A New SOI LIGBT Structure with Improved Latch-Up Performance

Woong-Je Sung*, Yong-Il Lee, Woo-Beom Choi and Man Young Sung

Abstract

In this paper, a new lateral insulated gate bipolar transistor (LIGBT) is proposed to improve the latch-up performance without current path underneath the n+ cathode region. The improvement of latch-up performance is verified using the two-dimensional simulator MEDICI and the simulation results on the latch-up current density are 3.12×10^{-4} A/㎛ for the proposed LIGBT and 0.94×10^{-4} A/㎛ for the conventional LIGBT. The proposed SOI LIGBT exhibits 3 times larger latch-up capability than the conventional SOI LIGBT.

Key Words : SOI, LIGBT(lateral insulated gate bipolar transistor), thyristor, latch-up, on-resistance,

1. Introduction[1)]

The silicon-on-insulator (SOI) lateral insulated gate bipolar transistors (LIGBT's) are commonly used in power integrated circuits because of the inherent low on-resistance, fast switching speed and high breakdown voltage [1], [2]. In on-state, p+ anode injects hole into n-epi layer and increases conductivity of n-epi layer. The high current handling capability relies on this conductivity modulation of the high resistivity n-epi layer. However, the parasitic thyristor composed of n+ cathode, p base, n-epi layer, p+ anode makes the LIGBT vulnerable to latch-up which leads to loss of gate control [3]. The latch-up occurs when a voltage drop across the n+ cathode/p base junction of the parasitic npn transistor is above 0.7 V [4]. In order to reduce the latch-up susceptibility, while allowing the device to conduct high currents, the resistance under n+ cathode region must be reduced.

In this paper, a new LIGBT structure which has no current path underneath n+ cathode region is presented to improve latch-up characteristics. The latch-up and forward voltage drop characteristics are investigated and compared to the conventional LIGBT by numerical simulation.

2. Device Structure and Operation

Fig. 1(a) shows the cross section of the conventional LIGBT fabricated on the SOI film. R_B is the resistance of the p-base layer underneath the n+ cathode and I_h indicates the hole current. In the forward active mode of operation, most of the hole current flows from the p+ anode, through the lateral pnp transistor, under the n+ cathode region and then to the p+ cathode region. If the hole current high enough, the voltage drop by R_B ×

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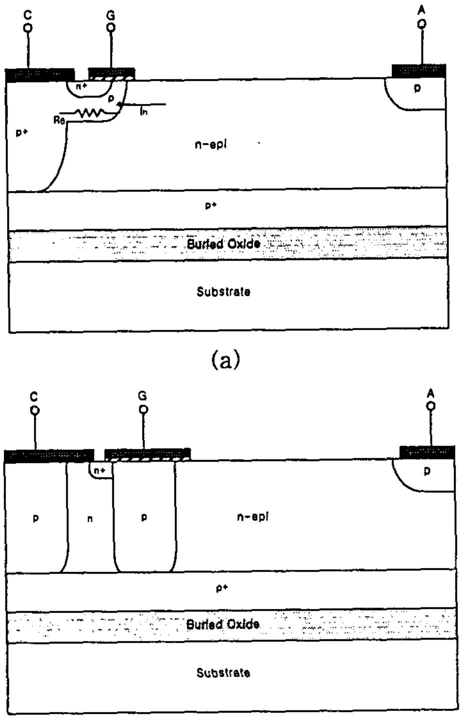
I_h is sufficient to turn on the parasitic npn transistor and latch-up occurs which leads to loss of gate control.

Fig. 1(b) illustrates the new LIGBT. The main difference between the conventional and new LIGBT is the existence of the current path underneath the n+ cathode. Operation of the new LIGBT is identical to that of conventional LIGBT. At the on-state, positive voltage is applied to the anode relative to the cathode. At a higher anode voltage, the anode pn junction starts to turn on and injects holes into the n-epi region. Most of the hole current flows through the buried p+ region, but there is no current path underneath the n+ cathode region. So neither the resistance R_B nor the voltage drop $R_B \times I_h$ exist. Therefore, the latch-up can be suppressed effectively.



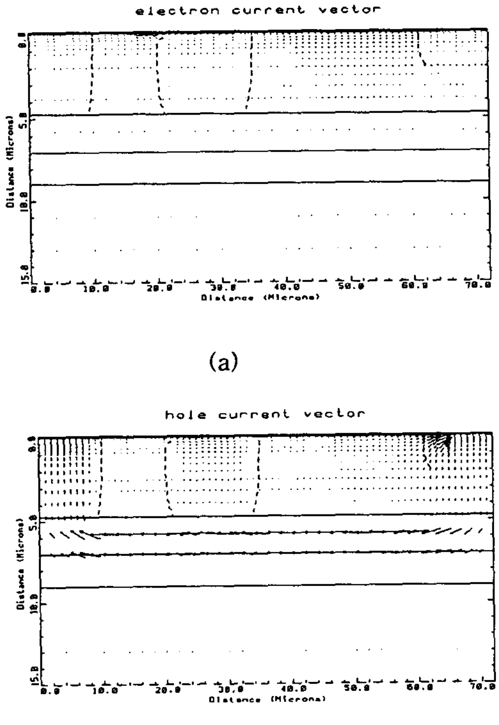
(a)

(b)

Fig. 1 Structure of (a) the conventional LIGBT and (b) the proposed LIGBT

3. Two-Dimensional Numerical Simulation

To analyze the latch-up performance of the proposed LIGBT, numerical simulations were performed using the 2-dimensional device simulator MEDICI. The simulated results correspond to a SOI LIGBT with a 5 ㎛ thick, n-type drift region of 72 ㎛ length and 1×10^{15} cm^{-3} doping concentration; a 200 ㎛ thick, p-type substrate with a concentration of 1×10^{16} cm^{-3}; and a 2 ㎛ thick isolation oxide layer. The surface doping concentrations of the p+ cathode well and p- base is 1×10^{19} cm^{-3} and 3×10^{17} cm^{-3}, respectively. The electron and the hole current vectors of the proposed LIGBT at the on state shown in Fig. 2(a) and (b), respectively. It is observed that most of the hole current flows through the buried p+ region.



(a)

(b)

Fig. 2. (a) the electron current vector and (b) the hole current vector of the proposed LIGBT.

For comparison, the simulated I-V characteristics of the conventional and the proposed LIGBT are shown in Fig. 3. The proposed LIGBT latches at anode current density of 3.12×10^{-4} A/㎛ with the gate bias of 25 V while the conventional LIGBT latches at anode current density of 0.94×10^{-4} A/㎛. The latch-up current density of the new SOI LIGBT exhibits 3 times improvement over that of the conventional SOI LIGBT. The forward conduction characteristics of the new LIGBT is better than that of the conventional LIGBT.

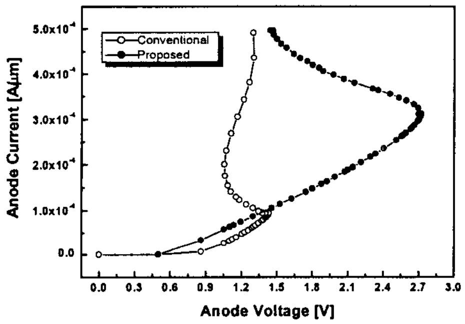


Fig. 3. I-V characteristics of the conventional and the proposed LIGBT.

4. Conclusions

We modified the LIGBT structure on SOI wafer for improving the latch-up characteristics. Its performance has been verified by the numerical simulation. The new LIGBT has no hole current path underneath the n+ cathode region. This structure allows the latch-up characteristics improve. Latch-up occurs at 3.12×10^{-4} A/㎛ for the proposed LIGBT while the conventional LIGBT latches at 0.94×10^{-4} A/㎛. It is observed that proposed device exhibits 3 times larger latch-up capability than the conventional LIGBT.

5. References

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