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Performance Enhancement of Bipolar Devices with Slot Pattern RESURF Approach in 40V BCD Technology

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Abstract

In this paper, a slot mask pattern in the collector region is proposed to enhance the RESURF (Reduced Surface Field) effect. From the simulation and measurement results, the breakdown voltage of the bipolar device based on 40V BCD technology is increased from 40V to 140V without extra masks and additional thermal drive-in.

1. Introduction

Conventional parasitical bipolar device in BCD technologies are usually designed by using a PW implant and HVNW (High Voltage N-type Well) or PBL (P-type Buried Layer) to enhance the 2-D depletion and RESURF effect as shown in Fig. 1(a) [1][2]. As a result, higher breakdown voltage is accomplished by increasing the length or decreasing the doping concentration of the collector region. In this paper, the RESURF effect is further enhanced by adding some slot patterns to the collector implant mask in the conventional RESURF structure without any extra layers [3][4]. The breakdown voltage is increased from 40V to 140V, and will not be limited by the existing doping profile based on 40V BCD technology.

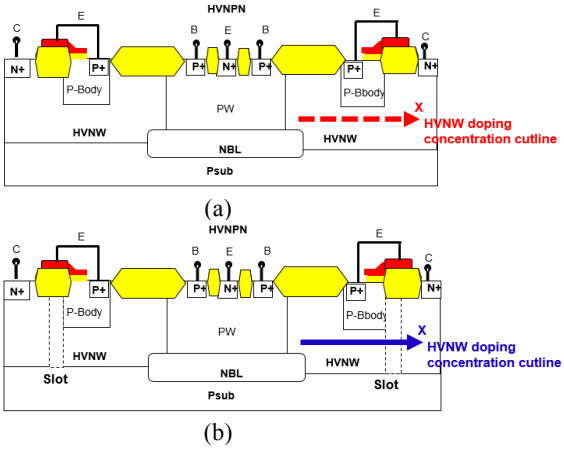

Fig. 1 The structure for (a) the conventional and (b) the novel NPN-BJT.

2. Mechanism

For the novel NPN-BJT, NVNW slot mask and PBODY implant are adopted in the collector region to from the double RESURF structure as shown in Fig. 1(b). In order to further increase the breakdown voltage of the existing high voltage devices in 40V BCD technology, the effective doping concentration in the critical RESURF structure was reduced by adding these slot patterns as shown in Fig.2. Consequently, the depletion region can be extended much longer than the conventional NPN-BJT. The maximum surface electric filed in the collector region become smaller as shown in Fig. 3 and hence higher breakdown voltage can be achieved.

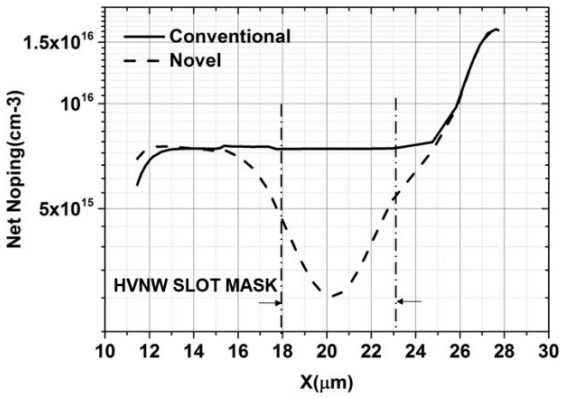

Fig. 2 The simulation of HVNW doping concentration in the collector region for the conventional and the novel NPN-BJT.

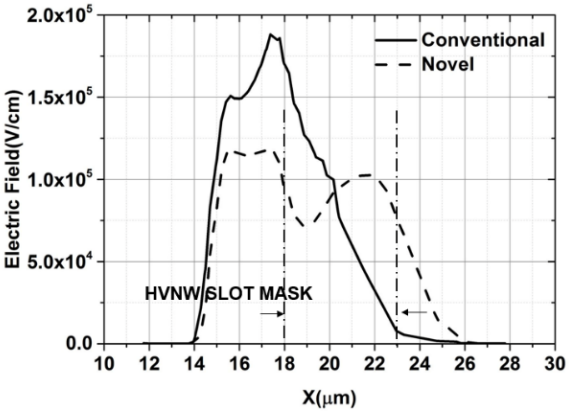

Fig. 3 The simulation of electric filed in collector region for the conventional and the novel NPN-BJT at 50V collector voltage bias.

3. Experiments and Measurements

The corresponding Ice-Vce curves for the conventional and novel NPN-BJT are shown in Fig. 4(a), 4(b). The measured I-V curves show that the open base breakdown voltage (BVceo) and the turn-on breakdown voltage are both increased significantly for the novel BJT, and the current gain (Beta) maintain at around 60 at 1~10uA collector current. Moreover, when the double RESURF works, BVceo of the BJT becomes scalable from 40V to 140V by selecting appropriate drift region length instead of being limited by early breakdown, as shown in Fig. 5. The breakdown voltage of the PNP-BJT is also increased by adopting slot patterns in the collector and base region. Therefore the lower concentration is achieved by lateral diffusion within the slot region defined by photolithography. Table I is a summary of the performance of the conventional and novel PNP-BJT and NPN-BJT including BVceo and Beta.

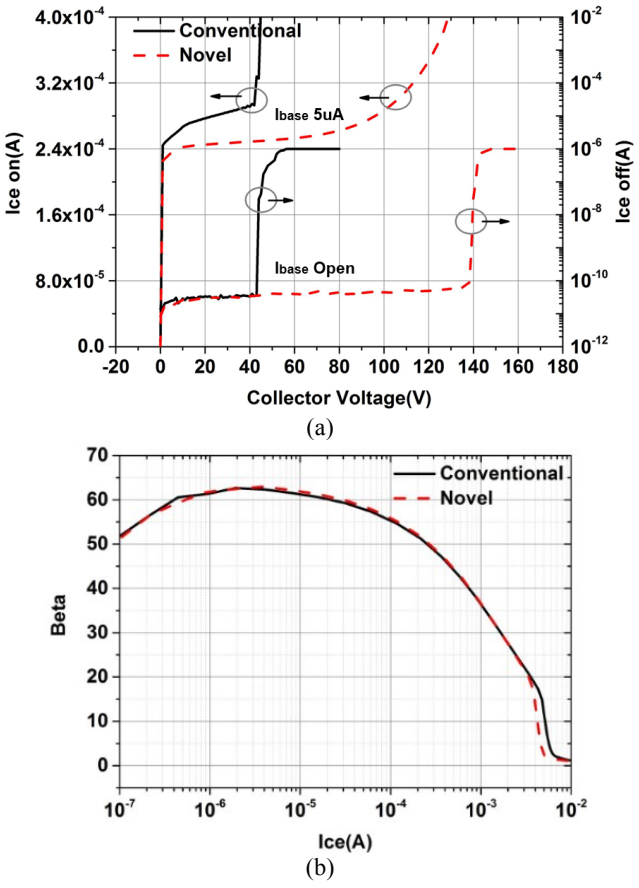

Fig. 4 (a) The Ice-Vce curves with different base current for the conventional and the novel structure of NPN-BJTs (b) The current gain for the conventional and the novel structure of NPN-BJT.

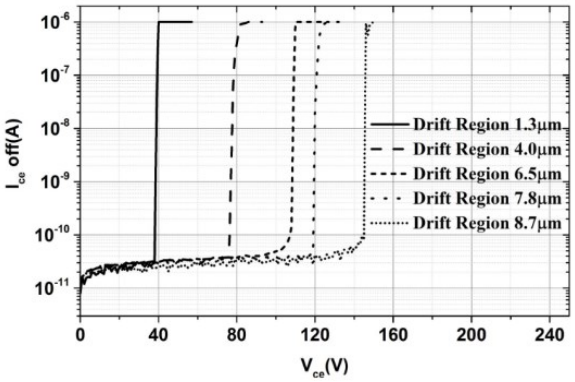

Fig. 5 The measurement BVceo is scalable of different drift region in the collector as RESURF occurring for the novel NPN-BJT.

Table I Device performance of NPN-BJT and PNP-BJT

	Slot Mask	BVceo (V)	Beta @ 1uA
Conventional NPN-BJT	X	40	60
Novel NPN-BJT	V	140	60
Conventional PNP-BJT	X	75	24
Novel PNP-BJT	V	140	24

4. Conclusion

In this work, the breakdown voltage of the bipolar devices are promoted from 40V to 140V by enhancing RESURF effect with slot patterns based on existing 40V BCD technology without any extra layers. Better performance and low cost can be achieved for these devices for high current and low noise applications in power ICs.

Acknowledgements

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