出國報告(出國類別：其他(參加國際會議))

赴法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會出國報告

服務機關：國防部軍備局中山科學研究院
姓名職稱：林家慶 聘用技士
派赴國家：法國
報告日期：99.7.12
出國時間：99.6.6~99.6.13

國防部軍備局中山科學研究院出國報告建議事項處理表			
報告名稱	赴法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會出國報告		
出國單位	第五研究所	出國人員級職/姓名	聘用技士/林家慶
公差地點	法國	出/返國日期	99. 6. 6 / 99. 6.13
建議事項	一、紅外光波段感測一直是本院光電元件的發展重點之一，除了砷化物與銻化物以外，含氮砷化物與高銦含量氮化物在紅外光波段的應用也逐漸引起廣大的注意，本院在砷化物與氮化物半導體材料與其光電元件亦有超過十年的研發經驗，可從現有技術擴展出新的應用與技術能量，例如利用現有的有機金屬氣相磊晶設備與分子束磊晶設備研發含氮砷化物與高銦含量氮化物材料，或者搭配矽圖案化基板發展矽基磊晶技術，均有機會改善現有元件效能，而相關的技術研發未來亦可應用於夜視感測等紅外熱像系統。 二、近代科技的發展迅速，同一材料、元件或技術在不同的想法下可產生不同的應用，參加本次研討會對此深有所感，本院爲國內重要研究機構，新技術與應用的研發亦是本院的發展方向之一，多方的吸收相關知識與情報才有助於研發計畫執行與研發方向調整，建議本院同仁應時時加強自己對科技的敏感度與知識的獵取，才能讓研發計畫與工作走在時代的尖端。		
處理意見	一、本院現有的砷化物或氮化物材料磊晶使用的基板分別爲砷化鎵與三氧化二鋁，可利用矽圖案化基板搭配現有的磊晶技術能量，發展矽基 III-V 族紅外光波段元件。 二、鼓勵同仁積極參加國內外相關技術研討會，以增進學識能力，提升研發能量，亦利於計畫執行與未來研發方向規劃。		

國外公差人員出國報告主官（管）審查意見表

本次林員前往法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會，爲歐洲半導體材料與光電科技之年度重要會議，所討論之內容涵蓋半導體材料，光電元件與奈米結構技術等，均爲世界各國研發機構之最新研究成果，極具參考價值。

有關半導體奈米結構技術與紅外光元件技術的研發，除了可提升本院科技水準外，亦極具產業價值與國防應用潛力，可與計畫並行積極研發相關技術，待技術成熟後即可應用於元件開發，發展紅外熱像感測相關技術，提供效能更佳的夜視系統與目標辨識定位能力。

參加國際重要會議，能擴展同仁的視野及學習不同之研究方法，有助於計畫執行與研發方向規劃；本所計畫的研究方向與世界發展趨勢同步，對國內產業界亦有很大的幫助，因此建議可繼續投資計畫發展，共同爲提升國內技術研發能力盡一份心力。

出國報告審核表

<table>
<tr><td colspan="4">出國報告名稱：赴法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會出國報告</td></tr>
<tr><td colspan="2">出國人姓名（2 人以上，以 1 人爲代表）</td><td>職稱</td><td>服務單位</td></tr>
<tr><td colspan="2">林家慶</td><td>聘用技士</td><td>國防部軍備局中山科學研究院</td></tr>
<tr><td>出國類別</td><td colspan="3">☐考察 ☐進修 ☐研究 ☐實習
■其他 參加國際會議 （例如國際會議、國際比賽、業務接洽等）</td></tr>
<tr><td colspan="2">出國期間：99 年 6 月 6 日至 99 年 6 月 13 日</td><td colspan="2">報告繳交日期：99 年 7 月 12 日</td></tr>
<tr><td>計畫主辦機關審核意見</td><td colspan="3">☐1.依限繳交出國報告
☐2.格式完整
■3.無抄襲相關出國報告
☐4.內容充實完備
☐5.建議具參考價值
☐6.送本機關參考或研辦
☐7.送上級機關參考
☐8.退回補正，原因：☐不符原核定出國計畫 ☐以外文撰寫或僅以所蒐集外文資料爲內容 ☐內容空洞簡略或未涵蓋規定要項 ☐抄襲相關出國報告之全部或部分內容 ☐電子檔案未依格式辦理 ☐未於資訊網登錄提要資料及傳送出國報告電子檔
☐9.本報告除上傳至出國報告資訊網外，將採行之公開發表：
☐辦理本機關出國報告座談會（說明會），與同仁進行知識分享。
☐於本機關業務會報提出報告
☐其他_____
敬會：保防官
☐10.其他處理意見及方式：
保防官核章</td></tr>
<tr><td>審核人</td><td>出國人員</td><td>初審（業管主管）</td><td>機關首長或其授權人員</td></tr>
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說明：

一、各機關可依需要自行增列審核項目內容，出國報告審核完畢本表請自行保存。

二、審核作業應儘速完成，以不影響出國人員上傳出國報告至「政府出版資料回應網公務出國報告專區」爲原則。

報　　告　　資　　料　　頁			
1.報告編號： CSIPW-99Z-H0001	2.出國類別： 其他(參加國際會議)	3.完成日期： 99 年 7 月 12 日	4.總頁數： 43
5.報告名稱：赴法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會出國報告			
6.核准文號	人令文號	99.05.26 國人管理字第 0990007833 號令	
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7.經　　費		新台幣：92,389 元	
8.出(返)國日期		99 年 6 月 6 日 至 99 年 6 月 13 日	
9.公 差 地 點		法國	
10.公 差 機 構		歐洲材料學會	
11.附　　記			

系統識別號

行政院及所屬各機關出國報告提要

出國報告名稱：赴法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會出國報告

頁數 43　含附件：■是□否

出國計畫主辦機關/聯絡人/電話
國防部軍備局中山科學研究院/張國仁/357082
出國人員姓名/服務機關/單位/職稱/電話
林家慶/國防部軍備局中山科學研究院/第五研究所/聘用技士/357082
出國類別：□1 考察□2 進修□3 研究□4 實習■5 其他(參加國際會議)

出國期間：99 年 6 月 6 日 至 99 年 6 月 13 日　　出國地區：法國

報告日期：99 年 7 月 12 日

分類號/目

關鍵詞：砷化物、氮化物、奈米結構、紅外線。

內容摘要：

爲執行 99 年度經濟部科技專案光電感測辨識模組與應用技術計畫，派員赴法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會，瞭解國際間三五族化合物材料與元件在紅外線之應用技術、半導體量子井(點)磊晶製程技術、感測材料與元件技術、微奈米製程技術與應用等之最新發展與趨勢，內容包含各類三五族半導體材料在紅外光波段的材料特性探討與元件應用，尤其是砷化物與氮化物材料的奈米結構特性更是重點主題之一，相關研發成果亦有助於現有紅外感測技術的突破，促進新技術的發展；此外，相關磊晶製程與元件製作技術可搭配本院已深耕多年的三五族半導體元件技術研究，使本院的技術研發能量更上一層樓。

目　　次

赴法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會出國報告

壹、 目的

本案爲執行 99 年度經濟部科技專案光電感測辨識模組與應用技術計畫-光電與材料項目出國計畫，派員赴法國參加 2010 歐洲材料學會-材料、光電與感測技術國際研討會，瞭解國際間三五族化合物材料與元件在紅外線之應用技術、半導體量子井(點)磊晶製程技術、感測材料與元件技術、微奈米製程技術與應用等之最新發展與趨勢，蒐集相關技術資訊有助於計畫工作執行與未來規劃參考，使計畫之技術研發方向能與世界接軌，提升計畫執行效益。.

貳、 過程

2010 歐洲材料學會-材料、光電與感測技術國際研討會由歐洲材料發展協會(European Materials Research Society, E-MRS)於法國斯特拉斯堡舉辦，該協會於 1983 年成立，目前有超過 3000 個會員加入，會員來自世界各地的產業界、學術界與研發機構，每年均舉辦材料與光電相關國際研討會議，每場研討會議平均提供 20 個研討主題，鑑於本計劃之研發項目與本院之相關研發領域，本次參加之研討主題爲 SYMPOSIUM A、F、G、R，參加之研會場次與內容如下:

場次	時間	主題
旅程	6 月 7 日 0900~1430	機場轉車至斯特拉斯堡會場
SYMPOSIUM F	6 月 7 日 1430~1700	報到及寬能隙半導體磊晶技術
SYMPOSIUM A	6 月 8 日 0900~1200	感測器與感測材料
SYMPOSIUM F	6 月 8 日 1400~1700	寬能隙半導體元件技術
SYMPOSIUM G	6 月 9 日 0900~1200	三-五族氮化物材料
SYMPOSIUM G	6 月 9 日 1400~1530	三-五族材料電子元件與應用
PLENARY SESSION	6 月 9 日 1530~1700	專題演講
SYMPOSIUM G	6 月 10 日 0900~1700	三-五-氮化合物元件技術與應用
SYMPOSIUM R	6 月 11 日 0900~1200	雷射製程於微奈米技術應用
Exhibition	6 月 11 日 1400~1700	產品展覽

以下就各研討主題所參加內容做相關論文說明。

SYMPOSIUM A

1. 從內嵌式感測器到感知材料 (From Embedded Sensorial Materials): 感測器材料(sensor material)亦即爲像壓電(piezoelectric)或熱電(thermoelectric)薄膜這類可使用於感測器的材料，而感知材料(sensorial material)則是材料本身具有感測器的元素，在這定義下人體皮膚(human skin)即是一個感知材料的生物學範例。對於各種健康監測的科技應用，內嵌式感測器很可能會傷害或降低宿主材料的強度；因此，對感測器整合而言一個很重要的參數即是宿主材料的傷害(wound)尺寸，使用晶片尺寸的封裝，此傷害尺寸爲 3mm，若以用於 RFID 系統的小晶片可將傷害尺寸降低爲 400μm，本論文藉由新技術可將傷害尺寸進一步降低，利用寬度 40μm 條狀既薄且小的矽材料是可行的，在對於人體皮膚這類感知材料中，如此小的感測器相對於宏觀的組織而言是同質性(homogeneous)的；從宿主內部來看，目的並非盡可能地塞進越多的感測器，而是要確定有適當的粒度(granularity)可供作爲專門用途的分析。因此，必須了解動物皮膚的生理學原理再定義設計原則，再轉換至微型感測器科技(microsensor technology)。
2. 用於微機電與光伏元件封裝的密封玻璃材料進展 (Advances in sealing glass materials for packaging of MEMS and photovoltaic devices): 將微機電的功能性電子零件與光伏元件密封在一起以預防嚴苛的環境是確保他們可以長久使用與保持效能的關鍵。隨著科技的進展，微小化、低溫製程與環境保護驅使著新密封材料的研究。因應這些市場需求，FERRO 公司發展一系列鉛基(lead based)與無鉛(lead free)的密封玻璃材料應用於密封微機電元件與光伏元件，本文並介紹相關密封材料的發展與製程結果。
3. 用於可撓式光伏微來源以流動性氧化物爲基礎的三維微結構的旋轉塗佈絕緣塗層 (FOx-based spin-on insulating coating of 3D microstructures for flexible photovoltaic microsources): 自主的微感測器網路將革命性改變人們與電子的互動方式，當一個能量等級爲在 100mm^3 體積內需要 100μW 時，光伏電池是最適合的能量來源；在此微尺度下，藉由利用微製程，矽材料提供了數個優勢於設計三維微結構太陽模組，在未來可被製作成任何尺寸、形狀、面積、電壓、電流與基板，並且完全是可撓式的。另外，內嵌式感測器也可整合至相同基板。然而，有些挑戰需要被克服，例如低成本大量生產、低溫製

4. 以自我聚集烷基硫醇/二硫醇單原子層修正金/砷化鎵蕭特基二極體爲基礎的新型氣體感測器 (Novel Gas Sensors Based on Self-Assembled Alkyl Thiol/Dithiol Monolayer Modified Au/GaAs Schottky Diodes): 自我聚集原子層(Self-assembled monolayers, SAMs)已被廣泛應用於微探針、生化感測器與分子電子學。最近幾年，由於其規則性的排列與電子傳輸特性，烷基硫醇類已成爲最常使用的 SAM 分子其中一種。在本論文中，使用一種新的方法製作 Au/GaAs 蕭特基二極體並利用 Alkyl Thiol/Dithiol 單原子層來偵測乙醇(ethanol)氣體、NO 與 NO_2。
5. 在重離子轟擊下的砷化銦/砷化鎵量子點之光激螢光效率退化現象 (Investigation of degradation of photoluminescence efficiency in InAs/GaAs quantum dots on heavy ion bombardment): InAs/GaAs 量子點的抗輻射能力比量子井結構好，因爲載子在量子點裡是三維的量子侷限，這個特性可使量子點結構能有效地運用於外太空應用。本篇論文使用分子束磊晶(molecular beam epitaxy)成長單層 InAs/GaAs 量子點結構，並使用能量 35keV 至 50keV 的硫磺離子(sulphur ions)轟擊試片，再量測低溫光激螢光的發光強度衰減現象，結果顯示在能量爲 50keV 時，已經沒有發光強度，這是由於量子點結構已被破壞導致，並可從此實驗中得到在量子點中的載子活化能。
6. 其餘相關論文請參考附件。

SYMPOSIUM F

1. 高亮度磷化銦鋁鎵發光二極體的量子井數目優化(Optimization of the number of quantum well pairs for high-brightness AlGaInP-based light emitting diodes): 本篇論文利用改變量子井數目來研究高亮度發光二極體溫度相依光激螢光特性與元件效能，當量子井數目從 2

2. 在氮化銦鎵/氮化鋁銦鎵量子井結構裡的銦與鋁相依的光電特性 (Indium and aluminum dependence of the optoelectronic properties in $In_{0.16}Ga_{0.84}N/In_yAl_zGa_{1-y-z}N$ quantum well structures): 晶格匹配與不匹配的閃鋅礦氮化銦鎵/氮化鋁銦鎵異質結構已用固態理論與多重能帶 k.p 模型來探討其光電特性。結果顯示，導電帶與價電帶能態的位置會依障礙層(barrier)的銦、鋁含量而改變；甚至發現在成分爲 $In_{0.16}Ga_{0.84}N/In_yAl_zGa_{1-y-z}N$ 的異質接面能態會從 type I 轉變爲 type II，如此特性對於設計在藍光波段的光電元件非常有用，而事實上，也可利用封包波函數(envelope wave function)與 k.p 步驟方法來模擬與驗證量子井內中間帶(interband)的傳輸。
3. 3C-碳化矽特性與元件 (3C-SiC Characterization and Devices): 碳化矽(Silicon Carbide, SiC)被視爲作爲高效率電子元件的完美材料，碳化矽現存有超過 200 種不同晶體結構，除了常見的六角 4H-SiC 結構，立方晶系的 3C-SiC 結構也引起很大的注意，因爲 3C-SiC 可利用氣相磊晶方式在大尺寸的矽基板上製作，並且有相對於電晶體控制元件的特性優勢。3C-SiC 在所有 SiC 結構裡有最小的能隙(2.3eV)，但仍大於矽的能隙(1.1eV)，因此，3C-SiC 元件非常適合用於最大 1500V 的中段電壓應用(medium voltage application)；另一可能應用爲可與邏輯電路整合並應用於較嚴苛的環境。論文裡已展示元件特性與材料特性有很大的關係，並可達到低電阻元件的製作，惟缺陷的關係仍無法有效達到電壓阻擋(voltage blocking)效果。因此，目前最重要的課題即是如何有效地降低 3C-SiC 材料的缺陷，以達到更好的元件效能。
4. 生長在 3C-碳化矽上的高品質立方晶系氮化銦、氮化鎵、氮化鋁與其合金之光學特性 (Optical properties of high-quality cubic InN, GaN, AlN and related alloys grown on 3C-SiC): 最近的結果顯示以分子束磊晶方式在 3C-SiC(001)基板上沉積薄膜可以有效改善閃鋅礦結構氮化銦、氮化鎵和氮化鋁的品質，因此，具有平滑表面的單一晶向的立方晶系薄膜有機會達成。但是除了製程以外，目前爲止這些材料的光學特性並未被深入探討，本文利用商用的實驗室橢圓儀(ellipsometer)與自製的 UV-VUV 橢圓儀來做複合量測以獲得在

5. 從超晶格結構的中間與內部能帶光譜觀察立方晶系氮化鋁/氮化鎵能帶偏移 (Band offset between cubic AlN/GaN from inter- and intraband spectroscopy of superlattices): 從量子井紅外偵測器與量子雷射基礎而來的超晶格子能帶傳輸理論(intersubband transitions, ISBT)，可以得知在立方晶系氮化鋁/氮化鎵超晶格裡氮化鋁與氮化鎵之間存在很大的能隙偏移，可產生 1.3 至 1.5μm 的紅外光譜範圍。然而，立方晶系氮化鋁/氮化鎵之間的能隙偏移仍未確定。本論文利用在 3C-SiC 基板上以分子束磊晶生長氮化鋁/氮化鎵超晶格結構，並利用室溫與低溫的光激螢光譜來觀察子能帶傳輸，結果顯示其子能帶傳輸區域在 1.55μm 附近，並經由計算求出氮化鋁與氮化鎵之間的能帶偏移 Ec:Ev 爲 53:47。
6. 其餘相關論文請參考附件。

SYMPOSIUM G

1. 追求縮小氮化銦鎵生長溫度異質結構生長溫度差距 (The pursuit of narrowing the growth temperature gap for InGaN heterostructures): 三元氮化銦鎵異質結構涵蓋很大的成分範圍可運用於各種不同重要的應用，例如高效率光源與光偵測器、抗輻射光電元件、先進高速光電元件與光通訊元件。由於二元氮化銦材料的能隙在 0.7eV 左右使得三族氮化物元件可操作在紅外至紫外光波段，近幾年高銦含量氮化銦鎵的製程研究亦持續進行，而一個主要議題在於如何整合高銦含量氮化銦鎵與寬能隙氮化物，最主要的障礙在於兩者之間的生長溫度差距；舉例來說，在低壓有機金屬化學氣相磊晶條件下氮化鎵與氮化銦之間的生長溫度差距超過 300℃，一個可能的解決辦法在於探索磊晶時的表面化學反應與生長表面穩定性的壓力相依性來找出一個壓力範圍可同時生長氮化鎵與氮化銦的溫度窗口。本實驗利用高壓化學氣相磊晶系統來尋找同時生長氮化鎵與氮化銦鎵的製程條件，實驗結果顯示一個共同的三族氮化物製程窗口是可能的。
2. 氮化銦的介面、塊材和表面電子特性 (Interface, bulk and surface electronic properties of InN): 利用一個三區段模型(three-region model)來探討高 n 型導電度氮化銦薄膜塊材、緩

3. 砷氮化銦鎵光二極體 (GaInNAs photodiodes): 將額外的銦與氮進入到砷化鎵可形成砷氮化銦鎵，這類稀釋氮化物材料(dilute nitride material)可在砷化鎵基板上成長晶格匹配的薄膜，使用砷氮化銦鎵作爲光二極體已經在傳統光二極體引起很大的注意，然而更有潛力的是使用砷氮化銦鎵製作雪崩型光二極體(avalanche photodiodes, APD)，本實驗設計一個偵測 1.3μm 波長的砷化鎵雪崩型光二極體，利用砷氮化銦鎵作爲光吸收層，高鋁含量的砷化鋁鎵作爲雪崩區域，鑒於砷化鋁鎵的大能隙可達到很好的頻帶增益，可超過現有的磷化銦(InP)雪崩型光二極體。
4. 氮效應在銻氮砷化鎵/砷化鋁鎵量子井的光特性 (Nitrogen effect on the optical properties of $GaAs_{0.9-x}N_xSb_{0.1}/GaAl_{0.15}As_{0.85}$ (x<1.3) quantum wells): 已經有好幾個研究團隊發表在三五族半導體合金中摻入一點點氮可引起能帶能量大量的降低，在這些材料中，砷氮化銦鎵最被廣泛研究。然而，要使用砷氮化銦鎵(InGaNAs)來製作波長在 1.55μm 的高品質雷射仍有困難；另外，已經有結果呈現另一個較好的選擇是使用生長在砷化鎵基板上的銻氮砷化鎵材料，可製作在室溫發光波長在 1.3~1.55μm 波長範圍的發光元件。在本研究中，將使用室溫光譜橢圓儀(room temperature spectroscopic ellipsometry, RTSE)來分析 $GaAs_{0.9-x}N_xSb_{0.1}/GaAl_{0.15}As_{0.85}$ 量子井的光學特性，試片是使用分子束磊晶在砷化鎵基板上成長 $GaAs_{0.9-x}N_xSb_{0.1}/GaAl_{0.15}As_{0.85}$ 量子井結構，所有試片的 $GaAs_{0.9-x}N_xSb_{0.1}$ 層厚度均爲 40nm，並變化不同氮含量(x 爲 0 至 1.3%)來觀察光學特性變化，結果顯示量子井的傳輸能量將隨著氮增加而降低。
5. 氮摻入效應在氮稀釋氮砷化銦量子點的光學與結構特性 (Effects of the nitrogen incorporation in the optical and structural characteristics of nitrogen-dilute InAsN QDs): 對於通訊產業而言，在砷化鎵上成長的砷化銦量子點結構已經引起很大的期望，因爲它可能有光纖通訊的最佳發光波長 1.55μm；然而，目前爲止的最長波長爲使用砷化銦鎵量子點

6. 有機金屬氣相沉積生長發光波長在 1.3μm 的氮砷化銦鎵/砷化鎵位置控制量子線(MOVPE grown InGaAsN/GaAs site-controlled quantum wires emitting at 1.3μm): 稀釋氮化物之氮砷化銦鎵/砷化鎵合金有希望作爲通訊波段的雷射與單光子發射器(single photon emitter)，在本研究中使用有機金屬氣相沉積氮砷化銦鎵奈米結構，特別是具有低溫發光波長在 1180nm 的 V 型溝槽量子線(V-groove quantum wires, QWRs)；一開始藉由氮摻入砷化銦鎵/砷化鎵量子井來獲得大於 1μm 的發光波長，爲了克服氮的沉積，在 520℃的低溫下成長奈米結構；再使用偏角度的(100)基板則可使奈米結構在 77K 的發光波長從 1180nm 紅位移至 1250nm；而氮砷化銦鎵 V 型溝槽量子線則是磊晶生長在圖案化砷化鎵(100)基板上。結果顯示氮已成功摻入至量子線結構，可以從 10K 的發光波長在 1180nm，而室溫則是在 1300nm 而得到證明。另外，在低激發功率下的光譜線寬爲 30meV，這是由於沿著量子線的結構與合金成份變動所導致。
7. 其餘相關論文請參考附件。

SYMPOSIUM R

1. 改善多晶矽光伏電池效率的先進雷射結構化製程 (Advanced laser texturing of multicrystalline photovolataic cells for the improvement of efficiency): 表面圖案化(surface texturing)是一種眾所皆知的減少光伏電池表面反射的技術，以矽單晶爲主的光伏電池一般是使用非等向性蝕刻(anisotropic etching)技術來製作表面圖案化，而此一技術並不適合用於以多晶矽爲主的光伏電池，因爲多晶矽有任意方向的晶粒，因此，雷射結構化是另一個適當的表面圖案化技術。本研究利用紫外光雷射直接在晶片表面儘可能小地形成六

2. 雷射製程應用於物體的形變量測 (APPLICATION OF THE LASER PROCESSING FOR MESUREMENT OF DEFORMATIONS OF OBJECTS): 使用在移動物體形變的干涉斑點的電子技術是以干涉圖形的減算過程爲基礎。第一個斑點影像在物體形變之前被記錄在電腦記憶體裡，接著記錄形變後的第二個影像，在監視器上可觀察到兩個影像之間的圖形關聯性差異，這些圖形的解讀有可能確定形變量，在此研究中的形變實驗結果來自於鋁與不鏽鋼兩種試樣。
3. 在石英玻璃上以脈衝二氧化碳雷射製作微米與奈米結構 (Pulsed CO2 laser induced micro and nano structuring on quartz glass): 雷射光已被廣泛使用在工業上，諸如雷射製造與切割以及像波導的客制化光學元件等各式各樣的應用。藉由控制雷射參數，有可能在大部分的材料上裁製出微米與奈米結構；二氧化碳雷射可使用在1.5kW的最大平均功率與10.6μm的發射波長，以及有能力產生微秒(micro-second)範圍的脈衝；在此研究中，被考慮的主要雷射參數包含平均功率(average power)、脈衝頻率(pulse frequency)、移動速度(traverse speed)與循環次數(duty cycle)，雷射被使用於熔融的石英基材上蝕刻通道，並接著分析雷射參數對表面型態的影響，微米與奈米結構則經由光學與表面型態檢測粗糙度；另外使用反應表面方法學(response surface methodology, RSM)來分析微米與奈米結構與雷射參數之間的關連性。
4. 其餘相關論文請參考附件。

參、心得

1. 紅外線元件方面:紅外感測元件爲本計畫一發展分項,亦是本院研發項目之一(紅外熱像感測),本次研討會中,紅外波段光電元件亦多有探討,總括來說共有兩系列的半導體材料可用來製作紅外波段元件,其一爲砷化物,另一爲氮化物。其中砷化物材料的發展較早,本計畫的紅外波段感測元件亦使用砷化物材料製作,波段大約在3000~4000nm,並使用量子井與量子點等奈米結構作爲主動層,而本院的紅外熱像技術使用銻化物材料,吸收波段大約在2000~5000nm,並且必須在低操作溫度下才有較好的影像表現。因此,以熱像應用技術來看,使用砷化物的奈米結構作爲感測元件可有效提高操作溫度(>100k),來降低感測系統製作成本與困難度,達到系統縮裝目的;以國防用途爲例,可提高搭載紅外夜視系統裝備的性能與機動性。而在本研討會提到的摻氮砷化物,則可利用少量的氮摻入來達到吸收波段調整的效果,一般而言,摻氮砷化物有比砷化物更長的吸收波段,可作爲更長波長的應用,且與砷化物一樣可製作奈米結構來提高操作溫度,對於應用上有更大的彈性。另外一種可作爲紅外感測波段的材料爲高銦含量的氮化物材料,其吸收波段大約在700~2500nm的近紅外波段區域,使用氮化物的好處在於整體氮化物的操作波段爲目前半導體材料中範圍最廣的,可從200nm的深紫外光延伸至2500nm的紅外光區域,因此有機會可在同一晶片上整合紫外光與紅外光感測元件,因爲280nm波長以下的紫外光在大氣中並不存在,可發出此波段光譜的物品必定是人爲製造,目前已知的高壓電塔、核電廠、短距通訊與飛彈發射等均會產生此波段光譜,若搭配紅外光檢測則可做雙重確認,可更準確的感測或追蹤目標物,惟目前高銦含量氮化物磊晶製程不易,仍有很大的挑戰需要突破,本研討會中亦有多篇論文探討此一議題,並提到在高壓環境下有機會在同一溫度窗口同時生長氮化鎵與含銦氮化物材料,值得持續關注了解其可行性。
2. 感測材料與元件方面:本次研討會發表的感測材料包羅萬象,從壓熱電、化學、半導體材料均有涉獵,感測元件則有微感測器、氣體感測、溫度感測、壓力感測與生化感測等,其中微感測器爲本次會議重點,亦有多篇論文發表利用砷化物半導體材料

3. 立方晶系半導體材料方面:這方面的主要研討放在3C-碳化矽材料，一般常見的碳化矽材料爲六方晶系結構(4H-SiC, 6H-SiC)，價格不斐且取得不易，而立方晶系的3C-碳化矽則可在矽基板上生長獲得，使用立方晶系材料的好處在於其結構爲非極性結構，不會在結構內部產生壓電極化現象使能帶彎曲，因而使得元件的操作波長在不同操作條件下不會產生大量偏移，這點對於發展氮化物材料光電元件有很大的幫助，尤其使用矽基板更可大幅降低成本。本院能源相關科專計畫亦規劃使用矽基板發展三五族太陽電池元件，可利用能源矽基技術，搭配現有磊晶製程設備，發展矽基氮化物磊晶與元件技術；而相關的碳化矽材料資訊亦可提供作爲本院未來新建案計畫的研究參考方向。
4. 雷射技術方面:本次會議在雷射技術方面的探討以雷射製程爲主，以雷射蝕刻方式製作微米、奈米結構，可應用於元件表面圖案化以增進元件效能，或是應用雷射印刷技術製作有機光電與電子元件；其中雷射微蝕刻製程可在晶片表面製作奈米等級圖案，以製作圖案化基板，可適用於目前的三五族半導體材料磊晶與元件製程，可提供另一種製作奈米圖案化基板方式的參考。

肆、 建議事項

一、紅外光波段感測一直是本院光電元件的發展重點之一，除了砷化物與銻化物以外，含氮砷化物與高銦含量氮化物在紅外光波段的應用也逐漸引起廣大的注意，本院在砷化物與氮化物半導體材料與其光電元件亦有超過十年的研發經驗，可從現有技術擴展出新的應用與技術能量，例如利用現有的有機金屬氣相磊晶設備與分子束磊晶設備研發含氮砷化物與高銦含量氮化物材料，或者搭配矽圖案化基板發展矽基磊晶技術，均有機會改善現有元件效能，而相關的技術研發未來亦可應用於夜視感測等紅外熱像系統。

二、近代科技的發展迅速，同一材料、元件或技術在不同的想法下可產生不同的應用，參加本次研討會對此深有所感，本院爲國內重要研究機構，新技術與應用的研發亦是本院的發展方向之一，多方的吸收相關知識與情報才有助於研發計畫執行與研發方向調整，建議本院同仁應時時加強自己對科技的敏感度與知識的獵取，才能讓研發計畫與工作走在時代的尖端。

附件 研討會相關論文

2010 A: From embedded sensors to sensorial materials

The symposium will cover the integration of sensors and electronics in materials such as metallic parts, textiles or carbon fibre components. It will gather the community working in the new field of sensorial materials who are driven by the final vision of a semi-finished part such as a gearwheel, a wing or a bearing with integrated sensors. The sensors will be integrated in a way that allows further processing and montage like for a standard part. This way, seen from the production of the final part, sensitivity is a borne-in ability of the material and does not need any special effort. To reach this vision, contributions from the areas of micro system technology, smart and sensor material development, associated manufacturing technologies etc. are mandatory and thus also invited to participate in the symposium.

From Embedded Sensors to Sensorial Materials

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Resume : A study on bioinspired design principles for sensorial materials is presented. While "sensor material" means a material used in sensors such as piezoelectric or thermoelectric thin films, a "sensorial material" refers to materials which have sensor elements for different quantities integrated with fine granularity. A biological example for a sensorial material in this sense is the human skin. Examples for technical applications are structural health monitoring or haptic arrays for robots. Embedded sensors may harm the function and reduce the strength of the host material, since the are an inhomogeneity and a mechanical weakness. Therefore, an important parameter of sensor integration is the size of the "wound" in the host material. Using a chip size package, this wound is 3mm. The thin and small chips used for RFID systems reduce it to 400μm. The paper describes the possibilities for further reduction by new technologies. Using thin and small silicon stripes a size of 40μm will be feasible. In a sensorial material, like in the human skin, the sensors are so small that the material is homogeneous with respect to its macroscopic texture. The determination of the granularity of sensor deployment is a predominant design issue. Internally, it is not the aim to integrate as much sensors as possible, but to determine the appropriate granularity for the measurement problem by analysis of the specific cognitive task has to be analysed. It is shown that the investigation of the human skin reveals important design principles. The authors have investigated the physiology of senses of the mammalian skin and identified design principles and ideas transferable to microsensor technology.

Advances in sealing glass materials for packaging of MEMS and photovoltaic devices

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Resume : Sealing the functional electronic components in MEMS and photovoltaic devices from the harsh environments, is the key to their long term survival and performance. As the technologies advance, minitiarurization, low temperature processing, and environmental safety are the key drivers that fuel the search of new seal materials. In response to these market requirements, Ferro has developed a series of low temperature lead based and lead free sealing glass materials for sealing MEMS devices and various photovoltaic devices. This paper will review the development of these seal materials and their process windows, with the knowledge derived from two design of experiments. Practical examples and cross sections of these seals will be presented and discussed.

FOx-based spin-on insulating coating of 3D microstructures for flexible photovoltaic microsources

Authors : Y.-A. Chapuis, F. Kahlouche, B. M. Serrano Mesa, S. Roques, P. Mongomery and A. Slaoui InESS, University of Strasbourg/CNRS, 23 rue du Loess - Strasbourg, 67037, France.

Resume : Networks of autonomous microsensors will revolutionize the way people interact with electronics, enabling ambient intelligence. Photovoltaic cells are the most promising power generators when a power level of 100 μW in a volume of 100 mm3 is required. At the microscale, by using microfabrication processes, silicon offers several advantages in the design of 3-D microstructured solar modules in any shape, size, area, voltage, current and substrate and which will be fully flexible in the future (using amorphous silicon – a:Si). In addition, embeded sensors can be integrated on the same substrate. However, several challenges need to be overcome in the fields of low-cost mass-production, low temperature processes and flexible materials. In this work, we investigate different spin-on-solutions (e.g. spin-on-glass- SoG) combined with silicon microfabrication processes to achieve 3-D microstructured solar modules with an area ≤ 0.1 cm² and an output voltage of up to 100 V. Spin-on-solutions are used such as low temperature spin-on oxide (≤ 250°C) for the dopant diffusion barrier, the electrical isolator and an antireflection coating. A solution of spin-on flowable oxide (FOx), which flows at low temperatures (250°C) and provides excellent gap filling and planarity properties, has been used to form insulating coating with ionic barrier properties on Si-based 3-D microstructured patterns (100 micro-cells – 200 × 200 μm² top sides - with 10 μm deep V-grooves formed in Si by KOH wet etching). The quality of the film morphology is characterized by mechanical stylus and optical interference microscopy. The functionality of the coated spinon oxide has been confirmed for deep V-groove Si-based 3-D microstructure photovoltaic cells. All fabrication processes are a:Si compatible.

Novel Gas Sensors Based on Self-Assembled Alkyl Thiol/Dithiol Monolayer Modified Au/GaAs Schottky Diodes

Authors : Bing-Jia Lin, Hur-Wei Yiou, Kuo-Kan Hsu, Chien-Hung Lee, and *Huey-Ing Chen Department of Chemical Engineering, National Cheng Kung University, Tainan, Taiwan, ROC.

Resume : Self-assembled monolayers (SAMs) have been extensively used in microprobes, biosensors, and molecular electronics. In recent years, alkanethiolate was one of popular SAM molecules owing to its regular arrangements and electron transport properties in molecular junctions. As reported, the chain length as well as the functional group of alkanethiolates played important roles on the architecture of SAMs and therefore would determined the sensing properties of the studied device. In this work, we attempted on a new approach to fabricate Au/GaAs Schottky diodes modified by alkyl thiol/dithiol monolayers for sensing ethanol(EtOH) vapor, NO, and NO2. The adsorption and arrangement of thiol/dithiol molecules with different carbon number on Au were studied by cyclic voltammetry (CV). Furthermore, sensing characteristics for three gases were investigated and compared. From the result of CV analysis, it revealed that, as increasing the carbon number, the arrangement of SAMs molecules tended to more ordered, and the adsorption amount was increased. However, the result of sensing measurements showed that, a maximum EtOH sensitivity of 123 was observed at carbon number of 6. Moreover, the device showed no remarkable sensing for NO and NO2. Further instead of alkanethiolate with alkanedithiol, it exhibited that the hexanedithiol modified device demonstrated high sensitivities to NO2 and NO. The sensitivities were 4.25 for NO at 100 ppm NO/N2, and 12.59 for NO2 at 103 ppm NO2/N2, respectively, under room-temperature detections.

ZnO nanoplatforms for multifunctional biomolecules sensors

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Resume : ZnO nanostructured thin films consisting of dense 2D arrays of ZnO nanorings and/or

nanorods have been fabricated on different substrates by using a hybrid approach of nanosphere colloidal lithography, self assembled monolayer deposition, metal-organic chemical vapour deposition and/or wet chemistry synthesis. The biosensing capability of the nanostructured films has been tested by integrating the ZnO thin films either to glass coverslips or to quartz piezoelectric sensors, in order to detect their changes upon the biomolecules uptake, respectively in the optical properties, by scanning laser confocal microscopy (SLCM), as well as in the mass load and the viscoelastic properties, by quartz crystal microbalance with dissipation monitoring (QCM-D). As proof of working, the adsorption processes of two model proteins, such as albumin and lysozyme, having opposite isoelectric values at the physiological pH of 7.4, have been investigated as function of various experimental parameters, related to the properties of both the sensing substrate (e.g., surface topography and chemistry) and the analyte solution (protein nature, bulk concentration, pH and ionic strength). Theoretical models of the proteins coverage and average orientation into the adlayers formed on the differently nanostructured ZnO thin films have been obtained by angular resolved XPS analysis. Finally, preliminary results of the surface functionalization of the nanostructured ZnO films by supported lipid bilayers are also shown, as promising and advanced biomimetic ZnO-based biosensors.

The effect of PET substrate preparation on the growth of ZnO ellipsoid like nanostructures

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Resume : ZnO is a wide band gap semiconductor with piezoelectric characteristic that make it suitable for many electronic application specially different type of sensors such as gas and SAW sensors. In this investigation ZnO thin films (~95 nm thickness) deposited on standard Poly Ethylene Terephthalate (PET) substrate (~100 μm thickness). The deposition of ZnO was carried out by RF sputtering (13.6 MHz) in Argon atmosphere and at room temperature. PET substrates were prepared with two different methods before deposition and the effect of these different methods on ZnO thin film properties were investigated. In the first method, PET substrates were annealed at atmosphere for 24 hours in 80˚ C and then they were immersed in dichloromethane solution for 18 minutes then rinsed with deionized water and dried with blowing air. In the second method, PET substrates were cleaned with deionized water in ultrasonic bath for ten minutes after immersing in dichloromethane and then were annealed at atmosphere for 30 min in 80˚C. SEM images show that the morphology of the deposited layer depends on the cleaning and preparation procedure where a grainy or nano-ellipsoid structure is achieved. The morphological, structural properties, Compositions and absorption band characterization of substrate and these films were investigated by scanning electron microscopy, X-Ray Diffraction and FTIR spectroscopy respectively.

Surfactant-assisted low-temperature synthesis of zinc oxide particles for sensor applications

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Resume : Zinc oxide is a direct and wide bandgap semiconductor material with a wide range of sensor applications due to its distinguished optical, electrical, and chemical properties. Recently, various physical and chemical routes have been used to prepare ZnO nanostructured materials in various geometrical morphologies. In this work, crystalline ZnO nanoparticles of a different particle size and morphology were prepared from a novel surfactant assisted precipitation in aqueous solutions. We studied the effect of some influential parameters, such as the pH value of the reaction, the temperature and the time of aging, and initial concentration of the solute, to the particle size and morphology. To protect the particles from aggregating and subsequently growth during the aging stage, the effect of some protective agents, such as sodium dodecylsulphate (SDS), ethylene glycol (EG) and citric acid (CA), was investigated. We found that the addition of the protective agent into the reaction vessel before the precipitation occur, led to a strong size

reduction below 20 nm and to a variety of particle shapes, such as spheres, ellipsoids, stars, fibres and hexagons. The presence of these additives was confirmed that submicronic zinc oxide particles resulted from nanocrystals oriented aggregation. The synthesized powders were characterized using transmission electron microscopy (TEM), X-ray diffractometry (XRD) and specific surface area (BET) measurements.

An Experimentally Verified Model of High Temperature Embedded SiC-based Sensor

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Resume : Embedded temperature sensors are essential for several embedded systems including automotive and aeronautic among many others. Thermistorsensor is very familiar as the absolute temperature-sensor. However, first, it has a non-linear connection between the temperature and the output voltage. Second, its integration within a semiconductor substrate is hard and mismatched with the CMOS technologies. Third, it has a limited measurable temperature range as a single temperature-sensor. To overcome these three limitations a new design is then mandatory such as the silicon carbide-based one. For its capability to support high temperature, silicon carbide semiconductor material supports wide temperature range (up to 500°C), than silicon- and thermistance-based sensors. In this paper, new and innovative compact design of silicon carbide based sensor is presented. Measurement accuracy and stability for reliable high temperature are reported. From a design point of view, a novel model of the proposed system is presented. This model, runs for a wide range of temperature, is based on the behavioural analysis of the proposed SiC based sensor. A comparative study between experimental and simulation is undertaken. Important to note that the proposed model and the experimental results reflect a successful agreement as far as an embedded temperature sensor is concerned.

Investigation of degradation of photoluminescence efficiency in InAs/GaAs quantum dots on heavy ion bombardment

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Resume : Radiation hardness of InAs/GaAs quantum dot (QD) based optoelectronic devices over quantum well structure have been demonstrated recently. Radiation hardness in QDs is due to the three dimensional quantum confinements of carriers in QDs. This property of QD's can be effectively used for devices that are used in outer-space application as well as in radiation prone environment. In the present study, we report the effect of heavy ion irradiation on molecular beam epitaxy grown single layer InAs/GaAs QD embedded on a GaAs matrix, induced by sulphur ions of energy ranging from 35 keV to 50 keV. Low temperature photoluminescence (PL) study showed degradation of PL efficiency with increase in energy of sulphur ions and PL quenches completely at 50 keV. The degradation in PL efficiency is attributed to the non-radiative recombination of photo-generated carriers in QDs with the holes that are thermally activated from defects created in GaAs capping layer. A model is proposed to explain the mechanism of degradation in PL efficiency, which very well matches with the experimental data. The quenching of PL is due to the complete dissociation of QDs with GaAs matrix, which destroyed the quantum confinement of the carriers. As-prepared sample showed activation energy of 123 meV, and found that on irradiation it decreases from 74 meV to 10 meV with 35 keV to 45 keV sulphur ions respectively. The decrease in activation energy is attributed to the formation of shallow defect levels (traps) in the vicinity of InAs/GaAs QDs, which become active even at low temperatures and contributes carriers for non-radiative recombination in QDs. Financial assistance from DST, Government of India is being kindly acknowledged.

Theoretical modeling on thermal annealing of self-assembled InAs/GaAs quantum dots and its experimental validation

Authors : Srujan M, K. Ghosh, S. Chakrabarti and S. Sengupta Center for Excellence in Nanoelectronics, Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai-400076

Resume : We present a model for the effect of thermal annealing on the photoluminescence (PL) properties of single-layer InAs/GaAs quantum dots (QDs), and follow it up with an experimental correlation. It is observed that In/Ga interdiffusion in QD and barrier material, modeled by Fickian diffusion, leads to a smoothening of band profiles in the heterostructure with decrease in generated strain and carrier confinement potentials. The Schrödinger equation is solved to obtain PL ground state energies of QDs annealed at different temperatures. Results from theoretical calculations are in good agreement with our experimental observations on PL peak blueshift with annealing. PL spectrum of the entire ensemble of QDs is calculated from a lognormal distribution of QD sizes derived from experimental AFM data, and its variation with annealing temperature is studied. Our method is validated by a close correlation between calculated and experimental variation in full-width-at-halfmaximum (FWHM) of the spectrum. The simplicity of the model along with its multiple useful features including computation of material interdiffusion, QD band profiles and full PL spectrum makes it a demanding tool in studying and predicting annealing effects on QD heterostructures. Financial assistance from DST is being acknowledged.

2010 F: Wide bandgap cubic semiconductors: from growth to devices

The aim of this symposium is to serve as an international forum for the discussion on the recent research progress in crystal growth, processing and characterization of wide bandgap semiconductors having the cubic (blende) crystalline structure. Despite their promising properties, these materials are generally difficult to elaborate in the cubic structure. Even if, at first glance, each case may be different, they share important issues to be tackled such as the choice of an adapted substrate, innovation in deposition techniques or the defect forming within the material (polytype inclusions, twins…). Their destiny is more probably linked together since the emergence of one of these cubic materials could help the others by providing better adapted seeds than the usual ones. The materials targeted are mainly 3C-SiC, diamond, cubic III-N materials and c-ZnO though emerging and new CWBS are also welcome. Both theoretical and experimental studies are within the scope of this simposium. Current challenges include the understanding and optimization of the growth processes for bulk and thin films; stabilization and production high-quality CWBS material; development of adapted deposition processes; determination of the fundamental and experimental properties of CWBS; processing challenges; possibility of CWBS cross-integration for bandgap engineering; device demonstration and identification of the potential of CWBS and the targeted applications. This symposium would be a unique opportunity for the different WBG cubic semiconductors communities to meet together and share experiences and perspectives on their respective materials.

Vapor phase vs. Liquid phase: what is the best choice for the growth of bulk 3C-SiC crystals?

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Resume : Although the growth of 6H and 4H-SiC polytypes seem to be almost solved, it is somewhat different for the cubic 3C-SiC polytype. This latter still is a highly challenging and exciting scientific issue, mainly because of the discrepancy between the stability range of this polytype and the operating conditions of the available bulk growth processes. Despite many previous attempts along the last decades, it is only very recently that some works have paved the way to a real 3C-SiC bulk growth development. Among the key results is the demonstration of 3C-SiC growth using a variant of the sublimation method, thereby demonstrating that the high

temperatures are not necessarily a lock to the growth of 3C. Another example is the achievement of a stable growth front over a very long time in a top seeded solution growth process. Both approaches have shown a real potential for growing high structural quality 3C-SiC crystals. The current state of the art of these two processes will be presented and compared with respect to the problems of size, doping or density of extended defects. Their respective strengths will also be discussed considering their future development.

Detailed study of the influence of surface misorientation on the density of Anti-Phase Boundaries in 3C-SiC layers grown on (001) silicon.

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Resume : The formation of Anti-Phase Domains (APD) is a commonly observed phenomenon in elaboration of a zinc-blend film (ex. 3C-SiC, GaAs) on {100} face of a substrate having a diamond structure (ex. Si, Ge). The Anti-Phase Boundaries (APB), delimiting adjacent APDs, are considered as an important source of deep levels or scattering centers – their elimination is thus crucial for the electronic quality of the film. For 3C SiC/Si the elaboration of the layer on the vicinal surface was proposed in late 80s as an effective way to reduce the APB density. However, the literature reports are a bit ambiguous concerning the value of the off-cut angle that allows a complete elimination of APBs within the layer. To clarify this detail we propose a thorough experimental study of the correlations between the surface misorientation (off-cut angle and direction) and the presence of APD/APB within the layer. To provide the access to the continuum of the offcut angles (0° to ~10°) and directions ([110] to [1 10]) the 3C SiC layers of different thickness were elaborated by CVD on (001) oriented Si wafers with spherical dimples. The technique of growing elongated (110) Si islands on the top of 3C SiC layer, proposed by Ishida et al, was used to reveal the orientation of the domains. SEM images were analyzed to provide the estimation of the proportions between both domain orientations. Additionally, the microstructure of Si islands was analyzed by HR-TEM.

Zinc-blende (cubic) GaN and AlGaN layers, structures and bulk crystals by molecular beam epitaxy

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Resume : The group III-nitrides normally crystallise in the hexagonal (wurtzite) structure. The unique feature of wurtzite group III-nitrides, in comparison with conventional III-V semiconductors, is the existence of very strong electric fields inside the crystal structure. The resulting charge separation within quantum wells can lead to a significant reduction in the efficiency of optoelectronic devices. As a result, the growth of non-polar group III-nitride structures has been the subject of considerable recent interest. The electric fields can be eliminated (reduced) in wurtzite material by growing in non-polar (semi-polar) directions. However, a direct way to eliminate electric fields would be to use non-polar (001) oriented zinc-blende (cubic) III-nitride layers. We have studied the growth of zinc-blende GaN and AlGaN layers, structures and bulk crystals by molecular beam epitaxy (MBE). We have developed a process for growth by MBE of free-standing cubic GaN layers. Undoped thick cubic GaN films were grown on semi-insulating GaAs (001) substrates by a modified plasma-assisted molecular beam epitaxy (PAMBE) method and were removed from the GaAs substrate after the growth. The resulting free-standing GaN wafers with thicknesses in the 30–100μm range may be used as substrates for further epitaxy of cubic GaN-based structures and devices. We have developed procedures to cleave the wafers into 10x10mm2 square substrates and to polish them to produce epi-ready surfaces. The first GaN/InGaN LEDs on our zinc-blende GaN substrates have been demonstrated by our collaborators at Sharp Laboratories of Europe

Growth of cubic GaN quantum dots

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Resume : In this contribution we report on the growth of cubic GaN quantum dots (QD) with 2 different methods. We will show reflection high electron energy diffraction (RHEED) patterns, atomic force microscopy (AFM) images and photoluminescence (PL) spectra of the c-GaN QDs. Both c-GaN QD growth methods begin with the plasma assisted molecular beam epitaxy (PAMBE) of a c-AlN buffer layer on (001) 3C-SiC substrate. In method 1 QDs are formed by Stranski-Krastanov (SK) transition of 2 to 10 monolayers of strained PAMBE grown c-GaN on the AlN layer. In method 2 QDs are formed by a droplet epitaxy process. Ga droplets are created by molecular beam deposition of Ga at low substrate temperature. Afterwards the Ga droplets are exposed to the N plasma beam while slowly evaporating the Ga from the surface. This leads to N super saturation of the Ga droplets and condensation of a crystalline GaN QD. For both methods the QDs are capped by a c-AlN layer. The RHEED pattern of the c-AlN cap layer shows long thin streaks of the cubic reflections indicating a smooth 2D surface free of hexagonal AlN clusters and confirms full epitaxial overgrowth. The AFM images verify the surface topology observed by RHEED. The PL measurements confirm the optical activity of the c-GaN QDs.

Transmission electron microscopy evaluation of 3C-SiC/Si templates for III-nitride semiconductor growth

Authors : Maxim Korytov, Sebastien Roy, Philippe Vennéguès, Jean-Michel Chauveau, Olivier Tottereau, Maud Nemoz, Marcin Zielinski, Marc Portail, Thierry Chassagne, Eric Frayssinet, and Yvon Cordier CRHEA-CNRS, rue Bernard Grégory, Sophia Antipolis, 06560 Valbonne, France

Resume : Silicon carbide (SiC) is used not only as a base for high-voltage devices, but also as a substrate for subsequent epitaxial growth of nitridebased heterostructures. For this application (111) oriented 3C-SiC films on silicon are considered as an interesting alternative of more expensive 4H-or 6H- wafers. In this contribution we investigate the influence of structural properties of 3C-SiC film on the quality of nitride heterostructures. 3C-SiC films were grown on (111) Si substrate by chemical vapor deposition. Subsequent III-nitride heterostructure growth was achieved by molecular beam epitaxy. High-resolution transmission electron microscopy and darkfield imaging were employed to confront structural defects in SiC layers with crystalline quality of subsequently grown heterostructures. Impacts of Si substrates disorientation, as well as of 3C-SiC film thickness and roughness are investigated.

Optimization of the Number of Quantum Well Pairs for High-Brightness AlGaInP-based Light Emitting Diodes

Authors : Korea Photonics Technology Institute

Resume : We investigated high-brightness light emitting diodes (LEDs) appropriate for general lighting applications in terms of their temperature dependent photoluminescence characteristics and device performance according to the change of quantum well pairs (QWs). As the number of QWs was increased from 2 to 35 pairs, internal quantum efficiency and device performances significantly improved, due to the suppression of carrier overflow by decreasing the carrier density in the active region and shortening the carrier transfer time from barrier to well. At a further increase in the number of QWs to 50 pairs, however, the optical and device performances started to degrade because of the increase in internal loss in the active region, such as the well volume itself acting as light absorbing layer and due to the aluminum oxide complexes in the barrier.

Nucleation kinetics of 3C-SiC single crystals from the vapour phase

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Resume : For long, the development of bulk 3C-SiC single crystals has suffered from the lack of both 3C-SiC seeds and an adapted growth process, the latter being able to overcome the polytypic 3C to 6H solid state transition that usually takes place for high temperatures. In a previous paper [1], we already demonstrated that 3C can be stabilized under real bulk growth conditions. Moreover, outstandingly low residual strain and extended defects density has been obtained using unseeded growth. However, this approach requires precise control of the nucleation stage, which proved particularly difficult given the extreme conditions of the process. This paper aims at obtaining fundamental data on the spontaneous nucleation of 3C on graphite from the vapour phase, by a detailed experimental study and an appropriate modelling of nucleation kinetics. [1] D. Chaussende, J. Eid, F. Mercier, R. Madar, M. Pons, Materials Science Forum, 615-617 (2009) 31

Chemical Synthesis and Optical Properties of AlN Nano-Structures
Authors : 1- S.H. Mousavi, Shahrood University of Technology, Shahrood, Iran 2- H. Haratizadeh, Shahrood University of Technology, Shahrood, Iran
Resume : Aluminum Nitrite is a unique material that exhibits semiconducting and piezoelectric dual properties. Using a solid–vapour phase thermal sublimation technique, nano-tips, nano-belts, nano-wires and AlN have been synthesized under specific growth conditions. These unique nanostructures unambiguously demonstrate that AlN probably has the richest family of nanostructures among all materials, both in structures and in properties. The nanostructures could have novel applications inoptoelectronics, sensors, transducers and biomedical sciences. The nitrite nanostructures to be reviewed in this paper were synthesized by a solid– vapor process. In principle, the thermal evaporation technique is a simple process in which condensed or powder source materials are vaporized at elevating temperature and then the resultant vapor phases condense under certain conditions (temperature, atmosphere, substrate etc) to form the desired products. The structural and optical properties of these synthesized samples are analyzed and compared at different conditions.

Indium and Aluminium dependence of the optoelectronic properties in In0.16Ga0.84N/InyAlzGa1-y-zN quantum well structures
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Resume : Optoelectronic properties of lattice-matched and pseudomorphically strained InxGa1-xN/InyAlzGa1-y-zN heterointerfaces having zinc blend structure, have been performed on the basis of the model solid theory and multi-band k.p. From the results obtained, we have studied, particularly, the effect of varying indium and aluminium compositions on the valence and conduction bands of Ga0.84 In0.16N/InyAlzGa1-y-zN heterostructure. It is found that both conduction and valence band states are modified when varying Al and In contents in the barrier material. More over, it is observed that the line-ups at Ga0.84In0.16N/InyAlzGa1-y-zN interface change from type I to type II. Such derived informations are used for the design of lattice matched heterostructure in modelling optoelectronic devices emitting at the blue spectral domain. In fact, using two different models; the one-version of the envelope wave function and the k.p method, analysis are made to investigate the effect of the barrier constituents and the well width on the Ga0.84In0.16N/InyAlzGa1-y-zN single quantum well interband transitions. Such investigations are done with the aim to achieve light emissions sweeping the blue spectral domain. Good agreements are obtained between the different results.

Design, Modeling and Optimization of 3C-SiC-based Devices
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Resume : Due to non commercial 3C-SiC wafers, 3C-SiC devices are still missing mature design and modeling techniques. This paper gives a new approach attempting to optimize the 3C-SiC devices epitaxial layer design and to model its parameters. In a previous work, optimal design of 4H-SiC and 6H-SiC based devices are proposed [4]. In this paper, however, an advanced 3C-SiC design parameters abacus is resulting form such 4H-SiC and 6H-SiC abacuses. A satisfactory trade-off between the on-resistance and the breakdown voltage is obtained. The doping concentration and width of the epitaxial layer are also optimized and discussed through several 3C-SiC schottky diodes and MOSFET transistors. [4] Tarek Ben Salah et al, 6. A novel design approach for the epitaxial layer for 4H-SiC and 6H-SiC power bipolar devices. Superlattices and Microstructures, 2006

The Potential of cubic 3C-SiC as Material for Electronic Devices
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Resume : Silicon Carbide (SiC) is regarded as a perfect material for high performing electronic devices. SiC exists in over 200 crystallographic different modifications, so called polytypes. Besides the commonly used hexagonal 4H-SiC polytype, the cubic 3C-SiC polytype has been of interest because of the possibility to fabricate 3C-SiC wafers by vapour phase epitaxy using large diameter silicon substrates and because of material property advantages with respect to MOS controlled devices. 3C-SiC has the smallest bandgap (2.3 eV) of all SiC polytypes, but the bandgap is still more than 1 eV larger than that for silicon. Hence, 3C-SiC devices should be well suited for medium voltage applications with voltage requirements of up to 1500 V. Another possible application is integrated circuits and logic for harsh environments. This paper will review the present state of the art of electronic devices made from 3C-SiC, including MOSFET devices and diodes. The device performance will be illustrated in relation to the material quality. It will be shown that high current handling capability in on-state is feasible and low onresistance devices can be achieved. However, voltage blocking is difficult due to the presence of extended defects in the base material. The leakage current in voltage blocking mode depends strongly on the density of these extended defects in the vicinity of the device. Hence, the reduction of the defect density is the one of the most important topics to realize electronic devices using 3C-SiC material. Approaches to achieve lower extended defect densities will be discussed.

Optical properties of high-quality cubic InN, GaN, AlN, and related alloys grown on 3C-SiC
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Resume : It was recently demonstrated that the quality of zinc blende InN, GaN, and AlN can be considerably improved if bulk 3C-SiC (001) is used as the substrate for the deposition of the films by molecular beam epitaxy. Thus, phase-pure cubic films with a smooth surface became available. Despite this progress, fundamental optical properties of these materials have not been reported so far. Here, we present a comprehensive optical characterization of all three binary cubic compounds as well as of related alloys. The dielectric function (DF) between 0.54 eV to 20 eV at room temperature and T=10 K is obtained by combining measurements with a commercial lab ellipsometer and a home-made UV-VUV ellipsometer attached to the Berlin Storage Ring for Synchrotron Radiation (BESSY II). The DFs of all nitrides show very sharp features which are correlated to the band gap as well as to high-energy critical points of the band structure. These data agree very well with theoretical results if exciton-hole interaction is taken into account in the calculations for the whole spectral range. The analysis of the experimental data yields for cubic

InN a gap of 0.595 eV. The direct gap of AlN amounts to 5.93 eV while the indirect one is found at about 5.3 eV. The DF data for GaN around the band gap are additionally compared to the results of photoreflectance, photoluminescence and photoluminescenceexcitation. A clear heavy-light hole splitting in the nearly unstrained layers on 3C-SiC is found. In the final part, the dependence of the transition energies on the alloy composition for InGaN and AlGaN is discussed, the bowing parameters are presented.

Band offset between cubic AlN/GaN from inter- and intraband spectroscopy of superlattices
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Resume : Intersubband transitions (ISBT) in superlattices (SL) form the basis for quantum well infrared photodetectors and quantum cascade lasers. It has been shown (E.A. DeCuir et al., Appl. Phys. Lett. 91, 041911 (2007)) that due to the large band offset between GaN and AlN ISBT in SL based on cubic GaN/AlN can be realised in the technologically important 1.3-1.5 μm infrared spectral range. However, the band offset between cubic GaN and cubic AlN has not yet been determined. We report the analysis of inter- and intrasubband transitions in GaN/AlN superlattices. SL struc-tures were fabricated by plasma-assisted molecular beam epitaxy on free standing 3CSiC substrates. The structural properties of our samples were studied by high resolution X-ray diffraction (HRXRD). Several peaks in the HRXRD spectra reveal a high structural perfection of the MQW region. Clear intersubband transitions were observed by photoluminescence spectroscopy (PL) at room temperature and 2 K. Infrared absorbance and photoconductivity spectra revealed clear intra-subband transitions in the spectral region of 1.55 _m measured at room temperature and 77 K. These transition energies were compared to calculated energies using a 1D Poisson Schrödinger solver. For the calculations standard parameters for cubic GaN and AlN were used, while the band offset be-tween GaN and AlN was varied. Optimal agreement between experimental and theoretical data was obtained for a band offset _ EC:_EV of 53:47.

2010 G: Physics and applications of novel gain materials based on III-V-N compounds

The low loss window of optical fibre has recently been extended to cover 1.3 to 1.7 μm, increasing the potential capacity of optical networks. As a result, optoelectronic devices operating in this wavelength range dominate photonics research. However, the tailoring of heterostructure properties is dictated by the different lattice constants of the binary III-Vs. As a result the range of useful compositions and the range of available band gaps are limited. Moreover, the alignment of the band edges, which is very important for the performance of devices, cannot be tailored by the combination of conventional materials. These limitations can be greatly reduced by incorporating a few percent of nitrogen as a group V element into GaAs or InGaAs, i.e. by creating the so-called "Dilute Nitrides". In most III-V materials, substituting an element for one with a smaller atomic radius reduces the lattice constant and increases the bandgap. However, replacing a fraction of arsenic atoms in GaAs with smaller N atoms rapidly reduces the bandgap and allows band alignment, lattice constant and strain to be tailored, opening up a new dimension of band engineering. The second class of novel gain materials is based on the In1-xGaxN compound. It was recently discovered that InN has a much smaller fundamental energy gap than was believed hitherto. As a consequence the range of wavelengths that can be accessed by alloying this material with GaN has been significantly extended. Indeed GaInN has the widest range of direct gap of any compound semiconductors ranging from 0.7 eV to 3.2 eV which can be utilised in optoelectronic device applications over a wide range of wavelengths, including numerous key wavelengths for applications in the medical, environmental and communications fields. From a devices point of view, a key commercial target for the In-rich material is high-efficiency low-cost solar cells. Efficiencies close to the theoretical limit could be achieved by use of the whole In1-xGaxN

composition range in graded layer cells and/or with quantum well multilayers; improved radiation hardness for space applications is an additional advantage. Furthermore, since the toxicity of materials used in existing solar cells is a serious concern for large scale deployment, In1-xGaxN also offers the benefit of a safer alternative.

The pursuit on narrowing the growth temperature gap for InGaN heterostructures
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Resume : Integrated ternary In1-xGaxN heterostructures over a large compositional range are of great importance for applications such as highefficient spectral agile light sources and detectors, radiation hardened magneto/optoelectronics, advanced high-speed optoelectronics and optical communication devices. The small band gap of the binary InN at around 0.7 eV inspires group III-nitride device structures that can operate from infra-red (IR) to ultra-violet (UV) spectral regime. While much progress has been made in the growth on InN and indium-rich In1-xGaxN alloy over the recent years, a major obstacle remains in the integration of indium-rich alloys into wide band-gap III nitride heterostructures. The obstacle is due to the encountered temperature gaps between the growth of group III-nitride binaries in presently employed low-pressure deposition techniques. For instance, the optimum growth temperatures of InN and GaN differ more than 300°C under low-pressure organometallic chemical vapor deposition growth condition. A potential pathway to address the temperature gap between the binaries is to explore the pressure dependency of surface chemical reactions and growth surface stabilization and to evaluate whether a pressure regime with a common InN and GaN growth temperature window exists. This pathway is presently explored at GSU, by establishing a high-pressure chemical vapor deposition (HPCVD) reactor system and assessing the processing conditions for InN and ternary InGaN epilayers. This contribution will discuss the HPCVD concept explored as well as the HPCVD system and the engineering tools needed to control and monitor gas phase reactions and growth surface chemistry. We will present results by x-ray diffraction, Raman, photo luminescence, and infrared reflectance. Based on the experimental characterization results, the influence of the growth pressure on compositional homogeneity and point defects is discussed. The presentation will conclude with the present state of research at GSU and provide an assessment to whether a common group III-nitride process window is possible.

Optimization of the asperities of the interfaces for InN/GaN quantum wells of higher thermal conductivity
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Resume : Quantum wells of InN/GaN have recently attracted a lot of attention due to their optical properties which are suitable for novel photonic devices, especially vertical cavity surface emitting lasers. However, in such structures the heat generation density reaches more than 106W/cm3. With the continuous reduction in the size of the optoelectronic devices and systems and their time scale which requires fast removal of enormous heat, methods for increasing the heat dissipation in these structures become extremely needed for system failure prevention. In this contribution we propose the engineering of the InN/GaN and GaN/InN interfaces to increase their thermal conductance and thus, increase the overall system thermal conductivity. Such interfaces engineering will certainly help to increase the heat dissipation in the InN/GaN quantum wells based lasers and therefore improve their performance. To calculate the thermal conductance of an interface the acoustic mismatch model and the diffuse mismatch model have been traditionally used. The acoustic mismatch model makes the simplifying assumption that the entire phonons

incident at an interface undergoes specular reflection or transmission and is governed by continuum mechanisms. In the diffuse mismatch model the assumption of complete specularity is replaced with the opposite extreme. It is assumed that all the phonons are diffusively scattered at the interface with a complete destruction of the acoustic correlation between the wavevectors of the incoming and outgoing phonons. Thus, in both acoustic mismatch model and diffuse mismatch model there are "strong" assumptions considered to be physically valid for all the phonons in the entire Brillouin zone. In order to approach to realistic and reasonable phonon mechanisms at the interface, one should consider that a phonon can specularly transmit and diffusively scatter, but according to certain criteria. In this contribution, we tackle this issue and in order to calculate the thermal conductance of the interface InN/GaN and GaN/InN we employ a newly developed model which rejects all the previously adopted strong assumptions. Instead the Debye approximation, we consider the detailed phonon spectrum of the materials calculated from ab-initio approaches. Another key development we present is that the phonon specularity and scatering at the interfaces are predicted from a statistical model for a reflection of a plane wave from an interface. Thus, in our model we allow for a given phonon to specularly and diffusively transmit. Nevertheless, the criteria of specularity and scattering are the angles of incident, the phonon wavelength and the interface asperities. Since in our model the interface thermal conductance depends on the interface asperities, we can predict the best conditions of the GaN/InN and InN/GaN interfaces which permit the higher thermal conductance. Thus, the proposed model is expected to contribute significantly to the engineering of superlattices and quantum wells of high performance in optical technologies.

Effect of doping on the mid-infrared intersubband absorption in III-nitride superlattices grown on Si(111) templates

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Resume : Extending the intersubband (ISB) transitions in III-N nanostructures from near-IR to longer wavelengths might have significant consequences for applications like imaging, remote sensing and mine detection. Although other technologies like MCT or GaAs have proven performance in this spectral range, they present limitations related to material growth, long response time or requirement of cryogenic temperatures. An alternative material system to overcome such impediments is AlGaN/GaN, with an LO-phonon energy well above the room temperature thermal energy. We have previously demonstrated photo-induced ISB absorption in the 1.3-10 μm spectral range using GaN/AlGaN [1]. In this contribution, we analyze the effect of Si doping on the ISB absorption. Si concentration around 5x1019 cm-3 provides direct absorption at room temperature. We discuss the interplay of exchange interaction, electric field screening, band filling and band gap renormalization, and their effects on interband and intersubband transitions. Exchange interaction is the dominant many-body effect at short wavelengths, inducing a blue shift of the ISB absorption line for increasing doping concentration. However, for long wavelengths, the carrier screening of the polarizationinduced internal electric field gains relevance, resulting in a red shift of the ISB transition. Experiments are explained by comparison with calculations using an 8-band k.p Schrödinger-Poisson solver.

Structural Characterization of novel InAlN and InAlGaN layers lattice matched to GaN for high-frequency electronics

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Resume : There is an increasing interest and recent progress for the attainment of InAlN alloys

lattice matched to GaN through different techniques, so that ternary III-N/GaN heterostructures can be grown strain-free. The same approach can be therefore extended for the fabrication of quaternary III-N/GaN without misfit. In this work, transmission electron microscopy and X-ray diffraction studies were carried out to demonstrate the adequate growth of high-quality 10-40 nm unstrained InxAl1-xN and InxAlyGa1-x-yN films lattice matched to ~200 nm polar GaN/sapphire templates. The layers were grown by RF plasma assisted molecular beam epitaxy and are heteroepitaxial singlephase wurtzite crystals. While the ternary alloys contain the required quantity of atoms to be coherent to the underlying network (x=0.18); intermediate compositions with varying x and y (lower and higher Ga contents) are used for the quaternaries. The key factor for these novel improved heteroepitaxies is the use of ultra-thin AlN layers or AlN/GaN/AlN multilayers as a spacer between the active epilayer and the template. Besides the important fact that no evident phase separation was found in the epilayers, they act as a barrier for the progress of threading dislocations coming from the GaN underlayer. These heterostructures have been actually implemented in HEMTs, showing excellent electron mobility, which makes them quite interesting for high-frequency electronic devices.

Interface, bulk and surface electronic properties of InN

Authors : P. D. C. King, T. D. Veal, and C. F. McConville Surface, Interface & Thin Films Group,Department of Physics,University of Warwick,Coventry,UK

Resume : A three-region model of the high n-type conductivity in InN will be presented, including contributions from the bulk, interface with the buffer layer and surface of the InN films. In particular, a parallel conduction analysis, incorporating dislocation and ionized impurity scattering and the differing surface and bulk mobilities, can account for the variation of both the Hall effect-measured electron concentration and the mobility with film thickness. For a set of In-polarity InN samples grown on GaN buffer layers under the same conditions (V/III ratio and temperature), as the film thickness is varied from 200 to 12000 nm, the electron density changes from 2 × 1019 cm-3 to 3 × 1017 cm-3 and the mobility from 300 cm2V-1s-1 to 2000 cm2V-1s-1 [1,2]. Similar results have also been observed for InN films grown on AlN buffer layers [3]. The findings of additional studies of the effects of the V/III ratio during growth on the interface-related electron density will also be presented [4]. Finally, our results will be placed in the context of recent data from other groups and the origins of the interface, surface and bulk conductivity will be discussed. [1] L. F. J. Piper, T. D. Veal, C. F. McConville, H. Lu and W. J. Schaff, Appl. Phys. Lett. 88 (2006) 252109. [2] P. D. C. King, T. D. Veal and C. F. McConville, J. Phys.: Condens. Matter, 21 (2009) 174201. [3] V. Cimalla, V. Lebedev, F. M. Morales, R. Goldhahn, and O. Ambacher, Appl. Phys. Lett. 89 (2006) 172109. [4] P. D. C. King, T. D. Veal, C. S. Gallinat, G. Koblmüller, L. R. Bailey, J. S. Speck and C. F. McConville, J. Appl. Phys. 104 (2008) 103703.

Can indium nitride surfaces be passivated?

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Resume : InN exhibits many favorable properties and as a consequence, there is enormous potential for InN to be implemented into many electronic and optoelectronic devices. Usually an electron depletion layer is observed at the surface of n-type group III-V semiconductors. However, it has been observed that InN exhibits a large accumulation of electrons at its surface. It has been recently discovered that this accumulation can be reduced by sulfur passivation. The electron accumulation layer on the surface of InN originates from the extremely low Gamma point conduction band minimum (CBM), resulting in the branch point energy, Eb, defined as the cross-over point between predominantly donorlike and acceptor-like surface states, being located high above the CBM. The ionized surface states in InN will be predominantly donor-like since the Fermi level is below Eb and hence the ionized surface states pin the surface Fermi level near Eb,

resulting in the Fermi level increasing with respect to the conduction and valence bands at the surface of InN. The development of surface passivation for InN is therefore desirable, ideally resulting in the surface becoming less chemically reactive and in a reduction of the surface band bending. The effects of treatment with ammonium sulfide solution on the band bending at the surface of InN has been investigated with x-ray photoemission spectroscopy. The surface Fermi level decreases by approximately 0.15 eV with sulfur treatment.

Applications of group III-nitride materials for solar power conversion devices
Authors : Wladek Walukiewicz,Lawrence Berkeley National Laboratory, Materials Sciences Division,Berkeley, CA 94708
Resume : The discovery of the low band gap of InN greatly expanded the range of the direct gaps of group III-nitride alloys from 0.64 to 6.1 eV in AlN. The potential of InGaN and InAlN as solar cell materials has been well established and there has been a significant worldwide effort aimed at practical realization of group III-nitride based photovoltaic devices. In this presentation I will review the current understanding of the properties of group III-nitrides with special emphasis on the In-rich alloys. The presentation will focus on the issues related to defect formation, electron surface accumulation and p-type doping. These properties are critical to any applications of the nitride materials for solar power conversion devices. The large range of the electron affinities of group III-nitride alloys offers a unique opportunity of
matching the conduction band edge of these materials to the valence band of standard semiconductors such as Si and Ge providing the unique band alignment configuration for the tandem solar cells. Most recent results on InGaN/Si hybrid tandem solar cells will be presented and prospects for other hybrid devices will be discussed. Finally I will report on a progress in utilization of group III-nitride alloys in novel designs of photoelectrochemical cells for solar light induced photolysis of water. The work was performed in collaboration with Solar Materials Research Group *Supported by US DOE

GaInNAs for photodiodes
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Resume : The additions of indium and nitrogen into GaAs result in GaInNAs, a dilute nitride material that can be grown lattice-matched to GaAs substrates whilst having band gaps smaller than GaAs. Research in using GaInNAs for photodiodes has largely remained focused on ordinary photodiodes. There are however further potentials in using GaInNAs in avalanche photodiodes (APDs). We present results from our investigations into two of such ideas. Firstly we carried out experimental work, following suggestion that GaInNAs may have suppressed electron ionisation coefficients due to band structure modifications brought on by the addition of nitrogen. Secondly we design a GaAs-based APD sensitive to 1.3_m light, using GaInNAs as the light absorber and AlGaAs (high Al content) as the avalanche region. In this approach, although GaInNAs is only used for light absorption, it enables the use of AlGaAs. The large bandgap of AlGaAs, which enables very thin AlGaAs avalanche region, is crucial to achieving gain-bandwidth products exceeding those of the current InP-based APDs.

Theory of Scattering and Impact Ionization in Dilute Nitride Avalanche Photodiodes
Authors : M. Seifikar, E.P. O'Reilly and S. Fahy Tyndall National Institute, Lee Maltings, Prospect Row, Cork, Ireland Department of Physics, University College Cork, Cork, Ireland
Resume : It is well established that replacing As by N in GaNAs leads to a strong perturbation of the conduction band structure, generally described using the band-anticrossing (BAC) model [1]. We have solved the supercell zone centre Hamiltonian for a large supercell with 4 million unit cells containing 8000 randomly placed N, to calculate the projected density of states. Our

calculations confirm the validity of using the BAC model (with energy broadening) to describe the evolution of the band dispersion with wavevector k in GaNAs. This strong perturbation also leads to a marked reduction in low-field electron mobility [2], and has been predicted to suppress electron multiplication in avalanche photodiodes [3]. We use the Boltzmann equation [4] to investigate for large electric fields the distribution of electrons and the electron drift velocity in the lowest conduction band of dilute nitride semiconductors. The overall transport behaviour calculated using the Boltzmann approximation is in good agreement with previous calculations using dynamical balance equations [5], but both sets of calculations show a much stronger negative differential velocity at higher fields than is observed experimentally [5]. References: [1] W Shan, et al. Phys. Rev. Lett. 82, 1221 (1999) [2] S Fahy, et al. Appl. Phys. Rev. B. 74, 035203 (2006) [3] AR Adams, Elec. Lett. 40, 1086, (2004) [4] EM Conwell, MO Vassel, Phys. Rev. 166, 797 (1968) [5] A Patane, et al. Phys. Rev. B 72, 033312 (2005)

Effect of the intense laser field on the exciton binding energy in Ga1- xInxNyAs1-y/GaAs quantum wells

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Resume : Effect of the intense laser field on the binding energy of ground state exciton in Ga1-xInxNyAs1-y/GaAs quantum well is investigated theoretically by a variational envelope function procedure. Also we have analyzed the influence of the well width and nitrogen and indium mole fractions on the excitonic binding. We have conclude that the excitonic binding is strongly depends on the intense laser field and nitrogen mole fraction.

Investigation of the band structure of InxGa1-xAs1-yNy/GaAs single quantum well with 10-band k.p model

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Resume : We have investigated the electronic band structure of InxGa1- xAs1-yNy/GaAs quantum well (QW) using finite element method (FEM) together with a band structure calculation based on 10-band k.p theory. The influence of well width and nitrogen and indium mole fractions on the band structure has been analyzed. It has been observed that incorporation of small amounts of nitrogen induces significant changes of the band structure. As a consequence, we have found that the band structure is strongly depends on indium and nitrogen mole fraction.

Optical and electrical properties of In-rich GaxIn1-xN structures

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Resume : Photoluminescence (PL), photoconductivity (PC) and Hall mobility of GaxIn1-xN grown by molecular beam epitaxial for x=0.22 and x=0.48 are presented. Measurements are carried out over a wide temperature range except the intensity dependence of PL radiation which is accomplished at room temperature. Band gap of GaxIn1-xN is observed to increase with Ga concentration. PC reveals a peak at 0.6 eV with a shoulder around 0.86 eV for x=0.22 as consistent with PL results. It is assumed that the PC peak at 0.6 eV originates from Ga deficient regions in GaxIn1-xN matrix, and the shoulder at around 0.86 eV corresponds to band gap energy of GaxIn1-xN. No PC signal is detected corresponding to PL peaks appearing at 1.3 eV for the sample with x=0.48. Density and mobility of carriers exhibit weak temperature dependence for x=0.22 and x=0.48 while the mobility decreases as Ga concentration increases. Carrier concentrations are used to investigate the influence of high carrier concentration on band gap of GaxIn1-xN whose outcomes are compared with the band gap obtained from the PL spectra.

Comparitave Study of GaAs and GaInNAs / GaAs Multi-Quantum Well Solar Cells
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Resume : Current voltage characteristics together with spectral quantum efficiency measurements are made on a number of GaAs and GaInNAs / GaAs multi-quantum well solar cells under illumination with AM1.5G. Nitrogen and Indium composition in the GaInNAs wells were selected as to ensured lattice matching to GaAs. The wells are shown to extend the spectral response to longer wavelengths but in some cases cause a reduction in the quantum efficiency even at wavelengths below the GaAs band gap. Furthermore, the addition of wells generally causes a large decrease in open circuit voltage due to the increased dark current.

I-V Characterization of a Staircase Quantum Well Infrared Photodetector
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Resume : In this work, a quantum well structure which consists of three different well thicknesses with three different barrier compositions producing staircase-like conduction band profile with the reputation of 30 period has been investigated. The doping concentrations of the wells are 5.0×10^16 cm- 3 and barriers are undoped. High doping concentration and thickness of the contact layers prevents band bending and provides good ohmic contacts for the device. Dark current measurements have been done at the range from 37K to 120K temperature. I-V measurements which were obtained at 37-60K have shoulder like steps as expected. Above 60K steps in the I-V curves diminish. I-V curves which were taken at the temperature range 37-60K shows that as the temperature decreases the threshold value moves to higher voltages. Activation energies of the carriers have been obtained experimentally from the temperature dependence of the I-V curves. The temperature dependence of the curves has been investigated at various bias voltages. Activation energy has been calculated at zero bias voltage from a linear fit to the data of activation energy change with bias voltage. The quantum wells of the structure assumed symmetric and having finite barrier heights, also Fermi energy of the electron population assumed independent of temperature. From the activation energy value at zero bias and Fermi energy value, barrier heights of the quantum wells and ground state energies were
obtained.

Nitrogen effect on the optical properties of GaAs0.9- xNxSb0.1 /GaAl0.15As0.85 (x<1.3) quantum wells
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Resume : Several research groups have shown that a small nitrogen incorporation into III–V semiconductor alloys induces a strong reduction of the band-gap energy. Among these materials, InGaNAs has been widely studied. However, it has been difficult to obtain lasers of good quality using InGaNAs alloys at 1.55 μm wavelength emission. It was demonstrated [1] that semiconductor alloys from the material GaAsSbN grown on a GaAs substrate can be a better candidate to optical devices that emit light at room temperature in the 1.3-1.55 mm wavelength range. In this work, the optical properties of GaAs0.9-xNxSb0.1/GaAl0.15As0.85 quantum wells (QWs) are investigated using room temperature spectroscopic ellipsometry (RTSE). The refractive index spectrum of a quantum well is essential to the design of optoelectronic devices. For this

purpose, we focus our study on the GaAs0.9- xNxSb0.1/GaAl0.15As0.85 QWs grown by molecular beam epitaxy (MBE) on GaAs substrate, and determine the QWs optical properties in the energy range from 0.75 to 5.5 eV. All samples consist of 40 nm-thick GaAs0.9-xNxSb0.1 well, with the same antimony and variable nitrogen compositions (x = 0.00 up to 1.3 %). We were able to distinguish the nitrogen effect on the QW fundamental transition energies, which is found to decrease with respect to nitrogen content. This result was compared to 8 band k.p calculations. [1] S. A. Lourenç, et al J. Appl. Phy 93, 8, 4475 (2003).

Indium and Aluminium dependence of the optoelectronic properties in In0.16Ga0.84N/InyAlzGa1-y-zN quantum well structures

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Resume : Optoelectronic properties of lattice-matched and pseudomorphically strained InxGa1-xN/InyAlzGa1-y-zN heterointerfaces having zinc blend structure, have been performed on the basis of the model solid theory and multi-band k.p. From the results obtained, we have studied, particularly, the effect of varying indium and aluminium compositions on the valence and conduction bands of Ga0.84 In0.16N/InyAlzGa1-y-zN heterostructure. It is found that both conduction and valence band states are modified when varying Al and In contents in the barrier material. More over, it is observed that the line-ups at Ga0.84In0.16N/InyAlzGa1-y-zN interface change from type I to type II. Such derived informations are used for the design of lattice matched heterostructure in modelling optoelectronic devices emitting at the blue spectral domain. In fact, using two different models; the one-version of the envelope wave function and the k.p method, analysis are made to investigate the effect of the barrier constituents and the well width on the Ga0.84In0.16N/InyAlzGa1-y-zN single quantum well interband transitions. Such investigations are done with the aim to achieve light emissions sweeping the blue spectral domain. Good agreements are obtained between the different results.

Structural properties of GaAsN/GaAs quantum wells studied at the atomic scale by cross-sectional scanning tunneling microscopy

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Resume : The optical emission of (In)GaAsN/GaAs quantum wells (QWs) shows typically a strong degradation when the N content is increased. This has been frequently attributed to different phenomena, such as N being incorporated in interstitial positions, compositional fluctuations in the alloy, or a rough top interface. All these have motivated a strong effort in the last years on the structural characterization of (In)GaAsN alloys, but only very few of these studies were performed using cross-sectional scanning tunneling microscopy (X-STM). This technique is very useful because it allows to image the cross section of a QW with atomic resolution and to distinguish between the different atoms in the alloy. In this work, we have used X-STM to study at the atomic scale the N distribution in Molecular Beam Epitaxy grown GaAsN/GaAs QWs with different N contents ranging between 1.0% and 2.5%. Structural properties with influence on the optical properties of the QWs are discussed, such as segregation, interface roughness, or the background N concentration in the barriers. While no nitrogen clustering is observed in the range of N contents studied, the upper interface roughness is found to increase with the amount of N, as well as the residual N concentration in the GaAs barriers.

Material gain calculation in Ga(In)NAs/Gas QWs

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Resume : We look into the gain of compressively strained Ga(In)NAs/GaAs quantum wells. The bandstructure is derived using the BAC model with two impurity levels one for sinlge-N and one for the N-pair atoms. We use the kselection rule and a Lorentzian lineshape function. In the model for the conduction band a many-impurity Anderson problem approach and Green's functions are used. From these we obtain information about a complex conduction band structure, its density of states and its fractional "Gamma" character. This information will be used as an input in the gain calculations. For the valence band structure we use previous experimental results. For example, we can weight every electron-hole transition by the fractional conduction band character. According to this we expect for instance that at k=0, the E0+ _ hh1 transition (where E0+ the upper band in the 2 BAC model) will be less important than what was found in previous models, giving thus a more realistic representation of the system. Gain is extracted as a function of energy and carrier density for various combinations of energy positions of the localized N states and their strength of mixing with the delocalized host states.

Band alignment and critical layer thickness of GaIn(N)As(Sb) QWs on GaAs and InP substrates

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Resume : We present a review of our calculated results based on the comparison of band alignment of strained and strain-compensated GaInNAs QWs and critical layer thickness of GaIn(N)As(Sb) QWs on GaAs and InP substrates for (001) and (111) orientations. We first present theoretical calculations to compare the band alignments of N-free and N-included laser devices on GaAs and InP substrates. Our calculations indicate that the band alignmnet of the N-based conventionally strained QW laser systems on InP substrates are better than that of the GaAs substrates. We have also shown that the introduction to the opposite strain to the barrier in N-based lasers on both GaAs and InP substrates not only results in deep electron wells but also causes the the electron wells being much deeper than that of the hole wells. Our calculated results indicated that the problems that has been met in GaInNAs QW due to high In and N concentrations could have been eliminated by means of incorporation of Sb atoms into GaInNAs. The use of quinary GaInNAsSb on InP substrates has brought improvements in critical layer thickness and allowed the tuning of the required wavelength.

The influence of As/III pressure ratio and annealing temperature on optical properties of GaInNAs quantum wells

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Resume : In general, it is expected that the control of nitrogen environments during the growth process can be very profitable since it can improve luminescence efficiency already for the as-grown material and reduce blueshift after annealing. In this work we applied contactless electrorefectance (CER), temperature dependent PL and time resolved spectroscopy to investigate quality and optical properties of GaInNAs samples obtained at various As/III pressure ratio and annealed in different temperature. The GaInNAs/GaAs QW samples were grown on n-type GaAs:Si substrates by a solid-source MBE system equipped with rf nitrogen plasma source. Triple QW structures of the nominal alloy compositions of Ga0.62In0.38As0.0995N0.005, each QW being 6.5 nm thick and separated by 20 nm GaAs barriers. We showed that changing the As/III pressure ratio we can control the nearest-neighbour environments. At low pressure As/III ratio we observed that ground state transition is composed with two CER resonance corresponding to

different nitrogen nearest-neighbour environments (N-Ga and Ga4-mInm-N bond). A high As pressure we observed only one CER resonance corresponds to the most favourable nitrogen nearest-neighbour environments. Using PL and time resolved spectroscopy we showed that samples obtained in higher As pressure have better optical properties then samples grow on low As pressure. The quality of samples can be still improved by annealing process for which exists some optimal temperature.

GaAsSbN-capped InAs quantum dots for 1.3 – 1.55 μm emission

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Resume : A recent approach to extend the emission wavelength of InAs/GaAs quantum dots (QD) to the 1.55 μm band is the use of GaAsSb capping layers. The strong red shift observed has been shown to have three contributions: the increased QD height due to reduced In-Ga intermixing during capping, the reduced strain, and a transition to a type-II band alignment at high Sb contents (~ 16 %). The main problem with this strategy is that emission at 1.55 μm can only be achieved with a type-II band alignment that degrades the photoluminescence (PL). In this work, we explore the possibility of reaching the 1.3 – 1.55 μm region with InAs QDs by adding small amounts of N to a low Sb content GaAsSb capping layer. The strong conduction band energy reduction experienced by the capping layer in the presence of N would red shift the QD PL emission and could allow reaching 1.55 μm while keeping a type-I band alignment. Several GaAsSbN-capped InAs QD samples with different Sb and N contents were grown by Molecular Beam Epitaxy. A PL peak wavelength shift of ~100 nm is found for N contents of ~ 2 %, together with a small FWHM broadening and a reduction of the integrated intensity. The role of the ionized nitrogen species on this PL degradation is studied by modifying the ion density through an external magnet. The effect of N on the temperature behaviour of the QD luminescence is discussed, as well as the impact of rapid thermal annealing on the PL properties of samples with different N contents.

MOVPE grown InGaAsN/GaAs site-controlled quantum wires emitting at 1.3μm

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Resume : Dilute nitride GaInAsN/GaAs alloys are promising for fabricating lasers and single photon emitters at telecom wavelengths. Here, we report significant progress on metallorganic vapor phase epitaxy (MOVPE) of GaInAsN nanostructures, especially V-groove quantum wires (QWRs), with emission wavelength of 1180nm at low temperature. At a first step, we obtained longwavelength emission (>1μm) by N incorporation into InGaAs/GaAs quantum wells (QWs). In order to overcome N desorption, we grow our nanostructures
at low temperature, typically 520°C. Moreover, the use of misoriented (100) substrates allowed us to redshift the emission from 1180nm to 1250nm at 77K. Our GaInAsN V-groove QWRs are grown on patterned on GaAs (100) substrates. In this site-controlled structure a combination of capillarity effect and growth rate anisotropy induce a self limiting profile during growth, forming a quasi-1D structure. Our first results show successful incorporation of Nitrogen in this structure, evidenced by emission redshift down to 1180nm at 10K, corresponding to 1300nm at room temperature. The observed linewidth at low excitation power is ~30meV, evidencing disorder due to structural and alloy fluctuations along the wires. An excited state appears at higher excitation powers, providing evidence for 2D quantum confinement. Preliminary results show that N experiences capillarity effects like those of group III adatoms.

Novel Ga(NAsP)-based Heterostructures for the Integration of Optoelectronic Functionalities on (001) Si-Substrate

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Resume : The novel direct band gap, dilute nitride Ga(NAsP)-material system allows for the first time the monolithic integration of a III/V laser material lattice matched to Si substrate. This lattice-matched approach offers the possibility for a high-quality, low defect density integration of a III/V-laser material potentially leading to long-term stable laser devices on Si-substrate. The broad area laser structures consist of pseudomorphically strained active Ga (NAsP)/(BGa)(AsP) multi-quantum-well heterostructures (MQWHs) embedded in thick doped (BGa)P waveguide layers, grown by a specific low-temperature metal organic vapour phase epitaxy (MOVPE) process on (001) Si-substrate. This paper will present and discuss the current status of the material and device optimization to realise electrical injection laser diodes as a basis for Siphotonics based optoelectronic integrated circuits (OEICs) with novel functionalities.

2010 R: Laser processing and diagnostics for micro and nano applications

The primary goal of the EMRS is to promote the materials agenda within the European Research Community, focusing on both fundamental and applied issues concerning materials development, assessment, functionality, and applications. This proposed symposium addresses laser and plasma materials synthesis, processing, and diagnostics with the special emphasis on micro-and nano-scale applications across a broad range of science and technologies, directed towards both fundamental and applied end goals. Laser ablation, patterning, micro/nano structuring, microanalysis and laser synthesis of nanomaterials of materials have been applied across the full range of scientific disciplines, covering materials science, engineering, photonics, biophotonics, display technologies and opto- and microelectronics for biosensing and environmental monitoring. The recent widespread availability ofhigh power and ultrashort pulse lasers has also opened up the realm of multiphoton materials rocessing, enabling the fabrication of subsurface structures inside functional dielectric hosts, aser direct write techniques and true nanoscale materials engineering, where structures of ub-wavelength dimensions can be designed and produced using photons. This symposium ill focus on the inherent interdisciplinarity of laser and plasma materials processing, and will ngage across the broadest range of topic areas. There will be great emphasis on the scope or research collaboration between laser scientists and those in the biological and life sciences renas, where the challenge exists for building bridges across these otherwise dissimilar ields. A dedicated session will address hot topics within the bioscience area, where laser and lasma processing can make significant inroads.

ULTRAFAST LASER ABLATION AND DEPOSITION OF WIDE BAND GAP EMICONDUCTORS
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Resume : We report on the properties of the ablation plume and the characteristics of the films produced by ultrafast PLD (about 300 fs, at 527 and 263 nm) of CdS and ZnS semiconductors. We analyzed the modification of the targets induced by different number of laser shots, deriving the damage/modification threshold and incubation coefficient of the materials. Plume characteristics were studied by exploiting time and space resolved emission spectroscopy and gated imaging. By appropriately changing the number of laser shots, we obtained less than one layer deposits consisting of isolated nanoparticles on mica substrates, and nanoparticle-assembled films on Si substrates. Crystalline quality and composition of the deposits was studied by using X-ray diffraction and X-ray photoelectron spectroscopy, while the surface morphology was analyzed by environmental scanning electron microscopy and atomic force microscopy. Photoluminiscence of the deposited films was also measured at room temperature. The results are discussed in terms of the composition and expansion dynamics of the semiconductor plasma plume and of the properties

of the deposited nanoparticles and nanostructured films. These results also allow investigating the influence of the laser irradiation wavelength on the obtained nanostructures in a range of laser fluences that are suitable for obtaining deposits.

Direct laser printing for high efficiency silicon solar cells fabrication

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Resume : Silicon solar cells still require cost reduction and improved efficiency to become more competitive. New architectures can provide a significant increase in efficiency, but today most of the approaches need additional processing steps. In this context, laser processing offers a unique way to replace technological steps like photolithography that is not compatible with the requirements of the photovoltaic industry. Selective ablation of dielectric with laser light is studied to open locally antireflection and passivation coatings at the front surface of silicon solar cells in order to take electric contacts. At the same time localised thermal effects induced by laser can be used favourably to activate or re-organise dopants that are present in the emitter. This paper proposes to investigate the influence of a nanosecond UV laser on phosphorous doped silicon emitters. Different crystalline silicon wafers with SiN layer and various doping concentrations (from 4x1019cm-3 to1020 cm-3) will be used. The interaction of the UV light with silicon will be characterised by optical and scanning microscopy, secondary-ion mass spectroscopy, sheet resistance cartography and I(V) measurements. Results will be apply to the fabrication of selective emitter solar cells that require high doping level in the electric contact areas and low doping concentration elsewhere. The process is potentially self- aligned and well suited to electroless or electrolytic metal contact deposition.

Excimer laser accelerated synthesis of morphology and size controlled ZnO nanocrystals

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Resume : The synthesis of ZnO nanocrystals is reported using a hydrothermal chemical growth technique combined with 248 nm nanosecond excimer laser annealing at fluences in the range 0 – 390mJ/cm^2. The effect of the annealing in controlling the morphology of the nanocrystals is investigated using optical spectroscopy and electron microscopy characterization. Laser annealing is shown to allow control of the crystal morphology from nanoparticles to nanorods as well as to modify the size distributions. A laser heating model is introduced in order to clarify the effect of the irradiation. The results indicate that not only does the laser accelerate

Sub-100nm-Structuring using Optical Near Fields of Nanoparticles

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Resume : Nanoscopic particles can be used for structuring large surface areas with single laser pulses, employing the effect of optical near fields. This enhancement of the incoming electrical field of the laser allows modifying the underlying surface locally while keeping the surrounding area intact, if the appropriate laser power is applied. In the case of dielectric spherical particles larger than or comparable to the wavelength of the illuminating laser pulse, the particle simply acts as a lens, focusing the light onto the surface underneath. The minimal focal spot which can be achieved in this way has a diameter of about λ/4. Smaller features well below 100 nm can be obtained by using metallic nanoparticles. When illuminated by light, these nanoparticles act as antennas which provide a field enhancement that is confined to a very small space (down to a few

tens of nanometres). The field enhancement in the nanoparticles can be calculated using e.g. Mie-theory or DDA (Discrete Dipole Approximation) calculations. For single particles, the calculations are in good agreement with the experimental results. For ordered arrays of nanostructures, the field of the adjacent particles has to be taken in account. We present several experimental examples for the application of the above-mentioned techniques for different size regimes and particle shapes and compare them to calculations.

Fabrication of three-dimensional structures by direct laser writing
Authors : K. Terzaki (1,2), A. Gaidukeviciute(1), E. Kasotakis (2), C. Fotakis (1,3), M. Vamvakaki (1,2), A. Mitraki (1,2), and M. Farsari (1).
Resume : Two-photon polymerization technology is a nonlinear optical technique which allows the fabrication of high resolution three-dimensional (3D) microstructures. The polymerization process is initiated when the beam of an ultra-fast infrared laser is tightly focused into the volume of a transparent, photosensitive material. Two-photon absorption takes place within the focal volume; by moving the focused laser beam threedimensionally within the material, complex 3D structures can be fabricated. Here, we present our most recent work into the structuring by two photon polymerization of a series of novel organic-inorganic hybrid photosensitive materials as well as materials with metal-binding affinity. The latter ones have been subsequently functionalized with amyloid peptides which immobilize both metals and calcium phosphates without the need of intermediate layers. Our results show that two-photon polymerization presents an interesting fabrication route for microstructured materials to be used as tissue engineering scaffolds.

Laser ablation on sapphire and GaN using monolayer of microspheres
Authors : Chii-Chang Chen, Chia-Hung Hou, Chia-Hua Chan, Alexis Fischer 1Department of Optics and Photonics, National Central University, 320 Jhung-Li, Taiwan 2Centrale de Proximité en Nanotechnologies de Paris Nord, Laboratoire de Physique des Lasers, Université de Paris 13 UMR-CNRS 7538, 93430 Villetaneuse, France
Resume : We report the laser-assisted fabrication of air-holes on sapphire and GaN substrates using ArF and XeCl lasers. The monolayer of SiO2 and polystyrene microspheres is deposited on the substrates. The beam of excimer laser is focused on the substrate surface by the microspheres. Since the power density is larger than the threshold of the laser ablation of sapphire and GaN. The air-holes can be fabricated on the substrates. The patterns may enhance the extraction efficiency of GaN LEDs.

Optical and structural characterization of InN thin films grown on various substrates by radiofrequency plasma discharge assisted pulsed laser deposition
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Resume : InN has attracted much attention due to its optical and electrical properties that make it suitable for the fabrication of IR optical devices and high-speed electronic devices. In this work we report on the optical and structural properties of InN thin films grown by radiofrequency (RF) plasma discharge assisted pulsed laser deposition (PLD). Sapphire and silicon substrates are considered for the growth of these films. The influence of the substrate type, as well as the influence of the growth parameters, on the optical and structural properties of the resulting InN thin films is discussed. The optical parameters are determined by means of ellipsometry. Due to the fact that there is little data available in the scientific literature for InN optical constants, the obtained refractive indexes (n) and absorptions (k) are discussed and compared with those found by other authors. The structural analysis of the samples is done by means of X-ray diffraction (XRD). Secondary ion mass spectroscopy (SIMS) analysis is used to determine the level of incorporation of nitrogen in the resulting structures. Moreover, the morphology of the thin films is investigated through techniques of atomic force microscopy (AFM) and scanning electron

microscopy (SEM).

Templating for functional nanodevices
Authors : Ionut Enculescu National Institute of Materials Physics, Magurele, Romania
Resume : The lecture will review the concept of template fabrication and its potential in obtaining nanostructures or nanostructured materials with controlled morphology and/or high aspect ratio. Several types of templates will be discussed including the most important characteristics in terms of material, geometry and obtaining method. A focus point of this part of the presentation will be the advantages and drawbacks of nanoporous membranes such as ion track polymer templates or anodic alumina in fabricating nanowire arrays. As examples, there will be presented the preparation of nanowire devices ranging from giant magnetoresistance magnetic field sensors to photodiodes or nanostructured electrodes for energy production or storage. Further the presentation will be dedicated to self assembled sphere arrays as templates for photonic materials or nanostructured electrodes for solar cells. Finally the opportunities of using template technology in relation with laser processing will be addressed.

Semiconductor nanocrystal – polymer composites fabricated by laser processing
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Resume : Hybrid nanocomposites with semiconductor nanocrystals (NCs) embedded in organic polymers are very promising materials for radiation detection and light emission devices, combining the advantages of polymer and the unique physical properties of inorganic NCs (quantum size related properties). In polymers, doped with specific precursors, NCs can be generated by laser processing giving rise to a hybrid nanocomposite in the laser-irradiated area. In this work we report on the formation of hybrid CdS NC - polymer composite by laser writing, being CdS one of the most promising photo-sensitive materials for applications in optics, optoelectronics, sensor and energy conversion, due to its large band gap and high electron mobility. Laser processing was performed on insulator (polymethylmethacrilate - PMMA) and semiconducting (poly[2-methoxy-5- (2-(2'-ethyl-hexyloxy)-1,4-phenylene vinylene] - MEHPPV) polymers doped with the specifically synthesized precursor cadmium-bis(benzylthiolate) methyl imidazole, [Cd(SBz)2]2.MIn, devised for being highly soluble in most of the common solvent in order to ensure homogeneous dispersion in polymers. The experiments were carried out with a 3rd Nd:YAG laser by varying fluence and pulse number and by placing the samples on a 3D
driving stage with spatial resolution of 5μm. The decomposition of the precursor molecules and the formation of CdS NCs is confirmed by optical, morphological and structural characterization of the organic/inorganic compound.

Advanced laser texturing of multicrystalline photovolataic cells for the improvement of efficiency
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Resume : The surface texturing is a well-known technique to reduce reflectance on the surface of photovoltaic cells by so-called multi-bounce effect. While the anisotropic etching is commonly used for photovoltaic cells based on single-crystalline silicon, it is not effective in the case of photovoltaic cell based on multicrystalline silicon because multicrystalline silicon has random orientations of grains. According to such circumstance, laser texturing is considered as a proper alternative. For surface texturing, both the size and spacing of texture units connected to the packing density and the microstructure related to the number of times multi-bounced are main factors in reflectance. The present paper indicates a new approach to texturing, which utilizes UV laser in order to make hexagonally-spaced texture units directly on the surface as small as possible

and the etching mask layer of SiNx to prevent the etching process from smoothing textured structures. It is demonstrated that well-made texture units with a cross section similar to a triangle are properly formed on the surface. Such surface structures effectively contribute to a decrease in reflectance. While wet-etched texture units usually have a cross section similar to a hemisphere and a change in the slope of their sides, the texture units built in the experiments have a cross section analogous to a triangle and a nearly constant slop of their sides.

APPLICATION OF THE LASER PROCESSING FOR MESUREMENT OF DEFORMATIONS OF OBJECTS

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Resume : Abstract The electronic technique of interferometry speckle, used in the measurement of the deformations of diffusing objects, is based on the process of subtraction of the figures of interferences. A first image of speckle is recorded before the deformation of the object in the RAM of a computer, followed a second after deformation. The square of the difference between the two images gives fringes of correlation in observable real times directly on the monitor. The interpretation of these fringes makes it possible to determine the deformation. In this communication, we have experimental results of deformation out of the plan of two samples out of Aluminium and stainless.