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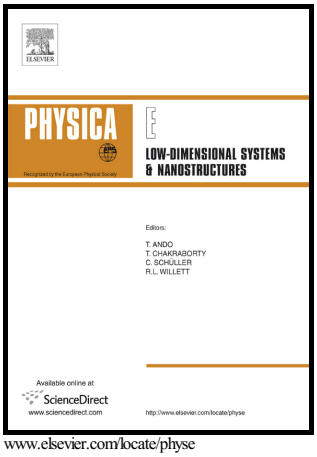

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PII: S1386-9477(17)30915-3
DOI: http://dx.doi.org/10.1016/j.physe.2017.08.014
Reference: PHYSE12894

To appear in: *Physica E: Low-dimensional Systems and Nanostructures*

Received date: 25 June 2017
Revised date: 8 August 2017
Accepted date: 15 August 2017

Cite this article as: Xiangyu Liu, Huiyong Hu, Meng Wang, Heming Zhang, Shimin Cui, Bin Shu and Bin Wang, Study of novel fully-depleted Ge double-gate Tunneling Field-Effect Transistors for improvement in on-state current and sub-threshold swing, *Physica E: Low-dimensional Systems and Nanostructures,* http://dx.doi.org/10.1016/j.physe.2017.08.014

Study of novel fully-depleted Ge double-gate Tunneling Field-Effect Transistors for improvement in on-state current and sub-threshold swing

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Abstract: In this paper, a novel fully-depleted (FD) Ge double-gate (DG) Tunneling Field-Effect Transistors (TFET) structure is studied by two-dimensional numerical simulation. The simulation results indicated that the on-state current I_{on} and on-off ratio of the FD Ge DG-TFET increases about 1 order of magnitude comparing with the Normal Ge DG-TFET, and I_{on}=3.95×10^{-5}/A·μm and the below 60 mV/decade subthreshold swing S=26.4 mV/decade are achieved. The impacts of the workfuntion of metal gate Φ_m, the doping concentration of n^+-type-channel N_D and the length of drain region L_D are investigated. It is indicated that the off-state current I_{off} includes the tunneling current at the middle of channel I_B the gated-induced drain leakage (GIDL) current I_{GIDL}. With optimized Φ_m and N_D, I_{off} is reduced about 2 orders of magnitude to 2.5×10^{-13}/A·μm with L_D increasing from 40nm to 100nm, and on-off ratio is increased to 1.58×10^7.

Keywords: fully-depleted (FD) structure; double-gate (DG); Tunneling Field-Effect Transistors (TFET); subthreshold swing (SS)

1. INTRODUCTION

For high-performance nano-scale CMOS technology, high standby power dissipation has become the critical issue due to the 60-mV/decade scalability limit of sub-threshold swing (SS) of MOSFET devices [1]-[5]. The tunneling field-effect transistor (TFET) based on band-to-band tunneling (BTBT) mechanism has attracted many research interests since it can achieve sub-60 mV/decade sub-threshold swing (SS) at room temperature, enabling ultralow power dissipation [6]-[8]. The TFET exploits the phenomenon of gate modulated BTBT to achieve a steep SS and a high on-off ratio at a low supply voltage. Along with a steep SS, the presence of large tunneling barrier at the source/body junction of TFETs reduces its off-state current I_{off} significantly. However, the tunneling barrier also significantly reduces the on-state current I_{on} of TFET[9]-[12].

The Si TFET has achieved a steep SS of 36 mV/decade, but I_{on} is limited by the large energy bandgap (~1.12 eV) [9]–[12]. To overcome the low value of I_{on} in Si TFET, the channel materials with low bandgap (Eg) and high band-to-band tunneling rate are used. The bandgap of Ge (~0.67 eV) is smaller than Si and Ge is easily integrated with the Si CMOS process, which makes Ge an ideal material for TFET. An extensive research effort has now been focused on Ge as the potential replacement for Si channel [13]–[15]. However, to realize well-behaved Ge n-TFET faces