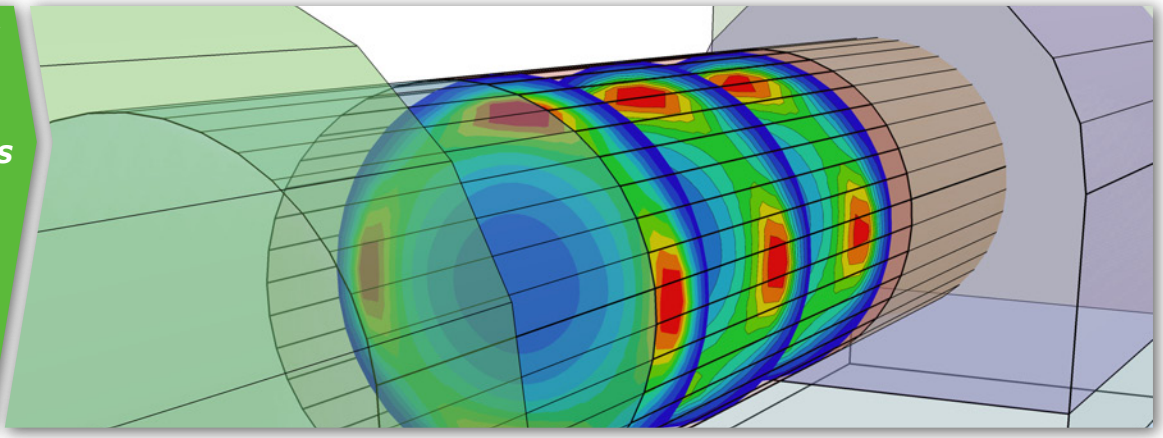
Transitioning to Quantum Devices

Tools for the Next Decade of Non-Planar Device Technologies

GTS Framework Application:

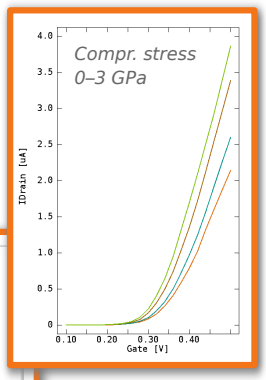
Non-planar Technologies

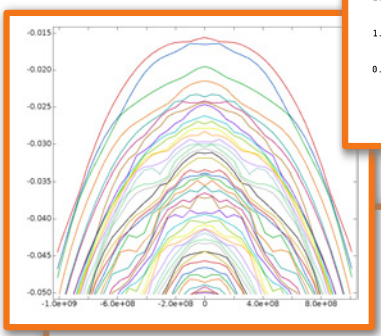
- ***Nanowires***
- ***FinFETs***
- ***Novel Channel Materials***

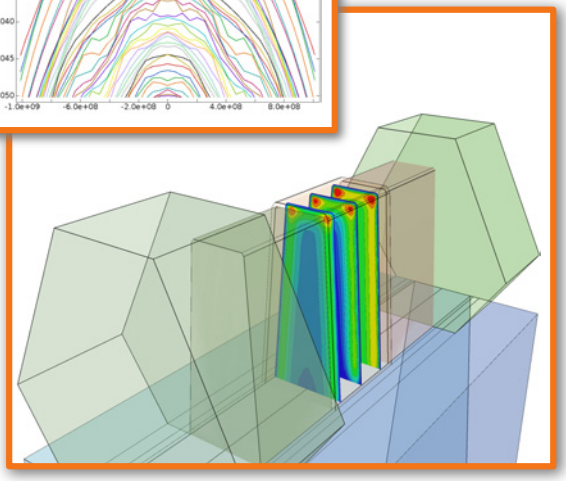


Geometrical confinement and strain in non-planar technologies allow to engineer transport properties of the device channel. Leveraging quantum effects is the key to boosting device performance.
Systematic design of devices like FinFETs and nanowires requires a new generation of simulation tools which truly capture the physics of quantum effects.

GTS Framework provides physics-based quantum-mechanical models, allowing for virtually parameter-free simulation of upcoming non-planar device generations. A unique tool flow was specifically developed for predictive simulation as well as optimization of quantum devices.







Coupling band structure and physical mobility modeling with device simulation for a FinFET

Key Features VSP

- Dimensions: 0D-3D (bulk, **film**, **wire**, dot)
- N×N up to 2nd-order bipolar **k·p band structure**
- **Unstructured 3D mesh** r-grid / k-grid
- E and k-based Kubo Greenwood integration
- Scattering processes: **phonons, impurities, surface roughness**
- Linearized Boltzmann transport (Kubo-Greenwood)
- **QTBM** – ballistic quantum transport
- **Novel gate stacks**
- **New channel mat.**: strained Si, Ge, SiGe, InGaAs

Developed in collaboration with Vienna University of Technology, group H. Kosina

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

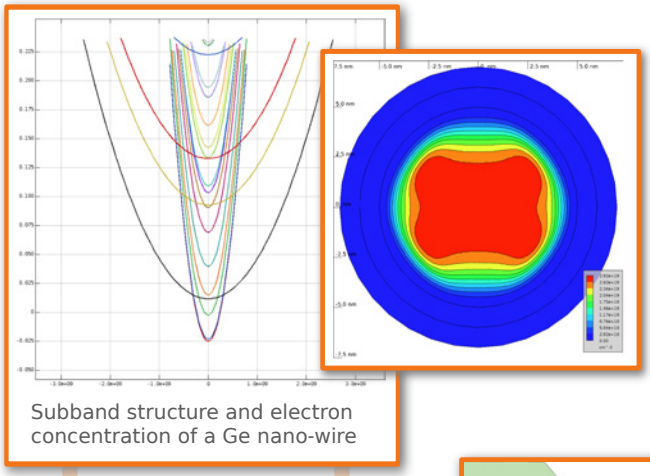
Full 3D Device Simulation with GTS Framework 2014

The First Physics-Based Commercial Solver for FinFETs and Nanowires

- Unique tool flow specifically developed for design and optimization of non-planar geometries
- Physics-based quantum-mechanical modeling allows precise engineering of channel transport properties, virtually free of empirical parameters

Closed-Boundary Schrödinger Poisson Solver

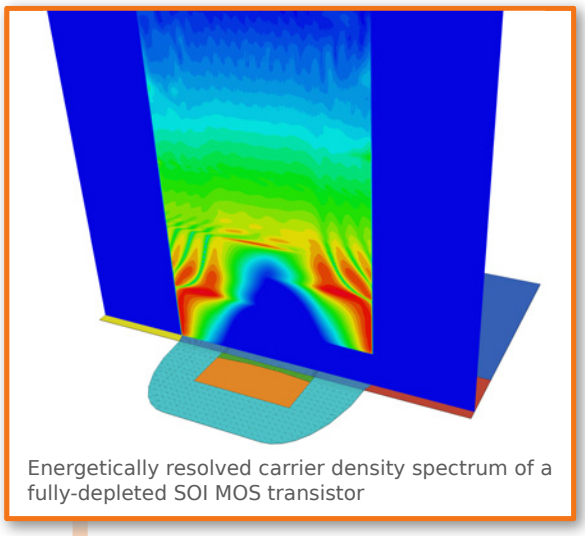
- Band structure & confinement
- Substrate and channel orientation
- Inhomogeneous strain distribution



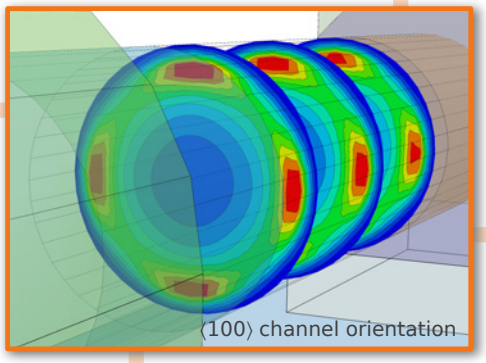
Subband structure and electron concentration of a Ge nano-wire

Open-Boundary Schrödinger Poisson Solver

- Real-space QTBM method: 1D, 2D, and 3D
- Quantum-mechanical tunneling
- Ballistic transport limit



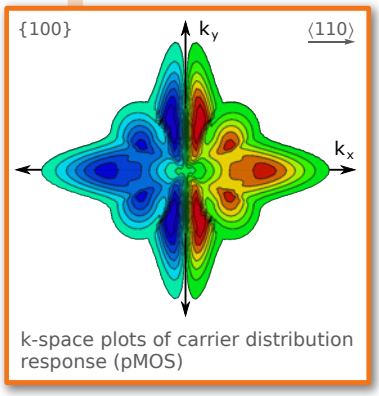
Energetically resolved carrier density spectrum of a fully-depleted SOI MOS transistor



⟨100⟩ channel orientation

Full 3D Device Simulation

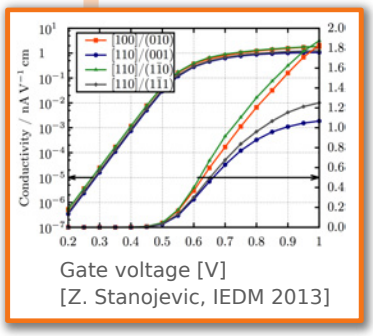
- Slice to determine transport properties of the channel
- Full coupling to S/P solver and Kubo-Greenwood solver



k-space plots of carrier distribution response (pMOS)

Kubo-Greenwood Solver

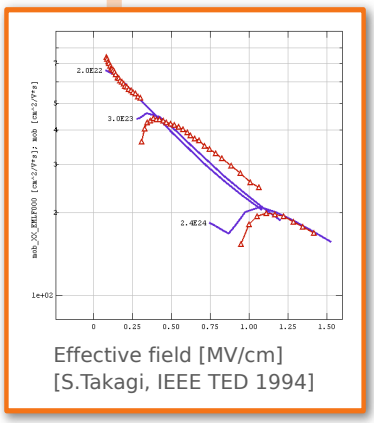
- Accurate low-field mobility from BTE
- Including ADP, IVS, IIS, and SRS
- Novel SRS model
- Only commercial solver for FinFETs and nanowires



Gate voltage [V]
[Z. Stanojevic, IEDM 2013]

Device Characteristics

- Transfer & output characteristics
- ID_{lin}, ID_{sat}, I_{ON}, I_{OFF}, V_{th}, SS



Effective field [MV/cm]
[S.Takagi, IEEE TED 1994]

Automatic Calibration Against Measured Data

- Inverse modeling framework
- Fitting of low-field mobility

Providing the data you need for efficient development of non-planar technologies.

Global TCAD Solutions GmbH
Landhausgasse 4 / 1a
1010 Vienna
Austria, EUROPE

eMail: office@globaltcad.com

Predictions based on physics.

globaltcad.com