新穎低溫缺陷鈍化技術於前瞻系統面板關鍵元件之應用與研究

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摘要

在此論文裡，我們研究了高介電常數材料與薄膜電晶體在超臨界二氧化碳流體混合水的熱處理下其電性的改變。首先，在室溫下，利用真空濺鍍系統成長極薄的氧化鉿薄膜，厚度約為 7 奈米，為了取代傳統的高溫退火製程，我們使用了溫度約 150°C 超臨界流體混合水的技術，為了驗證超臨界流體混合水能有效的使水分子進入到氧化鉿，進而減少薄膜的缺陷密度，我們經由紅外線光譜儀、熱脫附常壓游離質譜儀與 X 射線光電子能譜來做材料分析，結果均顯示於氧化鉿薄膜內氧的含量增加，而厚度為 7 奈米氧化鉿薄膜在閘極電壓 3 伏特的操作下，其單位面積漏電流約為 2×10^{-7} A/cm^2，並且得到較高的崩潰電壓，崩潰電壓約為 24 伏特，傳導機制亦由原本未經過處理的量子穿隧效應轉換為熱放射效應，以上主要的原因是由於氧化鉿薄膜的缺陷密度減少。

除此之外，我們利用電漿輔助化學氣相沉積，在低溫下製造非晶矽薄膜電晶體，但不可避免地，非晶矽薄膜在沉積過程中，由於懸鍵和晶格的錯位，會產生電性上的缺陷，這些缺陷會捕捉載子而使電流降低。而如何減少這些缺陷密度在非晶矽薄膜電晶體的製造中是很重要的。因此，我們發現經由超臨界流體技術的處理之後，非晶矽薄膜電晶體有較好的元件特性，其漏電流、非晶矽薄膜能帶中之缺陷態位密度、臨界電壓、次臨界擺幅和場效移動率都有顯著的提升。這些改善主要是因為超臨界流體的技術，能有效修補懸鍵，進而減少薄膜的缺陷密度。

由這些結果均顯示，藉由超臨界流體混合水的技術，能減少薄膜的缺陷密度。可預期的，若超臨界流體的特殊特性整合在高介電常數材料、薄膜電晶體、太陽能電池與記憶體製程上，將具有其優勢。

Application of Novel Low Temperature Trap-Passivation Technology for System on Panel

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Abstract

In this study, supercritical fluids (SCF) technology is employed originally to effectively improve the properties of low-temperature-deposited metal oxide dielectric films. In this work, 7 nm ultra-thin Hafnium Oxide (HfO_2) films are fabricated by sputtering method at room temperature, and replacing the conventional high temperature annealing with supercritical fluids treatment at 150 °C. The supercritical fluids act a transporter to deliver H_2O molecule into the HfO_2 films for repairing defect states. After this proposed process, the absorption peaks of Hf-O-Hf bonding apparently raise and the quantity of oxygen in HfO_2 film increases from FTIR and TDS measurement, individually. The leakage current density of 7 nm HfO_2 film is cut down to 2×10^{-7} A/cm^2 at |Vg| = 3 V, and the conduction mechanism is transferred from quantum tunneling to thermal emission because of the significantly reducing the defects in the HfO_2 film. Moreover, the higher breakdown voltage is obtained, reaching |Vg| = 24 V.

Additionally, supercritical fluids technology is also proposed to effectively passivate the defect states in hydrogenated amorphous silicon thin film transistors (a-Si:H TFTs) at low temperature (150 °C). After the treatment of supercritical fluids mixed with water and propyl-alcohol, the a-Si:H TFT exhibited superior transfer characteristics and lower threshold voltage. The improvement in electrical characteristics can be verified due to the significant reduction of density of states (DOS) in the mobility gap of amorphous silicon.

This proposed technology is also used to improve the transfer characteristics of Non-volatile Memories at 150 °C. From theses experimental results, the ideal capacitance-voltage curve, the better program / erase and retention time are obtained, such that the supercritical CO_2 treatment provide a novel method to enhance the transfer characteristics of Non-volatile Memories.