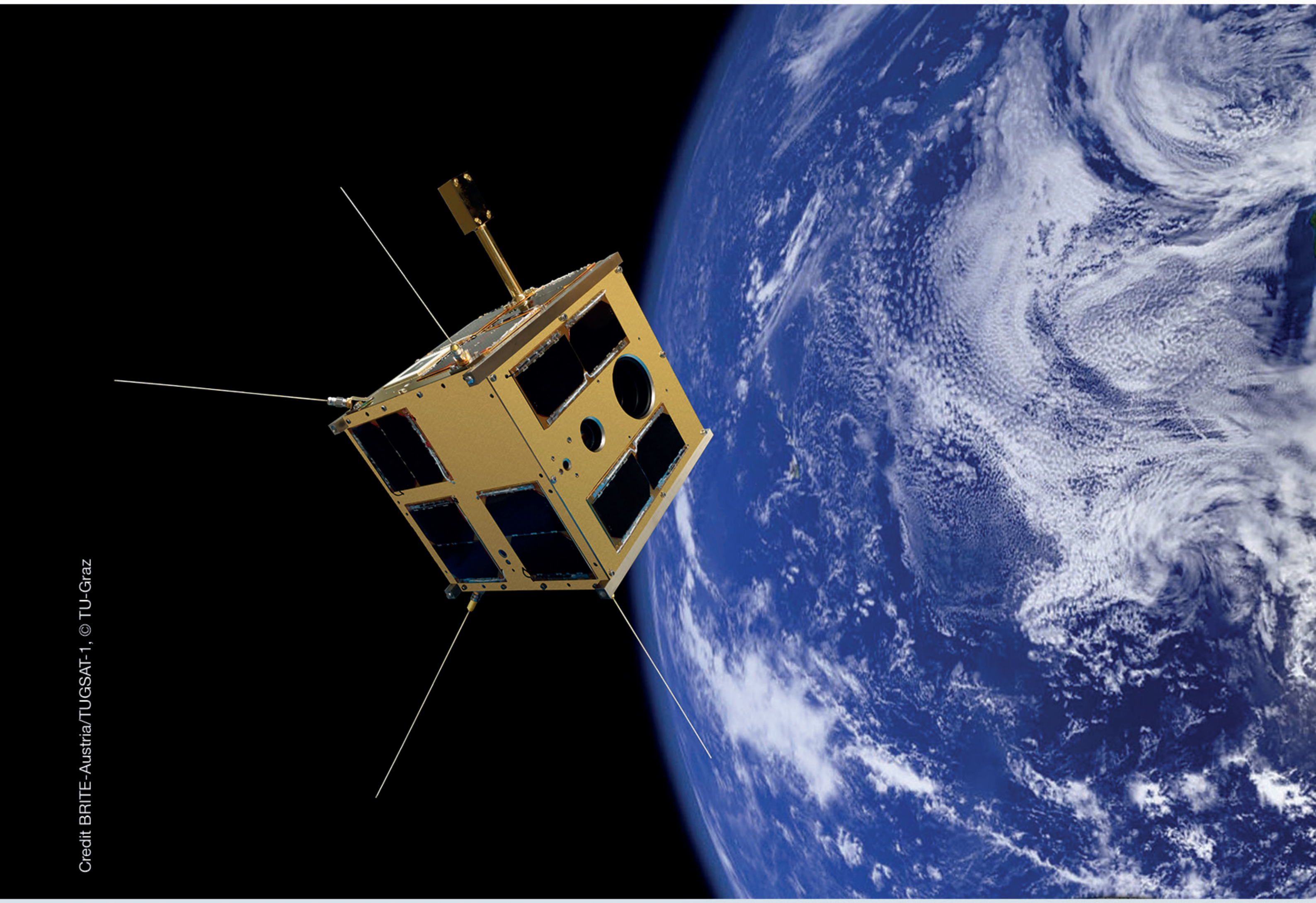
RADHARD SYMPOSIUM

Book of Abstracts

April 24th - 25th, 2018

Seibersdorf, Austria



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Chairmans's Invitation

On behalf of the RADHARD Symposium 2018 organizing team, it is my pleasure to invite you to the 3rd Edition of the RADHARD Symposium, held at the Seibersdorf Laboratories, close to Vienna, Austria.

The mission of the RADHARD Symposium is to provide you, complementary to the RADECS conference, with a forum for exchanging practical experiences in radiation hardness assurance, relevant for industrial applications as well as for science and research.

Our vision is that the RADHARD Symposium offers a space with plenty of room for conversation, initiating new joint projects and inviting you to attend the RADECS Conference.

The RADHARD 2018 - Symposium focuses on:

- Standards for Radiation Hardness Assurance
- Space Radiation Environment and Effects
- Test Laboratories and Practical Aspects of Testing

The RADHARD Symposium is addressed to space systems integrators, EEE manufacturers, industrial stakeholders, research and science as well as students interested in radiation. International experts present new results and highlighting reviews. We strongly encourage students to present their early research on radiation hardness effects.

Keynotes and training lectures on topics such as space radiation and radiation effects is an integral part of the symposium. It is our pleasure to present you two radiation hardness assurance experts with keynote lectures on „Standards for Hardness Testing and Radiation Testing" and „Radiation Tests on Commercial Components". Further, two training lectures are given on "Space Radiation Environment at LEO, MEO and GEO" and "Space Radiation Effects to Components and Systems".

The industrial aspect of radiation hardness testing is of particular importance. Thus, a contribution on „Characterization and Accreditation of Test Laboratories according to EN ISO / IEC 17025" will provide you with insights into the quality of radiation hardness testing. With regard to „Practical Aspects of Commercial off-the-shelf (COTS) Electronic Components in Space and Radiation Hardness Testing," seven selected presentations give an overview on experiences with small satellite missions, as well as practical aspects of medical applications of electronics in X-ray environments.

The RADHARD Symposium 2018 is organized by Seibersdorf Laboratories, supported by the Austrian Research Promotion Agency (FFG), and AUSTROSPACE, in liaison with Graz University of Technology, University of Applied Sciences Wiener Neustadt (FHWN), and with RADECS.

In particular, we would like to thank our sponsors, the Austrian Research Promotion Agency (FFG) and AUSTROSPACE, which enable us again to offer the RADHARD Symposium without participation fee this year.

The RADHARD Symposium is held in two half days, 24th and 25th April 2018. For the evening of the 1st day a come-together dinner is organized in the Vienna City Center.

Peter Beck

On behalf of the RADHARD Symposium 2018 Organizing Team

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www.landtmann.at

Program status at the editorial deadline.

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Program status at the editorial deadline.

Keynote
Standards for Space Radiation Hardness Assurance and Testing

Indranil Chatterjee
Airbus Defence and Space, Germany

Abstract

The space radiation environment consists of a variety of energetic particles with energies varying from keV to GeV. This leads to extremely harsh operating conditions for on-board electronics and systems on satellites and interplanetary probes. The characteristics of the radiation environment are highly dependent on the type of mission (date, duration and orbit). Space system providers require a holistic approach, from the device level to the system level to ensure functionality and performance of the electronics during the mission lifetime. A rigorous methodology, called Hardness Assurance, is needed to ensure this. It consists of those activities undertaken to ensure that the semiconductor devices used in the satellites perform to their design specifications after exposure to the space environment. It deals with system requirements, environmental definitions, component selection and testing, shielding and radiation tolerant design. Interplay of all these factors determines the viability of electronics in space. The presentation will address various topics in radiation modelling, testing, and electronic design and discuss on the changes ahead as we incorporate advanced technology nodes and new design paradigms in the space industry.

Session:
Space Radiation Environment

Space Radiation Environment at LEO, MEO and GEO

Christoph Tscherne, Peter Beck, Marcin Latocha, Michael Wind
Seibersdorf Laboratories, Austria

Abstract

Spacecraft in near-Earth orbits are exposed to a complex and harsh radiation environment that poses a great challenge to space mission design. Radiation accelerates the aging of EEE components, eventually leading to a decrease in performance or to a complete loss of functionality [1]. Radiation exposure of astronauts, as in the ISS, is a serious concern. In order to face these challenges, it is necessary to understand the nature and effects of space radiation. The space radiation environments at Low Earth Orbits (LEO), Medium Earth Orbits (MEO) and Geostationary Earth Orbits (GEO) compose of three main types of primary radiation: solar energetic particles (SEP), galactic cosmic radiation (GCR) and particles trapped in the Earth's radiation belts [2, 3]. All three types are of different origin, vary greatly in energy and flux and underlie short-term and long-term variations modulated by the sun's activity [4].
The presentation introduces the different types of orbits and discusses the origin and effects of the space radiation environment at LEO, MEO and GEO in detail. Characteristics of SEP, GCR and trapped particles are described and their influence on mission design is reviewed [5].

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Acknowledgments

I acknowledge the insightful talks and presentations of the lecturers of the RADECS 2017 and NSREC 2017 short courses and the information provided by SPENVIS, ESA's Space Environment Information System (http://swe.ssa.esa.int/; https://www.spenvis.oma.be/)

Session:
Radiation Effects and RHA Testing Facility

Space Radiation Effects to Components and Systems

Michael Wind, Peter Beck, Marcin Latocha, Christoph Tscherne
Seibersdorf Laboratories, Austria

Abstract

Semiconductor devices are pervasively deployed in analog and digital applications for earth and space due to being cheap, small, fast, light weighted, and offering high functionality. When exposed to ionizing radiation semiconductor devices are vulnerable to a variety of damaging mechanisms. Effects due to radiation have been observed and investigated for many decades by now and a lot of insight into the phenomena has been gathered and documented in literature (e.g. [1] - [6]). This presentation intends to give an overview on the major types of radiation effects, i.e. Total Ionizing Dose (TID), Single Event Effects (SEE) and Total Non-Ionizing Dose (TNID) effects. The basic radiation effects are illustrated that occur in electronics when they are exposed to the different radiation sources. Semiconductor parts being scheduled for operation in a radiation environment, e.g. satellite's electronics, require a decent knowledge on their susceptibility to the present radiation environment which raises the need for radiation tests. To assure the significance of such test and the comparability of the results testing is typically performed according to standards (e.g. [7] - [9]). Basic information on test procedures and available test standards is given.

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[9] European Space Component Coordination, Single Event Effects Test Method and Guidelines, ESCC Basic Specification No. 25100, issue 2, 2014

Characterisation and Accrediation of Testing Laboratories According to EN ISO/IEC 17025

Peter Beck, Marcin Latocha, Christoph Tscherne, Michael Wind
Seibersdorf Laboratories, Austria

Abstract

Seibersdorf Laboratories is operating the TEC-Laboratory, an accredited test house for total ionizing dose (TID) testing of electronic components and systems. The abbreviation TEC means test of electronic components. The testing procedures of the TEC-Laboratory are compliant with the EN ISO/IEC 17025 standard of test labs [1]. Further, the TEC-Laboratory is fully compliant with IEC 61340-5-1:2016, the standard on protection of electronic devices from electrostatic phenomena [2]. For maintaining the accreditation the TEC-Laboratory has been fully characterized and has been audited by an in depended governmental body certified for accreditation of test labs – the Accreditation Austria. The Accreditation Austria is a full member of the International Laboratory Accreditation Cooperation ILAC and a signatory of the MRA for "Testing, Calibration and Inspection". The TEC-Laboratory is also required to participate in relevant intercomparison testing programs between reassessments, as a further demonstration of technical competence. The TEC-Laboratory issue test reports showing the accreditation body's symbol as an indication of their accreditation.

The accredited testing at the TEC-Laboratory is compliant with ESCC Basic Specification No.22900 [3] and Steady-State Total Dose Irradiation Procedure of MIL-STD-750-F [4]. The radiation characterization of the TEC laboratory's Co-60 photon field is presented in detail. The back scattering of the walls have been investigated by measurements and Monte Carlo methods [5], [6].

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Keynote
Radiation Testing Comercial-off-the Shelf Components

Marc Poizat
European Space Agency

Abstract

Radiation hardness assurance for Smallsats (and Cubesats) is essentially based on the same principles as for large satellite programs. Additionally, the use of COTS is increasing also on mainstream projects for both cost and performance reasons. However the use of COTS has its disadvantages such as traceability, obsolescence, cost increase due to up-screening etc.

In this lecture, the basics of radiation hardness assurance will be introduced. Test methods and applicable standards for total ionizing dose, displacement damage and single event effects testing will be presented. Finally considerations and RHA best practices for Smallsats based on COTS will be proposed. Application examples will be presented.

References

2017 NSREC short course, Radiation Hardness Assurance for Satellite Systems – from Macro to Nano.

Session: Practical Aspects of COTS in Space and RHA Testing

Long Term Space Experience with COTS On-Board of CubeSats

Otto Koudelka, Rainer Kuschnig, Manuela Wenger
Graz University of Technology
Institute of Communication Networks and Satellite Communications

Abstract

TUGSAT-1 / BRITE-Austria, the first Austrian satellite was launched together with its sister satellite UniBRITE in February 2013. They are part of the world's first nanosatellite constellation to measure the brightness variations of massive luminous stars. Five nearly identical nanosatellites from Austria, Poland and Canada are in continuous operations since 2013. Each spacecraft carries a small telescope with CCD sensor as the scientific payload. Although designed for a lifetime of two years, the Austrian BRITEs are now in operations for more than five years and and show an excellent health status. None of the components are space-qualified, although critical components were radiation-tested. The CCD naturally has accumulated radiation damage, resulting in hot pixels and warm columns. A method called "chopping" was introduced to overcome the radiation impairments by image processing. Thus, the mission can be extended for at least two more years. This impressively demonstrates that challenging scientific requirements can be fulfilled by a low-cost nanosatellite mission [1].

In another project called OPS-SAT [2] TU Graz has developed an advanced on-board processor payload, a software-defined radio receiver and an optical payload with partners in Austria and Germany. These subsystems use selected industry-grade (non-Space-qualified) electronics components, such as system-on-chip modules, mixed-signal chips and single-photon counter modules. They were radiation-tested at ESTEC in 2015 up to 20 krad and showed no degradation.

The presentation will discuss the radiation effects identified in the BRITE mission and the countermeasures taken. Also the results of the OPS-SAT radiation tests will be shown.

References

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Acknowledgments

BRITE-Austria/TUGSAT-1 is funded by the Austrian Aeronautics and Space Agency within the ASAP program. OPS-SAT is funded by the ESA GSTP program.

Austrian Cube Sat Pegasus in Space

Reinhard Schnitzer[1], Carsten Scharlemann[1], Michael Taraba[2], Andreas Sinn[3], Thomas Riel[3]
[1] University of Applied Sciences Wiener Neustadt Ltd., Austria
[2] Space Tech Group
[3] TRAS

Abstract

The PEGASUS CubeSat was developed by a consortium of Austrian entities, mostly consisting of students and university staff. The satellite was launched together with seven other CubeSats in June 2017 into a Low Earth Orbit (LEO) [1]. The PEGASUS team developed the majority of the satellite's components by itself rather than using COTS. New concepts of structural elements and electronic components were developed and tested during the design process. Because of the limited budget of PEGASUS it was not possible to use space rated and radiation hardened electronic components. To a certain degree, design features such as redundancy, watch dogs, anti-latch-up circuits etc. were implemented in order to mitigate the risk due to the usage of non-space rated components.

Now, for almost one year, PEGASUS is working very successful in space. Since November 2017, the satellites collects science data and transmits them to one of the five grounds stations of the PEGASUS team. Although anomalies occurred during the operation, none could directly be linked to radiation. In the following, a summary of the operation and the data obtained is provided. Furthermore, an outlook is provided about the next mission CLIMB. CLIMB will directly tackle the issues with space radiation and the usage of COTS electronic components. For CLIMB, a novel multi emitter thruster will be tested to bring the satellite from a LEO to a higher orbit cloth to the Van Allen Belt. In this region, the Satellite is exposed to high concentrations of electrons in the range of hundreds of keV and energetic protons with energies exceeding 100 MeV.

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Strategies of using COTS at ESA's CubeSat Project RADCUBE with the RADMAG Instrument

Attila Hirn, András Gerecs, Balázs Zábori
Centre for Energy Research, Hungarian Academy of Sciences, Hungary

Abstract

In cooperation with Imperial College London, the Polish space company Astronika and the Hungarian small satellite developer C3S LLC, the Centre for Energy Research, Hungarian Academy of Sciences is developing a compact instrument, called RadMag, capable of providing scientific data on space radiation (proton and electron spectra, flux of heavier ions) and the status of the magnetosphere and fitting into approximately 1.2U following CubeSat standards. An ESA experiment comprising two radiation assurance boards is also included in the payload design. The first in-orbit demonstration of the instrument, in the frame of the ESA GSTP 6.3 RADCUBE programme, will be performed within a 3U CubeSat mission, called RADCUBE. The launch of the satellite is planned in late 2019.

In our presentation, the main objectives of the development, a brief description of the instrument and the present status of the development will be given. Limitations originating from the nature of the CubeSat IOD mission as well as our methods on EEE COTS components selection will be presented.

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Acknowledgments

The above activity is carried out under a programme of, and funded by, the European Space Agency (contract numbers: 4000117620/16/NL/LF/as and 4000120860/17/NL/GLC/as). The authors would like to thank Tomasz Szewczyk (ESA/ESTEC) for the discussion and his valuable help in component selection for the RadMag instrument.

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PRETTY: Passive Reflectometry based on the Interferometric Method and Dosimetry Measurements

H. Fragner[1], P. Beck[2], A. Dielacher[1], O. Koudelka[3], C. Tscherne[2], M. Wenger[3], M. Wind[2]
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[2] Seibersdorf Laboratories, TFZ Seibersdorf, 2444 Seibersdorf, Austria
[3] Graz University of Technology, Inffeldgasse 12, Graz 8010, Austria

Abstract

The PRETTY (Passive Reflectometry and Dosimetry) mission is an Austrian Cubesat mission currently under development in a Phase B study for the European Space Agency (ESA). The platform will host two different scientific payloads: A passive reflectometer, exploiting signals of opportunity for passive bistatic radar measurements and a reference dosimeter system, continuously assessing the ionizing dose on-board the PRETTY spacecraft.

The exploitation of signals from global navigation systems for passive bistatic radar applications has been proposed and implemented within numerous studies. The planned implementation is focusing on very low incidence angles whereby the direct and reflected signal will be received via the same antenna and RF front end. Apart from the reflection geometry the new aspect of the PRETTY reflectometer is the interferometric approach. The processing power intense task of correlating the two signal paths will be done in the digital domain using an FPGA. The demonstration of a passive reflectometer without the use of local code replica will implicitly show that also signals of unknown data modulation can be exploited for this purpose.

There is a great interest to correlate the satellite's radiation environment with the status of all other electronic systems of the satellite itself and its payloads. The objectives of the reference dosimeter payload are to assess the radiation mission dose during the whole CubeSat space mission and in particular at three geographic regions of interest with elevated radiation levels, such as the South Atlantic Anomaly (SAA), North Pole and the South Pole. The proposed dosimeter system is based on RADFET which is made of silicon and therefore its response can be used as reference dose for total ionizing dose (TID) effects. This measurement is representative for other silicon-based electronic systems e.g. during reliability testing of electronic components, in particular commercial components of-the-shelf (COTS) on-board CubeSat.

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Acknowledgments

The Phase B study for the PRETTY mission is funded by ESA GSTP Programme. The according Phase A study was funded by ASAP/FFG.

Experience of Using COTS for Space Ion-Thruster In Space and Radiation Hardness Testing

Robert-Jan Koopmans, Emre Ceribas, Thomas Hörbe, Bernhard Seifert, René Sedmik
FOTEC Forschungs- und Technologietransfer GmbH, Wiener Neustadt, Austria

Abstract

The IFM (Indium FEEP (Field Effect Emission Propulsion) Multi-Emitter) Nano Thruster currently under development at FOTEC was originally intended to be used in CubeSats operating in LEO (Low Earth Orbit). To reduce the costs as much as possible and thus make it attractive for CubeSat missions, the PPU (Power Processing Unit) consists entirely of COTS (Commercial Off-the-Shelf) components. The demand for propulsion systems for small satellites in orbits beyond LEO is growing. The corresponding radiation environment in MEO (Medium Earth Orbit) and beyond is harsher than in LEO. For this reason, a test campaign was designed and executed to find out how resilient the current PPU is to radiation.

The initial goal of the tests was to determine the functionality of the PPU up to level P, or 30 krad. The test was then further extended to level R, or 100 krad, and level A, or 300 krad. Rather than qualifying individual components according ECSS and MIL standards, system level radiation tests were conducted for which no standard exists. Three types of total ionizing dose (TID) tests were conducted at the TEC-Laboratory (Seibersdorf, Austria):

- a low dose rate test (0.015 rad/s) of the epoxy glue used to fix the emitter crown
- a low dose rate test (0.015 rad/s) of the PPU
- a high dose rate test (1.5 rad/s) of the PPU

As the crown emitter in the thruster can only operate under vacuum conditions, a functional test box was designed and built to mimic the firing of the crown emitters during irradiation.

During the test campaign, the irradiation of the PPU was several times interrupted. During these interruptions a full characterization of the PPU was performed. It could thus be determined which components had a reduced performance or were completely broken. The same characterization was performed with a PPU that had undergone the same firing simulation, but was not irradiated. In this way, a distinction could be made between components failing due to gamma radiation and due to other problems. In some cases, bipolar and CMOS devices demonstrate a sensitivity of the electrical parameter degradation at low dose rates. In order to determine the extent of this sensitivity the same test was performed three more times at a high dose rate. Each time the orientation of the PPU w.r.t. the radiation source was changed to investigate the effect of internal scattering of the gamma rays. At the end of the irradiation, all PPUs were subjected to accelerated aging by means of a thermal vacuum test at 100°C for 1 week at FOTEC. After this period, a full characterization of the PPUs were performed again.

Acknowledgments

The authors are grateful to the help of Seibersdorf Laboratories received during the preparation and execution of the test campaign at the TEC-Laboratory (Seibersdorf, Austria). The work leading to the results is funded by ESA under contract number 4000116898/16/NL/EM.

Ionizing Radiation and Radiation Hardness in Analog Integrated Circuits- Recent X-Ray testing

Varvara Bezhenova, Alicja Michalowska-Forsyth
Graz University of Technology, Institute of Electronics, Inffeldgasse 12/I, Graz 8010, Austria

Abstract

Development of radiation hardened integrated circuits (ICs) is a long iterative process. Radiation hardness assurance of such ICs involves multiple comparisons between various device and circuit topologies. In this talk we present the challenges of this process on an example of two test ICs designed at the Institute of Electronics at Graz University of Technology and fabricated in a commercial 180 nm CMOS process.

These ICs were tested against the effects of total ionizing dose at three different X-ray facilities, available in Austria. The comparison of the test results from different facilities is additional challenging task in the radiation hardness assurance procedure. This includes comparison of the dose rate estimation with different dosimetry tools available at these facilities as well as comparison of TID effects on ICs, irradiated at different X-ray sources.

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Space Radiation Dosimetry and Radiation Shielding Effectiveness of Composites in LEO orbit with Timepix and XRB Diodes on board Cubesat VZLUSAT-1

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Abstract

We present measurements and results on space radiation monitoring and dosimetry in LEO orbit 500 km performed with the semiconductor pixel detector Timepix and several XRB diodes on board the VZLUSAT-1. The Czech cubesat, part of the QB50 program, launched by PSLV rocket on 23rd June 2017, has been operating at a 500 km polar orbit. The main instrument, a 1D optics X-ray telescope, is equipped with a focal-plane Timepix detector (300 um silicon) which serves also as radiation monitor and quantum imaging dosemeter of the space radiation environment. A set of XRB diodes measure the ionizing doses (TID) and surround shielding composites for evaluation of their effectiveness. Preliminary results will be shown in the form of characterization and visualization of the space radiation field (Fig. 1 left), dose histograms, and dose maps along the satellite orbit (Fig. 1 right).

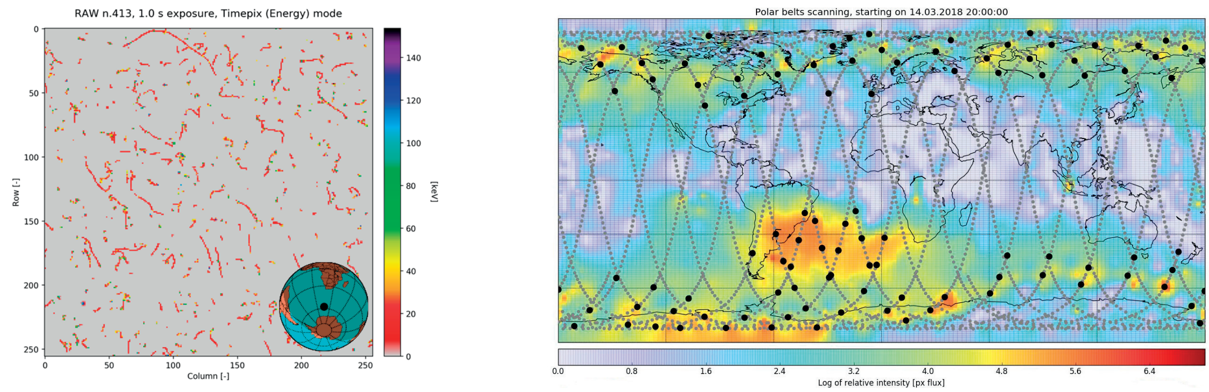

Fig. 1 – Left: Detection of space radiation (dominant electron) by Timepix. Right: measured dose map along VZLUSAT-1 orbit.

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List of Lecturers

Beck P., Seibersdorf Laboratories, Austria
Characterisation and Accrediation of Testing Laboratories According to EN ISO/IEC 17025

Bezhenova V., Technical University Graz, Austria
Ionizing Radiation and Radiation Hardness in Analog Integrated Circuits- Recent X-Ray testing

Chatterjee I., Airbus Group Inc, Germany
Keynote
Standards for Space Radiation Hardness Assurance and Testing

Fragner H., RUAG Space (Vienna), Austria
PRETTY – An Austrian Space Project on Passive Reflectometry and Dosimetry On-Board CubeSat

Granja C., Czech Aerospace Research Centre, Czech Republic
Space Radiation Dosimetry and Radiation Shielding Effectiveness of Composites in LEO orbit with Timepix and XRB Diodes on board Cubesat VZLUSAT-1

Hirn A., Hungarian Academy of Sciences Centre for Energy Research, Hungary
Strategies of using COTS at ESA's CubeSat Project RADCUBE with the RADMAG Instrument

Koudelka O., Wenger M., Technical University Graz, Austria
Long Term Space Experience with COTS On-Board CubeSat

Poizat M., European Space Agency, ESA
Keynote
Radiation Testing Comercial-off-the Shelf Components

Schnitzer R., Fachhochschule Wiener Neustadt, Austria
Use and Experience of COTS on Nanosatellite PEGASUS for the QB50 Project

Seifert B., FOTEC GmbH, Austria
Experience of Using COTS for Space Ion-Thruster In Space and Radiation Hardness Testing

Tscherne C., Seibersdorf Laboratories, Austria
Space Radiation Environment at LEO, MEO and GEO

Wind M., Seibersdorf Laboratories, Austria
Space Radiation Effects to Components and Systems

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