Outstanding Conference Paper Award: 2025 IEEE Nuclear and Space Radiation Effects Conference

THE recipients of the 2025 NSREC Outstanding Conference Paper Award are Vincent Goiffon, Clémentine Durnez, Antoine Jay, Ali Jouni, Vera Kharchenkova, Aubin Antonsanti, Valérian Lalucaa, Damien Lambert, Thomas Jarrin, Antoine Salih Alj, Richard Monflier, Nicolas Richard, Philippe Paillet, Anne Hémeryck, Daniel McGrath, and Cédric Virmontois for their paper entitled "Gamma-Ray Induced Displacement Damage in Silicon Microvolumes: Single Defect Generation Rate and Random Telegraph Signal."

For decades, identifying and characterizing individual semiconductor defects has been a fundamental challenge in radiation effects research. Traditional spectroscopic techniques, such as Deep-Level Transient Spectroscopy (DLTS) or Electron Paramagnetic Resonance (EPR), require high defect densities to produce measurable signals, effectively masking the behavior of isolated single-point defects. This study overcomes these long-standing limitations by leveraging the extreme sensitivity of modern CMOS Image Sensor (CIS) technology. With dark current levels now reaching below 1 e^-/s/pixel at room temperature, the millions of microvolumes within a pixel array can be utilized as a massive parallel detector capable of isolating, counting, and tracking individual electrically active defects directly within a fully functional device. Importantly, the same pixel array technology used here as a spectroscopic tool is also the structure that experiences radiation-induced dark current degradation, enabling a direct link between defect physics and device response.

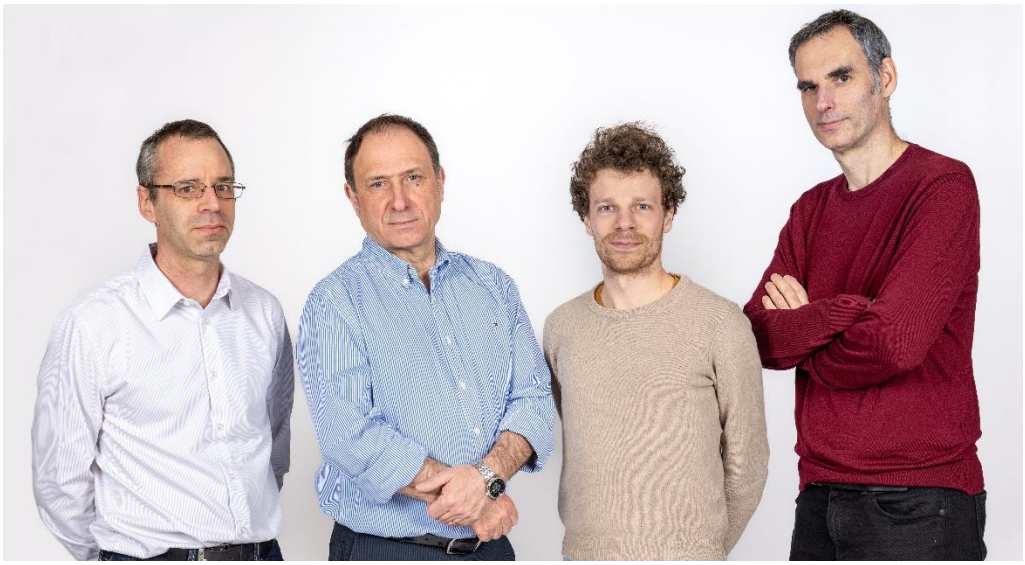
The research demonstrates that single displacement damage defects induced by ^{60}Co gamma-rays (through secondary electron generation) can be detected and precisely characterized in silicon. Through Dark Current Spectroscopy (DCS) and a multiscale modeling approach, the authors identified specific species, including the E-center (As–V or P–V) and the divacancy (V2), and extracted their individual generation-rate signatures, activation energies, and annealing temperatures.

A major finding is the clear experimental evidence that ^{60}Co gamma-rays generate bulk Dark Current Random Telegraph Signals (DC-RTS) in absence of avalanche multiplication and electric field enhancement. The study reveals two distinct RTS centers with characteristic signatures, consistently observed across numerous microvolumes, establishing a strong spatial and thermal correlation with the divacancy. These results show that simple bulk point defects—not only extended defect clusters—can be responsible for complex multi-level telegraphic noise in semiconductor devices.

The implications of this research extend to both semiconductor physics and Radiation-Hardness Assurance (RHA). By quantitatively bridging microscopic atomic-level traps and macroscopic device degradation, such as dark current increase, the study provides a physically grounded framework for predicting radiation response. Furthermore, it highlights an important evolution in radiation effects: in modern, TID-tolerant CIS technologies, Displacement Damage (DD) can become the



From left to right: Vincent Goiffon, Anne Hémeryck, Aubin Antonsanti, Richard Monflier, Antoine Salih Alj, Clémentine Durnez, Valérian Lalucaa, Cédric Virmontois, and Antoine Jay.



From left to right: Damien Lambert, Philippe Paillet, Thomas Jarrin, and Nicolas Richard.

dominant degradation mechanism under ^{60}Co gamma irradiation, at least up to 100 krad(Si). This shift should be carefully considered when using ^{60}Co sources for Total Ionizing Dose (TID) qualification of CIS technologies, as the observed device response may no longer be governed primarily by TID effects.

Ultimately, this work provides a robust experimental framework by delivering precise and reproducible single-defect signatures, including their temporal dynamics, that can be directly compared with ab-initio atomic-scale simulations. By establishing a quantitative link between measured electrical behaviors, observed temporal evolution and theoretical models, this research supports more physics-based modeling of radiation effects and enhances understanding of defect formation and dynamics in semiconductor materials. Such knowledge aids the prediction of device degradation under irradiation and informs strategies for defect identification and reduction during semiconductor fabrication. The results should contribute to the development of more reliable and resilient silicon technologies, including those intended for space applications.

Vincent Goiffon (S'08-M'09-SM'20) received his Diplôme d'Ingénieur in Aerospace Engineering (Master's degree) from ISAE-SUPAERO and a Research Master in Microelectronics from the Université de Toulouse, both in 2005, and his PhD in Electrical Engineering from ISAE-SUPAERO and Université de Toulouse, France, in 2008. He then joined the ISAE-SUPAERO Image Sensor Research Group as an Associate Professor that same year and has been a Full Professor since 2018, leading the Integrated Image Sensor Research Unit since 2021. His research focuses on CMOS image sensors, radiation effects, and the physics of dark current (DC) and random telegraph signal (RTS) phenomena in semiconductor devices. He has identified novel degradation mechanisms in pinned photodiode pixels and clarified the role of interface and bulk defects in DC-RTS. Vincent has coordinated several research and development projects, including CAMRAD and FURHI for ITER, and contributed to imaging systems for space and nuclear applications with ESA, CEA, Orano, and Airbus Defence and Space. His experimental achievements include world-first demonstrations of CMOS image sensor operation under extreme total ionizing doses (up to 1 Grad(Si)) and in high-radiation fusion environments. He has authored or coauthored over 140 publications and one book chapter, advised more than 25 PhD students recognized with international prizes, and received awards at IEEE NSREC, RADECS, and IISW. Since 2017, he has served as Associate Editor of the IEEE Transactions on Nuclear Science and actively contributed as reviewer, session chair, short course chair, and founding advisor of several ISAE-SUPAERO IEEE student chapters (including NPSS).

Clémentine Durnez received an engineering degree from ENSEEIHT (Toulouse, France) in 2014, followed by a PhD degree in Micro and Nano Systems from ISAE-SUPAERO (Toulouse, France) in 2017. During her PhD, she studied Random Telegraph Signal effects in several technologies of Image Sensors (visible and infrared devices). From 2017 to 2021, she worked as a radiation engineer with Airbus Toulouse, where she was in charge of radiation hardness assurance application for several projects. Since 2021, she joined the French Space Agency - CNES (Centre National d'Etudes Spatiales) - as an infrared detection engineer. She is currently working on several space projects and is involved in research projects aiming at investigating future technologies for space applications.

Antoine Jay received his PhD from École Polytechnique, where his research focused on computational approaches for the study of materials using first-principles methods. He is currently a researcher at the Centre National de la Recherche Scientifique (CNRS), working in solid-state physics and multiscale modeling of electronic device response under irradiation. His research addresses radiation-induced degradation mechanisms, from atomic-scale structural modifications to the impact of radiation-generated defects on charge carrier generation and recombination. In this context, he developed a computational framework for exploring metastable atomic configurations and associated transition states with *ab initio* accuracy. His work has contributed to the physical understanding of DC-RTS and defect-related fluctuations in CMOS devices.



Ali Jouni received his optical engineering degree from the Institut d'Optique, Palaiseau, France, in 2020 and his PhD from ISAE-SUPAERO, Toulouse, France, in 2024. His PhD research focused on space radiation effects on CMOS single photon avalanche diode (SPAD) arrays, by studying dark count rate degradation induced by ionizing and non-ionizing particles. He conducted radiation tests to compare experimental data with modeling approaches aiming to simulate the effect of high electric fields within p-n junctions. Additionally, he delved into understanding origins of RTS in SPADs and the nature of displacement damage defects. Since then, he has joined Sodern as an optoelectronics and radiation engineer. He focuses on characterizing state-of-the-art CMOS image sensors for star tracker applications. He received Outstanding Conference Paper and Outstanding Student Paper awards as first author for work presented at NSREC 2023.



Vera Kharchenkova (S'26) is currently pursuing an engineering degree at ISAE-SUPAERO, Toulouse, France. She completed an internship with the Image Sensor Research group, where she investigated the behavior of RTS pixels on irradiated CMOS Image Sensors.

Aubin Antonsanti received MS degrees in Electrical Engineering from INSA Lyon and in Nuclear Engineering from INSTN–CEA in 2020, and the PhD degree from ISAE-SUPAERO in 2025. His doctoral research, conducted in collaboration with CNES and NASA, focused on space radiation effects in advanced CMOS image sensors. From 2022 to 2023, he was a Research Assistant with the Radiation Effects and Analysis Group, NASA Goddard Space Flight Center, where he contributed to radiation hardness assurance for infrared detectors of the Roman Space Telescope and performed proton and gamma irradiation testing campaigns on CMOS image sensors. Since 2025, he has been an Opto-Electrical Engineer with CNES, where he is involved in the development and qualification of space imaging systems. His research interests include CMOS image sensors and radiation effects in semiconductor devices.

Valérian Lalucaa received the MS degrees in Electronic and Applied Physics from the ENSICAEN in 2010 and the PhD degree in Micro and Nano Systems from ISAE-SUPAERO, Toulouse, France, in 2013. From 2013 to 2016, he was a post-doctoral researcher at ISAE-SUPAERO, working on SPAD arrays for 3D integration processes. From 2016 to 2018, he was a post-doctoral researcher at Imec, Belgium, focusing on image sensor characterization methods and thick SPAD pixels for enhanced IR sensitivity. Since 2018, he has been an optoelectronic detection engineer for the CNES. His research interests include image sensor design and characterization methods, as well as hardening for space and other radiative environments.

Damien Lambert (S'05, M'11, SM'18) received the Engineering degree from the École Supérieure d'Electronique de l'Ouest (E.S.E.O.), Angers, France, in 2002, the master's degree in devices and microtechnologies from Rennes 2 University, Rennes, France, in 2002, and the PhD degree from the Commissariat à l'Energie Atomique (CEA) in collaboration with EADS and Montpellier II University in 2006. His main field of investigation was the sensitivity of integrated technologies to proton and neutron irradiation. After his PhD graduation in 2006, he joined EADS Nuclétudes, Les Ulis, France, where he focused on electronic system reliability. Since 2019, he works at CEA as a Research Engineer. His main topics are the evaluation and simulations of radiation effects in electronics, photonics, and systems. He has authored or coauthored more than 50 publications and presentations mainly at RADECS and NSREC (including the 2005 and 2006 NSREC Outstanding Conference Papers). He has served the community as a reviewer since 2006 and session chair (RADECS 2021 and NSREC 2025). Damien is a member of the Geant4 international collaboration.

Thomas Jarrin received his engineering degree from Ecole Nationale Supérieure des Mines de Nancy in 2018. At the end of the same year he started his PhD, dedicated to the simulation of displacement damage effects in semiconducting materials, which he received from Université Toulouse 3 Paul Sabatier in 2021. After a one-year post-doctoral research appointment at IFP Energies Nouvelles in Solaize, France, he started working in 2023 within a CEA Île-de-France (Bruyères-le-Châtel) antenna of the CEA-CESTA center. His research focuses on the simulation of radiation effects in materials employed for microelectronic applications, mainly at an atomic scale.

Antoine Salih Alj (Member, IEEE) earned the MS degree in Applied Physics Engineering from Institut National des Sciences Appliquées (INSA) in 2021 and the PhD in Microelectronics from ISAE-SUPAERO in 2024, each in Toulouse, France. In 2025, he served as a consultant for CNES, focusing on space detectors. That same year, he received the IEEE NPSS Paul Phelps Award and joined the Image Sensor Research Team at ISAE-SUPAERO as an Associate Professor. His research interests center on the design and testing of image sensors for advanced applications, as well as the investigation of radiation effects mechanisms.

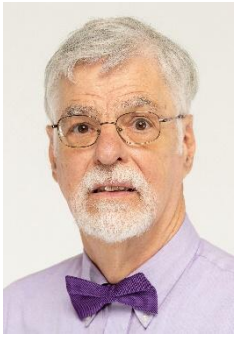
Richard Monflier was born in Toulouse, France, in 1991. He received his PhD degree in Micro and Nano Systems from the University of Toulouse in 2019. During his PhD, he studied the defects generated by laser annealing on silicon in the MPN (Materials and Processes for Nanoelectronics) team at LAAS-CNRS. Currently, he is a Research Engineer in the I2C (Instrumentation, Design, and Characterization) team at the same laboratory. His work focuses on developing instrumentation and methodologies for optical and electrical characterization to improve the robustness of semiconductor materials, especially diamond, GaN, and silicon.

Nicolas Richard received his PhD from the University of Marne-la-Vallée in 2001 and the Habilitation à Diriger des Recherches from the Université Paul Sabatier of Toulouse in 2014. He is currently research director at CEA-Cesta, Le Barp,

France. His field of expertise is atomic scale simulation of materials and the studies of the impact of the point defects on materials properties, mainly related to microelectronic and optoelectronic technologies under radiation. He has participated in numerous studies on the simulation of the generation of defects during manufacturing processes and under irradiation in microelectronic, as well as the characterization of defects in oxides and semiconductors and at oxide/oxide and oxide/semiconductor interfaces. He has authored or coauthored more than 115 publications and has been supervisor or co-supervisor of approximately ten PhD and post-doctoral students.

Philippe Paillet (M'97–SM'04–F'18) received his Master's Degree in Electrical Engineering from the Université Aix-Marseille I, France, in 1989 and his PhD degree in Electrical Engineering from the Université Montpellier II, France, in 1995. He joined the Commissariat à l'Energie Atomique (CEA) in Arpajon, France, in 1995 and is a senior member of the technical staff, project manager and International Expert of CEA. Philippe has been involved in numerous programs developing radiation-hardened electronic and optoelectronic technologies, characterizing the physical mechanisms responsible for radiation response of components and ICs, modeling the effects of radiation in MOS technologies and the creation of radiation-induced defects, and developing hardness assurance approaches. Philippe has served the radiation effects community as reviewer and Session Chairman for the IEEE Nuclear and Space Radiation Effects Conference (NSREC) and the Radiation Effects in Components and Systems (RADECS) European conference. He serves as Associate Editor for the *IEEE Transactions on Nuclear Science*. He has authored or co-authored more than 260 publications, articles, short courses, and book chapters, including two Best Papers at RADECS, two Meritorious Papers at NSREC, one Best Paper at HEART, and six Outstanding Papers at NSREC. He is currently serving as Vice-president of the RADECS Association (the Steering Group of RADECS Conferences) and RADECS Liaison to the IEEE Radiation Effects Steering Group. Philippe is a Fellow of IEEE and a Member of the NPSS and the Electron Devices Society of IEEE.

Anne Hemeryck received her PhD degree in Materials Science from the University of Toulouse in collaboration with CEA-DAM, Arpajon, France, in 2008, and the Habilitation à Diriger des Recherches in 2018. She carried out a postdoctoral fellowship at the University of Southern California, Los Angeles, USA, from 2009 to 2011, followed by a research position at Chimie ParisTech. She joined the CNRS in 2011 and is currently a Research Director at the Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS-CNRS), Toulouse, France, where she is also Head of the MNBT (Micro Nano Bio Technologies) Department. Her research focuses on atomic-scale modeling and multiscale simulations of materials for microelectronics, with particular emphasis on defect physics, reliability issues, radiation effects, and quantum technologies. Her work links atomistic simulations with experimental characterizations to predict material behavior and improve device robustness and performances. She has authored or co-authored more than 80 peer-reviewed scientific publications in international journals. She has been involved in numerous national and European research projects, including major collaborative programs such as ANR projects, European H2020 projects, and industrial partnerships with leading microelectronics companies working on SPADs and advanced technological processes.



Daniel McGrath received a B.S in physics from Virginia Tech and a PhD in physics from The Johns Hopkins University. He has pursued his work at Texas Instruments, Polaroid, Imaging Devices, Atmel, Eastman Kodak, Aptina, BAE Systems, and GOODiX Technology and is presently a Sr. Technology Fellow at TechInsights. He has also been an Associate Researcher at ISAE-SUPAERO since 2023. He has worked closely with manufacturing facilities in the USA, France, Italy, and Taiwan. He has worked for more than 45 years specializing in the device physics of pixels and in the integration of image-sensor process enhancements in the manufacturing flow. His career has spanned image sensor design and applications. These include small pixels for consumer applications, large pixels for high sensitivity, and pixels for photons from infrared through visible to gamma rays and particle detection. Recent work has taken him into the realm of photon counting for night vision, scientific, and time-of-flight applications. He has had an abiding interest on dark current throughout his career. Daniel continues to play an active role in the IEEE Sensors Council and IEEE Solid-State Circuits Society.

Cédric Virmontois (S'10–M'12–SM'19) received the Engineering degree in Physics from the Institut National des Sciences Appliquées (INSA), Toulouse, France, in 2008, and the PhD degree in Microelectronics from ISAE-SUPAERO, Toulouse, France, in 2012. His doctoral research focused on displacement damage–induced degradation mechanisms in CMOS image sensors. He developed models to characterize the degradation of key sensor performance parameters, particularly dark current and its associated random telegraph signal, and derived hardening-by-design techniques to mitigate space radiation effects in CMOS imagers. He is currently director of research with the Centre National d'Études Spatiales (CNES), Toulouse, France, within the Technology and Digital Directorate. From 2012 to 2018, he served as a Detection Chain Specialist, where he contributed to the development of imaging systems for future space missions, including electro-optical characterization, analysis, and testing of image sensors. His research activities have since expanded to various solid-state imaging technologies dedicated to visible and infrared applications, leveraging both ground-based and in-flight data to establish generic methodologies for predicting and mitigating space radiation effects. Since 2019, he has been recognized as a CNES Expert in solid-state image sensors and radiation effects. Since 2021, he has served as Head of the Optoelectronic Detection Department.