Physics of Carrier Transport in III/V-based Technology

III/V materials are considered good candidates for replacing silicon as channel material due to their low effective mass. Non-planar technology provides superior electrostatic control. Profound design decisions need to be made, and efficiently finding the most advantageous and reliable path is key to successful device design.

Only physical modeling provides substantial, reliable data for predictive simulation, and features a prediction window unachievable by conventional empirical models. Based on latest scientific research, GTS provides a comprehensive and efficient solution.

Applications
Physical simulation of devices, to predict:
- CV curves, conductance
- Device characteristics
- DIBL, subthreshold slope

Key Features
- Predictive, physical simulation
- Linearized Boltzmann transport
- Polar-optical phonon (POP) scattering
- Surface-roughness scattering (SRS)
- Non-parabolic, multi-valley electronic structure
- Dielectric model
- Optimizer, parameter fitting
- Interface for calibration of empirical models
- Computationally efficient, automatic job distribution in cluster

Developed in collaboration with the Vienna University of Technology, group T. Grasser and group H. Kosina
Tools: GTS Structure, VSP, Minimos-NT, GTS Vision.

Electron mobility vs. inversion density in the fin of an InGaAs / InAlAs / InP FinFET. Clearly telling the dominant scattering effects in each area, the physical models provide substantial data for decisions in device design and optimization.
Predictive Simulation of 60nm InGaAs Quantum-Well MISFETs

Device Level: Macroscopic Transport (Minimos-NT)

Self-consistent quantum correction ensures that carriers are confined to the InGaAs/InP-channel layers.

Electron concentration in linear / saturated regime

Sub-threshold slope 73.5mV/dec, DIBL 103.8mV/V

Resulting transfer characteristics

Structure Level: Microscopic Transport (VSP)

Multi-valley effective mass approach with non-parabolic correction.

Electronic structure

Electron mobility calculation

Includes all relevant scattering mechanisms, allowing to analyze and compare their influence.

Transport model verification

Excellent agreement between measured and simulated channel conductivity is achieved on the first attempt without further parameter adjustments.

Material parameters

Due to the unknown properties of the TaSiOx gate-dielectric, the dielectric constant and gate work function were calibrated against measured capacitance-voltage curves using our automated parameter fitting environment.

Scattering mechanisms considered for mobility:
- Acoustic phonons
- Polar optical phonons
- Non-polar optical phonons
- Surface roughness
- Impurities

Why rely on artificial parameters if one can build on physical values?

Predictions based on physics.

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