Multi-Scale, Multi-Physics of Radiation Effects

Announcement for the 2022 IEEE NSREC Short Course

MONDAY
JULY 18, 2022
PROVO, UTAH
USA

On behalf of the 2022 IEEE Nuclear and Space Radiation Effects Conference (NSREC) Committee, I cordially invite you to attend the 43nd IEEE NSREC Short Course. An outstanding group of technical experts will provide an in-depth discussion of the multi-scale, multi-physics of radiation effects on microelectronics.

Pr. Sylvain Girard
University of Saint-Etienne, Lab. Hubert Curien
Short Course Chair

ALL REGISTERED SHORT COURSE ATTENDEES WILL RECEIVE THE 1980-2022 NSREC SHORT COURSE COMPENDIUM CD/STICK.

WWW.NSREC.COM

COURSE DESCRIPTION

A short course, *"Multi-Scale, Multi-Physics of Radiation Effects"*, will be presented at the 2022 IEEE Nuclear and Space Radiation Effects Conference. A comprehensive understanding of radiation effects on modern microelectronics requires combining experimental and theoretical tools in order to assess the physical processes occurring at various scales. First, the relevant radiation environment should be determined and radiation transport through any materials surrounding the circuit or device of interest should be modeled. Then, the deposited energy can be evaluated as well as its conversion into charges or defects. The transport and recombination of these charges in the semi-conductor and insulator regions, their trapping in insulators or at the interfaces are at the basis of the description of electrical impact of radiation-induced defects and of the cumulative or transient effects at device, circuit or system levels.

The short course is organized into four sections, all featuring introductory material and advanced topics, with an emphasis on the physics involved in the radiation effects on microelectronics. The first section addresses the natural and man-made radiation environments, with emphasis on the simulation toolkits for the radiation-matter interactions. The second part focuses on the basics of radiation effects on microelectronic components and systems, discussing the single-event and total ionizing dose effects and focusing on their experimental characterizations. The third section illustrates the multi-scale approaches and associated simulation tools that can be used to model the cumulative dose effects at the various scales, from the device to the circuits. The final course deals with the existing multiscale simulation tools for Single Event Effects. The topics covered should benefit people new to the field as well as experienced engineers and scientists, by providing up-to-date material and insights.

The short course is intended for radiation effects engineers, component specialists, system designers, and other technical and management personnel involved in developing reliable systems designed to operate in radiation environments. It provides a unique opportunity for IEEE NSREC attendees to benefit from the expertise of excellent instructors, along with a critical review of state-of-the-art knowledge in the field. Electronic copies of detailed course notes will be provided to each participant.

Continuing Education Units (CEUs) will be available. For the interested attendees, an exam will be given at the end of the short course. The course is valued at 0.6 CEUs and is endorsed by the IEEE and by the International Association for Continuing Education and Training (IACET).

PART I – FROM RADIATION ENVIRONMENTS TO RADIATION-MATTER INTERACTIONS

Dr. Giovanni Santin, ESA/ESTEC and RHEA System, will address the natural and man-made radiation environments, with emphasis on simulation toolkits for radiation-matter interaction. An overview will be provided of the features of the diverse radiation fields to which electronics and humans are exposed in space and terrestrial environments. Modelling techniques will be introduced for transporting the external radiation through the structures up to the sensitive components (e.g., sensors or microelectronic circuits) and for the interactions therein, for rapid engineering assessment, as well as for detailed analyses, as a starting point for radiation effect calculation. The relevant physical interaction processes and related concepts and terminology will be introduced, with particular attention to the multi-physics aspect of the interactions and the multi-scale modelling in space and at ground accelerator and laser test facilities for modern technologies.

MONDAY
JULY 18, 2022
PROVO, UTAH
USA

SPONSORED BY

IEEE/NPSS Radiation Effects Committee

SUPPORTED BY

Aerospace Corporation
Analog Devices
Boeing
CAES
EMPC
EPC Space
IR HiRel, an Infineon Technologies Company
Jet Propulsion Laboratory
L3Harris
Radiation Test Solutions
Renesas
SkyWater Technologies
Southwest Research Institute

PART II – EXPERIMENTAL CHARACTERIZATION OF RADIATION EFFECTS PARAMETERS FOR DEVICE AND CIRCUIT LEVEL MODELING

Modeling radiation effects is a complex and challenging task faced by the community, since it requires not only the understanding of basic mechanisms of radiation effects, but also of their multi-physics nature. Therefore, modeling can only be addressed using multi-scale tools. At device level, it requires the knowledge of basic mechanisms induced by radiation interaction with the different layers constituting a modern device. At circuit level, the complexity grows even further, since circuit response to radiation will depend on device architecture, circuit layout and operating condition. Dr. Philippe Paillet, from CEA, will introduce the main key parameters that can be extracted from the experimental characterization of radiation effects in devices and circuits. Some of these parameters are needed as input for design of radiation-aware device and circuit models, others are required to check the validity of the simulations obtained using these models. This course will begin with the description of the main basic mechanisms of radiation effects, both cumulative (such as Total Ionizing Dose or Displacement Damage) and transient (such as Single Event Upset or Single Event Transient)). It will then explain the way to experimentally determine the relevant parameters to be taken into account for a meaningful modeling of these different effects at each level.

PART III – MODELING CUMULATIVE RADIATION EFFECTS: DEVICES TO INTEGRATED CIRCUITS

Designing integrated circuits requires accurate models to capture the physics of a circuit's fundamental devices. Transistors are the workhorse circuit elements and by far the most complex. Successful modeling of transistor operation has been one of the great achievements in physics and engineering in the past 100 years. New models are constantly being updated for new transistor technologies, as well as for addressing new challenges for older ones. Models are particularly important when we considered the unique challenges posed by cumulative radiation damage on devices. Accurate modeling at the device-level is critical to helping us understand the basic mechanisms of damage to transistors and helps us model radiation effects in circuits, through compact models that are radiation-aware. In this course, Professors Hugh Barnaby and Ivan Sanchez Esqueda, from Arizona State University, will review device physics and modeling of the two most prominent transistor families: Complimentary MOS (CMOS) field-effect transistors (FETs) and Bipolar Junction Transistor (BJT). Once the mechanisms of ionization and displacement damage in these transistors have been presented discussed, the instructors will describe, in detail, the various methods that are used to model these cumulative effects, from devices to integrated circuits.

PART IV – MULTI-SCALE, MULTI-PHYSICS MODELING AND SIMULATION OF SINGLE EVENT EFFECTS AT DEVICE AND CIRCUIT LEVELS

Prof. Jean-Luc Autran and Prof. Daniela Munteanu, Aix-Marseille University & CNRS, will provide a state-of-the-art overview of modeling and simulation of single event effects (SEE) at device and circuit levels. The presentation will primarily focus on the specific multi-scale, multi-physics, multi-domains nature of SEEs and on the main underlying physical mechanisms that leads to the occurrence of soft errors in digital circuits. In a first part, a meticulous review will address the different ways to model and simulate both in space and time this complex sequence of mechanisms from the particle-material interaction up to the electrical response of a given circuit. In a second part, the presentation will explore some specificities of modern technologies subjected to SEEs in terms of material diversity, device architectures, circuit layout complication, packaging and circuit local environment. The susceptibility of electronics in different environments (natural, artificial) or subjected to a combination of electrical and radiative degradations will be finally presented through the prism of modeling and simulation. This presentation will conclude by an overview of works and challenges ahead to anticipate the SEE susceptibility of future nanodevices and related circuits.