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Investigation of Ni/4H-SiC diodes as radiation detectors with low doped n-type 4H-SiC epilayers

F. Nava[a,*], G. Wagner[b], C. Lanzieri[c], P. Vanni[a], E. Vittone[d]

[a] *INFN and Dipartimento di Fisica, Università di Modena e Reggio Emilia, Via G. Campi 213/A, Modena 41100, Italy*
[b] *Institut für Kristallzüchtung, Max-Born-Strasse 2,Berlin D-12489, Germany*
[c] *Alenia Marconi Systems, Roma, Italy*
[d] *Dipartimento di Fisica Sperimentale, Università di Torino, INFM-UniTo e INFN-To, Torino, Italy*

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Abstract

The development of SiC minimum ionising particle (MIP) detectors imposes severe constrains in the electronic quality and the thickness of the material due to the relatively high value of the energy required to produce an electron–hole pair in this material by MIP against the value for Si. In this work, particle detectors were made using semiconductor epitaxial undoped n-type 4H-SiC as the detection medium. The thickness of the epilayer is on the order of 40 μm and the detectors are realised by the formation of a nickel silicide on the silicon surface of the epitaxial layer (Schottky contact) and of the ohmic contact on the back side of 4H-SiC substrate. The low doping concentration ($\cong 6 \times 10^{13}\,cm^{-3}$) of the epilayer allows the detector to be totally depleted at relatively low reverse voltages ($\cong 100\,V$). We present experimental data on the charge collection properties by using 5.486 MeV α-particles impinging on the Schottky contact. A 100% charge collection efficiency (CCE) is demonstrated for reverse voltages higher than the one needed to have a depletion region equal to the α-particle extrapolated range in SiC. The diffusion contribution of the minority change carriers to CCE is pointed out. By comparing measured CCE values to the outcomes of drift–diffusion simulation, values are inferred for the hole lifetime within the neutral region of the charge carrier generation layer.

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

1. Introduction

Silicon carbide (SiC) is one of the compound semiconductors studied for the development of high-power and high-temperature electron devices and integrated circuits [1,2]. During the last 3 years, SiC has also been considered for the realisation of neutron and charge-particle detectors, dosimeters and spectrometers, showing good performance and the potential of operating in hostile environments [3–10]. In addition, the availability of relatively large (2 in.) SiC wafers opens the field for microstrip detectors for particle tracking in areas with high radiation load at future

*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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