

Compact Capacitance Model of LDMOS for Circuit Simulation

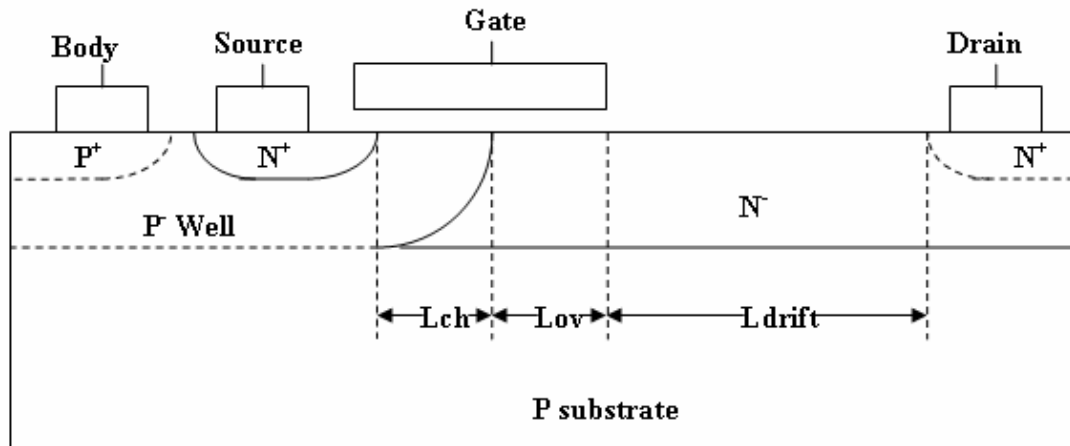
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- Introduction
- Non-Uniform doping in channel and its effect on capacitance
- Overlap region modeling
- Distributed RC network effect on C_{gd} modeling
- Conclusion

Introduction: LDMOS structure and capacitance features

- Channel is formed by lateral diffusion, so channel doping in channel is highly non-uniform
- There is significant overlap region between Gate and Drain
- Device is non-symmetry, which has substantial effect on C_{gd} modeling



Non-Uniform doping in channel and its effects on capacitance:

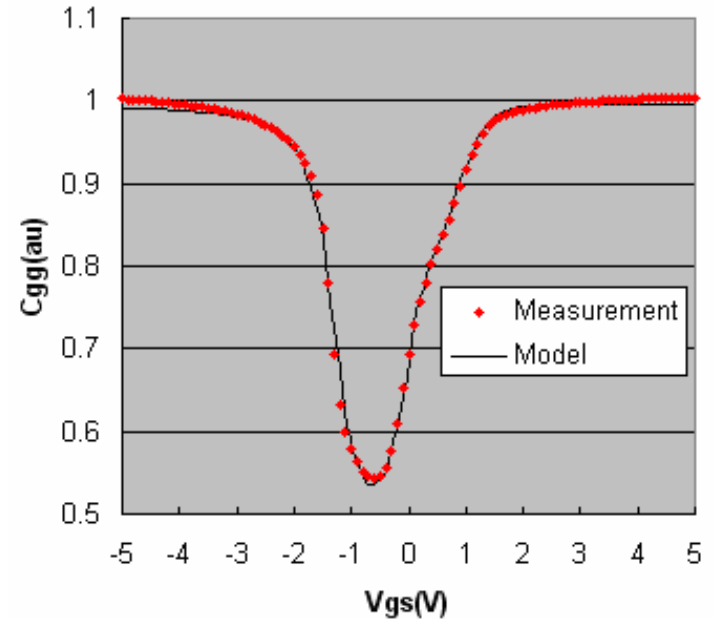
- Channel doping is high at source end and low at drain end
- Resulting different threshold voltage in different channel region
- As V_{gs} increase, drain side channel is inverted before source end. Channel charge contributes to C_{gd} completely.
- After total channel is inverted, channel charge are partitioned to both drain side and source side.
- Modeling charge effect through V_{th} modulation:

$$V_{th}(x) = V_{fb}(x) + \phi_b(x) + \frac{\sqrt{2qN_{ch}(x)\epsilon_{si}\phi_b(x)}}{C_{ox}}$$

$$N_{ch}(x) = N_s \times \exp\left(-\frac{x^2}{4x_0}\right)$$

Overlap region modeling:

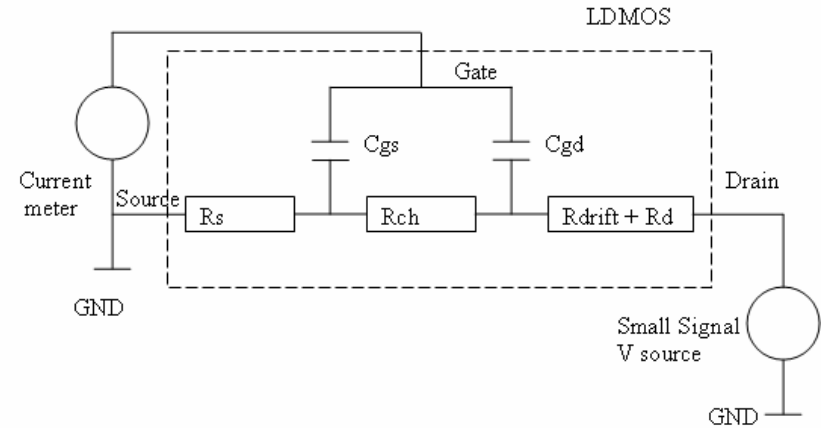
- LDMOS overlap region between Gate and Drain is significant.
- This part forms a separate MOS structure which can be in accumulation mode, depletion mode and inversion mode depends on different drain/gate/body biases
- The overlap region accounts for the two-step curve in C_{gg} plot
- Modeling of overlap region charge is essential for accurate prediction of capacitance, especially for C_{gd}



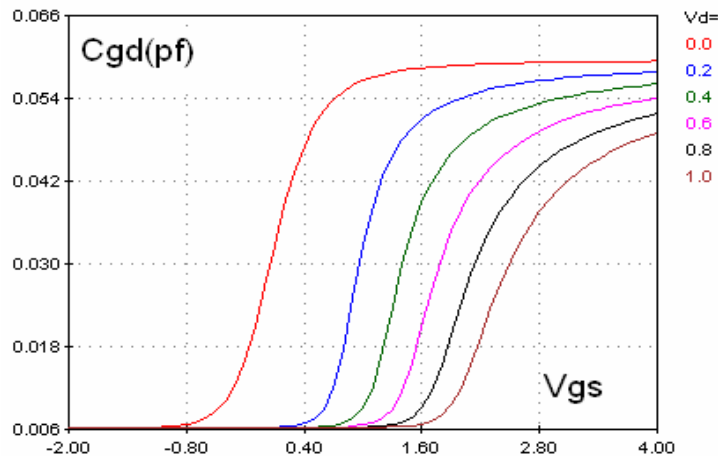
C_{gg} behavior showing two-step curve

Distributed RC network effect on Cgd modeling:

- Non-symmetry of device structure causes non-symmetry in Cgd and Cgs measurement
- Measured Cgd and Cgs are not the intrinsic Cgd and Cgs in the model.

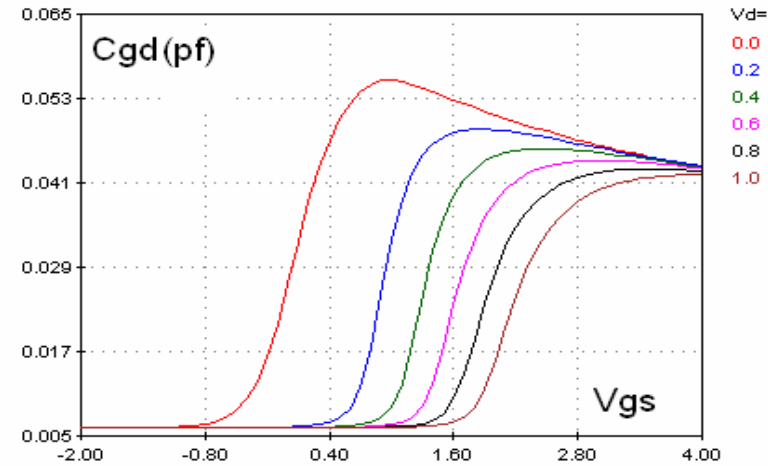


LDMOS Cgd measurement and modeling



(a)

Intrinsic Cgd without RC network effect

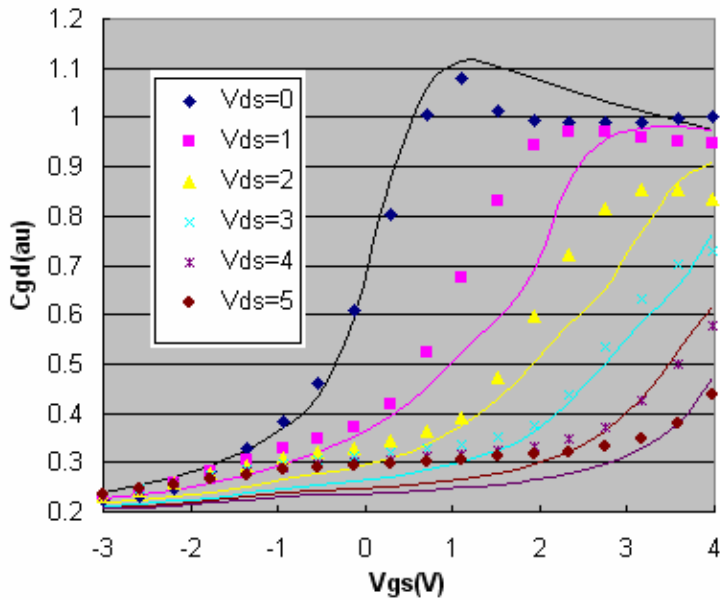


(b)

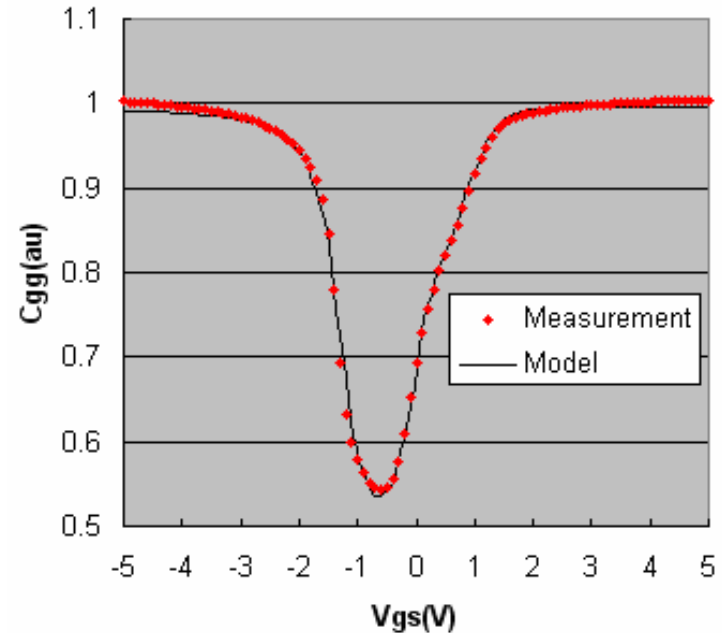
Cgd with RC network effect

Model verification:

- Model fitting results for C_{gd} and C_{gg} :



Cgd model results



Cgg model results

Conclusions:



- Lateral non-uniform doping effect on channel charge modeling has to be considered in LDMOS model
- Gate drain overlap region can be in accumulation, depletion and inversion region depends on biases. A separate MOS structure should be used to model this part of charge.
- Non-symmetry of device caused RC distribution effect has to be considered in C_{gd}/C_{gs} measurement and modeling