P087 Reliability Modeling on 90 nm n-channel MOSFETs with BSIM4 Dedicated to HCI Mechanisms
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Research Goal
- Developed MOSFET model
- 0.8
- 0.6
- 0.4
- 1.2
- 0.2
- 1.00E+04
- Mobility
- 0.8
- 1
- 0.4
- 0.2
- 1.00E+05
- 0.1μm
- 10.0μm
- Characterizations
- 1.2
- 0.4
- 1.2
- M
- 0.8
- 1
- 0.4
- 0.2
- 1.00E+04
- Measurement and Simulation of "Hot x 10 = (4)
- 0.4
- 0.6
- 1.2
- (2)
- 376
- 0.8
- 1
- 0.4
- 0.2
- 1.00E+03
- 10.0μm
- 0.2
- 1.00E+05
- 0.1μm
- 10.0μm
- 0.2

Introduction

Mobile degradation phenomenon

RD Model Equations

\[ N_{H0}/N_R = \frac{k_R}{k_N} N_0 \]  
(1)

\[ N_{Hk} = k_R N_{Hk} \]  
(2)

\[ N_{Ht} = \frac{C_{HICL}}{2k_N} \int_0^{V_T} \left[ \frac{N_{H0}}{x} \left( 1 - \frac{x}{V_T} \right) \right] dx \]  
(3)

\[ N_{Ht} = \left( \frac{k_R N_{Hk}}{n_{Hk}} \right) \frac{N_{Hk}}{122} D_H \]  
(4)

\[ \delta V_{TH0} = \frac{C_{HICL}}{k_N} \frac{N_{Hk}}{122} D_H \]  
(5)

Proposed Model

Threshold voltage shift due to HCI
Implemented to mobility model equation

Mobility Model

\[ \mu_{eff} = \mu_0 \left( 1 + \frac{U}{U_{TH0}} \right) \]  
(6)

\[ V_{TH} = V_{TH0} + \Delta V_{TH, body} \]  
(7)

\[ + \Delta V_{TH, minor, gate} + \Delta V_{TH, minor, channel} \]  
(8)

Conditions for Our Experiments

90 nm process n-channel MOSFET

Large: Channel Width 10.0μm
Channel Length 10.0μm

Short: Channel Width 10.0μm
Channel Length 0.1μm

Stress condition

Degradation parameter is based on 65nm process device’s, whereas our device is fabricated with 90nm process

- Temperature 300.15 [K]
- Time 1,000 [hours]

Id-Vg Characterizations

Measurement and Simulation Environment

Id-Vg Characterizations

Measurement and Simulation of Drain Output 1/f Noise Density

\[ S_{1/f} = C_{1/f} \left[ 1 + \frac{U}{U_{TH0}} \right] \]  
(9)

Summary

- HCI degradation model was studied and implemented in BSIM4 of our MDW-SPICE simulator
- BSIM4 and degradation model parameters were extracted with measurements of 90nm n-channel MOSFETs
- Simulation verifications of DC drain currents were performed with and without bias stresses
- 1/f noise model parameters were extracted with measurements
- Simulation verifications of drain output 1/f noise density were performed with and without bias stresses

References: