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Lifetime Study of Electronic Devices for Extreme Radiation Conditions

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Background
Recent boom in radiation technology development and increasing number of its emerging applications bring new requirements on related devices. Electronic devices connected to all aspects of our lives today proceed presently with highest speed. However, they are sensitive to radiation. The study of radiation effect on electronic devices is important for increasing their lifetime and the reliability of the whole technology, when used in radiation harsh environment like space, large accelerators, nuclear reactors etc. Our University Centre of Electron Accelerators (UCEA) is equipped with modern research linear electron accelerator with convertor to X-rays. We have studied the effect of both the X-rays and the high energy electrons on lifetime of devices used in radiation extreme conditions. The CERN accelerator component was tested by high energy electrons, the semiconductor devices for the first Slovak satellite were irradiated by X-rays and the semiconductor detectors for radiation imaging and dosimetry were tested by high energy electrons and compared to the experimental results obtained by their gamma-ray and fast neutron irradiation.

Methodology
The devices were tested at linear electron accelerator UELR-5-1S with scanning pulsed beam at UCEA in Trenčín, Slovakia with 5 MeV electrons. The repetition rate of the beam pulse can be set in the range from 5 to 240 Hz, which enables the dose rate to be modified. The electron beam has been scanning the width of 40 cm and the irradiated object either moved beneath the scanning beam (CERN accelerator component) or was irradiated in steady mode (small objects).
The CERN accelerator component was irradiated by 5 MeV electrons up to a dose of 2 MGy, to reveal its most radiation sensitive parts. Various commercial semiconductor devices for the skCUBE satellite power supply unit were tested by electrons converted to X-rays up to a dose of 1300 Gy representing the dose obtained by satellite on its orbit during more than 3 years. Finally, the semiconductor detectors were irradiated by 5 MeV electrons studying the effect of radiation of their detection properties and compared to the effects of other kinds of radiation: the fast neutrons and gamma-rays.

Results and conclusions
Our study has proved the functionality of the CERN accelerator component, the engine for dipole precise positioning, up to 2 MGy. However, the plastic parts of the component were destroyed mechanically only and had to be removed in final product. The commercial semiconductor devices for satellite power unit from various manufacturers were tested up to a dose of 1300 Gy of X-rays. The tested voltage references exhibited increasing output voltage with applied dose, spoiling the reference functionality. In the second kind of device degradation, the functionality was preserved, but the input current dramatically increased (e.g. battery chargers). In the case of semiconductor detectors, some of their detection properties improved (energy resolution) at small doses (1-2 kGy) followed by their degradation. However, after 120 kGy dose of electrons, the detectors were still functional with acceptable detection properties.

Country/Organization invited to participate

Slovakia

Primary author: Ms SAGATOVA, Andrea (University Centre of Electron Accelerators, Slovak Medical University in Bratislava, Slovakia)

Co-authors: Mr ZATKO, Bohumir (Institute of Electrical Engineering, Slovak Academy of Sciences, Slovakia); Mr FULOP, Marko (University Centre of Electron Accelerators, Slovak Medical University in Bratislava, Slovakia); Mr MAGYAR, Martin (RMC Nova Dubnica, Slovakia); Mr RAFAJ, Michal (RMC Nova Dubnica, Slovakia); Mr HYBLER, Peter (University Centre of Electron Accelerators, Slovak Medical University in Bratislava, Slovakia); Mr NECAS, Vladimir (Institute of Nuclear and Physical Engineering, Slovak University of Technology in Bratislava, Slovakia)

Presenter: Ms SAGATOVA, Andrea (University Centre of Electron Accelerators, Slovak Medical University in Bratislava, Slovakia)

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