

# A Compact Modeling of Quasi-Ballistic Si Nanowire MOSFET

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Recently, MOS transistors in LSIs have been ultra-scaled below 100 nm, and are suspected to be approaching the scaling limit. In near future, the device size will be comparable to or less than the mean free path of carriers in semiconductors. The device structure also suffers a great change, from the ordinary 2-dimensional MOSFET, through the Fin FET structure with the limited width, and finally to the nanowire MOSFET, emphasizing the 1-dimensional character. The carrier transport physics will inevitably undergo a great change in parallel. For investigation of the device physics and characteristics, and also for estimation of the device performance and parameter dependences, clarification of the device physics, as well as providing a reliable compact-modeling of the device, is strongly requested. Last year, we have already presented a compact-modeling of a ballistic Si-nanowire MOSFET[1,2]. The ballistic model, although very useful in some aspects, fundamentally lacks the carrier scattering effects, and the consideration of the effect was a matter of urgent necessity.

In this report, we present a compact model of the Si-nanowire quasi-ballistic MOSFET. The model uses the basic framework of the compact model of the ballistic nanowire MOSFET, and introduces the carrier transmission probability from the source to the drain representing the carrier scattering effect within the channel. The transmission probability was derived from the carrier scattering mode model[3,4] illustrated in Fig. 1. Carriers are injected from source into channel with the kinetic energy comparable to the thermal energy, and suffer the carrier scattering. Since the optical phonon energy of silicon is definitely larger than the thermal energy, carriers run suffering only the elastic scattering across the specific region (shown as Initial Elastic Zone in Fig. 1) close to the source edge. They suffer the energy relaxation due to optical phonon emission only beyond the Zone. The carriers back-scattered to the source degrade the device current. While those carriers who emit the optical phonon and are energized eventually sink in the drain constituting the drain current. We analyze the carrier transport using the flux equation approach and derive the carrier transmission probability. An example of  $I-V_D$  characteristics based on a reported subband structure[5] is shown in Fig. 2.

## Reference

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## Potential Profile

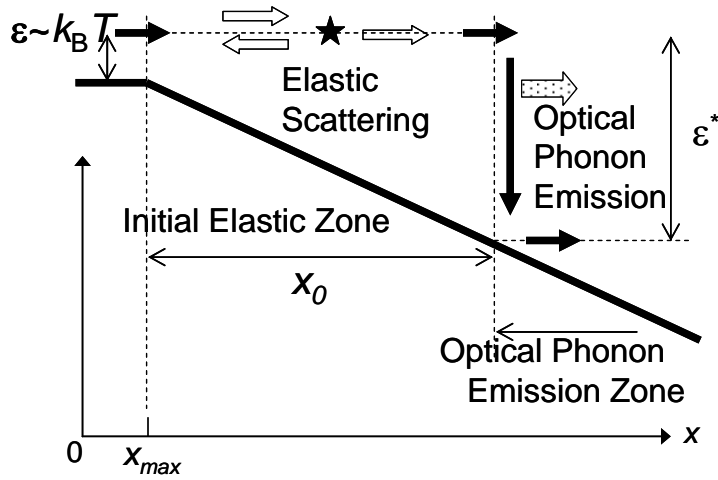


Fig. 1. Carrier scattering model in the channel with the linear potential profile.

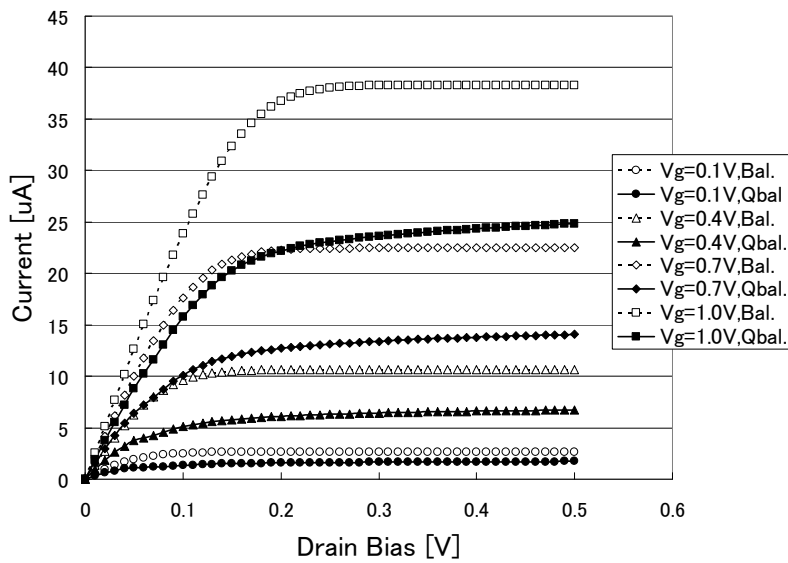


Fig. 2.  $I-V_D$  characteristics of a silicon nanowire MOSFET with the channel length 20nm and the wire diameter 1.5nm. Bal and Qbal respectively stand for ballistic and quasi-ballistic.