URN etd-0407109-183717-1393
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Statistics This thesis had been viewed 46 times. Download 0 times.
Department
Year 2004
Semester 1
Degree Master
Type of Document Master's Thesis
Language English
Title The Analytical Models for Subthreshold Behavior of Symmetrical Double-Gate MOSFETs With High-K Gate Dielectrics
Date of Defense 0000-00-00
Page Count 49

Keyword
Direct tunneling effects
Higher Dielectric Constant
Fringing Induced Barrier Lowing

Abstract
As gate oxides thickness scaled below 1.5nm, direct tunneling of carriers through the oxide has led to excessive gate leakage current that increase the static power dissipation of the chip.
Some of the materials such as Si3N4(K=7.5)、Al2O3(K=10)、Ta2O5(K=25)、ZrO2(K=25)、HfO2(K=30)、TiO2(K=30~100)、BST(K=200~300) with higher K values to prevent direct tunneling effects, the percentage of field lines originating from bottom of the gate electrode and terminating on the source/drain regions increase compared to the field lines terminating on the channel. These field lines finally induce an electric field from source to channel thereby reducing the source to channel barrier height. A weaker coupling between gate and channel due to fringing, which increases the source to channel barrier height resulting in FIBL effects (Fringing Induced Barrier Lowering) has been widely studied. The dielectric constant should lie in the range 10-30 and must be an insulator that has a band gap above ~5.0eV. Also, the alternative high-K material should be thermodynamically stable on Si upon high temperature anneals. The high-K film and its interfacial films would affect various device parameters like EOT, flat-band voltage, barrier heights, gate leakage current, and channel , and thus significantly affect the transistor behavior.
Some of threshold voltage analytical models are proposed to simulate the two dimensional effect in double-gate MOSFET's. However, the two-dimensional effects in gate-oxide dielectric are overlooked, which may be significant in thick high-permittivity insulators. In this work, we use the variational method to solve the 2D Poisson's equation. Based on the resultant solution, both analytical threshold voltage and subthreshold swing model with high-K dielectrics in the symmetrical SOI double-gate MOSFETs have been successfully developed. This model not only gives the physical insight into the symmetrical SOI double-gate MOSFETs with high-K device physics but also provides a basic designing guideline for the devices.
Advisory Committee T.K. Chiang - advisor

Files No Any Full Text File.
Date of Submission 2005-08-12