Proposal of High Reliability LDMOS Structure

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Research Background & Objective

LDMOS...Laterally Diffused MOS
Used as high-voltage switching

Adopting to automotive applications

If it were not highly reliable ...??

Accident !!!

Introduction

High reliability realization

• Reinforcement of Hot Carrier Endurance
  ✓ Suppression of Impact ionization around drain edge of intrinsic MOSFET of LDMOS
  ✓ Suppression of Current Expansion (Kirk effect)
• Reinforcement of ESD Endurance
  ✓ Generation of Bulk Breakdown (pn junction breakdown location is in bulk.)

Impact Ionization & Current Expansion

Conventional LDMOS

Purpose of Doping

To suppress Current Expansion
⇒ ① Highly doped p-body ② V, adjustment ③ n-drift 2
RESURF
⇒ ④ Highly doped p-body around drift edge ⑤ p-well along drift region
Low RonA ⇒ ⑥ n-drift 2

New LDMOS

Purpose of Doping

To suppress Current Expansion
⇒ ① p-buried layer 1
⇒ ② Aperture of p-buried layer 2 under n+ drain region
Reinforcement of RESURF
⇒ ③ p-buried layer 1 around drift edge ④ p-buried layer 2 along drift region

Comparison of Conventional & New

Conventional LDMOS

- Peak reduction at drift region
- No peak at channel side of drift region

New LDMOS

- Flat characteristic and small value

Result

Table: Comparison of Conventional & New

Item | Conventional LDMOS | New LDMOS
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Hole current density around drift side edge of intrinsic MOSFET | High | Low
Magnitude of electric field in drift region around drift side of intrinsic MOSFET | High | Low
Location of pn-junction breakdown | Bulk | Bulk
Current increase (current expansion) | Strong | Weak
| at ① p-buried layer and ② n-drift 2 |
$V_{DS,int}$ (V) at $BV_{DS}$ | 2.64 | 1.84
$BV_{DS}$ (V) | 68 | 61
RonA (mΩmm)$^2$ | 68.7 | 69.3
$V_{DS,int}$ at $I_{DS}=10^{-9}$A | 2.4 | 2.1

Conclusion

• Proposed a new LDMOS structure for automotive applications.
• Realized by forming dual p-buried layers.
• Leading to high reliability and wide SOA.

Challenge for the Future

• Reducing the on-resistance
• 3D Simulation, collaborating with Toronto University, Canada

References


AdvanceSoft Corporation is acknowledged for providing TCAD simulator.