«Saint Petersburg OPEN 2017»

BOOK of ABSTRACTS

4th International School and Conference on Optoelectronics, Photonics, Engineering and Nanostructures

April 3 – 6, 2017 • Saint Petersburg, Russia

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Silicon carbide of Ni/6H-SiC and Ti/4H-SiC type Schottky diode current-voltage characteristics modelling

P V Panchenko, S B Rybalka, A A Malakhanov, A A Demidov
Bryansk State Technical University, Brynask, 50 let Oktyabrya 7, Russia

Abstract. Forward current−voltage characteristics of Ni/6H-SiC and Ti/4H-SiC Schottky diode with Ni and Ti Schottky contact have been simulated based on in the physical analytical models based on Poisson's equation, drift–diffusion and continuity equations. On the base of analysis of *I-V* characteristics in terms of classical thermionic emission theory it is shown that the proposed simulation model of Schottky diode corresponds to the "ideal" diode with ideality factor $n \approx 1.1$. It is established that effective Schottky barrier height φ_B=1.57 eV for Ni/6H-SiC and φ_B=1.17 eV for Ti/4H-SiC Schottky diode.

1. Introduction

Silicon carbide (SiC) as material for semiconductor electronics has been studied at first in Leningrad (St. Petersburg) by the O.V. Losev's at the A.F. Ioffe Institute at the beginning of the 1930s. Now silicon carbide represents an excellent candidate for high-temperature power electronic device applications because of its high breakdown voltage, low series resistance, and stability under harsh chemical and high temperature conditions [1]. SiC Schottky diodes are of special interest since these unipolar devices avoid reverse recovery effects of bipolar devices, thereby offering higher frequency operation In particular, SiC Schottky diodes for power electronics in future must be produced by domestic company the «GROUP KREMNY L» (Bryansk). It is obviously that for development of component base on the base of SiC studying and optimisation of such important device as Schottky diode it is necessary. Earlier simulation of current-voltage (I-V) characteristics in 4H-SiC Schottky diode with Ni Schottky contact has been made [2]. Therefore in present work simulation of current-voltage (*I-V*) characteristics in Schottky diode on base of 6H-SiC and 4H-SiC type silicon carbide with Ni and Ti Schottky contact with used of TCAD program has been carried out.

2. Materials and methods

The materials parameters for simulation were following: the concentration of donors (nitrogen) in the substrate equals $N_D^+ = 10^{16} - 10^{18}$ cm^{-3}, in the epitaxial layer equals 8×10^{15}, anode material is Ni (nickel) and Ti (titanium), thickness of the epitaxial layer (4H-SiC and 6H-SiC) equals z=15 μm, radius of the structure equals r=200 μm. For simulation model of current-voltage characteristics has been solved electrostatic Poisson's equation in cylindrical coordinates together with continuity equations for electrons and holes. Because of this for calculation current-voltage (*I-V*) characteristics in Schottky diode was applied of the thermionic emission theory which taking into account of the electron-phonon interaction, quantum-mechanical tunneling through barrier and reduction of barrier height under influence of image force effect [3,4].

3. Results and discussion

For simulation model of current-voltage (*I-V*) characteristics has been solved electrostatic Poisson's equation in cylindrical coordinates together with drift–diffusion and continuity equations. For simulation forward current-voltage characteristics were chosen the following temperature: 300, 400, 500 and 600 K. Simulation results of forward current-voltage characteristics for Ni/4H-SiC and Ti/4H-SiC Schottky diodes in TCAD program are presented in Fig. 1 and Fig. 2.

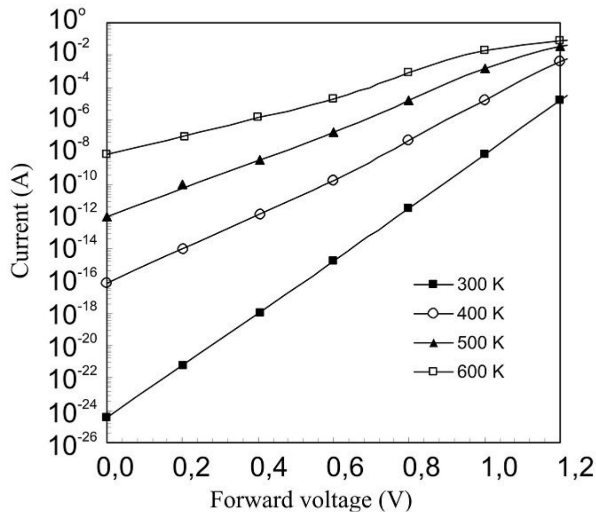

Figure 1. Ni/6H-SiC Schottky diode forward *I-V* characteristics.

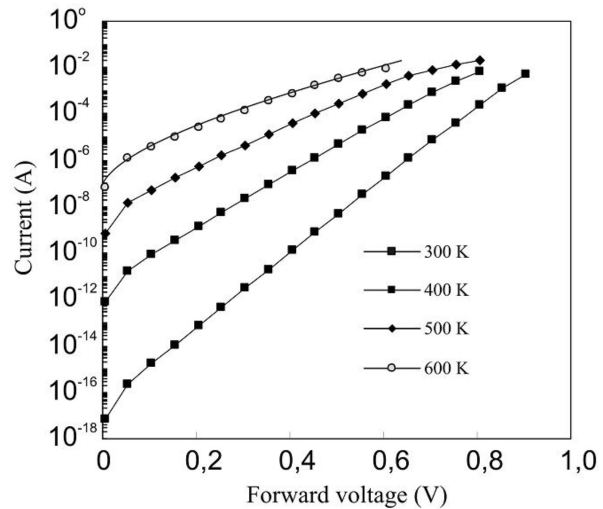

Figure 2. Ti/4H-SiC Schottky diode forward *I-V* characteristics.

Then results of forward current-voltage characteristics for Ni/4H-SiC and Ti/4H-SiC Schottky diodes were analyzed in framework of classical diode theory [3-5. to estimate the Schottky diode quality which for good Schottky diode is equal ~1.0÷1.1. In our case the obtained ideality coefficients n are close to good Schottky diode. Because of this it is established that effective Schottky barrier height φ_B=1.57 eV for Ni/6H-SiC and φ_B=1.17 eV for Ti/4H-SiC Schottky diode.

3. Conclusions.

Finally, forward current-voltage (*I-V*) characteristics in Ni/6H-SiC and Ti/4H-SiC Schottky diode with Ni and Ti Schottky contact have been obtained on the base of simulation model in TCAD in framework of the physical analytical models based on Poisson's equation, drift–diffusion and continuity equations. It is shown that forward current–voltage characteristics in terms of the Schottky diode simulation model corresponds to the "ideal" Schottky diode describes in framework of the classical thermionic emission theory with the ideality factor of Schottky diodes is close to good Schottky diode.

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