NANO-BALLISTIC SATURATION VELOCITY MODELLING TO ENHANCE CIRCUIT PERFORMANCES OF NANO-MOSFET

(FRG0248-TK-2/2010)

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SYNOPSIS

The modeling of nano-ballistic carrier transport nature across the nanoscale channel of a MOSFET based on streamlining of the randomly oriented velocity vectors in the presence of high electric field has been successfully done in this project. Detailed explanation of low-dimensional energy spectrums and carrier statistics for quasi 3D, 2D and 1D that invoked the quantum effects and the Fermi energy distributions in non-degenerate and degenerate region essential for nanoscale transistor was found respectively. The ballistic intrinsic velocity for Q3D, Q2D and Q1D system has been derived for non-degenerate and degenerate regime and analyzed its dependence towards temperature and carrier concentrations. Based on ballistic velocity field characteristics, the current-voltage (I-V) characteristics of a 2D nanoscale MOSFET has been derived successfully. The gate quantum confinement (QC) effects is analyzed and applied to the modeling of nano-MOSFET. The innovative linear and saturation region of drain current expressions of a nanoscale MOSFET is explained based on electric-field profiles at the source and drain end. A very well agreement of the theory applied and models developed with 80nm channel length fabricated MOSFET validates the explained physics based theory of a nano-ballistic carrier transport.

SINOPSIS

Pemodelan pergerakan balistik pembawa dalam transistor skala nano telah berjaya diperolehi dalam projek ini berdasarkan kepada penyelurusan vektor kelajuan tak tentu dengan kehadiran medan elektrik yang tinggi. Penjelasan terperinci berkenaan dimensi-rendah statistik pembawa dan spektrum tenaga bagi quasi 3D, 2D dan 1D yang menglibatkan kesan kuantum dan pengagihan tenaga fermi pada regim 'non-degenerate' dan 'degenerate' yang amat penting bagi transistor skala nano juga telah didapati. Kelajuan intrinsik balistik bagi sistem Q3D, Q2D dan Q1D telah dibangunkan bagi regim 'non-degenerate' dan 'degenerate' dan dianalisa kebergantungannya terhadap kepekatan pembawa dan suhu. Berdasarkan sifat medan kelajuan balistik, sifat arus-voltan (I-V) bagi MOSFET skala nano 2D telah berjaya dibangunkan. Kesan kekangan kuantum get di analisa dan digunakan bagi permodelan MOSFET-nano. Persamaan arus salir pada aras linear dan tepu bagi MOSFET-nano diterangkan berdasarkan profil medan elektrik di kawasan punca dan salir. Kesamaan yang amat baik di antara teori digunakan dan model dibangunkan dengan MOSFET 80nm yang difabrikasi mengesahkan penerangan teori berasaskan fizik bagi pergerakan balistik pembawa.