PUB2001-6

Presented at 3rd E-MRS 2001 SPRING MEETING Palais des Congrès Strasbourg (France) June 5 - 8, 2001

ELSEVIER

Applied Surface Science 184 (2001) 448–454

applied surface science

www.elsevier.com/locate/apsusc

Investigation of 4H–SiC Schottky diodes by ion beam induced charge (IBIC) technique

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Abstract

Ion beam induced charge technique has been used in order to investigate the charge collection properties of 4H–SiC epitaxial Schottky barrier nuclear detectors. In this work, 2 MeV He ions microbeam about 2 μm spot size scanned the total surface area of the detector in order to obtain maps of the charge collection efficiency (CCE) at different bias voltages. The maps turned out to be very homogeneous, with the conclusion that energy resolution of the detectors is not affected by non-homogeneous broadening due to fluctuations of CCE. Fitting the experimental data obtained for low bias voltages—corresponding to depletion layer widths narrower than He ions range—was possible only by including the contribution of diffusion. By this way, holes diffusion length was determined to be 2 μm. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: SiC; Nuclear detectors; Scottky barrier; IBIC; Diffusion length; Charge collection efficiency

1. Introduction

In the past years, considerable progress has been made in the area of epitaxial growth of high purity SiC layers on top of bulk SiC substrates. Contrary to the past, when the performance of SiC nuclear detectors was dominated by the effect of impurities and defects, now it is possible to use the good radiation resistance and the large band gap (3.3 eV) of 4H–SiC in order to realize nuclear or radiation detectors capable of working at high temperatures, and in high-radiation fields with extremely low dark currents and with a relatively large signal-to-noise ratio [1].

A particular problem related to nuclear detectors is the presence of inhomogeneities in the active regions, due to fluctuations of transport properties or simply to geometrical details of the electrodes arrangement or realization, which could deeply affect the energy resolution of the entire device. A unique method [2] in order to assess the uniformity of the detector response is ion beam induced charge (IBIC), which consists in measuring the charge induced at the electrodes by the movement of the charge carriers (electrons and holes) generated by high energy ions which are suitably focused in the frontal electrode and deflected in order to raster either the total surface area or some particular ROI. By dividing the induced charge by the total generated charge, the charge collection efficiency (CCE) is obtained, which may be mapped as a function of the hit position of the ion. Space charge effects, due to the non-collected charge, or also radiation damage effects, due to defects creation in the bulk of the material, may be avoided by using very low ion currents, of the order of less than 1 fA, and by limiting data acquisition to few scans of the investigated area, since few events per pixel are

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0169-4332/01/$ – see front matter
PII: S0169-4332(01)00533-5