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Investigation of 4H-SiC Schottky diodes by ion and X-ray micro beam induced charge collection techniques

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Abstract

Silicon carbide has recently emerged as an attractive material for ionisation radiation detection. The high band gap and high radiation damage resistance should allow the fabrication of detectors capable to operate at high temperature and in high radiation fields. The development of SiC radiation detectors in the field of spectroscopy imposes severe constraints in the electronic quality and homogeneity of the material. In this work we present an investigation of the charge collection properties of ‘detector grade’ 4H-SiC Schottky diodes performed by means of the X-ray and ion beam induced charge collection (XBICC and IBIC) techniques. Such techniques allow the minority carrier diffusion length of the material to be evaluated and mapping of the transport properties to be performed with a spatial resolution of the order of 1 μm . 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. IBIC measurements were performed using protons of energy 0.7–1.7 MeV. The IBIC spectra show a complete charge collection generated by ionisation in the depletion region. Similar analysis was also performed in steady state conditions using data from photocurrent measurements carried out at European Synchrotron Radiation Facility using 3 keV photons. IBIC and XBICC maps were obtained by recording the mean pulse height and the mean photocurrent as a function of the photon or ion impact co-ordinates. The analysis of such maps allowed us to individuate the spatial distribution of defects and contact imperfections.

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1. Introduction

Silicon carbide is a useful material for the fabrication of electronic devices for high power, high temperature and high frequency applications. Moreover, the wide band-gap, large saturation velocity, large breakdown voltage, high thermal conductivity, and radiation hardness make silicon an attractive material also for the realisation of ionising radiation detection. The recent development of SiC high purity crystal growth and SiC epitaxy has allowed the realisation of charge particle [1], neutron [2], and X-ray [3] detectors and dosimeters [5]. However, the realisation of advanced device structures and improvements of the performances of such detectors impose severe constraints, which require new

and advanced characterisation techniques to check the electronic quality and the homogeneity of the material.

In this paper we present a characterisation of 4H-SiC epitaxial Schottky diodes by means of the micro-ion beam induced charge (IBIC) [4,6] and micro-X-ray beam induced current (XBIC) [7,8] techniques. These two microscopy techniques make use of scanning high-energy probes (MeV ions or keV photons) to image the transport properties of semiconductor materials and devices. IBIC consists of measuring the charge induced by the movement of free carriers generated by MeV ions. Similarly, XBIC consists of measuring the photocurrent induced by X-rays from a synchrotron light source. Both the ion and X-ray beams are focussed onto the Schottky electrode into micrometric spot. Uniformity analysis of the detector performances were then carried out by imaging the charge collection efficiency or the photocurrent by deflecting the beam (IBIC case) or moving the sample perpendicularly to beam direction

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