RAD 10th Jubilee Spring Edition — INTERNATIONAL CONFERENCE ON RADIATION IN VARIOUS FIELDS OF RESEARCH
June 13-17, 2022 | Herceg Novi | Montenegro
BOOK OF ABSTRACTS

Behaviour of pMOS dosimeters during and after X-rays

Sandra Veljković[1], Stefan D. Ilić[1,2], Russell Duane[3], Marko S. Anđelković[4], Alberto J. Palma[5], Goran S. Ristić[1]

1 Applied Physics Laboratory, Faculty of Electronic Engineering, University of Niš, Niš, Serbia
2 Center of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Belgrade, Serbia
3 Tyndall National Institute, University College Cork, Cork, Ireland
4 IHP - Leibniz-Institut für innovative Mikroelektronik, Frankfurt (Oder), Germany
5 University of Granada, Granada, Spain

https://doi.org/10.21175/rad.spr.abstr.book.2022.26.13

Since it is important to control and reduce the absorbed radiation dose to a minimum, the detection of ionizing radiation is of great interest. The main component that could be used for this detection is a p-channel metal oxide semiconductor (MOS) transistor, so-called pMOS dosimeter. The fundamental idea of using a pMOS dosimeter is to transform the induced threshold voltage shift - ΔV_T, into the absorbed radiation dose - D. Compared to other dosimetry systems, the advantage of the pMOS dosimeter includes the possibility to read the dosimetry information immediately and without causing damage, the ability to store the absorbed dose, broad dose range, extremely low power consumption, interoperability with microprocessors, and inexpensive pricing. Also, it is also possible to reduce the geometry of sensors so that they can fit into other devices. Among pMOS dosimeters, the radiation sensitive field effect transistors (RADFET) are very useful for absorbed dose measurement due to unique performances. However, they are more expensive because of additional manufacturing processes. This indicates the need to test other MOS transistors as well, such as commercial transistors in addition to RADFETs.

This paper investigates the behaviour of three different types of pMOS transistors as X-ray dosimeters during and after the irradiation. The first type of used components was RADFET transistor manufactured at the Tyndall National Institute Cork, Ireland, available under the code STD 9707. These components have the aluminum gate and gate oxide thickness (d_{ox}) around 400 nm and the threshold voltage (V_{To}) measured prior to the experiments was about -7.2 V. The second type of examined components was pMOS transistors MGD 1A, manufactured at the Electronic Industry Niš, with three different gate oxide thicknesses, 314, 727 and 1226 nm. The third investigated group of components was commercial p-channel power vertical double diffused metal-oxide-semiconductor field-effect transistors (commercial p-channel VDMOSFETs), IRF 9520 type of two manufacturers. These components have the d_{ox} approximately 100 nm. The performed experiment consisted of irradiation at room temperature with X-rays up to total dose value of 160 Gy, at the Vinča Institute of Nuclear Science, Belgrade, Serbia. During the irradiation, the gate, source and drain were grounded. After irradiation, the spontaneous annealing, representing the room-temperature annealing without a gate voltage, was monitored for about 3 months.

A significant increase of the threshold voltage shift during the irradiation was observed, in all groups of components. This increase was the most pronounced for MGD components, and the slightest at commercial IRF, for which d_{ox} was the smallest. Slight changes, which were more pronounced in the first period of annealing were observed in all components. Regarding the STD components, the most pronounced increase of ΔV_T was observed for components with metal lids. During the irradiation of MGD components, the largest changes of ΔV_T were noted for components with d_{ox} of 727 and 1226 nm, which contain an additional CVD process during the oxide growth. Observed changes in the threshold voltages are caused by the formed gate oxide traps (N_{ot}) and interface traps (N_{it}). The influence of the gate oxide traps is more pronounced over the interface traps because the examined components have thick oxides. Also, the greatest change in the gate oxide traps was observed in MGD components with additional CVD process during the oxide growth. Since the changes of N_{ot} and N_{it} affect ΔV_T, their variations also lead to a change in the dosimeter important parameter such as fading, which refers to the irradiated dosimeter's threshold voltage recovery during annealing. It was observed that the fading is increasing with time for all components, and it was positive for most of the components except for MGD 1A3 and for IRF 9520.

Acknowledgments: This work was supported by the European Union's Horizon 2020 under grant agreement No. 857558, and the Ministry of Education, Science and Technology Development of the Republic of Serbia under grant No. 43011.