[1], D. Van Aken[2]
[1]EADS SODERN; [2]Cypress Semiconductors

We present the key results of multiple radiation characterization campaigns on the HAS2 radiation-hardened active pixel sensor. These characterizations encompassed Cobalt-60 total ionizing dose, proton and electron displacement damage tests at room and low temperature.

LN-4 Inner Belt Anisotropy Investigations Based on the Standard Radiation Environment Monitor (SREM)

M. Siegl[1], H.D.R. Evans[1], E.J. Daly[1], G. Santin[1], P. Nieminen[1], P. Bühler[2]
[1]ESA-ESTEC; [2]Vienna

Pitch angle flux anisotropy observations by the PROBA-1/SREM instrument are investigated and compared with the countrate derived from the directional response function of the instrument, the Badhwar-Konradi pitch angle distribution model and the AP-8 model.

LN-5 Experimental Validation of Fault Injection Analyses by the FLIPPER Tool

M. Alderighi[1], F. Casini[2], S. D'Angelo[1], M. Mancini[2], D. Merodio Codinachs[3], S. Pastore[2], C. Poivey[3], G.R. Sechi[1], G. Sorrenti[2], R. Weigand[3]
[1]Istituto di Astrofisica Spaziale e Fisica Cosmica; [2]Sanitas EG; [3]ESA-ESTEC

The paper discusses the experimental validation of fault injection analyses accomplished with the FLIPPER tool. Validation has been accomplished through accelerated proton testing of a benchmark design provided by the European Space Agency.

LN-6 Total Dose Effects on a FD-SOI Technology for Monolithic Pixel Sensors

D. Bisello[1,2], M. Battaglia[3,4], D. Contarato[4], P. Denes[4], P. Giubilato[1,2,4], S. Mattiazzo[1,2], D. Pantano[1,2], N. Pozzobon[1,2], M. Tessaro[2], J. Wyss[2,5]
[1]Università degli Studi di Padova ; [2]Istituto Nazionale di Fisica Nucleare, Sezione di Padova; [3]University of California; [4]Lawrence Berkeley National Laboratory; [5]Università degli Studi di Cassino

A monolithic pixel detector in deep-submicron Silicon On Insulator (SOI) technology has been developed and characterized. This summary presents the first assessments of the effect of ionizing radiation as regards the total dose damage on single transistors in the technology used for the development of the first prototype chip.

LN-7 Sensitive Volume and Triggering Criteria of SEB in Classic Planar VDMOS

A. Luu[1], P. Austin[1], F. Miller[2], N. Buard[2], T. Carrière[2], P. Poirot[3], R. Gaillard[3], M. Bafleur[1], G. Sarrabayrouse[1]
[1]LAASCNRS; [2]European Aeronautic Defence and Space Company; [3]INFODUC

This paper presents 2D numerical simulation results allowing to define the sensitive volume and triggering criteria of SEB for VDMOS of classic planar-type technology. The results analysis permits besides to better understand the SEB mechanism.

LN-8 Heavy Ion Testing at the Galactic Cosmic Ray Energy Peak

J.A. Pellish[1], M.A. Xapsos[1], K.A. LaBel[1], P.W. Marshall[2], D.F. Heidel[3], K.P. Rodbell[3], M.C. Hakey[4], P.E. Dodd[5], M.R. Shaneyfelt[5], J.R. Schwank[5], R.C. Baumann[6], X. Deng[6], A. Marshall[6], B.D. Sierawski[7], J.D. Black[7], R.A. Reed[7], R.D. Schrimpf[7], H.S. Kim[8], M.D. Berg[8], M.J. Campola[8], M.R. Friendlich[8], C.E. Perez[8], A.M. Phan[8], C.M. Seidleck[8]

[1]NASA Goddard Space Flight Center; [2]NASA consultant; [3]IBM; [4]IBM System and Technology Group; [5]Sandia National Laboratories; [6]Texas Instruments; [7]Vanderbilt Univ.; [8]MEI Technologies

A 1 GeV/u ^{56}Fe ion beam allows for true 90° tilt irradiations of various microelectronic components and reveals relevant upset trends for an abundant element at the GCR flux energy peak.

LN-9 Last Upgrades and Development of the Space Environment Information System (SPENVIS)

M. Kruglanski[1], N. Messios[1], E. De Donder[1], E. Gamby[1], S. Calders[1], L. Hetey[1], H. Evans[2], E. Daly[2]

[1]Belgium Institute for Space Aeronomy; [2]ESA-ESTEC

The ESA operational software SPENVIS allows rapid analysis of the hazardous space environment and its effects. This news presents the upgrades of existing models and additional new models planned for the release of June 2009.

LN-10 Transient and Steady State Radiation Responses of Solarization-Resistant Optical Fibers

S. Girard, C. Marcandella

CEA

We investigated the pulsed and steady state X-ray radiation responses of solarization-resistant optical fibers in the 200-1100 nm range of wavelengths. Their radiation sensitivities are compared to those of other classes of optical fibers.

LN-11 TCAD Simulations on CMOS Propagation Induced Pulse Broadening Effect: Dependence Analysis on the NMOS V_T

J.M. Mogollón, F.R. Palomo, M.A. Aguirre, J. Nápoles, H. Guzmán-Miranda, E. García-Sánchez

University of Sevilla

In this paper we explore the influence of the NMOS threshold voltage V_T on Propagation Induced Pulse Broadening PIPB effect by simulating the propagation of a SET through a self-feedback chain of CMOS inverters. Results are applicable in Multi-Vt CMOS Technologies.

LN-12 SEE Evaluation of a Low-Power 1μm-SOI 80C51 for Extremely Harsh Environments

S. Falmagne, J. Garnier, P. Manet, G. Berger, J.-D. Legat

Université Catholique de Louvain

In this paper, we present the SEE characterization of an 80C51 microcontroller optimized for high temperature and low-power applications. Its microarchitecture has been completely re-designed with deep low-power optimizations.

17.30 ADJOURN

Technical Program
Thursday, September 17, 2009

Session E – Hardness Assurance

08.55 Session Introduction
Chairs: C. Poivey (ESA-ESTEC) & K. LaBel (NASA GSFC)

E-1 Investigation of the Bias Effect on Total Dose Induced Degradation on Bipolar Linear Microcircuits

09.00 *Y. Gonzalez Velo[1], J. Boch[1], N.J.-H. Roche[1], S. Pérez[1], J.-R. Vaillé[1], L. Dusseau[1], F. Saigné[1], E. Lorfèvre[2], R.D. Schrimpf[3], C. Chatry[4], A. Canals[4]*
[1]Université Montpellier 2; [2]Centre National d'Etudes Spatiales; [3]Vanderbilt Univ.; [4]TRAD

Dose experiments are conducted on bipolar microcircuits to analyze the bias effect during irradiation. The worst-case is shown to be dose rate dependent. A time-saving evaluation procedure based on switching experiments is given.

E-2 Enhancing Observability of Signal Composition Response and Error Signatures during Dynamic SEE Analog to Digital Device Testing

09.15 *M. Berg, S. Buchner, , H. Kim, M. Friendlich, C. Perez, A. Phan, C. Seidleck, K. LaBel*
NASA

A novel method of dynamic SEE ADC testing is presented. The approach utilizes a FPGA core for processing and has proven to enhance error signature and signal integrity observation verses alternate techniques.

E-3 Failure Modes and Hardness Assurance for Linear Integrated Circuits in Space Applications

09.30 *A. Johnston, B. Rax*
Jet Propulsion Laboratory

Failure modes are investigated for linear integrated circuits, including load current effects. Results for large samples are used to develop a less conservative design approach that can extend their useful range in space environments.

Poster Papers

PE-1 Laser SEL Sensitivity Mapping of SRAM Cells

A.J. Burnell[1], A.M. Chugg[1],R. Harboe-Sørensen[2]
[1]MBDA UK Ltd; [2]ESA-ESTEC

It is shown that laser SEL sensitivity mapping at the cell level exhibits a repetitive pattern. In conjunction with depth profiling, individual sensitive regions are shown to be approximate fat ellipsoids, which has implications for SEL specifications in the space environment.

PE-2 Total-Dose Worst-Case Test Vectors for Logic Faults Induced in Combinational Circuits of Cell-Based ASICs

A.A. Abou-Auf, H.A. Abdel-Aziz, M.M. Abdel-Aziz
American Univ. in Cairo

We developed a methodology for identifying worst-case test vectors for logic faults induced in combinational circuits of cell-based ASICs induced by total dose. This methodology is independent of the design tools and the process technology.

PE-3 **Extensive SEU Impact Analysis of a PIC Microprocessor for Selective Hardening**
M. García-Valderas, M. Portela García, C. López-Ongil, L. Entrena
Universidad Carlos III de Madrid

In order to increase the robustness of a circuit against SEUs, fault injection is commonly used to locate weak areas. Autonomous emulation is used to locate weak areas in a PIC18 microprocessor, while it executes three different workloads.

PE-4 **A New Critical Variable Analysis in Processor-Based Systems**
S. Bergaoui, P. Vanhauwaert, R. Leveugle
TIMA Laboratory

The most critical information must be identified for selective hardening. In processor-based systems, the most critical variables must be identified in the application program. An improved algorithm is described and validated by fault injections.

INVITED LECTURE

09.45 **Cold Atoms, Atom Chips and Sensors Applications**
J.-P. Pocholle (TRT)

10.30 COFFEE BREAK

Session F – Terrestrial and Radiation Environments

10.55 Session Introduction
Chairs: D. Heynderickx (DHConsultancy) & M. Xapsos (NASA)

F-1 **Altitude and Underground Real-Time SER Tests of Embedded SRAM**
11.00 *T. Heijmen, J. Verwijst*
NXP Semiconductors

Altitude and underground real-time SER tests have been performed on embedded SRAMs. The results are used to validate the accelerated SER test methodology. Statistical analysis of the real-time SER results has been performed.

F-2 **Radiation Environments and Shielding Approach for Jupiter Europa Orbiter (JEO)**
11.15 *I. Jun, K. Clark, T.-Y. Yan, T. Van Houten*
Jet Propulsion Laboratory

A brief overview of the Jupiter Europa Orbiter (JEO) mission is presented along with a discussion of the challenges associated with the harsh radiation environment anticipated for the mission. The shielding approach appropriate for such a harsh radiation environment is discussed.

F-3 **MATSIM: The Development of a Voxel Model of the MATROSHKA Astronaut Dosimetric Phantom Exposed to Cosmic Radiation Onboard the International Space Station ISS**
11.30 *P. Beck[1], Th. Berger[2], M. Hajek[3], M. Latocha[1], G. Reitz[2], S. Rollet[1], N. Vana[3], A. Zechner[1,4]*
[1]Austrian Institute of Technology; [2]German Aerospace Center; [3]Vienna Univ. of Technology; [4]Graz Univ. of Technology

We developed a high resolution voxel model of the MATROSHKA astronaut dosimetric phantom and investigated the imparted energy within the phantom due to interaction with ionizing radiation. The mathematical model is validated by reference measurements.

F-4 **The Radiation Environment and Effects for future ESA Cosmic Vision Missions**

11.45 *J. Sørensen, G. Santin*
ESA-ESTEC

This paper describes some of the radiation environments and their effects encountered by the Cosmic Vision missions, with emphasis on the design specifications and verification tools, including new shielding analysis techniques.

Poster Papers

PF-1 **Electron Environment Specification Models for Navigation Orbits**

S. Bourdarie[1], D. Lazaro[1], A. Hands[2], K. Ryden[2], P. Nieminen[3]
[1]Office National d'Etudes et de Recherches Aérospatiales; [2]QinetiQ; [3]ESA-ESTEC

Electron environment specification models have been developed to assess long term effects (e.g. doses) as well as short term effects (e.g. internal charging) for navigation orbiting spacecraft design.

PF-2 **ICARE On-Board SAC-C: More than 8 years of SEU & MBU, Analysis and Prediction**

C. Boatella[1], G. Hubert[2], R. Ecoffet[1], S. Duzellier[2]
[1]CNES; [2]ONERA-DESP

This paper presents the SEU & MBU detected by several dedicated memories of the instrument ICARE onboard the Argentinean satellite SAC-C. The correlation between SEU rate and the space environment is shown along with the evolution of the geomagnetic cut-off, the geographical dependence of the MBU multiplicity inside the SAA is also shown.

PF-3 **Cosmic-Ray Heavy Ions Contributions to the Atmospheric Radiation Field**

F. Lei, A. Hands, P. Truscott, C. Dyer
QinetiQ

Although heavy ions constitute only ~1% of the total cosmic ray flux, they can make a significant contribution to the radiation field in the upper atmosphere. This contribution is evaluated by MC simulations within the QARM framework.

12.00 LUNCH

Session G – Photonics

13.40 Session Introduction
Chairs: A. Gusarov (SCK•CEN) & J. Kuhnhenn (Fraunhofer-INT)

G-1 Gamma-Radiation Effects on the Femto-Second Fiber Bragg Gratings Written in Ge-Doped Fibers

13.45 *A. Gusarov[1], B. Brichard[1], D.N. Nikogosyan[2]*
[1]SCK•CEN; [2]University College Cork

We studied the effect of Co60 gamma-radiation on the peak position and the amplitude of FBGs written with a femto-second UV laser. The Bragg peak shift under radiation is almost independent on the fiber type, the use of hydrogen loading, or grating amplitude.

G-2 Influence of Manufacturing Parameters and Temperature on the Radiation Sensitivity of Fiber Bragg Gratings

14.00 *H. Henschel, S.K. Hoeffgen, J. Kuhnhenn, U. Weinand*
Fraunhofer-INT

For the first time the influence of hydrogen loading pressure before and fiber tension during grating inscription, of the recoating procedure, and of the grating temperature on the radiation sensitivity of Bragg gratings was investigated.

G-3 Effects of Low Temperature Proton Irradiation on a Large Area CCD for Astrometric Applications

14.15 *G. Hopkinson[1], P. Gare[2], G. Sarri[2]*
[1]Surrey Satellite Technology Ltd; [2]ESA-ESTEC

Charge transfer and dark current effects are compared for regions of a large area 4500 x 1966 pixel CCD irradiated with 7.4 MeV protons at -130°C and at room temperature. Post-annealing measurements were also performed.

G-4 Proton Irradiation of InGaAs/InP and InGaAsP/InP Geiger-Mode Avalanche Photodiodes

14.30 *R.D. Harris, W.H. Farr, H.N. Becker*
Jet Propulsion Laboratory

Degradation of InP-based Geiger-mode avalanche photodiodes caused by proton irradiation is studied for the first time. Changes in the dark I-V characteristics as well as increases in the dark count rate are observed after irradiation.

Poster Papers

PG-1 A Simple Method for Optocoupler Selection in the Frame of Space Applications

D. Peyre[1], C. Binois[1], M.H. Mendenhall[2], R.A. Weller[2], R. Mangeret[1], G. Salvaterra[1], G. Montay[1], T. Beutier[1], M. Beaumel[3], R. Harboe-Sørensen[4], C. Poivey[4]
[1]ASTRIUM SAS; [2]Vanderbilt Univ.; [3]SODERN; [4]ESA-ESTEC

Proton irradiations were performed on three types of optocouplers at 3 energies 60 MeV, 100 MeV, 100 MeV and 200 MeV. GEANT4 allowed the calculation of the fluences needed to induce the same NIEL.

PG-2 Long-Term Exposure of Fiber Bragg Gratings in the BR1 Low-Flux Nuclear Reactor

A. Gusarov
SCK•CEN

We report the results of a long-term exposure of fiber Bragg gratings (FBGs) in the low-flux nuclear reactor. After 8+ year exposure the gratings show a decent degradation. The data confirm that

PG-3 **10 keV X-Ray Irradiation Effects on Phosphorus-Doped Fibers and Preforms: Electron Spin Resonance and Optical Studies**

G. Origlio[1], S. Girard[2], F. Messina[3], M. Cannas[3], A. Boukenter[1], R. Boscaino[3], Y. Ouerdane[1]
[1]Université de Lyon; [2]CEA; [3]Università di Palermo

The influence of X-ray irradiation on prototype phosphorus-doped canonical fibers and their related preforms was investigated by in-situ radiation induced attenuation, optical absorption and paramagnetic resonance spectroscopy.

PG-4 **Gamma Radiation Effects on CCTV Cameras - an Update**

R.E. Sharp
Isotron Ltd

This paper provides an update to the databank of results from the radiation testing of CCTV cameras for use in radiation environments associated with the nuclear power industry. Ten modern cameras have been tested using a standard methodology.

14.45 COFFEE BREAK

Session H – Dosimetry and Facilities

15.10 Session Introduction
Chairs: G. Berger (UCL) & W. Hajdas (Paul Scherrer Institut)

H-1 **The DIME Suite of Dosimeters**

15.15 *P.J. McNulty[1], K.F. Poole[1], P. Chandran[1], J. Winso[2], E. Ackermann[2], M. Fennell[2], J. Rolando[2], R. Dunlap[2]*
[1]Clemson Univ.; [2]Space Micro Inc

Simple dosimeters are described for single-event effects from cosmic-rays and nuclear-spallation reactions as well total-dose effects and displacement-damage. Measurement of these complex radiation environments is complicated by fluctuating temperature and voltages.

H-2 **A new Approach in Characterizing the Response of Silicon p-i-n diodes used as Radiation Monitoring Sensors**

15.30 *J. Mekki[1], M. Moll[1], M. Fahrer[1], M. Glaser[1], L. Dusseau[2]*
[1]CERN; [2]University Montpellier II

In this work the effect of radiation damage on Silicon p-i-n diodes have been studied. I-V characteristics of unirradiated and irradiated diodes up to 6.3×10^{13} n_{eq}/cm^2 have been measured and analyzed to give a more comprehensive understanding of the Si-bulk properties after irradiation.

H-3 **Validation of Geant4 Based Dose Computational Tools with REEF Experiments**

15.45 *F. Lei, S. Rason, K. Ford, P. Morris*
QinetiQ

This paper reports on the experiments carried out using the QinetiQs REEF (Realistic Electron Exposure Facility) for the validation of computational tools used in space radiation studies.

Poster Papers

PH-1 The Radiation Hardness Assurance Facility at INFN-LNS Catania for the Irradiation of Electronic Components in Air

M. Menichelli[1], B. Alpat[1], A. Papi[1], R. Harboe-Sørensen[2], P. Cirrone[3], F. Ferrera[3], P. Figuera[3], P. Finocchiaro[3], M. Lattauda[3], D. Rifuggiato[3], F. Bizzarri[4], D. Caraffini[4], M. Petasecca[4], F. Renzi[4], H. Denizli[5], O. Amuktan[6]

[1]Istituto Nazionale di Fisica Nucleare Sezione di Perugia; [2]ESA/ESTEC; [3]Laboratori Nazionali del Sud dell'INFN; [4]MAPRAD; [5]Abant Izzet Baysal Univ.; [6]Ortadogu Teknik Universitesi

This paper describes a beam flux monitoring system used at the Accelerator of INFN-LNS for SEE tests. The relatively high energy of the beam (20 MeV/nucleon) allows the irradiation of components in air.

PH-2 AGORFIRM, the AGOR Facility for IRradiations of Materials

E.R. van der Graaf[1], R.W. Ostendorf[1], M.-J. van Goethem[2], H.H. Kiewiet[1], M.A. Hofstee[1], S. Brandenburg[1]

[1]Kernfysisch Versneller Instituut (KVI); [2]on secondment at the KVI from the University Medical Centre Groningen

AGORFIRM is a facility for irradiations with protons and carbon ions, available for radiation damage and radiobiology studies. An overview is presented of the various beams and services and of recent characterization measurements and modeling.

16.00 RADECS GENERAL ASSEMBLY

17.30 ADJOURN

19.00 BELGIAN EVENING AT THE BELFRY

Technical Program
Friday, September 18, 2009

INVITED LECTURE

09.15 **The History of the Memling in Sint-Jan-Hospital Museum in Bruges: A Survey**
S. Goegebuer (Sint-Jan-Hospitaalmuseum)

Session I – Technology and Design Hardening

09.55 Session Introduction
Chairs: F. Faccio (CERN) & B. Bhuva (Vanderbilt Univ.)

I-1 **A Commercial 65nm CMOS Technology for Space Applications: Heavy Ion, Proton and Gamma Test Results and Modeling**

10.00 *P. Roche[1], G. Gasiot[1], S. Uznanski[1], J.-M. Daveau[1], J. Torras-Flaquer[1], S. Clerc[1], R. Harboe-Sørensen[2]*
[1]STMicroelectronics; [2]ESA-ESTEC

This paper presents experimental evidences that commercial CMOS technologies get intrinsically harder against space radiations with downscaling. When further using innovative rad-hard design techniques, electrical performances and radiation-hardness can be both met in standard CMOS 65 nm.

I-2 **High Speed Redundant Self Correcting Circuits for Radiation Hardened By Design Logic**

10.15 *D.E. Pettit, N.D. Hindman, D.W. Patterson, K.E. Nielsen, K.E. Holbert, L.T. Clark*
Arizona State Univ.

Self-correcting triple redundant circuits for SEE hardening fabricated on a 90 nm bulk CMOS process. TID tests indicate negligible ISB increase up to 3.2 Mrad(Si) and ion tests show SEE hardness beyond 100 MeV-cm^2/mg LET.

I-3 **A 90 nm Bulk CMOS Radiation Hardened by Design Cache Memory**

10.30 *X. Yao, D.W. Patterson, L.T. Clark, K.E. Holbert*
Arizona State Univ.

A RHBD high performance cache fabricated on 90 nm bulk CMOS is presented. Test silicon data arrays can read and write at 1.02 GHz. Radiation hardness was proved through irradiation with Co-60 and ion beams.

I-4 **Evaluating the Impact of DFM Library Optimizations on Alpha-induced SEU Sensitivity in a Microprocessor Core**

10.45 *P. Rech[1], A. Paccagnella[1], P. Bernardi[2], M. Grosso[2], M. Sonza Reorda[2], F. Melchiori[3], D. Appello[3]*
[1]Università di Padova; [2]Politecnico di Torino; [3]STMicroelectronics

We investigate and compare the reliability to alpha particles of a microprocessor core implemented with three different Design For Manufacturability (DFM) optimization strategies. We demonstrate that a strong application of DFM guidelines ensures a low soft-error rate.

Poster Papers

PI-1 **A Novel Error Correction Technique for Adjacent Errors**
C. Argyrides[1], P. Reviriego[2], D.K. Pradhan[1], J.A. Maestro[2]
[1]University of Bristol; [2]Universidad Antonio de Nebriia

We propose specific codes optimized to protect memories against multiple errors. This technique improves memory's reliability by 40X compared to Hamming codes and 2X the MTTF compared to REED Muller codes for clustored MBUs.

PI-2 Fault Tolerant FIR Filters Using Hamming Codes

S.-F. Liu, P. Reviriego, J.A. Maestro
Universidad Antonio de Nebrija

Hamming Codes have been used to protect different circuits against Single Event Upsets (SEUs). In this paper, the use of Hamming on FIR Filters is studied in order to provide optimized and efficient protection techniques.

PI-3 The Reliability and Availability Analysis of SEU Mitigation Techniques in SRAM-based FPGAs

Z.-M. Wang[1], L. Ding[1], H.-X. Guo[2], H. Zhou[2]
[1]PHD candidate, Tsinghua Univ.; [2]Northwest Institute of Nuclear Technology

Several reliability models are proposed to evaluate the efficiencies of different SEU mitigation techniques in SRAM-based FPGAs. These models may help designers to select proper protection according to the specification of system reliability or availability.

PI-4 Non-TMR SEU-Hardening Techniques for SiGe HBT Shift Registers and Clock Buffers

E.P. Wilcox[1], S.D. Phillips[1], J.D. Cressler[1], P.W. Marshall[2], M.A. Carts[3], J.A. Pellish[3], L. Richmond[4], W. Mathes[4], B. Randall[5], D. Post[5], B. Gilbert[5], E. Daniel[5]
[1]Georgia Institute of Technology; [2]Consultant; [3]NASA Goddard Space Flight Center; [4]General Dynamics C4 Systems; [5]Mayo Foundation

We report new results from both broad-beam, heavy-ion and proton experiments for circuit-level RHBD techniques in SiGe digital logic. Redundant circuit elements within the latches are used to significantly reduce single-event upset rates in shift registers and clock paths, without resorting to TMR techniques.

PI-5 Selection of the Optimal Interleaving Distance for Memories Suffering MCUs

P. Reviriego[1], J.A. Maestro[1], S. Baeg[2], S.J. Wen[3], R. Wong[3]
[1]Universidad Antonio de Nebrija; [2]School of Electrical Engineering and Computer Science; [3]Cisco Systems

To protect memories from MCUs, single error correction codes (SEC) and interleaving are commonly used. This paper determines the selection of the optimal interleaving distance (ID) that achieves a target reliability, minimizing area and complexity.

PI-6 Analyzing Transistor Size and Folding Method for Radiation Hardening

T. Assis, L. Brusamarello, F.L. Kastensmidt, G. Wirth, R. Reis
PGMICRO

The efficiency of transistor sizing and folding techniques to mitigate soft errors in CMOS circuits is evaluated using circuit and device simulations. It is shown that the efficiency of these techniques depends on the Linear Energy Transfer (LET) of the ionizing particle.

11.00 CLOSING OF THE CONFERENCE

11.30 LIGHT LUNCH

12.00 BUS TO IMEC FOR A TECHNICAL VISIT (pre-registered participants only)

AWARDS

RADECS 2007 AWARDS

A ceremony will be organized during the Gala dinner to AWARD outstanding works from the RADECS 2007.

Best Oral Presentation

This time two outstanding papers have been designated ex aequo

Effects of Guard Bands and Well Contacts in Mitigating Long SETs in Advanced CMOS Processes

Balaji Narasimham, Bharat L. Bhuva, Ronald D. Schrimpf, Lloyd W. Massengill, Matthew J. Gadlage, W. Timothy Holman, Arthur F. Witulski, William H. Robinson, Jeffrey D. Black - *Vanderbilt University, Nashville, TN, USA* and Joseph M. Benedetto - *Microelectronics Research and Development Corporation - Colorado Springs, CO, USA*

Channel Hot Carrier Stress on Irradiated 130-nm NMOSFETs: Impact of Bias Conditions During X-ray Exposure

M. Silvestri, S. Gerardin, A. Paccagnella - *Dipartimento di Ingegneria dell'Informazione, Università di Padova and INFN-Padova, Italy* and F. Faccio, L. Gonella - *Physic Department, Microelectronics Group, CERN, Geneva, CH* and D. Pantano - *INFN-Padova and Dipartimento di Fisica, Università di Padova, Italy* and V. Re, M. Manghisoni - *Dipartimento di Ingegneria Industriale, Università di Bergamo and INFN-Pavia, Italy* and L. Ratti - *Dipartimento di Elettronica, Università di Pavia and INFN-Pavia, Italy* and A. Ranieri - *Dipartimento Interateneo di Fisica and INFN-Bari, Italy*

Best Poster Presentation

Study of Single-Event Transients in High-Speed Operational Amplifiers

P. Jaulent, V. Pouget, D. Lewis, P. Fouillat - *IMS laboratory, University of Bordeaux 1, CNRS-UMR 5218, Talence, France*

Best Data Workshop

Single Event Effects Response of Embedded Power PCs in a Xilinx Virtex-4 for a Space Application

C. Poivey, M. Berg, M. Friendlich, H. Kim - *MEI Technologies, Seabrook, MD, USA* and D. Petrick - *NASA-GSFC, Greenbelt, MD, USA* and S. Stansberry - *ISI, Arlington, VA, USA* and K. LaBel - *NASA-GSFC, Greenbelt, MD, USA* and C. Seidleck, A. Phan, and T. Irwin - *MEI Technologies, Seabrook, MD, USA*

RADECS 2009 AWARDS

An AWARD committee will overview the scientific and technical output of the conference in order to elect the best Oral, Poster and Data Workshop contributions from RADECS 2009.

In addition, the **Jean Marie Palau Prize** was created to award outstanding contributions from dedicated students. This AWARD will be given to the students during the closure ceremony of the conference on Friday noon.

Richard Sharpe

Industrial Exhibition

Teresa Farris (Aeroflex)
Industrial Exhibit Chair (US)

RADECS exhibitors invite you to visit their exhibits on Tuesday-Thursday to see their latest radiation-hardened products and technologies and meet staff. A reception will be hosted by the exhibitors on Tuesday evening, September 15. Conference attendees and their guests can enjoy the reception and visit the exhibits. Please join us on Tuesday evening!

The Industrial Exhibition will be located in room Grote Witte Roos, level 2 of the Oud Sint-Jan Conference Center. The Welcome Reception on Tuesday, September 15 and the coffee breaks as announced in the program will take place in the Industrial Exhibition area.

If you have questions feel free to contact the Industrial Exhibition Chairs:

Teresa Farris, Teresa.Farris@aeroflex.com for US companies
and
Christian Chatry, Christian.Chatry@trad.fr for EU companies

Christian Chatry (TRAD)
Industrial Exhibit Chair (EU)

Exhibition Hours

Set-up:

Monday, September 14	14.00 – 18.00 hrs
Tuesday, September 15	08.00 – 10.00 hrs

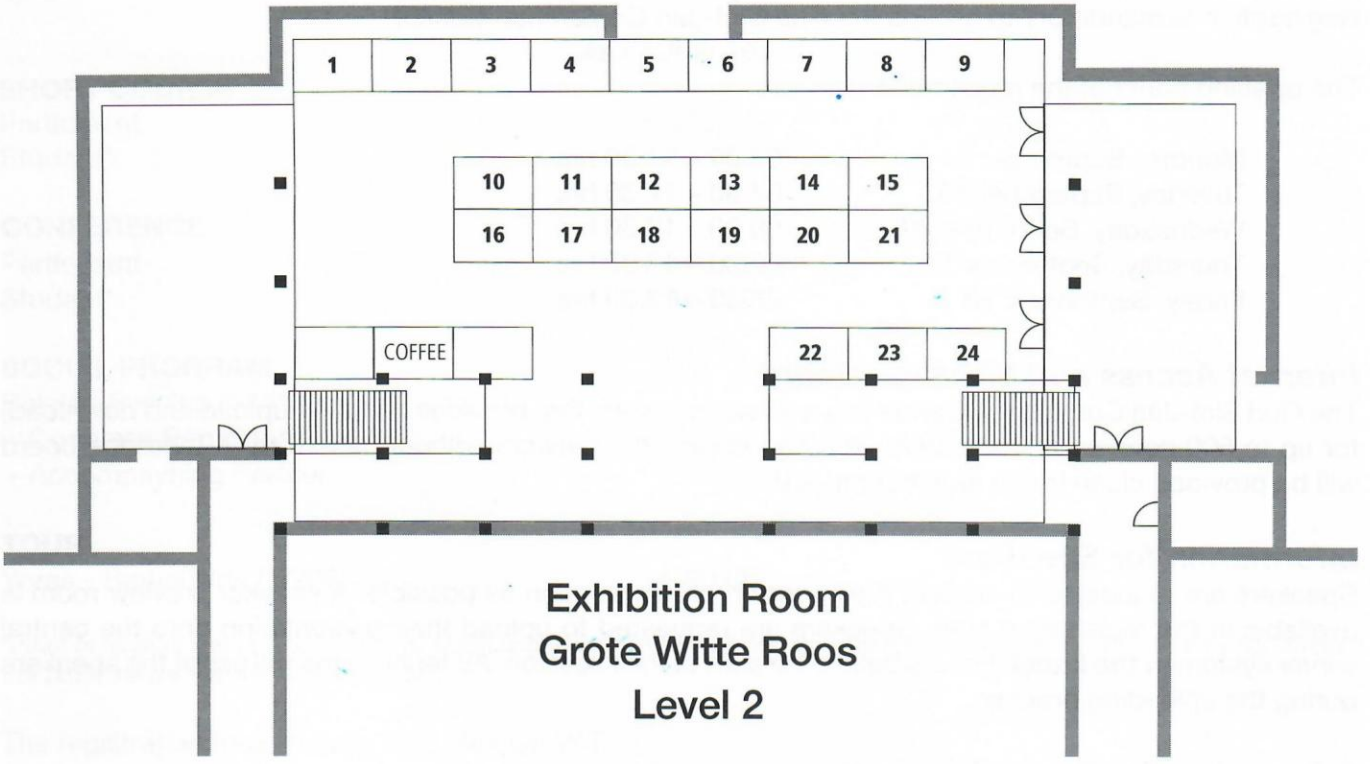
Exhibits Open:

Tuesday, September 15	10.30 – 19.30 hrs
Wednesday, September 16	09.00 – 15.15 hrs
Thursday, September 17	09.00 – 15.15 hrs

Teardown:

Thursday, September 17	15.30 – 18.00 hrs
Friday, September 18	08.00 – 12.00 hrs

Exhibitor List



Exhibition Room
Grote Witte Roos
Level 2

Exhibitor	Stand Space	Stand Space	Exhibitor
3D Plus	14	1	Texas Instruments
Actel Europe	5	2	International Rectifier
Aeroflex Colorado Springs	16	3	STMicroelectronics
Atmel	19	4	GESEC R&D
Belgian Institute for Space Aeronomy (BIRA-IASB)	7	5	Actel Europe
Crane Aerospace and Electronics	15	6	National Semiconductor
C-MAC MicroTechnology	12	7	Belgian Institute for Space Aeronomy (BIRA-IASB)
GESEC R&D	4	8	InfiniScale
Honeywell	20	9	Isotron
InfiniScale	8	10	Ixfiber
International Rectifier	2	11	SCK•CEN
Intersil	17	12	C-MAC MicroTechnology
Isocom	21	13	RADECS, NSREC 2010, IEEE
Isotron	9	14	3D Plus
Ixfiber	10	15	Crane Aerospace and Electronics
Maxwell Technologies	22	16	Aeroflex Colorado Springs
National Semiconductor	6	17	Intersil
RADECS, NSREC 2010, IEEE	13	18	TRAD
SCK•CEN	11	19	Atmel
Spacekey	23	20	Honeywell
STMicroelectronics	3	21	Isocom
Texas Instruments	1	22	Maxwell Technologies
The Svedberg Laboratory	24	23	Spacekey
TRAD	18	24	The Svedberg Laboratory

General Information

Registration desk and Conference Secretariat

Registration is mandatory to access the Oud Sint-Jan Conference Center.

The opening hours of the registration desk are:

Monday, September 14	07.30 – 17.30 hrs
Tuesday, September 15	07.30 – 17.30 hrs
Wednesday, September 16	08.00 – 17.30 hrs
Thursday, September 17	08.00 – 17.30 hrs
Friday, September 18	08.30 – 12.00 hrs

Internet Access and Message Board

The Oud Sint-Jan Conference Center has a wireless system that provides 10 Mb/s (upload and download) for up to 500 connected computers. You can access the network without password. A message board will be provided close to the registration desk.

Information for Speakers

Speakers are requested to contact their session chairs as soon as possible. A speaker preview room is available in the registration area. Speakers are requested to upload their presentation onto the central server system **at the latest** 2 hours before the start of their session. AV technicians will assist the speakers during the uploading process.

Information for Poster Presenters

Boards of 1 m width and 2 m height (A0 European style format) will be available during the poster session to be held on Wednesday afternoon, in room Morus, level 1. The poster room will be accessible from 15.00 hrs onwards on Monday, September 14. Adhesive materials will be provided on site.

Welcome Reception and Coffee Breaks

The Welcome Reception and coffee breaks will take place in the Industrial Exhibition area in room Grote Witte Roos, level 2.

Lunches

On Monday, September 14, lunch will be served in room Vives, level 1, for the short course participants. From Tuesday to Friday lunches will be served in room Vives and Erasmus, level 1. Access to the lunches is granted to the participants of the conference technical program. Guests who would like to join the participants for lunch are welcome. A limited number of guest lunch tickets can be bought at the registration desk at a rate of € 45,00 and must be ordered by 12.00 hrs the previous day.

Non-Smoking Policy

The Conference will have an overall non-smoking policy. Smoking is prohibited in the Oud Sint-Jan Conference Center as well as in the industrial exhibition and poster areas.

Climate

The weather is usually mild in September (18-22°C). An occasional shower, however, remains possible.

Liability

By registering into the Conference and/or by participating in the exhibition joined to the Conference, participants and exhibitors agree that neither the Organizing Committee nor the Administrative Secretariat assume any liability. Participants and exhibitors are advised to organize their own health, travel and personal insurances.

Registration

Registration Fees

	As of July 16
SHORT COURSE	
Participant	€ 400,00
Student*	€ 175,00
CONFERENCE	
Participant	€ 800,00
Student*	€ 550,00
SOCIAL PROGRAM	
Belgian Evening (17/09)	
- Congress Participant	included
- Accompayning Partner	€ 90,00
TOUR	
Ypres - Battlefields (17/09)	€ 90,00

*Proof of student status is to be sent to Medicongress by email (radecs@medicongress.com) or fax (+32 9 344 40 10). Without this proof the participant fee will be charged.

The registration fees include 21% Belgian VAT.

Payment

All payments are to be made in Euro, net of all bank charges and commissions for the receiver.
Payment is to be made by:

- Bank transfer
  Account Number: 123-6800465-25
  Account Name: RADECS
  Iban: BE70123680046525– Swift: BKCPBEBB
  Bank address: OBK Bank, Graaf Van Vlaanderenplein 19, 9000 Gent, Belgium

- Credit Card: All major credit cards are accepted.

Cancellations

Participants cancelling their registration before August 15, 2009 will receive a 50% refund. There will be no refunds for cancellations received after this date. Registered participants or accompanying persons not showing up at the Conference will NOT be reimbursed. Cancellations must be confirmed in writing to the Organizing Secretariat. All refunds will be processed after the Conference.

Social Program and Tour

Reception at the Town Hall – 19.00 – 20.00 hrs, Monday, September 14

A Welcome Reception is offered by the Mayor of Bruges at the Town Hall, located on the Burg Square in the heart of the city. Registered Short Course participants and Board Members wearing the official congress badge can attend free of charge.

Welcome Reception – 17.30 – 19.30 hrs, Tuesday, September 15

All registered participants and their guests are invited to the Welcome Reception which will take place in the Industrial Exhibition area, room Grote Witte Roos, level 2.

Belgian Evening at the Belfry – 19.30 – 23.00 hrs, Thursday, September 17

The conference organizers intend not to organize a classic Gala Dinner but to invite all participants to a big surprise evening called the 'Belgian Evening'. The purpose is to gather informally with local drinks and food and good music. It will be a seated dinner with a lot of enjoyment and entertainment. The historic and impressive Belfry of Bruges will be the perfect setting for this 'Belgian Evening'.

This evening is included in the registration fee for participants (pre-registration is mandatory!).

Partners/Guests can register at a rate of € 90,00. Registration for the Gala Dinner closes on Tuesday, September 15 at 18.00 hrs.

Dress code is business casual.

Tour to Ypres – The Battlefields of the Great War

08.45 – 18.00 hrs, Thursday, September 17

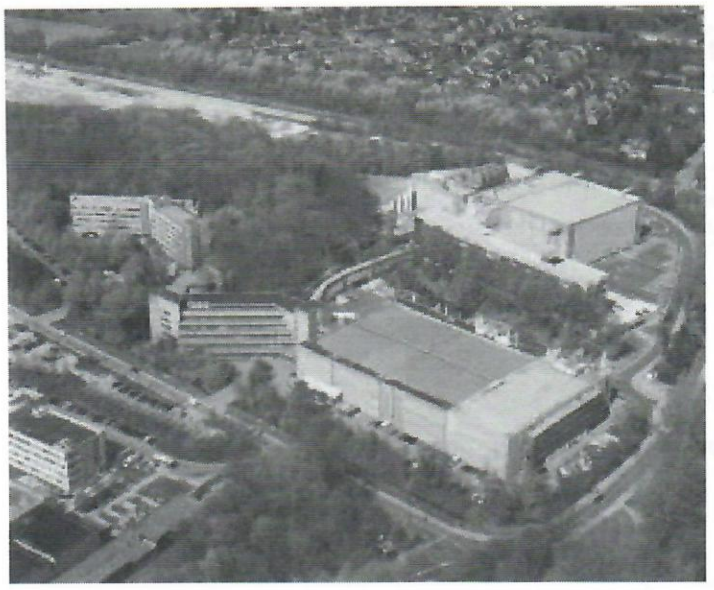
On our journey we stop to tramp through restored trenches, stroll amongst now tranquil war graves in Passchendale and Polygon Wood, clamber over craters and bunkers on the preserved Hill 60 battlefield and learn of the hardships the men endured for four long years. We visit the beautiful city of Ypres - which was rebuilt to medieval plans after being totally flattened in WWI - and the imposing Menin Gate Memorial to the missing soldiers.

Full day tour, including bus transport & lunch.
Rate per person: € 90,00 (registration until 17.30 hrs on Tuesday, September 15 if seats are still available)

Meeting point: registration desk of Oud Sint-Jan Conference Center **at 08.45 hrs sharp**

The tours Bruges and Ghent have been cancelled due to lack of interest (the minimum number of 20 participants was not reached). Registered partners/guests will receive a 100% refund.

Technical Visit to IMEC



IMEC
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IMEC is a world-leading independent research center in nanoelectronics and nanotechnology. IMEC vzw is headquartered in Leuven, Belgium, has a sister company in the Netherlands (IMEC-NL), offices in the US, China and Taiwan, and representatives in Japan. Its staff of more than 1,750 people includes over 500 industrial residents and guest researchers. In 2008, IMEC's revenue (P&L) was 280 M€. IMEC's "More Moore" research targets semiconductor scaling for sub-32nm nodes. The 8000 m^2 clean rooms include a fully equipped 200mm wafer size process line and a state-of-the-art 300mm prototype line. With its More than Moore research, IMEC invents technology for nomadic embedded systems, wireless autonomous transducer solutions, biomedical electronics, photovoltaics, organic electronics and GaN power electronics. IMEC's research bridges the gap between fundamental research at universities and technological development in industry. IMEC's unique processing and system know-how, intellectual property portfolio, state-of-the-art infrastructure and its strong and worldwide network position IMEC as a key partner for shaping the technology for future systems.

Practical Information

Pre-registration for the technical visit was mandatory. The technical visit is fully booked. Buses will leave from the Oud Sint-Jan Conference Center at 12.15 hrs sharp on Friday, September 18. Depending on traffic, the journey may take up to 2 hours.

The visit will last about 1.15 hours from 14.15 until 15.30 hrs. Several groups will be formed depending on the registration number.

Buses will leave from Leuven, IMEC visitor entrance at 15.45 hrs to Bruges. They will stop at the Brussels National Airport for those participants flying back on Friday night. Those who also want to stay in Brussels can take these buses and use the airport facility connections to the city center.

Organizers

SCK•CEN

STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

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