Predictive Simulation of Gate Stacks
From Microscopic Traps to Device and Circuit Reliability

Profund 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.

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 semiconductor 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

**Oxide Traps**
Charge Exchange
Neutral Stable
Structural Relaxation
Positive Metastable

**Interface Traps**
Hole Capture
Neutral $A$
Positive $B$
Hole Emission

**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.

Predictions based on physics.

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