O34 - Performance of electronic devices submitted to X-rays and high energy proton beams.

M.A.G. Silveira(a), J.A. De Lima(c), K.H. Cirne(a), L. E. Seixas(c), M. D. L. Barbosa (b), M. H. Tabacniks(b), N. Added(b), N.H. Medina(b), S. Gimenez(c) , R.B.B. Santos and W. Melo(c).

(a)Centro Universitário da FEI, São Bernardo do Campo, São Paulo, Brazil.

(b)Instituto de Física da Universidade de São Paulo, São Paulo, Brazil.

(c)Centro de Tecnologia da informação Paulo Archer, São Paulo, Brazil.

The study of ionizing radiation effects on materials used in electronic devices is of great relevance. Our group is part of a research network focused on helping to develop the needs of the Brazilian spatial program [1], which is one of the strategic areas of the country. For this purpose and to initiate the training of human resources on the interactions and effects of various types of ionizing radiation on materials, the effect of gamma and X-rays, protons and heavy ions were studied on selected CMOS circuits. Radiation effects on the integrated circuits are usually divided into two categories: Total Ionizing Dose (TID), and cumulative dose that shifts the threshold voltage and increases transistor's off-state current; Single Events Effects (SEE), a transient effect can deposit charge directly in the device and disturb the properties of electronic circuits [2]. A preliminary study on the damage of CMOS electronic devices after exposure to proton beam and X-rays is shown. The total dose applied to the devices is a function of the proton energy, the beam current and the irradiation time. The device damage was mainly due to the effects known as Total Ionizing Dose (TID) [3]. In CMOS-type devices, the effects of ionizing radiation are the creation of electron-hole pairs in the oxide layer changing operation mode parameters of the electronic device [3]. Indirectly, there will also be changes in the device due to the formation of secondary electrons from the interaction of photons with the material, since the charge carriers can be trapped both in the oxide layer and in the interface. In this study we used the 1.7 MV 5SDH tandem Pelletron accelerator of the *Instituto de Física da USP* with a proton beam of 2.6 MeV. In figure 1 the I_{DS}xV_{GS} curves, varying the gate voltage from 0 to 3V are shown for conventional rectangular-gate transistors (RGT's). The devices were exposed to different doses, varying the beam current, and irradiation time with the accumulated dose reaching up to 3.2 Grad. To study the effect of X-rays on the electronic devices an XRD-7000 (Shimadzu) X ray diffraction setup was used as a primary X-ray source. The devices were irradiated with a total dose of approximately 2.3 Grad at a 22 Mrad/min-rate. In Figure 2 the subthreshold slope and the off-state drain-source current (I_{OFF}) of conventional RGT's as a function of radiation dose are shown. The current as a function of the applied voltage between drain and source, before, during and after each irradiation showed changes in the leakage current and the threshold voltage.

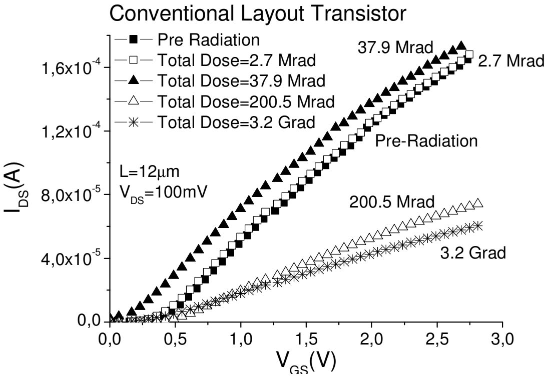

Figure 1. I_{DS}xV_{GS} plot of conventional CMOS irradiated with protons.

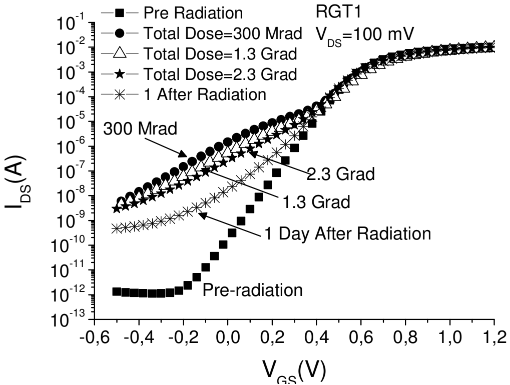

Figure 2. log(I_{DS})xV_{GS} plot of conventional CMOS irradiated with X-rays.

[1] S. Duzellier – "Radiation Effects on Electronic Devices in Space", Aerospace Science and Technology **9**, pp. 93-99, 2005.

[2] M. Boscherini et al., "Radiation demage of electronic components in space environment", Nucl. Inst. Of Met. Res. A, **514**, pp. 112-116, 2003.

[3] H. J. Barnaby, et al., "Proton radiation response mechanisms in bipolar analog circuits", IEEE Trans. Nucl. Sci., vol. **48**, no. 6, pp. 2074–2080, 2001.