Original Research Article

Study on the influence of silicon carbide JBS active region structure on device performance

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Abstract: The silicon carbide JBS active region is a key component in modern semiconductor devices, and its definition and structure are crucial to understanding the device performance. The silicon carbide SBD active region enables efficient current transmission and thermal management through precise control of the metal-semiconductor interface. The JBS diode combines the advantages of SBD and PiN diode, with low pass-on pressure drop characteristics and high blocking capability. To verify silicon carbide JBS diode active area structure on the influence of electrical, by changing the structure of source area short contact, to verify the positive guide and reverse blocking characteristics change, experimental validation and test results show that with the increase of the contact area is guide through the current density is bigger, the resistance is smaller, but the reverse leakage current also increases, vice versa. The structure of silicon carbide JBS active region has a significant and positive influence on the device performance, which provides an important reference for the application of silicon carbide JBS active region.

Keywords: Silicon carbide Schottky diode JBS; Active area

1. Overview of the silicon carbide JBS active area

SiC The material has a high forbidden band width and a high electron saturation speed, which enables the silicon carbide Schottky diode to perform well at high temperature, high frequency and high power conditions. As a key component of modern semiconductor devices, the definition and structure of the silicon carbide JBS (Junction Barrier Schottky) active region are crucial to understanding its impact on device performance[1]. The JBS diode combines the advantages of the SBD (Schottky Barrier Diode) and the PiN diodes,

Silicon carbide SBD active area, in short, by the precise control of the metal-semiconductor interface, to achieve efficient current transmission and thermal management. The structure usually includes a silicon carbide substrate, metal electrodes, and carefully designed interface layers, which together constitute the core of the silicon carbide SBD active region. Silicon carbide SBD is an important part of the low-voltage power electronic circuit[2].

The structure of PiN diode is different from that of ordinary diode. It adds a low-doping intrinsic (Intrinsic) semiconductor layer between the P region and the N region to form a P-i-N structure. The introduction of this layer makes PiN diode have unique advantages in performance and function. The PiN diode can withstand high reverse voltage and has good voltage resistance[3].

JBS diode adds a series of PN junctions to the active region of SBD diode, so JBS diode has the low conduction pressure drop characteristics of Schottky diode at the positive guide, and the high blocking ability of PiN junction diode at the reverse cut-off[4]. In N-type devices, the electrical characteristics of the device can be changed by changing the width of the P+ region in the active region and the spacing of the adjacent P+ region

(Schottky contact region)[5,6,7].

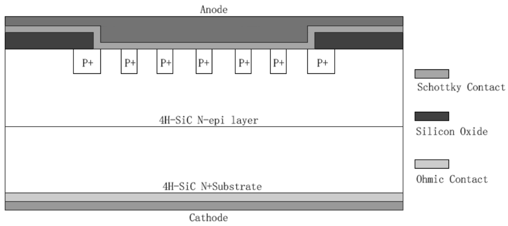

Figure 1. JBS structure diagram.

In addition, the silicon carbide JBS active area has good heat dissipation performance and thermal stability while also maintaining the efficient current transmission.

To sum up, the definition and structure of silicon carbide JBS active area not only reflects the exquisite technology and innovative thinking of modern semiconductor technology, but also provides a solid foundation for the improvement of device performance. By continuously optimizing the structure and material selection of the silicon carbide JBS active region, we can expect to achieve more efficient and reliable semiconductor devices in the future.

2. Experimental verification and test results

2.1. Experimental procedures and procedures

In the experimental design and implementation stage, a series of experiments were carefully planned to verify the influence of the structure of the silicon carbide JBS active region on the device performance. First, advanced experimental equipment, such as a high-precision current-voltage test system, is selected to ensure the accuracy and reliability of the experimental data. Then, detailed experimental steps and procedures were formulated, including sample preparation, construction of test environment, and setting of test parameters. In the process of sample preparation, strictly according to the characteristics and selection requirements of silicon carbide material, we adopt the optimized preparation process to ensure the quality and performance of the samples. In the construction of the test environment, the influence of temperature, humidity and other factors on the experimental results is considered, and the corresponding control measures are taken. In the setting of test parameters, according to the experimental purpose and needs, the appropriate current, voltage and other parameters are selected for testing.

The design of experimental steps and processes is crucial, which is directly related to the accuracy and reliability of experimental results. The control variable method is used to compare the device performance of different silicon carbide JBS active regions. In the same device area, except for the main junction and terminal with the same area and the same structure, only the injection structure is changed in the same active area, and the width of the fixed P + area remains unchanged. The influence on the device characteristics is analyzed by changing the size of the Schotbase contact region.

Table 1. Device comparison.

Device serial number	Device area	The Schottky contact zone width	P+ area width	Terminal structure and area
Device 1	identical	2.5μm	identical	identical
Device 2	identical	3μm	identical	identical

2.2. Preparation and method of experimental samples

The process flow of silicon carbide JBS device is a multi-step and high-precision process. The following is a brief description of the process flow:

Material selection and preparation: Select high-quality N-type silicon carbide epitaxial sheets, check their surface quality and crystal structure, and perform RCA cleaning.

Injection graphics making: Use lithography to transfer the designed device structure to a silicon carbide substrate to form a precise pattern. The etching technology (such as dry etching or wet etching) is used to remove the unnecessary material parts and form the initial structure of the device.

Doping: Adding specific impurities into the silicon carbide epitaxial layer by ion injection method to form the desired P-type region.

Activation: the high temperature activation treatment makes the dopant fully diffuse and activate to form a stable PN junction.

Sacrifice oxidation: Repair ion injection to silicon carbide surface trauma by peroxidation.

Terminal passivation: deposit of silicon oxide protection terminal field limit ring.

Back Ohm contact production: deposit the metal layer on the back of the wafer for rapid annealing to form ohm contact.

Front Schottky contact production: deposit a metal layer on the front of the wafer, etching figures, rapid annealing, forming Schottky contact.

Thinning metal: a thick metal layer on the back of the wafer. The thickness and uniformity of the metal layer are controlled to ensure good electrical contact and low contact resistance.

Passivation treatment: Make the passivation layer with polyimide.

In conclusion, the process process of silicon carbide JBS devices includes multiple key steps, such as material selection and preparation, epitaxial growth, doping and activation, lithography and etching, metallization, and heat treatment. Each step requires precise control of the process parameters and conditions to ensure that the performance and quality of the final device meet the design requirements.

In the course of the experiment, special attention was also paid to the accuracy and reproducibility of the data. Strictly follow the experimental procedures and procedures to ensure the consistency of each experimental condition. Meanwhile, the experimental data were measured and verified multiple times to ensure the reliability and accuracy of the results.

2.3. Test and comparison of performance parameters

In the stage of experimental verification and result analysis of the influence of silicon carbide JBS active area on device performance, the performance parameter test and comparison are the key link to evaluate its influence effect. In this study, the B1505A advanced test equipment and Kelvin test method from KEYSIGHT company were used to comprehensively test the current transmission characteristics in the active area of silicon carbide JBS.

The small current test curve, as shown in Figure 2, is the lnI – V curve, where V_fThe slope of the curve is similar between the 0.43V-0.6V, with the ideal factor n approaching about 1.002.

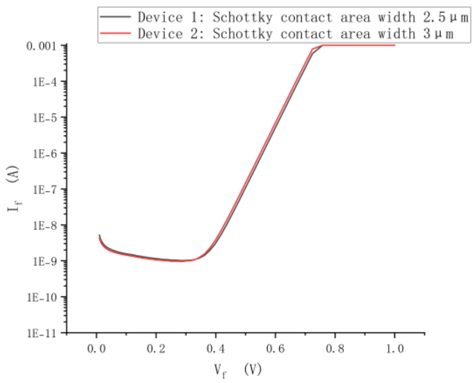

Figure 2. Positive small current test curve diagram.

As shown in the high current test, when the device reaches 20A, the forward pressure drop of device 1 is 1.344V, and the forward pressure drop of device 2 is 1.298V.

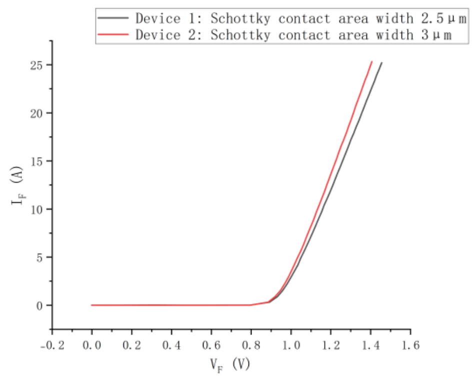

Figure 3. Forward large current I-V test curve diagram.

In the reverse test, the folding point in the analysis diagram between 300 and 400V is the reason for the test device, at 100 μA, device 1 is 1552V and device 2 is 1690V. At 1200V, device 1 is 3.29 μA and device 2 is 0.50 μA.

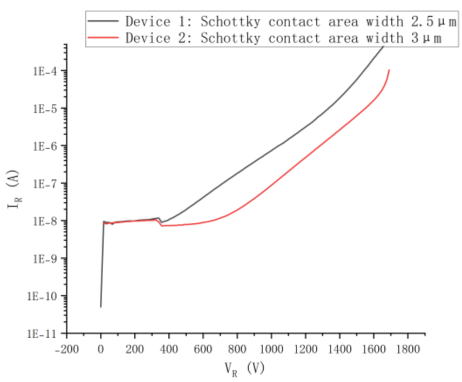

Figure 4. Reverse I-V test curve diagram.

In conclusion, the influence of the structure of the silicon carbide JBS active region on the device performance is comprehensively evaluated by performance parameter testing and comparison. The experimental results show that the silicon carbide JBS active region is excellent in both current transmission characteristics and thermal performance, which provides strong support for the improvement of device performance. This research result not only provides an important reference for the application of silicon carbide JBS active area, but also provides new ideas and methods for the research in related fields.

3. Conclusion

In the experimental results and analysis stage, the influence of the silicon carbide JBS active area on the device performance is tested and compared in detail. And, first of all, through the precision current transmission characteristic test, found that the structure of silicon carbide JBS of active area in the same injection P + area, different short contact area, small current test basic no change, in the large current test, the positive device 1 pressure drop than 2 device, current density device 2, in the reverse test, the device 1 leakage level is smaller than the device 2. So with the increase of the Schottky contact area, the current density is larger and the resistance is smaller, but the reverse leakage current also increases. On the contrary, the decrease of the Schottky contact area reduces the current density, the resistance becomes larger, and the reverse leakage current also decreases.

In conclusion, the structure of the silicon carbide JBS active region has a significant and positive effect on the device performance. You need to look at the demand to weigh the pros and cons together. Its excellent performance makes silicon carbide JBS devices have a wide application potential in power electronics, new energy vehicles and other fields. In the future, we will continue to deeply study the performance optimization mechanism of the silicon carbide JBS active area, and explore more innovative application scenarios.

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