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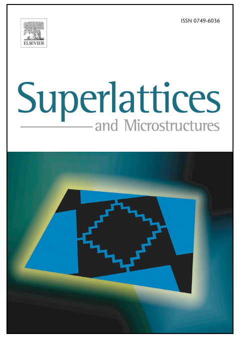

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Effective mass approximation versus full atomistic model to calculate the output characteristics of a gate-all-around germanium nanowire field effect transistor (GAA-GeNW-FET)

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Abstract: Here, we compare the output characteristics of a gate-all-around germanium nanowire field effect transistor (GAA-GeNW-FET) with 2.36 nm^2 square cross-section area using tight-binding (TB) $sp^3d^5s^*$ model (full atomistic model (FAM)) and effective mass approximation (EMA). Synopsys/QuantumWise Atomistix ToolKit (ATK) and Silvaco Atlas3D are used to consider the TB model and EMA, respectively. Results show that EMA predicted only one quantum state (QS) for quantum transport, whereas FAM predicted three QSs. A cosine function behavior is obtained by both methods for the first quantum state. The calculated bandgap value by EMA is almost twice smaller than that of the FAM. Also, a fluctuating current is predicted by both methods but in different oscillation values.

Keywords: Germanium nanowire field effect transistor; Tight-binding model; Effective mass approximation; Output characteristics, Quantum states, Fluctuating current

1. Introduction

Due to the fundamental problems such as electrostatic limits, low carriers mobility and tunneling from source to drain in sub-10nm metal oxide semiconductor field effect transistors (MOSFETs) [1-3], we need to design new devices to overcome these limitations. Nanowire FETs (NW-FETs or FinFETs) are prominent candidates for making integrated circuits (ICs) because of promising subthreshold swing (SS) and low drain-induced barrier lowering (DIBL) [4-7]. On the other hand, gate-all-around NW-FETs (GAA-NW-FETs) have a superb electrostatic control on the transistor channel and have been investigated in the literature as a future candidate for analog and digital applications [8-10].