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USE OF A PIN PHOTODIODE FOR DOSIMETRIC PURPOSES IN RADIATION PROCESSING

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ABSTRACT

In this work it will be presented the results obtained with a low cost commercial photodiode (SFH00206 – Siemens®) used as a gamma dosimeter for doses from 5 Gy up to 100 Gy in radiation processing. This dose range is encompassed by several industrial radiation applications carried out in the Radiation Technology Center at IPEN-CNEN/SP. The device photocurrent registered was linearly dependent on the dose rate with a sensitivity of 9.43 nA.Gy^{-1}.min. In all measurements, the current signals of the diode registered as a function of the exposure time were very stable. The accumulated charge in the diode as a function of the dose showed a linear response of the dosimeter with a correlation coefficient of about 0.9999.

1. INTRODUCTION

The proved efficiency of radiation processing in medical device sterilization and food preservation is contributing for a widespread use of gamma radiation in industrial applications. In this field, the radiation dosimetry is of uttermost importance for measuring with precision the doses in the product and contributing for validation processing [1]. Furthermore, the control of the industrial processes and the routine verification through the measure of the maximum, minimum and the distribution of dose, contribute for guarantee quality [2]. Dosimeters of polymethylmetacrylate (PMMA) are more widely used in industry [3], but not measure doses minor 100 Gy, such as required for irradiation blood (25 Gy). The necessity of providing the Radiation Processing Dosimetry Laboratory in the Radiation Technology Center at IPEN-CNEN/SP with dosimeters for measuring doses minor than 100 Gy (considered as low for industrial applications) allied with the possibility of improving the irradiation processes motivated the development of dosimetry system with diodes[4 – 7]

2. EXPERIMENTAL APPARATUS

The device under investigation is a photodiode type PIN model SFH-00206 manufactured by Siemens. The diode, whit an active area of 7.3 mm^2 and capacity of 72 pF at 0 V, is encapsulated in a polymer plastic of 1.2 mm of thickness [8]. The terminals were soldered at a 3 m long coaxial cable of 50 Ω of impedance. Temperature variations were monitored with thermocouple type k fixed so close sensible tip dosimeter (Figure 1). The diode and the thermocouple had been involved with 3 mm polyurethane and placed inside an acrylic pipe 270 x ∅ 12.5 mm. This probe was projected to facilitate handling, prevent the influence of the visible light, humidity and increase the resistance to mechanical damages. The dosimetric probe, presented in Figure 2, was connected in a photovoltaic mode to the input of a Keithley 617 electrometer with adjustable time resolution. Four Co-60 gamma facilities of IPEN-CNEN/SP had been used in this work: a irradiator Type I (Gammacell-220 - Atomic Energy of Canada Limited) and three panoramic irradiators Type II (Gammatron – Siemens AG, Panoramic - Yoshizawa Kiko Ltd and Multipurpose).

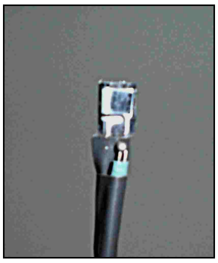

Figure 1. Photodiode SFH00206 and the thermocouple type K.

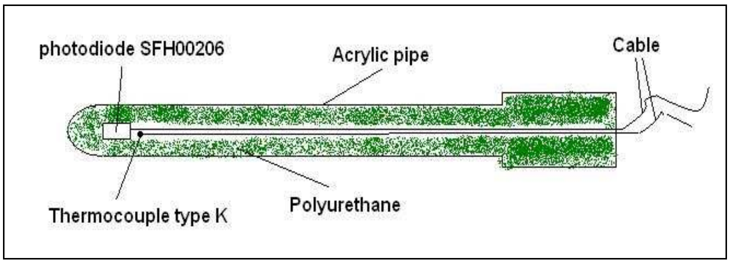

Figure 2. Dosimetric Probe.

3. RESULTS

The photocurrent generated in the sensitive volume of the diode as a function of exposure time to gamma-rays from irradiator Gammacell-220 (Atomic Energy of Canada Limited), with a dose rate of 39.8 Gy/min, is show at Figure 3. It is observed that current signals are very stable during the gamma-irradiation for doses up to 100 Gy. Results obtained with a dose rate of 12 Gy/min, obtained in the Gammacell-220 with a 70 % attenuator, are presented in Figure 4. Note that the absorbed dose is obtained by the integration of each current signal versus exposure time.

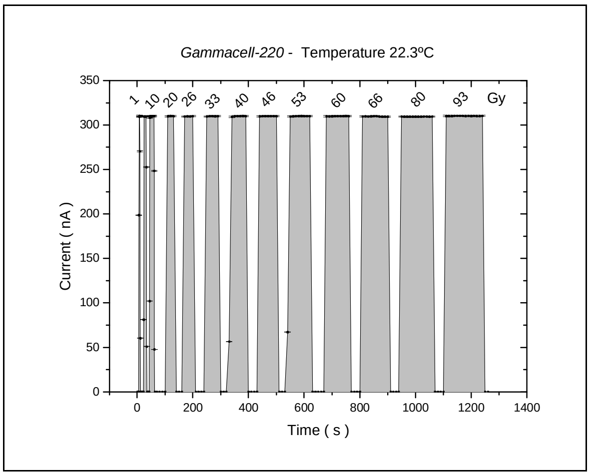

Figure 3. Current signal as a function of exposure time for dose rate 39.8 Gy/min

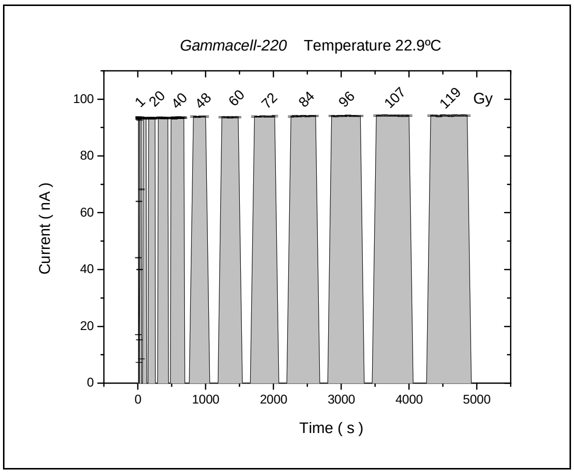

Figure 4. Current signal as a function of exposure time for dose rate 12 Gy/min

The probe was also tested in a Panoramic irradiator type II (Yoshizawa Kiko Co, Ltd), with a geometry completely different from Gammacell-220. Due to the fact that in this facility the reduction of dose rate is obtained by increasing the distance from the probe to the source, dose measurements were carried out at distances of 10 and 40 cm, which correspond to dose rates of 3.43 and 0.48 Gy/min, respectively. In such conditions, it was observed a reduction on current signals from 32.2 to 4.4 nA as can be seen in Figures 5 and 6. Both Figures evidencing that the current signals were very stable during the irradiation with different dose rates. It is also noted that to reach the same absorbed dose, the exposure time for 0.48 Gy/min was longer than the one required for 3.43 Gy/min.

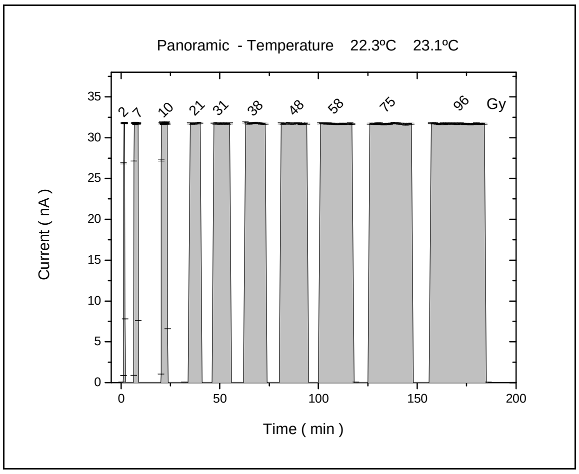

Figure 5. Current signal as a function of exposure time for dose rate 3.43 Gy/min

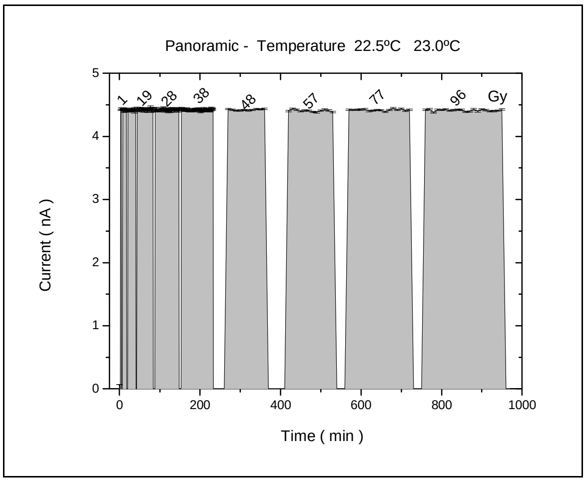

Figure 6. Current signal as a function of exposure time for dose rate 0,48 Gy/min

3.1. Calibration curve

The dosimeter calibration curve was achieved by the accumulated charge in the diode, obtained through the integration of recorded current signals during a time interval versus the total absorbed dose. The average calibration curves were obtained with the different dose rates got at Panoramic and Gammacell facilities. The linear dependence of the generated charge on total dose, with a correlation coefficient of about 0.9999, is presented in Figures 7 and 8. It is worth noting that, for each irradiator, the calibration curves obtained with different dose rates are coincident within the experimental errors.

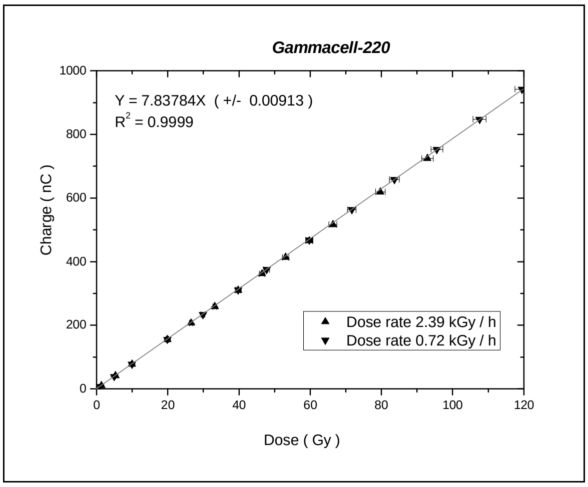

Figure 7. Calibration curves obtained at Gammacell-220.

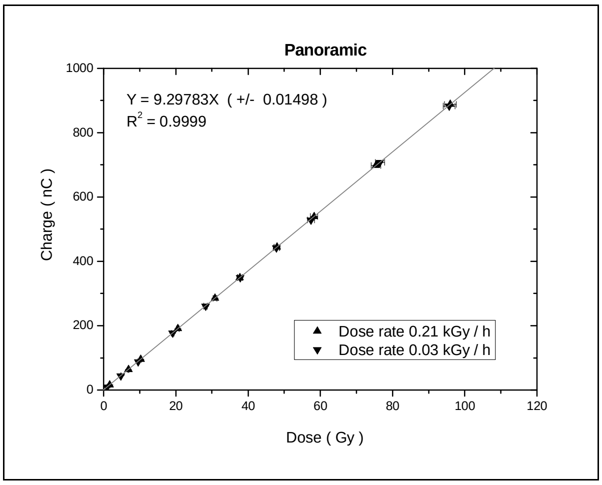

Figure 8. Calibration curves obtained at Panoramic irradiator.

3.2. Sensitivity

The diode photocurrent generated by the gamma rays from Co-60 as a function of the doses rate within the range of 6.1×10^{-2} to 1.9×10^{2} Gy/min is presented in Figure 9. In order to achieve the widest dose rate range possible, all gamma facilities at IPEN-CNEN/SP were used in these measurements. Despite of the wide dose rate range, the device response is linear with a sensitivity of 9.43 nA.Gy^{-1}.min.

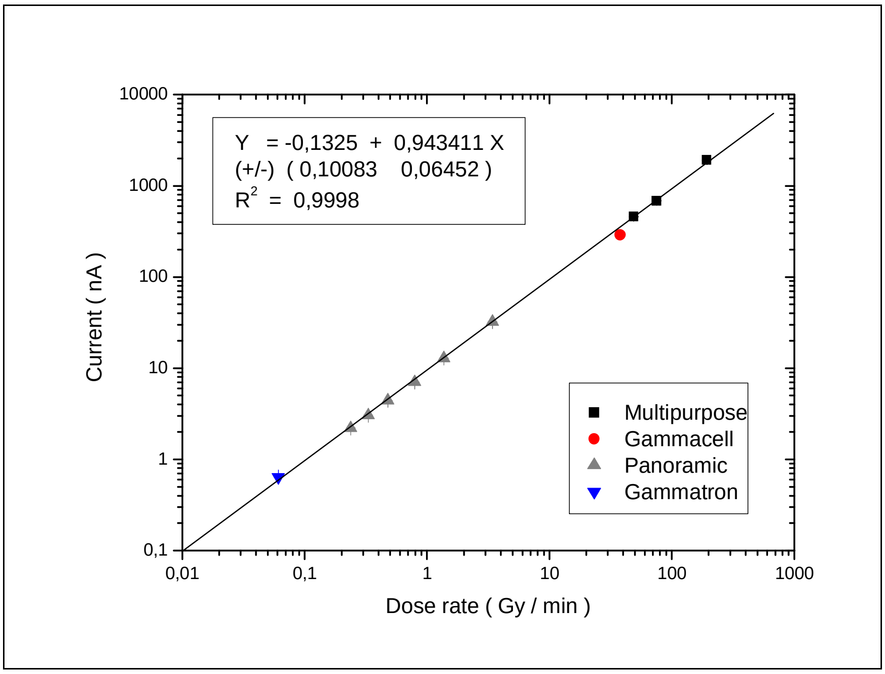

Figure 9. Current sensitivity versus dose rate.

4. CONCLUSIONS

The results obtained with the SFH00206 diode, operating in a photovoltaic mode, have shown stable current signals during gamma irradiation at Co-60 Panoramic and Gammacell facilities. The device dosimetric response, given by the accumulated charge in the diode as a function of the absorbed dose, was linear (correlation factor of 0.9999) for doses up to 100 Gy.

The total independence of the diode sensitivity (9.43 nA.Gy^{-1}.min) with dose rates from 6.1x10^{-2} to 1.9x10^{2} Gy/min allied with the current signals stability during the exposure times indicates that the SFH00206 diode can be used for dosimetric purposes in irradiation processes that involve absorbed doses up to 100 Gy.

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