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Simulation and Modeling of Nanowire transistors

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STATEMENT

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Engineering Physics.

The work included in the thesis was carried out by the author at the Engineering Physics and Mathematics Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis has been submitted for a degree or a qualification at any other university or institute.

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ABSTRACT

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Scaling challenges and performance are directing the research into new device structures in the nanoscale regime. Among these devices are the silicon nanowire transistors that had attracted broad attention from both the semiconductor industry and the academic researchers. This is attributable to its improved electrostatic control of the channel and consequent suppression for the short-channel effects. For the design and optimization of nanowire transistors numerical quantum-based device simulator is needed that helps to understand its physics and further enhance its behavior. It is worth mentioning that both computational efficiency and high accuracy, taking physical effects into consideration, are crucial in building a simulator.

The main objective of this work is to build a full numerical simulator for cylindrical nanowire transistors under MATLAB environment that can be used in the investigation of the device's properties and output characteristics with efficient simulation time. This simulator is based on the effective mass approximation and utilizes the cylindrical coordinate system in order to take the advantage of the symmetry in the φ – direction, thus, an isotropic effective mass has been introduced in the simulator. The objectives of this thesis are: 1) Investigating the quantization effects in nanowire transistors using a 1D self-consistent Poisson – Schrödinger solver in conjunction with a semi-classical current model; 2) Examining the upper performance limit of the transistor (ballistic case) through proposing a 2D numerical simulator that uses the mode space approach where the Non-Equilibrium Green's Function (NEGF) is used to solve the transport equation; 3) Studying the non-coherent transport via including a phenomenological model to the simulator. Accordingly, a complete simulator is achieved that has the great advantage of simulation time reduction while keeping high level of precision

Key Words: SNWTs, NEGF, Mode space, Isotropic effective mass.

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*No one who achieves success does so without the help of others.
The wise and confident acknowledge this help with gratitude.*
Alfred North Whitehead

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