Dosimetric characterization of thin diodes in an electron beam facility for radiation processing

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Introduction: Silicon diodes have been employed as relative dosimeters in clinical photon and electron beams. However, they are prone to radiation damage that produces a drop of their current sensitivities with increasing accumulated doses. This effect is attributed to the decrease of the minority carrier diffusion lengths which diminishes the sensitive volume of the diode. Theoretically, it is possible to mitigate the decay of the current sensitivity by choosing diodes with thicknesses smaller than the lowest minority carrier diffusion lengths anticipated for the foreseen accumulated dose. This surmise has been followed up in this work by evaluating the response of thin diodes (SFH00206K) for the dosimetry of electron beams used in radiation processing.

Methods: The diode with 10 μm of depletion layer at 0V was produced on n type Si wafers of 220 μm thickness. As a dosimeter, the device was housed in a probe and connected to an electrometer to be operated in short-circuit current mode without bias voltage. To carry out the irradiation, the probe was placed on a conveyor belt that crosses the radiation field of a 1.5 MeV electron beam.

Results: The currents were registered as a function of the exposure time for dose-rates within 2-8 kGy/s and accumulated doses up to 350 kGy. The dosimeter was characterized with respect to the linearity between current and dose-rate, repeatability and reproducibility of the current signals. Its lifespan was investigated, particularly addressing the stability of the current sensitivity factor with increasing absorbed doses. The measurements were benchmarked against calculations of the current taking into account the fraction of the electron energy deposited in the active volume of the diode, the dose-rate, and the values of diffusion lengths.

Conclusion: All experimental data so far obtained prove that this diode can be used in electron beam dosimetry. Furthermore, a fair agreement was found between theoretical and experimental results.