氮化鎵薄膜表面能態密度分佈之研究

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中文摘要

本論文主要以電容-電壓（Capacitance-Voltage）量測方式來探討氮化鎵薄膜材料表面能態密度分佈情形。對金屬-半導體接面之蕭基元件結構而言，若金半接面存有表面能態，依電中性原理，其電荷將與空乏區電荷相互補償，使得電容值產生變化，並使得 $1/C^2-V$ 曲線呈現非線性分佈，偏離原有之理想線性關係。實驗發現，未摻雜氮化鎵薄膜厚1.2 μm 的樣品之 $1/C^2-V$ 曲線分佈，我們確認了氮化鎵薄膜之金半接面存在表面能態。分佈範圍為傳導帶下方 0.78 至 1.78 電子伏特的能階範圍之內，能態密度分佈從 $5.4\times10^{12}\,eV^{-1}cm^{-2}$ 變化至 $4.4\times10^{12}\,eV^{-1}cm^{-2}$，使的 $1/C^2-V$ 圖明顯呈非線性分佈。

除此之外，我們亦發現酸洗之過程會改變 n 型氮化鎵表面能態之分佈，我們比較 n 型氮化鎵薄膜樣品在不做任何表面處理與進行硫化

銨及鹽酸的表面處理時其表面能態密度的變化。實驗結果發現，在熱平衡下，約傳導帶下方 0.85 個電子伏特處，表面能態密度大小明顯由不做任何表面處理之3.5×10^{12}降低至硫化銨表面處理之2.2×10^{12}與鹽酸表面處理之$2.1\times10^{12}\ eV^{-1}cm^{-2}$。由於表面氧原子之存在是造成表面能態之主要成因，上述表面能態密度之降低應是與硫化銨與鹽酸處理可以有效清除氮化鎵表面之氧原子分佈之性質直接相關。

Surface state density profiles of GaN using C-V measurement

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Abstract

This thesis is focused on profiling surface state density of GaN Schottky diode using capacitance-voltage measurement. It is known that if large quantity of surface states do exist on the GaN surface, the corresponding curve of the reciprocal square of the depletion capacitance vs. bias voltage ($C^{-2}-V$) will deviate from an ideal curve, i.e. a linear relationship curve. Indeed, we do find the $C^{-2}-V$ curve of an $1.2\,\mu m$-thick undoped GaN film exhibits non-linear characteristics. The calculated surface state density was found to vary from $5.4\times10^{12}\,eV^{-1}cm^{-2}$ to $4.4\times10^{12}\,eV^{-1}cm^{-2}$ located at from $0.78eV$ to $1.78eV$ below the conduction band.

In order to investigate the effects of chemical treatment, the solutions of $(NH_4)_2S_x$ and HCl was used to clean the n-GaN surface prior to the formation of Schottky contact. Our results show that the surface

state density of GaN can be reduced by these commonly used cleaning solutions. For example, we find that the surface state density at 0.85 below conduction band is decreased from $3.5\times10^{12}\ eV^{-1}cm^{-2}$ of untreated sample to $2.2\times10^{12}\ eV^{-1}cm^{-2}$ of $(NH_4)_2S_x$-treated GaN and to $2.1\times10^{12}\ eV^{-1}cm^{-2}$ of HCl-treated GaN. Such a surface state reduction is believed to the removal of oxygen or oxygen-gallium dangling bond by both chemical cleaning method.