利用鈷鈦催化金屬合成柱狀結構之奈米碳管之場發射特性的研究

研究生：林君翰　　指導教授：鄭晃忠 博士

國立交通大學電機學院產業研發碩士班

摘　要

本論文主要是針對柱狀結構之奈米碳管場發射陣列進行其場發射特性的研究。由於奈米碳管具有奈米级的管徑，極大的高寬比，堅強的機械性質及穩定的化學性質，因此，一直是極具潛力的場發射顯示器材料。由場發射的測試中，發現奈米碳管具有非常優異的場發射特性;我們利用熱化學氣相沉積系統進行奈米碳管的合成,可惜其密度很高(10^9~10^{10}/cm^2)，而密度較高的奈米碳管因為電場之遮蔽效應(screening effect)使得其場發射特性並不因其具有較高密度之場發射源而變好; 另外，因為電場的遮蔽效應，柱狀結構之奈米碳管僅有其周圍的奈米碳管會發射電子，因此，我們嘗試成長柱狀型態的碳管陣列，經由成長條件之控制，調變陣列間距與碳管長度的比值，我們發現雖然每個柱狀的碳管密度都很高，但是卻具有極佳的場發射特性。

本論文首先進行柱狀結構之奈米碳管場發射陣列的成長，發現鈷鈦雙層催化金屬(Co/Ti Bi-layered catalyst films)前處理後的顆粒比使用鐵鈦或鎳鈦做催化金屬的顆粒來的小而且均勻，因為催化金屬顆粒均勻可使奈米碳管成長的速率相同，因此，我們順利的利用鈷鈦雙層催化金屬合成高度相當一致的奈米碳管柱狀結構之奈米碳管場發射陣列。

另外,我們使用鈷鈦催化金屬所合成柱狀結構的奈米碳管，並且利用微影的方法來控制柱體和柱體之間的距離以及柱體高度來降低電場遮蔽效應，獲得最佳的場發射特性。根據本實驗，我們發現場發射電流密度與奈米碳管場發射陣列的周長大小有一定比

例的關連;再討論到不同柱體間距時,我們發現最佳的場發射特性存在於R/H Ratio(柱體間距與柱體高度的比值) 為 2.041 時，其起始電場(turn on field)是 0.808 V/μm，電流密度(current density)也高達 900.1 mA/cm^2，並且在固定電場 4.33 V/μm 一小時裡，場發射的可靠度亦相當良好，電流的變異大約為 6.52 %，其平均電流密度約 18.4 mA/cm^2，並且在塗佈螢光粉之陽極板上得到均勻之光源，因此，這種鈷鈦催化金屬合成的柱狀結構奈米碳管，具有相當潛力來應用在薄膜電晶體液晶顯示器上的背光源，以有效地降低製造材料成本。

Study on the Field Emission Characteristics of Carbon-Nanotubes Pillar Arrays Using Co/Ti Bi-Layered Catalyst

Student : Jun-Han Lin Advisor : Dr. Huang-Chung Cheng

Industrial Technology R & D Master Program of
Electrical and Computer Engineering College
National Chiao Tung University

Abstract

In this thesis, we focus our study on the field emission characteristics of carbon-nanotube (CNTs) pillar arrays. Due to CNTs' high aspect ratio, well chemical stability, high mechanical strength and small radii of curvature, carbon nanotubes have become the hot material for field emission display. Thermal chemical vapor deposition (TCVD) is used to grow the carbon nanotubes. However, the density of grown CNTs is still very high (10^9~10^{10}) and is difficult to be controlled. Besides, the electric field is screened because of the closely spaced CNTs, which results in a reduced effective electric field near the CNT emitters. As a result, turn-on electric field increases and emission current density decreases. To obtain the better field emission properties, the density of CNTs should be optimized.

The periphery of the carbon nanotube pillar plays a dominant role on the field emission effect and act as a major emission sites. Then the screen effect of CNTs can be controlled via the lithography-patterned structure of CNT pillar arrays. Therefore the CNT pillar array scheme is not only an effective way to reduce the complexity in processes but also a cost effective way to reduce the cost.

It is reported that uniform size of nanoparticles can easily grow CNTs with the same rate. Therefore, we first study the pretreatment of catalytic film including Ni/Ti, Fe/Ti, and Co/Ti as well as find that nanaparticles obtained by Co/Ti bi-layered are uniform in size and smaller than the other two bi-layered catalysts. We finally grow CNT pillar arrays with uniform length by properly controlling the growth parameters using Co/Ti bi-layered catalyst.

Then, we utilize the proposed method to synthesize CNT pillar arrays to reduce the screening effect via the pillar density design. In our study, we have found that the field emission current density is relevant to the perimeters of the field emission arrays. Finally, by adjusting the inter-pillar distance (R) and height (H) of CNT pillars, the optimization of the field emission characteristics can be obtained. According to our study, the optimum of the field emission is found at R/H ratio of 2.041. The effective turn-on field is as low as 0.808 V/μm. The maximum current density is as high as 900.1mA/cm^2. The reliability of the pillar arrays is also determined by a stress test at 4.33 V/μm for 1 hour. Those results show an excellent reliability for the CNT pillars with the current variation coefficient of 6.52 %, and average current density of 18.4 mA/cm^2 after the stress. A homogeneous light emission is also observed on the phosphor (P22) coated glasses. As a result, CNT pillars arrays are a potential candidate in the application of the back light unit for TFT-LCDs.

Contents

Table Lists

Chapter 1

Chapter 3

Figure Captions

Chapter 1

Chapter 2

Chapter 3