

## 介相材料建構奈米光電元件特性之研究

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### 摘要

在本論文中，我們利用離子佈植、高密度電漿及脈衝式高密度電漿等三種不同的方法將矽量子點摻雜至奈米介孔洞二氧化矽中，形成許多矽量子點/二氧化矽的表面態，而發出有效率的光激發螢光(PL)，其波長範圍為 410 nm ~ 580 nm。高密度電漿由於具有高擴散率及高解離率的特性，使得矽量子點能有效率地沈積在孔壁上，其密度可高達  $1 \times 10^{18} / \text{cm}^3$ 。相對應地，其主要波長(460 nm)峰值強度也較離子佈植的方法強上四倍以上。脈衝式高密度電漿的方法可更增加矽量子點在奈米介孔洞二氧化矽中的密度，其值高達  $8 \times 10^{18} / \text{cm}^3$ ，同樣地，其主要波長的光激發螢光強度也較純高密度電漿的方法強上二倍以上。

根據光激發螢光光譜，證明矽量子點/二氧化矽的表面態可當作有效率的藍光奈米材料，因此可用來做為紫外光至藍光範圍的光偵測器。此元件傾向利用電子傳輸為主，在 3V 時，其暗電流為  $2.3 \times 10^{-5} \text{ A/cm}^2$ ，主要偵測波長在 370 nm，在 3V 時，此波長下的光電轉換效率為 0.77 A/W，而此元件在 10 分鐘的可靠度量測中，也具有穩定的特性。

# Study of Mesostructural Materials Constructed Nano-optoelectronics

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## Abstract

In this thesis, we employed ion implantation, high-density plasma, and pulse high-density plasma methods to dope three-dimensional Si nanocrystals (NCs) within the nanopores of mesoporous silica films. Surface states of the resulting Si NCs/silica arrays initiate blue-white photoluminescence (PL). ICP makes reactive species highly mobile and enables deposited NCs bonded with pore-wall well, therefore, efficiently constructing photoemission arrays. The mean density of HDP-synthesized semiconducting NCs is as high as  $1 \times 10^{18}/\text{cm}^3$ . Accordingly, blue-PL of arrays obtained with HDP is 4 times stronger than those obtained with ion implantation.

Besides, the mean density of Pulse ICPCVD-based semiconducting NCs is as high as  $8 \times 10^{18}/\text{cm}^3$ . Accordingly, blue-PL of arrays obtained with Pulse ICP is 2 times stronger than those obtained with HDP.

According to photoluminescence spectra, this constructed enormous Si NCs/silica arrays has been demonstrated as an efficient blue-luminescent nanomaterial. By this characteristic, we also fabricate an UV to blue light photodetector using this nanomaterial. This photodetector tends to be electron-transport-dominated and the dark current is about  $2.3 \times 10^{-5} \text{ A}/\text{cm}^2$  at 3V reverse bias. The main detected wavelength is 370 nm, and the responsivity is about 0.77 A/W at 3V reverse bias. As for reliability, this device is stable under ten minute's measurement.

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