Chapter 5

Conclusions and Suggestions for Future Work

5.1 Conclusion

In this dissertation, the characteristics of DT-MOSFETs with different gate dielectric of various thicknesses were discussed. Then, reliability, and reverse Schottky contacts on the substrate for the DT-MOSFETs was also proposed. Finally, the nitrogen effects and aspect ratio effects on different substrate orientation was also investigated. Several important results are summarized as follows:

1. In Chapter 2, nMOSFETs of different dielectric types and thicknesses have been investigated in detail. When operating under the DT-mode, all the devices depict essentially the same threshold voltage, and close to the ideal subthreshold slope value of 60 mV/dec. The threshold voltage for N_2O-oxynitride devices is closer to 0.7 V than that of O_2-oxide counterparts due to its higher dielectric constant. For the DT-mode operation, the term [1- $\partial V_{TH}/\partial V_G$] should be taken into consideration in all formulas for calculating the device parameters. Saturation transconductance is found to increase significantly when operating under DT-mode. Finally, our results also show that both $G_{m.sat}$ and $G_{m.lin}$ are proportional to $\mu_n C_{OX}$, rather than γ.

2. In Chapter 3, hot carriers induced degradation in DT SOI-pMOSFETs for T-

and H-gate structures at various temperatures have been investigated in this dissertation. The maximum transconductance degradation, threshold voltage shift, and drive current degradation were measured. The ΔV_{TH} under DT-mode is less than that under conventional-mode due to its lower interface state generation by the negative body bias. In addition, ΔV_{TH} under conventional mode is alleviated at elevated temperature due to reduced impact ionization. More importantly, G_{mmax} and drive current degradations are found to be enhanced under DT-mode due to the "transconductance enlargement" effects by both the decreasing effective vertical electrical field and dynamic behavior at room temperature. At elevated temperature, these enhanced degradations under DT mode would be improved. In addition, the degradation of T-gate structure is worse than that of H-gate structure.

3. In Chapter 4, DT-MOSFETs with reverse Schottky barrier on substrate contacts has been presented for high voltage and high temperature operations. Due to the reverse Schottky diode between gate and substrate, DT-MOSFETs could operate at high voltage. Both the saturation current and subthreshold slope could be improved by this scheme. In addition, the electrical characteristics of DT-pMOSFETs with the reverse Schottky substrate contacts and its NBTI effects were reported in this dissertation. It was found that the saturation current, DIBL, transconductance, and subthreshold slope could all be simultaneously improved. In addition, the serious V_{TH}

degradation of NBTI stressing of conventional pMOSFETs was significantly reduced using the novel structure due to the alleviated electrical field across the gate oxide and the threshold voltage adjustment ability under DT-mode operation.

5.2 Suggestions for Future Work

There are some works valuable for future research:

1. In Chapter 2, we explain the electrical characteristics under DT-mode operation. However, the temperature effects were not investigated in this dissertation. More efforts could be done for electrical characteristics under DT-mode operation for future investigations.
2. In Chapter 3, the "enlargement" effects under DT-mode operation would enhance the degradation after stressing. However, we did not propose the exact formula to explain the "enlargement" behavior as stressing. Therefore, simulations and more electrical measurements for all kinds of DTMOS structures must be implemented in the future.
3. In Chapter 4, DT-MOSFETs with reverse Schottky barrier contacts on the substrate could be operated for higher application voltage. In addition, different kinds of metal silicide could be investigated due to its different work functions. Furthermore, the applications, such as ESD, of DT-MOSFETs with reverse

Schottky barrier contacts could be investigated in the future.