RADHARD SYMPOSIUM

Book of Abstracts

May 7th - 8th, 2024

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Energy, Mobility,
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AUSTROSPACE

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Chairman‘s Invitation

On behalf of the organizing team, it is my great pleasure to welcome you to the 9th edition of the annual RADHARD Symposium, hosted at Seibersdorf Laboratories near Vienna, Austria.

The RADHARD Symposium serves as a vital platform complementary to the RADECS conference, fostering the exchange of practical insights within the field of radiation hardness assurance (RHA). This event holds significance for both industrial applications and academic research, aiming to facilitate dialogue, idea exchange, and the inception of collaborative ventures.

The focus of this year’s RADHARD Symposium encompasses the following key areas:

- Laser Testing: Exploring principles and applications of laser testing for RHA testing, featuring keynote presentations by Stephen Buchner and Dale McMorrow from NRL and practical examples from Airbus Defence & Space
- Material Testing: Delve into industry standards and real-world examples in material testing with a keynote by Ricardo Martins from ESA and dedicated talks from the industry
- SmallSats & COTS Components
- Practical Aspects of Radiation Hardness Assurance Testing
- Innovative Testing Developments and Future Needs
- RADHARD Lecture Series
- Laboratory Visits of our TID and SEE Testing Facilities

We are honored to present three esteemed keynote speakers for this year’s Symposium. On the first day, Ricardo Martins from ESA will provide insights into the complexities of material testing. On the second day, Stephen Buchner and Dale McMorrow from NRL will share their expertise on laser testing principles and applications.

Our program offers a diverse range of talks and sessions, including presentations from renowned organizations such as ESA, NRL, Airbus D&S, CERN, PSI, and the Austrian Space Forum, among others. Furthermore, attendees will have the chance to attend training lectures on the space radiation environment and its effects on electronics, presented by Seibersdorf Laboratories. They will also have the opportunity to take guided laboratory tours of our ISO IEC 17025 accredited TEC-Laboratory for TID testing and our novel state-of-the-art SEE laser testing facility.

The RADHARD Symposium attracts a diverse range of attendees, including space system integrators, EEE manufacturers, industry stakeholders, researchers, and students. The event offers a forum for leading international experts to share their research insights and engage in thought-provoking discussions.

The 9th RADHARD Symposium is proudly organized by Seibersdorf Laboratories and enjoys the support of esteemed partners such as the Austrian Research Promotion Agency (FFG), the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, AUSTROSPACE, ecoplus The Business Agency of Lower Austria, and in cooperation with the Graz University of Technology, the University of Applied Sciences Wiener Neustadt, and the RADECS Association.

The 9th RADHARD Symposium is held on May 7th - 8th, 2024, at Seibersdorf Laboratories. For the convenience of our participants, the event will be streamed live and accessible to all registered attendees, whether onsite or online. Additionally, the recordings will be available for rewatching for up to one month after the event, ensuring that participants can revisit any sessions they wish to review.

We wish you interesting days at the 9th RADHARD Symposium at Seibersdorf Laboratories!

Christoph Tscherne

On behalf of the organizing team of the RADHARD Symposium

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Program status at the editorial deadline.

1st Day:
Tuesday, May 7th, 2024

Session:
Material Testing

Keynote

Materials in challenging space environment

Ricardo Martins[1], Nuno Dias[1], Adrian Tighe[1], Riccardo Rampini[1]

[1] ESA/ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands

Abstract

Space environment is highly challenging for the exposed materials used to manufacture spacecraft. Depending on the considered space mission, there are high vacuum levels, extreme thermal cycling, proton/electron/electromagnetic radiation or erosive atomic oxygen fluxes to be withstood [1]. Materials' Physics and Chemistry Section at the European Space Research and Technology Centre (ESTEC) is dealing with material degradation under these conditions, including possible failures and impact of mission objectives.

An introduction into these challenges will be provided, along with an overview of typical materials exposed to space environment. Real-life examples of materials' degradation in space environment will be described, along with its consequences on functional properties or, for instance, contamination risk for sensitive surfaces. Finally, approaches to assess the material degradation risk and to qualify exposed materials will be summarized. Standard techniques, as well as unique equipment available at ESTEC for simulation of space environment and testing of materials, will be presented. Best practices and applicable standards will be introduced.

References

[1] Holynska, Malgorzata, Tighe, Adrian, and Semprimoschnig, Christopher. „Coatings and Thin Films for Spacecraft Thermo-Optical and Related Functional Applications", Advanced Materials Interfaces, Volume 5, Issue 11, June 8, 2018, 1701644.

[2] ECSS-E-ST-10-04C. "Space Environment", June 2020.

Acknowledgments

Funding by European Space Agency (ESA) is acknowledged. The views expressed herein can in no way be taken to reflect the official opinion of ESA and are not intended to endorse particular technologies, companies, or products.

Influence of radiation on Self-Lubricating Polymer (used as cages for bearings)

Andreas Merstallinger[1], Zoltan Simon[1], Manuel Hochrainer[2], Christoph Tscherne[3], Cristina Paul[4]

[1] AAC GmbH , [2] Ensinger Sintimid GmbH, [3] Seibersdorf Labor GmbH, [4] ESA/ESTEC

Abstract

Mechanisms belong to critical components in space. This applies to the Large Deployable Reflectors (LDR) itself as well as to deployable arms (ABDM) needed to place the reflector in appropriate distance to the spacecraft. Also pointing mechanisms for solar arrays (SADM) or antennas (APMs) require a reasonable variety of bearings, even down to diameters of few millimetres. The most common way of their lubrication is by fluids. However, that limits their temperature range as the fluid would evaporate at too high temperatures of freeze when being too cold. It would ease the thermal management and decrease the related costs by reduction of mass, wiring, if fluid lubrication could be replaced by solid lubrication. Hereby, bearings may be operated in much wider temperature ranges from almost +160°C down to even cryogenic temperatures without contamination by outgassing.

Therefore, a new material based on PTFE was developed. The primary task was to develop a formulation that offers proper lubrication combined with sufficient tribological lifetime. However, tribological performance and mechanical stability of polymers depend strongly on the radiation environment. In typical mechanisms, the lubricating item (a cage) is not exposed to space, it is hidden by the housing and by bearing components made of steel. Hence, ATOX and several radiation types (UV, alpha, beta) can be ignored. Only X-ray affects those parts. Especially when using PTFE this may become a critical issue [1]: in a range of 1-10 MRad such material can already degraded, e.g. they may become brittle. Within the A3Lub2-project an application for LEO requires a stability after a dose of 1MRad being representative for a life of 15years.

The presentation will give an overview on the verification approach, i.e. material tests were done before and after exposure to radiation. Some results of those tests will be presented. Finally, their implication on the performance of the bearings will be discussed.

References

[1] Radiation effects design handbook.pdf (NASA, 1971).

Acknowledgments

The presented work was part of the ESA-project “A3Lub2”, contract No. 4000134713/21/NL/MG/idb, finalisation 2024.

Session:
RADHARD Lecture

A Journey Through the Cosmic Hazards: Understanding the Space Radiation Environment

Christoph Tscherne[1]

[1] Seibersdorf Labor GmbH, Austria

Abstract

Spacecraft in Earth orbit face a major threat: the complex and harsh radiation environment they encounter. This environment, characterized by its complexity and severity, presents significant challenges to mission planning and spacecraft durability. Radiation exposure accelerates the degradation of electrical, electronic, and electromechanical (EEE) components, resulting in degraded performance or failure [1].

To effectively address these challenges, a thorough understanding of space radiation is essential. In Earth orbits such as low Earth orbits (LEO), medium Earth orbits (MEO), and geostationary Earth orbits (GEO), the radiation environment includes solar energetic particles (SEP), galactic cosmic radiation (GCR), and charged particles trapped in the Earth‘s magnetic field. These types of radiation exhibit remarkable variations in energy and flux, subject to short-term fluctuations and long-term modulation influenced by solar activity [2].

This talk covers the unique characteristics of the various contributions to the space radiation environment. It provides a comprehensive review of SEP, GCR, and trapped particles, emphasizing their importance for mission planning and radiation hardness assurance (RHA) of spacecraft components [3, 4, 5]. By analyzing the characteristics of space radiation and its effects, this presentation aims to provide space mission designers with the knowledge needed to navigate and mitigate the challenges posed by the cosmic radiation environment.

References

[1] Poivey, Christian. „Total Ionizing and Non-Ionizing Dose Radiation Hardness Assurance.“ Short Course of NSREC 2017, 17 July 2017, New Orleans. USA. Presentation.

[2] Holmes-Siedle, Andrew G., and Len Adams. Handbook of radiation effects. 2nd ed., Oxford University Press, 2002.

[3] ECSS-Q-ST-60-15C. “Radiation hardness assurance – EEE components”, October 2012

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[5] SPENVIS - The European Space Agency (ESA) Space Environment Information System (SPENVIS), available online at http://swe.ssa.esa.int/; https://www.spenvis.oma.be/

Acknowledgments

We acknowledge the insightful talks and presentations of the lecturers of the RADECS and NSREC short courses and the information provided by SPENVIS, ESA‘s Space Environment Information System (http://swe.ssa.esa.int/; https://www.spenvis.oma.be/). https://www.spenvis.oma.be/).

Session:
Practical Aspects of Radiation Hardness Assurance Testing

RADNEXT – Building a Network of Irradiation Facilities: Achievements and Future Perspectives

Gerd Datzmann[1], Ennio Capria[2], Rubén García Alía[3]

[1] Datzmann interact & innovate GmbH, Germany
[2] ESRF, France
[3] CERN, Switzerland

Abstract

Radiation hardness qualification procedures for electronic components and systems often require testing at facilities – providing highly energetic protons, heavy ions, neutrons, electrons, gammas and to some extent pulsed X-rays, lasers, etc. – emulating the radiation effects of the devices under test close to reality. These probing radiations are generated mostly at particle accelerators or research reactors located almost exclusively at universities or publicly funded research institutions. Thus, users from industry as well as users from space agencies or academia are dependent on these organizations for providing them a fee-based service.

Interviews with experts in the field show a growing demand for testing versus a quasi-static offering from the facilities, with this being particularly true for testing with high energetic heavy ions. The matching of demand and supply is perceived as one of the biggest challenges in this field today and in the upcoming years. Radiation hardness assurance with respect to Single Event Effects (SEE) testing of electronic devices in Europe is performed in a limited number of facilities that offer professional beam-time service on a regular basis to external commercial customers. In the recent years, more and more companies are entering the field of radiation hardness assurance of electronic components. In addition, the pressure to minimize costs not only for commercially driven projects, is adding new requirements and constraints. One measure for lowering costs could be to use facilities in the own country avoiding long travels and customs issues. On the other side, established facilities provide a full-service approach and try to enable an efficient component testing workflow with little waiting times for their customers.

These challenges were the main reason why the European Union (EU) funded a network of 21 irradiation facilities in an infrastructure program called RADNEXT [1] (RADiation facility Network for the EXploration of effects for indusTry and research). This 4-year project was launched in June 2021 and aims – besides others – to tackle the aforementioned topics with a set of measures and initiatives. In general, RADNEXT has the goal to ease the access for external users and to harmonize the procedures. Via Transnational Access (TA) funding from the EU, more than 6000 hours of beam time are awarded free of charge to users from academia and industry.

This presentation will summarize the achievements of the TA program after almost three years of the RADNEXT project. Furthermore, the participation and engagement of industrial actors in the program will be highlighted. Since RADNEXT is an infrastructure program, some activities have been dedicated to observing the facility landscape and to develop a roadmap for the future of radiation testing. Therefore, planned upgraded of facilities currently delivering beams for radiation hardness assurance will be depicted as well as existing facilities that intend to start the business of providing beam time. Additionally, there is an ongoing discussion on building new facilities suitable for providing beam time to external users for radiation hardness testing. Since the RADNEXT project is scheduled to come to an end in June 2025, a few thoughts and ideas will be shared how this infrastructure network of facilities that has been established in the past years could be continued in a way that is beneficial for both facilities and users.

References

[1] R. G. Alía et al., „Heavy Ion Energy Deposition and SEE Intercomparison Within the RADNEXT Irradiation Facility Network,“ in IEEE Transactions on Nuclear Science, vol. 70, no. 8, pp. 1596-1605, Aug. 2023, doi: 10.1109/TNS.2023.3260309

Acknowledgments

RADNEXT has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement No 101008126

Overview of the 2023 R2E activities at CERN, with a focus on the SEE accelerator availability impact during the ion run

Daniel Söderström[1], Giuseppe Lerner[1] and Rubén García Alía[1] on behalf of the R2E team at CERN

[1] CERN, 1211 Geneva, Switzerland

Abstract

At the European Organization for Nuclear Research (CERN), protons and heavy ions are accelerated to very high energies before being collided in four locations at the Large Hadron Collider (LHC) or sent to a broad variety of fixed-target experiments within CERN's injectors. Operating the complex of particle accelerators utilized for this purpose requires control of a large number of electronic systems located in the harsh radiation environment created by the accelerated particles. Radiation hardness assurance (RHA) considerations of the equipment installed in the elevated radiation environments of the accelerator are key for a reliable operation of the machine, and thus for the physics output of the LHC experiments.

This contribution will further introduce the Radiation to Electronics (R2E) challenges and will cover some of the recent R2E activities related to the RHA of equipment at CERN, including investigations of the radiation-levels in the accelerator complex ([1], [2]), studies of energy deposition and induced single-event effects (SEE) in a range of radiation-testing facilities ([3]), mechanisms, testing, and RHA considerations of neutron-induced radiation effects ([4], [5]) and the coordination and main outcome of the HEARTS and RADNEXT EU projects coordinated by CERN. Included is also an overview of the accelerator performance during 2023 in terms of radiation-effects, focusing on the ion run which was performed during the final weeks of beam operation at CERN 2023.

References

[1] K. Biłko et al., IEEE Trans. Nucl. Sci., Vol. 70, No. 8, pp. 1606-1615, DOI: 10.1109/TNS.2023.3261181, 2023.

[2] A. Canesse et al., 14th International Particle Accelerator Conference, Venice, Italy, DOI: 10.18429/JACoW-IPAC2023-THPA046, 2023.

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[4] A. Coronetti et al., IEEE Trans. Nucl. Sci., Vol. 70, No. 8, pp. 1634-1642, DOI: 10.1109/TNS.2023.3239407, 2023.

[5] M. Cecchetto et al., IEEE Trans. Nucl. Sci., Vol. 70, No. 8, pp. 1587-1595, DOI: 10.1109/TNS.2023.3242460, 2023

Acknowledgments

We acknowledge the insightful talks and presentations of the lecturers of the RADECS and NSREC short courses and the information provided by SPENVIS, ESA's Space Environment Information System (http://swe.ssa.esa.int/; https://www.spenvis.oma.be/). https://www.spenvis.oma.be/).

Session: Innovative Testing Developments and Future Needs (Part 1)

RADNEXT – Building a Network of Irradiation Facilities: Achievements and Future Perspectives

Dr. Tigran Armand Rostomyan[1]

[1] Paul Scherrer Institute, Villigen, CH-5232, Switzerland

Abstract

The Proton Irradiation Facility (PIF) at Paul Scherrer Institute (PSI) provides a realistic space environment using protons with energies of up to 230 MeV from the COmpact MEdical Therapy (COMET) cyclotron. Numerous experiments utilize a broad range of energies and beam fields for testing and qualification of electronics and circuits as well as for calibration of particle detectors and radiation monitors. A Pixelated Ionization Chamber (PIC) for fast beam monitoring was designed and constructed for PIF. Its sensitive area covers the full beam aperture allowing for accurate, real-time settings of beam profiles for diameters of up to Ø = 10 cm. The detectors chamber entrance window is made of thin aluminized Mylar as a cathode. The anode plate consists of 157 golden pixels. Readout electronics converts ionization currents from all channels using programmable capacitive inputs capable to cover a very wide range of beam flux values. Further signal processing, digitalization and I/O functions are performed with a FPGA controller. The visualization software allows for fast and reliable adjustments of the beam profiles to any desired shape. First results from the commissioning of the PIC detector will be presented in the talk.

Acknowledgments

Many thanks to the RADHARD 2024 organizing committee for the opportunity to present this work.

Single Event Effect Testing using Medical Synchrotron

Martin Eizinger[1], Wolfgang Treberer-Treberspurg[2], Bernhard Seifert[1]

[1] FOTEC Forschungs- und Technologietransfer GmbH
[2] Fachhochschule Wiener Neustadt GmbH

Abstract

The feature size of commercial off-the-shelf electronic components has continuously decreased over decades, well below 80 nm [1]. This structure size – such as the gate length of a transistor – is directly related to the critical charge for a Single Event Upset (SEU) [2], meaning that the number of charge carriers required to cause an upset is lower in smaller devices. In the context of radiation induced Single Event Effects (SEEs), the critical charge is expressed in terms of the threshold Linear Energy Transfer (LET) [3]. For instance, an ionizing particle that locally causes an LET greater than the threshold LET excites enough electron-hole-pairs within the channel of a transistor to corrupt the logic state of the device (SEU).

In addition to the threshold LET, three other device-specific parameters define the SEU susceptibility of a device as a function of LET in the form of an integrated Weibull distribution [4]. Because the parameters vary between devices, they shall be obtained experimentally by exposing the sensitive region, or region of interest (ROI), to high energy particles. The highest fidelity can be achieved by heavy ion irradiation, but heavy ion accelerators are scarce, and heavy particles have a limited penetration depth into the target [5]. For this reason, heavy ion tests require preparation steps of the Device Under Test (DUT) such as decapping, and need to be performed in vacuum.

We present a simplified way to obtain an SEE characterization with less accuracy at more common medical particle accelerators. To demonstrate their suitability for Radiation Hardness Assurance (RHA) testing, specifically SEU testing of COTS electronics, irradiation tests with protons and carbon ions with a range well above the DUT thickness were performed. A combination of direct and indirect ionization effects serves to infer characteristic quantities such as the threshold LET and the cross-section. We present the methodology and first results for this indirect approach.

References

[1] D. Kobayashi, „Scaling Trends of Digital Single-Event Effects: A Survey of SEU and SET Parameters and Comparison With Transistor Performance,“ in IEEE Transactions on Nuclear Science, vol. 68, no. 2, pp. 124-148, Feb. 2021, doi: 10.1109/TNS.2020.3044659.

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Acknowledgments

The authors thank the Non-Clinical Research team at MedAustron for their support.

Heavy Ion Single Event Effects Test Results of the Magnetometer Frontend ASIC

Raphael Steinhöfler[1]

[1] Space Research Institute of the Austrian Academy of Sciences

Abstract

The magnetometer frontend ASIC (MFA-4) is a mixed signal chip that includes the circuitry necessary for operating a fluxgate sensor. Since years, this sensor technology constitutes the high-quality standard for magnetic field measurements in space. For each axis, a set of three coils provides magnetic excitation, sensing and compensation and requires a considerable extent of circuitry such as low noise amplifiers, demodulators [1], an analog to digital converter, signal processing logic and a high-precision, low-noise delta-sigma digital to analog converter with a fully differential current output stage [2].

A reduced version of this circuitry was implemented on a 180nm process. The silicon die was biased and exposed to a heavy ion beam at the Cyclotron of UCLouvain, during beamtime provided by the RADNEXT project [3]. Operational parameters and output signals were monitored during the process. We present the basic functionality of the ASIC and the findings from heavy ion irradiation up to 100 MeVcm²/mg.

References

[1] M. Scherzer, M. Auer and W. Magnes, „An Integrated Analog Lock-In Amplifier using a Passive 3-Path Band-Pass Filter for a Fluxgate Sensor Readout Circuit," 2023 21st IEEE Interregional NEWCAS Conference (NEWCAS), Edinburgh, United Kingdom, 2023, pp. 1-4, doi: 10.1109/NEWCAS57931.2023.10198130.

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[3] R. G. Alía et al., „Heavy Ion Energy Deposition and SEE Intercomparison Within the RADNEXT Irradiation Facility Network," in IEEE Transactions on Nuclear Science, vol. 70, no. 8, pp. 1596-1605, Aug. 2023, doi: 10.1109/TNS.2023.3260309.

Acknowledgments

We acknowledge and thank the RADNEXT project for enabling these heavy ion tests on our Magnetometer frontend ASIC, providing an insight into the capabilities of the used semiconductor technology.

2nd Day:
Wednesday, May 8th, 2024

Session:
Laser Testing

Keynote

Pulsed Laser Single-Event Effects, Part 1: Fundamental Concepts

Stephen P. Buchner[1,2] and Dale McMorrow[1]

[1] Naval Research Laboratory, Code 6816, Washington DC
[2] Jacobs, Inc., Landover, MD

Abstract

Traditional single-event effects (SEE) testing involves exposing a device or circuit to a beam of energetic particles, usually generated by an accelerator. Particles that pass through the device produce dense tracks of electron-hole pairs that can disrupt the normal operation of the device. Such testing plays an essential role in radiation effects qualification and hardness assurance procedures. Challenges and limitations of accelerator testing, however, include the lack of spatial selectivity (in broad-beam measurements) and the limited number of facilities available, such that beam time is often difficult to obtain.

Carrier generation induced by pulsed-laser excitation has become an essential tool for the investigation of SEEs in microelectronic and nano-electronic structures. The ability to focus optical pulses to micrometer, or sub-micrometer spot sizes provides spatial selectivity not available with broad-beam ion sources. The qualitative capabilities of this approach include, among others, sensitive node identification, radiation hardened circuit verification, basic mechanisms investigations, model validation and calibration, screening devices for space missions, and fault injection to understand error propagation in complex circuits. Recent effort has built upon the success enabled by these qualitative benefits, and has focused on putting the laser SEE approaches on a more quantitative basis.

This presentation will describe the differences between ion- and laser induced charge generation in semiconductor materials. It will cover the basic physics associated with the single-photon absorption (SPA) and two-photon absorption (TPA) excitation processes, and will include a discussion of the optical and nonlinear-optical processes that impact and shape the delivery of charge into semiconductor devices. Having described the basic mechanisms involved, the next presentation will give concrete, practical examples of how powerful and useful the pulsed-laser technique testing is for elucidating the various aspects of SEEs.

Keynote

Pulsed Laser Single-Event Effects, Part 2: Applications

Dale McMorrow[1] and Stephen P. Buchner[1,2]

[1] Naval Research Laboratory, Code 6816, Washington DC
[2] Jacobs, Inc., Landover, MD

Abstract

Traditional single-event effects (SEE) testing involves exposing a device or circuit to a beam of energetic particles, usually generated by an accelerator. Particles that pass through the device produce dense tracks of electron-hole pairs that can disrupt the normal operation of the device. Such testing plays an essential role in radiation effects qualification and hardness assurance procedures. Challenges and limitations of accelerator testing, however, include the lack of spatial selectivity (in broad-beam measurements) and the limited number of facilities available, such that beam time is often difficult to obtain.

Carrier generation induced by pulsed-laser excitation has become an essential tool for the investigation of single-event effects (SEEs) in microelectronic and nano-electronic structures. The ability to focus optical pulses to micrometer, or sub-micrometer spot sizes provides spatial selectivity that's not available with broad-beam ion sources. The qualitative capabilities of this approach include, among others, sensitive node identification, radiation hardened circuit verification, basic mechanisms investigations, model validation and calibration, screening devices for space missions, and fault injection to understand error propagation in complex circuits. Recent effort has built upon the success enabled by these qualitative benefits, and has focused on putting the laser SEE approaches on a more quantitative basis.

This presentation will present a range of case studies (examples) that illustrate the general utility and applicability of the pulsed laser SEE (PL SEE) approach, illustrating the various capabilities noted in the first talk. Examples utilizing both single-photon absorption (SPA) and two-photon absorption (TPA) excitation processes will be presented. This presentation will describe the current state-of-the-art in pulsed laser SEE (PL SEE), the efforts to put the PL SEE approach on a firm quantitative basis, and the recent efforts towards part screening and qualification.

Insights into Airbus Laser Testing for RHA

Sebastien Morand[1]

[1] Airbus D&S

Abstract

Pulsed Laser testing is part of Airbus testing solutions related to new technologies/devices preselection, to the control of SEE sensitivity non-regression, and to the experimental validation of the efficiency of single event effects mitigation solutions. Lessons learned and outlook for those applications are shared during this presentation.

Session:
RADHARD Lectures

Understanding Space Radiation Effects and Testing Strategies

Michael Wind[1]

[1] Seibersdorf Labor GmbH, Austria

Abstract

Semiconductor devices are an integral part of our world and are used in analog and digital applications on Earth and in space because they are cheap, small, fast, lightweight, and provide high functionality. However, their use in radiation environments - as is the case with space applications - can have serious consequences that may affect the performance of devices and systems in terms of correct functioning, service life and even destruction of the electronic components and/or systems used and therefore represent a risk for any space mission. Many findings on these phenomena have been compiled and documented in the literature (e.g. [1] - [5]). This presentation will give an overview on the main types of radiation effects that may occur in electronics when exposed to various radiation sources.

When designing a specific application, knowledge of the radiation sensitivity of the parts used is crucial to ensure a successful mission or at least to reduce the risk of failure. Therefore, testing may be required to gain adequate knowledge of their sensitivity to a given radiation environment [6]. This presentation will give an overview on test strategies and will also give an overview on the most relevant test standards.

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Session:
SmallSats & COTS Components

Exploring Slovakia‘s Contributions to the Space Sector

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Abstract

This presentation will delve into various aspects of Slovakia‘s involvement in space activities, including research initiatives and active participation in international space projects. One of the key highlights of the presentation will be the exploration of Slovakia‘s role in space research, particularly in areas such as spacecraft components, space debris research, software and CubeSat projects such as skCUBE and GRBAlpha. These endeavors showcase Slovakia‘s commitment to advancing scientific understanding and technological innovation in space exploration.

Furthermore, the presentation will shed light on Slovakia‘s collaboration on prestigious international missions such as Rosetta, BepiColombo, and JUICE underscoring the country‘s growing prominence and expertise in the global space community. Through these collaborations, Slovakia has contributed valuable resources and expertise, further solidifying its position as a key player in the space exploration area.

Additionally, the presentation will provide insights into the thriving ecosystem of Slovak space companies and their groundbreaking work in various sectors and the newly formed Stephanik consortium which currently plans to build a modular SmallSat as its first project. By showcasing the achievements and capabilities of these companies, the presentation aims to highlight the dynamic and innovative landscape of the Slovak space industry.

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Acknowledgments

I would like to acknowledge the Slovak Space Office for their valuable insights and information provided on the Slovak space industry for this presentation.

Status of the CLIMB CubeSat mission of FHWN

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Abstract

New space missions make extensive use of commercial off-the-shelf (COTS) components, which provide a state-of-the-art performance but require extensive environmental testing to mitigate risks due to the non-specified reliability. This especially applies to CubeSat space crafts, which continue to establish as a powerful tool for professional missions in science and industry. In accordance with this trend, the university of applied sciences Wiener Neustadt (FHWN) is developing the CLIMB 3U CubeSat mission. The satellite provides a high-power density to operate a Field Emission Electric Propulsion (FEEP) system and change its initial circular orbit of about 500 km altitude to a slightly elliptical one with an apogee at around 1000 km – well inside the inner Van Allen belt [1]. During this about 1.5 years mission, the space environment and its impact on the satellite is monitored by a radiation monitor, developed by Seibersdorf Laboratories and a COTS based magnetometer instrument, developed by FHWN. In order to address the harsh radiation exposure – accumulating to about 20 krad at an average shielding equivalent to 1 mm of aluminum – the CLIMB mission extensively employs established structures from the precursor mission PEGASUS and started to conduct radiation tests of critical, sensitive and modified components. The 2U PEGASUS satellite launched in 2017 as Austrians contribution of QB50 and recorded and provided data until its re-entry 01/2024.

We will present the environmental testing effort of the CLIMB mission, including thermal vacuum and irradiation studies. The integration of the FEEP system into a CubeSat introduces several challenges on the thermal concept due to the required high electrical power and correlated heat dissipation. For this reason, a specialized propulsion test chamber has been developed and thermal simulation studies were done. After exposing the On-Board-Computer of CLIMB to a total ionizing dose (TID) or 50 krad with a 60Co source, single event effect (SEE) tests were conducted with the proton beam at MedAustron [2]. Within this board level test, the beam mimicked a homogenous exposure by mapping the area with a pencil beam in a predefined pattern.

To account for radiation effects at the hardly shielded boom structure of the magnetometer instrument an Anisotropic Magneto Resistance (AMR) device with flight heritage is used as primary sensor (HMC1022). In addition, the latest generation of highly integrated AMR ICs (MMC5983MA) serve as secondary sensors and provide differential measurements along the boom [3]. Those secondary sensors have been TID tested to 30 krad and SEE tested on a component level with high MeV protons.

The presentation concludes with a summary of the results and the triggered modifications in the design, which will mitigate expected effects.

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ADLER-1 – First results from the APID-1 Space Debris instrument

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Abstract

Modeling the environment of Space Debris and Meteoroids (SD/M) in Low Earth Orbit presents significant challenges, particularly for sub-centimeter-sized particles that fall below the detection thresholds of ground-based observations. The MASTER model by ESA [1] serves as a crucial reference for risk assessments and mission planning. However, with the substantial increase in satellite operations over the past decade [2,3] , the absence of recent in-situ data for calibrating these models becomes apparent. The ADLER-1 mission, conducted at an altitude of ca. 500 km for 1,5 years, served as an in-orbit demonstrator for deploying a piezoelectric sensor array and a continuous-wave miniature radar to acquire pilot data. The APID-1 instrument on ADLER-1 recorded 117 impact events over approximately 400 days, allowing for a comparison with MASTER simulations [4].

Based upon a SPIRE LEMUR-class 3U CubeSat, ADLER-1 (UNOOSA designation LEMUR-2-KRYWE) platform with a mass of 6 kg in a 44,9° inclination orbit, deorbiting in June 2023. During the orbital phase, 80% of that period were used for scientific measurements. The payload consisted of a continuous-wave radar system as well as an electromechanical detector array APID-1.

A versatile data pipeline architecture was implemented for efficient data processing, enabling the deployment of new signal processing source codes. This architecture includes automatic execution of build, unit, and integration tests upon Pull Request (PR) submission and merging. The on-board computing source code facilitated over-the-air updates during the mission and over-the-air updates and configuration changes during the mission, and the adaptability of the ground processing system allowed for a comprehensive reassessment of the entire level 0 data set whenever a new analysis algorithm was iterated.

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Session:
Innovative Testing Developments and Future Needs (Part 2)

Charged-particle dosimetry, LET spectrometry and wide field-of-view directional tracking of space radiation in LEO orbit with miniaturized Timepix3 monitor onboard One-Web Joeysat satellite

Carlos Granja[1], Lukas Marek[1], Tomas Baca[2], Victor Colas[3], Marco Sabia[3], Maxime L'Huillier[4], Emmanuel Plascencia[4], Benjamin Azoulay[4], Marco Vuolo[5], et al.,

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Abstract

The mixed-composition and widely variable radiation field in LEO orbit is measured and characterized in high-resolution by a miniaturized low-power radiation monitor based on the semiconductor pixel detector Timepix3. Configured as the RadMon MPX monitor the detector is deployed in LEO orbit (600 km, polar sun synchronous) onboard the Joeysat One Web satellite (launched May 2023). The detector configuration and operation duty cycle were customized to enable an evenly distributed temporal operation (per-minute intervals) in view of the spacecraft resources (power supply) and payload memory slot and downlink data rate. The detector quantum imaging sensitivity [1] together with in-beam calibrations and detailed data processing (on ground) provide high-resolution information on radiation-particle type classes [2] resolved with spectral (energy loss, linear-energy-transfer LET) and directional-tracking information. Spacecraft time and spacecraft navigation-position stamp yield detailed radiation maps along the satellite orbit. Particle fluxes (total, partial) and dose rates (total, partial) are produced in wide range (over 8 order of magnitude) together with charged particle (proton, electron) LET spectra (range 0.01 – 500 keV/μm in silicon). These physics data products serve for detailed studies and in-orbit monitoring of radiation effects.

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Exascale Reconfigurable and Rad-Hard Accelerated Computing in Space

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[2] NanoXplore

Abstract

Radiation-hardened-by-design (RHBD) reconfigurable devices have gained a lot of attention thanks to their excellent compromise between costs and performance. Being of very limited use due to a lack of performance a few years ago, these devices are now capable of implementing a wide range of applications requiring high computational capabilities [1]. However, to further enhance computing capabilities and permit the effective implementation of Vision-Based Navigation (VBN) algorithms, an ad hoc HW accelerator able to elaborate multi-dimensional arrays (tensors) is needed [2]. Tensors are fundamental units to store data such as the weights of a node in a neural network. They perform basic math operations such as addition, elementwise multiplication, and matrix multiplication. This HW accelerator, defined as the Tensor Processing Unit (TPU), is an architecture customized for image elaboration algorithms and machine learning [3]. It can manage massive multiplications and additions at high speed with a limited design area and power consumption. Several design strategies investigated the efficient implementation of TPU on FPGA architectures by improving the pipeline strategy and resource sharing towards the TPU processing elements (PEs) or by unifying the tensor computation kernel. Nowadays, there are not any available design solutions for radiation-hardened TPU for FPGAs or ASICs having high performance and being radiation-hardened [4]. In this work, we present the first results achieved with an implementation of a TPU architecture on NG-Medium Radiation-Hardened FPGAs manufactured by NanoXplore.

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Acknowledgments

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List of Lecturers

BUCHNER Stephen, Naval Research Laboratory, USA
Pulsed Laser Single-Event Effects, Part 1: Fundamental Concepts

DATZMANN Gerd, Datzmann interact & innovate, Germany
RADNEXT - Building a Network of Irradiation Facilities: Achievements and Future Perspectives

EIZINGER Martin, FOTEC GmbH, Austria
Single Event Effect Testing using Medical Synchrotron

GRANJA Carlos, ADVACAM, Czech Republic
Charged-particle dosimetry, LET spectrometry and wide field-of-view directional tracking of space radiation in LEO orbit with miniaturized Timepix3 monitor onboard One-Web Joeysat satellite

GRÖMER Gernot, Austrian Space Forum, Austria
ADLER-1 - First results from the APID-1 Space Debris instrument

LÁSZLO Patrik, Needronix, Slovakia
Exploring Slovakia's Contributions to the Space Sector

MARTINS Ricardo, ESA/ESTEC, The Netherlands
Materials in challenging space environment

McMORROW Dale, Naval Research Laboratory, USA
Pulsed Laser Single-Event Effects, Part 2: Applications

MERSTALLINGER Andreas, AAC Research, Austria
Influence of radiation on Self-Lubricating Polymer used as cages for bearings

MORAND Sebastien, Airbus Defence & Space, France
Insights into Airbus Laser Testing for RHA

ROSTOMYAN Tigran Armand, Paul Scherrer Institute, Switzerland
Pixelated Ionization Chamber (PIC) for PIF

SÖDERSTRÖM Daniel, CERN, Switzerland
Overview of the 2023 R2E activities at CERN, with a focus on the SEE accelerator availability impact during the ion run

STEINHÖFLER Raphael, Space Research Institute of the Austrian Academy of Sciences, Austria
Heavy Ion Single Event Effects Test Results of the Magnetometer Frontend ASIC

STERPONE Luca, Politecnico di Torino, Italy
Exascale Reconfigurable and Rad-Hard Accelerated Computing in Space

TREBERSPURG Wolfgang, University of Applied Sciences Wiener Neustadt, Austria
Status of the CLIMB CubeSat mission of FHWN

TSCHERNE Christoph, Seibersdorf Labor GmbH, Austria
A Journey Through the Cosmic Hazards: Understanding the Space Radiation Environment

WIND Michael, Seibersdorf Labor GmbH, Austria
Understanding Space Radiation Effects and Testing Strategies

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