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

F. Navaa,∗, E. Vittoneb, P. Vannic, G. Verzellesi, P.G. Fuochie, C. Lanzierif, M. Glaserg

aINFN and Dipartimento di Fisica, Università di Modena e Reggio Emilia, Via G. Campi 213/A, I-41100 Modena, Italy
bDipartimento di Fisica Sperimentale, Università di Torino, INFM-UniTo e INFN-To Italy
cCNR-Istituto LAMEL, Bologna, Italy
dINFN and DSI, Università di Modena e Reggio Emilia, Italy
eCNR-Istituto ISOF, Bologna, Italy
fAlenia Marconi Systems, Roma, Italy
gCERN, Division EP TAI-SD, Geneve, Switzerland

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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 $\alpha$-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 $\alpha$-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, $\tau_p$, within the neutral region of the charge carrier generation layer. $\tau_p$ 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.

$^{\ast}$Corresponding author. Tel.: +39-059-20-55260; fax: +39-059-20-55235.
E-mail address: nava.filippo@unimo.it (F. Nava).

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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