# 栓塞結構中合成奈米碳管之研究

學生:陳冠廷　　指導教授: 周長彬

吳文發

國立交通大學機械工程學系碩士班

## 摘　要

本論文研究奈米碳管合成於栓塞結構中，以達成奈米碳管應用於內連線的製程開發。栓塞結構為二氧化矽/鎳(70Å)/氮化鈦(200Å)/矽基板之設計，以微波電漿化學氣相沉積系統合成奈米碳管，以氫氣作前處理之氣體，使栓塞結構內之觸媒層形成島狀化金屬顆粒，再通入甲烷作為合成奈米碳管之碳源。實驗內容如下 (i)觀察栓塞結構中，前處理參數對於合成碳管之影響，(ii)討論參數於不同直徑大小之栓塞結構中合成奈米碳管的影響。經由實驗觀察得到，在栓塞孔之前處理，高溫有助於金屬顆粒之形成，並有利於碳管之合成。當以相同參數合成奈米碳管，栓塞孔徑越小，較不易合成奈米碳管，推論由於當孔徑變小，製程反應氣體較不易擴散至栓塞孔內與觸煤反應，其可藉由提高製程溫度，合成奈米碳管於較小之介質孔內(0.5μm)，並建議提高甲烷流量可增進其合成碳管之密度。(iii)在奈米碳管頂部濺鍍銅金屬後之介面研究，在未經任何處理時，銅金屬並無擴散至碳管內部，並得知碳管與銅之介面有發現氧化合物存在，其介面研究上可幫

助未來碳管導入內連線。(iv)合成橫向之奈米碳管，探討奈米碳管與金屬鈦之接觸電阻，實驗中得知，奈米碳管會因不同接觸方式，對電阻值產生影響，並經 700℃退火後，接觸電阻皆大幅下降，推論金屬鈦與碳管之介面產生化合物碳化鈦。以上實驗提供未來碳管金屬化與內連線之製程參考，不同金屬與奈米碳管之介面為未來研究方向。

關鍵字: 奈米碳管、栓塞結構、微波電漿化學氣相沈積系統

# The study of carbon nanotubes synthesis in the plug structure

Student: Kuan-Ting Chen Advisor: Chang-Ping Chou
Wen-Fa Wu

Department of Mechanical Engineering
National Chiao Tung University

## Abstract

In the recent, how to achieve the development of manufacture using CNTs as interconnection material became an interesting issue. The aim of this thesis is describe the synthesis of carbon nanotubes (CNTs) from the plug. The microwave plasma chemical vapor deposition (MPCVD) is employed for CNTs synthesized. An experiment was conducted to elucidated plug manufacture, study of parameters, metallization of CNTs, the electronic conduction property associated with horizontally CNTs.

In the plug manufacture, the $SiO_2$/Ni/TiN/Si system was obtained by PVD deposition, the selected region was created via photolithography and dry etching. For the pretreatment, the Ni-coated substrate is processing using $H_2$ plasma with various flow rates. The Ni-coated substrate were examined by the scanning electron microscopy and the high-resolution transmission electron microscopy.

For the study of parameters, the nanoscale Ni-catalytic seeds are formed on the TiN layer by $H_2$ plasma treatment at the 350 and 450°C pretreatment. It is found that the size and morphology of Ni-catalytic became granular seeds in plug structure with 450°C. In the synthesis of CNTs, the length and density are controllable using CVD method was

observed. Thus, the vertically synthesis of CNTs in plug structure is due to adjust metal nanoparticles by pretreated.

For the metallization of CNTs, the ordered array of CNTs was covered by thin copper metal. The copper/CNTs matrixes structure have completed to embed each other. The thickness copper film coating on CNTs clean investigated by SEM, this can be seen on top of tubular form. In the other word, copper coat on the CNTs not only became the composites site but also shown well distribution of surface.

For the electronic conduction property, the horizontally-oriented CNT across the trenches of the catalytic metals on pre-defined titanium nitride (Ti) electrodes by means of the thermal chemical vapor deposition is investigated. The Ti, as the upper layer on Ni pads, not only plays a role as a barrier to prevent lateral growth but also serves as a buffer site that helps in forming smaller nano-sized Ni particles. The properties of the lateral CNT, following annealing treatment, are reported. The information about interface structure of CNT treated by annealing treatment is detected using standard dc techniques with a semiconductor parameter analyzer (HP-4156B). It is suggesting that the varied metal can provide different contact behaviors in horizontally-oriented CNT device.

Keywords: Carbon nanotubes, Plug structure, MPCVD