A Poisson-Schrödinger Equation coupled Monte Carlo method to Investigate Spin Transports in SpinFET

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Abstract

SpinFET (spin field effect transistor) was first proposed by Datta and Das in 1990[1] which has become the prototypical spintronic device scheme. The key point of SpinFET is the manipulation of spin polarization for information storage and transport. This can be achieved by the so called Rashba and Dresselhaus effects[2,3] in the 2DEG (2-dimensional electronic gas) system. Many works have been contributed to study these two effects [4-8]. But the systematical examination of the spin transport properties with both two effects included under different external voltages and in different materials is required to guide the future design of SpinFET. The spin precession is very sensitive to the quantum confinement and scatterings of electrons, thus the quantum effects and scattering events must be carefully considered while studying the spin transport. Monte Carlo[9-11] devices simulation can deal with the scattering event very well, and the Poisson-Schrödinger calculation[12] can give a clearly describe of the quantum effect.

In this paper we a Poisson-Schrödinger equation coupled Monte Carlo method to investigate the spin transports in SpinFET. The self-consistent Poisson-Schrödinger solver is essential for calculating the accurate spin precession vectors and 2-D scattering rates. The simulated SpinFET structure is like a conventional ultra thin body MOSFET, but the Source and Drain area is replaced by ferromagnetic materials. 2-D Poisson equation is solved in whole device, from Source to Drain the channel is cut into slices and the one dimensional Schrödinger equation is solved on each slices. The Monte Carlo simulation is used to simulate the electron transport and spin precession from source to drain. The scattering mechanisms include the impurity scattering, acoustic phonon scattering and polar phonon scattering. Intra-subband, inter-subband scattering and inter-valley scattering are also included. Schottky barrier contact model[13] is also involved in this simulator. The scattering influence on spin transport properties is fully examined in our former work [14]. Spin transport in GaAs and InSb SpinFETs are simulated [15], the gate bias and drain bias effects on the Spin precession in SpinFETs are also investigated. The simulation results show our method can get the detail information of spin precession in SpinFET, and is useful to study the spin polarization relaxation and the characterizations of SpinFET.

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