«Saint Petersburg OPEN 2020»

BOOK of ABSTRACTS

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Crystal growth and structural properties of nanostructures

Electric, Magnetic and Microwave Devices

Test element for high voltage SiC Schottky diodes quality control

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Abstract. In this study was constructed test element for quality control of SiC Schottky type high voltage diodes. It is shown that proposed test element give possibility for determination of parameters for testing diode before Schottky contact formation and therefore can be decrease production costs in production of SiC Schottky type high voltage diodes.

1. Introduction

The Schottky type diodes on the base of silicon carbide (SiC) have several advantages over traditional diodes because of high values of breakdown voltage and now are key components of power electronics [1]. In our previous studies it is established that SiC Schottky diodes produced by company the AO «GRUPPA KREMNY EL» (Bryansk, Russia) demonstrate good characteristics by *dV/dt* parameter [2]. However, one of some problems is determination of quality of produced diodes during their manufacturing procedure. Early was proposed test element for quality control of the manufacture of GaAs Schottky diodes, consisting of a Schottky diode formed on an epitaxial structure of one type of conductivity [3], but the main disadvantage of this test element is increased leakage currents of the Schottky diode because of higher field strength at the boundary of the metallization edge of the Schottky contact and the semiconductor. Therefore, structure 4H-SiC diode proposed in paper [4] is more preferable. Therefore the main goal of this study is to construct test element for quality control of SiC Schottky type diodes based on proposed in paper [4] Schottky structure diode.

2. Materials and methods

The proposed test element (see Fig. 1) has the following structure: on the silicon carbide substrate of n^+-type conductivity from 4H-SiC (1), an n^--type epitaxial layer with 13 μm thick (2) with an impurity concentration of 5×10^{15} cm^{-3} is formed. Further, for increasing of breakdown voltage was carried out implantation with boron ions (doses of 3×10^{15} cm^{-2} and 6×10^{15} cm^{-2}) with energies of 150 keV and 350 keV, respectively (depth of ≈0.67 μm), then p-type planar working junction 3 and a p-type dividing ring were formed (4) by annealing at a temperature of 1580 °C. Then, a silicon oxide layer SiO_2 (5) is formed two contact windows 6 were etched in oxide layer SiO_2.

3. Results and discussion

If voltage is applied between the planar working junction (3) and the dividing ring (4) (see Fig. 1) we can determine the pinch-off potential of ring after the formation of the dividing rings before the step

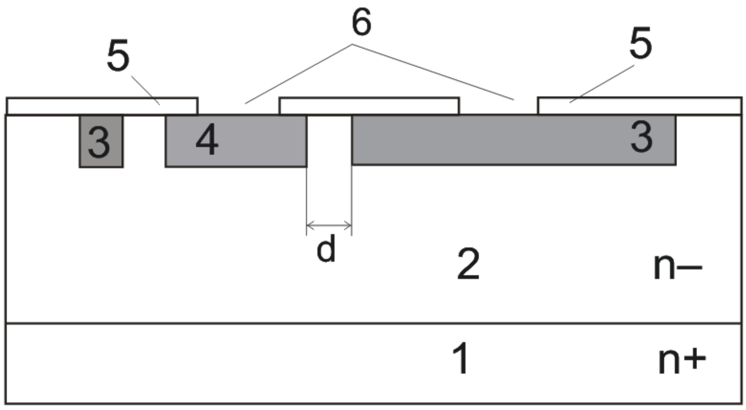

Figure 1. The structure of the test element: 1 – n^+-type substrate; 2 – n^--type epitaxial layer; 3 – p-type planar working junction (collector); 4 – p-type dividing ring (emitter); 5 – layer of SiO_2 silicon oxide; 6 – contact windows; d – is the gap between the emitter and the collector.

when Schottky contact is formed. Then, based on the obtained value of the ring potential, we can draw conclusions about the correct choice of the gap and the annealing mode, which increases the efficiency of control. As a rule, if pinch-off voltage $U_{p.o.}$ is high (>150 V) there is possibility redistribute of boron by mean of impulse annealing, but in case if $U_{p.o.}$ is small (<70 V) it lead to rejection of testing diode before Schottky contact formation that can be decrease production costs. Some test results of diode with various gap between emitter and collector are shown in Table 1. As follows from obtained data the optimal gap is 2.5 μm when breakdown voltage (~1550 V) is more then in case of 1.0 μm (~1150 V).

Table 1. The measurement results of the two test elements and Schottky diodes with different gaps d, fabricated on the same epitaxial structures and technological conditions.

No.	*d* (μm), gap between emitter and collector	Number of rings in testing diode	$U_{p.o.}$ (V), pinch-off voltage of emitter–collector for test cell	*U* (V), breakdown voltage (25°C)	*U* (V), breakdown voltage (60°C)	*dV/dt* (V/ns), speed of reverse voltage increase before failure
1	2.5	5	130	1550	1540	200
2	1.0	5	50	1150	1140	200

4. Conclusions.

Finally, the proposed test element allows to choose optimal parameters for SiC Schottky type high voltage diodes before Schottky contact formation operation and spare production costs.

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