Current-Voltage Characteristics of Ballistic Nanowire MOSFET by Numerical Analysis

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Recently, the metal oxide semiconductor field-effect transistor’s (MOSFETs) dimensions had been scaled into the nanoscale region due to the advancement of process technologies. ITRS 2003 predicts that novel MOSFETs with a 9 nm gate length will be produced in 2016 and it is expected that novel MOSFETs will be operated near ballistic scale in near future because the channel length of MOSFETs is comparable to or shorter than the mean free path of a carrier. Ballistic nanowire transistor has begun to obtained broad attention due to its unique advantages such as the excellent controllability of device current. Understanding of device physics and the over all properties of nanoscale devices, which is considered to be in ballistic regime, regarded as quite important subject in ballistic nanowire transistor research. Here we studied current-voltage characteristics of ballistic nanowire MOSFET based on numerical analysis.

If the subband structure was calculated and the threshold voltage was given, we can evaluate the current-voltage characteristics of ballistic nanowire MOSFET using compact model. In this paper, the subband structure was calculated by the first principles calculations with local density functional approximation.

The analysis model of ballistic nanowire MOSFET is gate all around n type, p type silicon nanowire [100] structure. Fig.1 shows the drain current-drain voltage (I-VD) characteristics of n type, p type silicon nanowire MOSFET evaluated for a room temperature of 300K. Fig.2 shows the drain current-gate voltage (I-VG) characteristics with the drain bias as the parameter. Fig.3 shows the transconductance variation as a function of the gate overdrive. Fig.4 shows the Drain conductance variation as a function of the gate overdrive. Fig.5 and Fig.6 shows the effect of quantum capacitance on I-VD characteristics at p type, n type channel. Hereα =0 (α =0) mean that the quantum capacitance is neglected (counted) in analysis process. More results and explanations will be show in the presentation.
Fig. 1. I-V_D characteristics.

Fig. 2. I-V_G characteristics.

Fig. 3. Transconductance.

Fig. 4. Conductance.

Fig. 5. Effect of quantum capacitance on I-V_D characteristics at p type channel.

Fig. 6. Effect of quantum capacitance on I-V_D characteristics at n type channel.