Evaluation of dosimetric parameters for diagnostic X rays beams with radiation tolerant silicon diodes

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Introduction: The dosimetric characteristics of some radiation hard silicon diodes have been investigated in our group in radiation processing and clinical electron beam dosimetry [1]. Despite of the enhanced radiation tolerance of these devices, they still exhibited a sensitivity drop with the dose mainly in radiation processing applications. The origin of this effect is attributed to the decrease of both minority carrier diffusion lengths and active volume of unbiased diodes with the accumulated dose. A new approach to keep constant the active volume of silicon devices has been made by implanting the junction on a thin epitaxial (EPI) layer [2]. In this work we present the response of EPI diodes [3], in diagnostic radiology, RQR (50 up to 150 kV), tomography, RQT (100 to 150 kV) and ortovoltage, T (10 to 50kV) beams, including the calibration coefficient in terms of air kerma.

Experimental: The EPI diode used was processed [3] at 75 μm thick epitaxial silicon layer grown on a highly doped n-type 300 μm thick Czochralski (Cz) silicon substrate. The device was connected in the short-circuit current mode to the input of an electrometer (6517B Keithley®) and positioned at the center of an X-ray beam from a Pantak/Seifert generator, previously calibrated by standardized ionization chambers. The short-term repeatability, linearity, reproducibility, energy, angular and dose-rate dependence were investigated.

Results and Discussion: The dynamic current of the diode presented good short term repeatability with coefficients of variation (CV) less than 0.07% for all X ray beams. The current response of EPI diode has been shown to be very linear with dose-rate in the range of 1.6 up to 240 mGy/min (Fig. 1). The linear relation between charge and dose in the whole energy range is evidenced in Fig. 2, as well as the energy dependence. Angular dependence for diagnostic radiology (70 kV) beam was not significant within an angle range of ± 45º. The calibration coefficient, N_K, in terms of air kerma, was also determined. Studies about the reproducibility are under way.

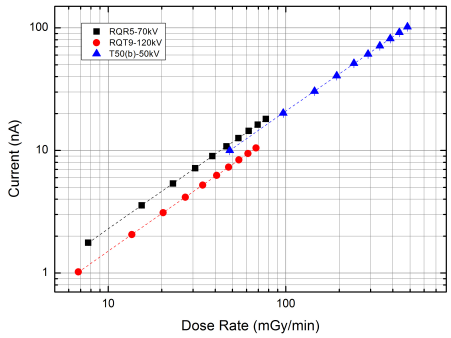

Fig. 1 - Current response as a function of dose rate for RQR (50 kV), RQT (120 kV) and T (50 kV) X rays beams.

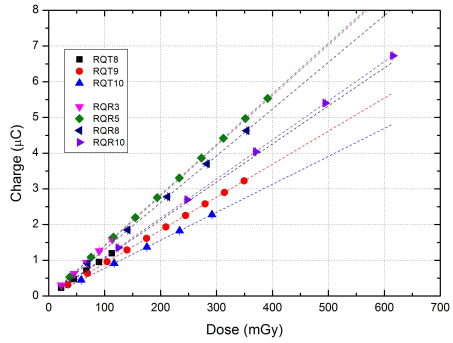

Fig. 2 - Charge-dose response for different RQR and RQT X rays beams.

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References:

[1] Santos, T. C. et al. **2011**. Evaluation of rad-hard epitaxial silicon diode in radiotherapy electron beam dosimetry. Radiat. Meas. *46*, 1662-1665.
[2] Bruzzi, M., et al., **2007**, Epitaxial silicon devices for dosimetry applications, Appl. Phys. Lett. 90, 172109.
[3] Lindstrom, G., et al., **2006**, Epitaxial silicon detectors for particle tracking-Radiation tolerance at extreme hadron fluences, Nucl. Instr. and Meth. A, 568, 66.