Newsletter #6

January 2022 – August 2022

ELICSIR: Enhancement of Scientific Excellence and Innovation Potential in Electronic Instrumentation for Ionizing Radiation Environments

Welcome to the sixth ELICSIR project newsletter!

This period in the project implementation was marked by the publication of papers, project staff mobility and project promotion.

Project website: elicsir-project.eu

Type of action: Coordination and Support
Topic: H2020-WIDESPREAD-2018-2020
Call: WIDESPREAD-3-2018-TWINNING

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857558.

Miloš Krstić's invited talk

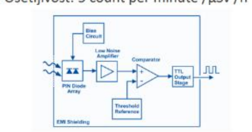
Prof. Dr. Miloš Krstić, a member of the ELICSIR project from IHP, gave an invited talk on the "Hardware Architectures for AI Applications" at the online training school "Introduction to Quantization in Neural Networks and Applications". This event was organized on February 17 and 18 by the Faculty of Electronic Engineering, University of Niš, Serbia. Prof. Krstić's presentation was followed by around 40 participants, mainly students and staff of the Faculty of Electronic Engineering. Having in mind the expansion in the development of AI technologies, this talk was very significant and was followed by a very interesting discussion regarding the possibilities in this area.

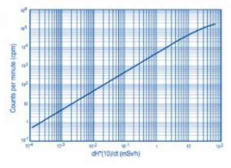
Miloš Marjanović's mobility at IHP

As a part of the ELICSIR project staff mobility, Miloš Marjanović, a teaching assistant at the Faculty of Electronic Engineering, University of Niš, spent two-and-a-half months at the IHP, Germany. Miloš Marjanović participated in staff mobility from January 10 to March 20. He used this time to expand his knowledge and conduct research primarily related to the SPICE simulations of Single Event Transients in CMOS circuits, which resulted in the creation of several scientific papers.

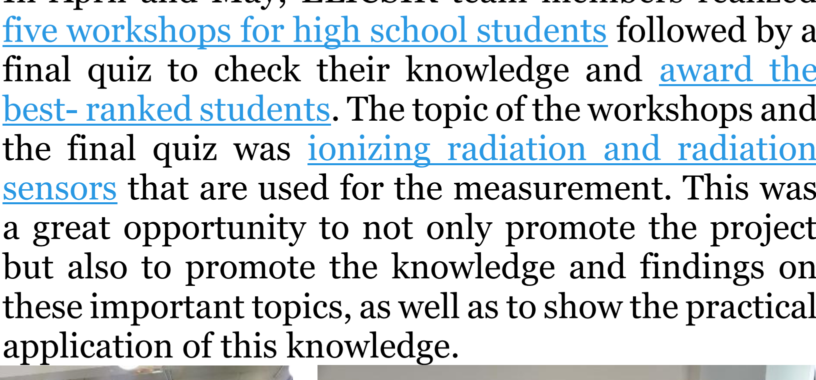
Also, for the interactive student training section on ELICSIR website, an exercise for SET simulation using open-source tools and models has been developed. During his stay, he gave an online lecture on "PS-BBICS: Pulse Stretching Bulk Built-in Current Sensor for On-Chip Measurement of Single Event Transients" summarizing the simulation results he achieved at IHP.

Five ELICSIR workshops for high school students





In April and May, ELICSIR team members realized five workshops for high school students followed by a final quiz to check their knowledge and award the best- ranked students. The topic of the workshops and the final quiz was ionizing radiation and radiation sensors that are used for the measurement. This was a great opportunity to not only promote the project but also to promote the knowledge and findings on these important topics, as well as to show the practical application of this knowledge.



ELICSIR project promoted at the International Fair of Technics and Technical Achievements

Nikola Mitrović, a teaching assistant at the Faculty of Electronic Engineering and a member of ELICSIR project team, promoted the project at the International Fair of Technics and Technical Achievements. The fair was organized in Belgrade from May 24 to May 27 and it gathered a large number of exhibitor and visitors, which was excellent for the promotion of the project. Our exhibition booth caused great attention due to a large number of devices that were used to demonstrate certain aspects of radiation and its research and measurement.

Cooperation with the Novelic company

The ELICSIR project members kept extending their cooperation with companies in the interest of the project and project promotion. Therefore, the Faculty of Electronic Engineering, University of Niš, hosted the promotion of Novelic, a company which deals with the development of radar and similar sensor technologies and operates within the Science and Technology Park Niš. This presentation gathered a large audience, which was also informed about the ELICSIR project and its activities. Moreover, ELICSIR team members and Novelic representatives exchanged their experience regarding sensors and sensor technologies.

Sandra Veljković's stay at Tyndall National Institute

Tyndall National Institute, Cork, Ireland, hosted a two-month staff mobility (April 4 – June 6) organized as a part of the ELICSIR project activities. Sandra Veljković, a PhD student at the Faculty of Electronics Engineering, University of Niš, completed a two-month training stage with Dr. Russell Duane. The training was related to using numerical simulation to validate measurement method techniques, such as the well-known McWhortur method for extracting oxide charge. Also, various component structures were formed in the simulator for further testing and analysis. She also had a tour of the silicon fabrication facility where process engineers demonstrated how a RADFET is fabricated. This experience will not only serve for the research work within the ELICSIR project, but also for her doctoral dissertation.

ELICSIR at RAD 2022 Conference Spring Edition

ELICSIR project team used the 10th Jubilee International Conference on Radiation in Various Fields of Research (Jubilee RAD 2022 Conference Spring Edition) for several project activities. Firstly, a special session with 7 oral presentations was organized in which the members of the project team talked about their research conducted within the project. Secondly, a meeting on the further implementation of the project was organized which was very fruitful since it was the first in-person meeting after a long time. In addition, the conference social events were used not only as team-building activities, but also for networking with other scientists.

Wednesday, June 15, 2022 (Hall A - Hunguest Hotel Sun Resort)
11:00 – 12:45 Oral Session: ELICSIR Project
Chairperson: Alberto Palma

11:00	Isidoro Ruiz-García, Juan Román-Raya, Marko S. Andjelković, Damián Guirado, Alberto J. Palma, Miguel A. Carvajal, **Compensation of the temperature effect of the dark current in photodiodes dosimeters**
11:15	Stefan D. Ilic, Marko S. Andjelkovic, Miguel Ángel Carvajal, Russell Duane, Milija Sarajlic, Srboljub Stankovic, Goran S. Ristic, **Stacked floating gate MOSFET as a passive dosimeter**
11:30	Russell Duane, Nikola Vasovic, Mary White, Alan Blake, Anne Marie McGarrigle, Srbolijub, **A Metal Oxide Semiconductor ionizing radiation detector architecture with increased voltage sensitivity**
11:45	Sandra Veljković, Stefan D. Ilić, Russell Duane, Marko S. Andjelković, Alberto J. Palma, Goran S. Ristić, **Behaviour of pMOS dosimeters during and after X-rays**
12:00	Antonio Pousibet Garrido, Pablo Escobedo Araque, Damián Guirado LLorente, Alberto José Palma López, Miguel Ángel Carvajal Rodríguez, **Battery-less NFC tag for radiation dose measurement with MOSFET dosimeters**
12:15	Nikola Mitrović, Sandra Veljković, Vojkan Davidović, Snežana Đorić-Veljković, Snežana Golubović, Emilija Živanović, Zoran Prijić, Danijel Danković, **Characterization of irradiated and NBT stressed p-channel power VDMOSFETs**
12:30	Milos Marjanovic, Marko Andjelkovic, Milos Krstic, Goran Ristic, **Simulation of single event transient effects in CMOS circuits using open access tools and device models**

Published joint scientific papers

https://doi.org/10.1016/j.nima.2022.166473

Sensitivity and fading of irradiated RADFETs with different gate voltages

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ARTICLE INFO

Keywords:
pMOS radiation dosimeter
RADFETs
Irradiation
Sensitivity
Annealing
Fading

ABSTRACT

The radiation-sensitive field-effect transistors (RADFETs) with an oxide thickness of 400 nm are irradiated with gate voltages of 2, 4 and 6 V, and without gate voltage. A detailed analysis of the mechanisms responsible for the creation of traps during irradiation is performed. The creation of the traps in the oxide, near and at the silicon/silicon-dioxide (Si/SiO_2) interface during irradiation is modelled very well. This modelling can also be used for other MOS transistors containing SiO_2. The behaviour of radiation traps during postirradiation annealing is analysed, and the corresponding functions for their modelling are obtained. The switching traps (STs) do not have significant influence on threshold voltage shift, and two radiation-induced trap types fit the fixed traps (FTs) very well. The fading does not depend on the positive gate voltage applied during irradiation, but it is twice lower in case there is no gate voltage. A new dosimetric parameter, called the Golden Ratio (GR), is proposed, which represents the ratio between the threshold voltage shift after irradiation and fading after spontaneous annealing. This parameter can be useful for comparing MOS dosimeters.

https://doi.org/10.1016/j.micpro.2022.104486

A design concept for radiation hardened RADFET readout system for space applications

Check for updates

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ARTICLE INFO

Keywords:
RADFET
Radiation hardness
Absorbed dose
Dose rate
Self-adaptive MPSoC

ABSTRACT

Instruments for measuring the absorbed dose and dose rate under radiation exposure, known as radiation dosimeters, are indispensable in space missions. They are composed of radiation sensors that generate current or voltage response when exposed to ionizing radiation, and processing electronics for computing the absorbed dose and dose rate. Among a wide range of existing radiation sensors, the Radiation Sensitive Field Effect Transistors (RADFETs) have unique advantages for absorbed dose measurement, and a proven record of successful exploitation in space missions. It has been shown that the RADFETs may be also used for the dose rate monitoring. In that regard, we propose a unique design concept that supports the simultaneous operation of a single RADFET as absorbed dose and dose rate monitor. This enables to reduce the cost of implementation, since the need for other types of radiation sensors can be minimized or eliminated. For processing the RADFET's response we propose a readout system composed of analog signal conditioner (ASC) and a self-adaptive multiprocessing system-on-chip (MPSoC). The soft error rate of MPSoC is monitored in real time with embedded sensors, allowing the autonomous switching between three operating modes (high-performance, de-stress and fault-tolerant), according to the application requirements and radiation conditions.

https://doi.org/10.3390/electronics11060918

Communication

Commercial P-Channel Power VDMOSFET as X-ray Dosimeter †

Goran S. Ristić [1,*], Stefan D. Ilić [1,2], Sandra Veljković [1], Aleksandar S. Jevtić [1], Strahinja Dimitrijević [1], Alberto J. Palma [3], Srboljub Stanković [4] and Marko S. Andjelković [5]

Abstract: The possibility of using commercial p-channel power vertical double-diffused metal-oxide-semiconductor field-effect transistors (VDMOSFETs) as X-ray sensors is investigated in this case study. In this aspect, the dependence of sensitivity on both the gate voltage and the mean energy for three X-ray beams is examined. The eight gate voltages from 0 to 21 V are applied, and the dependence of the sensitivity on the gate voltage is well fitted using the proposed equation. Regarding X-ray energy, the sensitivity first increases and then decreases as a consequence of the behavior of the mass energy-absorption coefficients and is the largest for RQR8 beam. As the mass energy-absorption coefficients of SiO_2 are not found in the literature, the mass energy-absorption coefficients of silicon are used. The behavior of irradiated transistors during annealing at room temperature without gate polarization is also considered.

Keywords: VDMOSFETs; X-ray; irradiation; sensitivity; fading

Citation: Ristić, G.S.; Ilić, S.D.; Veljković, S.; Jevtić, A.S.; Dimitrijević, S.; Palma, A.J.; Stanković, S.; Andjelković, M.S. Commercial P-Channel Power VDMOSFET as X-ray Dosimeter. *Electronics* **2022**, *11*, 918. https://doi.org/10.3390/electronics11060918

Academic Editors: Padmanabhan Balasubramanian and Lidia Dobrescu

http://doi.org/10.1049/mna2.12119

Fading of pMOS dosimeters over a long period of time

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Funding information
European Union's Horizon 2020 research and innovation programme, Grant/Award Number: 857558; Ministry of Education, Science and Technological Development of the Republic of Serbia, Grant/Award Number: (Project No. 43011).

Abstract

The fading of radiation-sensitive p-channel metal-oxide-semiconductor field-effect transistors (known as RADFETs or pMOS dosimeters) over a long time period of 10 years after irradiation has been investigated. Fading is, in addition to sensitivity, another characteristic of pMOS radiation dosimeters. It is considered as the recovery of threshold voltage of irradiated pMOS dosimeters during ambient annealing without gate polarization. Usually, there are the fading data for few months after irradiation only. Although fading is a very important dosimetric characteristic, here it is given for the first time in the literature in such a long period of time. Two types of pMOS dosimeters with oxide thicknesses of 400 and 1000 nm are used. They are irradiated without and with a 5 V polarization on the gate. For the first time, the authors came to a very significant result that the key role in fading has the voltage applied during irradiation, but not the thickness of the oxide, and that the pMOS dosimeters irradiated with gate voltage of 5 V have greater fading than pMOS dosimeters irradiated without a gate voltage. Fitting of threshold voltage shift and fading, performed using the radiation-induced E_γ and E_s traps, shows very good agreement with the experimental values.

https://doi.org/10.1142/S0218126622400035

Response of Commercial P-Channel Power VDMOS Transistors to Ionizing Irradiation and Bias Temperature Stress

Sandra Veljković, Nikola Mitrović, Vojkan Davidović, Snežana Golubović, Snežana Djorić-Veljković, Albena Paskaleva, Dencho Spassov, Srboljub Stanković, Marko Andjelković, Zoran Prijić, Ivica Manić, Aneta Prijić, Goran Ristić and Danijel Danković

Abstract

In this paper, the effects of successively applied static/pulsed negative bias temperature (NBT) stress and irradiation on commercial p-channel power vertical double-diffused metal-oxide semiconductor (VDMOS) transistors are investigated. To further illustrate the impacts of these stresses on the power devices, the relative contributions of gate oxide charge (N_{ot}) and interface traps (N_{it}) to threshold voltage shifts are shown and studied. It was shown that when irradiation without gate voltage is used, the duration of the pre-irradiation static NBT stress has a slightly larger effect on the radiation response of power VDMOS transistors. Regarding the fact that the investigated components are more likely to function in the dynamic mode than the static mode in practice, additional analysis was focused on the results obtained during the pulsed NBT stress after irradiation. For the components subjected to the pulsed NBT stress after the irradiation, the effects of N_{ot} neutralization and N_{it} passivation (usually related to annealing) are more enhanced than the components subjected to the static NBT stress, because only a high temperature is applied during the pulse-off state. It was observed that in devices previously irradiated with gate voltage applied, the decrease of threshold voltage shift is significantly greater during the pulsed NBT stress than during the static NBT stress.

https://doi.org/10.1016/j.microrel.2022.114726

PS-BBICS: Pulse stretching bulk built-in current sensor for on-chip measurement of single event transients

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A R T I C L E I N F O

Keywords:
Bulk built-in current sensor
Single event transients
Soft errors

A B S T R A C T

The bulk built-in current sensor (BBICS) is a cost-effective solution for detection of energetic particle strikes in integrated circuits. With an appropriate number of BBICSs distributed across the chip, the soft error locations can be identified, and the dynamic fault-tolerant mechanisms can be activated locally to correct the soft errors in the affected logic. In this work, we introduce a pulse stretching BBICS (PS-BBICS) constructed by connecting a standard BBICS and a custom-designed pulse stretching cell. The aim of PS-BBICS is to enable the on-chip measurement of the single event transient (SET) pulse width, allowing to detect the linear energy transfer (LET) of incident particles, and thus assess more accurately the radiation conditions. Based on Spectre simulations, we have shown that for the LET from 1 to 100 MeV cm^2 mg^{-1}, the SET pulse width detected by PS-BBICS varies by 620–800 ps. The threshold LET of PS-BBICS increases linearly with the number of monitored inverters and it is around 1.7 MeV cm^2 mg^{-1} for ten monitored inverters. On the other hand, the SET pulse width is independent of the number of monitored inverters for LET > 4 MeV cm^2 mg^{-1}. It was shown that supply voltage, temperature and process variations have strong impact on the response of PS-BBICS.