Quantum Cascade Laser Modeling based on the Pauli Master Equation

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Quantum Cascade Lasers are practical sources of radiation in the mid-infrared and Terahertz regions. Cross-plane electronic transport through these semiconductor heterostructures can be described semi-classically using the Pauli master equation. This equation is derived from from the Liouville-von Neumann equation by introducing the Markovian approximation. A Simulator solving the PME by means of a Monte Carlo method has been developed. All relevant electron-phonon scattering processes are included. As a prototypical example, a quantum cascade laser in the THz region has been investigated.

This is joint work with Oskar Baumgartner, and Goran Milovanovic.

Simulation of Surrounding Strain Effects on the Performance of Nanowires Devices

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The simulation method of surrounding strain effects on the performance of nanowires devices is developed including strain distributions, band structures, effective mobility and the I-V curves. FEM is used to calculate the strain distributions and $k \cdot p$ method is used to calculated the band structure. The Schrödinger-Poisson system is solved self-consistently. The effective mobility is calculated via modified Kubo-Greenwood formula The performance of Si and Ge nanowires FETs with different axial orientations, various surrounding material and surrounding stress induced during process can be simulated. The simulation can be served as a useful guide for future device optimization.

This is joint work with Honghua Xu, Gang Du, Chun Fan, Ruqi Han.

A Finite Volume Method for the Multi Subband Boltzmann Equation with realistic 2D Scattering in DG MOSFETs

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We propose a deterministic solver for the time-dependent multi-subband Boltzmann transport equation (MSBTE) for the two dimensional (2D) electron gas in double gate MOSFETs with flared out source/drain contacts. A realistic model with six-valleys of the conduction band of silicon and both intra-valley and inter-valley phonon-electron scattering is solved. We propose a second order finite volume method based on the positive and flux conservative (PFC) method to discretize the BTEs. In order to reduce the splitting error, the 2D transport problem in the wavevector space is solved directly by using the PFC method instead of splitting into two 1D problems. The solver is applied to a nanoscale DG MOSFET and the current-voltage characteristic is investigated. Comparison of the numerical results with ballistic solutions show that the scattering influence is not ignorable even when the size of a nanoscale semiconductor device goes to the scale of the electron mean free path.

This is joint work with Gang Du, Xiaoyan Liu, and Pingwen Zhang.