Analyzing Variability in Short-Channel Quantum Transport from Atomistic First Principles

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Due to random impurity fluctuations, the device-to-device variability is a serious challenge to emerging nanoelectronics. In this talk I shall present a theoretical formalism and its numerical realization to predict quantum-transport variability from atomistic first principles. Our approach is named the non-equilibrium coherent-potential approximation (NECPA) which can be applied to predict both the average and the variance of the transmission coefficients such that fluctuations due to random impurities can be predicted without lengthy brute force computations of ensemble of disordered configurations. As an example, we quantitatively analyzed the off-state tunnel conductance variability in Si nanosized field-effect transistor channels with channel lengths ranging from 6.5 to 15.2 nm doped with different concentrations of boron impurity atoms. The variability is predicted as a function of the doping concentration, channel length, and the doping positions. The device physics is understood from the microscopic details of the potential profile in the tunnel barrier. Time permitting, other systems will also be presented as examples.

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