氧空缺和雙極電荷層於多晶矽-氧化矽-氮化矽-氧化矽-矽形式非揮發性記憶體的應用

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摘　要

在本篇論文中，我們將由於氫氣退火在二氧化鉿(HfO_2)上產生的氧空缺應用到二氧化鉿(HfO_2)薄膜和二氧化鉿(HfO_2)微晶粒記憶體電容上。我們發現在 300 度 C 氫氣退火一小時後，二氧化鉿(HfO_2)薄膜記憶體電容表現出最大的遲滯電壓差值(hysteresis)。並且在 500 度 C 氫氣退火一小時後，二氧化鉿(HfO_2)微晶粒記憶體電容顯示出最大的遲滯電壓差值。我們確認以二氧化鉿(HfO_2)薄膜或二氧化鉿(HfO_2)微晶粒為電荷捕捉層的 SONOS 型記憶體結構可以藉由以氫氣退火所產生的氧空缺來增大記憶窗口。

再者，我們將在氧化鋁(Al_2O_3)和二氧化矽(SiO_2)的接面上產生的”本質偶極 ”(intrinsic dipole)的觀念應用到二氧化鉿(HfO_2)薄膜和二氧化鉿(HfO_2)微晶粒記憶體電容上。我們指出經由在 SONOS 型記憶體電容中引入一層極薄(約 1 奈米)的高介電常數材料(HfO_2 或 Al_2O_3)可以有效的調節金屬電極的功函數。我們

發現對於二氧化鉿(HfO_2)薄膜和二氧化鉿(HfO_2)微晶粒記憶體電容來說，經由在電荷捕捉層和穿遂氧化層的中間引入一層極薄(約 1 奈米)的氧化鋁(Al_2O_3)，配合適當的氫氣退火溫度，我們甚至可以得到更大的遲滯電壓差值。

最後，我們提出一種雙極電荷層的新穎 SONOS 型非揮發性快閃記憶體結構。我們在穿遂氧化層之上引入一層約 1 奈米的氧化鋁(Al_2O_3)來造成雙極電荷的產生，並且使得寫入動作較為簡易。因此我們得到較快的寫入速度。更甚的是，這種新穎結構的 SONOS 型記憶體較傳統 SONOS 記憶體有更好的資料持久性。因此我們相信具有雙極電荷層的 SONOS 型快閃記憶體將有機會參與下個世代非揮發性記憶體的應用。

Applications of Oxygen Vacancies and Dipole Layer Engineering on SONOS-type Nonvolatile Memory

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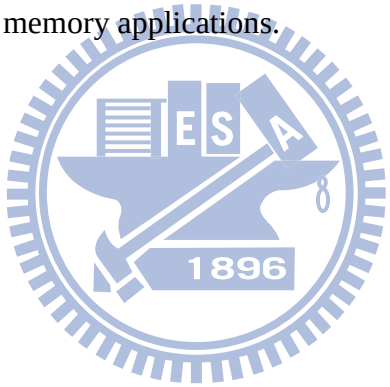
ABSTRACT

In this thesis, we utilize oxygen vacancies generated by forming gas anneal (FGA) to our HfO_2 thin film and nanocrystal memory capacitors. We find out that HfO_2 thin film memory capacitors show the highest hysteresis for FGA temperature of 300^oC for 1 hour. And HfO_2 nanocrystal memory capacitors demonstrate the largest hysteresis for FGA temperature of 500^oC for 1 hour. We confirm that it is effective to enlarge the memory window for SONOS-type memory structure with HfO_2 thin film or HfO_2 nanocrystal trapping layer by the FGA-generated oxygen vacancies.

Next, we adopt the concept of "intrinsic dipole" formed at Al_2O_3/SiO_2 interface to our HfO_2 thin film and nanocrystal memory capacitors. We demonstrate that modulating the gate effective work function by incorporating an ultra-thin (~1nm)

high-k layer (HfO_2 or Al_2O_3) in our SONOS-like memory capacitor is valid. We show that both for HfO_2 thin film and nanocrystal memory capacitor, the hysteresis could further be enhanced by incorporating a ~1nm Al_2O_3 layer between trapping layer and tunnel oxide with appropriate temperature of FGA.

Finally, we propose a novel nonvolatile SONOS-type flash memory with dipole layer engineering. We incorporate a ~1nm Al_2O_3 layer upon the tunnel oxide to induce dipole formation and results in easier programming. Thus we get higher programming speed. Furthermore, the novel SONOS-type flash memory exhibits better retention performance than the conventional SONOS memory. Therefore, we believe that SONOS-type flash memory with dipole layer engineering can be a candidate for next-generation nonvolatile memory applications.



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