New Technologies Meet Radiation Effects

Announcement for the 2020 IEEE NSREC Short Course

MONDAY
JULY 20, 2020
SANTA FE,
NEW MEXICO

On behalf of the 2020 IEEE Nuclear and Space Radiation Effects Conference (NSREC) Committee, I cordially invite you to attend the forty-first IEEE NSREC Short Course. A group of outstanding technical experts will provide an in-depth discussion of technology evolution and future trends, several new technologies important for space-borne systems, the response of these technologies to the space radiation environment, and new qualification methods for commercial space.

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Short Course Chairman

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COURSE DESCRIPTION

A one-day short course, *"New Technologies Meet Radiation Effects"*, will be presented at the 2020 IEEE Nuclear and Space Radiation Effects Conference. Advances in semiconductor technology with feature size scaling, new materials, and new device concepts enable new and improved capabilities for space-borne electronic systems. The responses of these new technologies to the space radiation environment need to be understood, and the qualification methods for their use must be carefully evaluated.

The short course is organized into four sections, all featuring introductory material and advanced topics. The first lecture will discuss the effects of scaling to smaller and smaller device and circuit geometries and how radiation response is affected. The second focuses on new memory technologies and their radiation survivability. The third lecture deals with wide-bandgap power devices and radiation reliability. The final section addresses use of commercial-of-the-shelf components (COTS) and radiation hardness assurance for commercial space systems. More detailed descriptions of each lecture are below. The topics covered should benefit those new to the field as well as experienced engineers and scientists by providing up-to-date material and insights.

The intended audience is 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 at registration.

For those interested in Continuing Education Units (CEUs), there will be an open-book exam at the end of the 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 - RADIATION EFFECTS IN A POST-MOORE WORLD

Dr. Dan Fleetwood, Vanderbilt University, will provide an overview of Moore's Law scaling and its powerful influences on radiation effects on microelectronics over the last ~55 years. The first part of the presentation will highlight significant milestones in the understanding and evolution of total-ionizing-dose effects, single-event effects, and displacement damage in the era of classical Dennard scaling. The second part of the presentation will illustrate the significant ways in which the end of Dennard scaling has influenced radiation effects due to the increasingly complex and diverse materials and devices that are incorporated in recent CMOS technology nodes. The presentation will conclude with a look forward to a future in which many types of devices are both increasingly vulnerable to radiation effects and difficult to test in a practical and cost-effective manner. The radiation responses of devices with alternative channels to silicon and transistors based on two-dimensional materials will also be discussed, with an emphasis on opportunities and challenges for ultimately scaled devices.

PART II - RADIATION EFFECTS IN EMERGING MEMORIES

Dr. Matthew Marinella, Sandia National Laboratories, will present an overview of device science, technology, and radiation effects in emerging nonvolatile memories. Although NAND Flash remains king of the >$50B nonvolatile memory market, emerging technologies including spin transfer torque magnetic memory (STT-MRAM), resistive memory (ReRAM), phase change memory (PCRAM), conductive bridge memory (CBRAM), and ferroelectric memory (FRAM) are all under development by major commercial foundries or are already in small volume production. The tutorial will review the relevant materials science, device physics, reliability, basic array circuitry, and commercial status for each these technologies. This will be followed by a discussion of the effects of radiation on each memory, including the physics of total ionizing dose and displacement damage on the device, and resulting effects on switching properties, retention, and endurance. Array-level single-event effects such as read and write upsets will be described, as well as combined effects that increase the bit error rate and retention failure probability of a system. Finally, the tutorial will provide an outlook on the role of emerging technologies in future radiation hard electronics.

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PART III – WIDE BANDGAP POWER – SiC, GaN – RADIATION RELIABILITY

Dr. Jean-Marie Lauenstein, NASA Goddard Space Flight Center, will discuss basic mechanisms of radiation effects in silicon carbide and gallium nitride wide-bandgap power technologies and the resulting effects on device reliability and survivability in a space environment. Both SiC and GaN power devices have undergone several generations of maturation since becoming commercially available. Although these technologies have penetrated into automotive, wireless, power supply, and other markets, their adoption into space applications is hindered in part by their susceptibilities to permanent degradation and catastrophic failure from heavy ions. Recently, substantial progress has been made in our understanding of the events underlying these heavy-ion effects. The modes and mechanisms of damage will be examined and contrasted with those occurring in silicon power devices. The impact of these differences on radiation test methodology and reliability will be discussed. This course will also cover total ionizing and non-ionizing dose tolerance and will conclude with a look toward future power technologies, giving a brief snapshot of the status of ultra-wide bandgap gallium oxide.

PART IV - RADIATION HARDNESS ASSURANCE IN THE "WILD WEST" OF COMMERCIAL SPACE

Dr. Robert Baumann, Radiosity Solutions LLC and Southern Methodist University (SMU), will begin with a brief historical examination of the early space-race zeitgeist of "failure is not an option" which prompted heavy use of aggressively-qualified, highly-customized, and hardened components. This approach has ultimately morphed into today's mantra of "good enough for the mission" adopted by much of the commercial space sector, which increasingly employs systems composed largely of up-screened commercial-of-the-shelf components (COTS). The presentation will take a detailed look at the physical mechanisms responsible for manufacturing variations in microelectronics and will provide specific examples of how these variations impact total ionizing dose and single-event effect performance. The presentation will conclude with a discussion of sampling, up-screening, system-design mitigation, and a look at the particular challenges posed by using COTS components in spacecraft electronics.

SANTA FE, NEW MEXICO (NORTHERN NEW MEXICO)

The Hilton Buffalo Thunder is located just outside downtown Santa Fe and provides access to many beautiful and historical Northern New Mexico attractions including the High Road Trip to Taos, Bandelier National Monument, Jemez Mountains, and many other world-renowned attractions. There is a rich and inspiring history in Northern New Mexico with influences from Hispanic, Anglo, and Native American cultures that are apparent in everything from the architecture to the food to the art. Santa Fe is known as a center for arts and culture and ranks as the country's third largest art market. You will find nearly 300 art galleries and the 3rd largest State Museum system in the country featuring culture, history, and traditions of the Southwest. Treat yourself to the colorful markets and experience why Santa Fe has been considered a hub for trading for hundreds of years. With a backdrop of the Sangre de Cristo Mountains, Santa Fe is also the home of the world-class Santa Fe Opera.

Santa Fe was nationally recognized by several organizations in 2018. This comprised of recognitions as one of the top 15 cities in the US by 2018 Travel+ Leisure World's Best Awards and was one of the top 30 US cities to visit in 2018 according to Trip Advisor. Santa Fe has also earned a stellar reputation with food-lovers ranging from local New Mexican flavors to authentic world cuisines in recent years. The Santa Fe Margarita Trail Tour was recently recognized as one of the 10 Best Food and Drink Trails to Explore according to Pop Sugar.

Photo courtesy of Hotel Buffalo Thunder

For the outdoor enthusiast, Northern New Mexico provides hiking and biking year-around amongst beautiful backdrops and historical sites. The great outdoors and open sky also allow everyone to relax and enjoy activities such as golf, white-water river rafting, horseback riding, and fly-fishing. Remember, we are going to be at an elevation of 7,000 feet and likely in sunny weather.

Please join us at the Hilton Santa Fe Buffalo Thunder for NSREC 2020 and enjoy everything Northern New Mexico has to offer.