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Radiation tolerance of epitaxial silicon carbide detectors for electrons, protons and gamma-rays

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Abstract

Particle 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 back side of 4H–SiC substrates with different micropipe densities from CREE. For radiation hardness studies, the detectors have been irradiated with protons (24 GeV/c) at a fluence of about 10^{14} cm^{-2} and with electrons (8.2 MeV) and gamma-rays (^{60}Co source) at doses ranging from 0 to 40 Mrad. We present experimental data on the charge collection properties by using 5.48, 4.14 and 2.00 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

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