Current response stability of a commercial PIN photodiode for low dose radiation processing applications

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The increasing interest in low-dose (<100 Gy) radiation processing applications, as irradiation of blood for transplants and substerelization of insects, has demanded efforts to develop reliable dosimetry systems with high sensitivity, good spatial resolution and stable response over the range of 5-100 Gy. Silicon diodes fulfil these requirements and their uses in diode-based dosimeters are deemed appropriate with the advantage of providing prompt dose-rate and dose results. However, due to the low radiation tolerance of such dosimeters, they are rarely employed in radiation processing, where absorbed doses of tens of kGy can be easily achieved in regular applications.

Experimentally, the low radiation hardness of ordinary silicon diodes operating in current mode manifests itself in a rapid drop of their current sensitivities with increasing accumulated doses. This effect is physically attributed to the decrease of the diffusion length of minority charge carriers, due to traps and defects induced by radiation in the silicon bulk, leading to the decrease of sensitive volume of the diode. Consequently, it is expected that thin diodes (with negligible thickness compared with the minority carrier diffusion lengths) are almost insensitive to variations of diffusion lengths and hence more resistant to radiation damage effects. From this assumption, a semiconductor dosimeter system was developed based on a commercial thin photodiode (type SFH206K) in a p-layer/intrinsic/n-layer (PIN) structure operating in short-circuit current mode.

In this work, the response of this diode as a dose-rate meter has been investigated with respect the linearity between dose-rate and current, particularly addressing the stability of the current sensitivity with the absorbed dose. The dose was gathered off-line by the integration of the current signal during the exposure time. Irradiations were performed in both ^{60}Co facilities of Panoramic and Gamma Cell types, covering the dose-rate range 8-660 Gy/h.

The current-response of the diode proved to be linearly dependent on the dose-rate characterized by a current sensitivity of 0.2 nA.h/Gy. The stability of the current delivered by the diode for each dose-rate was evaluated as a function of the absorbed dose in several steps from 100 Gy to 15 kGy. In all measurements, current intensities were stable during the exposure time and proportional to the dose-rates with sensitivities variation less than 5% (k=2).

In an attempt to lend further theoretical support to these results, calculations of the current generated in the sensitive volume of the diode were performed taking into account its dimensions, dose-rates and the values of diffusion lengths available in the literature. Good agreement between theoretical and experimental results was achieved.

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