# High-Voltage Super-Junction SOI-LDMOSFETs with Reduced Drift Length

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## INTRODUCTION

This paper describes high-voltage super-junction SOI-LDMOSFETs which have trench oxide in the drift region. The super-junction helps to increase the drift doping. The trench oxide in the p-column allows to reduce the drift length without degrading the breakdown voltage. Using the two-dimensional numerical simulator MINIMOS-NT [1], we confirm that the specific on-resistance of the device proposed is lower than that of conventional SOI-LDMOSFETs and the drift length is reduced to 65% of the conventional devices.

## DEVICE STRUCTURE AND RESULTS

The specific on-resistance ($R_{\rm sp}$) and the breakdown voltage (BV) of high-voltage SOI-LDMOSFETs strongly depend on the doping and the length of the drift layer. Conventionally the drift doping of the SOI-LDMOSFETs is restricted by the RESURF (Reduced Surface Field) effect. To achieve the best trade-off between $R_{\rm sp}$ and BV, we suggest a super-junction (SJ) [2] SOI-LDMOSFET which has an extra p-column and a trench oxide in the drift (Figure 1). The extra p column is doped to achieve a balanced charge condition which means that the net depletion layer charge is zero, but it does not contribute to on-state conduction. The trench oxide in the p-column helps to reduce the drift length without further decreasing the conduction area.

Our device is designed to achieve a BV of 300 V with an SOI thickness $t_{\rm soi}$ of 7.0 $\mu$m and with a buried oxide thickness $t_{\rm ox}$ of 2.0 $\mu$m. With an n-column width $W_{\rm N}$ of 3.5 $\mu$m, a p-column width $W_{\rm P}$ of 0.5 $\mu$m and a drift length $L_{\rm d}$ of 13.0 $\mu$m the doping concentration of the n-column can be raised up to 6.0 $\times$ $10^{15}$ cm$^{-3}$. Figure 2 and Table I show the potential distribution (at the drain voltage of 300 V) of the suggested device and comparison of the simulation results with the conventional SOI-LDMOSFET, respectively. For the proposed device with an n column doping $N_{\rm D}$ of 6.0 $\times$ $10^{15}$ cm$^{-3}$ and a drift length $L_{\rm d}$ of 13.0 $\mu$m, a maximum BV of 300 V is obtained at p-column doping $N_{\rm A}$ = 1.5 $\times$ $10^{16}$ cm$^{-3}$. These results demonstrate that the drift length can be reduced with a trench oxide in the p-column.

## CONCLUSION

A high-voltage SJ SOI-LDMOSFET transistor with a trench oxide in the drift region is proposed. A lower specific on-resistance is obtained in the proposed device. Our simulations confirm that the $R_{\rm sp}$ of the trench SJ SOI-LDMOSFETs is about 83% and the n-drift length is about 65% of that of conventional SOI-LDMOSFETs, respectively. With this new device concept it is possible to reduce the device size and the specific on-resistance without degrading the breakdown voltage.

## REFERENCES

1. Institute for Microelectronics, MINIMOS-NT 2.0 User's Guide, http://www.iue.tuwien.ac.at/software/minimos-nt (2002).
2. M. Saggio, D. Fagone, and S. Musumeci, "MDmesh$^{\rm TM}$: innovative technology for high voltage PowerMOSFETs", in Proc. 12th Intl. Symp. Power Semiconductor Devices & ICs (ISPSD), p. 65-68 (2000).

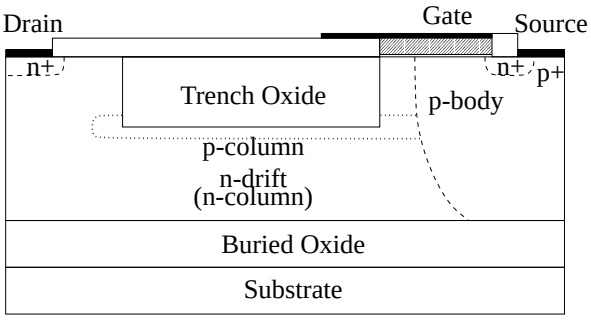


Figure 1: Schematic of the SJ SOI-LDMOSFET with a trench oxide in the drift.

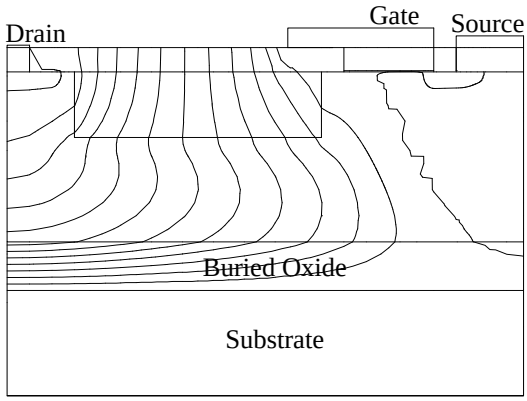


Figure 2: Potential distribution of a SJ SOI-LDMOSFET with a trench oxide at $V_{\rm DS}$ = 300 V.

| | Conventional SOI-LDMOSFET | SJ SOI-LDMOSFET with a trench oxide |
|---|---|---|
| $N_{\rm D}$, cm$^{-3}$ | 2.3 $\times$ $10^{15}$ | 6.0 $\times$ $10^{15}$ |
| $L_{\rm d}$, $\mu$m | 20.0 | 13.0 |
| $R_{\rm sp}$, m$\Omega$ cm$^2$ | 33.4 | 27.5 |
| BV, V | 300 | 300 |

Table I: DC performance comparison.