Extended Abstracts of the 2002 International Conference on Solid State Devices and Materials, Nagoya, 2002, pp. 402-403

P2-10

A New Lateral Trench Electrode IGBT with p+ diverter for Superior Electrical Characteristics

Ey Goo Kang, Dae Jong Kim and Man Young Sung

Korea University, Department of Electrical Engineering
1-5 ga, Anam-dong, Sungbuk-ku, Seoul, Korea
Phone: +82-2-3290-4267 Fax: +82-2-921-0544 E-mail: keg@elec.korea.ac.kr

1. Introduction

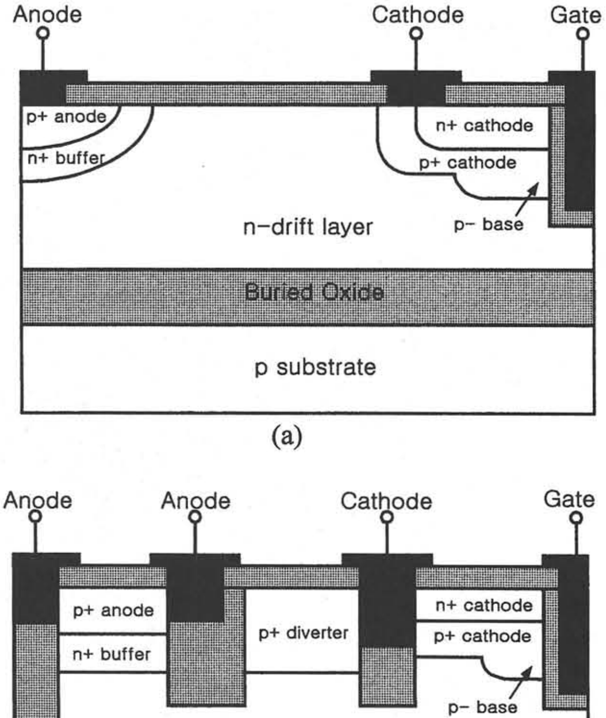
The Lateral Insulated Gate Bipolar Transistor (LIGBT) is a promising device for power applications that integrate MOS gate control with bipolar conductivity modulation to achieve high input impedance and low on-state voltage drop [1]. Previous studies could reduce the voltage drop due to hole current in the p-base region and increase the latch-up current density. But This LTIGBT with p+ diverter was not appreciated as effective structure because forward blocking voltage was decreased, greatly. Generally, if the LTIGBT had p+ divert region, forward blocking voltage was decreased, greatly because n-drift layer corresponding to punch-through was reduced [2].

In this paper, we proposed a Lateral Trench Electrode IGBT(LTEIGBT) with p+ diverter in which the length of the n-drift layer was no more than 17 ㎛ and the electrodes of LTEIGBT with p+ diverter were replace with trench-type ones. The p+ diverter was placed between anode electrode and cathode electrode. And we fabricated a small sized LTEIGBT with p+ diverter. And we analyze the electrical characteristics of the proposed device.

2. Devices structure and operation

Fig. 1 illustrates the conventional LTIGBT and the proposed LTEIGBT with p+ diverter. The main difference between the conventional LTIGBT and the proposed LTIGBT with p+ diverter is the placement of the cathode, anode electrode and p+ divert region. As the electrodes of the proposed device are formed of trench structures, it can easily be made into a small size. This is because the trench-oxide layer play a role of mask, it is effective in forming an n+ cathode, p+ anode junction and p+ devert region, as well. In addition to, the electric field in this device centers on the trench-oxide layer so that this device can have a higher blocking voltage in spite of its small size and having p+ diverter.

The current paths of the LTEIGBT with p+ diverter are two paths. One of two paths is identical to that of the conventional LTIGBT. In the forward active mode of operation, the anode pn junction starts to turn on and injects holes into the n-drift of the transistor. Some of these holes will recombine with the electrons flowing from the vertical channel, and some of them will flow from the n-drift to the p+ cathode without flowing through the p-base layer, directly. The other current path is toward p+ divert region. The electron current induces the hole current to flow directly into the cathode contact via the p+ divert region without passing p+ cathode region beneath n+ cathode. This current doesn't relate to latch up.



(a)

(b)

Fig. 1 The cross sections of the conventional LTIGBT and the proposed LTEIGBT with p+ diverter.

3. Results and Discussion

The LTEIGBT with p+ diverter was fabricated by employing a CMOS compatible process with a 4-7Ωcm n-type (100) silicon wafer. The n-drift length and depth of LTEIGBT with p+ diverter are 19μm and 10μm, respectively. The depth of n-buffer and p-base are 4μm. The depth of n+ anode is 0.5μm. And the depth of p+ cathode is 1μm. The depth of n+ cathode is 0.21μm. The thickness of the gate oxide is 100nm. Fig. 2 shows the plan of surface of the fabricated LTEIGBT with p+ diverter.

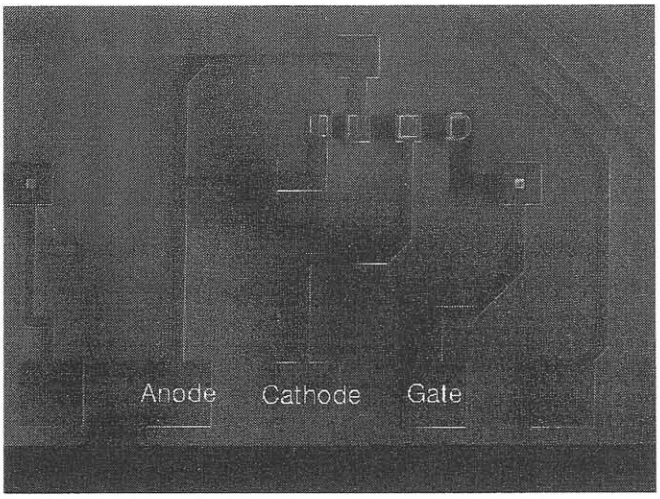


Fig. 2 The plane surface of the fabricated LTEIGBT with p+ diverter

I-V characteristics of the LTEIGBT with p+ diverter and the conventional LTIGBT are shown in Fig. 3. When the gate voltage is applied 12V, the forward conduction currents of the proposed LTEIGBT with p+ diverter and the conventional LTIGBT are 90mA and 70mA, respectively, at the same breakdown voltage of 150V. In spite of the small size, the forward conduction current of the proposed LTEIGBT with p+ diverter is higher than the conventional LTIGBT. Fig. 4 is shown to the forward blocking characteristics. As the electrodes of proposed LTIGBT with p+ diverter are made of trench-type ones, the electric field in the device centers trench-oxide layer. Thus, the punch through breakdown of LTIGBT with p+ diverter occurs, lately. Forward blocking voltage of the same sized conventional LTIGBT is no more than 105V. But forward blocking voltage of the proposed LTIGBT is about 140V. The forward blocking voltage of the LTIGBT with p+ diverter increased 1.3 times more than that of the conventional LTIGBT.

4. Conclusions

A new LTEIGBT with p+ diverter was proposed effectively to suppress latch-up of LTIGBT. The p+ diverter was placed between anode electrode region and cathode electrode. The forward blocking voltage of the proposed LTEIGBT with p+ diverter was about 140V. The conventional LTIGBT of the same size was no more than 105V. The forward blocking voltage of LTEIGBT with p+ diverter increased 1.25 times more than that of the conventional LTIGBT. And the forward conduction currents of the proposed LTEIGBT with p+ diverter and the conventional LTIGBT are 90mA and 70mA, respectively, at the same breakdown voltage of 150V.

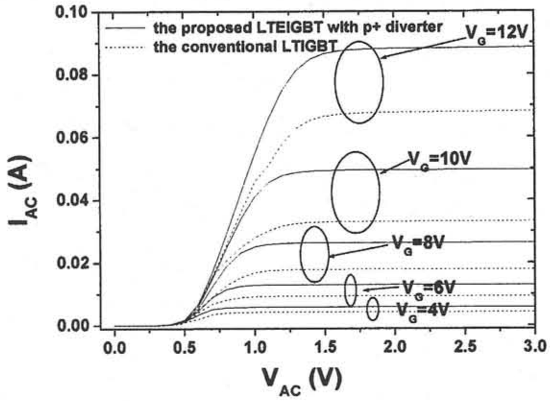


Fig. 3 The I-V characteristics of the LTEIGBT with p+ diverter and the conventional LTIGBT.

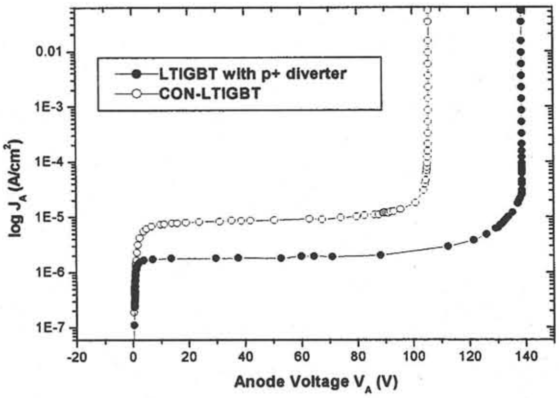


Fig. 4 The forward blocking characteristics of the LTEIGBT with p+ diverter and the conventional LTIGBT

Acknowledgments

This work is supported by KOSEF (Korea Science and Engineering Foundation) 1999-2-302-017-5 and the Ministry of Science and Technology 2000-J-EH-01-B02

References

[1] T. P. Chow, Proc. ISPSD, pp. 57 –61, 1994
[2] N. Thapar and B. J. Baliga, Solid State Electronics, Vol. 42, No. 5, pp. 771-776, 1998