超薄氮化矽閘極介電層之可靠度研究

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摘　要

在元件尺寸快速微縮的需求之下，為了獲得更佳的元件效能，必須使用超薄閘極介電層。而傳統的二氧化矽閘極介電層在厚度小於 2 奈米時，將會發生相當嚴重的漏電流問題。氮化矽被認為是在目前的科技之下最佳的解決方案。在本論文中，我們針對超薄氮化矽閘極介電層的可靠度問題進行研究。在負電壓不穩定性(NBTI)和熱電子入射(HCI)的實驗當中，我們對元件生命週期和閘極介電層的構造、氮含量等參數之間的關係作一系列的分析。而我們發現在閘極介電層加入氮原子，將對元件可靠度產生相當大的影響。此外我們使用了電荷幫浦(charge pumping)的方法來分析臨界電壓飄移和界面缺陷(interface-states)的關係。我們發現基板熱電子入射將可以提高界面缺陷修補的速率。但這個方法對於臨界電壓回復(recovery)並沒有太大的幫助。因為這個方法無法改變電荷從其他缺陷(slow states, oxide traps)釋放的速度。

A Study on the Reliability of Ultrathin Oxynitride Gate Dielectrics

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Abstract

For aggressive scaling of device size, ultrathin gate dielectrics are needed to obtain high performance. However, traditional silicon dioxide (SiO_2) gate dielectric suffers high gate leakage current when its thickness is thinner than 2.0nm. To alleviate this issue, alternative gate dielectric is necessary, and oxynitride is the most likely solution for near-term technology node. In this work, we focus our attention on characterizing its reliability issues including negative-bias-temperature instability (NBTI) and hot-carrier injection (HCI). The relationships between device lifetime and gate dielectric characteristics such as stack structure, nitrogen profile and concentration. We found that nitrogen plays an important role in NBT and HCI degradations. We have also performed charge pumping experiment to study the correlation between threshold voltage shift and interface-states. Experimental results show that substrate hot electron injection can effectively anneal out the interface traps.

However, it only has little effect on threshold voltage recovery, as it does not alter the charge detrapping of slow states and oxide traps.