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Nuclear Instruments and Methods in Physics Research A 583 (2007) 177–180
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

Performances of 4H-SiC Schottky diodes as neutron detectors

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Available online 4 September 2007

Abstract

Large area 4H-SiC Schottky diodes equipped with a ^{6}LiF converter were tested as neutron detectors in the epithermal column realized for Boron Neutron Capture Therapy (BNCT) applications at the fast reactor TAPIRO (ENEA Casaccia Roma). The neutron spectra were assessed using the Monte Carlo code MCNP-4C. The performances of SiC detectors were evaluated with neutron fluences in the range of 10^{9}–10^{13} cm^{-2} which is typical for BNCT. Spectra of alpha and tritium particles generated by ^{6}Li(n,α)^{3}H reaction were collected at various neutron fluences and spectra obtained by interposing polyethylene moderators of different thickness. Only weak damaging effects primarily due to the alpha particles were observed; at neutron fluence of 10^{13} cm^{-2} the count rate decreased by $<0.3\%$. The experimental results were compared with the theoretical ones calculated using MCNP-4C and SRIM codes.

PACS: 29.40.Wk; 87.53.Pb

Keywords: Radiation detector; Neutron detection; Boron neutron capture therapy; Epitaxial silicon carbide; Neutron beam monitoring; MCNP

1. Introduction

It is well known that 4H-SiC Schottky diodes can be used as neutron detectors via neutron-induced charged particles produced by converters like ^{6}LiF. The capabilities of such type of detectors to discriminate gamma from neutron signals were well established [1,2]. Moreover, the wide band gap makes SiC very suitable for high-temperature applications [2,3].

A possible use of 4H-SiC neutron detectors is the monitoring of neutron flux in Boron Neutron Capture Therapy (BNCT), where the total neutron fluence required for the treatment is around 10^{12} cm^{-2} [4]. In this field, the knowledge of the actual neutron flux and spectrum and the possibility of a priori simulation have an important role. In order to test the reliability of simulation methods and the capabilities of 4H-SiC detectors, the response to epithermal neutron fluxes realized for BNCT was studied [5]. Various neutron fluences and spectra obtained by interposing polyethylene moderators of different thickness were used and experimental results were compared with simulations by means of MCNP-4C and SRIM codes.

2. Experimental

4H-SiC detectors were made using a process described in a previous work [6]. 4H-SiC Schottky diodes, with large area Ni/Au electrodes (3 or 5 mm diameter), were realized by Alenia Marconi System JV (Rome) on 50 μm epitaxial layers, deposited by the Institute of Crystal Growth (IKZ, Berlin) on LMP n-type 4H-SiC wafers (purchased from CREE Res. Inc.). Circular ^{6}LiF converters, about 100 μm thick and with a diameter of 4.6 mm, were placed externally and close to the electrodes (the distance was smaller than 1 mm).

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doi:10.1016/j.nima.2007.08.241