Title of the course:

Charge transport in low dimensional structures (6 lectures)

Lecturer:

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Period: second week

Abstract

Shrinking the dimensions of today electronic devices makes the effects of quantum confinement more and more relevant. For example, in double gate (DG) MOSFETs the barrier potential between the two gate oxide layers creates a quantum well whose length is comparable with the de Broglie length. Usually, one adopts a quasi-static description, along the confining direction, based on a coupled Schrödinger-Poisson system, which leads to a subband decomposition, while the charge transport along the longitudinal direction is described by a semiclassical Boltzmann equation for each subband. The numerical simulations, that have been performed by employing Monte Carlo or deterministic methods, are very expensive from a computational point of view. Consequently, it is a demanding task to replace the Boltzmann equations with macroscopic models like drift-diffusion, energy-transport or hydrodynamic ones.

The main aim of the lectures is to show how to employ the Maximum Entropy Principle for getting energy-transport and hydrodynamical models in the presence of confinement effects. The analytical and numerical issues will be tackled and examples of application to semiconductor devices, like DG-MOSFETs and nano-scale MOSFET, will be presented.

Specific topics will be covered:

1) band structure and Boltzmann equation for charge transport in semiconductors;

2) quantum confinement and quasi 2D-electron gas;

3) Maximum Entropy Principle and application to electron transport;

4) mathematical models for charge transport in Double-Gate MOSFET;

5) 2DEG-3DEG charge transport model;

6) numerical methods and simulations.

Prerequisites:

the lectures of the first week on quantum transport will be considered as a necessary background.