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Numerical Simulation of Electrical Characteristics on Uniaxial Strained Bulk and SOI FinFETs

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ABSTRACTS

In this paper, electrical characteristics of fin-typed metal-oxide-semiconductor field effect transistor (MOSFET) with oxide nitride stacked capping layer is numerically studied. Compared the simulation results between strained bulk FinFET and strained SOI one, the strained bulk FinFET shows promising characteristics, and therefore the strained bulk FinFET may play an important role in the trend of scaling by the advantage of a much lower cost of fabrication for the electronic industry.

INTRODUCTION

Single gate FETs strained with diverse materials are very popular and have been investigated in decades [1]. Strained FETs are possible candidates for next generation high performance devices. Higher speed is due to higher carrier mobility which comes from the mismatch between two different lattice constants and the conduction energy band bending, leading to a smaller effective mass of the electron in the channel region in contrast with pure silicon (Si) MOSFETs. On the other hand, the advantages of SOI technology are high speed, less leakage current and high density [2]. SOI structure, however, has some fatal drawbacks, e.g., floating-body effect and self-heating effect. By the Body effect, the threshold voltage is changed and the device will be operated in the incorrect region.

In this paper, we computationally explore electrical characteristics of bulk and SOI FinFETs with an oxide nitride stacked capping layer. Strained impacts on their performance are examined with 3D.

COMPUTATIONAL MODEL AND RESULTS

As shown in Fig. 1, Si bulk and SOI substrates are examined for a 25 nm FinFET, where the oxide thickness is fixed at 1.4 nm. A 3D density-gradient simulation is performed to explore these electrical characteristics. The 3D hydrodynamic and density-gradient equations are solved with the adaptive finite volume and the monotone iterative methods [3]. To valid the simulation, mobility with considering strained effect, band bending, for example, should be adjusted carefully.

Figures 2 and 3 show the doping profile and electrostatic potential of the strained bulk FinFET and SOI one. The oxide layer of SOI one leads to a different distribution of doping conditions and electrostatic potential, which changes the grounded substrate to a floating body. From Fig. 4, we observe the stress distribution of cross-section of the FinFET with face perpendicular to the direction from source to drain, which is resulted form the oxide nitride capping layer. Therefore, Si channel is strained to make the electron having a higher mobility. The IdVd and IdVg curves, shown in Fig. 5, indicate that the strained bulk FinFET and SOI one have almost matched characteristics. The IdVd values of SOI are not more than 3.79% than bulk one. Table 1 indicates the bulk one has a smaller SS and DIBL values than SOI one.

CONCLUSIONS

Our preliminary investigation has shown that the strained bulk FinFET posses acceptable electrical properties compared with SOI one. Due to a significant advantage of less cost of fabrication, the strained bulk FinFET is a candidate for the scaling of VLSI devices in the near future.

ACKNOWLEDGEMENT

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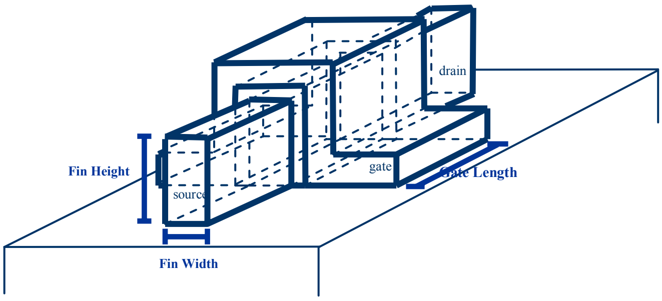

Fig. 1. The FinFET structure used for the 3D simulation.

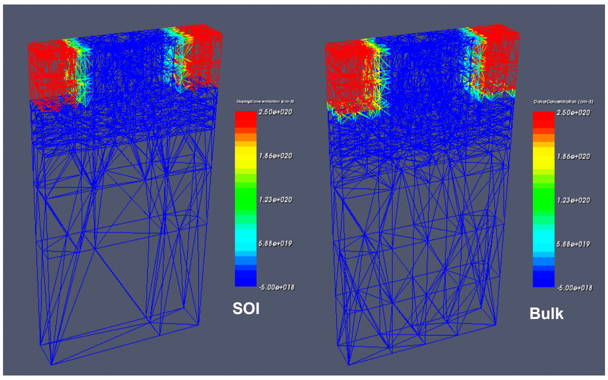

Fig. 2. The 3D doping distribution of the strained bulk FinFET (the right plot) and strained SOI one (the left one).

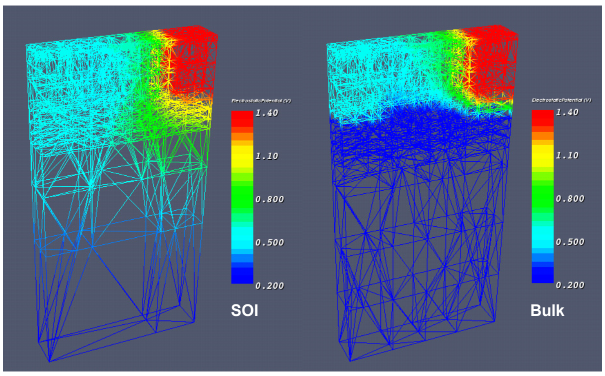

Fig. 3. The 3D electrostatic potential distribution of the strained bulk FinFET (the right plot) and strained SOI one (the left one).

Table 1. Comparison of the extracted subthreshold swing (SS) and drain induced barrier height lowering (DIBL) between the strained bulk FinFET and strained SOI one.

	SOI	Bulk
S.S. (mA/mV)	75.82	64.75
DIBL (mV)	89.20	56.08

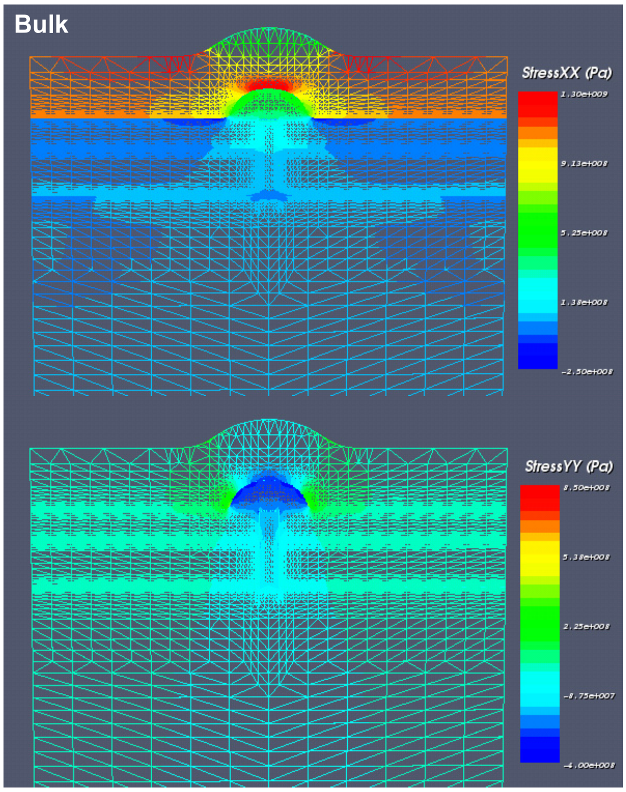

Fig. 4. The stress distribution of the cross-section of the FinFET with face perpendicular to the direction from source to drain.

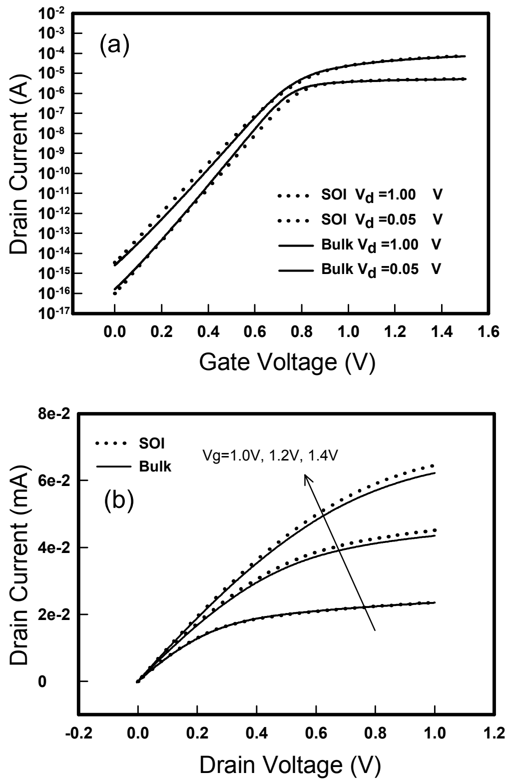

Fig. 5. The simulated (a) IdVg and (b) IdVd characteristics of the strained bulk FinFET and strained SOI one.