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Low Switching Loss Dual RESURF 40V N-LDMOS with Grounded Field Plate for DC-DC Converters

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Research Objective and Background

Research Objective

Development of LDMOS structure for DC-DC converters handling 40V in automotive applications

LDMOS: Lateral Double Diffused MOS

Research Background

DC-DC Converter for Automotive Application

- High efficiency
- High frequency
- High reliability

Requirements for its Switching Device

- Low specific on-resistance
- Low switching loss
- High hot carrier endurance
- Wide SOA

SOA: Safe Operating Area

Our Approach

LDMOS for 40V switching device

- Mature CMOS process usage
- One-chip integration with other circuits

Based on our Previous Proposed LDMOS

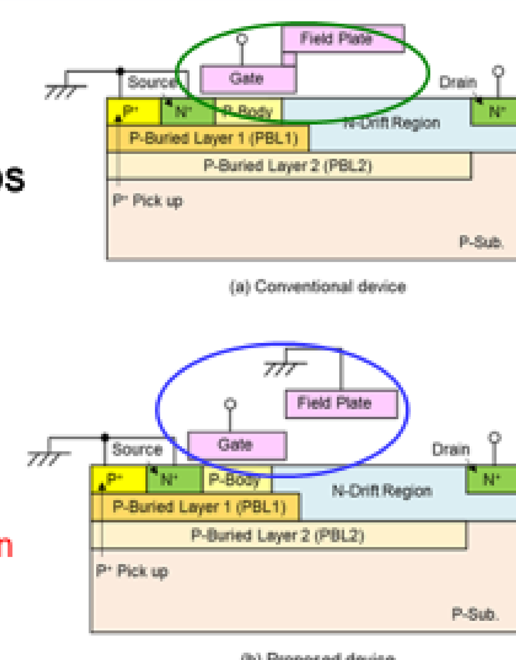
- Dual RESURF structure
- Field plate connected to gate

New Proposal

- Dual RESURF structure
- Field plate connected to ground
  → Miller capacitance reduction

Investigation of Its optimal size and location

TCAD Simulation Verification



Proposed LDMOS Structure and Operation

Proposed LDMOS Structure and Feature

Length of drift region L_D : 2650 nm

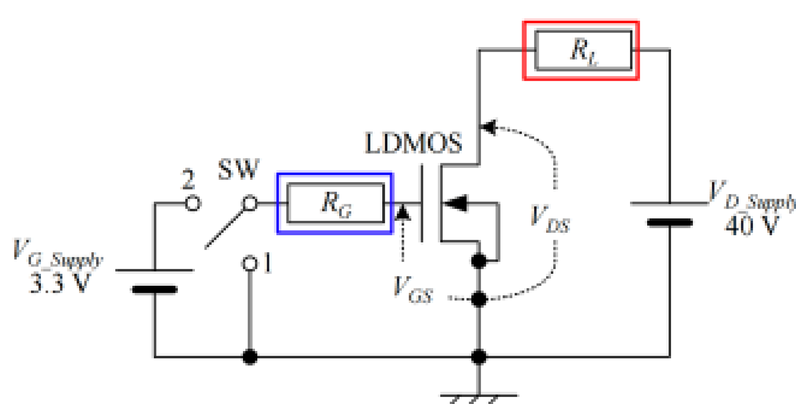
Field plate L_{FP}(standard $L_{FP\text{-}std}$) : 1625 nm

Thickness of oxide interlayer between field plate and drift region T_{OX1}(standard $T_{OX1\text{-}std}$): 308 nm

Oxide interlayer between field plate and the gate T_{OX2}(standard $T_{OX2\text{-}std}$): 100 nm

Breakdown voltage between drain and source BV_{DS} : 61 V

Simulation Circuit as Switching Device



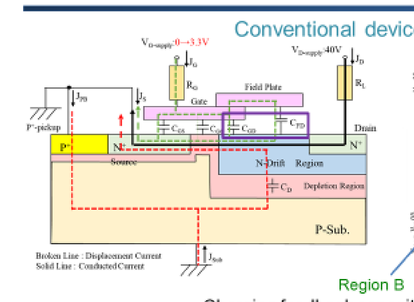
Specific on-resistance: 40.8 mΩmm²

Load resistance R_L : 5.33Ωmm²

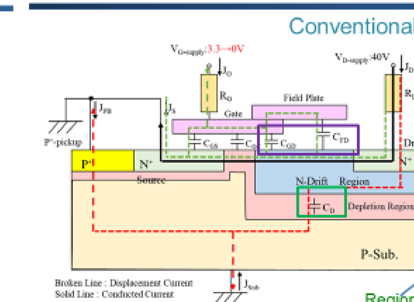
Gate resistance R_G : 1.07Ωmm²

Extrapolated threshold voltage: 1.05V

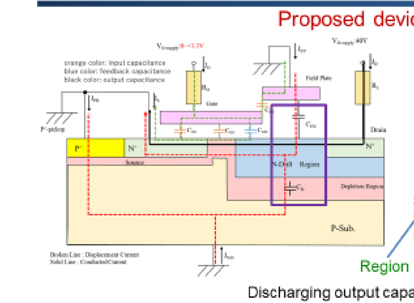
Turn-On Simulation Results (Region B) — Conventional device



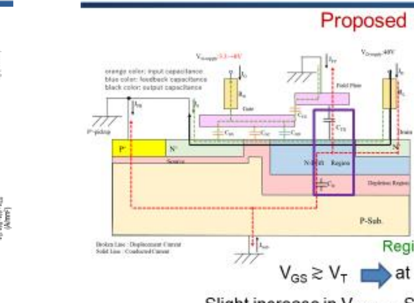
Turn-Off Simulation Results (Region B) — Conventional device



Turn-On Simulation Results (Region B) — Proposed device

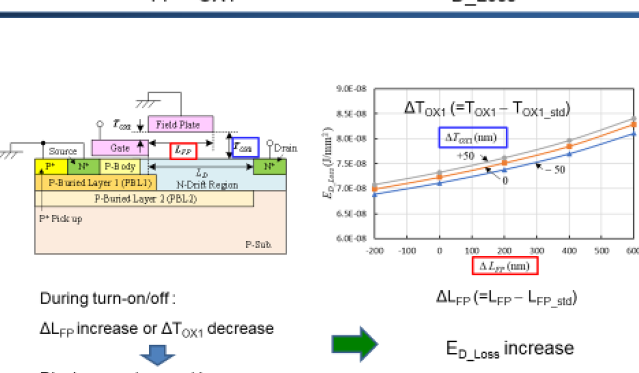


Turn-Off Simulation Results (Region B) — Proposed device

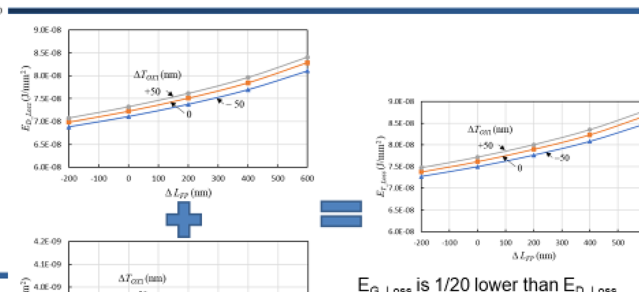


Optimization Simulation Results

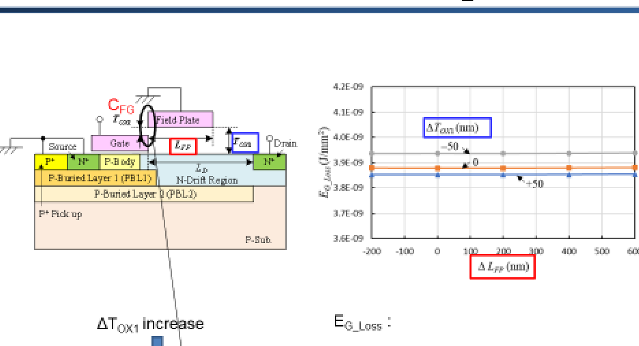
L_{FP} T_{OX1} for Drain Loss E_{D_Loss}



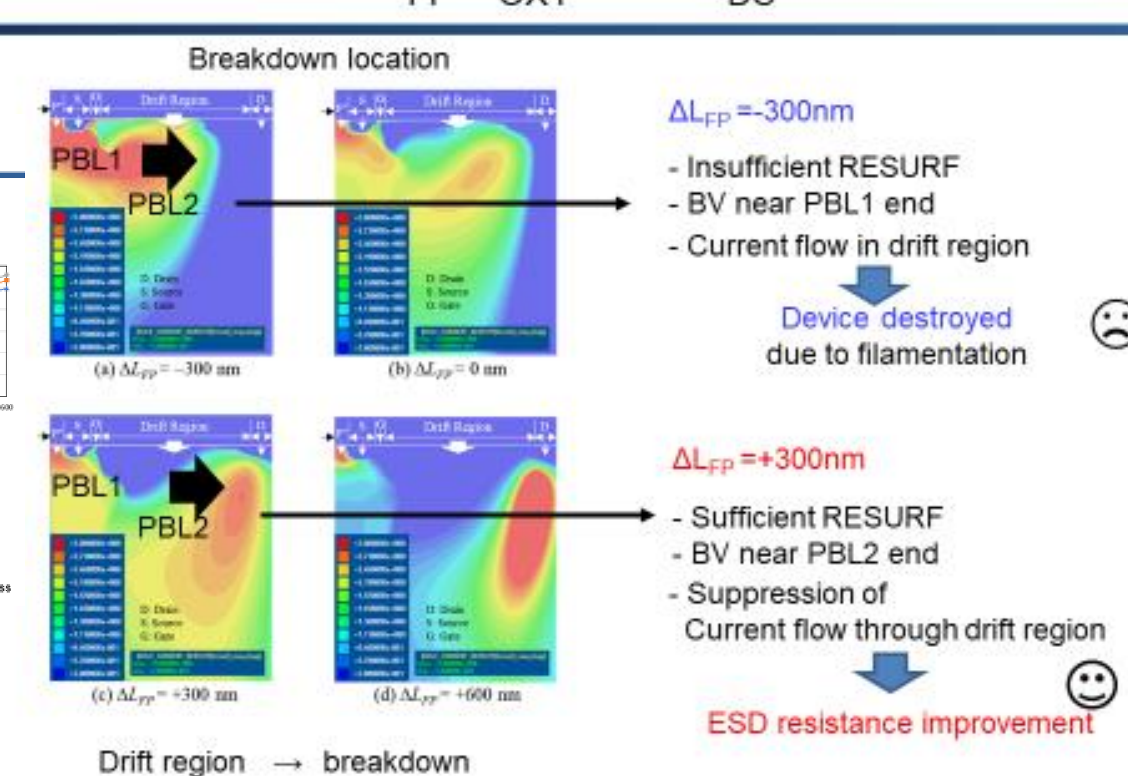
L_{FP} T_{OX1} for Switching Loss



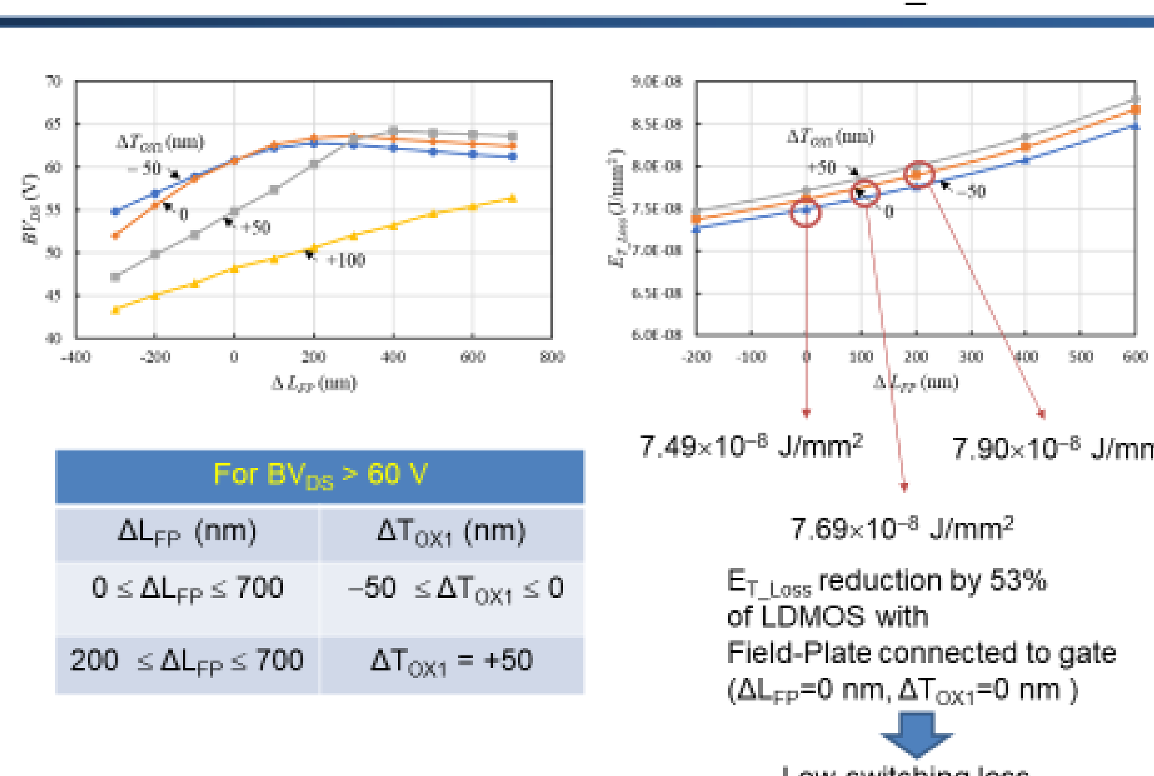
L_{FP} T_{OX1} for Gate Loss E_{G_Loss}



L_{FP} T_{OX1} for BV_{DS}

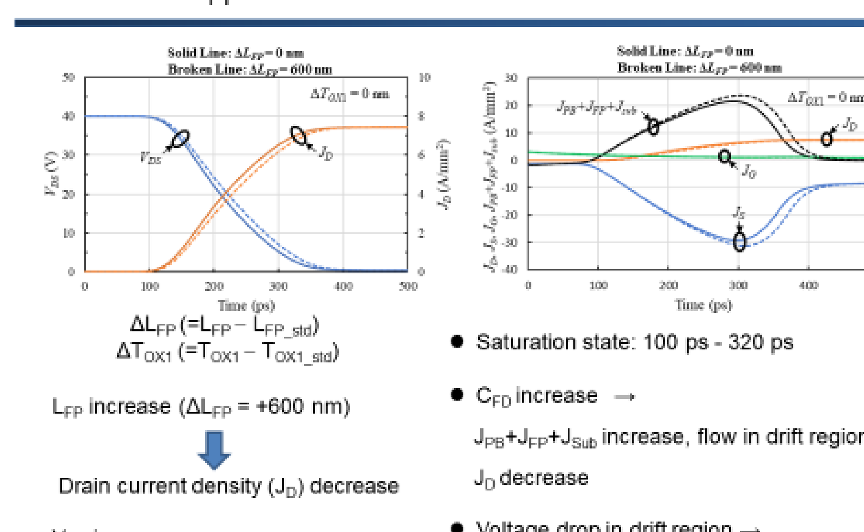


L_{FP} , T_{OX1} for Switching Loss E_{T_Loss}

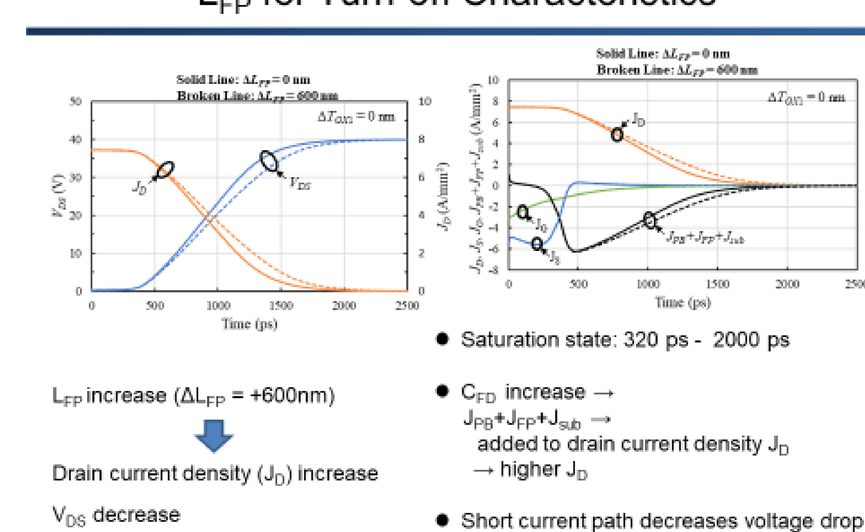


Discussion & Conclusion

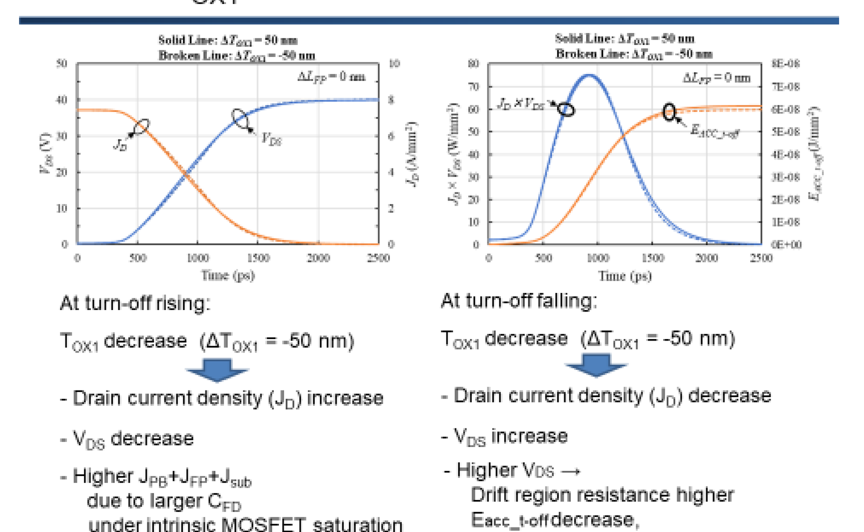
L_{FP} for Turn-on Characteristics



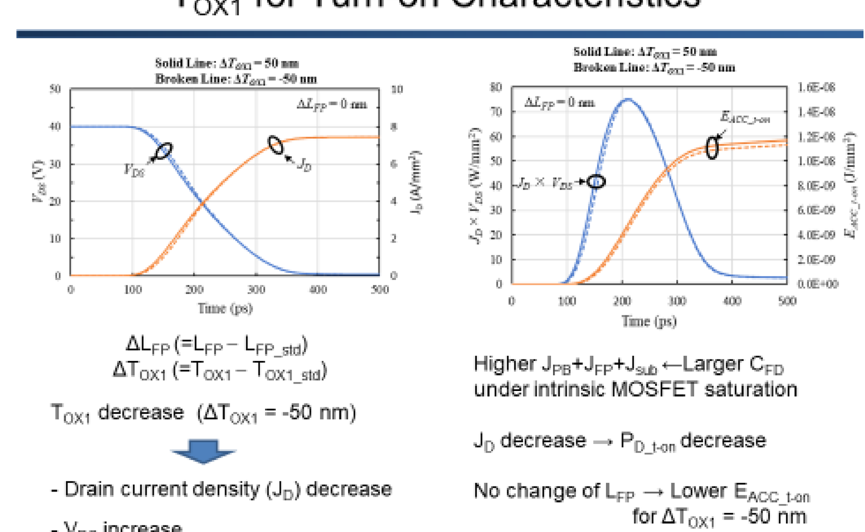
L_{FP} for Turn-off Characteristics



T_{OX1} for Turn-off Characteristics



T_{OX1} for Turn-on Characteristics



- Field Plate connected to ground
- Its size, location optimization of ΔL_{FP}, ΔT_{OX1}

For 0 nm ≤ ΔL_{FP} ≤ 200 nm, −50 nm ≤ ΔT_{OX1} ≤ 0 nm,

○ Switching loss reduction by 50 %

○ High ESD endurance

- Verified with TCAD simulation

H.Y. Du, J. Matsuda, A. Kuwana, and H. Kobayashi, "Low Switching Loss Dual RESURF 40 V N-LDMOS with Ground Field Plate for DC-DC Converters," in MWSCAS, Fukuoka, Japan (Aug. 2022)