Studies of the Sensitivity Dependence of Float Zone Silicon Diodes on Gamma Absorbed Dose

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Speaker
In this work it is presented the dosimetric results obtained with a batch of nine junction silicon diodes, developed in the framework of CERN RD50 Collaboration, as on-line gamma dosimeters. The samples irradiation was performed using a $^{60}$Co irradiator (Gammacell 220) which delivers a dose-rate of 2 kGy/h. The diodes were irradiated with different doses from 5 kGy up to 50 kGy.

Keywords: Rad-hard silicon diodes, gamma dosimetry.
1. Introduction

Several advantages of silicon diodes which include small size, low cost, high sensitivity and wide availability, make them suitable for dosimetry and for radiation field mapping [1]. However, the small radiation tolerance of ordinary silicon devices has imposed constraints on their application in intense radiation fields such as found in industrial radiation processes. This scenario has been changed with the development of radiation hard silicon devices to be used as track detectors in high-energy physics (HEP) experiments. Currently, the most used devices in HEP are grown by the float zone (FZ) technique, due to their high purity and resistivity [2-3].

These results associated with previous results obtained in our research group with rad-hard Si diodes [1,4] have encouraged us to evaluate the stability of FZ silicon diodes response as online gamma dosimeter.

2. Materials and methods

The n type FZ diodes used in this work, with active area of 25 mm², were processed by the Microelectronics Center of Helsinki University of Technology on Si wafer of 300 µm thickness and resistivity of 10 kΩ.cm. The nine samples were irradiated at CTR-IPEN-CNEN/SP with gamma rays from a ⁶⁰Co source (Gammacell 220 – Nordion) in order to each diode received different doses from 5 kGy up to 50 kGy (5, 10, 15, 20, 25, 30, 35, 40 and 50 kGy).

During the irradiation, the unbiased diodes were connected through a low-noise coaxial cable to the input of a KEITHLEY® 617 electrometer, in order to monitor the devices photocurrent as a function of the exposure time. The devices were enclosed in a black PMMA chamber to provide protection from mechanical stress and light.

3. Results

The current values obtained during the samples irradiation are presented in Figure 1. The currents decreased about 3% and 19% for samples that absorbed 5 kGy and 50 kGy, respectively. This drop was expected since the sensitivity of the diodes falls with the radiation dose [5].

All the samples exhibited the same current response behaviour; however, the values are slightly different. This difference can be observed from the Figure 2 that shows an enlargement of the graph shown in Figure 1 for absorbed doses up to 5 kGy. The maximum difference between the current values obtained during the irradiation steps in this interval was about 3%.

The dosimetric parameter utilized to study the response of these devices was the charge (obtained through the integration of the current signals) as a function of the exposure time. The dose-response curve of this batch of diodes is shown in the Figure 3.
FIGURE 1. Current values obtained during the irradiation steps as a function of exposure time to each sample.

FIGURE 2. Current values obtained during the irradiation steps as a function of exposure time to each sample up to 5 kGy of absorbed dose.
According to Figure 3, a second order polynomial was fitted to dose-response curve. In order to evaluate the reproducibility of the devices, we have compared the charge generated in the samples for an absorbed dose about 5 kGy. The results are presented in Figure 4.

The maximum variation of the charge was about 3%. It is important to note that these results are better than those obtained with routine polymethylmetacrilate (PMMA) dosimeters used in radiation processing dosimetry [6].
4. Conclusions

The results obtained show that the dosimetric response of FZ devices for the batch analyzed presents a small and acceptable variation. In addition, the good result from reproducibility study indicates that these devices can be used as on-line dosimeter in gamma radiation processing.

Complementary dosimetric characteristics of the FZ diodes still remains under study in our research group.

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References


