氮化鋁鎵薄膜表面六角丘狀結構之螢光光譜和拉曼光譜之研究

研究生：林碧軒　　　　　指導教授：李明知 教授

國立交通大學

電子物理研究所

中文摘要

本論文主要針對金屬有機化學氣相磊晶系統(MOCVD system)所成長的氮化鋁鎵薄膜($Al_xGa_{1-x}N$)做一系列的微螢光光譜(μ-PL)和微拉曼光譜(μ-Raman)之研究。在顯微鏡下，我們可以在樣品表面觀察到幾種不同形狀的六角丘狀結構(Hillock)，它們的大小分佈是約2~16 μm。

藉由顯微鏡載台的刻度，可以標定Hillock的位置，由此方式我們可以針對同一顆Hillock進行μ-PL和μ-Raman的量測。因為應力對螢光光譜的影響很小，而且Hillock內外的鋁組成濃度，從EDX

(Energy Dispersion X-ray Spectrometer)所量測出來的結果與微螢光光譜所推算出來的一致,所以將使用微螢光光譜去決定 Hillock 的鋁組成濃度。

從微螢光光譜的量測中,發現 Hillock 結構內部會出現額外的發光譜峰(能量位置約～3.51eV),有別於該結構外部近帶躍遷的譜峰位置(能量位置約～3.62eV)。根據微螢光光譜可以推導出 Hillock 內外的鋁組成濃度分別是約 4%和約 11%,進而再去計算出此濃度下所對應之沒有受到應力影響的 E_2 模態位置,Hillock 內部約在 568.5cm^{-1} 而其外部約在 570.2cm^{-1}。接著使用微拉曼光譜去針對 Hillock 結構進行實際量測,實驗結果顯示,Hillock 結構內部 E_2 模態位置約在 570 cm^{-1},其外部位置約在 573 cm^{-1}。比較微螢光光譜和微拉曼光譜之計算和量測結果,發現 E_2 模態位置在 Hillock 結構內外分別有約 1.5 cm^{-1} 和約 3 cm^{-1} 的偏差,而此實驗結果顯示,Hillock 結構受到了壓縮的應力影響。

我們亦使用微拉曼光譜去分析 Hillock 結構之形成機制。其結果顯示,Hillock 結構內部之 E_2 模態位置約在 570 cm^{-1} 而不會隨著聚焦深度變深而改變;聚焦深度越深,隨之出現的是 sapphire E_g 位於 577 cm^{-1} 的訊號。由微拉曼光譜的縱深分析結果,其證明了 Hillock 結構形成是從 AlN 緩衝層開始長成。

Photoluminescence and Raman Scattering Studies of Hillocks on $Al_xGa_{1-x}N$ Film

Student : Bi-Hsuan Lin **Advisor : Dr. Ming-Chih Lee**

Institute of Electrophysics

National Chiao Tung University

Abstract

In this article, we analyzed $Al_xGa_{1-x}N$ epilayer which was grown by MOCVD system, with the aid of the micro-photoluminescence (μ-PL) and micro-Raman (μ-Raman) systems. Under the microscope, we observed several types of hexagonal hillocks on the epilayer with sizes from 2 to 16 μm.

By using the microscope to demarcate the hillock position, we can combine the μ-PL and μ-Raman system to study the same hillock on this sample. Because the PL results are relatively insensitive to the strain and the Al fraction from Energy Dispersion X-ray Spectrometer (EDX) measurements agrees with that deduced from μ-PL whether inside or

outside the hillock, so we used μ-PL spectra to determine the Al fraction of hillock.

From the μ-PL spectra, we found that an additional emission peak at (~3.51eV) inside the hillock structure, that differs from the near-band-edge emission (~3.62eV) outside the hillock. According to the PL peak position, the calculated Al fraction is about 4% and 11% inside and outside the hillock. From the Al fraction, we also obtained the strain free E_2 mode frequency to be 568.5cm^{-1} and 570.2 cm^{-1} inside and outside the hillock, respectively. However, the experimental results of μ-Raman spectra show that E_2 mode frequency is ~570 cm^{-1} and ~573 cm^{-1} inside and outside the hillock, respectively. These are blue shifted by ~1.5 cm^{-1} and ~3 cm^{-1} so that hillocks bear compressive stress.

We also used μ-Raman scattering to investigate how deep hillocks are formed. The results showed that the E_2 mode frequency remains at ~570 cm^{-1} inside hillock, it dose not shift while the focus depth increases. However, the sapphire E_g mode frequency at 577 cm^{-1} grows obviously with the increasing focus depth. According to the depth analysis, it is evident that the formation of hillock is from the AlN buffer layer.