GTS Framework 2014.09

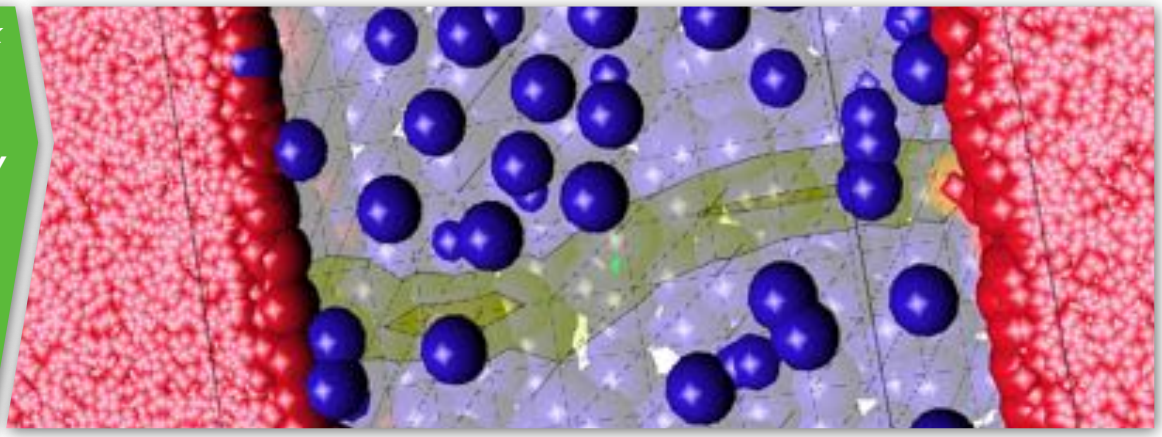
Predictive Simulation of Gate Stacks

From Microscopic Traps to Device and Circuit Reliability

GTS Framework Application:

Reliability & Variability Analysis

- ***NBTI***
- ***PBTI***
- ***HCD***



Profound understanding of degradation physics is key to optimizing device and circuit reliability of your technology.

With the latest implementation of the nonradiative multiphonon (NMP) model, Minimos-NT allows accurate simulation of BTI phenomena.

Applications

Engineering device reliability by numerical experiments – analyzing effects of:

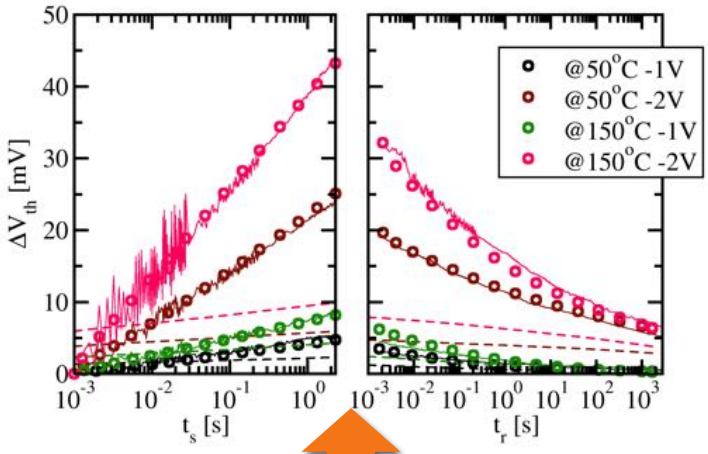
- Reducing defect density
- Shifting traps in energy
- Reducing the electrostatic impact

Key Features Minimos-NT

- Predictive simulation of **gate stacks**
- Characterization by **inverse modeling**
- Novel **channel materials**
- Bias temperature instability (BTI)
- Non-radiative multiphonon (NMP) and double well (DW) model
- **Atomistic traps and dopants**
- Analysis of both **FinFETs** and **planar tech.**
- Reliability on the device and circuit levels
- Automatic job distribution in cluster

Developed in collaboration with Vienna University of Technology, group T. Grasser

Tools: GTS Structure, Minimos-NT, GTS Vision.

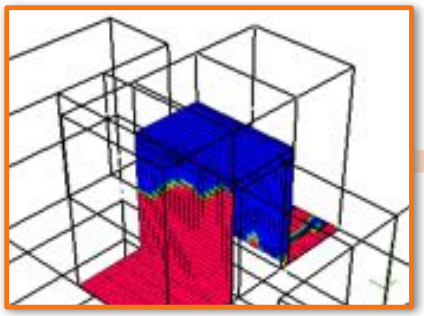


	mean	σ
N_T [cm^{-3}]	$4 \cdot 10^{18}$	
Et [eV]	-1.05	0.15
Et_prime [eV]	-0.35	0.4
R [1]	0.6	0.4
S [1]	2.3	1.8
R_prime [1]	0.6	0.45

Inverse modeling of the spatial trap density N_T (bulk and interface), and statistical distribution of the trap parameters.

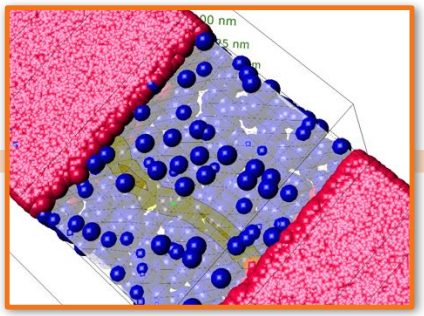
Variability and Reliability Simulation with GTS Framework 2014

Predictive Simulation of Time Zero Variability



Metal grain roughness

WKF fluctuation due to varying grain orientation in gate materials



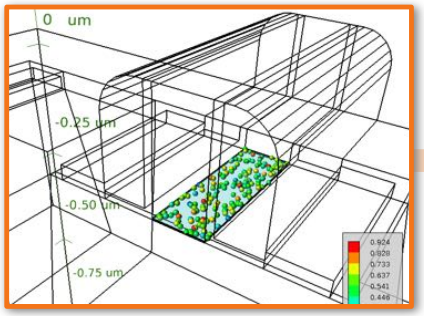
Discrete random dopants

Formation of percolation path due to the atomistic nature of dopants

Line edge roughness

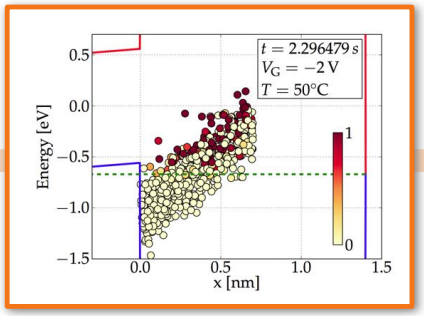
Geometrical variation of semi-conductor surfaces or interfaces

Predictive Simulation of Device Reliability



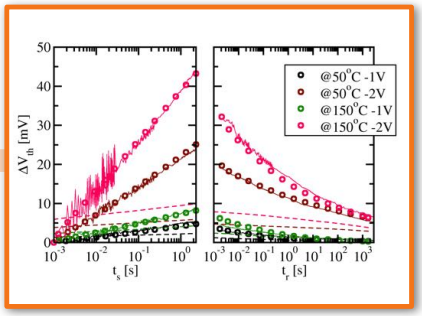
Discrete oxide and interface traps

The stochastic spatial and energy distribution according to the data extracted for the gate stack



Trap occupation

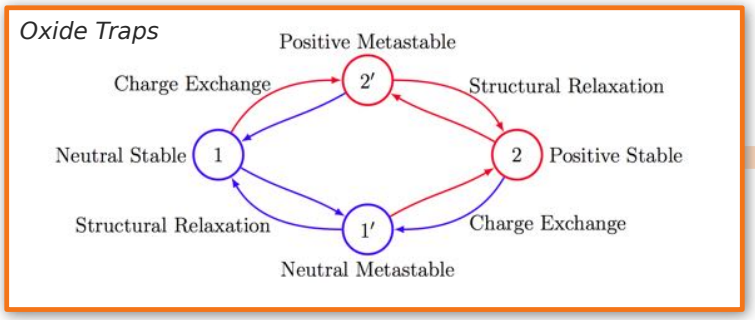
Trap occupation results from the transient solution of the transitions between the trap states and the interaction with bulk and gate



Statistical device degradation

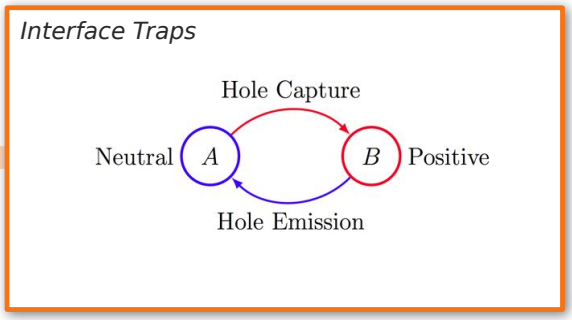
Shift of V_{th} resulting from self-consistent device simulation considering trap occupation

Accurately Capturing Physical Properties of Oxide and Interface Traps



Non-radiative multi-phonon (NMP) model

State diagram showing all possible transitions in the NMP four-state model implemented in Minimos-NT



Double well (DW) model

State diagram with the neutral state A and the positive state B of the double well model

Understanding device degradation is key for strategies to increase reliability & yield.

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Predictions based on physics.

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