Osaka University Global COE "Center for Electronic Devices Innovation"

GCOE Global Seminar

Quantum Transport in Nanowire FETs: The k.p Method

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Abstract:

A three-dimensional, self-consistent full-quantum transport simulator for nanowire field effect transistors is developed based on the eight-band k.p method. The mode-space Hamiltonian is constructed via a unitary transformation from the Hamiltonian discretized in the k-space, with its size being greatly reduced by selecting only the modes that contribute to the transport. An approximate but highly accurate method to solve the cross-sectional eigenvalue problems is devised, and the numerical bottleneck of the mode-space approach is hence resolved. A highly efficient device simulator is therefore developed.

Using the simulator, device simulations on p-type Si nanowire MOSFETs have been performed. With the k.p parameters tuned against the sp3s* tight-binding method, full transport calculations from the k.p and the tight-binding methods agree reasonably well, and the spin-orbit coupling effect is found to be negligible in the final current-voltage characteristics. Simulations of nanowire devices with cross sections from 3×3 nm2 up to 10×10 nm2 are then performed. The subthreshold characteristics, t hreshold voltages, and ON-state currents for the three respective transport directions of the [100], [110], and [111] directions are examined. Some simulation results on p-type nanowire Schottky barrier MOSFETs will be also shown, and example simulations on band-to-band tunneling nanowire FETs will be also demonstrated.

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