

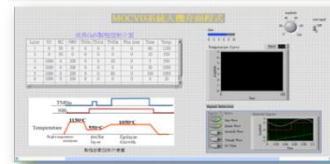
組別：電能組



整合WSN無線感測器於智慧型綠 能實驗室環境監測



MOCVD系統人機介面程式

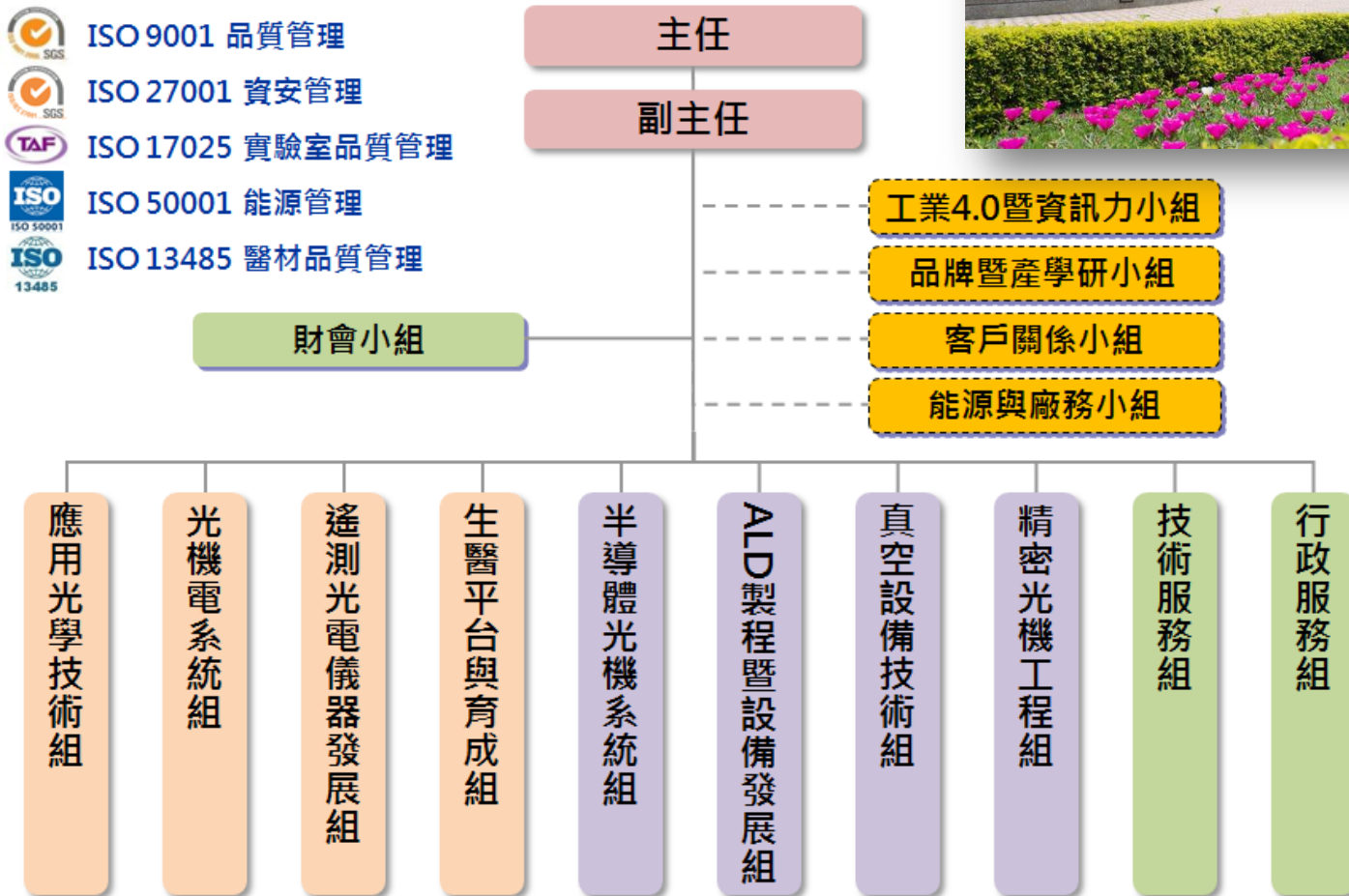


MOCVD電控系統裝置圖



陳永祥/國家實驗研究院儀器科技研究中心

組織架構

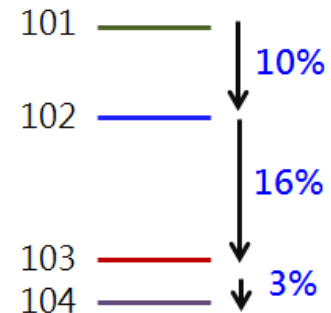
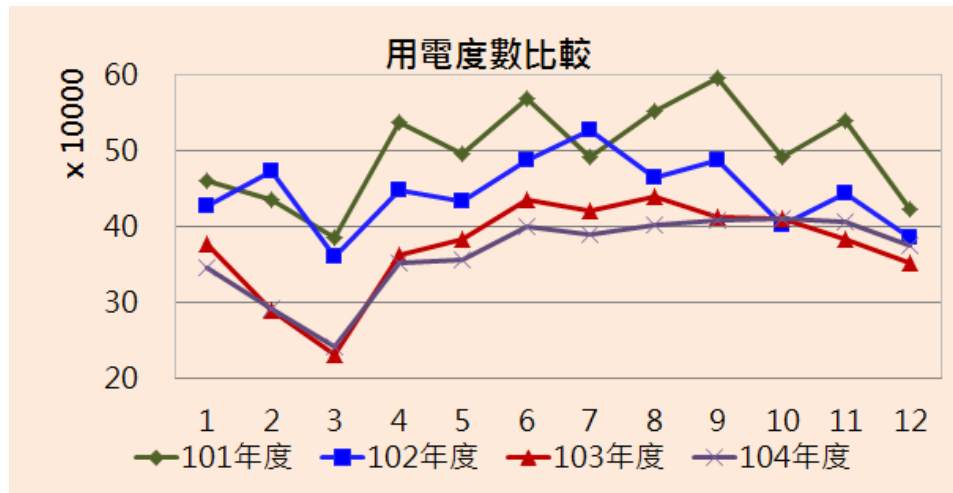


8

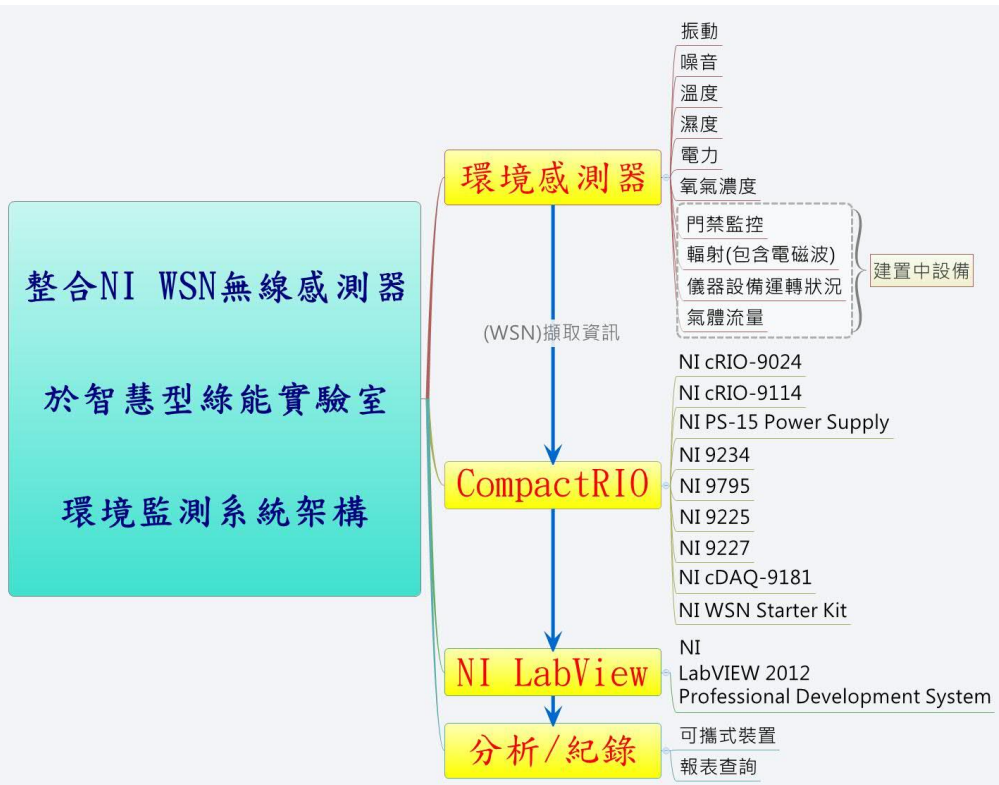
節能減碳-強化能源管理

推動能源管理系統且通過 ISO 50001 驗證

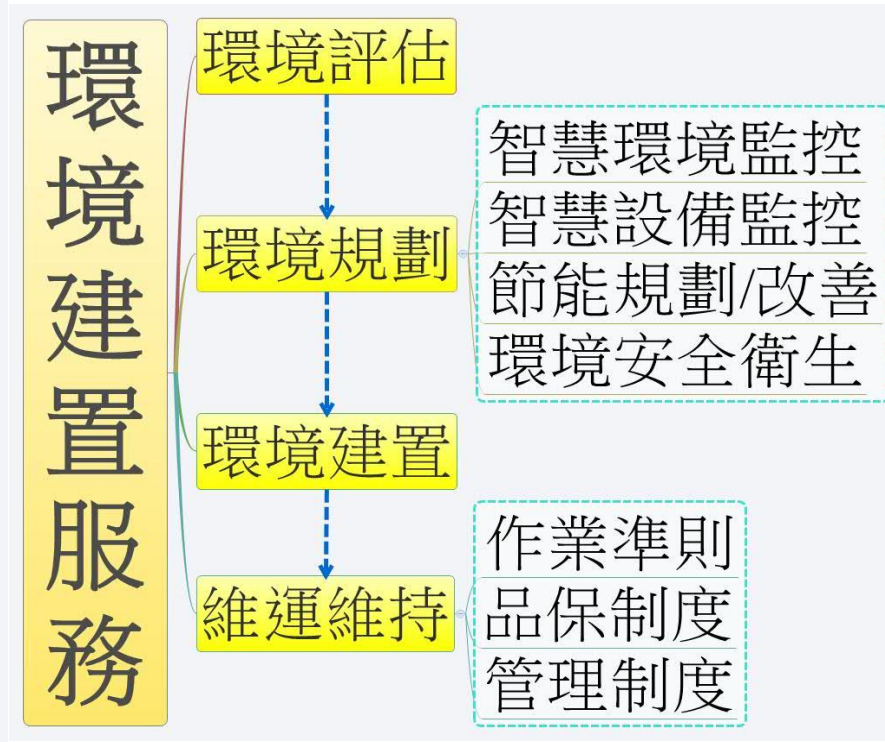
- 導入與建置能源管理系統，已順利於 103 年 12 月 11 日通過驗證稽核，符合 ISO 50001 標準規範，且於 103 年 12 月 31 日獲頒證書。
- 配合能源管理系統之導入，持續推動節能減碳措施，102 年度達成約 10% 之節能效益，103 年更達成較 102 年約 16% 之節能效益，節電費用約 242 萬元。
- 104 年 1 至 12 月較 103 年同期達成約 3% 節能效益。



智慧型綠能實驗室環境監測架構及儀科中心之環境建置服務

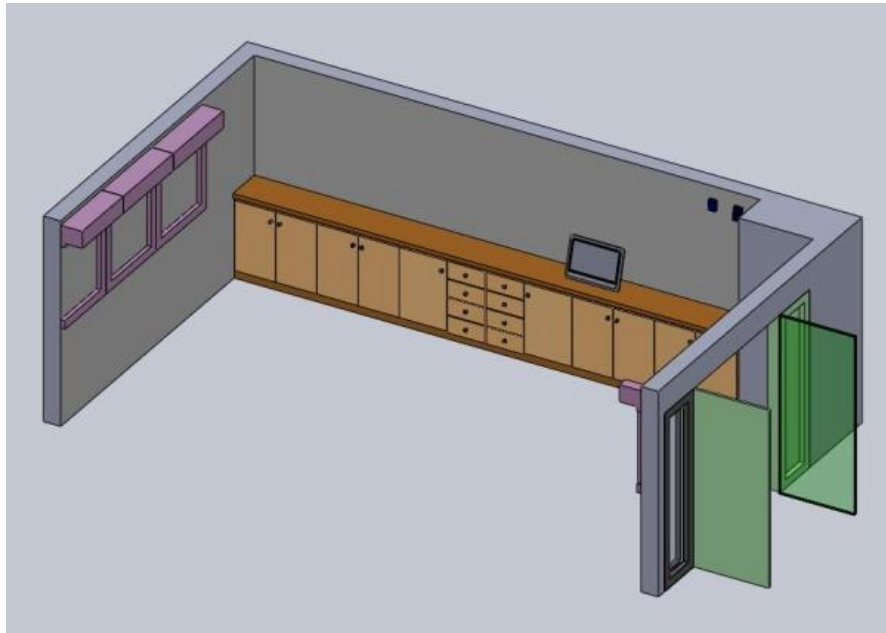


智慧型綠能實驗室環境監測架構



儀科中心之環境建置服務

儀科中心示範實驗室

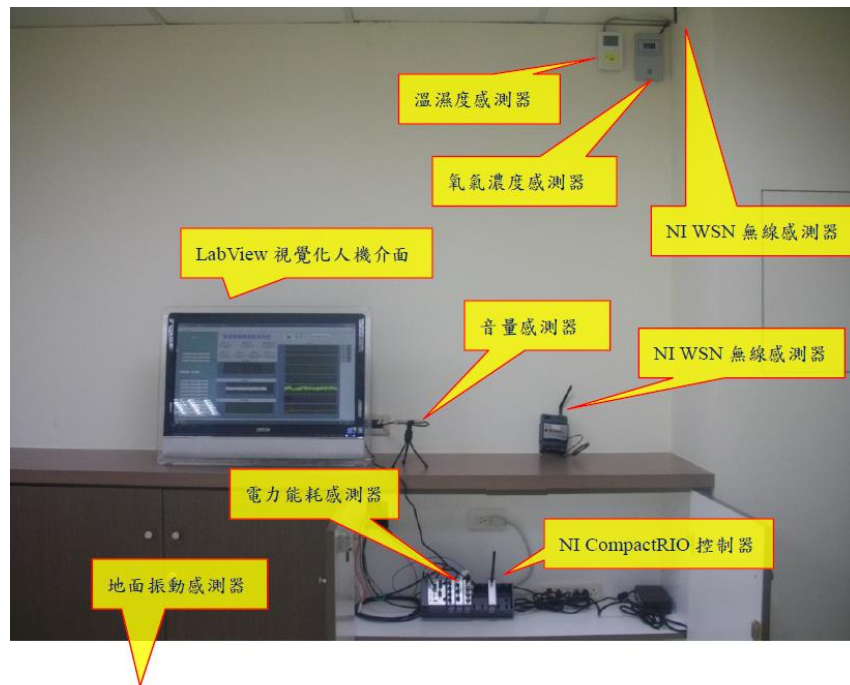


實驗室設計規劃

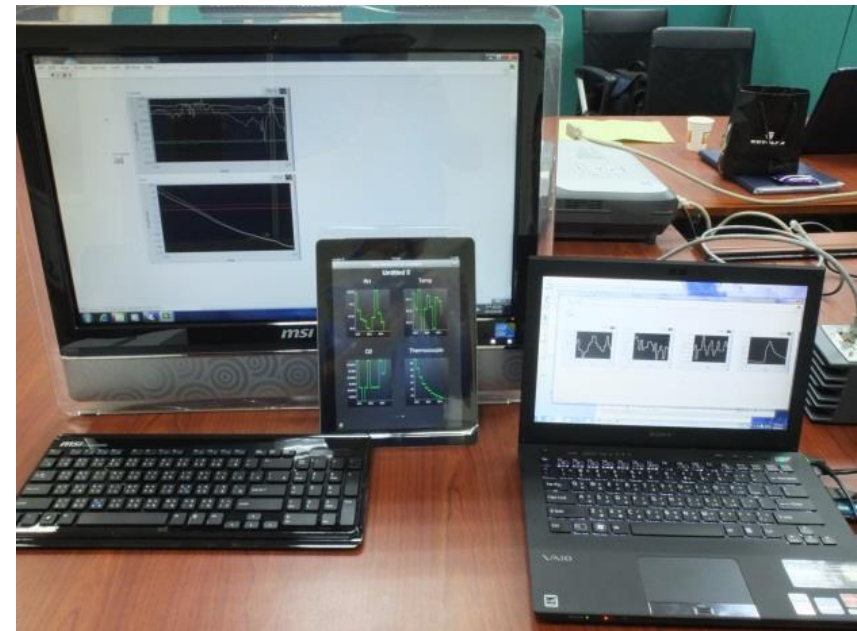


現場實景

智慧型綠能實驗室環境監測系統



智慧型綠能實驗室環境監測系統



可攜式設備(NB/Pad)遠端監視環境資訊參數

研究目的

由於早期之磊晶系統缺乏智慧型人機介面統合製程變數，因此造成良率下降與成本上升，為提高製程再現性與磊晶品質，本研究加載NI LabVIEW人機介面進行參數整合，以提高製程之再現性。

技術與挑戰

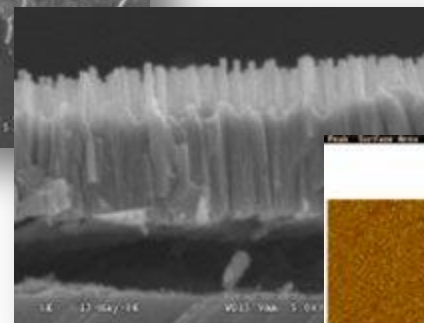
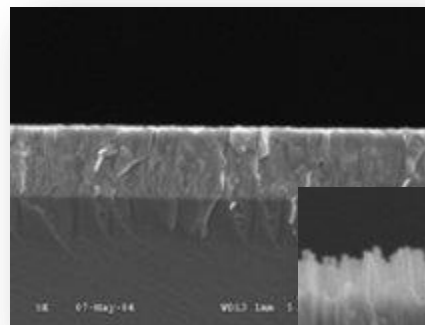
製程系統常因單元數太多，易造成成本增加、維修不易、複雜性薄膜結構沉積方式不易撰寫與再現性不佳等缺點。

解決方式

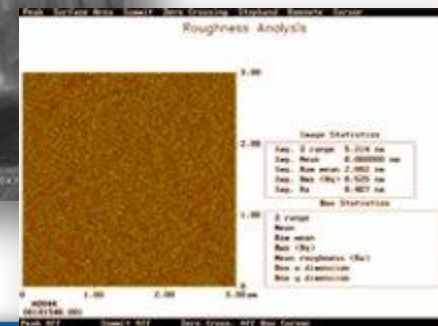
透過NI LabVIEW程控可完全解決上述缺點，達到自動化之目的。

系統簡介

- 因應能源政策，於1997年透過自行開發之超高真空系統(1×10^{-9} Torr)，進行 III-V 族氮化物薄膜磊晶薄膜成長。
- 早期為手動設計，其再現性、氣體流量、環境條件與製程溫度皆無法透過介面統一控制，因此不適合量產製程。(相同製程參數，其結果不同)



參數相似，形貌不同



NI LabVIEW設備

IEEE 1394 Camera Bruker Tensor 27 FTIR



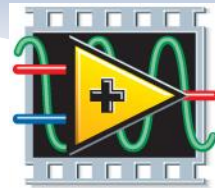
NI PXI-1033



NI PXI-7334



NI PCI-4472

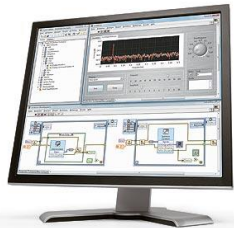


NATIONAL INSTRUMENTS

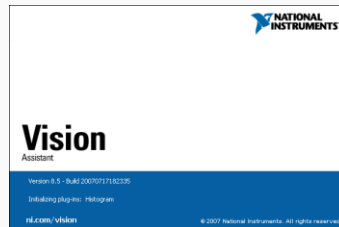
LabVIEW™

Graphical System Design Platform

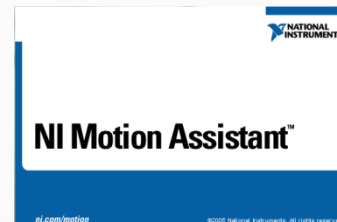
NI LabVIEW 2012



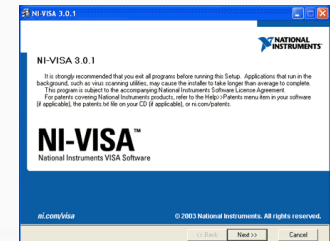
NI Vision Assistant 2012



NI Motion Assistant 2012



NI VISA-RS 232



化學束磊晶系統(Chemical Beam Epitaxy)

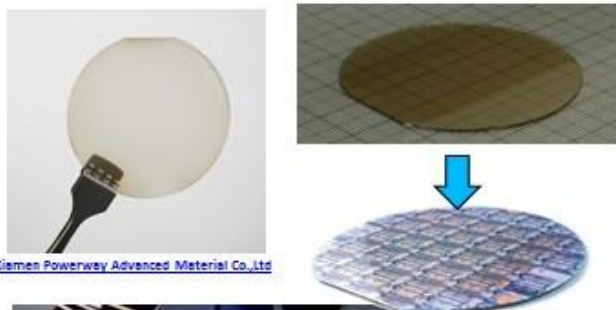


- 透過技術精進，以NI LabVIEW 為人機介面，控制參數包括溫度、流量、進氣方式與溫度等。並以FTIR in-situ同步量測前驅物於製程中裂解與反應過程。
- 透過新系統製程的設計，可成功鍍製氮化物磊晶薄膜，並發表其結果至高品質國際期刊。

III-V 族氮化物基本性質與應用

Gallium nitride, GaN

- Hexagonal
- $E_g \sim 3.4 \text{ eV}$
- a axis $\sim 3.189 \text{ \AA}$
- c axis $\sim 5.182 \text{ \AA}$



Xiemen Powerway Advanced Material Co., Ltd

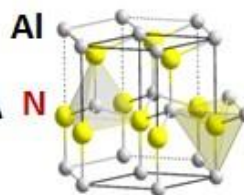


Ref. by Creative Commons Licence

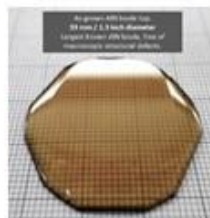
Applications : LEDs, Solar cell, power device

Aluminium Nitride, AlN

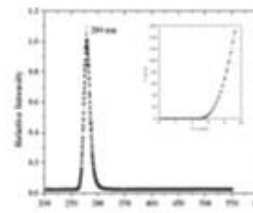
- Hexagonal
- $E_g \sim 6.2 \text{ eV}$
- a axis $\sim 3.111 \text{ \AA}$
- c axis $\sim 4.98 \text{ \AA}$



<http://www.crystal-co.com/applications/led.html>



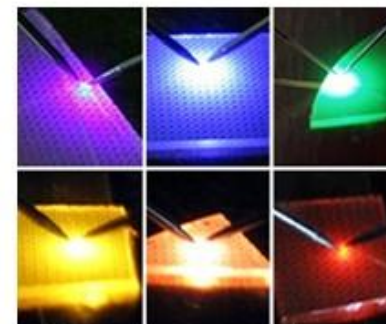
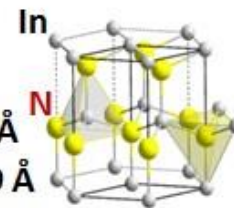
<http://www.hexatechinc.com/news-events.html>



Ref. Manhattan, Kansas

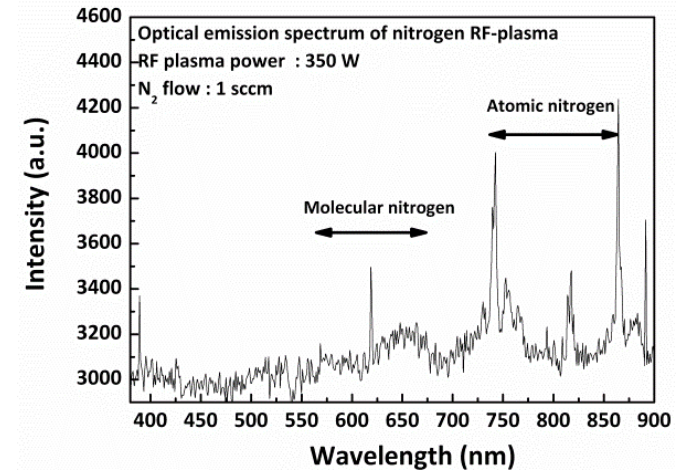
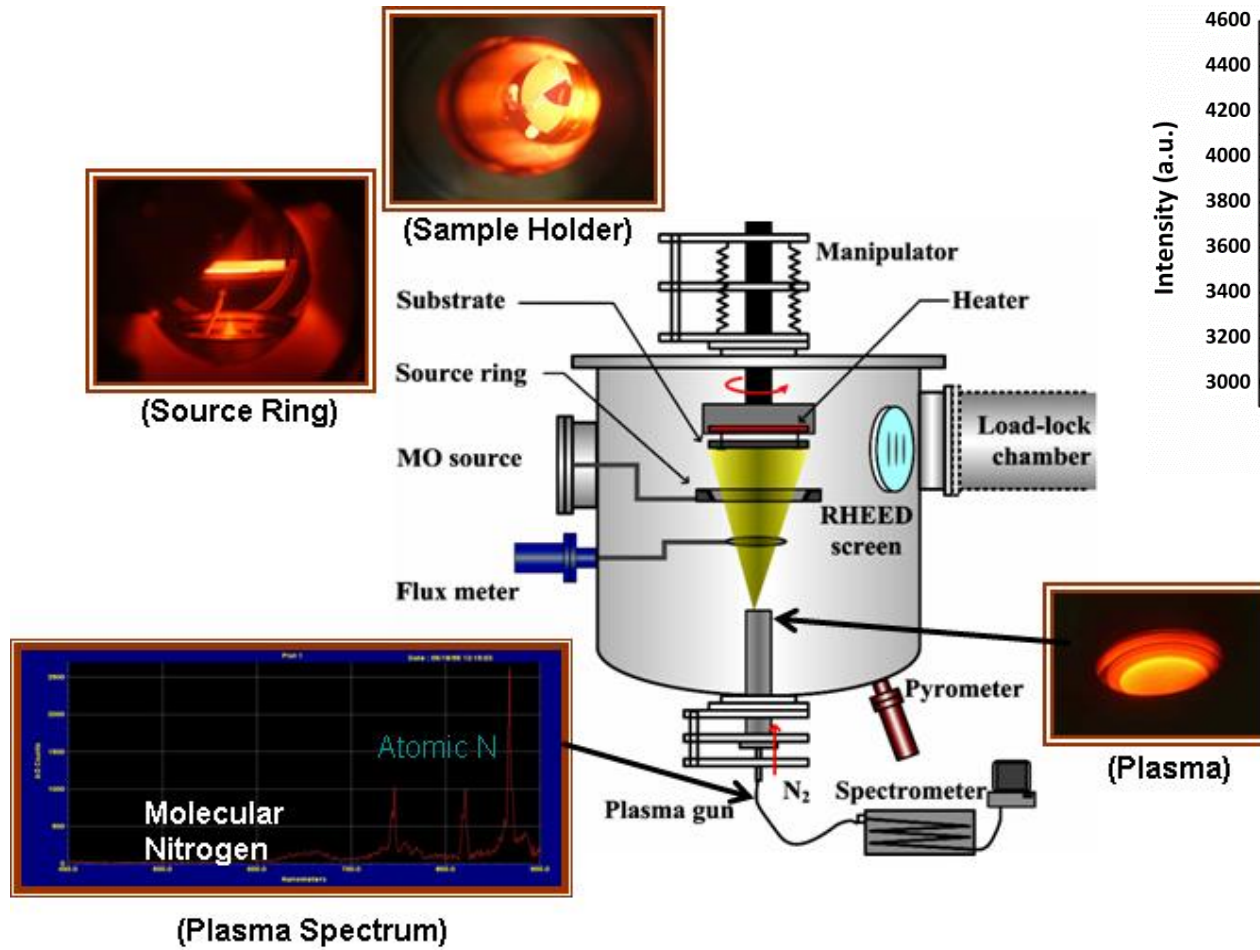
Indium Nitride, InN

- Hexagonal
- $E_g \sim 0.7 \text{ eV}$
- a axis $\sim 3.54 \text{ \AA}$
- c axis $\sim 5.709 \text{ \AA}$



<https://www.research.a-star.edu.sg/research/6252>

化學東磊晶系統系統架構



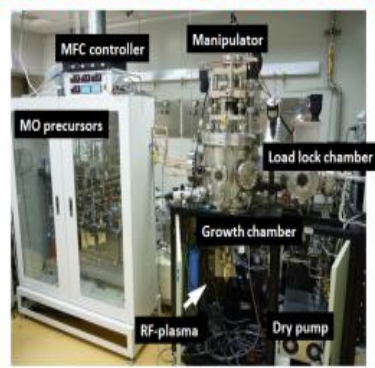
自動化人機介面

化學束磊晶系統開發與整合

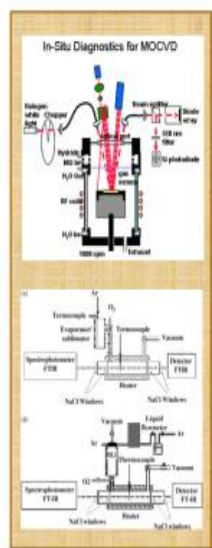


前驅物管路
設計製作

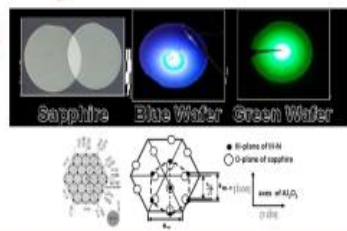
磊晶系統與儀控
電控系統整合



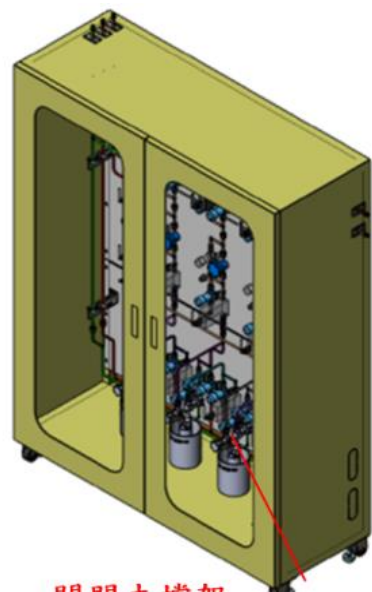
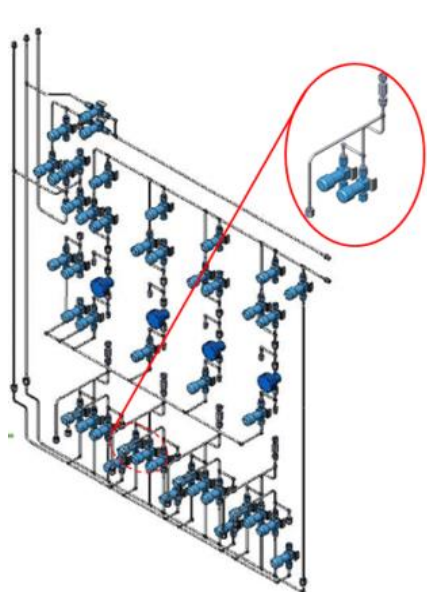
即時磊晶
監控架設



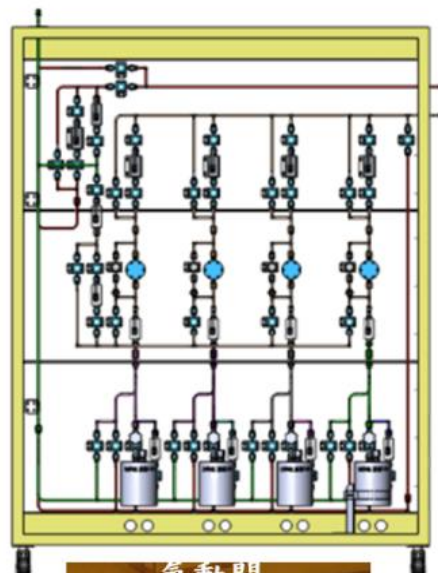
GaN 製程開發



化學東磊晶系統前驅物管路與流道設計



閥門支撐架



氣體混合箱

管路



氣動閥

單元元件轉接頭



逆止閥

化學東磊晶系統系統外觀

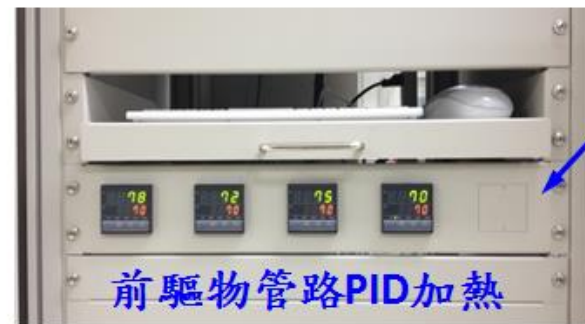
前驅物管路

警報器



完成閥門與電磁閥間連結與作動

電控系統



前驅物管路PID加熱

化學東磊晶系統控制系統

電磁閥



PLC



電控系統外觀

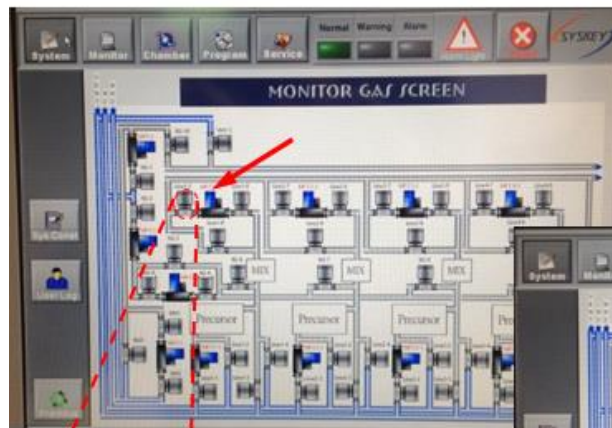


觸控螢幕



電腦與控制卡

化學東磊晶系統製程指令人機介面

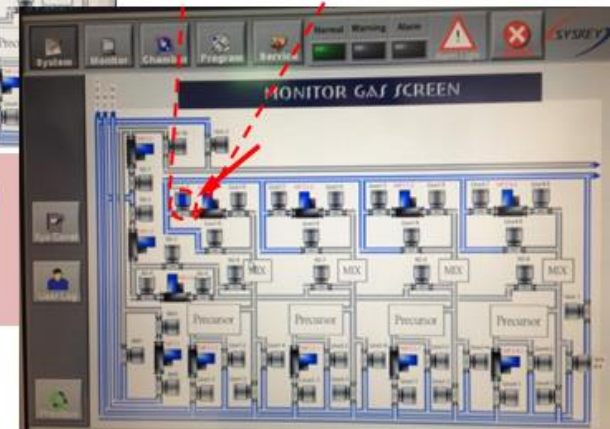


可於螢幕上直接點選圖示進行閥門開啟與關閉。例如，點選圈選處之閥門圖示。

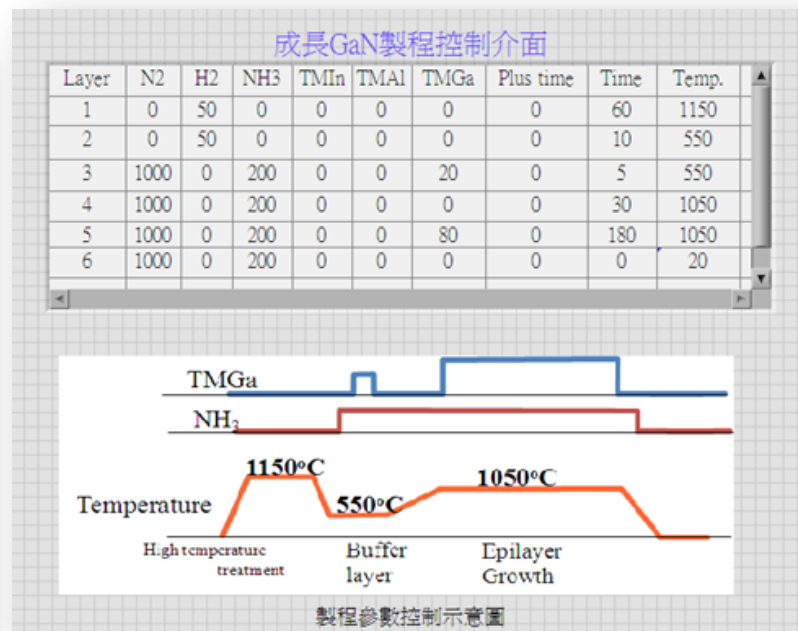
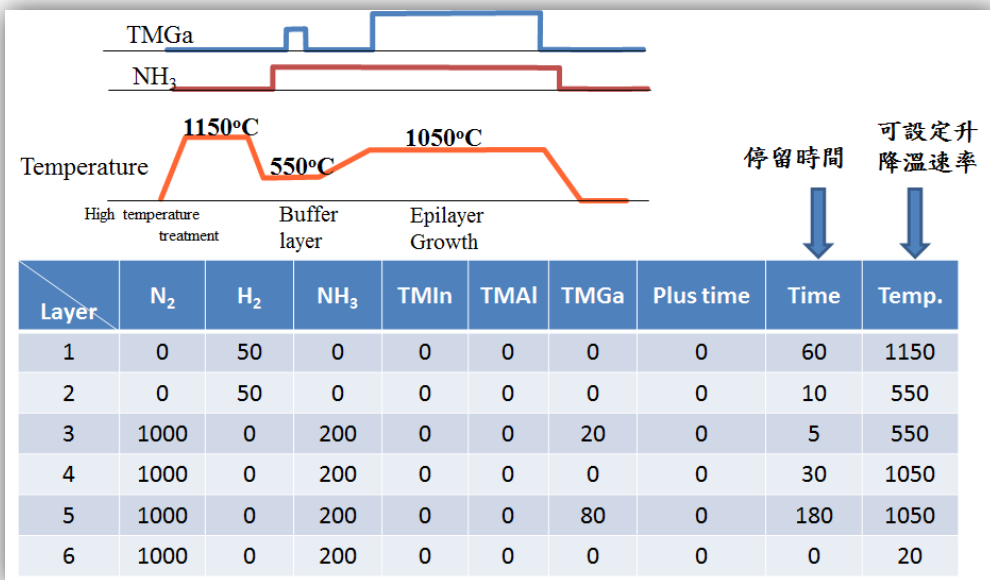


點選之後螢幕會出現詢問開啟或關閉的選單。當點擊“OPEN”後即可開啟閥門。

當開啟閥門後，可於圖示上看見閥門內部已呈現藍色，代表氣體以經由閥門開啟進入管路。經測試後，42個閥門均可正常作動



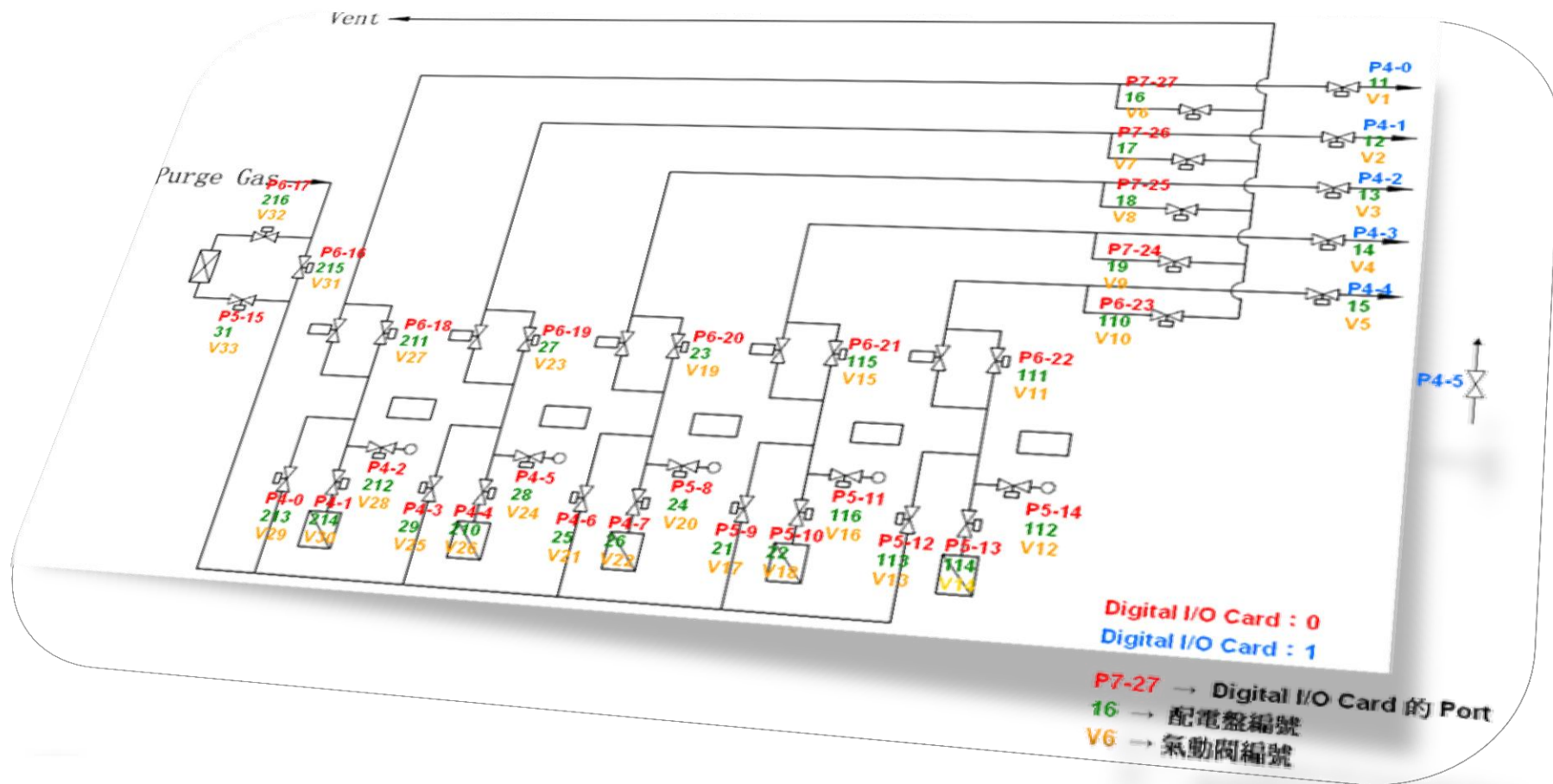
化學束磊晶系統成長GaN為例



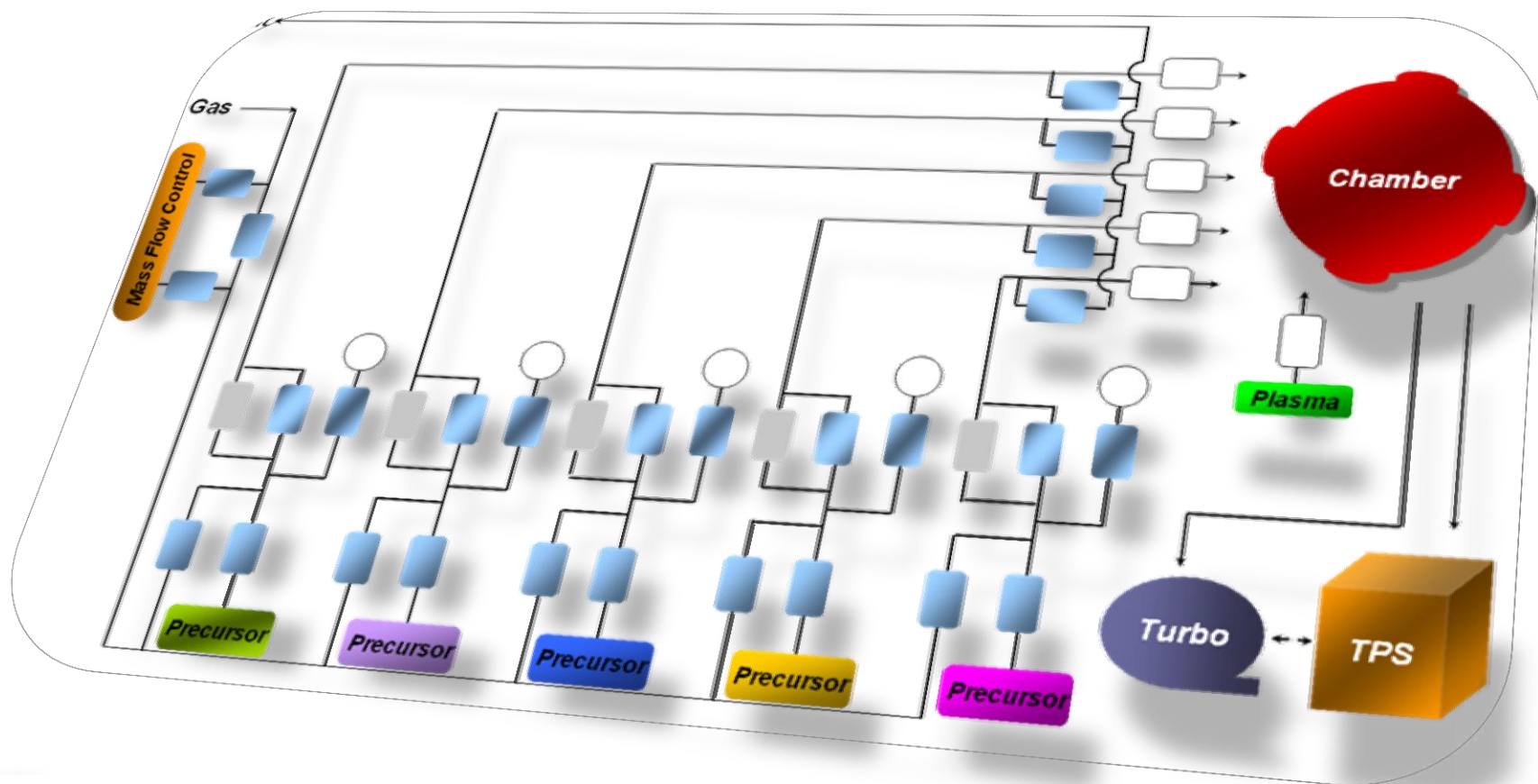
成長GaN為例之製程指令

LabVIEW製程指令控制參數

管路系統配置圖(1)



管路系統配置圖(2)



智慧無線環境監測系統

NI 9795: WSN Gateway
負責與 WSN Node 溝通



NI WSN-3202: AI 模組
(接氧氣濃度感測器)



NI WSN-3212: 溫度模組
(接熱電偶)

NI cRIO-9024 CompactRIO

NI 9225及NI 9227: 構成電力功率及品質量測

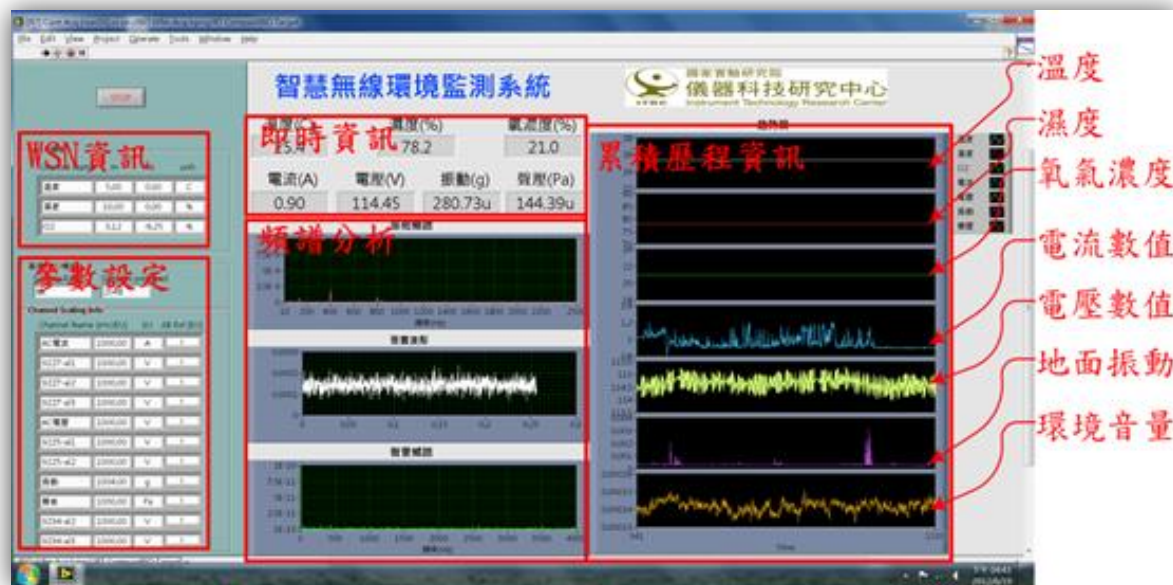
NI 9234: 量振動與噪音等動態訊號
(接加速規與麥克風)

接網路線即可與遠端或雲端溝通
(無網路狀態亦可獨立運作，如長期資料記錄)



iPad 3G + Data Dashboard (APP)
可直接連接雲端上的量測資料

智慧無線環境監測系統LabVIEW人機介面

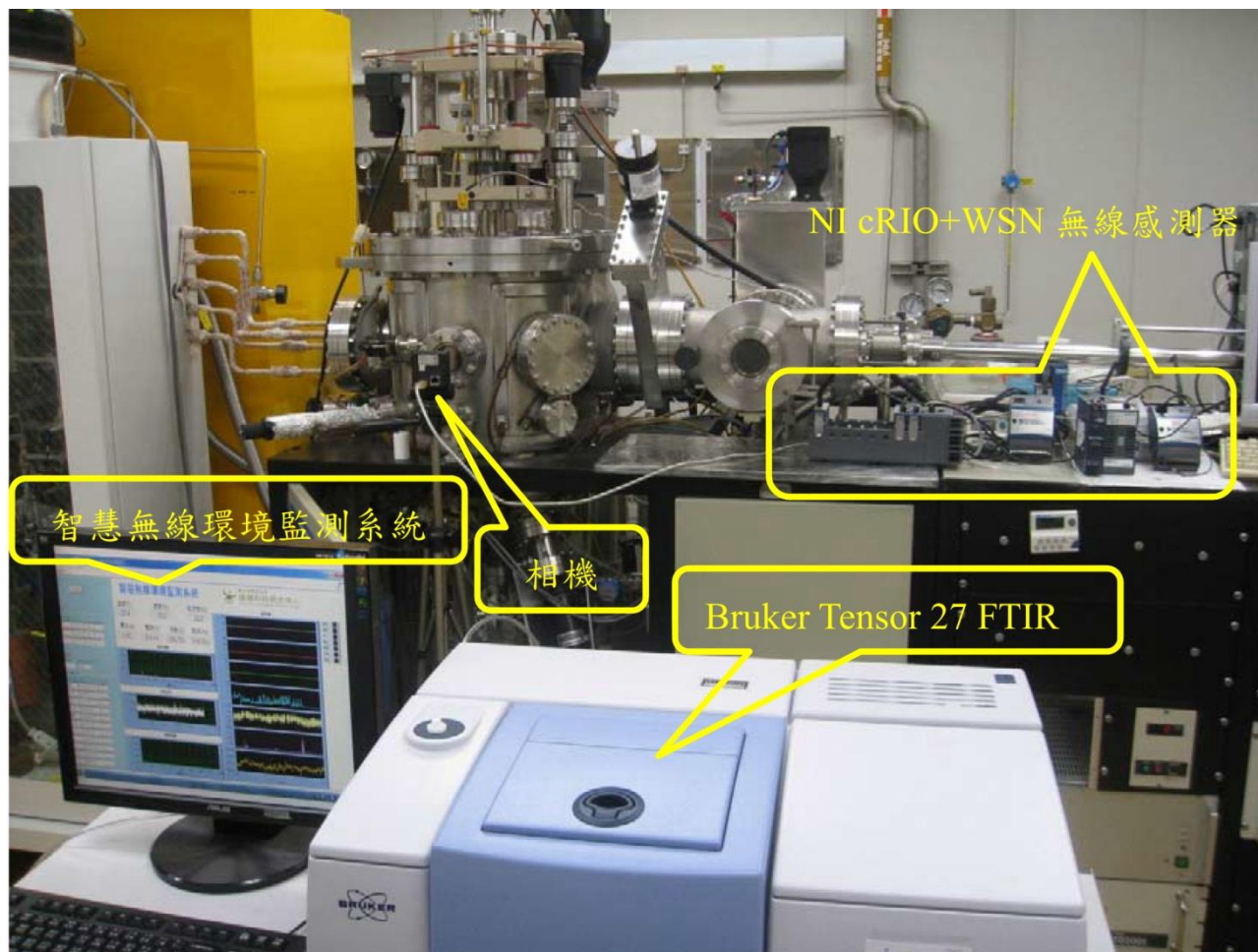


LabVIEW人機介面

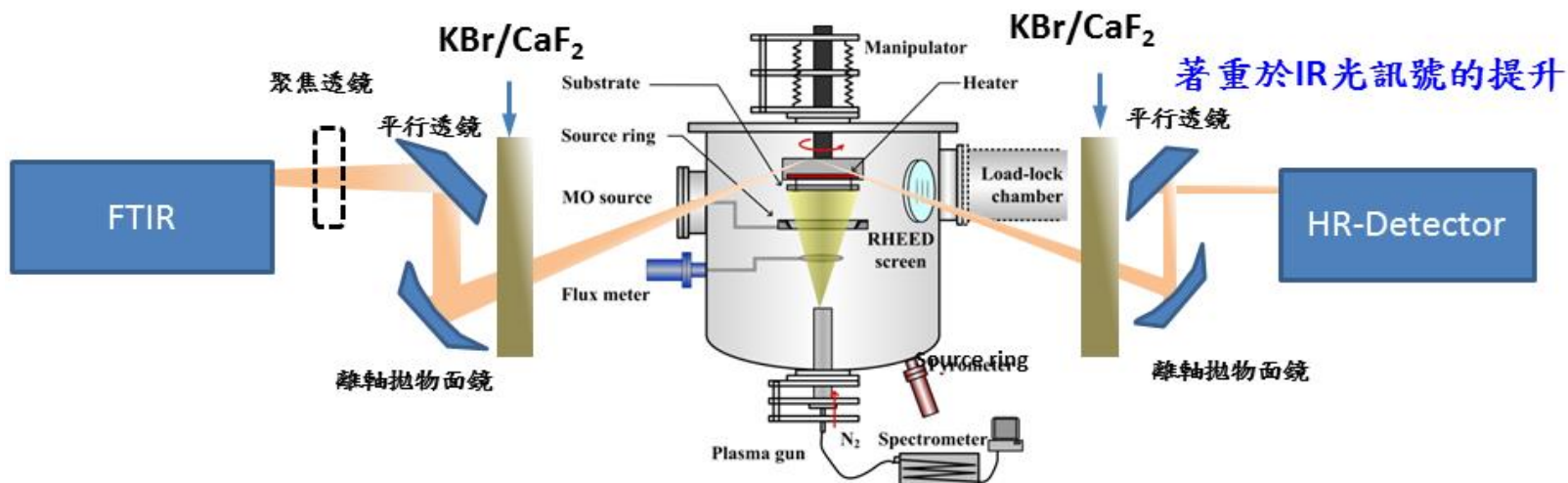


LabVIEW製程指令控制參數

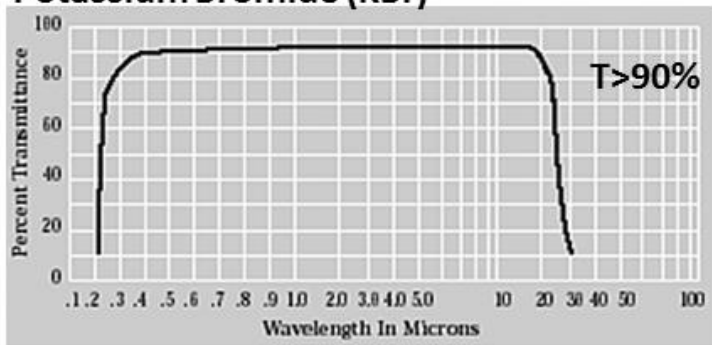
磊晶室量測參數實驗實際架設圖



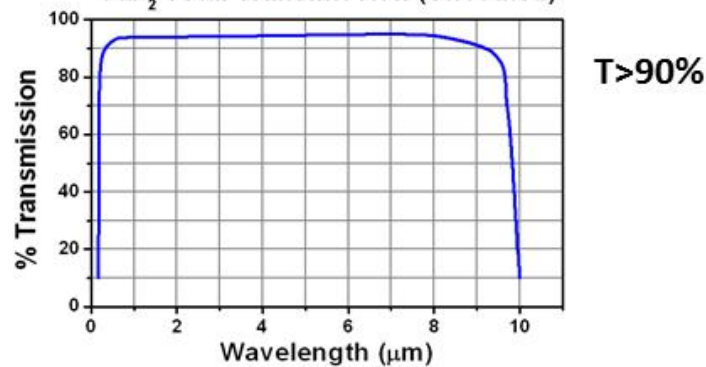
FTIR in-situ即時監控製程系統架構



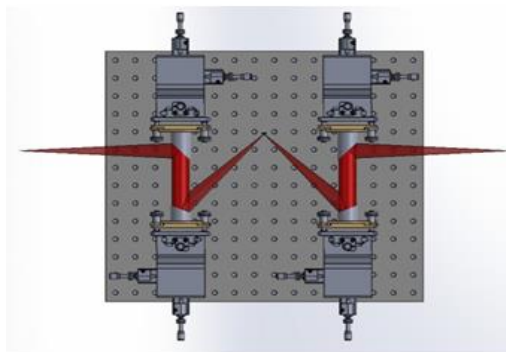
Potassium Bromide (KBr)



CaF₂ Total Transmission (Uncoated)



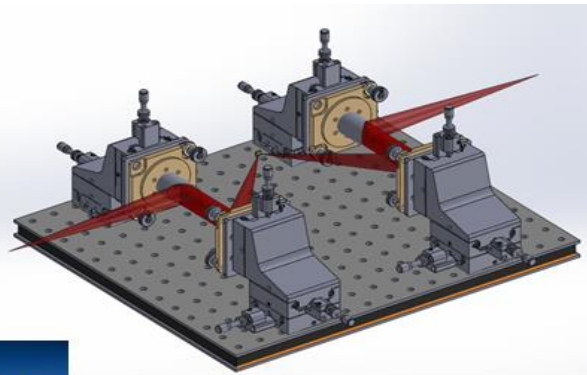
FTIR in-situ 光路設計與模擬及系統導入



45° Off-Axis Mirrors

直徑:25.4 mm

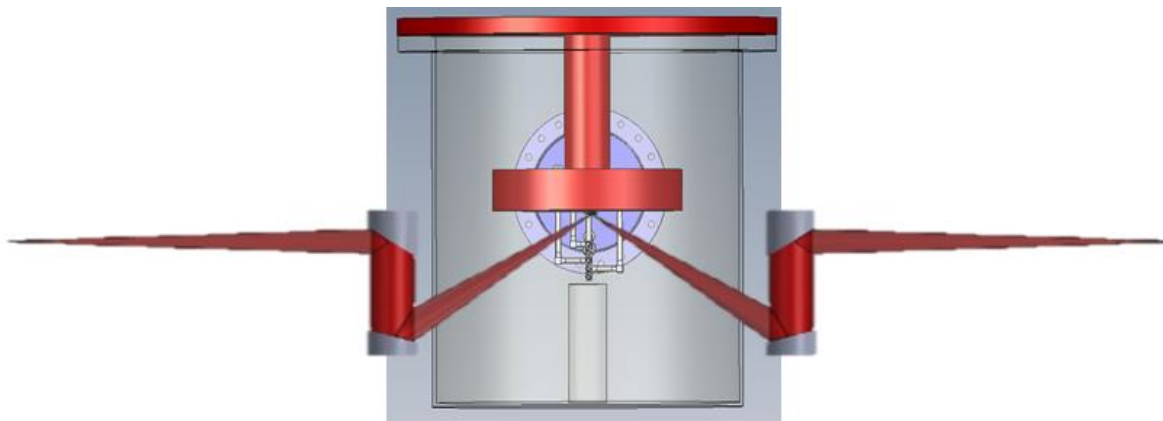
有效焦距 EFL (mm):148.79 mm



90° Off-Axis Mirrors

直徑:25.4 mm

有效焦距 EFL (mm):203.2 mm

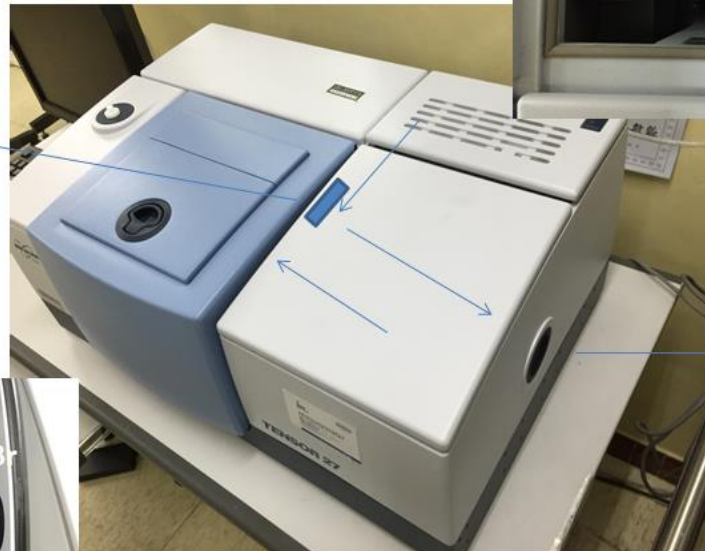


架設Bruker Tensor 27 FTIR

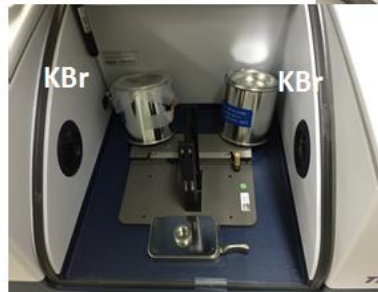
可外接HR detector



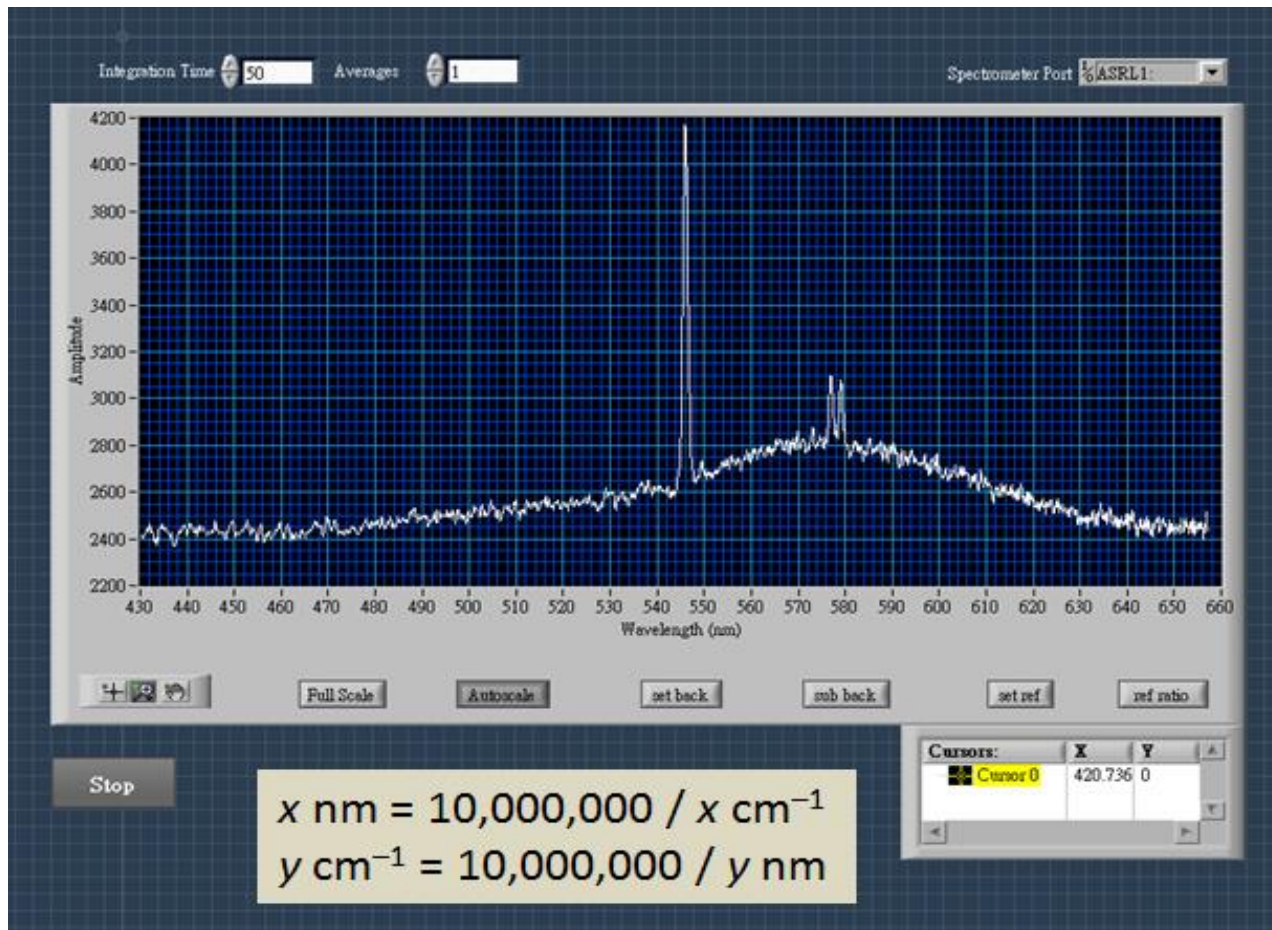
有反射鏡可控制光路從哪個出口出光



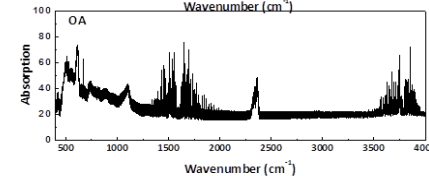
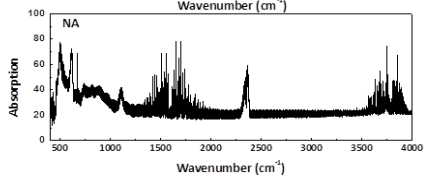
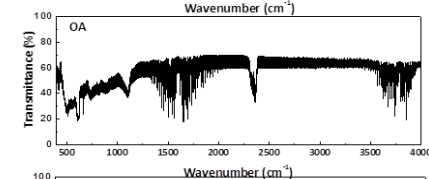
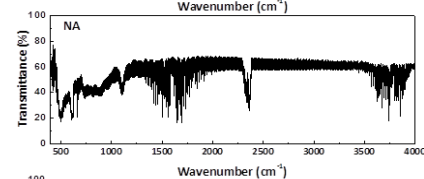
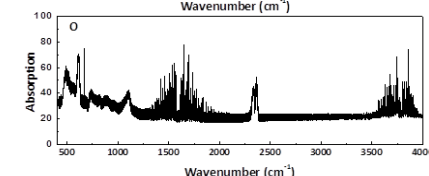
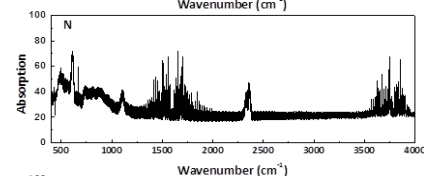
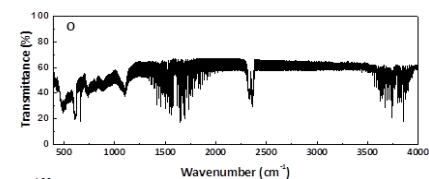
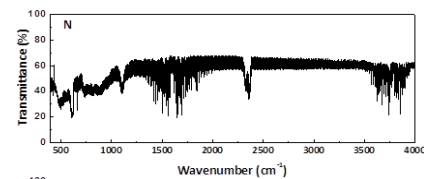
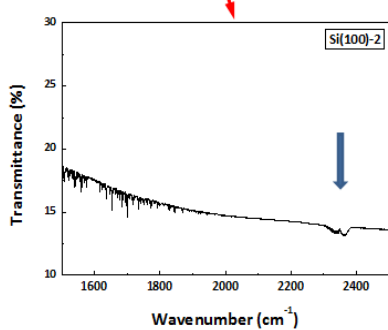
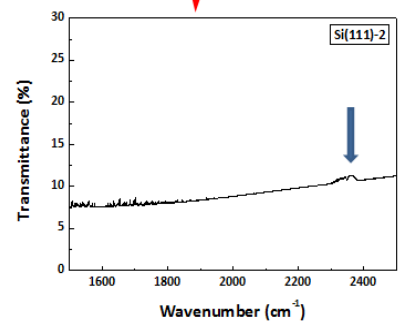
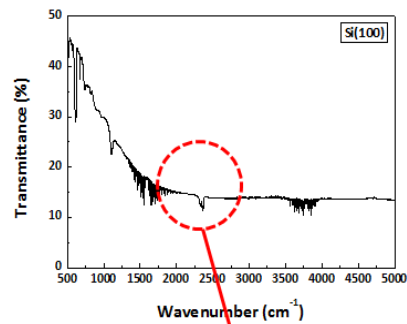
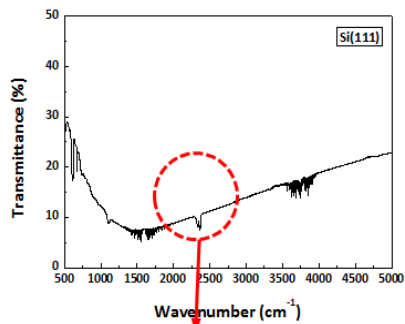
加裝一透鏡後即可由此出口出光



Labview材料光譜訊號特徵分析人機介面

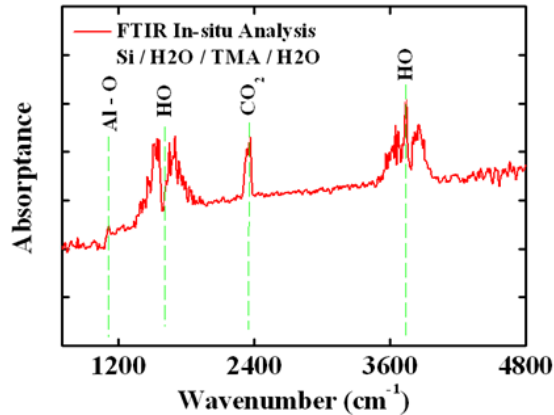


FTIR量測結果

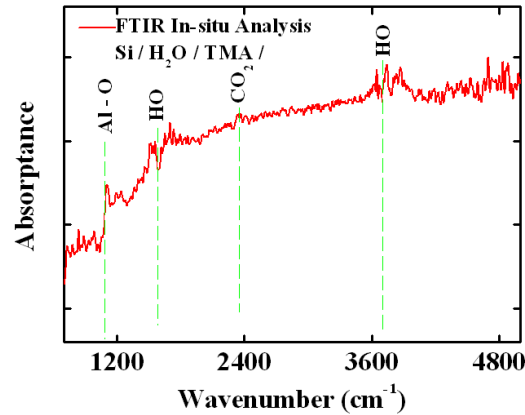


FTIR in-situ 製程即時監控量測

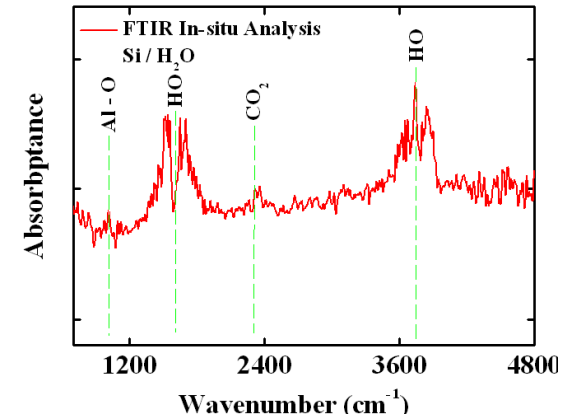
- (a) 水氣通入腔體，吸附於基板表面，形成OH鍵結之光譜。
- (b) 先驅物通入腔體，於基板表面形成Al-O之鍵結與副產物CO₂。
- (c) 水氣通入腔體，於基板表面測得知OH鍵結訊號。



(a)



(b)

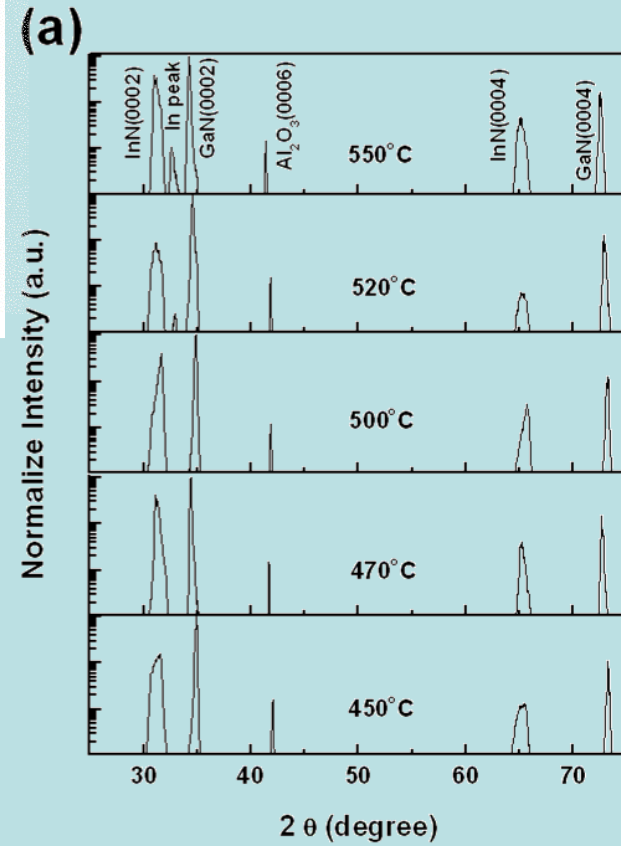
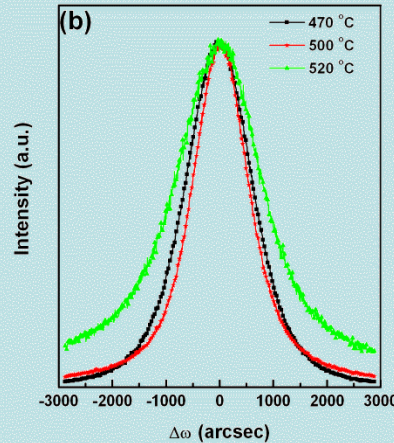
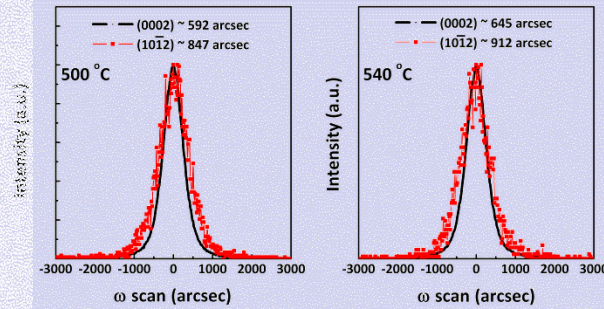
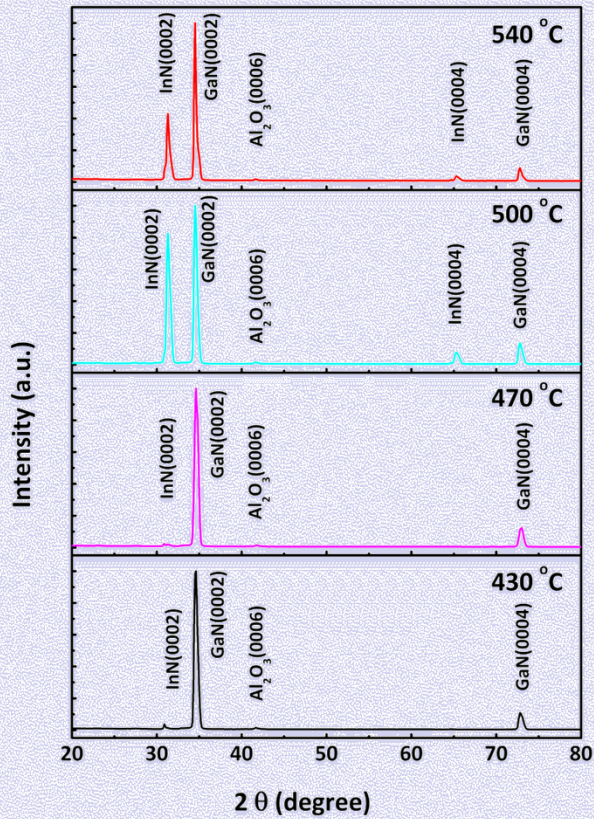


(c)

結果比較

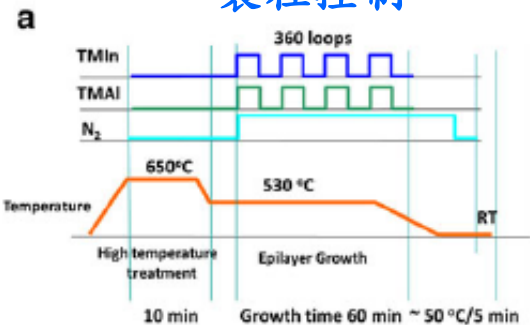
After

Before

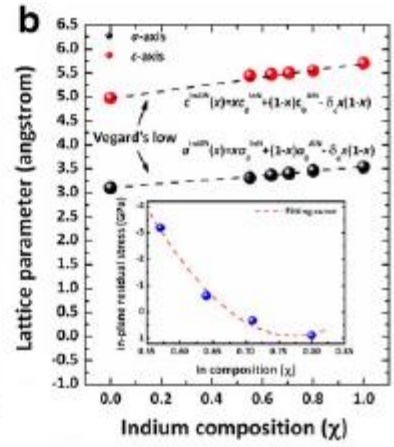
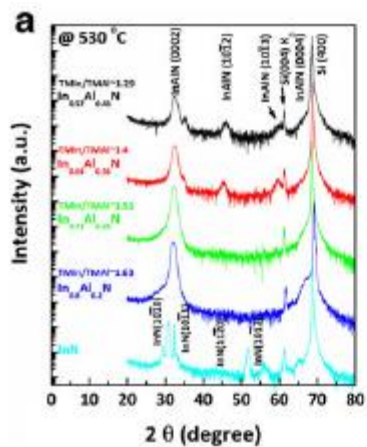
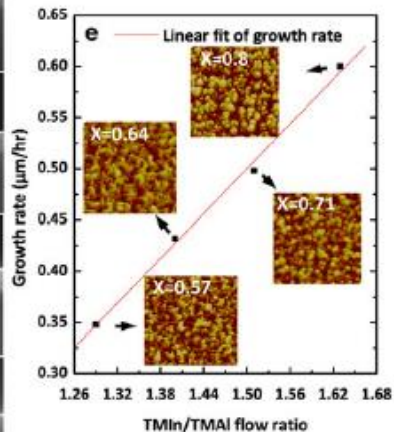
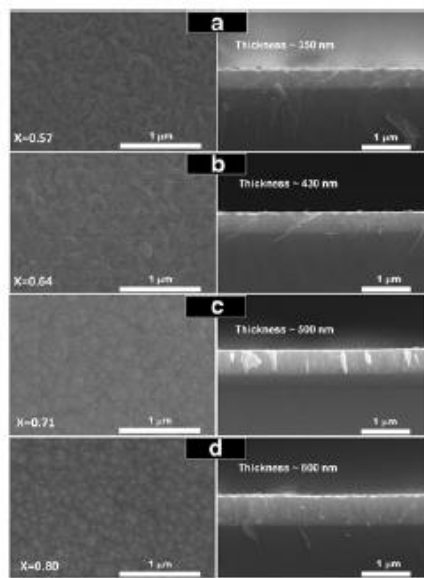
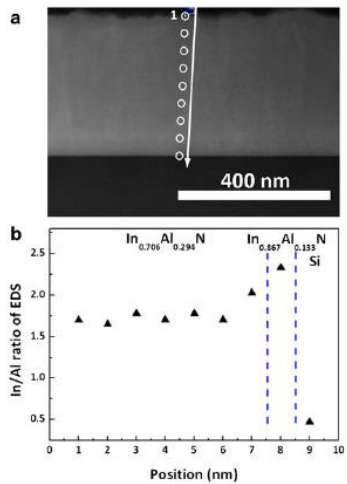
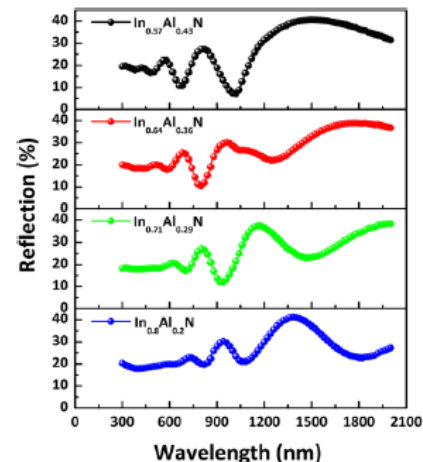
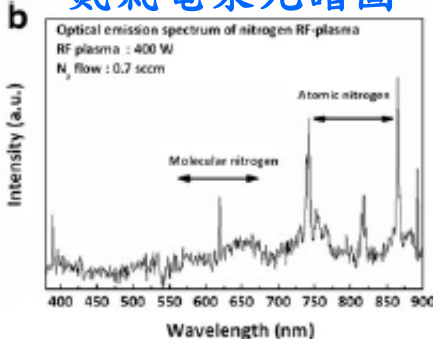


In_xAl_{1-x}N 多元合金薄膜沉積

製程控制

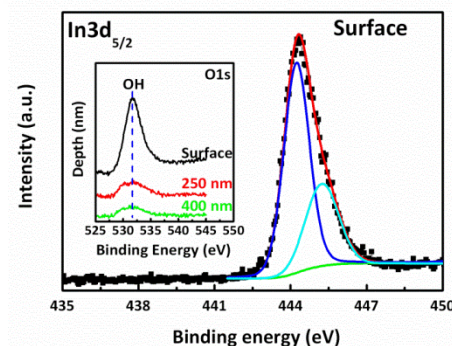
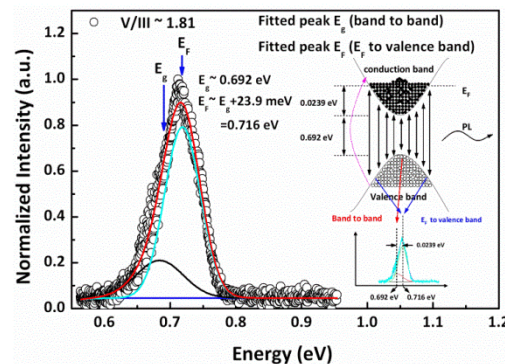
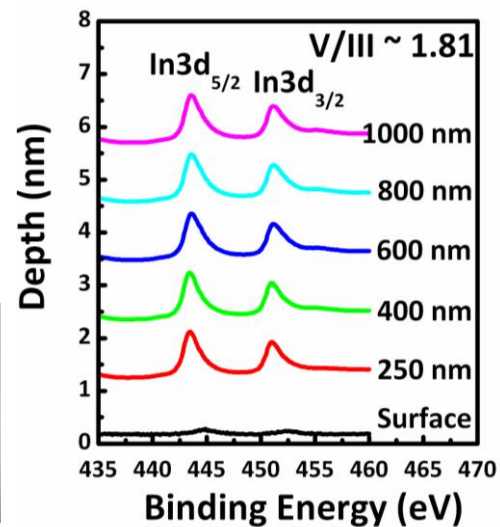
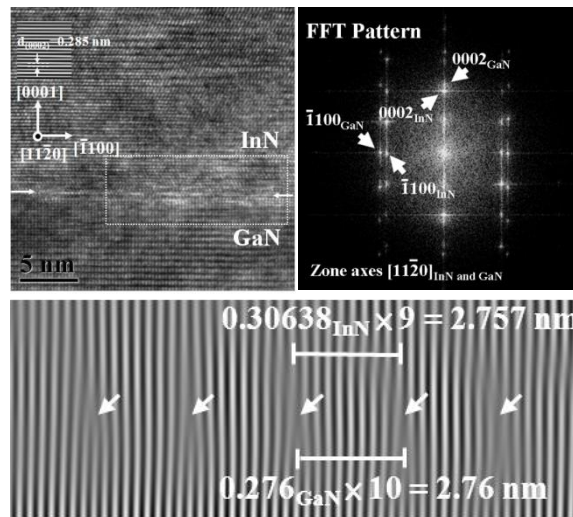
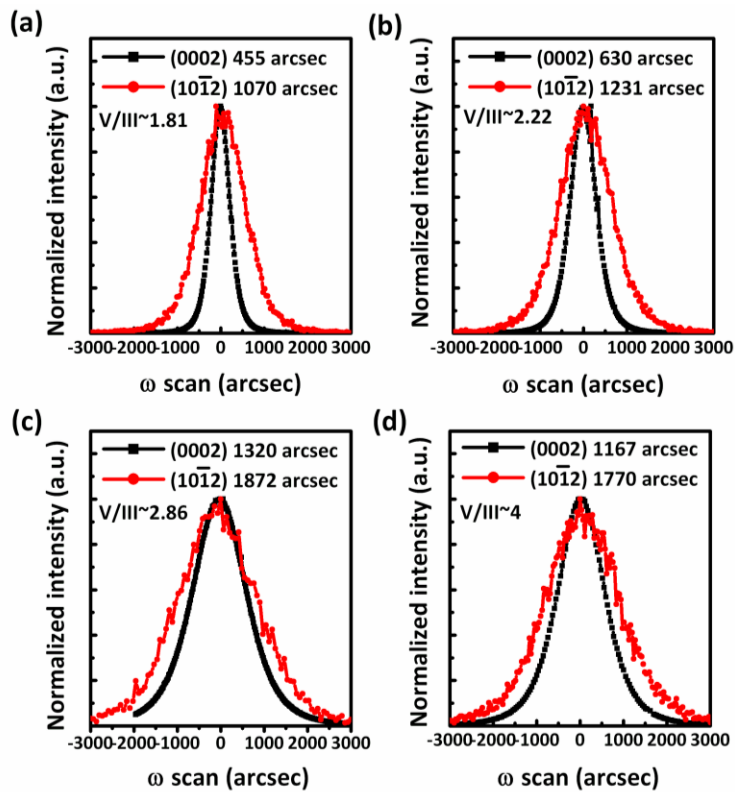


氮氣電漿光譜圖



W. C. Chen, Y. H. Wu, C. Y. Peng, C. N. Hsiao and L. Chang, *Nanoscale Research Letters*, 9 :204 (2014) (Impact Factor : 2.481)

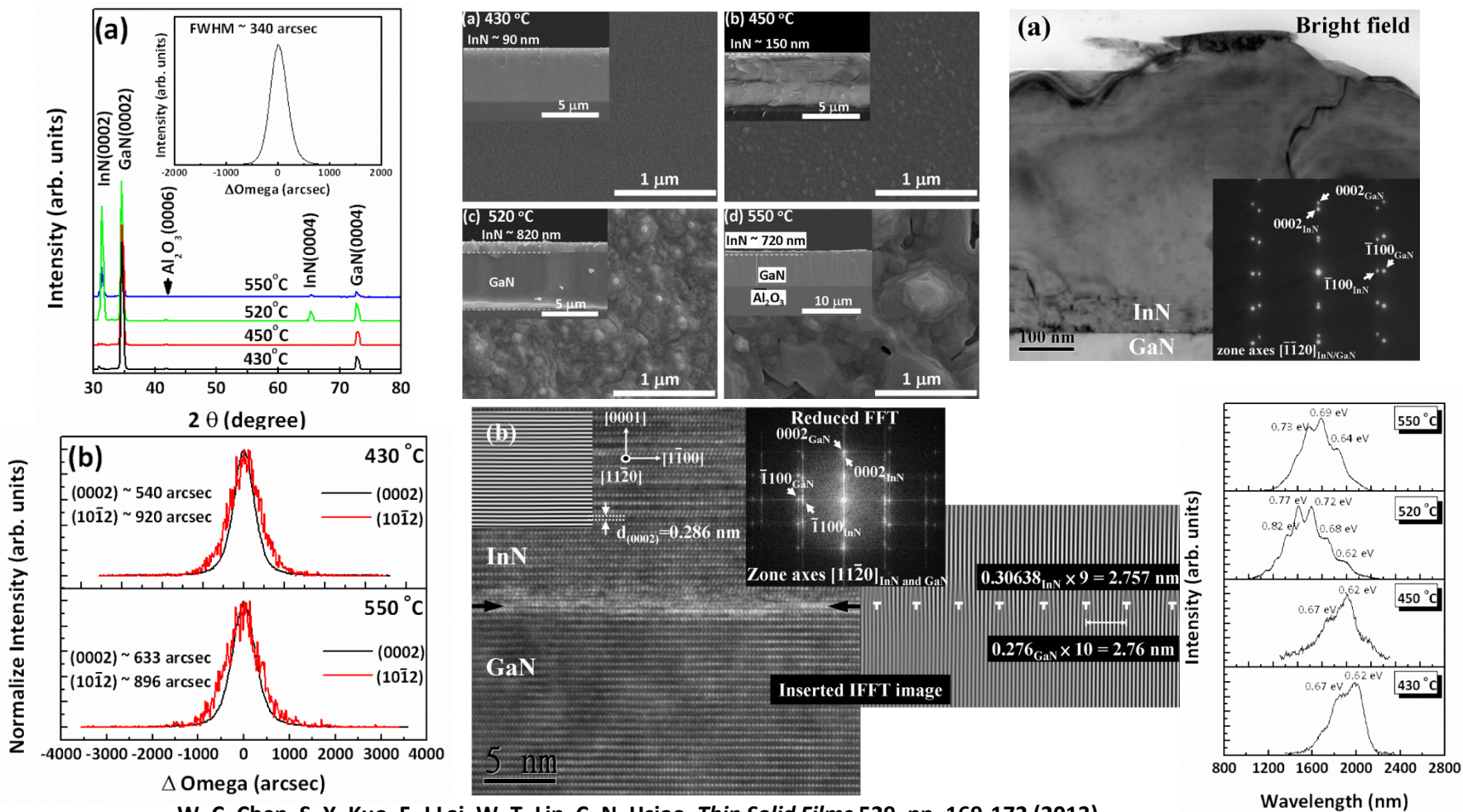
不同流量比成長InN薄膜之結果



結晶品質甚優，與國際上發表的高品質InN薄膜相似

W. C. Chen, J.-S. Tian, Y. H. Wu, S. Y. Kuo, W. L. Wang, F.-I. Lai, L. Chang, *ECS Journal of Solid State Science and Technology* 2(7), P305-P310 (2013)

不同溫度成長InN薄膜之結果



W. C. Chen, S. Y. Kuo, F.-I. Lai, W. T. Lin, C. N. Hsiao, *Thin Solid Films* 529, pp. 169-172 (2013).

研究成果

- **W. C. Chen, S. Y. Kuo, F.-I Lai, W. T. Lin, C. N. Hsiao, D. P. Tsai, “ Indium nitride epilayer prepared by UHV- plasma-assisted metalorganic molecule beam epitaxy”, *Journal of Vacuum Science and Technology B* 29(5), 051204 (2011).**
- **W. C. Chen, S. Y. Kuo, W. L. Wang, J.-S. Tian, W. T. Lin, F.-I Lai and L. Chang, “Study of InN epitaxial flims and nanorods grown on GaN template by RF-MOMBE”, *Nanoscale Research Letters* 7:468 (2012).**
- **W. C. Chen, J.-S. Tian, Y. H. Wu, S. Y. Kuo, W. L. Wang, F.-I Lai, L. Chang, “Influence of V/III flow ratio on properties of InN/GaN by plasma-assisted metal-organic molecular beam epitaxy”, *ECS Journal of Solid State Science and Technology* 2(7), P305-P310 (2013).**
- **W. C. Chen, S. Y. Kuo, F.-I Lai, W. T. Lin, C. N. Hsiao, “Effect of substrate temperature on structural and optical properties of InN epilayer grown on GaN template”, *Thin Solid Films* 529, pp. 169-172 (2013).**
- **W. C. Chen, Y. H. Wu, C .Y. Peng, C. N. Hsiao and L. Chang, “Effect of In/Al ratios on structural and optical properties of InAlN films grown on Si(100) by RF-MOMBE”, *Nanoscale Research Letters*, 9 :204 (2014).**
- **W. C. Chen, Y .H.n Wu, J.-S. Tian, T .C. Yen, P .Y. Lin, J. Y. Chen, C. N. Hsiao and L. Chang, “Effect of growth temperature on structural quality of In-rich InxAl1-xN alloys on Si (111) substrate by RF-MOMBE”, *ISRN Nanomaterials* 2014, Article ID 980206, 6 pages (2014).**

結論

- 本中心自行設計開發之化學束磊晶系統搭載NI LabVIEW人機介面可成功地成長出高品質之氮化物磊晶薄膜。
- 導入FTIR in-situ 即時監控製程開發，藉由此即時量測得知氣相中反應物與其相關元素等資訊。
- 透過搭載人機介面所成長之氮化物磊晶薄膜之結果得知，可有效降低該誤差量，因此具有較佳之結晶品質。
- 藉由NI產品的可靠性更可確保化學束磊晶系統實驗室環境監控系統的穩定性。

2016
科學工業園區廠務技術研討會

主辦單位： 台灣科學工業園區科學工業同業公會 科技部新竹科學工業園區管理局
 協辦單位： 財團法人中興工程顧問社

NAR Labs 國家實驗研究院
 儀器科技研究中心

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