國　立　交　通　大　學

材料科學與工程學系

博士論文

新穎碳基奈米材料在場發射應用上的合成與改質

Fabrication and Modification of New Carbon Based Nanomaterials for Field Emission Devices

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中華民國 九十三 年 六 月

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摘　　要

場發射顯示器是一個由許多場發射源組成的高亮度平面顯示器。在未來的平面顯示器中，場發射顯示器是一個令人值得期待的一個技術。由於深具潛力，奈米碳基材料已被視為場發射源的最佳材料之一。因此本論文的研究主要著重在如何提升奈米碳基材料的場發射電子特性。研究方向分為兩大類：第一則是材料改質，藉此提升材料場發射之電子特性。第二則是合成新穎的奈米碳基材料，利用其獨特的奈米效應來增加場發射電流。

在材料改質方面，主要是利用偏壓效應、P 型或 N 型之摻雜源與類鑽碳披覆來提升傳統碳基材料的電子特性。實驗結果顯示，偏壓效應除了可提升材料的成長速度，並可提供電場使材料在垂直基板方向成長。而在摻雜 N 型或 P 型的方面，提供多餘的電子或電洞明顯使單位面積的場發射電流密度增加。

而在合成新穎奈米碳基材料上，除了利用上述方法提升奈米碳管的場發射特性之外。我們也首先發表了新穎的奈米碳基材料:奈米石墨尖錐與奈米碳化鉻顆粒。相對於奈米碳管的石墨空心結構，穿透式電子顯微鏡發現奈米石墨尖錐呈現出石墨組成的實心結構與垂直基板的成長方向。此外，頂部的針狀結構亦提高了電子激發效率與場發射特徵常數(β)。若先鍍上一層鉻的金屬薄膜，可發現金屬鉻會被成長中的每根奈米石墨尖錐由下往上舉起，並逐漸碳化成一顆一顆的奈米碳化鉻顆粒。而這些奈米級大小的碳化鉻在場發射量測中，藉其本身的量子尺寸效應提供了較佳的表面電子傳輸，明顯地增加了場發射電流。這種自發性對位形成的微小奈米顆粒將可以被應用在許多方面。此外，利用半導體技術我們成功製造了一具有低孔徑 (4 微米) 的金屬/絕緣體/半導體 (MIS)的三極場發射元件。元件中的閘極結構可輕易的激發電子跳出，除了增加場發射電流之外，也有效地降低起始電壓。

Fabrication and Modification of New Carbon Based Nanomaterials for Field Emission Devices

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Abstract

Field emission display (FED) is a promising flat panel display in which the images are formed from large array of pixels, each addressed by controllable field emission sources. Recently, carbon based nanomaterials have attracted great interest owing to their potential application of field emission. This dissertation mainly aims at the improvement of carbon based nanomaterials on field emission characteristic. Research can be divided into two following categories. First is modifying materials' property in order to enhance their field emission characteristic. Second is fabricating new carbon based nanomaterials to increase their field emission currents by using their unique properties.

The bias effect; N or P-type dopants and diamond-like carbon cladding are used to improve field emission characteristics of materials. Experimental results indicate that bias effect would not only increase the growth rate but also lead to the well-aligned inclination. Doping additional electrons or holes into carbon material system results in the increase of field emission currents.

In the fabrication of new material field, graphite nanotip and itself capped with Cr nano particles have been first reported in the world. Compared to the hollow structure of nanotubes, graphite nanotips display the solid body and well aligned growth direction. The needle-like shape causes the electrons easily induced and larger field enhancement (β). Pre-deposition of Cr thin film will form the nanocrystalline chromium carbides on the top of the individual graphite nanotips, providing higher surface conductivity for electrons transportation. This self-alignment could be used in many applications. Moreover, low threshold voltage and high current density characterization is successfully achieved by using gated structure device.

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