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The Ultimate Scaling Limit of Monolayer Material Field-Effect-Transistors

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Abstract : Monolayer graphene and dichaclogenide semiconductor materials attract extensive research interest for potential nanoelectronics applications. The ultimate scaling limit of double gate MoS2 Field-Effect-Transistors (FETs) with a monolayer thin body is examined and compared with ultra-thin-body Si FETs by using self-consistent quantum transport simulation in the presence of phonon scattering. Modelling of phonon scattering, quantum mechanical effects, and self-consistent electrostatics allows us to accurately assess the performance potential of monolayer MoS2 FETs. The results revealed that monolayer MoS2 FETs show 52% smaller Drain Induced Barrier Lowering (DIBL) and 13% Smaller Sub-Threshold Swing (SS) than 3 nm-thick-body Si FETs at a channel length of 10 nm with the same gating. With a requirement of SS<100mV/dec, the scaling limit of monolayer MoS2 FETs is assessed to be 5 nm, comparing with 8nm of the ultra-thin-body Si counterparts due to the monolayer thin body and higher effective mass which reduces direct source-to-drain tunnelling. By comparing with the ITRS target for high performance logic devices of 2023; double gate monolayer MoS2 FETs can fulfil the ITRS requirements.

Keywords : nanotransistors, monolayer 2D materials, quantum transport, scaling limit
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