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Monte Carlo analysis of a lateral IBIC experiment on a 4H-SiC Schottky diode

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ABSTRACT

The transport properties of a 4H-SiC Schottky diode have been investigated by the ion beam induced charge (IBIC) technique in lateral geometry through the analysis of the charge collection efficiency (CCE) profile at a fixed applied reverse bias voltage.

The cross section of the sample orthogonal to the electrodes was irradiated by a rarefied 4 MeV proton microbeam and the charge pulses have been recorded as function of incident proton position with a spatial resolution of 2 μm.

The CCE profile shows a broad plateau with CCE values close to 100% occurring at the depletion layer, whereas in the neutral region, the exponentially decreasing profile indicates the dominant role played by the diffusion transport mechanism.

Mapping of charge pulses was accomplished by a novel computational approach, which consists in mapping the Gunn's weighting potential by solving the electrostatic problem by finite element method and hence evaluating the induced charge at the sensing electrode by a Monte Carlo method. The combination of these two computational methods enabled an exhaustive interpretation of the experimental profiles and allowed an accurate evaluation both of the electrical characteristics of the active region (e.g. electric field profiles) and of basic transport parameters (i.e. diffusion length and minority carrier lifetime).

1. Introduction

In the last 17 years, the measurement of the charge induced at sensitive electrodes in consequence of the irradiation of samples with light (mainly H or He) ions was successfully applied for the evaluation of the transport properties and the electrostatic features of numerous semiconductor basic devices, such as junction or Schottky diodes, solar cells, MOS diodes and to probe the effects of heavy ion irradiation on solid state detectors [1]. In order to exploit the full analytical capabilities of this technique, a theory based on fundamental electrostatic theorems and lemmas has been developed and validated by benchmark experiments [2,3]. All these experiments have been carried out in frontal geometry (i.e. irradiating the sensitive electrode) and the results have been interpreted by comparing the experimental profiles and images with maps of charge pulses accomplished by solving numerically the adjoint carrier continuity equations [4] by the finite element method [3].

The purpose of this paper is to present another approach to the problem of the evaluation of the induced charge, based on a simple, one-dimensional Monte Carlo algorithm. The experiment we have studied is the lateral IBIC analysis carried out for the first time on the epitaxial layer of a 4H-SiC Schottky diode. This experimental approach allows a direct and meaningful view of the mechanisms underlying the formation of the induced charge pulses, with a clear discrimination of the different contributions deriving from the charge generation in the depletion or neutral regions. The Monte Carlo method presented in this paper simulates the transport of carriers in the active region and takes into account both diffusion and drift mechanisms.

2. Experiment

2.1. Experimental set-up

The sample under test is a Schottky diode fabricated by Alenia Marconi Systems on an *n*-type (around 50 μm thick) epitaxial layer produced by the Institut für Kristallzüchtung (IKZ), Berlin on low micropipe density (16–30 cm^{-3}), *n*+ substrate from CREE. The Schottky and ohmic electrodes (1.5 mm diameter) were made by

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