氮化銦奈米點之光激螢光研究

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中文摘要

利用原子力顯微鏡和光激螢光量測技術研究氮化銦奈米點的特性。藉由調變三甲基銦的沉積時間或基板溫度來控制奈米點的大小。從原子力顯微鏡觀察到隨著沉積時間的下降或基板溫度的下降，奈米點的尺寸會下降和點密度會增加。而且奈米點的形狀是呈現六角狀。光激螢光光譜顯示氮化銦薄膜發光主要由兩個機制所主導，主要發光機制為簡併電子到淺層授子能階的躍遷，而另一個低能量的發光來源為簡併電子到深層授子能階的躍遷。從螢光光譜可以看出自聚性奈米點的深層授子能階發光被抑制，表示具有較佳的晶體結構，且隨著奈米點尺寸變小，螢光譜峰能量有藍移的趨勢。進一步由變溫螢光光譜可以得知，奈米點的譜峰不會隨著溫度有明顯的紅移，且當溫度逐漸增加，奈米點會出現另一高能量的譜峰，而且這個譜峰在較大的奈米點可以更明顯的分辨出來，這個譜峰和主要的譜峰能量差大約 100 毫電子伏特。從積分強度對溫度的變化，可得到分別在低溫和高溫所主導的兩個活化能，薄膜和奈米點的小活化能約為 10 毫電子伏特，此能量對應為淺層授子能階的束縛能；薄膜的大活化能約為60毫電子伏特，此為深層授子能階的束縛能；而奈米點的大活化能約為90毫電子伏特，提供載子從主要躍遷態到高能量譜峰的能階。

Photoluminescence studies of InN nano-dots

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Abstract

InN nano-dots were grown by metal organic vapor phase epitaxy. The dot size was controlled by tuning the deposition time of the TMIn source or varying the substrate temperature. Atomic force microscopy (AFM) and photoluminescence (PL) measurements were employed to investigate the characteristics of InN nano-dots.

AFM studies show the dot size increases and dot density decreases with increasing the substrate temperature or raising the deposition time. Moreover, the shape of InN dot is hexagonal.

The PL emission of the InN epilayer is composed of two parts (I_{sh} , I_{da}). The dominant PL emission (I_{sh}) is attributed to the transition from degenerate electrons to shallow acceptors, and the lower energy part (I_{da}) is due to the transition from degenerate electrons to deep acceptors. The deep acceptor emission (I_{da}) of InN dots is suppressed due to the improved crystal quality of InN nano-dots. From size-dependent PL spectra, the peak energy shows blue

shift with decreasing the size of InN dots.

Temperature-dependent PL spectra show that InN dots have temperature stability of the emission energy. A high-energy shoulder (I_H) appears in PL spectra at higher temperature and can be observed more clearly for larger dots. The energy separation of the dominant PL emission (I_{sh}) and the high-energy shoulder (I_H) is about 100 meV.

Two activation energies dominant respectively at the low and high temperature region were obtained from the integrated PL intensity versus inverse temperature plot. The smaller activation energies (E_{a1}) of the InN epilayer and dots are about 10 meV and equal to the binding energy of the shallow acceptors. The larger activation energy (E_{a2}) of the epilayer is about 60 meV and associated with the transition from the deep acceptor level to the valence band. The other larger activation energy (E_{a3}) of InN dots is about 90 meV, so we suggest E_{a3} is the thermal activation energy for carriers from I_{sh} state to I_H state.