氮化鋁鎵薄膜表面六角丘狀（Hexagonal Hillock）結構之研究

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中文摘要

本論文主要是對金屬有機化學氣相磊晶系統（MOCVD system）所成長的氮化鋁鎵（$Al_xGa_{1-x}N$，x～0.12）薄膜作一系列的微螢光光譜（Micro- Photoluminescence）及微拉曼光譜（Micro-Raman）分析。該薄膜於顯微鏡下可顯見多種不同類型之六角丘狀（Hexagonal Hillock）結構，類似六角錐體的截斷面，大小約為2～16μm。於微螢光光譜的分析中，發現該結構內部會出現額外的發光譜峰（能量位置約～3.5eV），有別於近帶躍遷的譜峰位置（～3.6eV）。針對六角丘之微拉曼光譜的分析得知，該結構的E_2模態之譜峰位置約在 570 cm^{-1}，相較平坦處之574 cm^{-1}，約有將近4cm^{-1}的 紅移，且譜峰的半高寬由結構內的 5 cm^{-1}微幅增加為平坦處之 6 cm^{-1}。此外，從 X 光微區分析的能量散佈光譜儀（Energy Dispersive X-ray Spectro-meter）量測中可以發現，該結構的鋁組成濃度約為 5～6 %，遠較平坦處之組成（～12 %）低，此結果與螢光光譜所得之結果相當吻合，而與拉曼光譜所得出的結果（4%於結構內部、8%於平坦處）比較有

些微差異，這可能是應力影響了E_2模態之譜峰位置，進而影響了鋁組成濃度的計算。綜合以上的數據，推測丘狀結構額外的譜峰可能導因於鋁組成的降低所致。根據現有的量測結果，我們推論丘狀結構所表現之特殊光學特性，很可能來自於鋁組成的降低而非以前所推論的雜質態之貢獻。

Studies of Hexagonal Hillocks on $Al_xGa_{1-x}N$ Thin Film

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Abstract

In this article, we analyzed AlxGa1-xN epilayer which was grown by MOCVD system, with the aid of the micro-photoluminescence (μ-PL) and micro-Raman (μ-Raman) systems. Under the microscopy, we observed several types of hexagonal hillocks on the epilayer. They looked like truncated hexagonal pyramids with their sizes from 2 to 16 μm. From the μ-PL spectra, an additional emission peak at (~3.5eV) inside the hillock structure was found, that differs from the near-band-edge emission (~3.6eV) on the plain region. According to the μ-Raman spectra, the E_2 mode peak of the hillock is ~570 cm^{-1} that is red shifted by about 4 cm^{-1} with respect to the plain region (~574cm^{-1}). The FWHM of the E_2 mode

is 5 cm^{-1} inside the hillock structure, that is slightly narrower than 6 cm^{-1} on the plain region. The above data suggest that Al concentration on the hillocks may be reduced to cause the additional PL peak.

Besides, from the microanalysis － Energy Dispersion X-ray Spectrometer（EDX）, we found that the Al concentration is about 5～6% inside the hillocks, that is less than ～12% on the plain region. These results agreed well with PL spectra. However, the results from the Raman spectra（Al concentration is about 4% inside the hillock and 8% on the plain region）are lower than those from PL and EDX measurements, because of the strain effect on the E_2 mode frequency, that may underestimate the Al concentration.

Based on our measurements, the optical characteristics of hillocks are attributed to the Al concentration variation, but not contributed from transitions involving defect levels as suggested previously.