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Radiation tolerance of epitaxial silicon carbide detectors for electrons and γ-rays

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Abstract

Particles detectors were made using semiconductor epitaxial 4H-SiC as the detection medium. The investigated detectors are formed by Schottky contact (Au) on the epitaxial layer and an ohmic contact on the backside of 4H-SiC substrates with different micropipe densities from CREE. For radiation hardness studies, the detectors have been irradiated with electrons (8.2 MeV) and γ-rays (^{60}Co source) at fluences and doses ranging from 0 to 9.48×10^{14} e/cm^2 and 40 Mrad, respectively. We present experimental data on the charge collection properties by using 4.14 MeV α-particles impinging on the Schottky contact. Hundred percent Charge Collection Efficiency, CCE, is demonstrated for reverse voltages higher than the one needed to have a depletion region equal to the α-particle projected range, even after the irradiation at the highest dose. By comparing measured CCE values with the outcomes of drift–diffusion simulations, values are inferred for the hole lifetime, τ_p, within the neutral region of the charge carrier generation layer. τ_p was found to decrease with increasing radiation levels, ranging from 300 ns in non-irradiated detectors to 3 ns in the most irradiated ones. The diffusion contribution of the minority charge carriers to CCE is pointed out.

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Keywords: Radiation hardness; Device simulation; Silicon carbide; Semiconductor detectors; Charge-particle spectroscopy

1. Introduction

It was shown that silicon carbide (SiC) is a useful material for the realisation of neutron [1] and charge particle [2–4] detectors, of dosimeters [5] and spectrometers [6], showing good performances and the potential of operating in high radiation damage environments [4–7].

There has always been considerable interest in studying irradiation damage. This is due to its interesting physics as well as the technological importance.

High-energy particle bombardment, such as proton, neutron, electron and pion irradiation, as well as γ-ray irradiation, is often used [8–11].

Such an irradiation can create vacancies, interstitials and their associated defects. In a

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