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109-1 Performance of a thin epitaxial diode as a relative dosimeter in radiation protection

Authors:

Josemary A. C. Gonçalves (IPEN-CNEN/SP - Instituto de Pesquisas Energéticas e Nucleares) ; Patrícia de Lara Antonio (IPEN-CNEN/SP - Instituto de Pesquisas Energéticas e Nucleares) ; Leonardo Carmargo dos Santos (IPEN-CNEN/SP - Instituto de Pesquisas Energéticas e Nucleares) ; Maria da Penha Albuquerque Potiens (IPEN-CNEN/SP - Instituto de Pesquisas Energéticas e Nucleares) ; Linda V. E. Caldas (IPEN-CNEN/SP - Instituto de Pesquisas Energéticas e Nucleares) ; Carmen Cecília Bueno (IPEN-CNEN/SP - Instituto de Pesquisas Energéticas e Nucleares)

Abstract:

Silicon diodes have been used as relative dosimeters in radiation protection, medical imaging, and radiation therapy. Usually, the diode operates in the short-circuit current mode and remains unbiased to minimize the dark current contribution to the radiation-induced current signal. The dosimetric parameter is the net output current linearly dependent on the dose rate within certain limits. The corresponding collected charge (obtained as the integral of the current signal) is proportional to the dose.

Many articles in the literature report several advantages of diode-based dosimeters despite a key drawback regarding their sensitivity decay with increasing accumulated doses. This issue has been tackled by developing devices with different geometries or tailoring the impurity density in the silicon bulk grown through distinct techniques. A combined approach of these strategies outcomes the epitaxial diode under investigation in this work. It has a thin n-type epitaxial layer (50 μm, 25 mm^2) grown on a 300 μm Cz Si substrate. The p^+-n junction is provided by a highly doped p-type silicon layer (≅ 1 μm) on the front side of the diode. This structure, which keeps the active volume constant with a tiny entrance window and negligible dark current, opens up potential applications for radiation protection dosimetry.

The diode is housed in a light-tight polymethylmethacrylate probe with an entrance window covered by a thin (8.3 mg/cm^2) black paperboard. The planar pad (p^+) signal electrode is directly connected to the input of a Keithley® 6517B electrometer with the backplane n^+ grounded and the guard ring structure floating. The current measurements are performed in the short-circuit mode without externally applied voltage to the diode.

The sensitivity, repeatability, reproducibility, dose-response linearity, and directional response are evaluated for N60, N80, N100, and N150 beam qualities [1]. Irradiations are performed with a Pantak-Seifert 160HS Isovolt X-ray generator previously standardized by a Radcal 10X5-180 ionization chamber calibrated at the PTB. The probe is positioned at the center of a circular irradiation field of 42 cm diameter, with 99% homogeneity, at 250 cm from the X-ray tube (focal spot).

The current signals produced by photon beams of different qualities (60 -150 kV) are stable and characterized by repeatabilities better than 5%. The dose-responses curves are also linear but slightly dependent on the photon energy. The angular dependence and long-term stability parameters remain to be investigated. To give theoretical support to the data sensitivity calculations, assuming the diode is a thin abrupt junction, are underway.

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Keywords:

Epitaxial diode, Rad-hard diode, Dosimetry, Radiation protection dosimetry