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PII: S0038-1101(17)30766-9
DOI: https://doi.org/10.1016/j.sse.2017.10.020
Reference: SSE 7333

To appear in: *Solid-State Electronics*

Please cite this article as: Ko, K., Son, D., Kang, M., Shin, H., Comparison of Work Function Variation between FinFET and 3D Stacked Nanowire FET Devices for 6-T SRAM Reliability, *Solid-State Electronics* (2017), doi: https://doi.org/10.1016/j.sse.2017.10.020

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Comparison of Work Function Variation between FinFET and 3D Stacked Nanowire FET Devices for 6-T SRAM Reliability

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Abstract. In this work, work-function variation(WFV) on 5 nm node gate-all-around(GAA) silicon 3D stacked nanowire FET(NWFET) and FinFET devices are studied for 6-T SRAM cells through 3D technology computer-aided design(TCAD) simulation. The NWFET devices have strong immunity for the unprecedented short channel effects(SCEs) compared with the FinFET devices owing to increased gate controllability. However, due to the narrow gate area, the single NWFET is more vulnerable to WFV effects than FinFET devices. Our results show that the WFV effects on single NWFETs are larger than the FinFETs by 45%-55%. In the case of standard SRAM bit cells(high density : 111 bit cell), the variation of read stability(read static noise margin) on single NWFETs are larger than the FinFETs by 65%-75%. Therefore, to improve the performance and having immunity to WFV effects, it is important to analyze the degree of variability in 3D stacked device architectures without area penalty. Moreover, we investigated the WFV effects for an accurate guideline with regard to grain size(GS) and channel area of 3D stacked NWFET in 6-T SRAM bit cells.

Keyword: Work Function Variation, Threshold voltage fluctuation, gate-all-around, FinFET, 3D stacked NWFET, 6-T SRAM, Read Static Noise Margin.

1. Introduction

In recent development trends of electronics industry, the aggressive shrink of electronic device size is carried out to achieve higher performance and efficiency. As devices are ultra-scaling down, materials with a high dielectric constant(HK) have been introduced not only to prevent severe gate leakage current but also to improve the gate controllability. Consequently, gate materials have also been replaced, from polysilicon-gate electrodes to metal electrodes, given that HK materials are not compatible with a polysilicon gate. However, using an ultra-scaled metal-gate device causes a new critical problem such as WFV due to the dependency of WF on the orientation of metal grain. Therefore, WFV in high-K/metal-gate(HK/MG) device should be considered to cope with a critical risk of device [1-4].

To overcome these undesired effects, 3D stacked NW device architectures are suggested as alternative future scaling devices [5]. Conventionally, the GAA NWFET devices are emerging to be a

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