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Experimental study on Improving Unclamped Inductive Switching Characteristics of the New Power MOSFET Employing Deep Body Contact

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1. Introduction

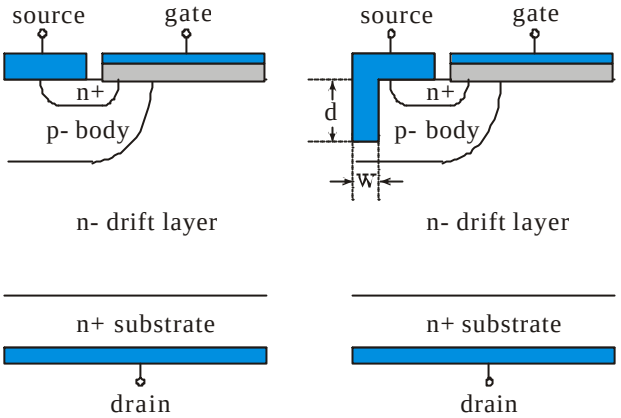
It is well known that the power MOSFETs are required to have a low conduction and switching losses in many power applications. Also they are required to have the ruggedness that would prevent the parasitic bipolar transistor from the turning on under a high current condition, such as UIS (Unclamped Inductive Switching).

The failure of MOSFETs during the UIS is due to the activating of the parasitic NPN bipolar transistor under the breakdown mode [1]. In order to suppress the turning on of the parasitic bipolar transistor, several methods have been reported [1]-[3]. One is to reduce the resistance of the p-body beneath the n+ source using high-energy implantation and/or employing sidewall process. However, it is rather difficult to control the doping concentration and the geometry of sidewall without altering the threshold voltage [2]. Another is to divert the direction of the current flow from the edge to the bottom of the p-body employing the split well structure or adding p+ distributed diodes which resulting in an additional device area for the p+ well [1][3]. In order to improve the UIS capability without sacrificing other device characteristics and additional cost, our previous work have proposed the modified source structure employing Deep Body Contact (DBC) and numerically verified it using MEDICI. [4]

The purpose of this paper is to fabricate 60V DBC Power MOSFET using 7 Masks CMOS compatible and Deep Si Trench process, which can achieve high avalanche energy for the breakdown under the flat p-body region without sacrificing any area. In order to verify the mechanism of proposed structure, 2-D numerical simulation is performed using the physical parameters identical to those of fabricated device are listed in table I.

Table I. The parameters of the proposed structure.

parameter	value	unit
Xj (p-body)	1.5	㎛
W (DBC)	1	㎛
d (DBC)	1.3	㎛



(a) conventional (b) proposed

Fig. 1 Cross-sectional view of a conventional power MOSFET and proposed structure

2. Simulation and Experimental results

The proposed structure is shown in Fig. 1 and the circuit diagram of the UIS is shown in Fig. 2. Our simulation result shows that the depth of a deep body contact is more effective to improve avalanche energy than the width of a deep body contact. Under the UIS condition, the avalanche generation rates are shown in Fig. 3. It should be noted that the point of the maximum generation rate in the proposed structure is under the flat p-body, while that of the conventional one is located in the edge of the p-body. In addition, the value of the generation rate in proposed structure is less than that of the conventional structure so that the proposed structure is more reliable than the conventional one.

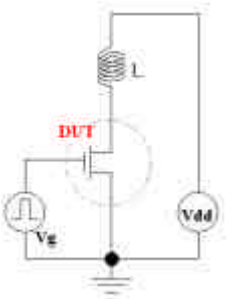
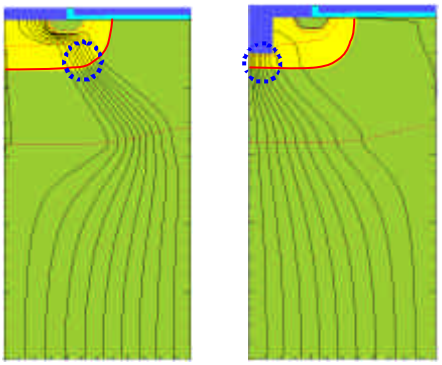
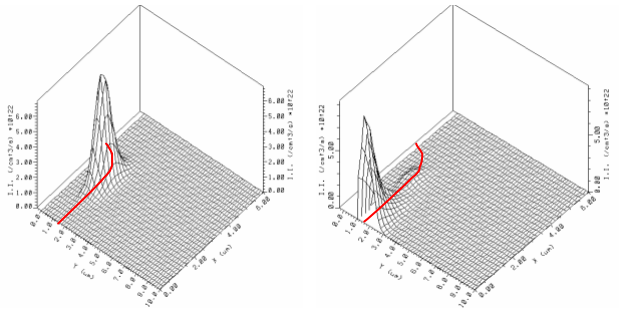


Fig. 2 Circuit diagram of UIS



(a) conventional (b) proposed



(a) conventional (b) proposed

Fig. 3 Simulated flowlines and generation rates due to impact ionization of conventional and the proposed devices

The measured breakdown voltage of the proposed structure decreases as the depth and width of deep body contact increases as shown in Fig. 4. In the proposed structure, the breakdown occurs when the depletion layer to the p-body reaches the deep body contact.

Fig. 5 shows the measured transfer characteristics. The Rdson of the proposed structure is slightly smaller than that of conventional one because the proposed one is expected to have low contact resistance due to the widening of source contact area. The measured drain voltage and current during the UIS are shown in Fig. 6. As shown in Fig. 6, the total discharge time of the proposed device is slightly larger than that of the conventional device because the proposed device has lower breakdown voltage than the conventional device due to the deep body contact [5].

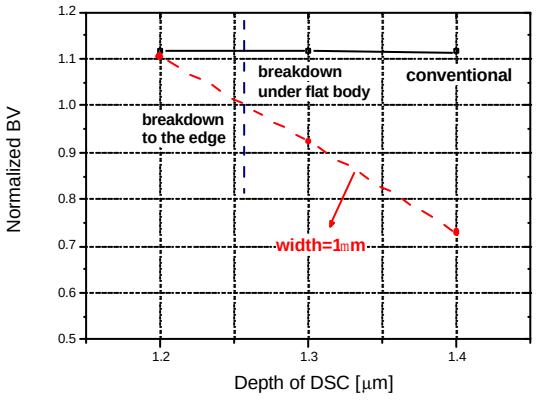


Fig. 4 Normalized measured breakdown voltage varying the depth and width of deep body contact

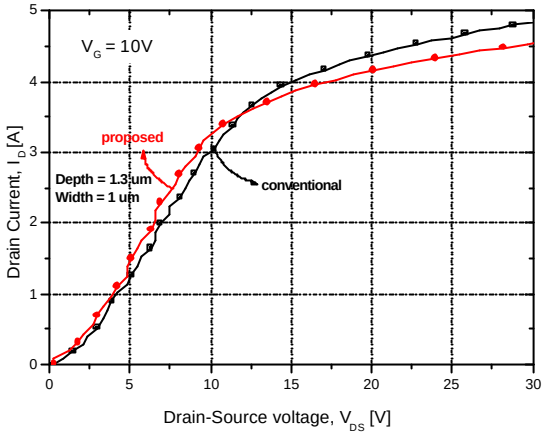


Fig. 5 Measured transfer characteristics

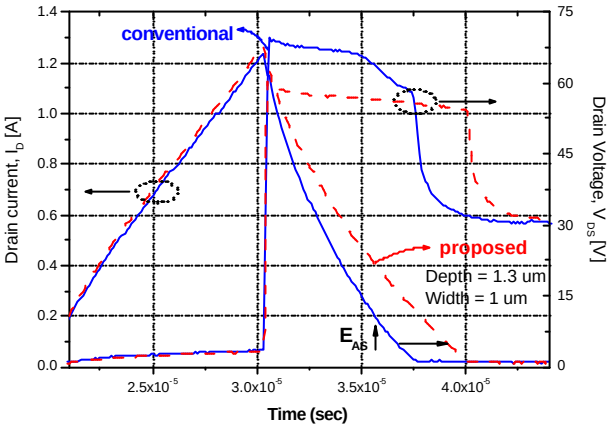


Fig. 6 Measured waveforms under UIS

3. Conclusion

We have successfully fabricated a new 60V power MOSFET employing a deep body contact and measured the UIS characteristics. It should be noticed that Deep Body Contact alters the breakdown path to the flat p-body to increase the avalanche energy by 12% without sacrificing other device characteristics and device area. The optimum depth of a deep body contact is found to be 1.3μm, which also decreases Rdson due to the reduction of source contact resistance. The proposed device fabricated without JFET implantation will be further investigated in the structure employing JFET, in which the UIS is more serious, because the breakdown path is moved further to the surface.

References:

[1] J.Zeng et al, *ISPSD'99*, pp. 205-208, 1999.
[2] C.Kocon et al, *ISPSD'2000*, pp. 157-160, 2000.
[3] R.K.Williams et al, *IEDM'97*, pp. 363-366, 1997.
[4] Soo-Seong Kim et al, SSDM'02, pp. 398-399, 2002.
[5] A.Narazaki et al, *ISPSD'2000*, pp. 377-380, 2000.