

行政院國家科學委員會專題研究計畫 成果報告

在現有 LED 架構下製備具高反射率及高散熱率之薄膜鍍層
之研究

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行政院國家科學委員會補助專題研究計畫

成果報告
 期中進度報告

在現有 LED 架構下製備具高反射率及高散熱率之薄膜鍍層之研究

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中 華 民 國 99 年 08 月 31 日

行政院國家科學委員會補助專題研究計畫成果報告

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中文摘要：本研究以鍍膜技術來製造高反射率鍍層之結構，鍍層分為單層及多層兩部份；單層部份之鍍層材料有：鈦(Ti)、鉻(Cr)、氧化鋁(Al_2O_3)、銀(Ag)及錫金(AuSn)等；多層部份之鍍層結構則為：藍寶石基板/鈦/銀/錫金、藍寶石基板/鉻/銀/錫金、藍寶石基板/氧化鋁/銀/錫金等三種結構鍍層；接合強度則利用簡易動態剝離和拉伸實驗測試單層及多層薄膜間之接合強度。實驗結果顯示在反射率方面，以藍寶石基板/銀鍍層所測得之反射率最佳；多層結構則以藍寶石基板/氧化鋁/銀/錫金可提升之反射率最多。在接合強度測試方面，單層鍍層結構以藍寶石基板/氧化鋁鍍層之接合強度 74 MPa 為最好；在多層鍍層結構則以藍寶石基板/鉻/銀/錫金鍍層之接合強度 101 MPa 最好。

關鍵詞：高反射率及高散熱率鍍層、藍寶石基板、接合強度

英文摘要：High reflectance coatings were produced on LED sapphire substrate to enhance the reflective efficiency in LED. The coating layers were divided into single layer coating and multilayer coatings. On single layer coating, Ti, Cr, Al_2O_3 , AuSn were used. On multilayer coatings, Ti/Ag/AuSn, Cr/Ag/AuSn and Al_2O_3 /Ag/AuSn were used. In this study, the adhesion strength between coating layers was also measured by simple lap test and tensile test. Experimental results show that single layer coating using Ag has the best performance in reflectance. While, multi-layer coatings using Al_2O_3 /Ag/AuSn structure have the best effect of reflectance improvement. On adhesion strength measurement in single layer coating, the highest adhesion strength can be found on sapphire/ Al_2O_3 structure which the adhesion strength can be measured to be 74MPa. On the other hand in multi-layer coatings, the highest adhesion strength can be found on sapphire/Cr/Ag/AuSn structure which the adhesion strength can be measured to be 101MPa.

Keywords: High reflectance coating, Sapphire substrate, Adhesion strength

1.前言

在現今發光二極體(LED)市場中,如何提高反射率為設計 LED 的主要考量之一。提高反射率可在 LED 藍寶石基板背面鍍上金屬鍍層;鍍層材料的選擇是首要關鍵,另外鍍層與 LED 基板的附著力也是重要因素。在專業的鍍膜領域中,測量接合強度是能夠分析鍍層間之附著力的唯一方式[1]。銀金屬在光譜分析儀的測量上具有廣大的反射波長,因此常被使用在反射鏡,在玻璃基板上它也具有極高的反射率和低穿透率 [2],因此是極佳之材料選擇。對於分析和量測薄膜鍍層之光學特性本研究主要是藉由光譜分析儀,因為它結構簡單和準確性及耐久性很高。一般研究所使用之反射鏡大部份是鍍上一層厚厚的銀金屬在玻璃表面上[3-5]。銀金屬之薄膜鍍層是首選,因為可以藉由良好的半導體製程開發的技術應用到製造一個微型的 LED 上。而在一般反射鏡之製作會先以鈦層製備在玻璃基板當作底層材料,而銀薄膜鍍層在製備在鈦層上。此設計在開發及製造上是一個合適之結構。文獻中有些報導是可供參考,其中 Among them 和 Lung-Chien Chen 的報告 [6],主要探討在藍寶石基板上提供解決反射率方案。他們採用多層介電質之材料,使具有布拉格反射率,並有高反射率和達到長期的耐用性之特質。但是,其所使用之結構為介質層二氧化矽 /二氧化鈦層之布拉格反射率,所以波長只限制在 400nm 到 700nm 的範圍下才具有高反射率。

在附著性方面,雖然在藍寶石基板上,以銀金屬為最好的反射鏡材料,但銀鍍層和藍寶石基板接合性差,鍍層容易脫落。因此,在銀層和藍寶石基板之間,需增加緩衝層和保護層。緩衝層的作用在於它能夠增加藍寶石基板與銀層之間之接合

性,但此緩衝層不能減少整體反射率。如果銀鍍層裸露在大氣中,易受到大氣之溫度和濕度之影響,造成容易產生化學反應以致反射率下降,因此在銀鍍層之上再增加保護層是必要的。因此,本研究主要探討如何運用鈦(Ti)、鉻(Cr)、氧化鋁(Al_2O_3)、銀(Ag)及錫金(AuSn)等材料作為鍍膜層,以增強現有之 LED 反射率。鍍層設計除單層鍍膜外,並設計 3 層薄膜結構:(a) 藍寶石基板/鈦 /銀 /錫金,(b) 藍寶石基板/鉻/銀/錫金和 (c) 藍寶石基板 /氧化鋁/銀/錫金結構,本研究以探討鍍層的最佳接合強度和最佳光學特性為主要項目[7~8]。

2.實驗步驟

本實驗所選用的反射率材料為銀金屬,銀不只穩定,且具有廣大的光譜範圍和非常高的反射率及散熱性。在本研究中,我們設計了兩種鍍層結構:單層與多層結構;單層所使用之材料有鈦(Ti)、鉻(Cr)、氧化鋁(Al_2O_3)、銀(Ag)及錫金(AuSn),多層結構則主要是藍寶石基板/鈦/銀/錫金,藍寶石基板/鉻/銀/錫金,和藍寶石基板/氧化鋁/銀/錫金。多層結構之第一層鍍層作為緩衝層,使用材料為鈦,鉻和氧化鋁等材料,並運用物理蒸鍍法之電子槍方式來沉積。沉積速率約為 0.2nm/sec,設定 150 秒和 300 秒來製備不同厚度之鍍層。第二層鍍層作為反射鏡層,使用材料為銀金屬。沉積速率約為 0.5nm/sec,設定 1000 秒和 2000 秒來製備不同厚度之鍍層。第三層鍍層作為保護層,使用的材料為錫金。沉積速率約為 0.5nm/sec,設定 6000 秒來製備鍍層。

本研究之檢測方式可分為兩個層面,其一為鍍層的特性與結構分析;其二是光學特性分析。鍍層的特性與結構分析

部分主要為利用掃瞄式電子顯微鏡(SEM)觀察，接合強度測試則利用簡單膠帶剝離法及 Lap-Shear 測試法來測試本此實驗鍍層結構之接合強度，如圖一所示為剝離及 Lap-Shear 測試法架構之示意圖。而光學特性分析部分則用日立的 U- 4100 光譜分析儀來探討及量測反射率和穿透率等光學性質。

3. 實驗結果與討論

3.1 鍍層微觀結構和接合強度測試

圖二為藍寶石基板/鈦/銀 /錫金，藍寶石基板/鉻/銀/錫金和藍寶石基板/氧化鋁/銀/錫金之微觀結構。由於第一層緩衝層的厚度非常薄，在微觀下其介面不容易觀察。第二層是銀鍍層反射鏡層，厚度約為 $0.3\ \mu\text{m}$ ， $0.6\ \mu\text{m}$ 和 $1\ \mu\text{m}$ ，分別運用在藍寶石基板/鈦/銀/錫金，藍寶石基板/鉻/銀/錫金，和藍寶石基板/氧化鋁/銀/錫金等鍍層結構。第三層錫金層為保護層，其厚度約為 $3\ \mu\text{m}$ 。在接合強度試驗方面，表一為使用簡單膠帶剝離法測試各種鍍層材料和鍍層厚度下，各種鍍層結構之附著性。結果顯示除了銀鍍層外其於皆通過測試，即膠帶無法將鍍層撕下。此方法雖然簡易，但實質效益有限，且無量化數據可供比較。因此本研究再利用 Lap-Shear 測試法測試各種鍍層材料和鍍層厚度下，各種鍍層結構之附著性。結果發現多層結構以藍寶石基板/鉻/銀/錫金之結構有最高之接合強度。測試後之最高接合強度可達到約 101MPa。而相對地在藍寶石基板/氧化鋁/銀/錫金結構下，其接合強度可測得約只達 1MPa。表二為本次實驗單層和多層鍍層結構與各種鍍層材料和鍍層厚度及接合強度測量值。圖三為經接合強度測試

後之斷裂界面觀察：(a) 顯示在藍寶石基板/鈦 30nm/銀 1000nm /錫金 3000nm 結構下，觀察到鈦鍍層約有 95% 的面積斷裂於藍寶石基板與鈦鍍層之間的界面層。然而，另外 5% 的區域則為銀和鈦鍍層間之斷裂。此試片所測量之接合強度為 23MPa。圖三(b)顯示在藍寶石 /鉻 60nm/銀 1000nm /錫金 3000nm 結構下之斷裂表面。由斷裂界面觀察可知，約 70% 面積斷裂於鉻和銀鍍層界面之間。然而，30% 的面積被發現斷裂於銀和錫金鍍層之間。此試片所測量之接合強度為 30MPa。圖三(c)顯示在藍寶石 /氧化鋁 30nm/銀 1000nm /錫金 3000nm 結構下之斷裂面。約 95% 面積斷裂於銀鍍層和氧化鋁層之間界面。然而，5% 的區域被發現斷裂於銀和錫金鍍層之間的裂縫。此試片所測量之接合強度為 11MPa。

3.2 高反射率之光學特性的結構最佳設計

在藍寶石基板/鈦/銀/錫金，藍寶石基板/鉻/銀/錫金，藍寶石基板/氧化鋁/銀/錫金結構下，反射率和穿透率測量結果如表二所示。量測先進行標準片鋁鏡校正反射率後，再進行本實驗所有結構之反射率數據。在另一方面以相同機台量測穿透率部份，此部份先進行標準為空氣校正穿透率後，再進行本實驗所有結構之穿透率數據。結果顯示，單層之鈦，鉻鍍層在藍寶石基板上，反射率和低穿透率甚低。在波長 460nm 測量反射率值約為 14% 至 25%。單層之氧化鋁鍍層在藍寶石基板上，在波長 460nm 反射率值約為 10%。雖然單層銀鍍層在藍寶石基板上具有甚非常佳的反射率，在波長 460nm 其測量之反射率值約為 47% 至 52%，但因銀鍍層容易

從藍寶石基板上脫落，從接合強度得知銀和藍寶石基板有很差之附著性。

多層結構測量方面，第一種為藍寶石基板/鈦/銀/錫金結構，結果顯示此種結構在各種不同厚度的鍍層，其反射率和穿透率皆低，在波長 460nm 所測量之反射率值約為 18% 至 22%，另外在波長 300 到 1600nm 所測量之穿透率值為 0%。第二種為藍寶石基板/鉻/銀/錫金結構，結果顯示此種結構在各種不同厚度的鍍層材料，其反射率和穿透率皆低，在波長 460nm 所測量之反射率值約為 20% 至 27%，另外在波長 300 到 1600nm 所測量之穿透率值為 0%。第三種為藍寶石基板/氧化鋁/銀/錫金結構，在波長 460nm 所測量之反射率值約 41% 至 48%，另外在波長 300 到 1600nm 所測量之穿透率值為 0%。在這些結構，我們發現第三種結構具有最佳的反射特性。在設計有氧化鋁當緩衝層的反射鏡結構中，其反射率與鈦和鉻作為緩衝層相比，可有 200% 的提昇。圖四顯示本次實驗所有結構之反射率和穿透率的結果。

4. 結論

- 1 單層結構以銀金屬有最好的反射率，而銀鍍層厚度增加則其反射率也隨之增加，但單層銀鍍層之附著性差，容易從藍寶石基板上脫落。
- 2 單層結構以藍寶石基板/氧化鋁結構有最佳之接合強度。
- 3 多層結構以藍寶石基板/氧化鋁/銀/錫金結構具有最佳的反射率。
- 4 多層結構以藍寶石基板/鉻/銀/錫金結構有最佳之接合強度。

5. 參考文獻

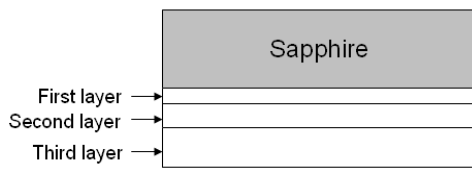
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6. 自評

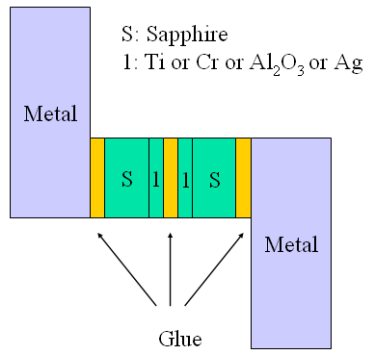
本計畫原為三年期計畫，計畫核定後為一年計畫。因此原計畫規畫執行之散熱研究，本年度雖有進度但無完整之結果，本年度計畫按照計畫書之進度執行，執行成果豐碩，不僅達成原有之目標且有超前，本計畫之成果也已投稿國內研討會論文一篇及國外研討會一篇供二篇論文。



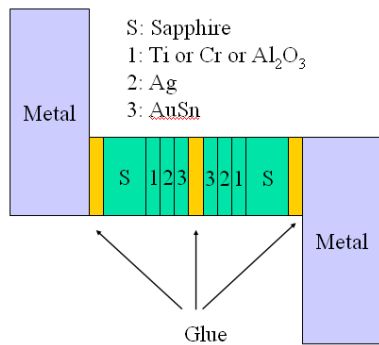
(a)



(b)

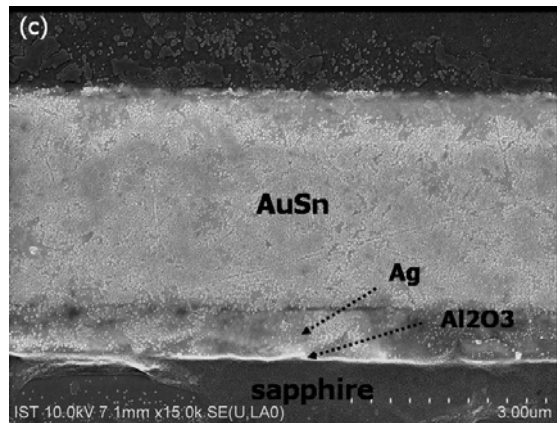
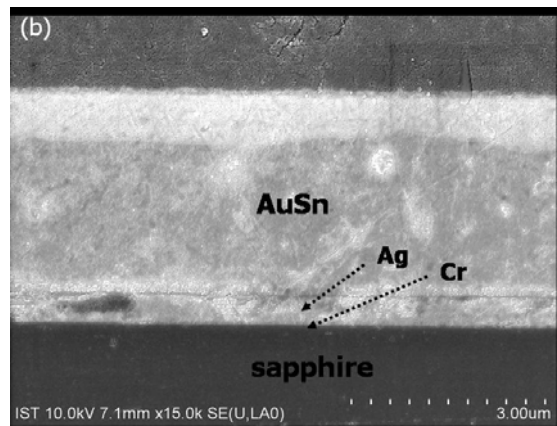
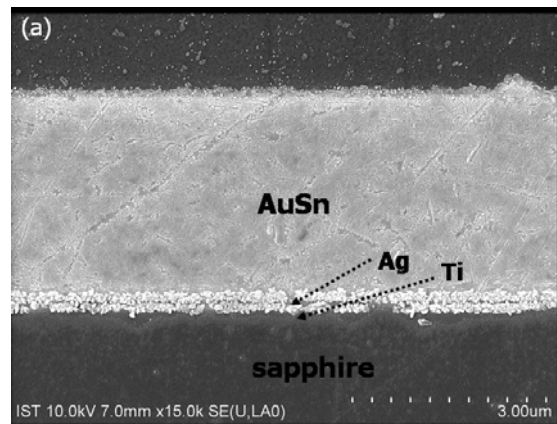


(c)

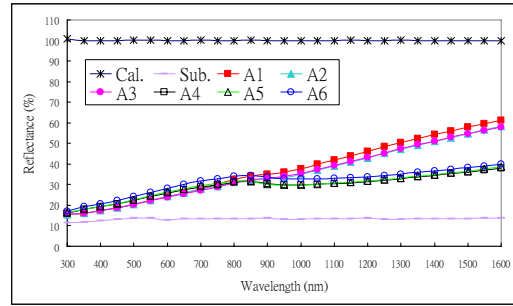
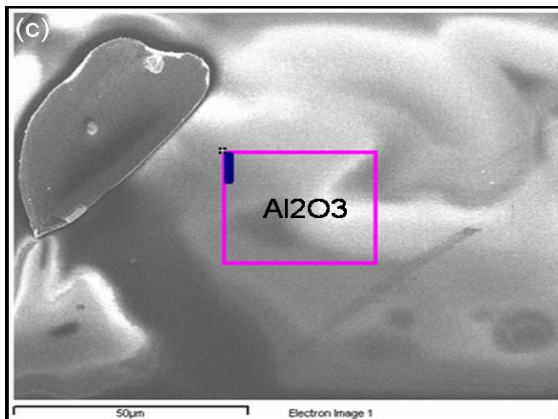
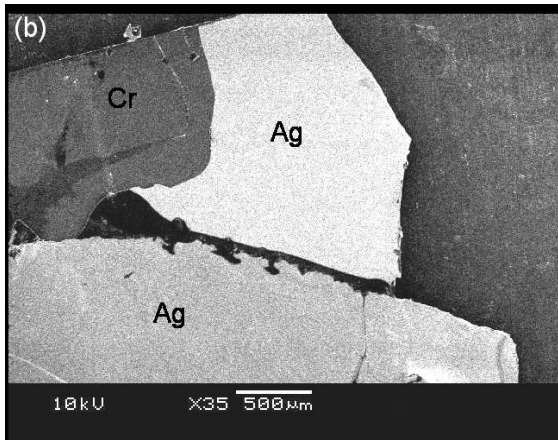
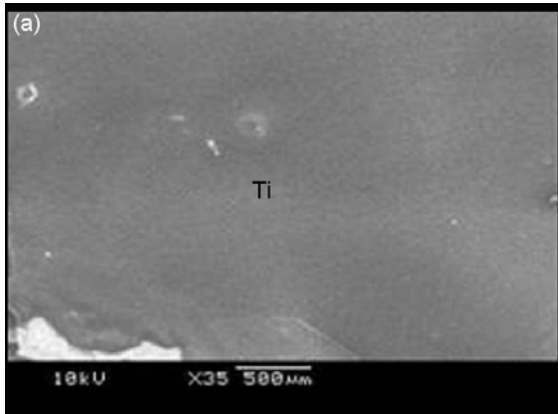


(d)

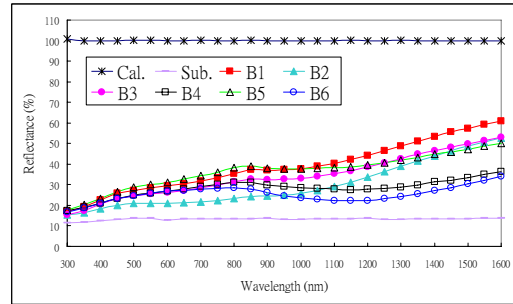
圖一 反射鏡鍍層結構和接合強度試驗之示意圖: (a) 鍍在藍寶石基板背面之多層結構, (b) 以 3M 膠帶簡單剝離測試, (c) 單層鍍層接合強度試驗結構示意圖和 (d) 多層鍍層接合強度試驗結構示意圖



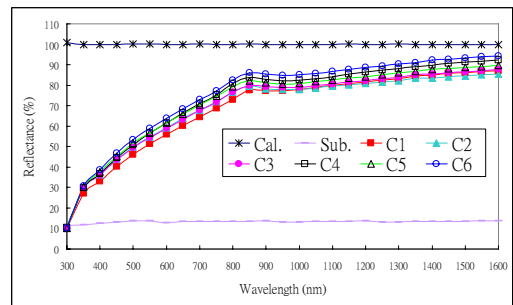
圖二 以 SEM 觀察結構之鍍層之顯微結構: (a) 藍寶石基板/鈦/銀/錫金, (b) 藍寶石基板/鉻/銀/錫金, 以及 (c) 藍寶石基板/氧化鋁/銀/錫金結構



(a)



(b)



(c)

圖四 反射率和穿透率的測試結果: (a) 藍寶石基板/鈦/銀/錫金, (b) 藍寶石基板/鉻/銀/錫金, 以及 (c) 藍寶石基板/氧化鋁/銀/錫金結構。

圖三 為接合強度試驗後之斷裂界面觀察: (a) 藍寶石基板/鈦/銀/錫金, (b) 藍寶石基板/鉻/銀/錫金, 以及 (c) 藍寶石基板/氧化鋁/銀/錫金結構

表一 各種鍍層材料和鍍層厚度條件下，以膠帶做簡易之剝離之測試結果

Simple peeling test for Single-layer structure	OK	Fail
sapphire/Ti 30nm	V	
sapphire/Ti 60nm	V	
sapphire/Cr 30nm	V	
sapphire/Cr 60nm	V	
sapphire/ Al ₂ O ₃ 30nm	V	
sapphire/ Al ₂ O ₃ 60nm	V	
sapphire/Ag (100nm or 500nm or 1000nm)		V
All multi layer structures	V	

表二單層和多層鍍層結構在各種不同鍍層厚度之條件下之接合強度測量值

Single layer coating and Multi layer coating structure for lap shear test	Adhesion Strength (MPa)
sapphire/Ti 30nm	33.7
sapphire/Ti 60nm	25.5
sapphire/Cr 30nm	46.3
sapphire/Cr 60nm	56.4
sapphire/ Al ₂ O ₃ 30nm	43.3
sapphire/ Al ₂ O ₃ 60nm	74.1
sapphire/Ag100nm	3.7
sapphire/Ag500nm	0.5
sapphire/Ag1000nm	3.0
sapphire/AuSn 3000nm	1.6
sapphire/Ti 30nm/Ag 100nm /AuSn 3000nm	15.2
sapphire/Ti 30nm/Ag 500nm /AuSn 3000nm	15.2
sapphire/Ti 30nm/Ag 1000nm /AuSn 3000nm	23.0

/AuSn 3000nm	
sapphire/Ti 60nm/Ag 100nm /AuSn 3000nm	35.8
sapphire/Ti 60nm/Ag 500nm/AuSn 3000nm	54.2
sapphire/Ti 60nm/Ag 1000nm/AuSn 3000nm	35.9
sapphire/Cr 30nm/Ag 100nm/ AuSn 3000nm	51.4
sapphire/Cr 30nm/Ag 500nm/ AuSn 3000nm	12.4
sapphire/Cr 30nm/Ag 1000nm/ AuSn 3000nm	11.7
sapphire/Cr 60nm/Ag 100nm/ AuSn 3000nm	39.3
sapphire/Cr 60nm/Ag 500nm/ AuSn 3000nm	101.0
sapphire/Cr 60nm/Ag 1000nm/ AuSn 3000nm	30.9
sapphire/ Al ₂ O ₃ 30nm/Ag 100nm/ AuSn 3000nm	4.1
sapphire/ Al ₂ O ₃ 30nm/Ag 500nm/ AuSn 3000nm	2.9
sapphire/ Al ₂ O ₃ 30nm/Ag 1000nm/ AuSn 3000nm	11.2
sapphire/ Al ₂ O ₃ 60nm/Ag 100nm/ AuSn 3000nm	1.8
sapphire/ Al ₂ O ₃ 60nm/Ag 500nm/ AuSn 3000nm	5.0
sapphire/ Al ₂ O ₃ 60nm/Ag 1000nm/ AuSn 3000nm	11.9

表三 在單層和多層鍍層的結構搭配各種鍍層厚度之反射率和穿透率的測量結果

Hitachi U-4100			
Symbol	Wavelength @ 460 (nm)	Reflectance(%)	Transmittance(%)
Cal.	Calibration using Al mirror	99.9	---
Cal.	Calibration in air	---	99.9
	sapphire substrate	13.1	91.3
	sapphire/Ti 30nm	14.2	21.9
	sapphire/Ti 60nm	22.1	9.4
	sapphire/Cr 30nm	20.7	7.1
	sapphire/Cr 60nm	24.9	1.5
	sapphire/ Al ₂ O ₃ 30nm	10.9	86.8
	sapphire/ Al ₂ O ₃ 60nm	10.3	87.9
	sapphire/Ag100nm	47	0
	sapphire/Ag500nm	48.1	0
	sapphire/Ag 1000nm	51.6	0
	sapphire/AuSn 3000nm	30.1	0
A1	sapphire/Ti 30nm/Ag 100nm /AuSn 3000nm	18.9	0
A2	sapphire/Ti 30nm/Ag 500nm /AuSn 3000nm	18.8	0
A3	sapphire/Ti 30nm/Ag 1000nm /AuSn 3000nm	18.8	0
A4	sapphire/Ti 60nm/Ag 100nm /AuSn 3000nm	21	0
A5	sapphire/Ti	21	0

	60nm/Ag 500nm/AuSn 3000nm		
A6	sapphire/Ti 60nm/Ag 1000nm/AuSn 3000nm	22.4	0
B1	sapphire/Cr 30nm/Ag 100nm/ AuSn 3000nm	26.2	0
B2	sapphire/Cr 30nm/Ag 500nm/ AuSn 3000nm	20.3	0
B3	sapphire/Cr 30nm/Ag 1000nm/ AuSn 3000nm	23.6	0
B4	sapphire/Cr 60nm/Ag 100nm/ AuSn 3000nm	23.7	0
B5	sapphire/Cr 60nm/Ag 500nm/ AuSn 3000nm	27.1	0
B6	sapphire/Cr 60nm/Ag 1000nm/ AuSn 3000nm	23.6	0
C1	sapphire/ Al ₂ O ₃ 30nm/Ag 100nm/ AuSn 3000nm	41.5	0
C2	sapphire/ Al ₂ O ₃ 30nm/Ag 500nm/ AuSn 3000nm	45.3	0
C3	sapphire/ Al ₂ O ₃ 30nm/Ag 1000nm/ AuSn 3000nm	44.6	0
C4	sapphire/ Al ₂ O ₃ 60nm/Ag 100nm/ AuSn 3000nm	45.9	0
C5	sapphire/ Al ₂ O ₃	46.7	0

	60nm/Ag 500nm/ AuSn 3000nm		
C6	sapphire/ Al₂O₃ 60nm/Ag 1000nm/ AuSn 3000nm	48.4	0

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：99年1月15日

計畫編號	NSC 98-2221-E-216-008
計畫名稱	在現有 LED 架構下製備具高反射率及高散熱率之薄膜鍍層之研究
出國人員姓名 服務機關及職稱	林育立 中華大學機械工程學系教授
會議時間地點	自 99 年 1 月 3 日至 99 年 1 月 8 日香港
會議名稱	IEEE 國際奈米電子研討會 IEEE International NanoElectronics Conference (INEC)
發表論文題目	1.Atomic Structure of Hydrous Ruthenium Oxide Coating on Carbon-Nanotube for Supercapacitor 2.Junction Temperature for High-Power LED Packages with Diamond film

一、參加會議經過

本次會議(IEEE 國際奈米電子研討會)於九十九年一月三日至一月八日共計六日，於香港城市大學舉行，筆者與博士生許政義於一月三日搭乘長榮航空班機於下午二時許抵達香港赤臘角國際機場，隨即搭車至市中心帝樂文娜公館(本次會議筆者下榻之旅館)，稍作休息後即搭乘地下鐵赴本次會議之場所:香港城市大學，辦理報到手續；今天因尚無演講活動因此辦完一切手續後就返回飯店。本次會議空前浩大，有來自全世界超過三十個國家共發表超過七百篇之論文，其中有兩百多篇為口頭講演及四百多篇之論文展示。此次會議也與另一研討會” NanoMan: The 1st International Conference on Nanomanufacturing” 共同舉辦，該研討會共有接近兩百篇論文。筆者此次共發表兩篇文章，其中一篇為口頭報告另外一篇則為論文海報展示。第二天一大早就到會場，因昨晚事先已擬妥今天要聽的場次，因此早上就聽了幾場有興趣的研究報告，尤其是會議一開始網網邀請重量級之演講者，這種演講更是筆者一定不會放過的。另外早上十點十五分在口頭報告的中場休息時間也穿插論文海報展示的活動。與一般上台口頭報告不同，海報可以放的東西比較多且展示時間也較長，加上作者可以在旁即時解釋及討論論文內容，而且同一時間有幾十甚至上百篇論文同時展示，因此其重要性並不輸於比口頭報告。筆者對於材料方面尤其是鍍層方面較有興趣，因此選擇的聽講題目大都在這個領域，筆者也發現雖然此次會議奈米材料的題材還是受到重視，不過奈米材料的發展好像也達到一定的瓶頸，最近此領域熱門的程度有下降的趨勢，隨著全球能源的愈來愈缺乏，最近對於能源材料方面的研究有漸趨熱絡的趨勢，這也可給我們作為未來研究的參考。筆者的論文為星期一上午一點十五分的海報發表，及星期下午三點五十分之口頭報告，因筆者所研究不僅利用顯微鏡觀察材料之性質更結合奈米材料及能源方面的應用，因此吸引不少來自世界各國研究者的目光與興趣，會議最後在十六日下午六點是四十五分最後一場報告後劃下句點。因本次會議結束時間時間較晚因此只能搭乘十七日之班機回國。

二、與會心得

此次會議有超過來自全世界三十多個國家一千多名學者專家與會，從會議的流程可發現主辦單位在各項安排都十分注重，可謂是成功的一次大型國際研討會。本次會議也有一些小缺點，會議之宣導並不是十分理想，因此在會議中心外之街道並無會議舉行之資訊，也有可能是新加坡政府規定。另外會議安排之地點也不太理想，並不是大型之會展中心，只利用管理大學之行政大樓來作為會議中心，這與號稱有八百餘篇參予之研討會好像不太符合。再研究主題方面雖然此次會議奈米材料的題材還是受到重視，不過奈米材料的發展好像也達到一定的瓶頸，最近此領域熱門的程度有下降的趨勢，隨著全球能源的愈來愈缺乏，最近對於能源材料方面的研究有漸趨熱絡的趨勢，這也可給我們作為未來研究的參考。

三、攜回資料名稱及內容

1. Proceeding of The 4th International Conference on Technological Advances of Thin Films & Surface Coatings
2. Disk of The 4th International Conference on Technological Advances of Thin Films & Surface Coatings

出席國際學術會議心得報告

計畫編號	NSC 98-2221-E-216-008
計畫名稱	在現有 LED 架構下製備具高反射率及高散熱率之薄膜鍍層之研究
出國人員姓名	林育立
服務機關及職稱	中華大學機械工程學系教授
會議時間地點	自 99 年 1 月 3 日至 99 年 1 月 8 日香港
會議名稱	IEEE 國際奈米電子研討會 IEEE International NanoElectronics Conference (INEC)
發表論文題目	1.Atomic Structure of Hydrous Ruthenium Oxide Coating on Carbon-Nanotube for Supercapacitor 2.Junction Temperature for High-Power LED Packages with Diamond film

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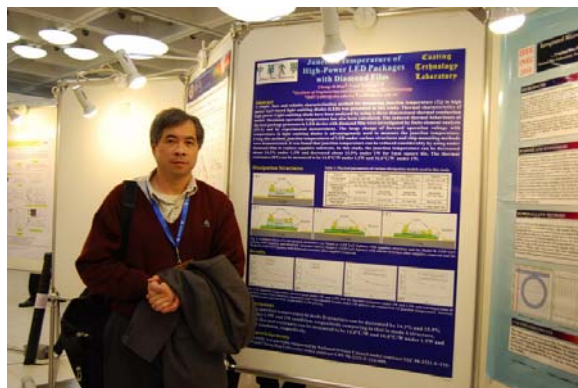
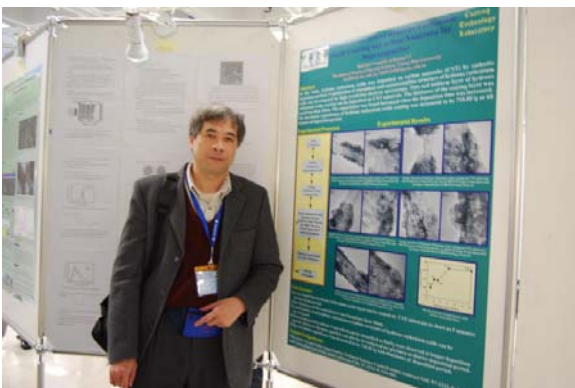
二、與會心得

此次會議有超過來自全世界三十多個國家二千多名學者專家與會，從會議的流程可發現主辦單位在各項安排都十分注重，可謂是成功的一次大型國際研討會。本次會議的場地：香港城市大學，位於九龍塘地鐵站附近，且旁邊還有一間大型百貨公司，因此地點的安排十分便利，本次會議也邀請重量級演講者，而且一次就邀請二、三十位之多，可見主辦單位之用心。尤其是可邀請到諾貝爾得主蒞臨更是一大賣點，而他的演講也是另人印象深刻，從他深入淺出的演講內容，加上詼諧的口語及豐富的投影片設計，搭配聲效，真是一場非常好的演講。而他也提出未來奈米科技的挑戰及他對未來奈米科技的發展較憂心的事情，在在都讓人覺得他不僅是在學術上貢獻一己之力，同時也利用他的聲望，希望可對人類的進步產生正面的影響，且現在他也在教育下一代方面貢獻自己的力量。筆者有機會私下與他簡短晤談並合影留念，是此行另一小收穫。本次會議主辦單位除在會議休息片段提供小餐點外，在中午也提供中餐，這是貼心的安排，不過中餐以桌菜進行則有點不方便，因此很多人都沒有參與午餐，雖然本次會議有一些小缺點，但仍值得對大會的細致安排給予肯定，也可給國內以後辦理大型研討會的很好的借鏡。

三、攜回資料名稱及內容

1. Program of IEEE International NanoElectronics Conference
2. Disk of IEEE International NanoElectronics Conference

四、參與會議照片



Atomic Structure of Hydrous Ruthenium Oxide Coating on Carbon-Nanotube for Supercapacitor

Yuli Lin* and H.-S Huang

Abstract. In this study, hydrous ruthenium oxide with carbon nanotube additives was deposited on Ti substrate by cathodic deposition method. Combination of amorphous and nanocrystalline structure of hydrous ruthenium oxide was investigated by high resolution electron microscopy. It was found that thin hydrous ruthenium oxide coating layer can be deposited on CNT substrate. The thickness of the coating layer was found less than 10nm. The capacitance was found increased when the deposition time was increased. The maximum capacitance of hydrous ruthenium oxide coating was measured to be 718.8F/g.

Background

Nowadays, capacitor has been extensively used for offering the function of equalizing distribution of power. However, the capacitor used today could only provide limited density of power which was not suitable for those electrical appliances needing high-density of power to start. Supercapacitors (Electrochemical Capacitors) have many advantages using in electrical devices for their larger electrical capacity, high power density and long cycle life [1].

Supercapacitor is a kind of storage of electricity between secondary battery and capacitor. Comparing with secondary battery, supercapacitor does not only have higher density of power but also can be recharged many times. It also has larger density of energy, offering higher transient power and higher reliability. In general, supercapacitors can be classified into two categories, namely, pseudo-capacitors [2] and double-layer capacitors [3]. The former stores electrical charges in electrode surface by faradic reaction. While, in the latter, electrical charges are stored at the double-layer formed at electrode/electrolyte interface. Various methods have been utilized to manufacture electrode including cyclic voltammetric method [4], sol-gel method [5], cathodic deposition method [6] and etc. Hydrous ruthenium oxides were found to be a superior material for supercapacitor, which can offer higher capacity of electric charge than any other materials. Utilizing hydrous ruthenium oxide ($\text{RuO}_x \cdot (\text{OH})_y$) as a supercapacitor material, the H^+ transits easily in itself, and Ru^{4+} could increase the capacity. Ruthenium not only has several different oxide forms; but also could go on oxidation reduction itself [7].

Current Results

Hydrous ruthenium oxide with carbon nanotube additives was deposited on Ti substrate by cathodic deposition method. Ti substrate was first cleaned thoroughly by acetone and followed by chemical etching of 5%HF for 5 minutes and 50%HCl for 15 minutes. The purpose of adding carbon nanotube is to increase the effective area of hydrous ruthenium oxide coatings. The concentration of carbon nanotube added in the deposition process is 0.05wt%. The time of specimens which were immersed into the deposition bath varied from 5 minutes to 60 minutes. The electrical capacity characteristics of coating were examined by cyclic voltammetry. The microstructure of hydrous ruthenium oxide coating was also observed by high resolution electron microscopy.

Figure 1(a), (b) show the atomic structure of hydrous ruthenium oxide coating on CNT substrate with 5 minutes of deposition period. Combination of amorphous and nanocrystalline structure of hydrous ruthenium oxide can be investigated. Nanosized particles (about 2 nm) which can be identified as RuO_2 and Ru were observed on this specimen. The capacitance of this specimen was measured to be 213.8F/g.

Figure 2(a), (b) demonstrate the atomic structure of hydrous ruthenium oxide coating on CNT substrate with 10 minutes of deposition period. Nanoparticles embedded in amorphous phase can be observed on this specimen. The capacitance of this specimen was measured to be 411.3F/g. Combination of RuO_2 and Ru particles can also be observed. Figure 3(a), (b) reveal the atomic structure of hydrous ruthenium oxide coating on CNT substrate with 15 minutes of deposition period. Combination of amorphous and nanocrystalline structure of hydrous ruthenium oxide was also investigated. RuO_2 particles were found at this specimen.

Figure 4(a), (b) show the atomic structure of hydrous ruthenium oxide coating on CNT substrate with 30 minutes of deposition period. The capacitance of this specimen was measured to be 713.7F/g. Addition to amorphous structure, RuO_2 nanosized particles (about 2 nm) was the only particles to be observed on this specimen. Figure 5(a), (b) reveal the atomic structure of hydrous ruthenium oxide coating on CNT substrate with 60 minutes of deposition period. The capacitance of this specimen was measured to be 718.8F/g. It was found that more uniform hydrous ruthenium oxide layer was coated on CNT substrate. The thickness of the coated layer was found less than 10nm. Combination of amorphous and nanocrystalline structure of hydrous ruthenium oxide was also investigated. Nanosized particles (about 2 nm) which can be identified as RuO_2 were observed on this specimen.

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Figure 6 illustrates the distribution of measured capacitance with various deposition periods. The measured capacitance of hydrous ruthenium oxide on CNT substrate was 213.8F/g for specimen with 5 minutes of deposition period. However, the capacitance was increased to 718.8F/g when the deposition period was increased to 60 minutes.

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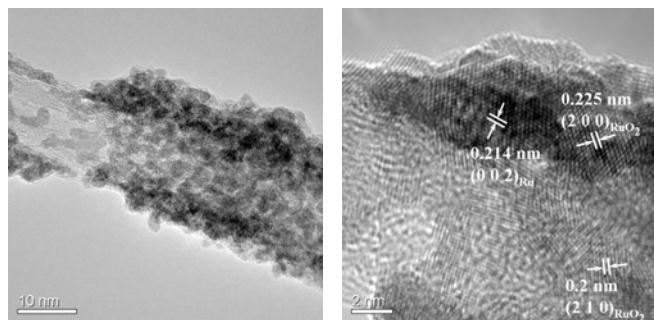


Figure 1. Atomic structure of hydrous ruthenium oxide coating on CNT substrate with 5 minutes of deposition period, (a) HRTEM image of specimen and (b) higher magnification of HRTEM image form (a).

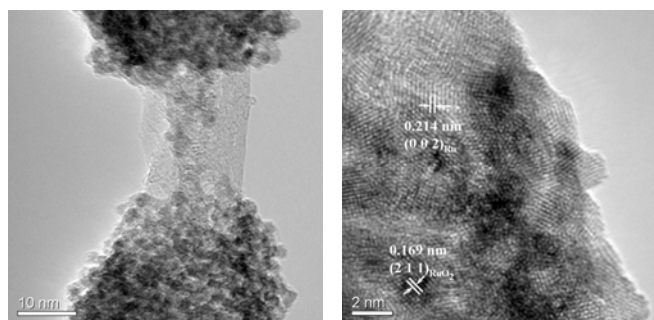


Figure 2. Atomic structure of hydrous ruthenium oxide coating on CNT substrate with 10 minutes of deposition period, (a) HRTEM image of specimen and (b) higher magnification of HRTEM image form (a).

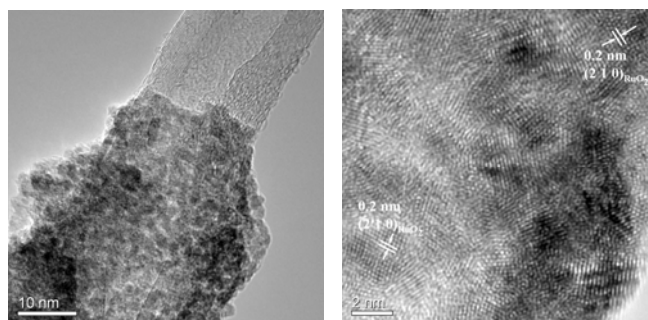


Figure 3. Atomic structure of hydrous ruthenium oxide coating on CNT substrate with 15 minutes of deposition period, (a) HRTEM image of specimen and (b) higher magnification of HRTEM image form (a).

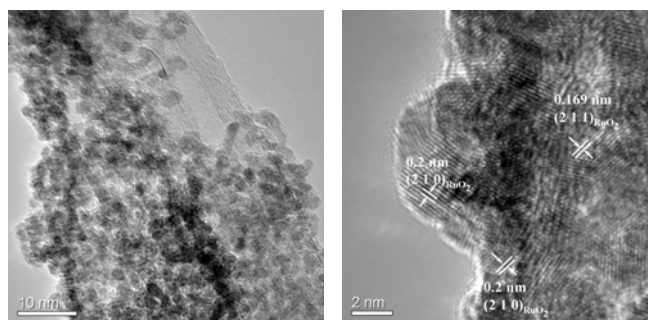


Figure 4. Atomic structure of hydrous ruthenium oxide coating on CNT substrate with 30 minutes of deposition period, (a) HRTEM image of specimen and (b) higher magnification of HRTEM image form (a).

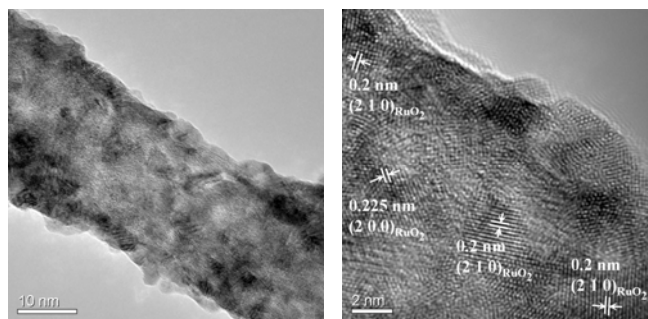


Figure 5. Atomic structure of hydrous ruthenium oxide coating on CNT substrate with 60 minutes of deposition period, (a) HRTEM image of specimen and (b) higher magnification of HRTEM image form (a).

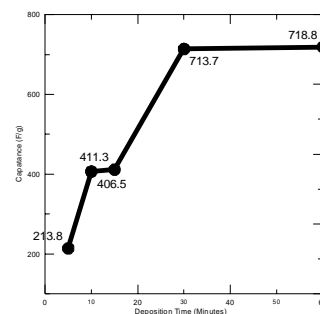


Figure 6. The distribution of measured capacitance with various deposition periods.

Junction Temperature of High-Power LED Packages with Diamond film

Cheng-Yi Hsu¹ and Yuli Lin^{1,*}

Abstract. A simple, fast, and reliable characterization of thermal properties method to determine junction temperature (T_j) in high power GaN-based light emitting diodes (LED) was presented in this study. Thermal characteristics of high power Light-emitting-diode have been analyzed by using a three-dimensional thermal conduction model. Maximum operation temperature has also been calculated. The induced thermal behaviours of the best package processes for LED device with diamond film were investigated by finite element analysis (FEA) and by experimental measurement. The large change of forward operation voltage with temperature in light emitting diodes is advantageously used to measure junction temperature. Using this method, junction temperatures (T_j) of a LED under various structures and chip mounting methods were measured. It was found that the junction temperature can be reduced considerably by diamond film substrates. For diamond film substrates LED, as much as two-fold reduction in junction temperature can be achieved compared to other structures. In this study, we will report how we can achieve the junction temperature had to decrease about 10 percent for more than 1.5W- power dissipation for 1mm square die. It was found that the thermal resistance using diamond film structure is measured to be 17°C/W which is the lowest than other structures.

Background

High-power Light Emitting Diode (LED) can be potentially used for general lighting to alleviate the global warming problem. However, the LED associated with high cost, high junction temperature, low luminous efficiency, and low reliability have to be resolved before becoming realized. The increase in the light-output efficiencies of LED is the main cause of such a marked transition. Accordingly, many researchers are developing LED technology with a view to general lighting applications. However, depending on the power conversion efficiency, some of the input energy becomes photons, which are immediately emitted out of the device, while the rest remains in the device as heat, which increases the junction temperature. Since an LED is a semiconductor device, many of its properties strongly depend on thermal temperature [1~11].

As the junction temperature is increased, both the operating voltage and the wavelength changed, and the reliability and output efficiency are degraded. Thus, the problem of heat flow in an LED is inevitable in high-power applications.

Current Results

In order to evaluate what is the better way for packaging LED device with diamond film. The samples utilized in this work are diamond film on silicon wafer. The thickness of diamond film is 20 μ m after remove silicon wafer. Figure 1(a) and (b) shows the SEM images of diamond films. In this study, we established three kinds of model structures. Table 1 shows the physical parameters of the model used. In our models, normal GaN /Sapphire blue high power LED was used. The samples utilized in this work are 40 mil blue GaN LED chips which were obtained from an LED manufacturer. Figure 2(a) shows the conventional configuration of GaN LED structure. The thicknesses of the nitride film and sapphire substrate are 5 and 90 μ m, respectively. A thin semi-transparent oxidized ITO layer was coated on top of the p-type layer to enhance the spreading of the current structure. Figure 2(b) shows the high power LED chips mounted onto heat sink using silver epoxy without encapsulates. The heat sink used in this study is diamond film which has a high thermal conductivity. The heat sink was then mounted onto Cu substrate using silver epoxy. The Cu substrate with an area of 10 \times 10 cm² and a height of 0.2 cm was used. In this study, the LED chip was also considered for evaluation of the influence on thermal conductivity for diamond film during package process. In addition, a sliding boundary condition instead of fixed-end boundary was set on the bottom surface of the package substrate for model the substrate handling on the heating dissipation stage by diamond film.

From the simulation result, it was found that the junction temperature had the reduction of 10.7% using diamond film on top of Cu substrate. The simulation result was confirmed by experiments which shows that a reduction of 11.5% in junction temperature measurement using diamond film on top of Cu substrate. Table 2 demonstrates all the experimental measured in this study for various mode structures. It was found that the thermal resistance using diamond film structure is measured to be 17°C/W which is the lowest than other structures. Figure 3(a) ~ (b) shows the measurement of the junction temperature and thermal resistance vs. different structures under various powers conditions. The LED using diamond film structure not only has the lowest junction temperature but also had the lowest thermal resistance than other structures under various powers. Figure 3(c) shows the comparison of the simulation and experimental results in junction temperature measurement with different structure at 1W. It was found that a good agreement between the experimental result and the simulation data on various structures.

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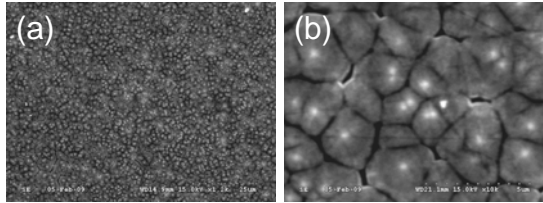


Fig. 1. SEM images of Diamond structure : (a) low magnification and (b) higher magnification of (a).

Table 1 The physical parameters of the model

Material	Mode 1 Structure	Mode 2 Structure	Mode 3 Structure
LED Dimensions L x W x H	GaN 1mm*1mm* 5 μ m	GaN 1mm*1mm* 5 μ m	GaN 1mm*1mm* 5 μ m
Adhesion Material	Sapphire 1mm*1mm*90 μ m	Sapphire 1mm*1mm*90 μ m	Sapphire 1mm*1mm*90 μ m
High thermal conductivity Material (Heat Sink)	Diamond Film 1mm*1mm*20 μ m	No Heat Sink Used	Graphite Film 1mm*1mm*3mm
Adhesion Material	Silver epoxy 5 μ m	Silver epoxy 5 μ m	Silver epoxy 5 μ m
Board Material L x W x H	Cu 100mm x 80 mm x3 mm	Cu 100mm x 80 mm x3 mm	Cu 100mm x 80 mm x3 mm

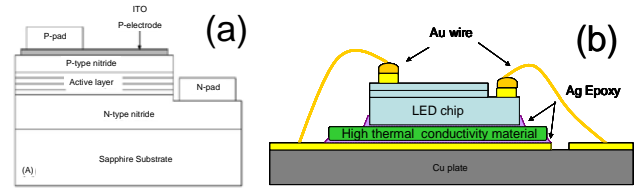


Fig. 2. Configurations of GaN LED structure: (a) conventional structure and (b) mount on high thermal conductivity material (heat sink) adhesion Cu plate.

Table 2 The experimental results for various mode structures

Type	Structure	Rth(°C/W) @1W	Tj(°C) @1W	Rth(°C/W) @1.5W	Tj(°C) @1.5W
Mode 1	LED on Diamond Film	19.7	42.3	17.0	45.2
Mode 2	LED	24.2	47.8	20.9	51.1
Mode 3	LED on Graphite Film	34.0	58.9	33.1	70.7

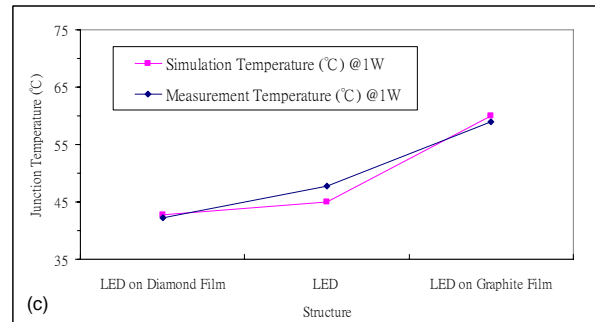
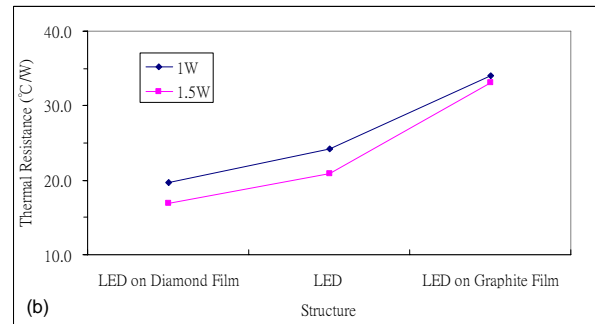
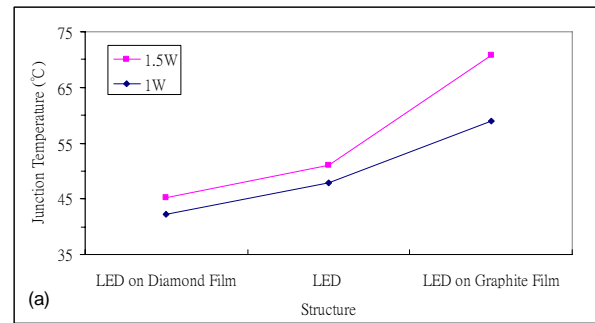


Fig. 3. Measurement curves of the (a) junction temperature and (b) thermal resistance vs. different structure under various powers (1W, 1.5W) and (c) junction temperature vs. different structure in the simulation and experiment data under various powers (1W)

無研發成果推廣資料

98 年度專題研究計畫研究成果彙整表

計畫主持人：林育立		計畫編號：98-2221-E-216-008-					
計畫名稱：在現有 LED 架構下製備具高反射率及高散熱率之薄膜鍍層之研究							
成果項目		量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）	
		實際已達成數（被接受或已發表）	預期總達成數（含實際已達成數）	本計畫實際貢獻百分比			
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	1	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	3	3	100%	人次	
		博士生	2	2	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	1	100%		
		專書	0	0	100%		章/本
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

<p style="text-align: center;">其他成果</p> <p>(無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)</p>	<p style="text-align: center;">無</p>
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	成果項目	量化	名稱或內容性質簡述
科 教 處 計 畫 加 填 項 目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與(閱聽)人數	0	

國科會補助專題研究計畫成果報告自評表

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1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

達成目標

未達成目標（請說明，以 100 字為限）

實驗失敗

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其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

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LED 散熱為研究此領域重要之課題，本計畫不只按照計畫書之內容完成在現有 LED 架構下製備具高反射率及高散熱率之薄膜鍍層，計畫結果也發表於期刊上，計畫之結果不僅可供業界參考作為改善之依據，也可作為有興趣研究此領域之學者專家作為後續研究之依據，本實驗室未來也會繼續在 LED 散熱持續研發，為社會國家貢獻力量。

