Sensitivity of Magnetic Czochralski Silicon Diode for Gamma-Radiation Dosimetry

Fábio de Camargo  
IPEN-CNEN/SP, Cx. Postal 11049, CEP: 05.422-970 - São Paulo/SP, Brazil

Helen Jamil Khoury  
UFPE, Brazil

Eija Tuominen, Jaakko Härkönen  
Helsinki Institute of Physics, Finland

Josemary A. C. Gonçalves, Carmen Cecília Bueno  
IPEN-CNEN/SP and PUC/SP, Brazil

The small radiation tolerance of ordinary silicon devices has imposed constraints on their application in intense radiation fields such as found in industrial radiation processing. Indeed, the radiation damage of silicon detectors has also been one of the major challenges from high-energy physics experiments and had led to a broad line of investigations world-wide to enhance the radiation tolerance of these devices. Among several approaches to perform this task, it was developed, in the framework of CERN RD50 Collaboration, a high oxygen concentration and high resistivity magnetic Czochralski (MCz) Si detector which is a good candidate for improved radiation hardness. This device is a p⁺-n-n⁺ junction diode made on n-type MCz Si wafer (300 μm thickness, active area of 36 mm² and nominal resistivity of about 900 Ω cm) with a multiple guard ring (MGR) structure around the contact pads, manufactured by Okmetic Oyj and processed by the Microelectronics Center of Helsinki University of Technology.

In this work, it has been investigated the performance of the MCz diode intended for gamma-radiation dosimetry in irradiation processes that have been carried out in the Radiation Technology Center (CTR) at IPEN-CNEN/SP. The device was enclosed in a chamber of black PMMA to provide protection from mechanical stress, light and moisture. The signal electrode (p⁺) was connected in a photovoltaic mode to the input of a Keithley 617 electrometer. The diode’s dark current measured at room temperature (typically 25 °C) was about 20 pA. The irradiation was performed using a 60Co source available in facilities of Gammacell 220 and Panoramic Source in CTR, with different dose rates with rastreability through the International Dose Assurance Services (IDAS) from IAEA. The measurements of the average radiation-induced current of the MCz diode were carried out as a function of the dose rates from 3.54 Gy/h up to 2.82 kGy/h. In this range, the diode response was linear and the sensitivity obtained was (0.46 ± 0.01) μA/(kGy/h). However, it still remains to be investigated the reproducibility and reliability of the MCz diode measurements as well as the radiation damage related to higher total doses. These studies are under way.