Energy Dependence of an Epitaxial Diode in Standard Diagnostic Radiology Beams

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The overall response of a radiation-hard epitaxial diode has been previously investigated for radiation diagnostic radiology qualities (RQR-3, RQR-5, RQR-8, and RQR-10) and computed tomography qualities (RQT-8, RQT-9, and RQT-10) beams. The EPI diode has a thin n-type epitaxial layer (25-75 μm) grown on a thick (300-500 μm) Czochralski silicon substrate and a p-n junction provided by a highly doped p-type silicon layer (≅ 1 μm). When operating as a dosimeter in the short-circuit current mode, the dosimetric parameters of the diode regarding repeatability (< 0.3%), long-term stability (0.4%/year), angular response (< 3%, ± 5º), dose rate dependence (< 3%), and signal-to-noise ratio (≥ 1500) fully adhered to the IEC 61674 recommendations [1]. However, compliance with the energy dependence requirement (≤ 5%) was not achieved for RQR-10 and RQT-10 beams, with average energies of 60 keV upward. This unexpected dependence, experimentally manifested by variations in the charge sensitivities, might be associated with the physical phenomena underlying the photon interaction with the complex design of the EPI diode. This work aims to provide a theoretical basis for the data previously gathered with the EPI diode and validate its use as a dosimeter for low-energy photon beams. It has been accomplished through current and charge sensitivities calculations considering the diode as a thin abrupt junction supported on a highly doped Czochralski substrate, the minority carriers' diffusion lengths, and the X-ray energy spectra from a Pantak-Seifert 160HS Isovolt X-ray generator. The theoretical results are compared to the experimental ones, as visible in Fig.1. Despite the overall data agreement in the low-energy region, the discrepancy between the experimental and calculated values for photons of 60 keV upward remains to be investigated. Studies in this direction are underway.

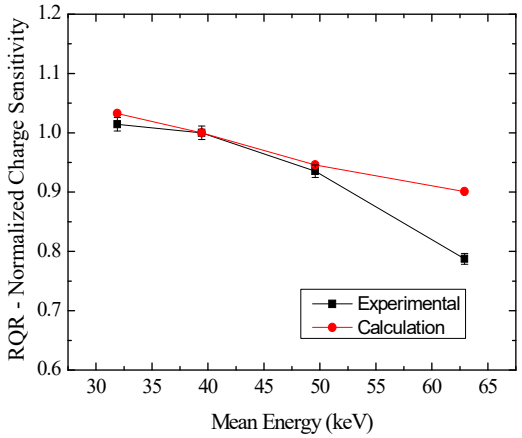

Fig. 1. Comparison between theoretical and experimental RQR charge sensitivities of EPI diodes.

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Reference

[1] IEC 61674, Medical Electrical Equipment - Dosimeters with Ionization Chambers and/or Semiconductor Detectors as used in X-Ray Diagnostic Imaging, second ed. (2012).