出國報告(出國類別：其他(開會))

光電半導體元件與系統應用關鍵計畫－雷射光電技術出國報告

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：美國
出國時間：101.8.11~101.8.18
報告日期：101.9.17

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	光電半導體元件與系統應用關鍵計畫－雷射光電技術出國報告		
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	美國	出/返國日期	101.8.11 / 101.8.18
建議事項	1. 紅外線感測元件的雜訊問題一直是元件發展的重要議題，而降低漏電流可直接改善元件效能，報告中提到的原子層沉積技術，因其具有成長速度慢可成長高品質薄膜之優點，目前大多用於電晶體之高介電(high-k)層之研發與製作，本院亦有原子層沉積系統，可發展相關介電層成長技術，以利應用於紅外線感測元件。 2. 室溫熱像爲本計畫發展之一重要主軸，相較於低溫紅外線熱影像技術，室溫熱像因無致冷裝置可大幅降低製作成本，除軍事用途外，亦可廣泛應用於民生用途，本次會議展覽會場相關紅外線廠商展出之室溫熱像產品，其解析度高達 640×480，爲目前室溫熱像高階產品，可評估是否採購以作爲計畫未來發展室溫熱像技術之參考。 3. 科技的發展日新月異，如何提升固有技術水準以及開發新技術，一直是科技研發人員所追求的目標，本院爲國內軍事科技研發重鎮，爲提升本院技術能量，科技同仁除在工作上克盡職責外，亦應注意科技研發動向與趨勢，一方面可提升自己的知識水準，另一方面對於技術研發工作亦有相當助益。		
處理意見	1. 本院之原子層沉積系統目前可沉積氧化鉿與氧化鋁兩種介電質薄膜，相關技術正在研發階段，未來可應用於本院研發之紅外線感測元件。 2. 該公司產品經查國內有代理商代理其產品，已聯絡並取得相關資料，與計畫主持人討論後，在計畫預算經費許可下，可考慮採購以作爲計畫未來技術與產品發展之參考。 3. 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。		

報　　告　　資　　料　　頁			
1.報告編號： CSIPW-101Z-H0003	2.出國類別： 其他(開會)	3.完成日期： 101 年 9 月 17 日	4.總頁數： 65
5.報告名稱：光電半導體元件與系統應用關鍵計畫－雷射光電技術出國報告			
6.核准文號	人令文號	101.7.6 國人管理字第 1010008714 號	
	部令文號	101.7.2 國備科產字第 1010009869 號	
7.經　　費		新台幣：125568　元	
8.出(返)國日期		101 年 8 月 11 日至 101 年 8 月 18 日	
9.公 差 地 點		美國	
10.公 差 機 構		光學與光子國際學會	
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：光電半導體元件與系統應用關鍵計畫－雷射光電技術出國報告

頁數 65 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/林家慶/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(開會)

出國期間：101 年 8 月 11 日至 101 年 8 月 18 日 出國地區：美國

報告日期：101 年 9 月 17 日

分類號/目

關鍵詞：

紅外線感測、奈米結構、光電材料、光電元件

內容摘要：(二百至三百字)

為執行 101 年度經濟部科技專案光電半導體元件與系統應用關鍵計畫，派員赴美國參加 2012 SPIE 光學與光子國際研討會，瞭解國際間光學量測應用技術、紅外線材料發展與元件製程技術、奈米結構於光電元件應用等最科技發展趨勢，內容包含新紅外線材料技術研發與應用，以及元件製程技術的改善，相關研發成果有助於改良現有紅外線感測元件；而奈米結構應用於光電與電子元件之效能提升與元件結構開發，均有助於本院光電元件技術發展，提升技術能量；另外，展覽會場所收集之室溫熱像相關資料，亦可作為未來發展高階室溫熱像產品之參考，俾利計畫執行與未來建案規劃。

目　　次

光電半導體元件與系統應用關鍵計畫－雷射光電技術出國報告

壹、 目的

本案爲執行 101 年度經濟部科技專案光電半導體元件與系統應用關鍵計畫-雷射光電技術項目出國計畫，派員赴美國參加 2012 SPIE 光學與光子國際研討會，研討及蒐集最新光電技術領域相關應用技術，瞭解光電材料、元件與系統最新發展技術，汲取相關技術知識與經驗，俾利室溫紅外線熱影像與雷射光斑精密角度量測技術開發執行與後續建案規劃作業。

貳、 過程

本次參加之會議由國際光學與光子協會(SPIE, the international society of optics and photonics)於美國聖地牙哥舉辦，該協會於 1995 年成立，目的爲發展以光爲基礎之先進科技，該協會每年均在北美、歐洲、亞洲等地舉辦超過 25 場技術研討會、展覽和教育課程，目前已任命超過 900 個終生會員；本次會議「2012 SPIE 光學與光子國際研討會」爲該協會舉辦之年度重要光電領域國際會議，會議內容區分爲四大主題:奈米科學與工程(NanoScience+Engineering)、太陽能源與科技(Solar Energy+Technology)、有機光子與電子(Organic Photonics+Electronics)、光學工程與應用(Optics Engineering+Applications)，共包含 77 項會議項目，發表論文超過 2000 篇，發表國家包含美洲地區的美國、加拿大、墨西哥等國，歐洲地區的英國、法國、德國、西班牙等國，亞洲地區的台灣、中國、日本、韓國等國，總計超過 50 個國家研究機構發表論文，會議參加人數超過 4000 人，而展覽會場亦有超過 200 家廠商參展，會議主席與共同主席由下列專家學者擔任:David L. Andrews (University of East Anglia Norwich, UK)、James G. Grote (Air Force Research Lab., USA)、Satoshi Kawata (Osaka University, JAP)、Manijeh Razeghi (Northwestern University, USA)、Martha Symko-Davies (National Renewable Energy Lab., USA)與 Zakya H. Kafafi (National Science Foundation, USA)，參展廠商領域多爲光學元件、光學鍍膜、測試與量測設備、雷射組件與系統、偵測器以及相機與影像系統等，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奈米科學與工程與光學工程與應用，參加之研會場次如下:

- 超材料:基礎與應用 (Metamaterials : Fundamentals and Applications)

- 光學系統校正、容錯與比對 (Optical System Alignment, Tolerancing, and Verification)
- 干涉學:技術與分析 (Interferometry : Techniques and Analysis)
- 紅外線遠端感測與設備 (Infrared Remote Sensing and Instrumentation)
- 紅外線感測器、元件與應用 (Infrared Sensors, Devices, and Applications)
- 固態照明國際研討會 (Twelfth International Conference on Solid State Lighting and Fourth International Conference on White LEDs and Solid State Lighting)
- 奈米磊晶:材料與元件 (Nanoepitaxy : Materials and Devices)

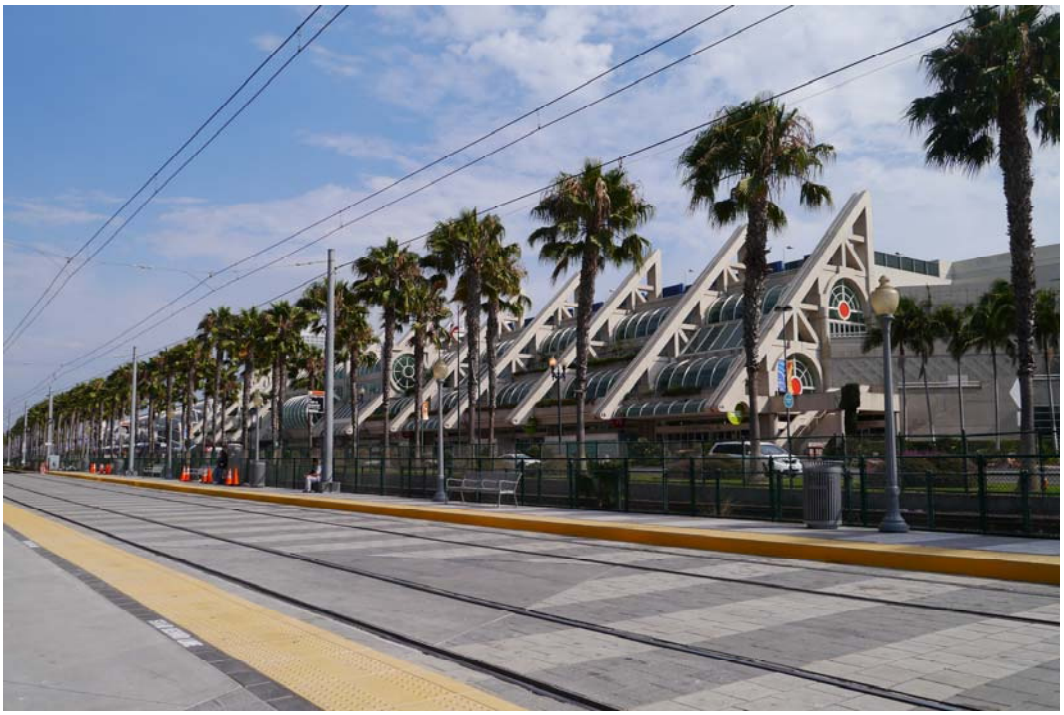
研討會議程參與時間如下表，相關議程內容亦列於附件一:

國防部軍備局中山科學研究院出國人員工作計畫表

日　期	星期	行程		公差地點	工　作　項　目	備　考
		出發	抵達			
101.08.11	六	桃園	聖地牙哥		去程。	夜宿聖地牙哥。
101.08.12	日			美國加州聖地牙哥	1.辦理註冊報到。 2.研討光學系統校正與比對技術,有助於雷射光斑定位技術開發。 3.研討紅外線遠端感測與設備技術,可作為開發紅外線影像技術之參考。	夜宿聖地牙哥。
101.08.13	一			美國加州聖地牙哥	1.研討奈米光學、奈米磊晶材料與元件之特性相關技術,可應用於計畫光機設計與製作。 2.研討固態光源與應用技術,做為計畫開發光源之參考。	夜宿聖地牙哥。
101.08.14	二			美國加州聖地牙哥	1.研討紅外線元件與應用技術,做為開發紅外線元件之參考。 2.研討光學微操作技術,做為開發精密定位之參考。	夜宿聖地牙哥。

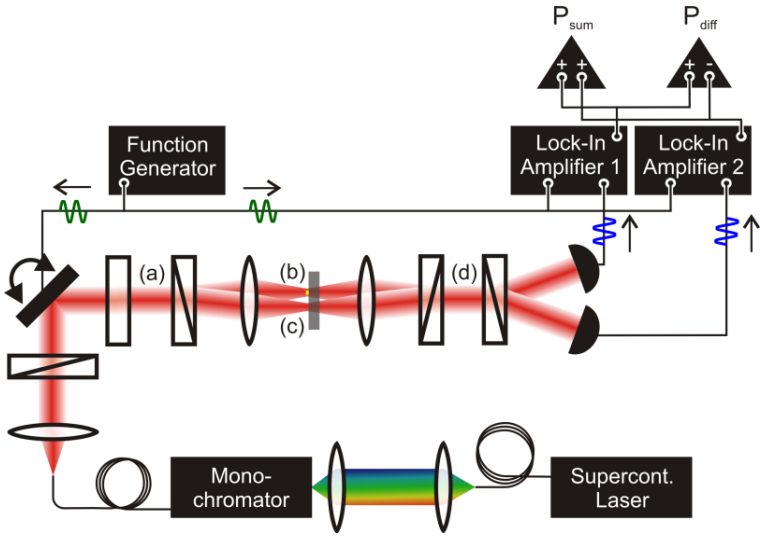
101.08.15	三			美國加州聖地牙哥	1.研討先進光學系統設計與最佳化，有助於雷射光斑定位技術開發。 2.研討表面反射、散射與繞射技術，可為雷射光斑絕對定位開發之參考。	夜宿聖地牙哥。
101.08.16	四			美國加州聖地牙哥	1.研討奈米光子材料與元件技術等，有助於紅外線元件開發。 2.參觀參展廠商產品展覽並蒐集精密定位與紅外線熱像最新產品資訊等相關資料。	夜宿聖地牙哥。
101.08.17	五	聖地牙哥			回程。	夜宿機上。
101.08.18	六		桃園		回程。	

下圖爲本次研討會會議地點 San Diego Convention Center

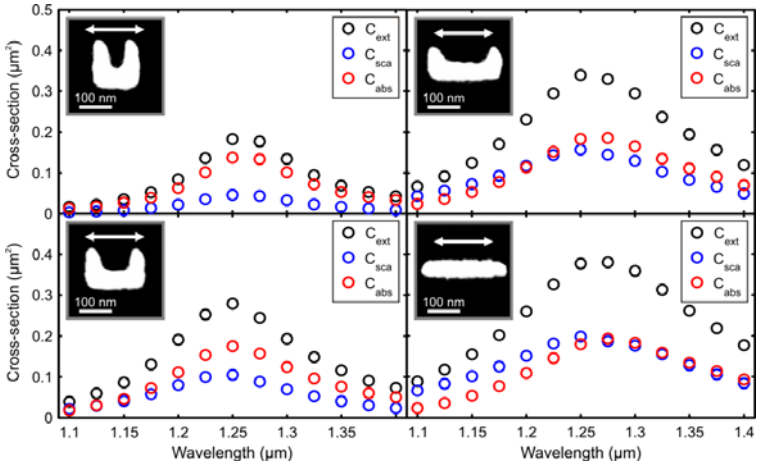


本次會議議程主題幾乎含括所有光電方面的應用，部分會議主題甚至長達三至四天，無法全程參與所有之規劃議程，以下就所參與之技術會議報告內容作重點說明:

1. 單一金屬奈米天線截面的散射與吸收的定量測量(Quantitative measurement of scattering and absorption cross sections of individual metal nano-antennas): 本篇報告由德國 Karlsruher Institut of Technology 發表，內容關於使用一個干涉計節空間調變技術來量測單一金屬奈米物體－例如裂縫環狀的共振器(split-ring resonators)或是直形天線(straight antennas)－的絕對吸收與散射。因爲在典型光學聚焦的奈米物體裡，入射光幾乎不會改變，而該團隊之前利用鎖相技術(lock-in technique)發現其實相對穿透有等於或小於 1 %的變化，在本報告中利用一個基於光學理論與雷射聚焦面積的絕對量測來確定絕對消光截面，此消光截面即是吸收與散射的總和，並使用具有偏光靈敏干涉計的空間調變技術來決定在前進方向散射強度的實部與虛部(即爲消光與散射截面)，實驗裝置如下圖:

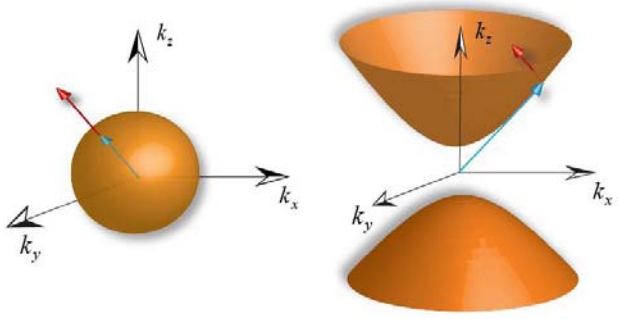


奈米物體相對於波長的吸收與散射可由數學推導得知，實驗上由於玻璃的粗糙度會大於奈米天線產生的干涉訊號，因此使用 30 nm 厚度的原子等級平整度的氮化矽(SiN)薄膜替代。實驗結果顯示當奈米天線由環狀轉變爲直線形，其散射(Csca)與消光(Cext)的比例會增加，如下圖所示。

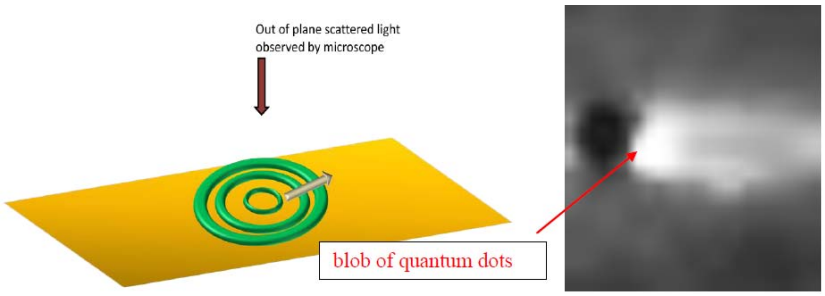


2. 控制具有散熱器與曲線型態的雙曲線超材料的反射與穿透(Control of reflectance and transmittance in hyperbolic metamaterials with scatterers and curvilinear geometries):本篇報告由美國 Cornell University 發表，內容是關於降低具有散熱器的薄片型雙曲線超材料的反射，就跟平面型雙曲線超材料一樣好，反射的降低是藉由加強在前進與後退方向的穿透無互相作用來達成，實驗的結果非常近似於馬克斯威爾方程式的數值解，本研究可延升至一些很重要的應用，例如在光伏元件內光侷限的頻寬增強。

3. 在雙曲線超材料裡的單光子共振圓錐(Single photon resonance cone in hyperbolic metamaterials): 本篇報告由加拿大 University of Alberta 發表，內容是關於在雙曲線超材料的近場(near-field)裡有一無限的局部態位密度(local density of states)，這會將自發性的放射導向超材料態位的共振圓錐。理論上使用格林函數來計算態位密度，在靠近一個雙曲線散射介質的局部態位密度是無限的，並使用自發性放射的半古典理論來分析由於態位密度的獨特性，一個射子再靠近超材料的衰減速率的發散，其發散爲一點雙極的發散，如下圖



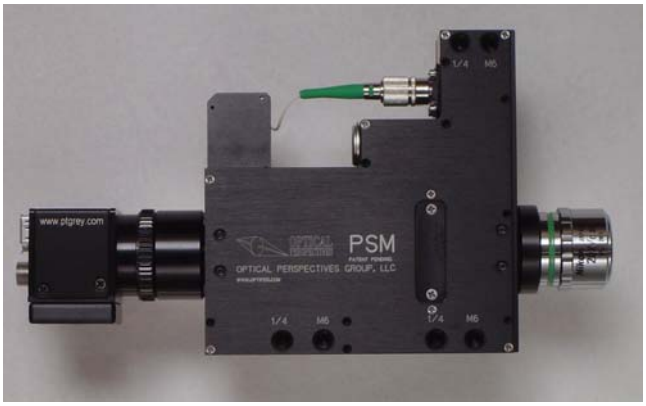
真空中圓形發散會導致一有限的態位密度，而異向性超材料則有一雙曲線發散關係可允許具有很大 k 值的波向量傳遞。實驗上在一金屬基板上以 PMMA 材料製作環形結構，在有效介質趨近下，此結構可產生一獨特的表面態位，將量子點放置在此環形結構內部，在光學灌注之下，可發現一螢光由量子點發射產生自發性放射現象，如下圖所示:



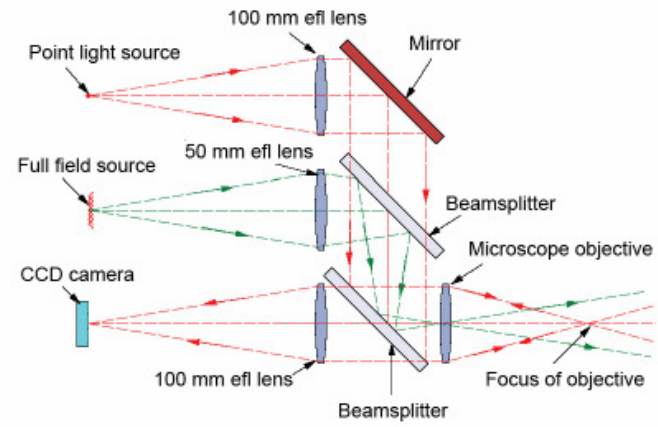
此一發現亦開啓超材料在量子光學的應用。

4. 使用一個自動共點顯微鏡實際對焦(Practical alignment using an autostigmatic microscope):

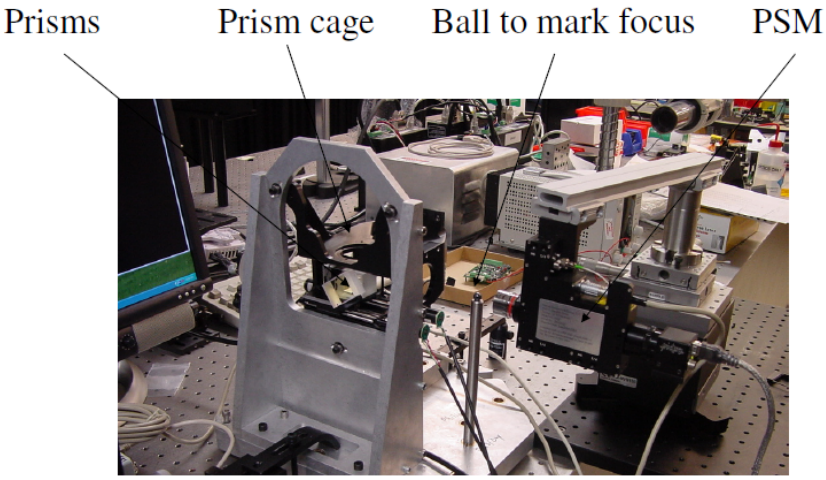
本篇報告由美國 Optical Perspectives Group, LLC 發表，內容是關於使用自動共點顯微鏡來校正光學鏡片或儀器。自動共點顯微鏡即爲一具有內部點光源之顯微鏡，並具有內部分光鏡可反射光源回傳的影像，商業型名稱是點光源顯微鏡(Point Source Microscope, PSM)，下圖爲該公司點光源顯微鏡示意圖:



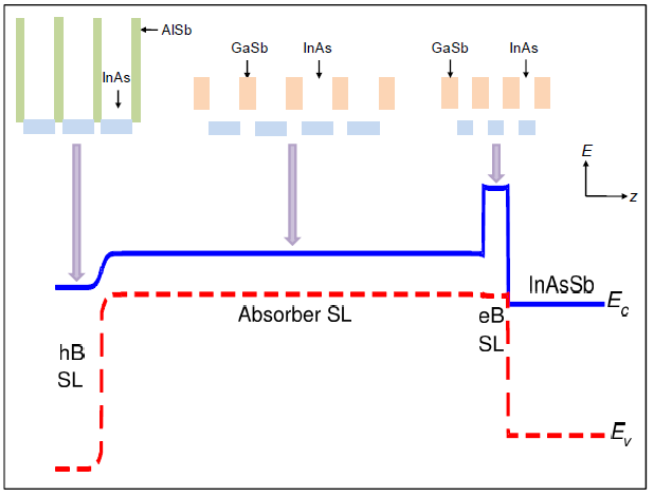
下圖爲其內部構造:



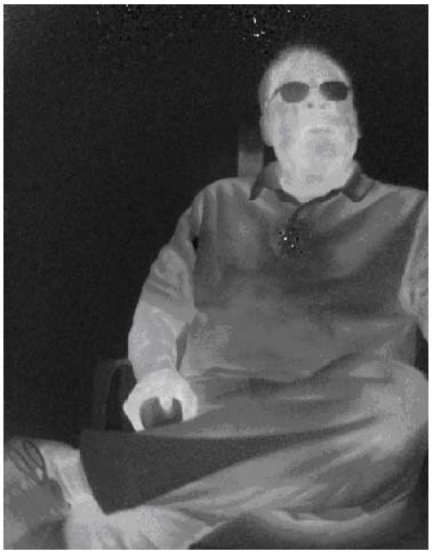
實際應用上，先對焦在一平面獲得一參考點，移動顯微鏡並聚焦在一校正基準面，通常爲一球形體，並形成聚焦，將球形體移開，放上待測鏡片或鏡面，調整直到光線聚焦在中心點，以下爲一校正棱鏡示意圖。



5. 在噴射推進實驗室的位障型紅外線偵測器研究(Barrier infrared detector research at the Jet Propulsion Laboratory): 本篇報告由美國 Jet Propulsion Laboratory 發表，內容關於使用分子束磊晶(Molecular Beam Epitaxy, MBE)方式成長位障型紅外線偵測器(Barrier InfraRed Detector, BIRD)，其偵測器結構包含一砷化銦/銻化鎵(InAs/GaSb)超晶格結構吸收層，一砷化銦/銻化鋁(InAs/GaAl)超晶格結構之電洞位障阻擋層，以及一短週期砷化銦/銻化鎵(InAs/GaSb)超晶格結構之電子位障阻擋層，其元件能帶圖如下所示:

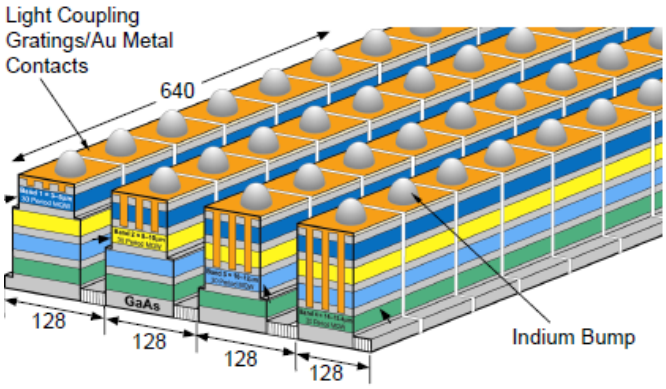


報告中亦提到其元件之位障阻擋層均爲單極性位障(unipolar barrier)，意思爲阻擋單一極性載子，亦即電洞位障只會阻擋電洞，電子位障只會阻擋電洞，可增加元件效率。在 0.2 V 偏壓下，元件漏電流密度爲 1×10^{-5} A/cm2，響應度(Responsivity)爲 1.5 A/W，偵測度(Detectivity)爲 1.1×10^{11} cm-Hz$^{1/2}$/W，吸收波長爲 8.2 μm，其漏電流特性已可與 MCT 偵測器媲美。此外，該團隊亦將此位障紅外線偵測器元件製作成 1024×1024 焦平面陣列(focal plane array, FPA)，其影像品質如下所示。

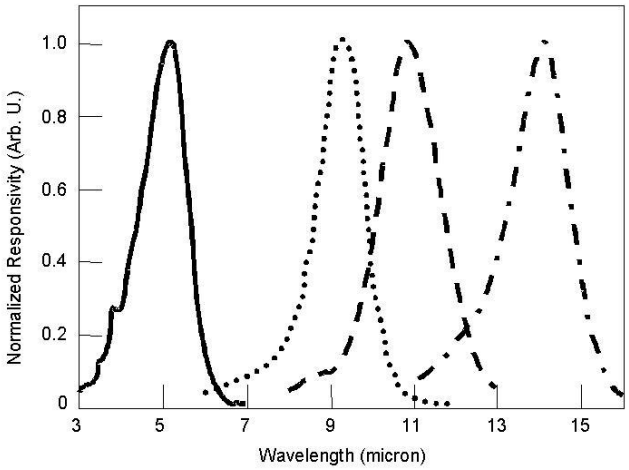


6. 用於超光譜熱影像設備之多重顏色量子井紅外線光偵測器焦平面陣列(Multicolor QWIP FPAs for hyperspectral thermal emission instruments): 本篇報告由美國 Jet Propulsion Laboratory 發表，內容關於利用四波段的紅外線感測元件製作焦平面陣列應用於熱像偵測。其四波段紅外線元件係由堆疊型的量砷化鎵/砷化鋁鎵($GaAs/Al_xGa_{1-x}As$)量子井結構形成，實際結構包含一波長在 4-5 μm 的 15 層堆疊量子井結構，一波長在 7-10 μm 的 25 層

堆疊量子井結構，一波長在 10-12 μm 的 25 層堆疊量子井結構，一波長在 13-15 μm 的 30 層堆疊量子井結構，每一個堆疊量子井結構之間用一層高度 n 型摻雜之 GaAs 接觸層(contact layer)隔開。在 FPA 製作上利用不同蝕刻深度來區別吸收波段，並用金屬將不需使用之量子井結構層做一短路連接，來分別不同波段之訊號，其製作示意圖如下所示:



該四波段紅外線元件其光譜響應圖如下所示:



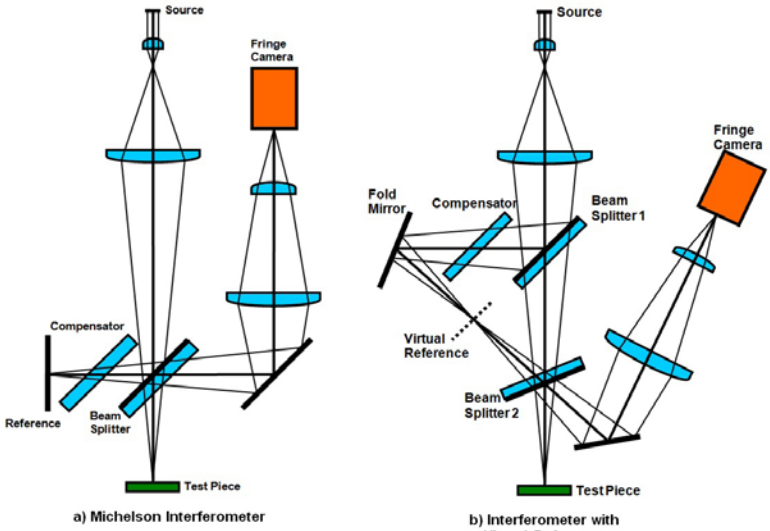
報告中亦提及搭載該偵測器設備之飛行器已於今年(2012)進行第一次試飛。

7. 在銻化鎵與砷化銦基板上利用原子層沉積介電質的基礎與電特性(Fundamental and electrical characterization of atomic layer deposited dielectrics on GaSb and InAs substrates):

本篇報告由美國 Jet Propulsion Laboratory 發表，內容是關於利用兩種原子層沉積方式(atomic layer deposition, ALD)，電漿原子層沉積(Plasma ALD)與熱原子層沉積(Thermal ALD)來沉積氧化鉿(HfO2)並比較其特性，其鉿元素原料爲 TEMAHf，沉積速率爲 0.8 Å/cycle，結果顯示利用電漿原子層沉積方式有較光滑的表面平整度，並將其應用在

InAs/GaSb 超晶格結構紅外線偵測器之鈍化層(passivation layer)，以降低元件表面漏電流。

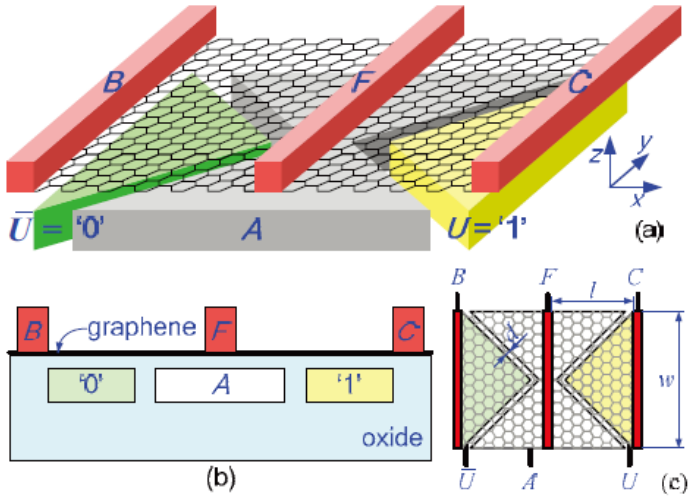
8. 使用虛擬參考干涉儀的次埃米表面度量(Sub-Angstrom surface metrology with a virtual reference interferometer): 本篇報告由美國 Zemetrics, Inc.發表，內容是關於利用一改良型之干涉儀量測超平滑表面(super-smooth surface)。一般非接觸式、3D 光學干涉儀可提供具有超平滑表面之物體(如硬碟基板與超級拋光之光學元件)的詳細形貌量測，然而干涉儀系統對於量測表面的粗糙度(roughness)有 1 埃米 (Å)或以下的貢獻，要降低系統誤差必須像降低雜訊一樣需要特別處理，然而兩者很難同時達成，在本報告利用一參考光束來消除中間至高波段的空間頻率，由於此種方式並非在一實際表面，因此稱爲虛擬參考干涉儀。下圖 a 爲一般量測表面粗糙度之具有低雜訊之邁克深干涉儀，其參考表面影像會影響待測表面之波紋(waviness)與粗糙度，而 b 爲改良式結構，利用另一組分光鏡(Beam Splitter 1)將入射光一分爲二，一道光直接經過分光鏡 1 與 2 到達待測物，另一道光則經過倍鏡(Fold Mirror)到分光鏡 2，與待測物的反射光結合再進入相機，此參考光並無一實際表面，因此稱爲虛擬參考平面。



最後利用此一干涉儀所量測的物體表面粗糙度，在無高通過濾情形下可小於 1 Å，再加上高通過濾後，其粗糙度可小於 0.2 Å。

9. 概述石墨烯 P-N 接面元件(Graphene P-N junction devices: an overview): 本篇報告由美國 College of Nanoscale Science and Engineering 發表，內容是關於利用石墨烯材料製作 P-N 接面元件甚至是邏輯元件。石墨烯 P-N 接面元件係在一層石墨烯上或下形成一共平面的分

離電極閘(split gates)，並在電極閘上施加不同的電壓來形成半導體的 P-N 接面，下圖爲電極閘在上的元件示意圖:



首先石墨烯薄片必須放置在一非常平整平面上以降低電子散射，若在電極上加一正偏壓，可將費米能階(Fermi level)提升至高於狄拉克點(Dirac point)，形成 N 型(圖中以'1'表示)；反之，若在電極上加一負偏壓，則形成 P 型(圖中以'0'表示)。因此，可利用可在三個電極上施加不同偏壓來形成邏輯運算，其運算模式如下圖表示

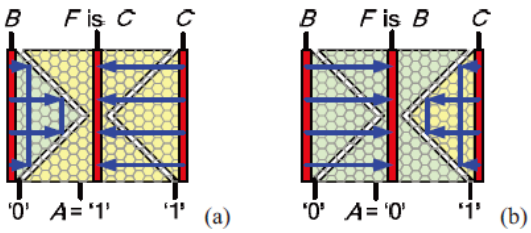
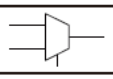
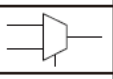
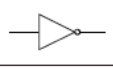
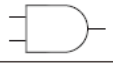
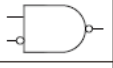
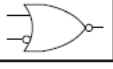


Figure 2. Operations of the device if configured as a 2:1 multiplexer: (a) The input A is '1', the output $F = C$, (b) when input A is '0', the output $F = B$.

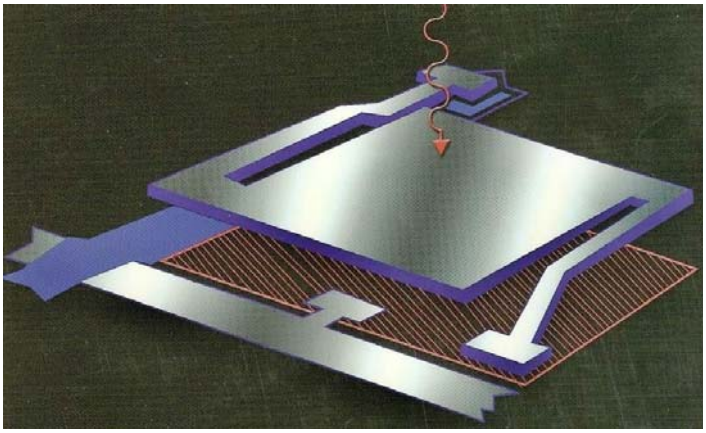
Table 1. Multi-function and reconfigurability

		$U = 1$		$U = 0$	
V_B	V_C	Function	Output	Function	Output
B	C		$AC + \bar{A}B$		$\bar{A}C + AB$
1	0		$\bar{A}$		A
0	C		AC		$\overline{A\bar{C}}$
B	1		$A + B$		$\overline{A + \bar{B}}$

報告中亦將石墨烯邏輯元件與半導體製程的互補式金氧半電晶體(CMOS)做比較，結果發現在切換速度上，石墨烯邏輯元件有大於 80 %的改善，然而，再與 22 nm 的 CMOS 元件時，石墨烯邏輯元件的功率消耗大於 CMOS 元件，可能是由於漏電流導致，因此，如何有效降低石墨烯元件的漏電流將有賴於新的摻雜技術或是氧化物材料。

10.設計和發展以奈米碳管和石墨烯爲基礎之室溫熱像器於紅外線影像之應用(Design and

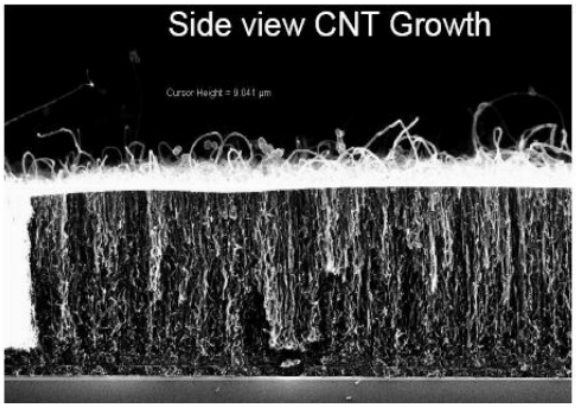
development of CNT and grapheme-based microbolometer for IR imaging applications): 本篇報告由美國 Magnolia Optical Technologies, Inc.發表，內容是關於利用碳微結構材料製作室溫熱像元件。以奈米碳管爲例，單壁奈米碳管 (Single wall carbon nanotubes, SWCNT)已被視爲可取代氧化釩和非晶矽來製作室溫熱像感測焦平面陣列的潛力材料，因爲 SWCNT 有較低的熱質量(thermal mass)，在紅外波段有高吸收係數(absorption coefficient)，電阻溫度係數(temperature coefficient of resistance, TCR)大於 4 %/K，此外，SWCNT 可使用於 CMOS 製作流程，亦可降低非致冷型 IRFPA 的製作成本。下圖爲元件示意圖:

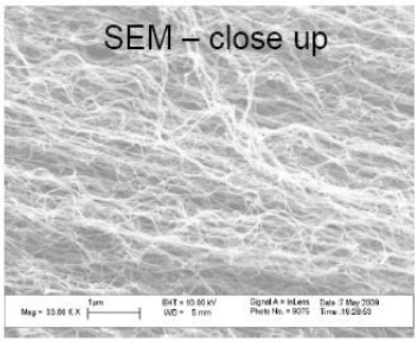


在製作上，可將 SWCNT 室溫熱像感測元件製程銜接於 CMOS 製程之後，因爲 SWCNT 可以被清潔至相容於 CMOS 製作廠房的潔淨度需求，並且已有展示小於 17 微米平方之 SWCNT 室溫熱像感測元件仍有足夠的良率，甚至也有證據指出 SWCNT 元件不像氧化釩和非晶矽元件受限於 1/f 雜訊。下圖爲將 SWCNT 應用於矽晶圓上以製作室溫熱像感測元件之系統:

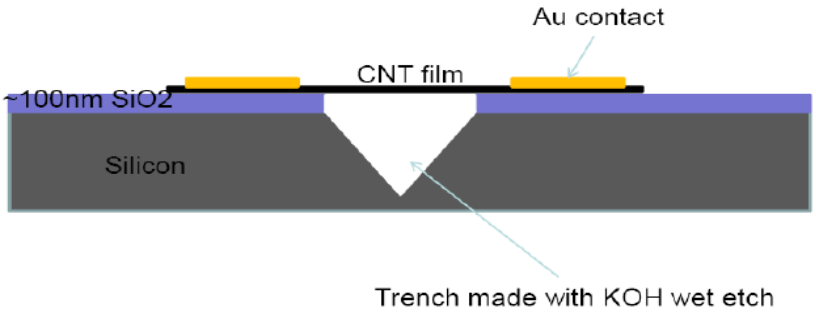
SWCNT 的製作使用一高真空的化學氣相沉積系統(Chemical Vapor Deposition, CVD)來成長，系統設備圖如下:

其所沉積的奈米碳管結果如下:



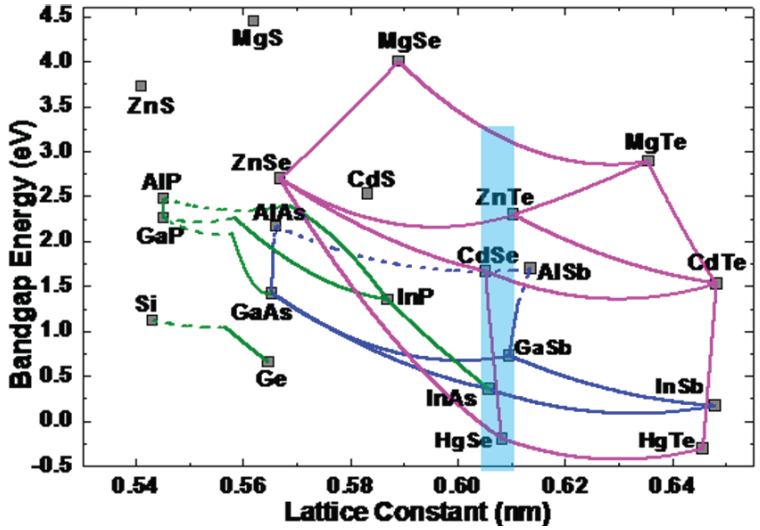


而 SWCNT 應用於室溫熱像感測元件的元件雛形以下圖表示:



報告中亦提到該團隊目標在研發適用於中、長紅外線波段的高效能、高幀速率的非致冷型奈米室溫熱像元件，並認爲奈米碳管和石墨烯可作爲研發下一世代之高效能小像素室溫熱像元件陣列。

11. 綜觀在陸軍研究實驗室的汞鎘硒材料在紅外線應用的研究(Overview of HgCdSe material research for IR applications at the Army Research Laboratory): 本篇報告由美國 Army Research Laboratory 發表，內容是關於將汞鎘硒 (HgCdSe)作爲新的紅外線感測材料應用。目前汞鎘碲 (HgCdTe, MCT)在鎘碲/矽(CdTe/Si)材料上可作爲中波段與長波段紅外線的應用，然而在中長波段紅外線應用上，由於 HgCdTe 與 Si 晶格差異所產生的差排(dislocation)缺陷問題將導致元件效能降低，若使用晶格匹配的基板，則必須付出很大的成本；本報告提出之 HgCdSe 材料作爲一新的紅外線材料，與 HgCdTe 非常相似，且可使用目前已有商業化，可取得的大面積基板，例如 GaSb 基板；此外，利用 MBE 成長 HgCdSe，也可以與其他 III-V 或 II-VI 材料整合，發展從 UV 至 IR 的多波段感測元件。下圖爲不同半導體材料晶格與能隙對照圖，可看出 HgCdSe 與 UV 波段的 II-VI 材料具有相同之晶格常數，可以整合發展 UV/IR 雙波段感測元件。



報告亦提出可在 Si 基板上利用 MBE 成長低缺陷 ZnTe 薄膜，其 ZnTe 薄膜 XRD 半高寬可小於 70 arcsec，蝕刻孔密度(etching pits density, EPD)小 10^5 cm^{-2}，因 ZnTe 晶格與 HgCdSe 匹配，可以此複合基板來生長高品質 HgCdSe 薄膜以製作紅外線元件。

12. 具有內嵌接觸氮化鎵發光二極體製程發展(Process development of GaN light emitting diodes with imbedded contacts): 本篇報告由台灣國立中興大學發表，內容是關於將氮化鎵 LED 元件製作後，將藍寶石基板經由拋光研磨成一特定角度的傾斜角，再鑲嵌於一杯狀的銅座上，優點在於可有較佳之散熱，較寬廣之光萃取角度，因而可提升光輸出功率與轉

換效率。

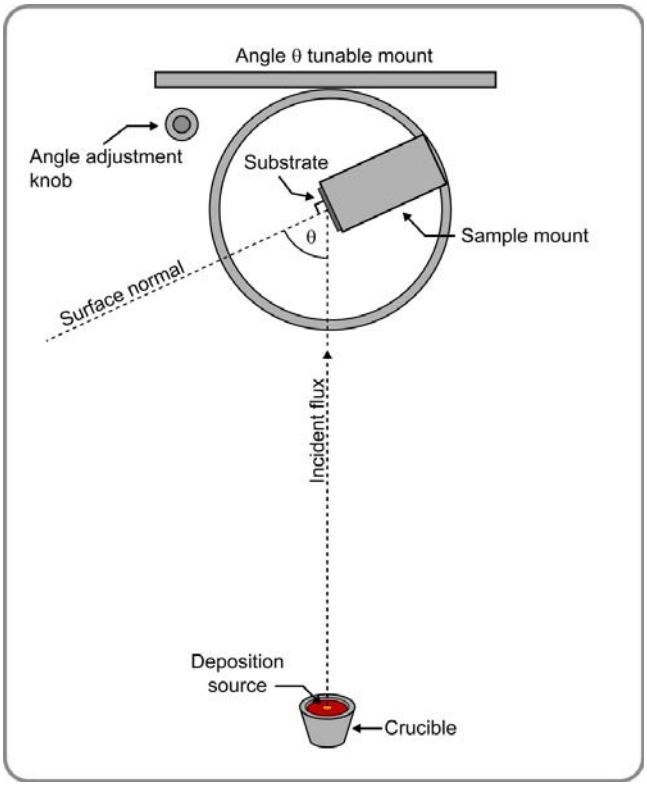
13. 用於固態照明的以高溫度(400℃)玻璃基礎的螢光粉轉換白光發光二極體(High-temperature (400℃) glass-based phosphor-converted white light emitting diodes for solid state lighting): 本篇報告由台灣國立中山大學發表，內容是關於利用玻璃螢光粉轉換來製作白光 LED，並探討在高溫環境下的元件特性。實驗上將玻璃螢光粉轉換白光 LED 與矽基螢光粉轉換白光 LED 在 150、250、350、450 ℃下作光強度、色度與穿透特性作比較，結果顯示玻璃螢光粉轉換白光 LED 在強度衰減、色度位移與穿透損失上有較佳的熱穩定性，相較於矽基螢光粉由於其低熱穩定性在 250 ℃下即無法承受，這一新的應用發展對於下一世代高功率、高溫與絕對可靠的照明需求有關鍵性的影響。

14. 在長波段紅外線化銦/銻化鎵超晶格的後成長退火研究(Post growth annealing study on LWIR InAs/GaSb superlattices): 本篇報告由美國 Air Force Research Laboratory 發表，內容是探討第二型(type-II) 長波段紅外線超晶格結構在退火後對其電特性的影響。實驗上將具有超晶格結構晶片在 440、480、515 ℃下分別退火 30 分鐘，並用光譜光電導(spectral photoconductivity)、溫度相依霍爾效應(temperature dependent Hall effect)與時間解析泵探針(time-resolved pump-probe)測量方式分析電特性，結果顯示經過退火後材料能隙仍維持不變，載子生命週期由 12 ns 增加至 15 ns，電子遷移率(electron mobility)在 440 與 480 ℃退火後幾乎不變，而在 515 ℃退火後，電子遷移率由 4500 增加到 6300 cm^2/Vs。

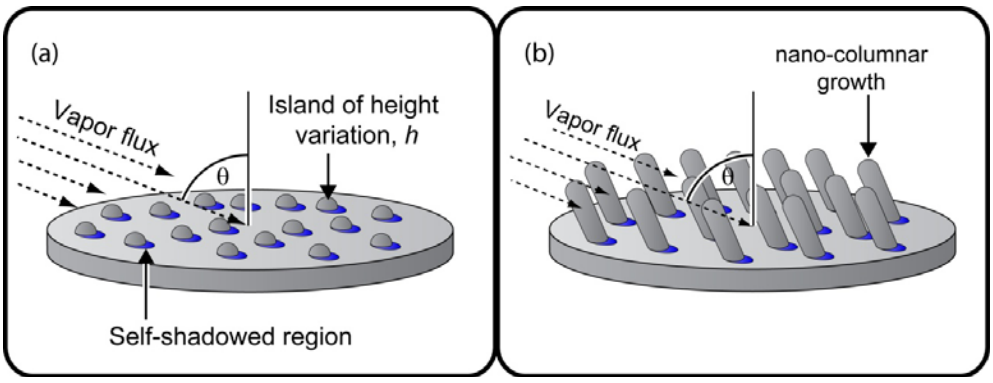
15. 砷化銦/銻化銦砷第二型超晶格的溫度相依少數載子生命週期 (Temperature-dependent minority carrier lifetime of InAs/$InAs_{1-x}Sb_x$ type-II superlattices): 本篇報告由美國 Arizona State University 發表，內容是利用時間解析光激螢光譜(Time-resolved photoluminescence)來量測 InAs/$InAs_{1-x}Sb_x$ 第二型超晶格(type-II superlattices, T2SLs)的少數載子生命週期。一般使用的中波段紅外線砷化銦/銻化銦鎵(InAs/$Ga_{1-x}In_xSb$)第二型超晶格，其載子生命週期在 77 K 爲 50~80 ns，長波段 InAs/$Ga_{1-x}In_xSb$ 第二型超晶格載子生命週期在 77 K 爲 10~40 ns，然而，在材料上 InAs 的載子生命週期爲 325 ns，$InAs_{0.8}Sb_{0.2}$ 的載子生命週期爲 250 ns，

均比 GaSb 的載子生命週期 100 ns 來得高，在 InAs/$Ga_{1-x}In_xSb$ 結構中由於 Ga 關聯的缺陷限制了載子生命週期，因此，在 InAs/$InAs_{1-x}Sb_x$ T2SLs 中應有較長的少數載子生命週期。實驗上利用 MBE 在 GaSb 基板上生長 20 個週期的 InAs/$InAs_{1-x}Sb_x$ 超晶格結構，與一層 AlSb 阻擋層來侷限電子在超晶格之中，最後用時間解析光激螢光譜來做分析。結果顯示相較於 InAs/$Ga_{1-x}In_xSb$ 結構，使用 InAs/$InAs_{1-x}Sb_x$ 超晶格結構的少數載子生命週期大於一個數量級，超過 400 ns，此一特性亦可讓 InAs/$InAs_{1-x}Sb_x$ 超晶格結構的紅外線元件操作於較高溫度之下。

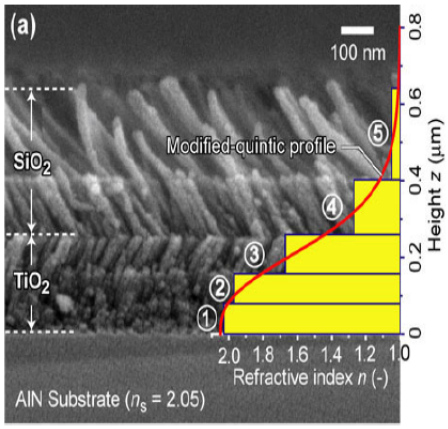
16. 發展大面積奈米結構抗反射鍍膜應用於光電紅外感測器(Development of large area nanostructured antireflection coatings for EO/IR sensor applications): 本篇報告由美國 Magnolia Optical Technologies, Inc.發表，內容爲使用奈米線發展高品質抗反射鍍膜來降低反射損失。其奈米結構抗反射鍍膜是以一斜角蒸鍍系統來製作，系統圖如下所示:



將所要蒸鍍材料放於坩鍋內，再以電子槍蒸鍍方式將奈米線/奈米柱鍍於材料表面，其奈米線/奈米柱成長方式以下圖表示:

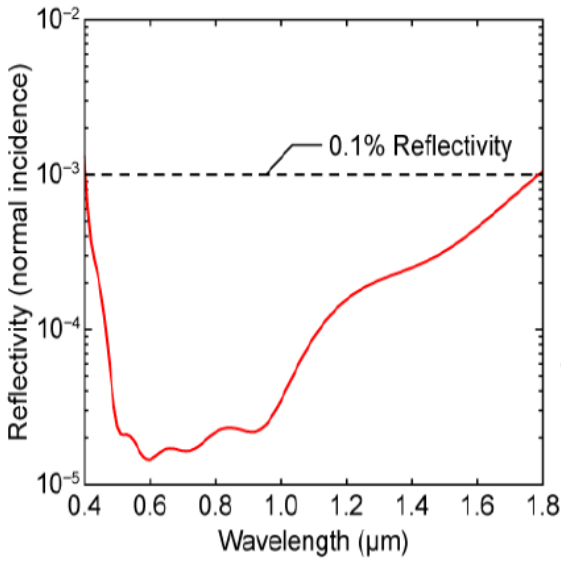


實驗上使用 TiO2 與 SiO2 兩種材料，藉由改變蒸鍍角度與厚度來調變折射率，使其達到最佳的抗反射效果，下圖爲在 AlN 基板使用 3 層 TiO_2 與 3 層 SiO_2 的實驗結果，可看出其漸進式的折射率變化效果。



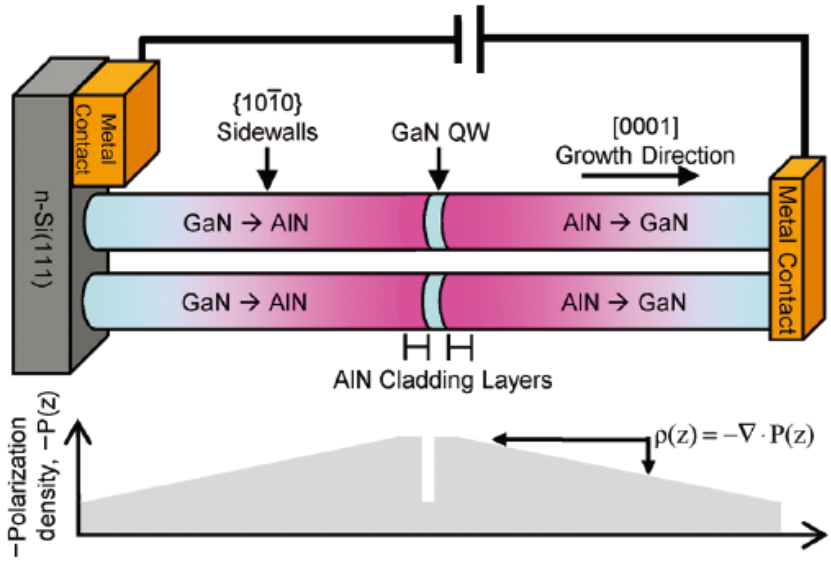
Layer No.	1	2	3	4	5
Source	TiO_2			SiO_2	
Deposition angle	25°	40°	65°	–68°	–87°
Thickness (nm)	77.4	80.2	99.3	145.0	223.0
Refractive index, *n*	2.03	1.97	1.67	1.27	1.05

另外，若在 Si 基板上，使用多孔矽或是 TiO_2/SiO_2 的奈米線組合，可將反射率降至 0.1 以下，如下圖:

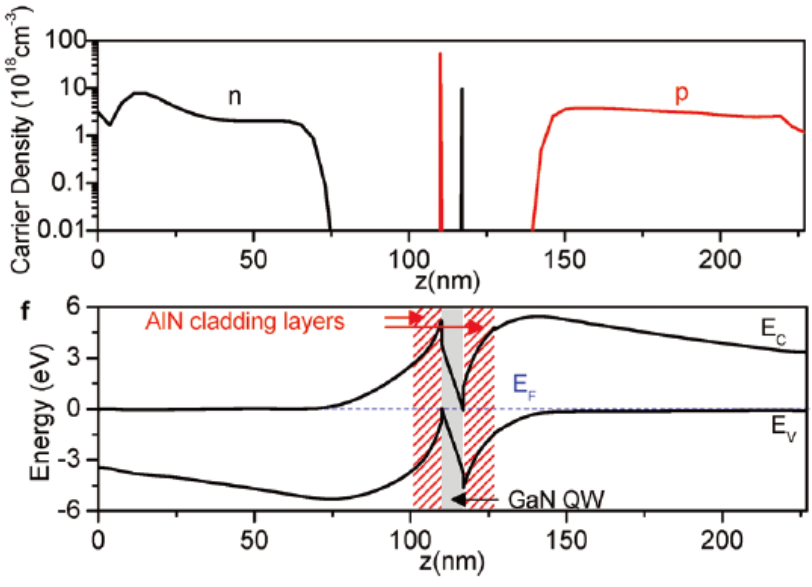


可見從紫外到近紅外波段都有很好的抗反射效果，亦可使用於紅外線感測器的應用需求。

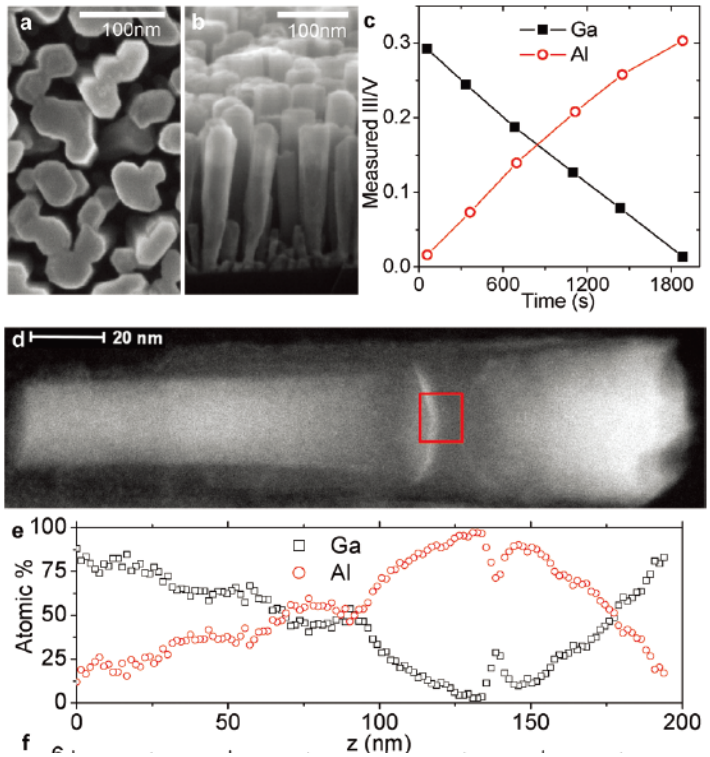
17. 藉由極化工程製作無摻雜之漸進式奈米線深紫外光發光二極體(Graded nanowire deep ultraviolet LEDs without impurity dopingby polarization engineering): 本篇報告由美國 The Ohio State University 發表，內容關於使用奈米線製作無 P 與 N 摻雜之氮化鎵紫外光 LED。目前所有的光電與電子元件都必須使用施體或受體的摻雜來形成 PN 接面，才可有元件的特性，本報告利用極化電荷來形成 P 型與 N 型區域，製作上使用矽基板在其上氮化物奈米線，奈米線成分組成爲一開始成長由氮化鎵線性漸變至氮化鋁之漸變層，再成長氮化鎵量子井，隨後成長由氮化鋁線性漸變至氮化鎵之漸變層，如下圖所示:



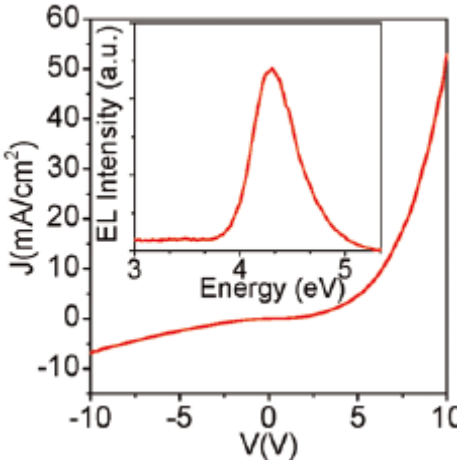
此結構可藉由極化效應在左側形成一 N 型區域，右側形成一 P 型區域，其載子濃度分布與能帶圖如下圖:



由能帶圖可清楚看到 N 型與 P 型區域形成與中間量子井主動層。奈米線的掃描式電子顯微鏡照片與其實際量測原子成分組成如下圖所示:

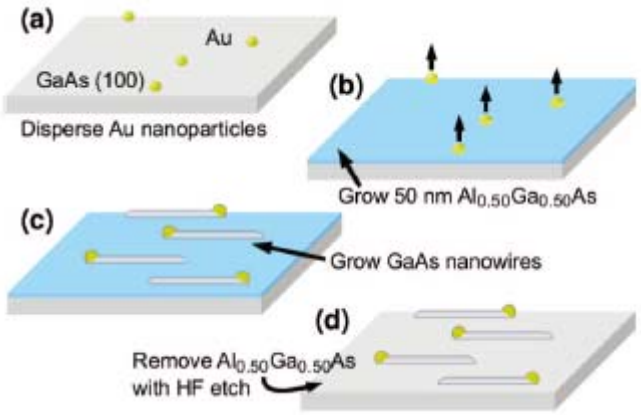


而實際製作成之 LED 元件發光光譜及電流-電壓特性如下圖:

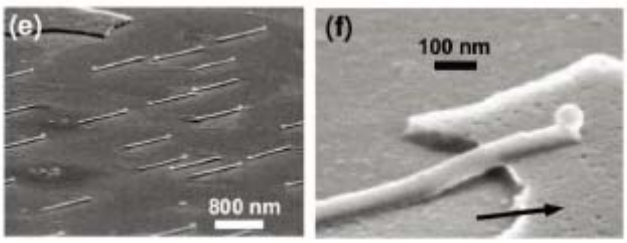


其發光能量在 4.3 eV 左右，換算成波長爲 288 nm，顯示元件可操作在深紫外光區域，而電流-電壓特性則顯示啓動電壓約在 5 V 左右，略大於一般氮化鎵 LED 的 3 V，可能是由於氮化鋁的高能隙影響所造成。報告中亦提及可將此極化之氮化物奈米線技術擴展至氮化銦鎵材料，即可將發光波長向下延伸至可見光區域，亦可將此技術用於發展電晶體、光二極體、太陽電池等其他光電及電子元件。

18. 利用有機金屬氣相化學沉積技術成長有次序排列之三五族奈米線陣列與其在奈米電子之應用(Ordered array of III-V nanowire growth by MOCVD and applications in nanoelectronics): 本篇報告由美國 University of Illinois at Urbana-Champaign 發表，內容爲在 GaAs 或 Si 基板上成長 GaAs 垂直型與平面型奈米線，要成長垂直型奈米線須使用方向爲(111)之基板，而平面型奈米線須使用方向爲(100)之基板，下圖爲 GaAs 平面型奈米線成長示意圖:



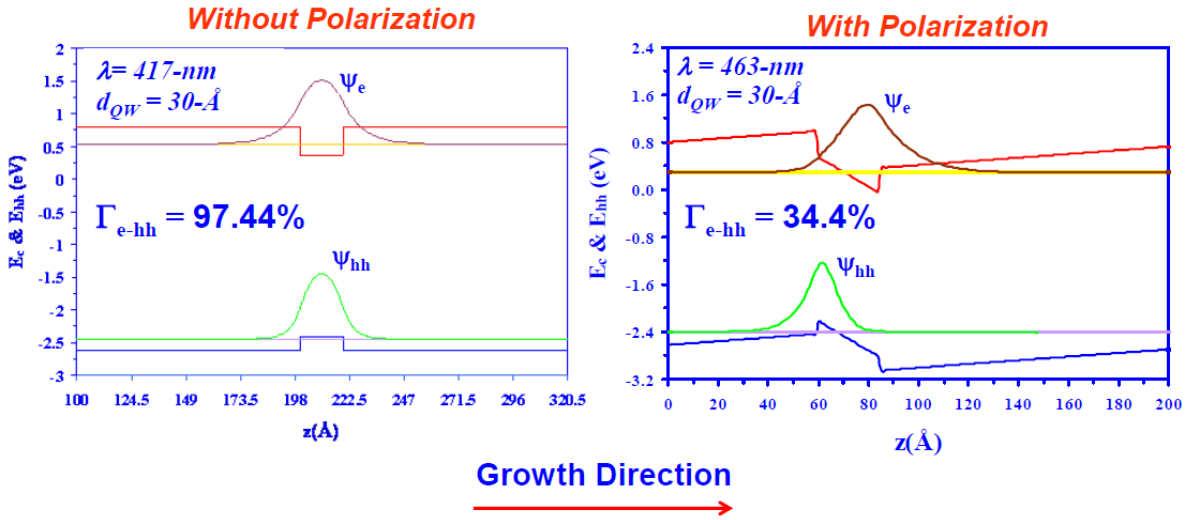
基本上先在基板上放置金觸媒(Au catalyst)，首先在 625 ℃成長一層 AlGaAs 犧牲層，厚度約 25~50 nm，接著在 460 ℃成長 GaAs 奈米線，最後再用氫氟酸將 AlGaAs 犧牲層移除，如此可將奈米線與基板分離，但仍同時保持一致的排列方向，如下圖所示，圖中黑色箭頭所指即爲 AlGaAs 犧牲層。



報告中亦提及若要製作相同間隔之奈米線陣列，則必須電子束顯影技術(e-beam photolithography)將金觸媒整齊排列在基板上，再利用 MOCVD 生長，即可得到排列整齊之奈米線陣列。在電子元件製作上，可在 GaAs 奈米線生長後成長一層 AlGaAs，由於 AlGaAs 能隙大於 GaAs，可在介面形成具有高電子遷移率之二維電子氣結構(2 dimensional electron gas, 2DEG)，並且由於奈米線本身具有低缺陷密度，可減少漏電流行程途徑，因此可製作特性良好之電子元件。

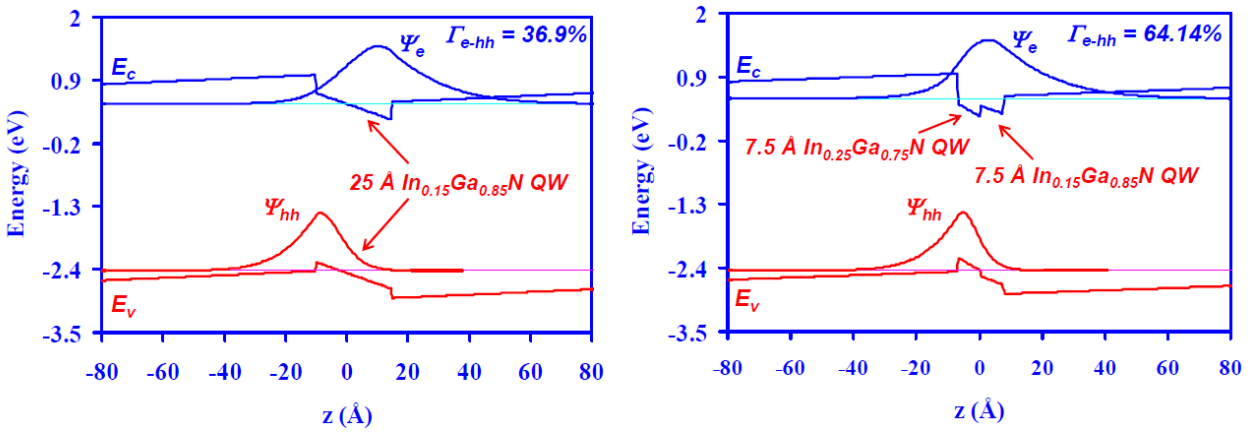
19. 氮化鎵奈米線與薄膜之熱穩定性(Thermal stability of gallium nitride: nanowires versus films): 本篇報告由美國 National Institute of Standards and Technology 發表，內容提及由於氮化鎵奈米線與薄膜的材料特性不同導致有不同的熱穩定性，薄膜特性爲極化(polar)、應力(strain)與平面式成長模式(layer by layer)，奈米線特性爲非極化(non-polar)、無應力(strain-free)與原子層生長模式(atomic layer growth)，報告中亦顯示氮化鎵奈米線與薄膜在高溫熱解下的圖片來探討熱分解機制，結果顯示欲分解氮化鎵需要之能量爲 4 eV，氮化鎵奈米線的分解溫度爲 700~900 ℃，而氮化鎵薄膜的分解溫度則必須大於 1000 ℃。

20. 用於高效率三族氮化物發光二極體之主動層之工程奈米結構:磊晶與物理(Engineering nanostructures in active regions for high-efficiency III-nitride light-emitting diodes: epitaxy and physics): 本篇報告由美國 Lehigh University 發表，內容是關於利用能帶工程來調變氮化銦鎵(InGaN)量子井主動層的能帶，以獲得較高的載子結合效率增加光強度。傳統的氮化物 LED，由於極化特性的關係，使得量子井能帶在導電帶最低點與價電帶最高點並不在同一能量軸上，亦使得電子與電洞載子分佈重疊部分較少，因此，其電子-電洞複合效率理論上只有 34.4 %，若此量子井爲非極化，則電子-電洞複合效率可高達 97.4 %，兩者能帶示意圖如下圖所示:

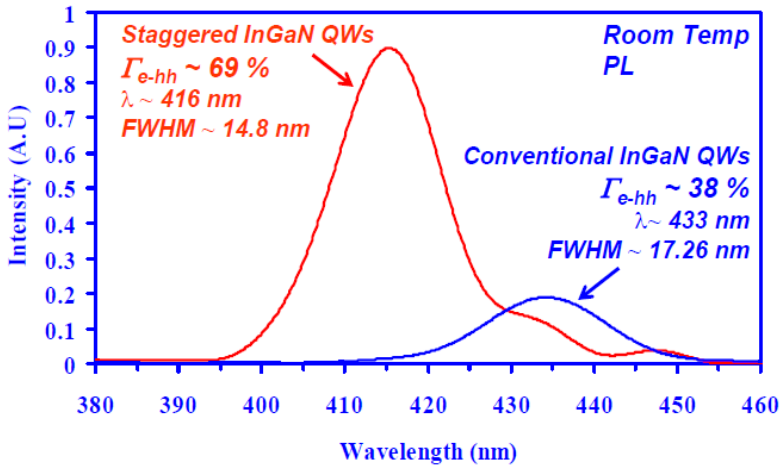


因此，爲提高電子-電洞複合效率，將量子井內的單一組成 InGaN 層改爲具有兩種組成之 InGaN 層，在實驗上使用 GaN / 25-Å $In_{0.15}Ga_{0.85}N$ / GaN 與 GaN / 7.5-Å $In_{0.25}Ga_{0.75}N$ / 7.5-Å $In_{0.15}Ga_{0.85}N$ / GaN 兩種量子井結構作比較，此結構之發光波長在 420~430 nm 左右，由下

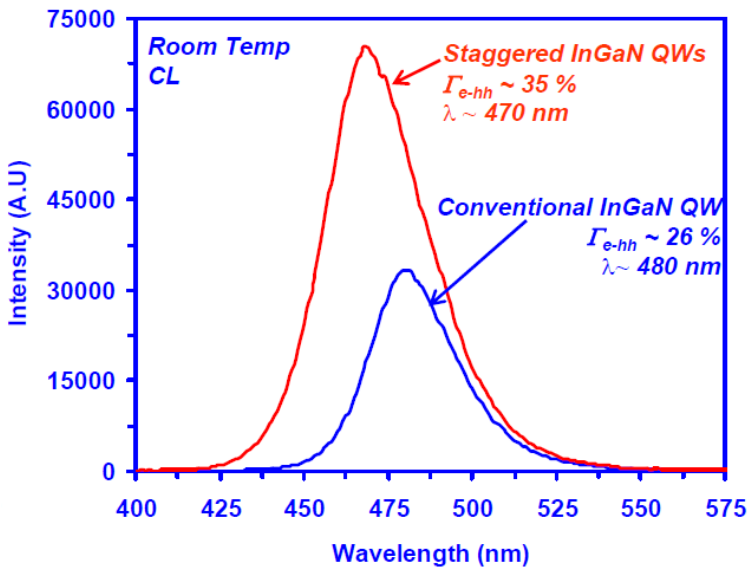
圖的能帶與電子與電洞載子分佈可看出，其電子載子分佈較靠近中心點，兩者重疊部分較多可提高電子-電洞複合效率，經計算可將效率由 36.9 %提高至 64.14 %。



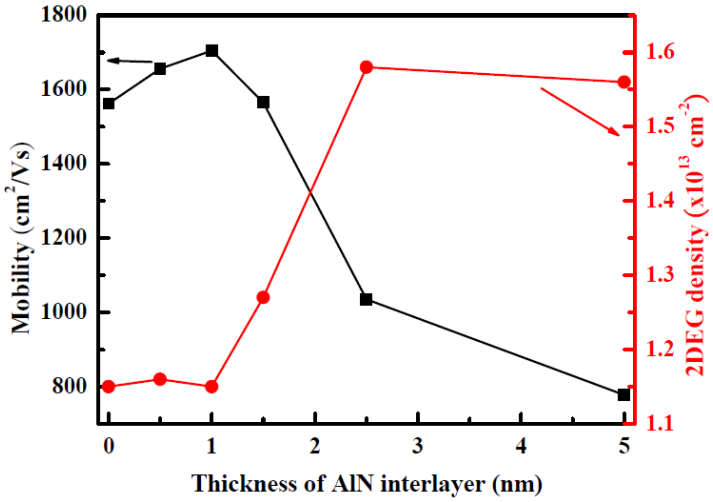
而在元件上的表現，則可看出其發光強度提高 4 倍以上，如下圖所示:



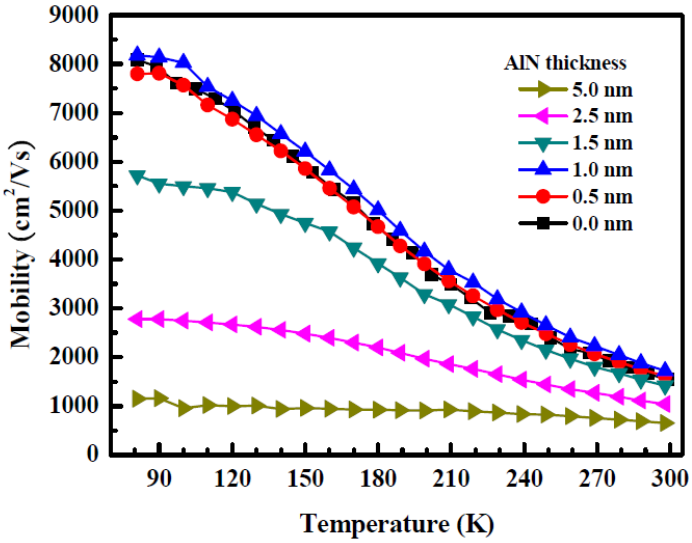
另外，若將量子井的銦含量提高，可將發光波長由藍光延伸至綠光，使用下列兩種量子井結構做比較，GaN / 27-Å $In_{0.26}Ga_{0.74}N$/GaN 與 GaN / 13-Å $In_{0.28}Ga_{0.72}N$ / 13-Å $In_{0.21}Ga_{0.79}N$ / GaN，在電子-電洞複合效率可由 26 %提高至 35 %，而發光強度可提高 2 倍以上，如下圖所示。



21. 具有氮化鋁中間層之氮化鋁鎵/氮化鋁/氮化鎵高電子移動率電晶體結構特性(Characterization of AlGaN/AlN/GaN high-electron mobility transistor structure with a nano-scale AlN interlayer): 本篇報告由台灣虎尾科技大學發表發表，內容是關於製作氮化鋁高電子移動率電晶體結構特性分析。作法爲利用有機金屬氣相磊晶系統成長具有氮化鋁中間層之氮化鋁鎵/氮化鋁/氮化鎵高電子移動率電晶體結構，實驗結果發現，在氮化鋁中間層厚度爲 1nm 時，有最佳之表面型態，其表面粗糙度爲 0.382 nm；同樣地，在霍爾效應量測結果顯示，氮化鋁中間層厚度爲 1nm 時可達到超過 1500 cm2/Vs 的室溫電子移動率，而 2DEG 濃度仍可維持在 1.15×10^{13} cm^{-2}，如下圖所示:



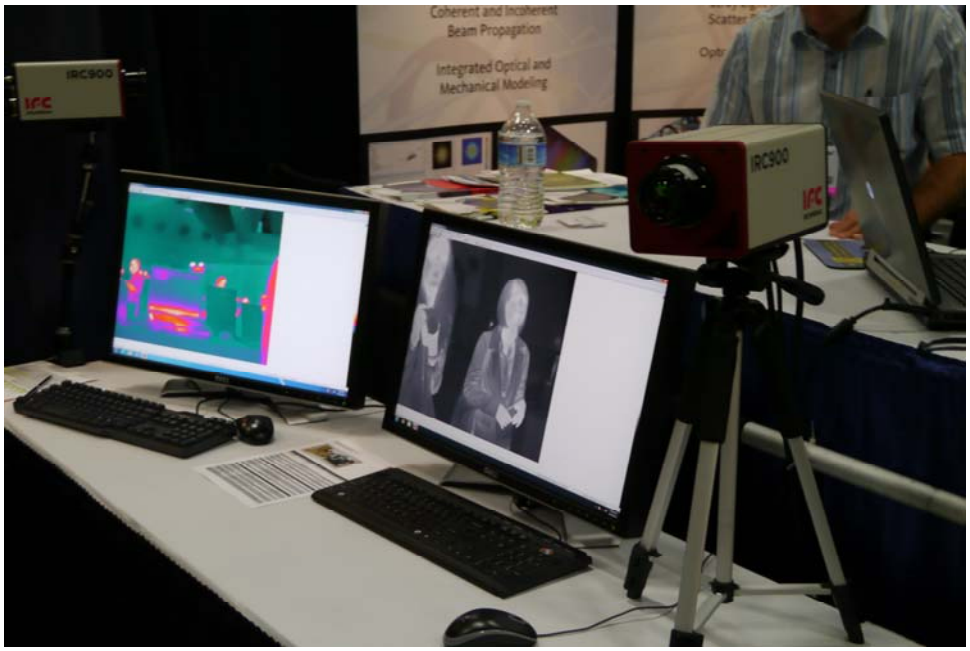
而低溫的電子移動率量測結果顯示，當氮化鋁厚度由 1 nm 增加至 1.5 nm 時，電子移動率會由 8180 降低至 5720 cm2/Vs，如下圖所示:



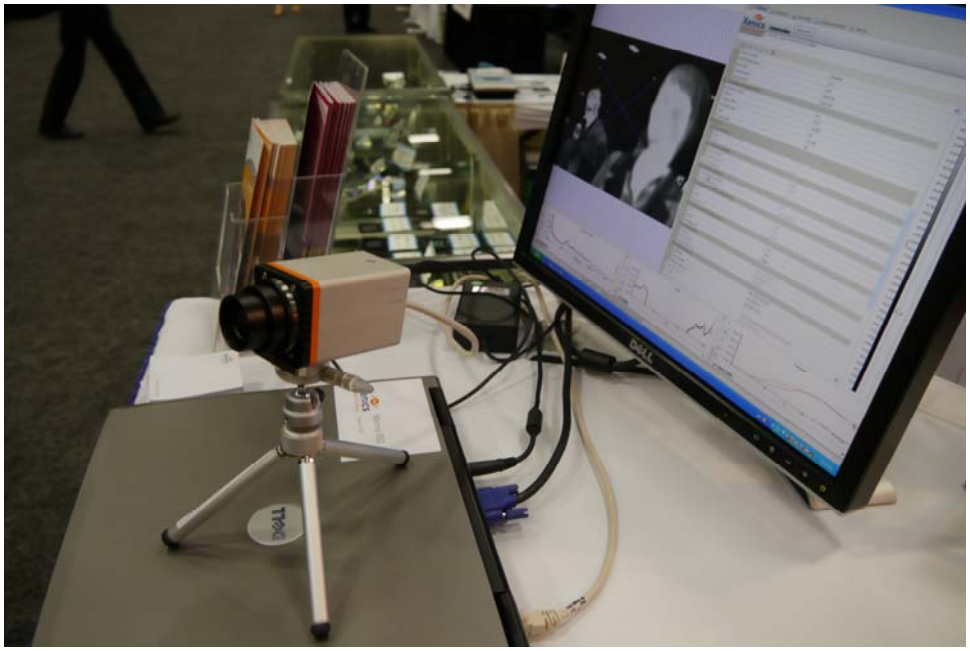
因此，具有氮化鋁中間層之高電子移動率電晶體結構對於發展高頻、高功率電子元件有很大的幫助。

本次會議中發表的論文，提出諸多新的想法，可供研發方向參考，例如新的紅外線材料 HgCdSe，可使用商業化基板來降低成本與其他波段整合；利用能帶極化改變 PN 極性與利用施加電場改變石墨烯的 PN 極性來製作邏輯電路，展示了非傳統的 PN 接面製程；本院目前亦有發展石墨烯與室溫熱像，本次會議中亦有石墨烯室溫熱像的論文發表，可作爲本院未來技術整合發展參考，惟目前相關技術仍在實驗發展階段，尚無法在室溫操作，但值得持續關注；另本計畫在前期已發展出雙波段紅外線元件，而四波段紅外線元件可涵蓋幾乎所有紅外線偵測波段，其相關製程亦可作爲本院紅外線技術發展的參考。

在研討會展覽部份，有超過 200 家廠商參展，廠商清單如附件二，其中亦不乏有紅外線領域廠商參展，計有 IRCameras、Teledyne Judson Technologies、Syntronics、Xenics、Sensors Unlimited-Goodrich ISR Systems、Element Six Technologies、Energetiq Technology、MOXTEK、Newport、PerkinElmer、Spectral Instruments 等，本次參觀重點爲室溫熱像產品，亦爲本計畫發展的重點項目之一，現場僅有 Xenics 展出室溫熱像產品，其他多爲需致冷器之紅外線產品，且均爲單一波段，亦即可區分爲短、中、長三個波段，並無多波段之紅外線相機展出，現場詢問廠商，多數均回答並無雙波段之紅外線相機，顯示雙波段以上產品仍未成爲商品主流，僅有 IRCameras 公司回應可客製化雙波段紅外線熱像機，但像場展示仍爲單一波段產品，下圖爲該公司現場展示 IRC900 系列之中波段致冷型紅外線熱像機與影像，其解析度可高達 1280×1024，該熱像機型錄資料參照附件三。



另一家 Xenics 公司現場展示之紅外線熱像機更爲齊全，有短、中、長波段之致冷型紅外線熱像機，亦有室溫熱像模組與系統展示，其偵測器以非晶矽(amorphous-Si)製作，解析度爲640×480，其體積遠小於致冷型紅外線熱像機，現場亦有核心模組展示，體積只有 5(公分)X5(公分)X3(公分)左右，可作爲系統整合，而室溫熱像影像亦非常清晰，下圖爲室溫熱像實機照片，該公司相關產品型錄參照於附件三。



由本次參展產品發現紅外線熱像仍以單一波段產品爲主，然而論文發表中有提及搭載多波段偵測器之飛行測試已於今年試飛，顯示多波段產品仍屬於研發階段或僅限於特定用途，本計畫前期已研發出雙波段紅外線元件熱像機，並已證實可應用於醫療與工業用途，相關技術在國內仍居於領先地位，雖該期計畫已結束，仍可繼續推廣其應用；而本期計畫執行之室溫熱像技術，由本次參展之產品可看出發展潛力，在體積小的優勢之下，仍保有清晰的影像品質，非常適用於整合至其他系統，例如車用紅外線、監視系統等，相較於致冷型紅外線產品，除了軍用市場外，將有更大的民生應用市場，亦可扶植國內業界進入紅外線產品應用市場，開創另一波市場商機。

參、 心得

1. 超材料是一個最近興起的熱門研究領域，主要是利用人工的方式製造各種不同結構的材料來產生自然界所不存在的特性或現象，其大小通常爲奈米級尺寸，可應用於微波、光學、光電等各領域，例如報告中提到的奈米天線可增強天線效能並改變使用方式，而利用雙曲超材料製作的單光子源則可作爲量子光學方面的應用；此外，由在此主題發表論文的國家可發現，研究超材料的研究團隊以歐美地區爲主，亞洲地區發表的論文數量不到十篇，可見在新興研究領域發展上歐美國家仍居於領先地位。
2. 由光學測量主題發表之論文可以發現除了利用新技術改善目前的光學系統外，光學測量之技術已達到奈米級，甚至埃米級的高精度水準，綜觀目前材料與元件的發展趨勢，均以奈米級尺寸爲其發展方向，試想若無更高精確度之量測技術，如何得知材料與元件之特性，更遑論發展其應用，因此，高精度量測技術發展有其必要性；而本計畫利用不變形雷射光斑技術發展之光斑尺與高精度解角器則有異曲同工之妙，將不變形光斑之絕對定位技術應用於高精密度工具機，可發展奈米級尺寸之材料與元件，提高我國科技技術水準，與世界發展趨勢同步。
3. 本次會議亦提出多種新的紅外線材料應用，例如在第二型超晶格紅外線元件結構中，以 InAsSb 取代 GaInSb，可提高少數載子生命週期，使元件效能提升並可操作在較高環境溫度下；而以 HgCdSe 取代 HgCdTe 的好處在於 HgCdSe 可以使用大面積的商業化基板，例如晶格匹配之 GaSb 基板，即使使用 Si 基板，其晶格差異度也遠比 HgCdTe 小，因此可降低成本，並保持同樣的元件效能，另一方面，HgCdSe 亦可與具有相近晶格之寬能隙 II-VI 族材料整合來製作 UV 至 IR 的多波段感測器；另外，使用奈米碳管或石墨烯製作紅外熱像感測元件因可與積體電路製程整合，其發展潛力不容小覷，惟目前仍在實驗室發展階段，且其操作溫度尚無法在室溫環境下操作，但值得持續關注了解其發展狀況。
4. 在紅外線元件製作方面，目前已有四波段的紅外線元件製作技術，其波長涵蓋範圍幾乎已涵蓋所有紅外線偵測波段，但在元件製作上如何區別各波段的訊號，使其不互相干擾並將其取出利用，將是元件製作重點；另外，以原子層沉積技術在紅外感測元件上沉積介電質鈍化層，利用原子層沉積技術可製作高品質薄膜的優點，可更有效地降低元件漏電流，改

5. 在奈米結構應用於光電元件方面，利用能帶工程改善 LED 元件結構之載子複合效率以增強發光強度可作爲思考元件發展方向的參考，鑒於目前高功率 LED 在高電流操作環境下所產生的熱處理問題，多數均以加強散熱裝置來解決，然而熱的產生是由於輸入能量無法有效轉換成光能而產生的剩餘能量所導致，因此若能提高轉換效率亦即提高載子複合效率，則能減少熱的產生，一方面可提高光輸出功率，另一方面亦可降低散熱裝置的成本，如此從基本面來改善問題，則可簡化元件製程與成本並提高產品附加價值。
6. 另外在電子元件應用方面，平面型奈米線可提供發展高功率元件的另一種思維，在本次會議發表中提到利用磊晶基板方向來生長 GaAs 平面型奈米線，並在 GaAs 奈米線上磊晶一層 AlGaAs 來形成 2DEG 結構，可製作功率電子元件。一般而言晶體缺陷的方向與長晶/磊晶成長方向相同，因此平面型奈米線內的缺陷方向應與基板表面平行，亦即不會往上延升，此時若在奈米線表面成長另一異質材料，其介面處幾乎無缺陷存在，可確保電子在通道內不會受到缺陷影響，對於元件效能提昇有很大的幫助，雖然奈米結構元件製程具有較大的挑戰，此一結構亦可評估用於氮化鎵高功率電子元件的製作。

肆、 建議事項

1. 紅外線感測元件的雜訊問題一直是元件發展的重要議題，而降低漏電流可直接改善元件效能，報告中提到的原子層沉積技術，因其具有成長速度慢可成長高品質薄膜之優點，目前大多用於電晶體之高介電(high-k)層之研發與製作，本院亦有原子層沉積系統，可發展相關介電層成長技術，以利應用於紅外線感測元件。
2. 室溫熱像爲本計畫發展之一重要主軸，相較於低溫紅外線熱影像技術，室溫熱像因無致冷裝置可大幅降低製作成本，除軍事用途外，亦可廣泛應用於民生用途，本次會議展覽會場相關紅外線廠商展出之室溫熱像產品，其解析度高達 640×480，爲目前室溫熱像高階產品，可評估是否採購以作爲計畫未來發展室溫熱像技術之參考。
3. 科技的發展日新月異，如何提升固有技術水準以及開發新技術，一直是科技研發人員所追求的目標，本院爲國內軍事科技研發重鎮，爲提升本院技術能量，科技同仁除在工作上克盡職責外，亦應注意科技研發動向與趨勢，一方面可提升自己的知識水準，另一方面對於技術研發工作亦有相當助益。

附件一

研討會相關議程表

Conference 8455 · Room: Conv. Ctr. 6C

Sunday-Thursday 12-16 August 2012 • Proceedings of SPIE Vol. 8455

Metamaterials: Fundamentals and Applications V

Conference Chairs: **Allan D. Boardman,** Univ. of Salford (United Kingdom); **Nader Engheta,** Univ. of Pennsylvania (USA); **Mikhail A. Noginov,** Norfolk State Univ. (USA); **Nikolay I. Zheludev,** Univ. of Southampton (United Kingdom)

Program Committee: **David L. Andrews,** Univ. of East Anglia Norwich (United Kingdom); **Koray Aydin,** Northwestern Univ. (USA); **Rola Aylo,** Univ. of Dayton (USA); **Igal Brener,** Sandia National Labs. (USA); **Larry R. Dalton,** Univ. of Washington (USA); **Ildar R. Gabitov,** The Univ. of Arizona (USA); **Javier García de Abajo,** Consejo Superior de Investigaciones Cientificas (Spain); **Satoshi Kawata,** Osaka Univ. (Japan); **Jacob B. Khurgin,** The Johns Hopkins Univ. (USA); **Yuri S. Kivshar,** The Australian National Univ. (Australia); **Joachim R. Krenn,** Karl-Franzens-Univ. Graz (Austria); **Akhlesh Lakhtakia,** The Pennsylvania State Univ. (USA); **Ulf Leonhardt,** Univ. of St. Andrews (United Kingdom); **Natalia M. Litchinitser,** Univ. at Buffalo (USA); **Martin W. McCall,** Imperial College London (United Kingdom); **Martin Moskovits,** API Nanotronics Corp. (USA) and Univ. of California, Santa Barbara (USA); **Evgenii E. Narimanov,** Purdue Univ. (USA); **Vladimir M. Shalaev,** Purdue Univ. (USA); **Gennady B. Shvets,** The Univ. of Texas at Austin (USA); **David R. Smith,** Duke Univ. (USA); **Costas M. Soukoulis,** Iowa State Univ. (USA); **Mark I. Stockman,** Georgia State Univ. (USA); **Sergei Tretyakov,** Aalto Univ. School of Science and Technology (Finland); **Din Ping Tsai,** National Taiwan Univ. (Taiwan); **Augustine M. Urbas,** Air Force Research Lab. (USA); **Martin Wegener,** Karlsruher Institut für Technologie (Germany)

Sunday 12 August

Opening Remarks

Room: Conv. Ctr. 6C . . . . . Sun. 8:30 to 8:35 am

Session Chair: **Mikhail A. Noginov,** Norfolk State Univ. (USA)

SESSION 1

Room: Conv. Ctr. 6C . . . . . Sun. 8:35 to 10:15 am

Nanoantennas

Session Chair: **Mark Brongersma,** Geballe Lab. for Advanced Materials (GLAM) (USA)

8:35 am: **Quantitative measurement of scattering and absorption cross sections of individual metal nano-antennas** *(Keynote Presentation)*, Martin Wegener, Martin Husnik, Richard Diehl, Jens Niegemann, Karlsruher Institut für Technologie (Germany); Kurt Busch, Humboldt-Univ. zu Berlin (Germany); Stefan Linden, Rheinische Friedrich-Wilhelms-Univ. Bonn (Germany). [8455-01]

9:20 am: **Plasmonic nanoantennas and their applications** *(Invited Paper)*, Ertugrul Cubukcu, Univ. of Pennsylvania (USA) . . . . . [8455-02]

9:45 am: **Luminescence in the array of plasmonic nanoantennas**, Andrey K. Sarychev, Institute for Theoretical and Applied Electrodynamics (Russian Federation); Ilya A. Fyodorov, Moscow Institute of Physics and Technology (Russian Federation); Andrey N. Lagarkov, Institute for Theoretical and Applied Electrodynamics (Russian Federation); Gena Tartakovsky, Del Mar Photonics, Inc. (USA); Alexei Bogdanov, Hitachi Global Storage Technologies, Inc. (USA) . . . . . [8455-03]

10:00 am: **Spectral properties of V- and Y-shaped plasmonic antennas with widely tailorable amplitude and phase control for birefringent surface optics**, Mikhail A. Kats, Harvard School of Engineering and Applied Sciences (USA); Patrice Genevet, Harvard School of Engineering and Applied Sciences (USA) and Texas A&M Univ. (USA); Nanfang Yu, Harvard School of Engineering and Applied Sciences (USA); Guillaume Aoust, Harvard School of Engineering and Applied Sciences (USA) and Ecole Polytechnique (France); Romain Blanchard, Harvard School of Engineering and Applied Sciences (USA); Francesco Aieta, Harvard School of Engineering and Applied Sciences (USA) and Univ.Politecnica delle Marche (Italy); Zeno Gaburro, Harvard School of Engineering and Applied Sciences (USA) and Univ. degli Studi di Trento (Italy); Federico Capasso, Harvard School of Engineering and Applied Sciences (USA) . . . . . [8455-04]

Coffee Break . . . . . 10:15 to 10:45 am

SESSION 2

Room: Conv. Ctr. 6C . . . . . Sun. 10:45 to 11:55 am

Hyperbolic Metamaterials I

Session Chair: **Martin Wegener,** Karlsruher Institut für Technologie (Germany)

10:45 am: **Thermal hyper-conductivity: beyond Stefan-Boltzmann law** *(Invited Paper)*, Evgenii E. Narimanov, Purdue Univ. (USA); Igor I. Smolyaninov, Univ. of Maryland, College Park (USA) . . . . . [8455-05]

11:10 am: **Control of reflectance and transmittance in hyperbolic metamaterials with scatterers and curvilinear geometries**, Thejaswi U. Tumkur, John K. Kitur, Lei Gu, Norfolk State Univ. (USA); Brennan Chu, Cornell Univ. (USA); Evgenii e. Narimanov, Purdue Univ. (USA); Mikhail A. Noginov, Norfolk State Univ. (USA) . . . . . [8455-06]

11:25 am: **Single photon resonance cone in hyperbolic metamaterials**, Ward D. Newman, Zubin Jacob, Univ. of Alberta (Canada) . . . . . [8455-07]

11:40 am: **Modeling of the optical properties of periodic arrays of metal-coated Si nanopillars**, Ronald W. Rendell, U. S. Naval Research Lab. (USA); Orest J. Glembocki, James P. Long, U.S. Naval Research Lab. (USA); Junpeng Gao, The Univ. of Alabama in Huntsville (USA); Joshua D. Caldwell, U.S. Naval Research Lab. (USA); Francisco J. Bezares, American Society for Engineering Education (USA) . . . . . [8455-08]

Lunch Break . . . . . 11:55 am to 1:45 pm

SESSION 3

Room: Conv. Ctr. 6C . . . . . Sun. 1:45 to 3:15 pm

Nonlinear Metamaterials I

Session Chair: **Jacob B. Khurgin,** Johns Hopkins Univ. (USA)

1:45 pm: **Metadevices** *(Keynote Presentation)*, Nikolay I. Zheludev, Optoelectronics Research Ctr. (United Kingdom). . . . . [8455-09]

2:30 pm: **Nonlinear and active RF metamaterial applications using embedded devices**, Alexander R. Katko, Allen M. Hawkes, Steven A. Cummer, Duke Univ. (USA). . . . . [8455-11]

2:45 pm: **Variable focus nonlinear lens via transformation optics**, Apra Pandey, Natalia M. Litchinitser, Univ. at Buffalo (USA). . . . . [8455-12]

3:00 pm: **Nonlinear response of high-temperature superconducting terahertz metamaterials**, Nathaniel K. Grady, Los Alamos National Lab. (USA); Bradford G. Perkins, Jr., Harold Y. Hwang, Massachusetts Institute of Technology (USA); Ranjan Singh, Hao Yang, Jie Xiong, Li Yan, Quanxi Jia, Antoinette J. Taylor, Los Alamos National Lab. (USA); Keith A. Nelson, Massachusetts Institute of Technology (USA); Hou-Tong Chen, Los Alamos National Lab. (USA). . . . . [8455-13]

Coffee Break . . . . . 3:15 to 3:45 pm

Conference 8455 · Room: Conv. Ctr. 6C

SESSION 4

Room: Conv. Ctr. 6C . . . . . Sun. 3:45 to 6:00 pm

Plasmonic Metamaterials I

Session Chair: **Nikolay I. Zheludev,** Univ. of Southampton (United Kingdom)

3:45 pm: **Plasmonic and semiconductor building blocks for metadevices** *(Invited Paper)*, Mark L. Brongersma, Stanford Univ. (USA) . . . . . [8455-14]

4:10 pm: **Plasmon-induced transparency and plasmonic toroidal lasing spaser in three-dimensional metamaterials** *(Invited Paper)*, Din Ping Tsai, Wei Ting Chen, Pin Chieh Wu, Chih Ting Hsiao, Kuang-Yu Yang, Yao-Wei Huang, Chun Yen Liao, National Taiwan Univ. (Taiwan); Vassili A. Fedotov, Vassili Savinov, Nikolay I. Zheludev, Optoelectronics Research Ctr. (United Kingdom) . . . . . [8455-15]

4:35 pm: **Various approaches to loss mitigation in nanoplasmonics and their limitations** *(Invited Paper)*, Jacob B. Khurgin, Johns Hopkins Univ. (USA) . . . . . [8455-16]

5:00 pm: **Plasmon excitation between adjoining metal nanorods: field enhancement and optical sensing**, Andrey K. Sarychev, Institute for Theoretical and Applied Electrodynamics (Russian Federation); Andrey Ivanov, Alexander Shalygin, Lomonosov Moscow State Univ. (Russian Federation); Petr Vorobev, Sergey Vergiles, L.D. Landau Institute for Theoretical Physics (Russian Federation) . . . . . [8455-17]

5:15 pm: **Probing plasmonic and dielectric resonances within periodic and random arrays of Ag- and Au-coated Si nanopillars**, Joshua D. Caldwell, Francisco J. Bezares, James P. Long, Orest J. Glembocki, Ronald W. Rendell, Sharka M. Prokes, Erin Cleveland, Hayden Chun, U.S. Naval Research Lab. (USA); Richard Kasica, National Institute of Standards and Technology (USA); Loretta Shirey, U.S. Naval Research Lab. (USA). . . . . [8455-18]

5:30 pm: **Local density of states in lossy plasmonic nanostructures**, Yaroslav A. Urzhumov, David R. Smith, Duke Univ. (USA) . . . . . [8455-19]

5:45 pm: **Surface-plasmon holography with white light illumination**, Miyu Ozaki, RIKEN (Japan) and Tokyo Denki Univ. (Japan); Jun-ichi Kato, RIKEN (Japan); Satoshi Kawata, RIKEN (Japan) and Osaka Univ. (Japan) . . . [8455-20]

SYMPOSIUM-WIDE PLENARY SESSION

Room: Conv. Ctr. 6A . . . . . Sun. 6:00 to 7:25 pm

6:00 pm: **Introduction and Opening Remarks**

6:05 pm: **The Exciting Science of Light with Metamaterials**
Vladimir M. Shalaev, Purdue Univ. (USA)

6:45 pm: **Future of Optics and Photonics**
Bahaa E. A. Saleh, CREOL, The College of Optics and Photonics at the Univ. of Central Florida (USA)

See page 10 for details.

Monday 13 August

PLENARY SESSION

Room: Conv. Ctr. 6A . . . . . Mon. 8:30 am to 12:00 pm

NanoScience + Engineering

Session Chairs: **Satoshi Kawata,** Osaka Univ. (Japan) and **Manijeh Razeghi,** Northwestern Univ. (USA)

8:30 am: **The Light and Sound Fantastic: Radiation Pressure at the Nanoscale**
Oskar Painter, California Institute of Technology (USA)

9:15 am **Organics and Nanostructures for Nonlinear Optics**
Nasser Peyghambarian, College of Optical Sciences, The Univ. of Arizona (USA)

10:00 to 10:30 am: Coffee Break

10:30 am: **From Nanophotonics, to Metaphotonics, to Dynamic Photonics: Controlling Light Propagation and Light-Matter Interactions for Emerging Technologies**
Paras Prasad, University at Buffalo (USA)

11:15 am: **Global Activities in Novel-Nano Magnetic Materials for Magnetic, Optoelectronics Applications**
Misoon Mah, Asian Office of Aerospace Development (Japan)

See page 11 for details.

Lunch Break . . . . . 12:00 to 1:30 pm

SESSION 5

Room: Conv. Ctr. 6C . . . . . Mon. 1:30 to 2:55 pm

Hyperbolic Metamaterials II

Session Chair: **David R. Smith,** Duke Univ. (USA)

1:30 pm: **Optical properties of hyperbolic metamaterial interfaces** *(Invited Paper)*, Igor I. Smolyaninov, BAE Systems (USA). . . . . [8455-21]

1:55 pm: **Enhancing absorption using metamaterials with hyperbolic dispersion**, Thejaswi U. Tumkur, Lei Gu, John K. Kitur, Norfolk State Univ. (USA); Evgenii E. Narimanov, Purdue Univ. (USA); Mikhail A. Noginov, Norfolk State Univ. (USA). . . . . [8455-22]

2:10 pm: **Coupling nitrogen vacancy centers in diamond to hyperbolic metamaterials**, Saman Jahani, Zubin Jacob, Univ. of Alberta (Canada)[8455-23]

2:25 pm: **Giant photonic lamb shift in hyperbolic metamaterials**, Cristian Cortes, Zubin Jacob, Univ. of Alberta (Canada) . . . . . [8455-24]

2:40 pm: **Effects of nonlocal response on the density of states of hyperbolic metamaterials**, Wei Yan, Niels A. Mortensen, Martijn Wubs, Technical Univ. of Denmark (Denmark). . . . . [8455-25]

Coffee Break . . . . . 2:55 to 3:25 pm

SESSION 6

Room: Conv. Ctr. 6C . . . . . Mon. 3:25 to 6:05 pm

Novel Trends and Concepts

Session Chair: **Igor I. Smolyaninov,** BAE Systems (USA)

3:25 pm: **Controlling electromagnetic fields with phase discontinuities** *(Invited Paper)*, Patrice Genevet, Nanfang Yu, Mikhail A. Kats, Francesco Aieta, Zeno Gaburro, Federico Capasso, Harvard School of Engineering and Applied Sciences (USA) . . . . . [8455-26]

3:50 pm: **Electron energy loss spectroscopy on photonic metamaterials** *(Invited Paper)*, Stefan Linden, Felix von Cube, Rheinische Friedrich-Wilhelms-Univ. Bonn (Germany); Stephan H. Irsen, Ctr. of Advanced European Studies and Research (Germany). . . . . [8455-27]

4:15 pm: **Symmetry breaking and negative coupling leads to optical negative index of closed rings** *(Invited Paper)*, Boubacar Kante, Xiang Zhang, Univ. of California, Berkeley (USA) . . . . . [8455-28]

4:40 pm: **Metamaterial thermal antenna**, Sean Molesky, Zubin Jacob, Univ. of Alberta (Canada) . . . . . [8455-29]

4:55 pm: **Casimir force reversal using metamaterials**, Venkatesh K. Pappakrishnan, Pattabhiraju C. Mundru, Dentcho A. Genov, Louisiana Tech Univ. (USA) . . . . . [8455-30]

5:10 pm: **Radiation pressure and photon momentum in negative-index media**, Masud Mansuripur, College of Optical Sciences, The Univ. of Arizona (USA); Armis R. Zakharian, Corning Incorporated (USA) . . . . . [8455-31]

5:25 pm: **The trouble with the Lorentz law of force**, Masud Mansuripur, College of Optical Sciences, The Univ. of Arizona (USA) . . . . . [8455-32]

5:40 pm: **Nonlocal and nonlinear optical plasmonic metamaterials** *(Invited Paper)*, David R. Smith, Cristian Ciraci, Antoine Moreau, Duke Univ. (USA) . . . . . [8455-10]

Tuesday 14 August

SESSION 7

Room: Conv. Ctr. 6C . . . . . Tues. 8:00 to 10:30 am

Making Metamaterials

Session Chair: **Rashid Zia,** Brown Univ. (USA)

8:00 am: **Realization of metamaterial structures by non-lithographic processes** *(Invited Paper)*, Alberto Piqué, Nicholas A. Charipar, Heungsoo Kim, Matthew A. Kiriels, Scott A. Mathews, U.S. Naval Research Lab. (USA)[8455-33]

8:25 am: **All dielectric optical metamaterials** *(Invited Paper)*, Jason G. Valentine, Joy Garnett, Parikshit Moitra, Vanderbilt Univ. (USA) . . . . . [8455-34]

8:50 am: **Advances in eutectic and nanoparticle based composite materials for plasmonics and metamaterials** *(Invited Paper)*, Dorota A. Pawlak, Marcin Gajc, Katarzyna Sadecka, Andrzej Stefanski, Andrzej Klos, Pawel Osewski, Krzysztof Bienkowski, Barbara Surma, Institute of Electronic Materials Technology (Poland) . . . . . [8455-105]

9:15 am: **3D plasmonic and metamaterial structures**, David B. Burckel, Sandia National Labs. (USA) . . . . . [8455-35]

9:30 am: **Natural metamaterials: volume plasmons in manganites with nanoscale phase separation**, Andrey K. Sarychev, Institute for Theoretical and Applied Electrodynamics (Russian Federation); Sergey O. Boyarintsev, Institute for Theoretical and Applied Electromagnetics (Russian Federation) and Moscow Institute of Physics and Technology (Russian Federation); Andrey L. Rakhmanov, Kliment I. Kugel, Institute for Theoretical and Applied Electromagnetics (Russian Federation); Yuriy P. Sukhorukov, Institute of Metal Physics (Russian Federation) . . . . . [8455-36]

9:45 am: **Observation of spoof-like field enhancements in Ag thin films deposited by plasma enhanced ALD**, Sharka M. Prokes, Orest J. Glembocki, U.S. Naval Research Lab. (USA); Erin Cleveland, American Society for Engineering Education (USA); Joshua D. Caldwell, Edward E. Foos, U.S. Naval Research Lab. (USA); Jaakko Niinistö, Mikko Ritala, Univ. of Helsinki (Finland) . . . . . [8455-37]

10:00 am: **Atomic layer deposition silver: a natural metamaterial?**, Orest J. Glembocki, Sharka M. Prokes, U.S. Naval Research Lab. (USA); Erin Cleveland, U.S. Naval Research Lab (USA); Ronald W. Rendell, Joshua D. Caldwell, Edward E. Foos, U.S. Naval Research Lab. (USA); Jaakko Niinistö, Mikko Ritala, Univ. of Helsinki (Finland) . . . . . [8455-38]

10:15 am: **Three-dimensional optical metamaterials made by self-assembly**, Fu Min Huang, Silvia Vignolini, Univ. of Cambridge (United Kingdom); Jatin Sinha, Univ. of Southampton (United Kingdom); Ulrich Steiner, Univ. of Cambridge (United Kingdom); Philip N. Bartlett, Univ. of Southampton (United Kingdom); Jeremy J. Baumberg, Univ. of Cambridge (United Kingdom)[8455-39]

Coffee Break . . . . . 10:30 to 11:00 am

SESSION 8

Room: Conv. Ctr. 6C . . . . . Tues. 11:00 am to 12:40 pm

Magnetic Metamaterials

Session Chair: **Uriel Levy,** The Hebrew Univ. of Jerusalem (Israel)

11:00 am: **Atomic probes for optical magnetic fields: natural magnetic emitters from the UV to the near IR** *(Invited Paper)*, Rashid Zia, Brown Univ. (USA) . . . . . [8455-40]

11:25 am: **Modification of electric and magnetic dipole emission in anisotropic plasmonic systems**, Natalia Noginova, Rabia Hussain, Mikhail A. Noginov, Norfolk State Univ. (USA); Jarrett Vella, Augustine M. Urbas, Air Force Research Lab. (USA) . . . . . [8455-41]

11:40 am: **Experimental demonstration of magnetic response of silicon nanoparticles at visible frequencies**, Arseniy I. Kuznetsov, A*STAR - Data Storage Institute (Singapore); Andrey E. Miroshnichenko, The Australian National Univ. (Australia); Yuan Hsing Fu, JingBo Zhang, Boris S. Luk'yanchuk, A*STAR - Data Storage Institute (Singapore) . . . . . [8455-42]

11:55 am: **Experimental evidence for natural homogeneous magnetic semiconductor with negative refractive index**, Adil-Geral Kussow, Akim Akyurtlu, Yassine Ait El Aoud, Univ. of Massachusetts Lowell (USA) . . [8455-43]

12:10 pm: **Bottom-up metamaterials with an isotropic magnetic response in the visible**, Stefan Mühlig, Friedrich-Schiller-Univ. Jena (Germany); José Dintinger, Ecole Polytechnique Fédérale de Lausanne (Switzerland); Alastair Cunningham, Univ. of Geneva (Switzerland); Toralf Scharf, Ecole Polytechnique Fédérale de Lausanne (Switzerland); Thomas Bürgi, Univ. of Geneva (Switzerland); Carsten Rockstuhl, Falk L. Lederer, Friedrich-Schiller-Univ. Jena (Germany) . . . . . [8455-44]

12:25 pm: **The two-photon interference mediated by the magnetic resonances in optical metamaterials**, Shuming Wang, Nanjing Univ. (China) . . . . . [8455-45]

Lunch/Exhibition Break . . . . . 12:40 to 1:55 pm

SESSION 9

Room: Conv. Ctr. 6C . . . . . Tues. 1:55 to 3:30 pm

Metamaterials Lenses and Focusing

Session Chair: **Jason Gage Valentine,** Vanderbilt Univ. (USA)

1:55 pm: **Controlling transmission, dispersion, and focusing of light using periodic and semi-periodic metamaterials** *(Invited Paper)*, Uriel Levy, Ilya Goykhman, Boris Desiatov, Avner Yanai, Meir Grajower, The Hebrew Univ. of Jerusalem (Israel). . . . . [8455-46]

2:20 pm: **Diffraction and sub-diffraction optics of planar metal lenses** *(Invited Paper)*, Alexander V. Kildishev, Satoshi Ishii, Xingjie Ni, Vladimir M. Shalaev, Vladimir P. Drachev, Purdue Univ. (USA) . . . . . [8455-47]

2:45 pm: **Super-resolution for a point source using positive refraction**, Juan Carlos Miñano, Pablo Benítez, Juan Carlos González, Dejan Grabovickic, Hamed Ahmadpanahi, Univ. Politécnica de Madrid (Spain) . . . . . [8455-48]

3:00 pm: **Three-dimensional terahertz Luneburg lens**, Fan Zhou, Northwestern Univ. (USA); Wei Cao, Weili Zhang, Oklahoma State Univ. (USA); Cheng Sun, Northwestern Univ. (USA) . . . . . [8455-49]

3:15 pm: **Acoustic resonators for far-field control of sound on a subwavelength scale**, Fabrice Lemoult, Mathias Fink, Geoffroy Lerosey, Ecole Supérieure de Physique et de Chimie Industrielles (France). . . . . [8455-50]

Coffee Break . . . . . 3:30 to 4:00 pm

SESSION 10

Room: Conv. Ctr. 6C . . . . . Tues. 4:00 to 5:15 pm

NIMs, Cloaks, and Transformation Optics

Session Chair: **Alexander V. Kildishev,** Purdue Univ. (USA)

4:00 pm: **Symmetry/parity of ring-resonators and optical isotropy of metamaterials**, Boubacar Kante, Kevin O'Brien, Avi Niv, Xiaobo Yin, Xiang Zhang, Univ. of California, Berkeley (USA) . . . . . [8455-51]

4:15 pm: **A non-magnetic invisibility cloak in air**, Boubacar Kante, Dylan Germain, André de Lustrac, Institut d'Électronique Fondamentale (France) . . . . . [8455-52]

4:30 pm: **An innovative cloak enables arbitrary objects hidden with visions and movements**, Tsung-Yu Huang, Ta-Jen Yen, National Tsing Hua Univ. (Taiwan) . . . . . [8455-53]

4:45 pm: **Optical zero index metamaterials for transformation optics applications**, Seokho Yun, Lan Lin, Zhi Hao Jiang, Ding Ma, Zhiwen Liu, Douglas H. Werner, Theresa S. Mayer, The Pennsylvania State Univ. (USA) . . . . . [8455-54]

5:00 pm: **Hybrid metal/semiconductor nanostructures for optoelectronics**, Pengyu Fan, Stanford Univ. (USA); Uday K. Chettiar, Nader Engheta, Univ. of Pennsylvania (USA); Mark L. Brongersma, Stanford Univ. (USA) . . . . . [8455-55]

Conference 8455 · Room: Conv. Ctr. 6C

Wednesday 15 August

SESSION 11
Room: Conv. Ctr. 6C . . . . . Wed. 8:00 to 10:05 am

Metamaterial Absorbers

Session Chair: **Costas M. Soukoulis,** Iowa State Univ. (USA)

8:00 am: **Complete optical absorption in graphene** *(Invited Paper)*, Sukosin Thongrattanasiri, Consejo Superior de Investigaciones Cientificas (Spain); Frank H. L. Koppens, ICFO - Institut de Ciencies Fotoniques (Spain); Javier Garcia de Abajo, Consejo Superior de Investigaciones Cientificas (Spain). . . . . [8455-56]

8:25 am: **Electromagnetically induced absorption in metamaterials** *(Invited Paper)*, Philippe Tassin, Lei Zhang, Aditya Jain, Rongkuo Zhao, Thomas Koschny, Costas M. Soukoulis, Ames Lab. (USA) . . . . . [8455-57]

8:50 am: **Isotropic and anisotropic continuous index photon traps based on composite optical materials**, Dentcho A. Genov, Louisiana Tech Univ. (USA) . . . . . [8455-58]

9:05 am: **Light absorption enhancement using resonant dielectric structures for photovoltaics**, Jonathan Grandidier, Raymond A. Weitekamp, Colton Bukowsky, California Institute of Technology (USA); Agustin Mihi, Univ. of Illinois at Urbana-Champaign (USA); Michael G. Deceglie, Dennis M. Callahan, California Institute of Technology (USA); Paul V. Braun, Univ. of Illinois at Urbana-Champaign (USA); Robert H. Grubbs, Harry A. Atwater, California Institute of Technology (USA) . . . . . [8455-59]

9:20 am: **Wideband perfect light absorber and identification of the absorption mechanism**, Joshua R. Hendrickson, Air Force Research Lab. (USA); Boyang Zhang, Junpeng Gao, The Univ. of Alabama in Huntsville (USA); Walter Buchwald, Solid State Scientific Corp. (USA); Richard Soref, University of Massachusetts Boston (USA) . . . . . [8455-60]

9:35 am: **Dynamic metamaterial electromagnetic wave absorbers**, Willie J. Padilla, Boston College (USA) . . . . . [8455-61]

9:50 am: **Plamonic metamaterials as designable perfect absorber at visible frequencies**, Hung-Ying Chen, Chun-Yuan Wang, Meng-Hsien Lin, National Tsing Hua Univ. (Taiwan); Uday K. Chettiar, Nader Engheta, Univ. of Pennsylvania (USA); Shangjr Gwo, National Tsing Hua Univ. (Taiwan) [8455-62]

Coffee Break . . . . . 10:05 to 10:35 am

SESSION 12
Room: Conv. Ctr. 6C . . . . . Wed. 10:35 to 11:50 am

Gain and Stimulated Emission

Session Chair: **F. Javier Garcia de Abajo,**
Consejo Superior de Investigaciones Cientificas (Spain)

10:35 am: **Amplification and spasing** *(Invited Paper)*, Mark I. Stockman, Georgia State Univ. (USA) . . . . . [8455-63]

11:00 am: **Amplification and lasing in nanoplasmonic metamaterials** *(Invited Paper)*, Sebastian Wuestner, Andreas Pusch, Joachim M. Hamm, Kosmas L. Tsakmakidis, Ortwin Hess, Imperial College London (United Kingdom) [8455-64]

11:25 am: **Bringing gain in metamaterials** *(Invited Paper)*, Costas M. Soukoulis, Iowa State Univ. (USA) and Foundation for Research and Technology-Hellas (Greece) . . . . . [8455-65]

Lunch/Exhibition Break . . . . . 11:50 am to 1:20 pm

SESSION 13
Room: Conv. Ctr. 6C . . . . . Wed. 1:20 to 3:10 pm

Chirality and Vortixes

Session Chair: **Fumin Huang,** Guangdong Univ. of Technology (China)

1:20 pm: **Chiral and multifunctional metamaterials** *(Invited Paper)*, Thierry Verbiest, Katholieke Univ. Leuven (Belgium). . . . . [8455-66]

1:45 pm: **A transparent, polarization-independent, ultrathin, and chiral 90 degrees polarization rotator using electromagnetic wave tunneling**, Mehmet Mutlu, Ekmel Ozbay, Bilkent Univ. (Turkey) . . . . . [8455-67]

2:00 pm: **Demonstration of diode-like asymmetric transmission of linearly polarized waves in a chiral structure supported by electromagnetic tunneling**, Mehmet Mutlu, Ahmet Emin Akosman, Bilkent Univ. (Turkey); Andriy E. Serebryannikov, Technische Univ. Hamburg-Harburg (Germany); Ekmel Ozbay, Bilkent Univ. (Turkey) . . . . . [8455-68]

2:15 pm: **Time-resolved pump-probe measurement of polarization rotation in nano-structured chiral metamaterial**, Jae-Heun Woo, Hae-young Shin, Minji Gwon, Ewha Womans Univ. (Korea, Republic of); Mircea Vomir, Marie Barthelemy, Institut de Physique et Chimie des Matériaux de Strasbourg (France); Dong-Wook Kim, Seokhyun Yoon, Ewha Womans Univ. (Korea, Republic of); Jean-Yves Bigot, Institut de Physique et Chimie des Matériaux de Strasbourg (France); Jeong-Weon Wu, Ewha Womans Univ. (Korea, Republic of) . . . . . [8455-69]

2:30 pm: **Unconventional light in unconventional materials** *(Invited Paper)*, Natalia M. Litchinitser, Apra Pandey, Jinwei Zeng, Xi Wang, Steven Shipsey, Alexander N. Cartwright, Univ. at Buffalo (USA) . . . . . [8455-70]

2:55 pm: **Optical vortices in metamaterials**, Jinwei Zeng, Apra Pandey, Xi Wang, Steven Shipsey, Alexander N. Cartwright, Natalia M. Litchinitser, Univ. at Buffalo (USA). . . . . [8455-71]

Coffee Break . . . . . 3:10 to 3:40 pm

SESSION 14
Room: Conv. Ctr. 6C . . . . . Wed. 3:40 to 4:55 pm

Theory and Modeling

Session Chair: **Natalia M. Litchinitser,** Univ. at Buffalo (USA)

3:40 pm: **Dispersion in media containing resonant inclusions: where does it come from?**, Fabrice Lemoult, Mathias Fink, Geoffroy Lerosey, Ecole Supérieure de Physique et de Chimie Industrielles (France). . . . . [8455-73]

3:55 pm: **Anderson localization effects via the invariant measure for discretely disordered negative and positive index structures**, Glen J. Kissel, Univ. of Southern Indiana (USA) . . . . . [8455-74]

4:10 pm: **Anisotropic spatial harmonic analysis**, Xingjie Ni, Alexander V. Kildishev, Purdue Univ. (USA) . . . . . [8455-75]

4:25 pm: **Optical functions of nanocrystalline ZnO containing voids**, Alexander V. Gavrilenko, Krishnaveni Dondapati, Vladimir I. Gavrilenko, Norfolk State Univ. (USA). . . . . [8455-76]

4:40 pm: **Generalized Fresnel coefficients of anomalous reflection and refraction from metainterfaces**, Zeno Gaburro, Harvard School of Engineering and Applied Sciences (USA) and Univ. degli Studi di Trento (Italy); Federico Capasso, Harvard School of Engineering and Applied Sciences (USA) [8455-77]

POSTERS-WEDNESDAY
Room: Conv. Ctr. Exhibition Hall B2 . Wed. 5:30 to 7:30 pm

Conference attendees are invited to attend the poster session on Wednesday evening. Come view the posters, enjoy light refreshments, ask questions, and network with colleagues in your field. Authors of poster papers will be present to answer questions concerning their papers. Attendees are required to wear their conference registration badges to the poster sessions. Poster authors, view poster presentation guidelines at http://spie.org/x30293.xml.

Interaction of Tm^{3+} ions electronic excitations with low frequency acoustic phonons in crystal $KTm(MoO_4)_2$, Sergey Poperezhai, Vladimir Kut'ko, Institute for Low Temperature Physics and Engineering (Ukraine); Dmytro Kamenskyi, Forschungszentrum Rossendorf (Germany) . . . . . [8455-99]

Thermal analysis of energetic materials, Huisheng Zhou, Anhui Univ. of Science and Technology (China). . . . . [8455-100]

The invariant measure for Anderson localized negative index metamaterials continuously disordered, Glen J. Kissel, Aaron Williams, Univ. of Southern Indiana (USA). . . . . [8455-101]

Magnetic nanoparticles for tunable microwave metamaterials, Natalia Noginova, Norfolk State Univ. (USA) and Cornell Univ. (USA); Quincy Williams, Norfolk State Univ. (USA); Panagiotis Dallas, Emmanuel P. Giannelis, Cornell Univ. (USA) . . . . . [8455-103]

Nonlinear cloaking at microwave frequencies, Mikhail K. Khodzitsky, Egor Sedykh, Egor Gurvitz, National Research Univ. of Information Technologies, Mechanics and Optics (Russian Federation). . . . . [8455-104]

Thursday 16 August

SESSION 15
Room: Conv. Ctr. 6C . . . . . Thurs. 8:00 to 10:15 am

Plasmonic Metamaterials II

Session Chair: **Ekmel Özbay,** Bilkent Univ. (Turkey)

8:00 am: **Direct assembly of 3D metamaterials and plasmonics at nm and sub-nm regimes** *(Invited Paper)*, Jeremy J. Baumberg, Fu Min Huang, Silvia Vignolini, Richard Taylor, Matthew Millyard, Matthew Hawkeye, Univ. of Cambridge (United Kingdom) . . . . . [8455-78]

8:25 am: **Strongly coupled nanorod arrays: a multifaceted plasmonic metamaterial** *(Invited Paper)*, Wayne Dickson, Gregory A. Wurtz, Anatoly V. Zayats, King's College London (United Kingdom) . . . . . [8455-79]

8:50 am: **Plasmonic metamaterials: beyond noble metals** *(Invited Paper)*, Alexandra Boltasseva, Purdue Univ. (USA) . . . . . [8455-80]

9:15 am: **Controlling light with a plasmonic meta-surface**, Xingjie Ni, Naresh K. Emani, Alexander V. Kildishev, Alexandra Boltasseva, Vladimir M. Shalaev, Purdue Univ. (USA) . . . . . [8455-81]

9:30 am: **Plasmon induced transparency in cascaded Π-shaped structures**, Arif Engin Çetin, Alp A. Artar, Mustafa Turkmen, Ahmet A. Yanik, Hatice Altug, Boston Univ. (USA) . . . . . [8455-82]

9:45 am: **Metal, concentric, gradient, indexed, dielectric metamaterials: plasmonic Roche limit in metal-dielectric-metal structure and plasmonic microdisk resonator filter/coupler**, Yung-Chiang Lan, Bo Han Cheng, Ruei-Cheng Shiu, National Cheng Kung Univ. (Taiwan) . . . . . [8455-83]

10:00 am: **Engineering dispersion in omnidirectional single-layer plasmonic metamaterials at visible frequencies**, Stanley P. Burgos, Ryan Briggs, Harry A. Atwater, California Institute of Technology (USA) . . . . . [8455-84]

Coffee Break . . . . . 10:15 to 10:45 am

SESSION 16
Room: Conv. Ctr. 6C . . . . . Thurs. 10:45 am to 12:15 pm

Applications of Metamaterials

Session Chair: **Dragomir Neshev,**
The Australian National Univ. (Australia)

10:45 am: **Metamaterial based biosensors and photodetectors** *(Invited Paper)*, Ekmel Ozbay, Bilkent Univ. (Turkey) . . . . . [8455-85]

11:10 am: **Applied metamaterials: functional metaphotonic devices for energy and sensing** *(Invited Paper)*, Koray Aydin, Northwestern Univ. (USA) . . . . . [8455-86]

11:35 am: **Applied metamaterials** *(Invited Paper)*, Augustine M. Urbas, Air Force Research Lab. (USA) . . . . . [8455-87]

12:00 pm: **Photothermal studies on infrared plasmonic metamaterials for biosensing using a tunable quantum cascade laser**, Aiket Mertiri, Ronen Adato, Mi Kyung Hong, Hatice Altug, Shyamsunder Erramilli, Boston Univ. (USA) . . . . . [8455-88]

Lunch/Exhibition Break . . . . . 12:15 to 1:30 pm

SESSION 17
Room: Conv. Ctr. 6C . . . . . Thurs. 1:30 to 3:05 pm

Nonlinear Metamaterials II

Session Chair: **Augustine Urbas,** Air Force Research Lab. (USA)

1:30 pm: **Tunable and nonlinear metamaterials based on liquid crystals** *(Invited Paper)*, Dragomir N. Neshev, The Australian National Univ. (Australia) . . . . . [8455-89]

1:55 pm: **Nonlocal optical phenomena in metamaterials** *(Invited Paper)*, Viktor A. Podolskiy, Brian Wells, Univ. of Massachusetts Lowell (USA); Gregory A. Wurtz, King's College London (United Kingdom); Robert J. Pollard, William Hendren, Queen's Univ. Belfast (United Kingdom); Gary P. Wiederrecht, David Gosztola, Argonne National Lab. (USA); Anatoly V. Zayats, King's College London (United Kingdom) . . . . . [8455-90]

2:20 pm: **Active nonlinear metamaterials loaded with negative differential resistance elements and circuits**, John P. Barrett III, Steven A. Cummer, Duke Univ. (USA) . . . . . [8455-91]

2:35 pm: **Nonlinear imaging with four-wave mixing: image enhancement and non-reciprocal possibilities**, Ekaterina Poutrina, Cristian Ciraci, David R. Smith, Duke Univ. (USA) . . . . . [8455-92]

2:50 pm: **Tailoring optical nonlinearities of metamaterials by means of symmetric and antisymmetric modes**, Maxim R. Shcherbakov, Lomonosov Moscow State Univ. (Russian Federation); Jörg Reinhold, Arkadi Chipouline, Christian Helgert, Thomas Pertsch, Friedrich-Schiller-Univ. Jena (Germany); Andrey A. Fedyanin, Lomonosov Moscow State Univ. (Russian Federation) . . . . . [8455-93]

Coffee Break . . . . . 3:05 to 3:35 pm

SESSION 18
Room: Conv. Ctr. 6C . . . . . Thurs. 3:35 to 5:20 pm

Active and Tunable Metamaterials

Session Chair: **Viktor A. Podolskiy,**
Univ. of Massachusetts Lowell (USA)

3:35 pm: **Electronically switchable terahertz metamaterial devices** *(Invited Paper)*, Klm Reichel, Nicholas Karl, Wai Lam Chan, Daniel M. Mittleman, Rice Univ. (USA); Hou-Tong Chen, Antoinette J. Taylor, The Ctr. for Integrated Nanotechnologies (USA); Igal Brener, Michael J. Cich, Sandia National Labs. (USA) . . . . . [8455-94]

4:00 pm: **Active negative index metamaterial powered by an electron beam** *(Invited Paper)*, Gennady B. Shvets, Simeon Trendafilov, Andrea Alù, The Univ. of Texas at Austin (USA); Michael A. Shapiro, Richard J. Temkin, Plasma Science and Fusion Ctr. (USA) . . . . . [8455-95]

4:25 pm: **Electrical tuning of mid-infrared metamaterials based on semiconductor device structures** *(Invited Paper)*, Young Chul Jun, John L. Reno, Eric A. Shaner, Igal Brener, Sandia National Labs. (USA) . . . . . [8455-96]

4:50 pm: **Reconfigurable gradient index using VO_2 memory metamaterials**, Michael D. Goldflam, Univ. of California, San Diego (USA); Tom Driscoll, Univ. of California, San Diego (USA) and Duke Univ. (USA); Brian Chapler, Omar Khatib, Univ. of California, San Diego (USA); Nan M. Jokerst, Sabarni Palit, David R. Smith, Duke Univ. (USA); Bong-Jun Kim, Electronics and Telecommunications Research Institute (Korea, Republic of); Giwan Seo, Univ. of Science and Technology (Korea, Republic of); Hyun Tak Kim, Electronics and Telecommunications Research Institute (Korea, Republic of) and Univ. of Science and Technology (Korea, Republic of); Massimiliano Di Ventra, Dimitri N. Basov, Univ. of California, San Diego (USA) . . . . . [8455-97]

5:05 pm: **Tunable quantum metamaterials,** Ruzan Sokhoyan, Harry A. Atwater, California Institute of Technology (USA) . . . . . [8455-98]

Closing Remarks . . . . . Thurs. 5:20 to 5:25 pm

Session Chair: **Mikhail A. Noginov,** Norfolk State Univ. (USA)

Conference 8491 · Room: Conv. Ctr. 1B

Sunday-Monday 12-13 August 2012 • Proceedings of SPIE Vol. 8491

Optical System Alignment, Tolerancing, and Verification VI

Conference Chairs: **José Sasián,** College of Optical Sciences, The Univ. of Arizona (USA); **Richard N. Youngworth,** Riyo LLC (USA)

Program Committee: **Scott C. Burkhart,** Lawrence Livermore National Lab. (USA); **Matthew B. Dubin,** College of Optical Sciences, The Univ. of Arizona (USA); **Sen Han,** Soochow Univ. (China); **Jürgen Jahns,** FernUniv. in Hagen (Germany); **Chao-Wen Liang,** National Central Univ. (Taiwan); **Robert M. Malone,** National Security Technologies, LLC (USA); **Maria D. Nowak,** NASA Goddard Space Flight Ctr. (USA); **Raymond G. Ohl IV,** NASA Goddard Space Flight Ctr. (USA); **Craig Olson,** L-3 Communications Sonoma EO (USA); **Robert E. Parks,** Optical Perspectives Group, LLC (USA); **Mitchell C. Ruda,** Ruda-Cardinal, Inc. (USA); **Daniel G. Smith,** Nikon Research Corp. of America (USA); **Peng Su,** College of Optical Sciences, The Univ. of Arizona (USA); **Yana Z. Williams,** Ametek/Atlas Material Testing Solution (USA)

Sunday 12 August

SESSION 1

Room: Conv. Ctr. 1B . . . . . Sun. 8:50 to 10:30 am

Desensitization and Tolerancing

Session Chair: **Robert M. Malone,** National Security Technologies, LLC (USA)

8:50 am: **Wavefront coding to reduce the alignment sensitivity of two-mirror telescopes,** Brian Catanzaro, CFE Services (USA) . . . . . [8491-01]

9:10 am: **Ultra-precision fabrication of high density micro-optical backbone interconnection for data center and mobile application,** Ulrich Lohmann, Jürgen Jahns, FernUniv. in Hagen (Germany); Christoph Werner, Thomas Wagner, EUROMICRON Werkzeuge GmbH (Germany) . . . . . [8491-02]

9:30 am: **Tolerancing considerations for visual system** *(Invited Paper),* Jim Schwiegerling, The Univ. of Arizona (USA). . . . . [8491-03]

10:00 am: **Practical method of cost-based tolerancing** *(Invited Paper),* Akira Yabe, Consultant (Germany) . . . . . [8491-04]

Coffee Break . . . . . 10:30 to 11:00 am

SESSION 2

Room: Conv. Ctr. 1B . . . . . Sun. 11:00 am to 12:20 pm

Alignment and Baffle Tolerances in Space Systems

Session Chair: **Ulrich Lohmann,** FernUniv. in Hagen (Germany)

11:00 am: **Optical alignment for space spectrometers explained,** Oana van der Togt, Folkert Draaisma, TNO (Netherlands) . . . . . [8491-05]

11:20 am: **Precise alignment of x-ray mirror components utilizing pneumatic actuators,** Stephen E. Kendrick, Paul Atcheson, Robert Warden, Jerold Cole, Beth Kelsic, Diane Fear, Ball Aerospace & Technologies Corp. (USA) . . . . . [8491-06]

11:40 am: **Alignment solutions for the Optical Development System Lab for the ATLAS instrument,** Tyler C. Evans, SGT, Inc. (USA). . . . . [8491-07]

12:00 pm: **Stray light and baffle assembly sensitivity analysis of the Formosat-5 telescope,** Ting-Ming Huang, Cheng-Fang Ho, Po-Han Huang, Yu-Chuan Lin, Shenq-Tsong Chang, Instrument Technology Research Ctr. (Taiwan). . . . . [8491-08]

Lunch Break . . . . . 12:20 to 1:50 pm

SESSION 3

Room: Conv. Ctr. 1B . . . . . Sun. 1:50 to 3:10 pm

Verification and Optomechanics

Session Chair: **Yana Z. Williams,** Atlas Material Testing Technology LLC (USA)

1:50 pm: **Optical design and performance testing of an athermal SWIR gas correlation imager,** Anthony A. Tanbakuchi, Mark W. Smith, Sandia National Labs (USA); Jeff A. Mercier, Sandia National Labs. (USA); Aaron M. Ison, Sandia National Labs (USA); Todd J. Embree, Sandia National Labs. (USA); Steven R. Vigil, Sandia National Labs (USA) . . . . . [8491-09]

2:10 pm: **Rapid spatial characterization measurements of a multi-element focal plane using derived geometrical information,** James W. Baer, Thomas F. Drouillard II, Ball Aerospace & Technologies Corp. (USA) . . . . . [8491-10]

2:30 pm: **A support structure for a compliant deformable mirror,** F. Ernesto Penado, James H. Clark III, Joel Dugdale, Northern Arizona Univ. (USA) . . . . . [8491-11]

2:50 pm: **Opposed Port Alignment System (OPAS): A commercial astronomical telescope modified for viewing the interior of the NIF target chamber,** Anastacia M. Manuel, Tom McCarville, Lynn Seppala, Jeff L. Klingmann, Daniel H. Kalantar, Lawrence Livermore National Lab. (USA) . . . . . [8491-12]

Coffee Break . . . . . 3:10 to 3:40 pm

SESSION 4

Room: Conv. Ctr. 1B . . . . . Sun. 3:40 to 5:30 pm

Optical System Alignment

Session Chair: **Sen Han,** Soochow Univ. (China)

3:40 pm: **Use of a flat panel display for measurement of sine condition violations,** Sara Lampen, Matthew B. Dubin, James H. Burge, College of Optical Sciences, The Univ. of Arizona (USA). . . . . [8491-13]

4:00 pm: **Binocular collimation vs conditional alignment** *(Invited Paper),* William J. Cook, U.S. Army (USA) and Captain's Nautical Supplies (USA) and ATM Publishing (USA). . . . . [8491-14]

4:30 pm: **Practical alignment using an autostigmatic microscope,** Robert E. Parks, Optical Perspectives Group, LLC (USA) . . . . . [8491-15]

4:50 pm: **Optomechanical design and alignment strategies demonstrated on a zoom system,** Mario Sondermann, Hannes Scheibe, Benjamin John, Thomas Nobis, Carl Zeiss AG (Germany) . . . . . [8491-16]

5:10 pm: **Computer-aided alignment method using rms WFE value as an optimization criterion,** Yunjong Kim, Univ. of Science & Technology (Korea, Republic of) and Korea Research Institute of Standards and Science (Korea, Republic of); Ho-Soon Yang, Korea Research Institute of Standards and Science (Korea, Republic of) and University of Science and Technology (Korea, Republic of); Yun-Woo Lee, Korea Research Institue of Standards and Science (Korea, Republic of). . . . . [8491-17]

SYMPOSIUM-WIDE PLENARY SESSION

Room: Conv. Ctr. 6A. . . . . Sun. 6:00 to 7:25 pm

6:00 pm: **Introduction and Opening Remarks**

6:05 pm: **The Exciting Science of Light with Metamaterials**
Vladimir M. Shalaev, Purdue Univ. (USA)

6:45 pm: **Future of Optics and Photonics**
Bahaa E. A. Saleh, CREOL, The College of Optics and Photonics at the Univ. of Central Florida (USA)

See page 10 for details.

Monday 13 August

POSTERS-MONDAY
Room: Conv. Ctr. Exhibition Hall B2 . Mon. 5:30 to 7:30 pm

Conference attendees are invited to attend the poster session on Monday evening. Come view the posters, enjoy light refreshments, ask questions, and network with colleagues in your field. Authors of poster papers will be present to answer questions concerning their papers. Attendees are required to wear their conference registration badges to the poster sessions. Poster authors, view poster presentation guidelines at http://spie.org/x30293.xml.

Conference 8493 · Room: Conv. Ctr. 8

Monday-Wednesday 13-15 August 2012 • Proceedings of SPIE Vol. 8493

Interferometry XVI: Techniques and Analysis

Conference Chairs: **Joanna Schmit,** Bruker Nano Surfaces Division (USA); **Katherine Creath,** 4D Technology Corp. (USA) and Optineering (USA) and The Univ. of Arizona (USA); **Catherine E. Towers,** Univ. of Leeds (United Kingdom)

'Conference Co-Chair: **Jan Burke,** Bremer Institut für Angewandte Strahltechnik (Germany)'

Program Committee: **Astrid Aksnes,** Norwegian Univ. of Science and Technology (Norway); **Armando Albertazzi Gonçalves, Jr.,** Univ. Federal de Santa Catarina (Brazil); **Brent C. Bergner,** Spectrum Scientific, Inc. (USA); **Arnaud Dubois,** Institut d'Optique Graduate School (France); **Cosme Furlong,** Worcester Polytechnic Institute (USA); **Ulf Griesmann,** National Institute of Standards and Technology (USA); **Werner P. O. Jüptner,** Bremer Institut für angewandte Strahltechnik GmbH (Germany); **Guillermo H. Kaufmann,** Univ. Nacional de Rosario (Argentina); **Seung-Woo Kim,** KAIST (Korea, Republic of); **Angarai R. Ganesan,** Indian Institute of Technology Madras (India); **Malgorzata Kujawinska,** Warsaw Univ. of Technology (Poland); **Michael B. North Morris,** 4D Technology Corp. (USA); **Wolfgang Osten,** Univ. Stuttgart (Germany); **Yukitoshi Otani,** Utsunomiya Univ. (Japan); **Jannick P. Rolland,** Univ. of Rochester (USA); **Manuel Servin,** Ctr. de Investigaciones en Óptica, A.C. (Mexico); **H. Philip Stahl,** NASA Marshall Space Flight Ctr. (USA); **Mitsuo Takeda,** The Univ. of Electro-Communications (Japan); **Benito Vazquez Dorrio,** Univ. de Vigo (Spain); **Wei Wang,** Heriot-Watt Univ. (United Kingdom); **Song Zhang,** Iowa State Univ. (USA)

Monday 13 August

SESSION 1

Room: Conv. Ctr. 8 . . . . . Mon. 8:30 to 10:20 am

On the Fringe

Session Chair: **Katherine Creath,** The Univ. of Arizona (USA) and Optineering (USA) and 4D Technology Corp. (USA)

8:30 am: **Measurement and modeling of the thermal behavior of a laboratory DASH interferometer** *(Invited Paper)*, Kenneth D. Marr, Christoph R. Englert, U.S. Naval Research Lab. (USA); John M. Harlander, St. Cloud State Univ. (USA) . . . . . [8493-01]

9:00 am: **Digital holography reconstruction algorithms to estimate the morphology and depth of non-spherical absorbing particles**, Daniel R. Guildenbecher, Sandia National Labs. (USA); Jian Gao, Purdue Univ. (USA); Phillip L. Reu, Sandia National Labs. (USA); Jun Chen, Purdue Univ. (USA) . . . . . [8493-02]

9:20 am: **Spectrally resolved complex transmittance measurements of infrared nanostructured devices**, Julien Jaeck, Adrien Fallou, Grégory Vincent, ONERA (France); Jean-Luc Pelouard, Ctr. National de la Recherche Scientifique (France); Jérôme Primot, Riad Haïdar, ONERA (France). . . . . [8493-03]

9:40 am: **A digital gradient sensing method for evaluating orthogonal stress gradients in transparent solids subjected to mechanical loads**, Hareesh V. Tippur, Chandru Periasamy, Auburn Univ. (USA) . . . . . [8493-04]

10:00 am: **An interferometric observation of topological effect by novel axially symmetrical wave plate**, Toshitaka Wakayama, Toru Yoshizawa, Saitama Medical Univ. (Japan); Yukitoshi Otani, Utsunomiya Univ. (Japan). . . . . [8493-05]

Coffee Break . . . . . 10:20 to 10:50 am

SESSION 2

Room: Conv. Ctr. 8 . . . . . Mon. 10:50 am to 12:10 pm

Optical Coherence Tomography

Session Chair: **Jannick P. Rolland,** Univ. of Rochester (USA)

10:50 am: **Nondestructive metrology of layered polymeric optical materials using optical coherence tomography**, Jianing Yao, Panomsak Meemon, Kye-Sung Lee, Stephen Head, Jannick P. Rolland, Univ. of Rochester (USA) . . . . . [8493-06]

11:10 am: **Characterization of ink-jet printed organic RGB color filters with spectral domain optical coherence tomography**, Jakub Czajkowski, Paulina Vlimi, Rafal Sitz, Janne Lauri, Tapio Fabritius, Risto Myllylä, Univ. of Oulu (Finland). . . . . [8493-07]

11:30 am: **Wavelength-scanning polarimetric interferometry using channeled spectroscopic polarization state generator**, Kazuhiko Oka, Takahiro Kinoshita, Hokkaido Univ. (Japan) . . . . . [8493-08]

11:50 am: **Composite low-coherence interferometer for imaging of immersed tissue with high accuracy**, I-Jen Hsu, Chun-Wei Chang, Chung Yuan Christian Univ. (Taiwan) . . . . . [8493-09]

Lunch Break . . . . . 12:10 to 1:40 pm

SESSION 3

Room: Conv. Ctr. 8 . . . . . Mon. 1:40 to 3:10 pm

Spatial Structures and Aberrations

Session Chair: **Brent C. Bergner,** Spectrum Scientific, Inc. (USA)

1:40 pm: **Sub-Angstrom surface metrology with a virtual reference interferometer** *(Invited Paper)*, Klaus R. Freischlad, Zemetrics, Inc. (USA) . . . . . [8493-10]

2:10 pm: **Comparison of the area structure function to alternate approaches for optical surface characterization**, Liangyu He, Angela Davies, Christopher J. Evans, The Univ. of North Carolina at Charlotte (USA) . [8493-11]

2:30 pm: **Diffraction effects for interferometric measurements due to imaging aberrations**, Ping Zhou, Chunyu Zhao, James H. Burge, College of Optical Sciences, The Univ. of Arizona (USA). . . . . [8493-12]

2:50 pm: **Fitting high-order Zernike polynomials to finite data**, Benjamin J. Lewis, James H. Burge, College of Optical Sciences, The Univ. of Arizona (USA) . . . . . [8493-13]

Coffee Break . . . . . 3:10 to 3:40 pm

SESSION 4

Room: Conv. Ctr. 8 . . . . . Mon. 3:40 to 4:50 pm

Calibration Techniques

Session Chair: **Michael B. North Morris,** 4D Technology Corp. (USA)

3:40 pm: **Calibrating the sag due to gravity of horizontal interferometer reference flats** *(Invited Paper)*, Jan Burke, CSIRO Materials Science and Engineering (Australia); Ulf Griesmann, National Institute of Standards and Technology (USA) . . . . . [8493-14]

4:10 pm: **Absolute interferometric tests of spherical surfaces based on rotational and translational shears**, Johannes A. Soons, Ulf Griesmann, National Institute of Standards and Technology (USA). . . . . [8493-15]

4:30 pm: **Self calibration for slope-dependent errors in profilometry by using the random ball test**, Yue Zhou, The Univ. of North Carolina at Charlotte (USA) . . . . . [8493-16]

Conference 8493 · Room: Conv. Ctr. 8

POSTERS-MONDAY
Room: Conv. Ctr. Exhibition Hall B2 . Mon. 5:30 to 7:30 pm

Conference attendees are invited to attend the poster session on Monday evening. Come view the posters, enjoy light refreshments, ask questions, and network with colleagues in your field. Authors of poster papers will be present to answer questions concerning their papers. Attendees are required to wear their conference registration badges to the poster sessions. Poster authors, view poster presentation guidelines at http://spie.org/x30293.xml.

A real-time adaptive phase-shifting interferometry, Weirui Zhao, Genrui Cao, Beijing Institute of Technology (China) . . . . . [8493-41]

Single shot phase shifting interferometry using a two-step self-tuning phase shifting method, David Ignacio Serrano Garcia, Noel-Ivan Toto-Arellano, Amalia Martinez-Garcia, Juan Antonio Rayas-Alvarez, Ctr. de Investigaciones en Óptica, A.C. (Mexico) . . . . . [8493-42]

Towards a general theory for *M*x *N* pixelated carrier interferometry, Jose Moises Padilla, Manuel Servin, Julio C. Estrada-Rico, Adonai Gonzalez, Ctr. de Investigaciones en Óptica, A.C. (Mexico) . . . . . [8493-43]

Study of the refractometric stability of an interferometer equipment for gauge block calibration, Javier Diz-Bugarin, Benito Vazquez Dorrio, Jesus Blanco-García, Univ. de Vigo (Spain); Francisco Yebra, Ismael Outomuro, Lab. Oficial de Metroloxía de Galicia (Spain); Marta Miranda, Univ. de Vigo (Spain); Marta Otero, Francisco Rodriguez, Jose Luis Valencia, Lab. Oficial de Metroloxía de Galicia (Spain). . . . . [8493-44]

Refractive index sensor using long period fiber gratings and Mach Zehnder interferometer all optical fiber, Monica C. Hernandez, Univ. de Guanajuato (Mexico); Juan C. Hernández, Univ. de Guanajuto (Mexico); Julian M. Estudillo, Roberto Rojas, Ruth I. Mata, Edgar Méndez, Héctor J. Estrada, Univ. de Guanajuato (Mexico) . . . . . [8493-46]

Evaluation of interferometric patterns of supersonic fluid flows by the differential Fourier transform method, Francisco Rodriguez-Lorenzo, AIMEN Technology Ctr (Spain); Benito Vazquez Dorrio, Jesus Blanco-García, Univ. de Vigo (Spain) . . . . . [8493-47]

Polynomial fitting model for phase reconstruction: interferograms with high fringe density, Daniel Malacara-Doblado, Ctr. de Investigaciones en Óptica, A.C. (Mexico). . . . . [8493-48]

Spatial and temporal study of a semisolid membrane by high speed optical interferometry, David A. Gutiérrez-Hernández, Carlos Perez-Lopez, Ctr. de Investigaciones en Óptica, A.C. (Mexico); Juan C. Martinez-Espinosa, Juan A. Aranda-Ruiz, Instituto Politécnico Nacional (Mexico). . . . . [8493-49]

Selection of phase-recovery algorithms for fringe processing in optical measurement of micro-surface, Yongjian Zhu, Zhejiang Univ. of Science and Technology (China); Jingxin Na, Jilin Univ. (China); Weiqing Pan, Zhejiang Univ. of Science and Technology (China); Anhu Li, Tongji Univ. (China); Yanan Zhi, Shanghai Institute of Optics & Fine Mechanics (China); Yong Li, Zhejiang Univ. of Science and Technology (China). . . . . [8493-50]

Digital holographic interferometry applied to mixed-mode fracture analysis, Paulo Acioly M. dos Santos, Luiz Carlos da Silva Nunes, Gabriela N. de Oliveira, Univ. Federal Fluminense (Brazil) . . . . . [8493-51]

Software configurable optical test system for non-null testing of refractive optics, Margaret Z. Dominguez, Peng Su, Robert E. Parks, James H. Burge, College of Optical Sciences, The Univ. of Arizona (USA) . . . . . [8493-52]

Precision improving of double beam shadow moiré interferometer by phase shifting interferometry for the stress of flexible substrate, Kuo-Ting Huang, Hsi-Chao Chen, Ssu-Fan Lin, Ke-Ming Lin, Hong-Ye Syue, National Yunlin Univ. of Science and Technology (Taiwan) . . . . . [8493-53]

Dynamic interferometric moiré patterns as optical numerical code generator, Paulo Acioly M. dos Santos, Gabriela N. de Oliveira, Marcos E. de Oliveira, Univ. Federal Fluminense (Brazil) . . . . . [8493-54]

Fiber-optic low coherence sensor to blood hematocrit measurement based on Fabry-Perot interferometer, Michal Kruczkowski, Gdansk Univ. of Technology (Poland) . . . . . [8493-55]

Tuesday 14 August

SESSION 5
Room: Conv. Ctr. 8 . . . . . Tues. 8:30 to 10:10 am

Fringe Analysis
Session Chair: **Yukitoshi Otani,** Utsunomiya Univ. (Japan)

8:30 am: **How to remove fundamental-frequency phase errors from phase-shifting results**, Jan Burke, Bremer Institut für angewandte Strahltechnik GmbH (Germany) . . . . . [8493-19]

8:50 am: **Error estimation of phase detection algorithms and comparison of window functions**, Ryohei Hanayama, The Graduate School for the Creation of New Photonics Industries (Japan); Kenichi Hibino, National Institute of Advanced Industrial Science and Technology (Japan) . . . . . [8493-20]

9:10 am: **Regularized self-tuning phase demodulation for phase-shifting interferometry with arbitrary phase shifts**, Orlando M. Medina, Julio C. Estrada-Rico, Manuel Servin, Ctr. de Investigaciones en Óptica, A.C. (Mexico). . . . . [8493-21]

9:30 am: **Analyzing of fringe patterns polluted by noise and nonlinearity using S-Transform**, Min Zhong, Wenjing Chen, Sichuan Univ. (China) [8493-22]

9:50 am: **Sinusoidal wavelength-scanning interferometer for profile measurement of metal surfaces**, Osami Sasaki, Niigata Univ. (Japan)[8493-23]

Coffee Break . . . . . 10:10 to 10:40 am

SESSION 6
Room: Conv. Ctr. 8 . . . . . Tues. 10:40 am to 12:10 pm

Unwrapping Techniques
Session Chair: **Benito Vazquez Dorrio,** Univ. de Vigo (Spain)

10:40 am: **Dynamic 4-dimensional microscope system with automated background leveling** *(Invited Paper)*, Goldie L. Goldstein, 4D Technology Corp. (USA) and College of Optical Sciences, The Univ. of Arizona (USA); Katherine Creath, 4D Technology Corp. (USA) and The Univ. of Arizona (USA) and Optineering (USA) . . . . . [8493-24]

11:10 am: **Generalized theory of phase unwrapping approaches and optimal wavelength selection strategies for multi-wavelength interferometric techniques**, Konstantinos Falaggis, Warsaw Univ. of Technology (Poland); David P. Towers, Catherine E. Towers, Univ. of Leeds (United Kingdom). . . . . [8493-25]

11:30 am: **Recursive linear systems for phase unwrapping**, Julio C. Estrada-Rico, Manuel Servin, Ctr. de Investigaciones en Óptica, A.C. (Mexico) [8493-26]

11:50 am: **Phase unwrapping fitting local planes to phase gradient**, Efrén González-Ramírez, Enrique de la Rosa Miranda, Univ. Autónoma de Zacatecas (Mexico); Luis R. Berriel-Valdos, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico); Tonatiuh Saucedo Anaya, José I. de la Rosa-Vargas, María A. Araiza-Esquivel, Univ. Autónoma de Zacatecas (Mexico) . . . . . [8493-27]

Lunch/Exhibition Break . . . . . 12:10 to 1:45 pm

Fringe Art Awards Voting and Presentation
Room: Conv. Ctr. 8 . . . . . Tues. 1:45 to 2:00 pm

Session Chair: **Joanna Schmit,** Bruker Nano Surfaces Division (USA)

Please join us for voting on your favorite Fringe Art followed by the presentation ceremony to award the best Fringe Art. The winner will receive an award certificate and a silly optical prize.

SESSION 7

Room: Conv. Ctr. 8 . . . . . Tues. 2:00 to 3:30 pm

Specular and Translucent Object Measurement

Session Chair: **Jan Burke,** Bremer Institut für angewandte Strahltechnik GmbH (Germany)

2:00 pm: **Deflectometry challenges interferometry: the competition gets tougher!** *(Invited Paper)*, Christian Faber, E. Olesch, R. Krobot, Gerd Häusler, Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany) . . . . . [8493-28]

2:30 pm: **Optimization of dynamic structured illumination for surface slope measurements**, Guillaume P. Butel, The Univ. of Arizona (USA); Greg A. Smith, James H. Burge, College of Optical Sciences, The Univ. of Arizona (USA) . . . . . [8493-29]

2:50 pm: **Recovering shapes of specular objects in motion via normal vector map consistency**, Alexey Pak, Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung (Germany) . . . . . [8493-30]

3:10 pm: **Fast error simulation of optical 3D measurements at translucent objects**, Peter Lutzke, Peter Kühmstedt, Gunther Notni, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany). . . . . [8493-31]

Coffee Break . . . . . 3:30 to 4:00 pm

PLENARY SESSION

Room: Conv. Ctr. 6A . . . . . Tues. 4:00 to 5:35 pm

Optical Engineering

Session Chairs: **Jose Sasian,** College of Optical Sciences, The Univ. of Arizona (USA); **R. John Koshel,** Photon Engineering LLC (USA) and College of Optical Sciences, The Univ. of Arizona (USA)

4:00 pm: **Welcome and Opening Remarks**

4:05 pm: **A New Job for Telescopes: Making Solar Electricity**
J. Roger P. Angel, Steward Observatory Mirror Lab., The Univ. of Arizona College of Optical Sciences (USA) and REhnu LLC (USA)

4:50 pm: **From Titanic to the Tiny: Three Decades of Underwater Optical Imaging**
Jules S. Jaffe, Scripps Institution of Oceanography (USA)

See page 14 for details.

PANEL DISCUSSION

Methods and Applications of Deflectometry

Date: **Tuesday 14 August**
Time: **8:00 to 10:00 PM**
Room: **Marriott Hotel, Oceanside**

Moderators:
Peng Su, College of Optical Sciences, The Univ. of Arizona (USA); **Jan Burke,** Bremer Institut für angewandte Strahltechnik (Germany)
Panelists:
Christian Faber, Univ. Erlangen-Nuremberg (Germany); **Robert E. Parks,** College of Optical Sciences, The Univ. of Arizona (USA)

Further panelists to be confirmed.

Large or very large optical components, aspherics, and freeform optics have proven very difficult and expensive to measure with interferometry. As the interest and market for such components continues to grow, the need has become apparent to complement (and sometimes even replace) interferometry with a technique that is more versatile and less sensitive to misalignments. Simply and inexpensively measuring the distortion of a reflected fringe pattern (e.g. from a computer screen), a technique known as deflectometry, is capable of stunning sensitivity, since it is a gradient technique - however the calculation of the absolute shape is an unsolved problem. The question is, how urgently do we need the absolute shape? Could the slope data be sufficient? Also, there are numerous applications besides precision optics where deflectometry excels by its versatility - portable systems could be realized with as little as a laptop with web cam, or even a smartphone, and still function as serious measurement equipment.

We invite anyone working in deflectometry to come along, share their latest research and applications with a brief presentation, and point out the problems yet to solve. Interferometrists looking for solutions (or picking on the weaknesses of deflectometry) are also invited. We are hoping to get an idea of where we are, where the gaps and show-stoppers are, and come up with a roadmap for technical development and industrial implementation that we could use to set up meaningful collaborations and develop the full potential of this emerging discipline.

Wednesday 15 August

SESSION 8

Room: Conv. Ctr. 8 . . . . . Wed. 9:00 to 10:20 am

Digital Holography

Session Chair: **Ulf Griesmann,** National Institute of Standards and Technology (USA)

9:00 am: **Single-shot multi-wavelength shape measurements with restricted aperture**, Silke Huferath-von Luepke, Edwin N. Kamau, Christoph von Kopylow, Thomas Kreis, Bremer Institut für angewandte Strahltechnik GmbH (Germany) . . . . . [8493-33]

9:20 am: **Instantaneously captured images using multi-wavelength digital holography**, Joseph W. Haus, Ben Dapore, Partha Banerjee, Georges T. Nehmetallah, Paul F. McManamon, Nicholas Miller, Peter Powers, Univ. of Dayton (USA). . . . . [8493-34]

9:40 am: **Accurate and quantitative phase retrieval methods for a series of defocused images with application to in-line Gabor microscopy**, Konstantinos Falaggis, Tomasz Kozacki, Michał Józwik, Malgorzata Kujawinska, Warsaw Univ. of Technology (Poland) . . . . . [8493-35]

10:00 am: **Water drops lenses applied to digital holographic microscopy**, Alejandro Restrepo-Martinez, Francisco E. López, Instituto Tecnológico Metropolitano (Colombia) . . . . . [8493-36]

Coffee Break . . . . . 10:20 to 10:50 am

SESSION 9

Room: Conv. Ctr. 8 . . . . . Wed. 10:50 am to 12:10 pm

Strain and Shape Measurement

Session Chair: **Joanna Schmit,** Bruker Corp. (USA)

10:50 am: **Image quality improvement of an achromatic DSPI interferometer**, Armando Albertazzi Gonçalves, Jr., Matias R. Viotti, Univ. Federal de Santa Catarina (Brazil). . . . . [8493-37]

11:10 am: **Three-dimensional data processing with advanced computer graphics tools**, Song Zhang, Iowa State Univ. (USA) . . . . . [8493-38]

11:30 am: **Analysis of solving the point correspondence problem by trifocal tensor for real-time phase measurement profilometry**, Kai Zhong, Zhongwei Li, Huazhong Univ. of Science and Technology (China). . . . . [8493-39]

11:50 am: **Improve Fourier transform profilometry by locally area modulating squared binary structured pattern**, Song Zhang, William Lohry, Iowa State Univ. (USA) . . . . . [8493-40]

Conference 8511 · Room: Conv. Ctr. 3

Monday-Tuesday 13-14 August 2012 • Proceedings of SPIE Vol. 8511

Infrared Remote Sensing and Instrumentation XX

Conference Chairs: **Marija Strojnik,** Ctr. de Investigaciones en Óptica, A.C. (Mexico); **Gonzalo Paez,** Ctr. de Investigaciones en Óptica, A.C. (Mexico)

Program Committee: **John Antoniades,** BAE Systems (USA); **Gabriele E. Arnold,** Deutsches Zentrum für Luft- und Raumfahrt e.V. (Germany); **Gail J. Brown,** Air Force Research Lab. (USA); **Catherine J. Cesarsky,** European Southern Observatory (Germany); **Jam Farhoomand,** TechnoScience Corp. (USA); **Gerald T. Fraser,** National Institute of Standards and Technology (USA); **John C. Gille,** National Ctr. for Atmospheric Research (USA); **Sarath D. Gunapala,** Jet Propulsion Lab. (USA); **Dietrich Lemke,** Max-Planck-Institut für Astronomie (Germany); **Neil R. Malone,** Raytheon Co. (USA); **Stanley J. Wellard,** Space Dynamics Lab. (USA); **Jan L. Williams,** e-Systems Management Consultants (USA); **Jürgen Wolf,** NASA Ames Research Ctr. (USA)

Sunday 12 August

SYMPOSIUM-WIDE PLENARY SESSION

Room: Conv. Ctr. 6A . . . . . Sun. 6:00 to 7:25 pm

6:00 pm: **Introduction and Opening Remarks**

6:05 pm: **The Exciting Science of Light with Metamaterials**
Vladimir M. Shalaev, Purdue Univ. (USA)

6:45 pm: **Future of Optics and Photonics**
Bahaa E. A. Saleh, CREOL, The College of Optics and Photonics at the Univ. of Central Florida (USA)

See page 10 for details.

Monday 13 August

WELCOME AND OPENING REMARKS

Room: Conv. Ctr. 3 . . . . . Mon. 9:00 to 9:20 am

Session Chairs: **Marija Strojnik,** Ctr. de Investigaciones en Óptica, A.C. (Mexico); **Gonzalo Paez,** Ctr. de Investigaciones en Óptica, A.C. (Mexico)

SESSION 1

Room: Conv. Ctr. 3 . . . . . Mon. 9:20 am to 12:20 pm

Infrared Activities at the Jet Propulsion Laboratory

Session Chair: **Sarath D. Gunapala,** Jet Propulsion Lab. (USA)

9:20 am: **Infrared instrument support for HyspIRI-TIR,** William R. Johnson, Simon J. Hook, Marc C. Foote, Bjorn T. Eng, Bruno M. Jau, Jet Propulsion Lab. (USA) . . . . . [8511-02]

9:40 am: **Inductively coupled plasma etching for delineation of InAs/GaSb pixels,** Jean Nguyen, Sir B. Rafol, Alexander Soibel, Arezou Khoshakhlagh, David Z. Ting, John K. Liu, Jason M. Mumolo, Sarath D. Gunapala, Jet Propulsion Lab. (USA) . . . . . [8511-03]

Coffee Break . . . . . 10:00 to 10:30 am

10:30 am: **Barrier infrared detector research at the Jet Propulsion Laboratory** *(Invited Paper),* David Z. Ting, Sam A. Keo, John K. Liu, Jason M. Mumolo, Arezou Khoshakhlagh, Alexander Soibel, Jean Nguyen, Linda Höglund, Sir B. Rafol, Cory J. Hill, Sarath D. Gunapala, Jet Propulsion Lab. (USA) . . . . . [8511-04]

11:00 am: **Multicolor QWIP FPAs for hyperspectral thermal emission instruments,** Alexander Soibel, Edward M. Luong, Jason M. Mumolo, John K. Liu, Sir B. Rafol, Sam A. Keo, William R. Johnson, Daniel W. Wilson, Cory J. Hill, David Z. Ting, Sarath D. Gunapala, Jet Propulsion Lab. (USA) . . . . . [8511-05]

11:20 am: **Minority carrier lifetime and photoluminescence studies of antimony-based superlattices,** Linda Höglund, Alexander Soibel, David Z. Ting, Arezou Khoshakhlagh, Sarath D. Gunapala, Jet Propulsion Lab. (USA) . . . . . [8511-06]

11:40 am: **Characterization of infrared focal plane arrays,** Sir B. Rafol, Sarath D. Gunapala, David Z. Ting, Alexander Soibel, Arezou Khoshakhlagh, Jean Nguyen, John K. Liu, Jason M. Mumolo, Sam A. Keo, Edward M. Luong, Linda Höglund, Jet Propulsion Lab. (USA) . . . . . [8511-07]

12:00 pm: **Fundamental and electrical characterization of atomic layer deposited dielectrics on GaSb and InAs substrates,** Frank Greer, Anita M. Fisher, Jean Nguyen, Alexander Soibel, Arezou Khoshakhlagh, Robert Kowalczyk, Sam A. Keo, Edward M. Luong, David Z. Ting, Sarath D. Gunapala, Jet Propulsion Lab. (USA) . . . . . [8511-08]

Lunch Break . . . . . 12:20 to 1:30 pm

SESSION 2

Room: Conv. Ctr. 3 . . . . . Mon. 1:30 to 4:30 pm

Infrared Missions and Instruments

Session Chairs: **Marija Strojnik,** Ctr. de Investigaciones en Óptica, A.C. (Mexico); **Stanley J. Wellard,** Space Dynamics Lab. (USA)

1:30 pm: **Fourier transform spectrometer servo characterization and improvement,** Morgan Davidson, Jason Swasey, John Elwell, Space Dynamics Lab. (USA) . . . . . [8511-46]

1:50 pm: **LINC-NIRVANA for the LBT: setting up the world's largest NIR binoculars for astronomy** *(Invited Paper),* Ralph Hofferbert, Harald Baumeister, Thomas Bertram, Jürgen Berwein, Peter Bizenberger, Armin Boehm, Michael Boehm, Jose Luis Borelli, Matthieu Brangier, Florian Briegel, Albert Conrad, Fulvio De Bonis, Roman Follert, Tom M. Herbst, Armin Huber, Frank Kittmann, Martin Kürster, Werner Laun, Ulrich Mall, Daniel Meschke, Lars Mohr, Vianak Naranjo, Aleksei Pavlov, Jorg-Uwe Pott, Hans-Walter Rix, Ralf-Rainer Rohloff, Eva Schinnerer, Clemens Storz, Jan Trowitzsch, Zhaojun Yan, Xianyu Zhang, Max-Planck-Institut für Astronomie (Germany); Andreas Eckart, Matthew Horrobin, Steffen Rost, Christian Straubmeier, Inke Wank, Jens Zuther, Univ. zu Köln (Germany); Udo Beckmann, Claus Connot, Matthias Heininger, Tim Kroener, Eddy Nussbaum, Dieter Schertl, Gerd P. Weigelt, Max-Planck-Institut für Radioastronomie (Germany); Maria Bergomi, Alessandro Brunelli, Jacopo Farinato, Roberto Ragazzoni, Valentina Viotto, INAF - Osservatorio Astronomico di Padova (Italy); Carmelo Arcidiacono, Emiliano Diolaiti, Italo Foppiani, Matteo Lombini, Laura Schreiber, INAF - Osservatorio Astronomico di Bologna (Italy); Francesco D'Alessio, Gianluca Li Causi, Dario Lorenzetti, Fabrizio Vitali, INAF-Osservatorio Astronomico di Roma (Italy); Mario Bertero, Patrizia Boccacci, Andrea La Camera, Univ. degli Studi di Genova (Italy) . . . . . [8511-09]

2:20 pm: **Stratospheric Observatory for Infrared Astronomy (SOFIA)** *(Invited Paper),* Eric E. Becklin, NASA Ames Research Ctr. (USA); Robert D. Gehrz, Univ. of Minnesota, Twin Cities (USA); Thomas L. Roellig, NASA Ames Research Ctr. (USA) . . . . . [8511-10]

2:50 pm: **Infrared remote sensing of planetary surfaces: an overview, outstanding questions, and prospects** *(Invited Paper),* Gabriele E. Arnold, Deutsches Zentrum für Luft- und Raumfahrt e.V. (Germany) . . . . . [8511-11]

Coffee Break . . . . . 3:20 to 3:50 pm

3:50 pm: **If EM waves don't interfere, what causes interferograms?,** Stanley J. Wellard, Space Dynamics Lab. (USA) . . . . . [8511-45]

4:10 pm: **Airborne measurement of atmospheric methane concentration using pulsed lidar,** Anand K. Ramanathan, Kenji Numata, Stewart T. Wu, Steven X. Li, Martha W. Dawsey, Jianping Mao, Stephan R. Kawa, Haris Riris, NASA Goddard Space Flight Ctr. (USA) . . . . . [8511-13]

Conference 8511 · Room: Conv. Ctr. 3

SESSION 3

Room: Conv. Ctr. 3 . . . . . Mon. 4:30 to 6:00 pm

Novel Infrared Technologies and In-Flight Calibration

Session Chairs: **Gonzalo Paez,** Ctr. de Investigaciones en Óptica, A.C. (Mexico); **Sergey N. Mekhontsev,** National Institute of Standards and Technology (USA)

4:30 pm: **Interband cascade lasers for sensing operating in continuous wave mode at room temperature** *(Invited Paper)*, Sven Höfling, Adam Bauer, Robert Weih, Martin Kamp, Alfred W. Forchel, Julius-Maximilians-Univ. Würzburg (Germany) . . . . . [8511-14]

5:00 pm: **GaAs/AlGaAs resonant tunneling diodes with a GaInNAs absorption layer for telecommunication light sensing**, Fabian Hartmann, Fabian Langer, Dirk Bisping, A. Musterer, Sven Höfling, Martin Kamp, Alfred W. Forchel, Lukas Worschech, Julius-Maximilians-Univ. Würzburg (Germany) . . . . . [8511-15]

5:20 pm: **Sensitive detectors of terahertz radiation based on $Pb_{1-x}Sn_xTe(In)$**, Dmitry Dolzhenko, Lomonosov Moscow State Univ. (Russian Federation); Andrey V. Nicorici, Institute of Applied Physics (Moldova); Ludmila I. Ryabova, Dmitry R. Khokhlov, Lomonosov Moscow State Univ. (Russian Federation) . . . . . [8511-16]

5:40 pm: **In-flight blackbody calibration sources for the GLORIA interferometer,** Friedhelm Olschewski, Bergische Univ. Wuppertal (Germany); Christian Rolf, Forschungszentrum Jülich GmbH (Germany); Philipp Steffens, Bergische Univ. Wuppertal (Germany); Anne Kleinert, Christof Piesch, Andreas Ebersoldt, Karlsruher Institut für Technologie (Germany); Christian Monte, Berndt Gutschwager, Joerg Hollandt, Physikalisch-Technische Bundesanstalt (Germany); Peter Preusse, Forschungszentrum Jülich GmbH (Germany); Felix Friedl-Vallon, Karlsruher Institut für Technologie (Germany); Ralf Koppmann, Bergische Univ. Wuppertal (Germany) . . . . . [8511-17]

POSTERS-MONDAY

Room: Conv. Ctr. Exhibition Hall B2 . Mon. 5:30 to 7:30 pm

Conference attendees are invited to attend the poster session on Monday evening. Come view the posters, enjoy light refreshments, ask questions, and network with colleagues in your field. Authors of poster papers will be present to answer questions concerning their papers. Attendees are required to wear their conference registration badges to the poster sessions. Poster authors, view poster presentation guidelines at http://spie.org/x30293.xml.

Metrological advantages of the light source based on optically connected integrating spheres, Leonid A. Mikheenko, Volodymyr N. Borovytsky, Zahar V. Fesenko, National Technical Univ. of Ukraine (Ukraine) . . . . . [8511-39]

Improvement of the signal-to-noise ratio in the acquisition of photoplethysmographic images, Luis F. Corral Martinez, Gonzalo Paez, Marija Strojnik, Ctr. de Investigaciones en Óptica, A.C. (Mexico) . . . . . [8511-40]

Qualitative performance analysis of a rotationally shearing interferometer for testing components without rotational symmetry, Enoch Gutierrez-Herrera, Tecnológico de Monterrey (Mexico); Marija Strojnik, Gonzalo Paez, Ctr. de Investigaciones en Óptica, A.C. (Mexico); Juan Manuel Lopez-Ramirez, Tecnológico de Monterrey (Mexico) . . . . . [8511-41]

Methods for edge enhancement in color images based on derivative operations, Jorge L. Flores-Nuñez, Univ. de Guadalajara (Mexico); José A. Ferrari, Gastón A. Ayubi, J. Matías Di Martino, Ariel Fernández, Julia R. Alonso, Univ. de la República (Uruguay) . . . . . [8511-42]

Vectorial shearing interferometer used in defocus detection, Guillermo García-Torales, Jorge Sanchez Preciado, Jorge L. Flores-Nuñez, Univ. de Guadalajara (Mexico) . . . . . [8511-43]

Implementation of a fluorescence-based thermal-to-visible converter, Mariana Alfaro, Gonzalo Paez, Marija Strojnik, Ctr. de Investigaciones en Óptica, A.C. (Mexico) . . . . . [8511-44]

Tuesday 14 August

SESSION 4

Room: Conv. Ctr. 3 . . . . . Tues. 8:20 to 11:50 am

Instruments for Infrared Atmospheric Probing

Session Chairs: **Gabriele E. Arnold,** Deutsches Zentrum für Luft- und Raumfahrt e.V. (Germany); **Marija Strojnik,** Ctr. de Investigaciones en Óptica, A.C. (Mexico)

8:20 am: **Mexican InfraRed Observation Satellite (MIROS): instrument concept and mission description**, Enrique Pacheco-Cabrera, Ctr. de Investigación Científica y de Educación Superior de Ensenada (Mexico); Michael Schmidt, Comisión Nacional Para el Conocimiento y Uso de la Biodiversidad (Mexico); Francisco J. Mendieta, Ctr. de Investigación Científica y de Educación Superior de Ensenada (Mexico); Eckehard Lorenz, Deutsches Zentrum für Luft- und Raumfahrt e.V. (Germany) . . . . . [8511-18]

8:40 am: **Final correction algorithms for HIRDLS version 7 data** *(Invited Paper)*, John C. Gille, Univ. of Colorado at Boulder (USA) and National Ctr. for Atmospheric Research (USA); Charles Cavanaugh, Gene L. Francis, Christopher Halvorson, Craig Hartsough, Bruno Nardi, Maria B. Rivas, Lesley Smith, National Ctr. for Atmospheric Research (USA) . . . . . [8511-19]

9:10 am: **The engineering model for the multispectral imager of the EarthCARE spacecraft**, Abelardo Perez-Albinana, Robert V. Geisthorpe, Alain Lefebvre, European Space Research and Technology Ctr. (Netherlands); Maximilian Sauer, Klaus-Werner Kruse, Ralf Münzenmayer, EADS Astrium GmbH (Germany); Guy C. Balster, Mark Chang, Julie Everett, Andy Barnes, Nigel Bates, Matt Price, Mark Skipper, Surrey Satellite Technology Ltd. (United Kingdom); Bryan T. G. de Goeij, Eliart A. Meijer, Frits van der Knaap, Adriaan Van't Hof, TNO (Netherlands) . . . . . [8511-20]

9:30 am: **Lessons learned from three years' operation of TANSO-FTS on GOSAT**, Hiroshi Suto, Akihiko Kuze, Kei Shiomi, Masakatsu Nakajima, Japan Aerospace Exploration Agency (Japan) . . . . . [8511-21]

9:50 am: **Absolute radiance re-calibration of FIRST**, Harri Latvakoski, Space Dynamics Lab. (USA); Martin Mlynczak, David G. Johnson, Richard Cageao, NASA Langley Research Ctr. (USA); Jason A. Swasey, Kendall Johnson, Space Dynamics Lab. (USA). . . . . [8511-22]

10:10 am: **Infrared remote sensing of the ionosphere-thermosphere response to auroral particle precipitation at E-region altitudes**, Christopher J. Mertens, NASA Langley Research Ctr. (USA); Xiaojing Xu, Science Systems and Applications, Inc. (USA); Stanley J. Wellard, Space Dynamics Lab. (USA). . . . . [8511-23]

Coffee Break . . . . . 10:30 to 11:00 am

11:00 am: **The evolution of the performance of the AVHRR, HIRS and AMSU-A instruments on board MetOp-A after over five years in orbit**, Douglas R. Batties, HE Space Operations, Inc. (USA); Robert W. Lambeck, Dell Perot Systems (USA); Abelardo Perez-Albinana, European Space Research and Technology Ctr. (Netherlands); Xiangqian Wu, Changyong Cao, NOAA-NESDIS (USA); Helmut Bauch, VEGA-Deutschland GmbH (Germany); Francois Montagner, European Organisation for the Exploitation of Meteorological Satellites (Germany) . . . . . [8511-24]

11:20 am: **Recent advances in improvement of forecast skill and understanding climate processes using AIRS Version-5 products** *(Invited Paper)*, Joel Susskind, NASA Goddard Space Flight Ctr. (USA); Gyula I. Molnar, Morgan State Univ. (USA); Lena Iredell, SAIC (USA); Oreste Reale, GESTAR/USRA (USA). . . . . [8511-25]

SESSION 5

Room: Conv. Ctr. 3 . . . . . Tues. 11:50 am to 12:30 pm

Radiometry and Thermography I

Session Chairs: **John C. Gille,** Univ. of Colorado at Boulder (USA); **Gonzalo Paez,** Ctr. de Investigaciones en Óptica, A.C. (Mexico)

11:50 am: **Expansion of the temperature and wavelength ranges of NIST infrared spectroradiometry capabilities for thermal sources and materials**, Sergey N. Mekhontsev, National Institute of Standards and Technology (USA); Vladimir B. Khromchenko, Space Dynamics Lab. (USA); Boris Wilthan, Leonard M. Hanssen, National Institute of Standards and Technology (USA) . . [8511-26]

12:10 pm: **Infrared reflectometry of blackbody and radiometer cavities for satellite instrumentation**, Leonard M. Hanssen, Jinan Zeng, National Institute of Standards and Technology (USA). . . . . [8511-27]

Lunch/Exhibition Break . . . . . 12:30 to 2:00 pm

SESSION 6
Room: Conv. Ctr. 3 . . . . . Tues. 2:00 to 3:10 pm

Radiometry and Thermography II

Session Chairs: **John C. Gille,** Univ. of Colorado at Boulder (USA); **Gonzalo Paez,** Ctr. de Investigaciones en Óptica, A.C. (Mexico)

2:00 pm: **Microscale thermal imaging of advanced organic and polymeric materials** *(Invited Paper)*, Junko Morikawa, Tokyo Institute of Technology (Japan). . . . . [8511-28]

2:30 pm: **Generation of a GIS-based environment for infrared thermography analysis of buildings**, Marco Scaioni, Tongji Univ. (China); Elisabetta Rosina, Luigi Barazzetti, Mattia Previtali, Veronica Redaelli, Politecnico di Milano (Italy) . [8511-29]

2:50 pm: **Simultaneous measurement of temperature and emissivity with stereo dual wavelength thermography**, Gennaro Cardone, Univ. degli Studi di Napoli Federico II (Italy). . . . . [8511-30]

SESSION 7
Room: Conv. Ctr. 3 . . . . . Tues. 3:10 to 6:00 pm

Toward Larger and More Robust Infrared Arrays at Raytheon

Session Chairs: **Neil R. Malone,** Raytheon Co. (USA); **Decosta Lindsay,** Raytheon Co. (USA)

3:10 pm: **Performance results from MISSE7 focal plane flown on International Space Station (ISS) for two years**, Neil R. Malone, Raytheon Co. (USA) . . . . . [8511-31]

Coffee Break . . . . . 3:30 to 4:00 pm

4:00 pm: **Blinker pixels in infrared focal plane arrays**, Raymond Boe, Raytheon Co. (USA) . . . . . [8511-32]

4:20 pm: **Lifetime evaluation of field effect transistors**, Albert Linder, Raytheon Co. (USA) . . . . . [8511-33]

4:40 pm: **Radiometric analysis for infrared focal planes**, Decosta Lindsay, Raytheon Co. (USA) . . . . . [8511-35]

5:00 pm: **Large format infrared digital focal planes**, Micky Harris, Raytheon Co. (USA). . . . . [8511-36]

5:20 pm: **Large format SIPIN focal plane yield advancements**, Bryan Kean, Raytheon Co. (USA) . . . . . [8511-37]

5:40 pm: **Infrared focal plane alignment capabilities at Raytheon,** Russell Parlato, Raytheon Co. (USA) . . . . . [8511-38]

CONCLUDING REMARKS
Room: Conv. Ctr. 3 . . . . . Tues. 6:00 to 6:20 pm

Session Chairs: **Marija Strojnik,** Ctr. de Investigaciones en Óptica, A.C. (Mexico); **Gonzalo Paez,** Ctr. de Investigaciones en Óptica, A.C. (Mexico)

Conference 8484 · Room: Conv. Ctr. 6D

Monday-Thursday 13-16 August 2012 • Proceedings of SPIE Vol. 8484

Twelfth International Conference on Solid State Lighting and Fourth International Conference on White LEDs and Solid State Lighting

Conference Chairs: **Matthew H. Kane,** Massachusetts Maritime Academy (USA); **Christian Wetzel,** Rensselaer Polytechnic Institute (USA); **Jian-Jang Huang,** National Taiwan Univ. (Taiwan); **Ian T. Ferguson,** The Univ. of North Carolina at Charlotte (USA)

Program Committee: **Srinath K. Aanegola,** GE Global Research (India); **Ian E. Ashdown,** byHeart Consultants Ltd. (Canada); **Lianghui Chen,** Institute of Semiconductors (China); **Wood Hi Cheng,** National Sun Yat-Sen Univ. (Taiwan); **John W. Curran,** LED Transformations, LLC (USA); **Nikolaus Dietz,** Georgia State Univ. (USA); **Samuel Graham,** Georgia Institute of Technology (USA); **Volker K. Härle,** OSRAM Opto Semiconductors GmbH (Germany); **Christoph Hoelen,** Philips Lighting B.V. (Netherlands); **Jianzhong Jiao,** OSRAM Opto Semiconductors Inc. (USA); **Asif M. Khan,** Univ. of South Carolina (USA); **Michael R. Krames,** Soraa, Inc. (USA); **Yung Sheng Liu,** National Tsing Hua Univ. (Taiwan); **Eun-Hyun Park,** Kyung Hee Univ. (Korea, Republic of); **Seong-Ju Park,** Gwangju Institute of Science and Technology (Korea, Republic of); **Jeff Quinlan,** Acuity Brands Lighting, Inc. (USA); **Robert V. Steele,** Strategies Unlimited (USA); **Chih-Chung Yang,** National Taiwan Univ. (Taiwan); **Yiting Zhu,** Rensselaer Polytechnic Institute (USA)

Monday 13 August

POSTERS-MONDAY

Room: Conv. Ctr. Exhibition Hall B2 . Mon. 5:30 to 7:30 pm

Conference attendees are invited to attend the poster session on Monday evening. Come view the posters, enjoy light refreshments, ask questions, and network with colleagues in your field. Authors of poster papers will be present to answer questions concerning their papers. Attendees are required to wear their conference registration badges to the poster sessions. Poster authors, view poster presentation guidelines at http://spie.org/x30293.xml.

Fluorescent SiC with pseudo-periodic moth-eye structures, Yiyu Ou, Imran Aljaz, Haiyan Ou, Technical Univ. of Denmark (Denmark). . . . . [8484-43]

Surface-structure film by glass mold with down-size sintering method, Yi-Chien Lo, Xuan-Hao Li, Jung-Lin Tsai, Ching-Cherng Sun, Ching-Yi Chen, Chong-Jhih Jiang, National Central Univ. (Taiwan). . . . . [8484-44]

Enhanced optical power of InGaN/GaN near-ultraviolet light emitting diodes by surface plasmon in silver nanoparticles, Sang-Hyun Hong, Chu-Young Cho, Sang-Jun Lee, Sang Youp Yim, Seong-Ju Park, Gwangju Institute of Science and Technology (Korea, Republic of) . . . . . [8484-45]

Improved light output power of GaN-based green light emitting diodes by periodic sub-wavelength structure, Jung-Hoon Song, Han-Min Lee, Young Chul Lee, Yu-Shin Park, Gwangju Institute of Science and Technology (Korea, Republic of); Hyung-Duk Ko, Samsung Digital City (Korea, Republic of); Sung-Tae Kim, Samsung Electro-Mechanics (Korea, Republic of); Gun-Young Jung, Seong-Ju Park, Gwangju Institute of Science and Technology (Korea, Republic of) . . . . . [8484-46]

Evaluation of electrical and thermal coupling in solid state lighting systems, Han-Kuei Fu, Chien-Ping Wang, Hsin-Chien Chiang, Tzung-Te Chen, Chiu Ling Chen, Pei-Ting Chou, Industrial Technology Research Institute (Taiwan). . . . . [8484-47]

LED package with side-emitting enhancement silicone lens achieved by hydrophobic material coating and dispensing, Chien Lin Chang Chien, Yu-Che Huang, Chung Min Chang, National Tsing Hua Univ. (Taiwan); Syue Fong Hu, Chang Wen Sun, Advanced Optoelectronic Technology, Inc. (Taiwan); Ming-Chuen Yip, Welleun Fang, National Tsing Hua Univ. (Taiwan) . . . . . [8484-48]

Optical trapping using a superluminescent diode, Dennis Tierney, Steve Riechman, Sean Gravelle, Mathew Fletcher, Heidrun Schmitzer, Xavier Univ. (USA) . . . . . [8484-49]

Effects of strains and defects on the internal quantum efficiency of InGaN/GaN nanorod light emitting diodes, Li-Chuan Huang, Chun-Hsiang Chang, Liang-Yi Chen, Jin-Yi Chen, Jian-Jang Huang, National Taiwan Univ. (Taiwan) . . . . . [8484-50]

Automated hardware-software system for LED's verification and certification, Aleksandr N. Chertov, Elena V. Gorbunova, Maria G. Serikova, Vladimir S. Peretyagin, Anatoly D. Vakulenko, National Research Univ. of Information Technologies, Mechanics and Optics (Russian Federation)[8484-51]

Graphene on Ag films for reflectively conductive layer ohmic contacts to p-type GaN in GaN-based light emitting diodes, Lung-Chien Chen, Ching-Ho Tien, Min-Hsueh Chiang, National Taipei Univ. of Technology (Taiwan) [8484-52]

Using artificial neural networks approach for the color enhancement of high-power LEDs, Hsi-Chao Chen, Guo-Yang Wu, Peng-Ying Chen, Mei-Jyun Lai, Kuo-Ting Huang, National Yunlin Univ. of Science and Technology (Taiwan) . . . . . [8484-53]

High-yield thin GaN LED using metal bonding and laser lift-off technology, Ray-Hua Horng, Re-Ching Lin, Wei-Cheng Kao, Dong-Sing Wuu, Ching-Ho Chen, National Chung Hsing Univ. (Taiwan) . . . . . [8484-54]

Effect of the nucleation layer thickness on the physical properties of epitaxial InN layers, Sampath Gamage, Matara K. I. Senevirathna, Ramazan Atalay, Georgia State Univ. (USA); Max Buegler, Georgia State Univ. (USA) and Technische Univ. Berlin (Germany); Agu U. Perera, Georgia State Univ. (USA); Axel Hoffmann, Technische Univ. Berlin (Germany); Andrew G. Melton, Ian T. Ferguson, The Univ. of North Carolina at Charlotte (USA); Nikolaus Dietz, Georgia State Univ. (USA) . . . . . [8484-55]

TECHNICAL EVENT

Marriott Hotel, Marina F . . . . . .Mon. 8:00 to 10:00 pm

Illumination

Chair: **Jake Jacobsen,** Synopsys, Inc. (USA)

Interest in free-form optics has been increasing in recent years. With advances in computational methods, the use of such surfaces has become practical for a wide range of applications where precise tailoring the illumination pattern is critical. At this year's technical event we will discuss issues surrounding the specification and use of free-form optics for illumination systems.
The following speakers have agreed to talk at the event and participate in a panel discussion afterwards:

Dr. William Cassarly, Synopsys, Inc. (USA)

Prof. Pablo Benítez, Univ. Politécnica de Madrid (Spain) and Light Prescriptions Innovators LLC (USA)

Prof. Harald Ries, Optics and Energy Concepts AG (Germany)

At the end of the planned event, time permitting, any member of the audience may present information within the broad field of illumination. Light refreshments will be served.

Light refreshments sponsored by:

The Optical Solutions Group at

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Conference 8484 · Room: Conv. Ctr. 6D

Tuesday 14 August

PLENARY SESSION

Room: Conv. Ctr. 6A . . . . . Tues. 8:30 to 10:00 am

OLEDs and Solid State Lighting

Session Chairs: **Mathew K. Mathai,** Plextronics, Inc. (USA); **Matthew H. Kane,** Massachusetts Maritime Academy (USA)

8:30 am: **Development of charge generation layers for multiphoton emission OLED** *(Presentation Only)*, Junji Kido, Hisahiro Sasabe, Yong-Jin Pu, Yamagata Univ. (Japan) . . . . . .[8476-101]

9:15 am: **LED development with nanostructures and nanophotonics** *(Presentation Only)*, Chih-Chung Yang, National Taiwan Univ. (Taiwan). . . . . .[8484-102]

Coffee Break . . . . . 10:00 to 10:30 am

SESSION 1

Room: Conv. Ctr. 6E . . . . . Tues. 10:30 am to 12:30 pm

NOTE ROOM CHANGE

Solid State Lighting and OLEDs

Joint Session with Conference 8476

Session Chairs: **Ian T. Ferguson,** The Univ. of North Carolina at Charlotte (USA); **Juergen Kreis,** AIXTRON SE (Germany)

10:30 am: **OLED-based physiologically-friendly very low-color temperature illumination for night** *(Invited Paper)*, Jwo-Huei Jou, Shih-Ming Shen, Ming-Chun Tang, Pin-Chu Chen, Chun-Yu Hsieh, Chin-Chiao Lin, National Tsing Hua Univ. (Taiwan); Szu-Hao Chen, Yi-Shan Wang, Chien-Chih Chen, Ching-Chun Wang, Industrial Technology Research Institute (Taiwan); Chien-Tien Chen, National Tsing Hua Univ. (Taiwan). . . . . [8476-44]

11:00 am: **White light quality of phosphor converted LEDs from a phosphor materials perspective of view: an evaluation based on combined thermal and optical simulations** *(Invited Paper)*, Franz-Peter Wenzl, Christian Sommer, JOANNEUM RESEARCH Forschungsgesellschaft mbH (Austria); Peter Pachler, Hans Hoschopf, TridonicAtco Optoelectronics GmbH (Austria); Gregor Langer, Austria Technologie & Systemtechnik AG (Austria); Paul Fulmek, Johann Nicolics, Technische Univ. Wien (Austria); Paul Hartmann, JOANNEUM RESEARCH Forschungsgesellschaft mbH (Austria) . . . . . [8484-01]

11:30 am: **Towards high-efficiency solution processed WOLEDs for lighting applications** *(Invited Paper)*, Jonathan F. Mamoury, Enrico Orselli, Dominique Bascour, Olivier Gaudin, Jean-Pierre Catinat, Solvay S.A. (Belgium); Neetu Chopra, Jing Wang, Sergei Li, Eli Scott, Venkataramanan Seshadri, Christophe Grenier, Christopher T. Brown, Mathew K. Mathai, Plextronics, Inc. (USA) . . . . . [8476-45]

12:00 pm: **Crack-free GaN deposition on Si substrate with temperature-graded AlN buffer growth and the emission characteristics of overgrown InGaN/GaN quantum wells** *(Invited Paper)*, Chih-Yen Chen, Wen-Ming Chang, Wei-Lun Chung, Yen-Hung Liu, Chieh Hsieh, Che-Hao Liao, Shao-Ying Ting, Yean-Woei Kiang, Chih-Chung Yang, National Taiwan Univ. (Taiwan). [8484-02]

Lunch/Exhibition Break . . . . . 12:30 to 2:00 pm

SESSION 2

Room: Conv. Ctr. 6D . . . . . Tues. 2:00 to 3:40 pm

LED Design I

Session Chair: **J. Kumar,** Anna Univ. Chennai (India)

2:00 pm: **Recent progress of phosphor-free single-chip white LEDs**, Xia Guo, Bao Lu Guan, Zhi Ping Su, Beijing Univ. of Technology (China) . [8484-03]

2:20 pm: **Process development of GaN light emitting diodes with imbedded contacts**, Ray-Hua Horng, National Chung Hsing Univ. (Taiwan); Yu Wei Kuo, National Cheng Kung Univ. (Taiwan). . . . . [8484-04]

2:40 pm: **Electrical properties of Ti/Al ohmic contacts to molecular beam epitaxy-grown N-face n-type GaN for vertical-structure LEDs**, Joon-Woo Jeon, Tae-Yeon Seong, Korea Univ. (Korea, Republic of); Gon Namkoong, Old Dominion Univ. (USA) . . . . . [8484-05]

3:00 pm: **Enhanced optical output power of InGaN/GaN light emitting diodes by bandgap-engineering of electron blocking layer**, Sang-Jun Lee, Chu-Young Cho, Sang-Hyun Hong, Gwangju Institute of Science and Technology (Korea, Republic of); Sang-Heon Han, Sukho Yoon, Sung-Tae Kim, Samsung LED Co. Ltd. (Korea, Republic of); Seong-Ju Park, Gwangju Institute of Science and Technology (Korea, Republic of) . . . . . [8484-06]

3:20 pm: **High-temperature (400°C) glass based phosphor-converted white light emitting diodes for solid state lighting**, Wood Hi Cheng, National Sun Yat-Sen Univ. (Taiwan); Chun Chin Tsai, Far East Univ. (Taiwan). . . . . [8484-07]

Coffee Break . . . . . 3:40 to 4:00 pm

SESSION 3

Room: Conv. Ctr. 6D . . . . . Tues. 4:00 to 5:20 pm

Thermal Management and Lifetime Issues

Session Chair: **Seong-Ju Park,** Gwangju Institute of Science and Technology (Korea, Republic of)

4:00 pm: **Uncertainty analysis in lifetime measurement for white light emitting diodes**, Haiping Shen, Xiaoli Zhou, Wanlu Wanlu, Muqing Liu, Fudan Univ. (China) . . . . . [8484-08]

4:20 pm: **Determining thermal resistance in LEDs through an induced transient heating method**, Shweta Natarajan, Yishak Habtemichael, Samuel Graham, Georgia Institute of Technology (USA). . . . . [8484-09]

4:40 pm: **Heat spreading improvement on thin-GaN light emitting diodes by using diamond-like carbon passivation layer**, Yen-Shuo Liu, Cheng-Yi Liu, National Central Univ. (Taiwan). . . . . [8484-10]

5:00 pm: **A quantitative dimming method for LED based on PWM**, Jiyong Wang, Zhejiang Univ. (China); Tongsheng Mou, Zhejiang Univ. (China) and SENSING Instruments Co., Ltd. (China); Jianping Wang, SENSING Instruments Co., Ltd. (China) . . . . . [8484-11]

Wednesday 15 August

SESSION 4

Room: Conv. Ctr. 6D . . . . . Wed. 8:30 to 10:30 am

Novel Buffer Layers and Substrates

Session Chair: **Wang N. Wang,** Univ. of Bath (United Kingdom)

8:30 am: **Study of lighting emitting pattern and light extraction efficiency on GaN LEDs on PSS substrates**, Hong-yu Lin, Cheng-yi Liu, National Central Univ. (Taiwan) . . . . . [8484-12]

8:50 am: **Effect of PSS pattern morphology on light extraction efficiency**, Syu Fong Li, Cheng-Yi Liu, National Central Univ. (Taiwan) . . . . . [8484-13]

9:10 am: **Lift-off of epitaxial layer upon high-temperature regrowth of porous n-GaN**, Jin-Ho Kang, Mohamed E. AbdRabou, SooHee Kim, Chonnam National Univ. (Korea, Republic of); Sang-Wan Ryu, Chonnam National Univ (Korea, Republic of). . . . . [8484-14]

9:30 am: **Effect of SiNx interlayer on structural and electrical properties of nonpolar a-plane (11-20) gallium nitride**, Ji Hoon Kim, Jung Ho Park, Korea Univ. (Korea, Republic of); Kwang Hyeon Baik, Yong Gon Seo, Sung-Min Hwang, Korea Electronics Technology Institute (Korea, Republic of). . [8484-15]

9:50 am: **High-efficiency blue light emitting diode with air voids embedded in lateral epitaxially overgrown GaN using a metal mask**, Chu-Young Cho, Kwang Jae Lee, Sang-Hyun Hong, Sang-Jun Lee, Jae-Joon Kim, Seong-Ju Park, Gwangju Institute of Science and Technology (Korea, Republic of). . . . . [8484-16]

10:10 am: **Wafer-level photoelectrochemical liftoff of patterned sapphire substrate for fabricating vertical light emitting diode**, Chieh Hsieh, Horng-Shyang Chen, Chih-Yen Chen, Che-Hao Liao, Chun-Han Lin, Cheng-Hung Lin, Shao-Ying Ting, Yu-Feng Yao, Hao-Tsung Chen, Yean-Woei Kiang, Chih-Chung Yang, National Taiwan Univ. (Taiwan). . . . . [8484-17]

Coffee Break . . . . . 10:30 to 11:00 am

SESSION 5
Room: Conv. Ctr. 6D . . . . . Wed. 11:00 am to 12:10 pm

Nanostructured LEDs
Session Chair: **Chih-Chung Yang,** National Taiwan Univ. (Taiwan)

11:00 am: **Localized surface plasmon coupled light emitting diode with metal nanoparticles on its surface**, Dong-Ming Yeh, Yu-Lung Jung, Che-Wei Huang, Hung-Yu Tseng, Chih-Yen Chen, Che-Hao Liao, Chieh Hsieh, Horng-Shyang Chen, Yean-Woei Kiang, Chih-Chung Yang, National Taiwan Univ. (Taiwan) . . . . . [8484-18]

11:20 am: **Regularly-patterned InGaN/GaN nanorod light emitting diode arrays with c-plane disk-like and m-plane core-shell quantum wells**, Che-Hao Liao, Horng-Shyang Chen, Dong-Ming Yeh, Wen-Ming Chang, Yu-Feng Yao, Chih-Yen Chen, Shao-Ying Ting, Hao-Tsung Chen, Chia-Ying Su, Chieh Hsieh, Yean-Woei Kiang, Chih-Chung Yang, National Taiwan Univ. (Taiwan) . . . . . [8484-20]

11:40 pm: **Mode interactions in a GaN-based light emitting diode with surface photonic crystals and nanoholes** *(Invited Paper)*, Tsung-Han Tsai, Yu-Feng Yin, Yen-Chen Lin, Szu-Chieh Wang, Yun-Wei Cheng, Jian-Jang Huang, National Taiwan Univ. (Taiwan) . . . . . [8484-21]

Lunch/Exhibition Break . . . . . 12:10 to 2:00 pm

SESSION 6
Room: Conv. Ctr. 6D . . . . . Wed. 2:00 to 3:20 pm

Phosphors and Color Management
Session Chair: **Yiting Zhu,** Rensselaer Polytechnic Institute (USA)

2:00 pm: **The impact of the silicone encapsulation layers on the white light quality of phosphor converted LEDs**, Christian Sommer, Paul Hartmann, JOANNEUM RESEARCH Forschungsgesellschaft mbH (Austria); Peter Pachler, Tridonic Jennersdorf GmbH (Austria); Hans Hoschopf, TridonicAtco Optoelectronics GmbH (Austria); Gregor Langer, Austria Technologie & Systemtechnik AG (Austria); Paul Fulmek, Johann Nicolics, Technische Univ. Wien (Austria); Franz-Peter Wenzl, JOANNEUM RESEARCH Forschungsgesellschaft mbH (Austria) . . . . . [8484-22]

2:20 pm: **Effect of different colored background lighting on LED glare perception**, Kathryn Sweater Hickcox, Nadarajah Narendran, John D. Bullough, Jean Paul Freyssinier, Rensselaer Polytechnic Institute (USA) . . . . . [8484-23]

2:40 pm: **Comparative study on the phosphor converted white LEDs performance based on phosphor characterization**, Yu-Shin Lu, Lextar Electronics Corp. (Taiwan) . . . . . [8484-24]

3:00 pm: **How to assess color uniformity in LED lighting**, Ivan Moreno, Luz Maria Garcia, Alejandra Bugarin, Univ. Autónoma de Zacatecas (Mexico) . . . . . [8484-25]

Coffee Break . . . . . 3:20 to 3:50 pm

SESSION 7
Room: Conv. Ctr. 6D . . . . . Wed. 3:50 to 5:00 pm

LED Design II
Session Chair: **Wood Hi Cheng,** National Sun Yat-Sen Univ. (Taiwan)

3:50 pm: **On light emission based on nitrides** *(Invited Paper)*, J. Kumar, Krishnan Baskar, Anna Univ. Chennai (India) . . . . . [8484-26]

4:20 pm: **Low-voltage CdZnO/ZnO multiple quantum-well light emitting diode with p-type GaN**, Horng-Shyang Chen, Shao-Ying Ting, Yu-Feng Yao, Hao-Tsung Chen, Wen-Ming Chang, Che-Hao Liao, Chih-Yen Chen, Chieh Hsieh, Yean-Woei Kiang, Chih-Chung Yang, National Taiwan Univ. (Taiwan) . . . . . [8484-27]

4:40 pm: **Multiple wavelength LED on monolithic QW structure**, Abdullah J. Zakariya, Patrick LiKamWa, CREOL, The College of Optics and Photonics, Univ. of Central Florida (USA) . . . . . [8484-29]

Thursday 16 August

SESSION 8
Room: Conv. Ctr. 6D . . . . . Thurs. 8:40 to 10:30 am

LED Materials
Session Chair: **Andrew G. Melton,** The Univ. of North Carolina at Charlotte (USA)

8:40 am: **Growth and characterization of indium-rich InGaN epilayers grown by high-pressure CVD** *(Invited Paper)*, Nikolaus Dietz, Ramazan Atalay, Sampath Gamage, Kasuni Nanayakkara, Rasanga Samaraweera, Matara K. I. Senevirathna, Agu U. Perera, Georgia State Univ. (USA); Andrew G. Melton, Ian T. Ferguson, The Univ. of North Carolina at Charlotte (USA) . . . . . [8484-30]

9:10 am: **High-thermal stability of indium-rich InGaN films (33 and 60%) grown by pulsed laser deposition**, Tzu-Yu Wang, Kun-Ching Shen, Sin-Liang Ou, Dong-Sing Wuu, Ray-Hua Horng, National Chung Hsing Univ. (Taiwan) . . . . . [8484-31]

9:30 am: **Fabrication of p-ZnO thin films by ZrN codoping**, Gowrishankar Subramaniam, Balakrishnan Lakshmi Narayanan, Gopalakrishnan Nammalvar, National Institute of Technology, Tiruchirappalli (India) . . . . . [8484-32]

9:50 am: **Effect of V/III molar ratio and reactor pressure on the optical properties InN**, Max Buegler, Technische Univ. Berlin (Germany); Sampath Gamage, Matara K. I. Senevirathna, Ramazan Atalay, Georgia State Univ. (USA); Ronny Kirste, Technische Univ. Berlin (Germany); Liqin Su, Andrew G. Melton, The Univ. of North Carolina at Charlotte (USA); James Tweedie, Ramon Collazo, North Carolina State Univ. (USA); Ian T. Ferguson, The Univ. of North Carolina at Charlotte (USA); Zlatko Sitar, North Carolina State Univ. (USA); Axel Hoffmann, Technische Univ. Berlin (Germany); Nikolaus Dietz, Georgia State Univ. (USA) . . . . . [8484-33]

10:10 am: **Nuclear science and optical studies of InAlGaP materials grown on GaAs by metalorganic chemical vapor deposition**, Lin Li, Peking Univ. (China); Yi Zhe Huang, National Taiwan Univ (Taiwan); Shu-De Yao, Peking Univ. (China); Zhe Chuan Feng, National Taiwan Univ. (Taiwan); Ian T. Ferguson, The Univ. of North Carolina at Charlotte (USA) . . . . . [8484-34]

Coffee Break . . . . . 10:30 to 11:00 am

SESSION 9
Room: Conv. Ctr. 6D . . . . . Thurs. 11:00 am to 12:20 pm

Optical Design and Studies
Session Chair: **Nikolaus Dietz,** Georgia State Univ. (USA)

11:00 am: **A numerical study on the surface plasmon coupling with radiating dipoles in the quantum wells of a light emitting diode**, Yang Kuo, Yean-Woei Kiang, Chih-Chung Yang, National Taiwan Univ. (Taiwan). [8484-35]

11:20 am: **Optics for efficient focusing of LED light**, Ivan Moreno, Maricruz Ramirez-Sierra, Diego Esparza, Univ. Autónoma de Zacatecas (Mexico) . . . . . [8484-36]

11:40 am: **Reduction in power consumption with the implementation of LED**, Sourav Sarkar, West Bengal Univ. of Technology (India); Amitava Sengupta, Philips Electronics India Pvt. Ltd. (India) . . . . . [8484-37]

12:00 pm: **Time-resolved and temperature-varied photoluminescence studies of InGaN/GaN multiple quantum well structures**, Lei Liu, Peking Univ (China); J. H. Yang, National Taiwan Univ. (Taiwan); Xiaodong Hu, Peking Univ. (China); Jian-Jang Huang, Zhe Chuan Feng, National Taiwan Univ. (Taiwan) . . . . . [8484-38]

Lunch/Exhibition Break . . . . . 12:20 to 2:00 pm

SESSION 10
Room: Conv. Ctr. 6D . . . . . Thurs. 2:00 to 3:00 pm

Applications
Session Chair: **Jian-Jang Huang,** National Taiwan Univ. (Taiwan)

2:00 pm: **Design of optical lens for LED road lighting**, Chi-Feng Lin, Yu-Bin Fang, National Ctr. for High-performance Computing (Taiwan); Tao-Hsing Chen, National Kaohsiung Univ. of Applied Sciences (Taiwan) . . . . . [8484-40]

2:20 pm: **Transparent image generator by using vertically-aligned (VA) polymer-stabilized liquid crystal (PSLC)**, Mu Hao Wang, National Taiwan Univ. (Taiwan) . . . . . [8484-41]

2:40 pm: **Measurements of UGR of LED light by a DSLR colorimeter**, Shau-Wei Hsu, Cheng-Hsien Chen, Yuh-Der Jiaan, Industrial Technology Research Institute (Taiwan) . . . . . [8484-42]

Conference 8512 · Room: Conv. Ctr. 9

Tuesday-Wednesday 14-15 August 2012 • Proceedings of SPIE Vol. 8512

Infrared Sensors, Devices, and Applications II

Conference Chairs: **Paul D. LeVan,** Air Force Research Lab. (USA); **Ashok K. Sood,** Magnolia Optical Technologies, Inc. (USA); **Priyalal S. Wijewarnasuriya,** U.S. Army Research Lab. (USA); **Arvind I. D'Souza,** DRS Sensors & Targeting Systems, Inc. (USA)

Program Committee: **Sumith Bandara,** U.S. Army Night Vision & Electronic Sensors Directorate (USA); **Eustace L. Dereniak,** College of Optical Sciences, The Univ. of Arizona (USA); **Nibir K. Dhar,** Defense Advanced Research Projects Agency (USA); **Patti S. Gillespie,** U.S. Army Research Lab. (USA); **Barbara G. Grant,** Lines and Lights Technology (USA); **Sarath D. Gunapala,** Jet Propulsion Lab. (USA); **John P. Hartke,** U.S. Military Academy (USA); **John E. Hubbs,** Ball Aerospace & Technologies Corp. (USA); **Sanjay Krishna,** Ctr. for High Technology Materials (USA); **Michael W. Kudenov,** College of Optical Sciences, The Univ. of Arizona (USA); **Randolph E. Longshore,** Raytheon Missile Systems (Retired) (USA); **Hiroshi Murakami,** Japan Aerospace Exploration Agency (Japan); **Manijeh Razeghi,** Northwestern Univ. (USA); **James A. Stobie,** BAE Systems (USA); **Jimmy Xu,** Brown Univ. (USA); **Sung-shik Yoo,** Northrop Grumman Electronic Systems (USA)

Monday 13 August

POSTERS-MONDAY

Room: Conv. Ctr. Exhibition Hall B2 . Mon. 5:30 to 7:30 pm

Conference attendees are invited to attend the poster session on Monday evening. Come view the posters, enjoy light refreshments, ask questions, and network with colleagues in your field. Authors of poster papers will be present to answer questions concerning their papers. Attendees are required to wear their conference registration badges to the poster sessions. Poster authors, view poster presentation guidelines at http://spie.org/x30293.xml.

Optimization of biogas production using MEMS-based near infrared inline-sensor, Ray Saupe, Fraunhofer-Institut für Elektronische Nanosysteme (USA); Thomas Selder, Fraunhofer-Institut für Elektronische Nanosysteme (Germany); Volker Stock, Fraunhofer-Institut für Elektronische Nanosysteme (USA); Thomas Otto, Thomas Gessner, Fraunhofer-Institut für Elektronische Nanosysteme (Germany) . . . . . [8512-36]

Tuesday 14 August

SESSION 1

Room: Conv. Ctr. 9 . . . . . Tues. 8:30 to 10:10 am

Graphene and Related Detectors

Session Chairs: **Ashok K. Sood,** Magnolia Optical Technologies, Inc. (USA); **Paul D. LeVan,** Air Force Research Lab. (USA)

8:30 am: **Graphene science and technology: a new frontier in multifunctional material and electronics** *(Invited Paper)*, Madan Dubey, U.S. Army Research Lab. (USA) . . . . . [8512-01]

9:00 am: **Characterization of polymeric composite films with MWCNT and Ag nanoparticles**, Matthew E. Edwards, Ashok K. Batra, Ashwith K. Chilvery, Padmaja Guggilla, Manmohan D. Aggarwal, Alabama A&M Univ. (USA)[8512-02]

9:20 am: **Graphene P-N junction devices: an overview** *(Invited Paper)*, Je Ung Lee, College of Nanoscale Science & Engineering (USA) . . . . . [8512-03]

9:50 am: **Design and development of CNT and graphene-based microbolometer for IR imaging applications**, Ashok K. Sood, E. James Egerton, Yash R. Puri, Magnolia Optical Technologies, Inc. (USA); Akin Akturk, Neil Goldsman, Univ. of Maryland, College Park (USA); Nibir K. Dhar, Defense Advanced Research Projects Agency (USA); Priyalal S. Wijewarnasuriya, Madan Dubey, U.S. Army Research Lab. (USA) . . . . . [8512-04]

Coffee Break . . . . . 10:10 to 10:40 am

SESSION 2

Room: Conv. Ctr. 9 . . . . . Tues. 10:40 am to 12:10 pm

EO-IR and Applications

Session Chairs: **Priyalal S. Wijewarnasuriya,** U.S. Army Research Lab. (USA); **Ashok K. Sood,** Magnolia Optical Technologies, Inc. (USA)

10:40 am: **EO-IR material and device research at the Army Research Laboratory** *(Invited Paper)*, Parvez N. Uppal, U.S. Army Research Lab. (USA) . . . . . [8512-05]

11:10 am: **NIR reflectance spectroscopy for nondestructive moisture content determination of different varieties of in-shell peanuts**, Chari V. Kandala, Jaya Sundaram, Agricultural Research Service (USA). . . . . [8512-06]

11:30 am: **Overview of HgCdSe material research for IR applications at the Army Research Laboratory**, Gregory N. Brill, Yuanping Chen, U.S. Army Research Lab. (USA). . . . . [8512-07]

11:50 am: **Common-path interferometer for stimulated Raman scattering (SRS) and coherent anti-Stokes Raman scattering applications (CARS)**, Gabriela Negrete-Gonzalez, Ctr. de Investigación e Innovación Tecnológica (Mexico); Herman L. Offerhaus, Univ. Twente (Netherlands); Fernando Martinez-Pinon, Jose A. Alvarez-Chavez, Ctr. de Investigación e Innovación Tecnológica (Mexico). . . . . [8512-08]

Lunch/Exhibition Break . . . . . 12:10 to 2:00 pm

SESSION 3

Room: Conv. Ctr. 9 . . . . . Tues. 2:00 to 3:10 pm

Advanced Concepts and Materials

Session Chairs: **Arvind I. D'Souza,** DRS Sensors & Targeting Systems, Inc. (USA); **Sumith Bandara,** U.S. Army Night Vision & Electronic Sensors Directorate (USA)

2:00 pm: **Integrated EO/IR programs at DARPA /MTO** *(Invited Paper)*, Nibir K. Dhar, Defense Advanced Research Projects Agency (USA) . . [8512-09]

2:30 pm: **Design and performance modeling of an HgCdTe-based SWIR micro-camera**, Christopher Anton, Episensors, Inc. (USA); Silviu Velicu, Fikri Aqariden, EPIR Technologies, Inc. (USA) . . . . . [8512-10]

2:50 pm: **Study on fluorescence of $Na_2KSb(Cs)$ multi-alkali photocathode film during growth process**, Xiaofeng Li, North Night Vision Technology Co., Ltd. (China) . . . . . [8512-12]

Coffee Break . . . . . 3:10 to 3:40 pm

SESSION 4

Room: Conv. Ctr. 9 . . . . . Tues. 3:40 to 5:00 pm

Miscellaneous Detector Applications

Session Chairs: **Paul D. LeVan,** Air Force Research Lab. (USA); **Sumith Bandara,** U.S. Army Night Vision & Electronic Sensors Directorate (USA)

3:40 pm: **Fast scan-fail device for class 1 operation of scanning micromirrors at a high-laser power in the near-infrared region**, Siegwart Bogatscher, Christian Giesel, Thorsten Beuth, Harsha Umesh Babu, Lelie Shinohara, Nico Heussner, Wilhelm Stork, Karlsruher Institut für Technologie (Germany) . . . . . [8512-13]

4:00 pm: **Silver halide integrated waveguides for the mid-infrared**, Tomer Lewi, Abraham Katzir, Tel Aviv Univ. (Israel) . . . . . [8512-14]

4:20 pm: **A NiTiNOL membrane controlled by an external heat source**, Margarita Tecpoyotl-Torres, Ramon Cabello-Ruiz, Jose Gerardo Vera-Dimas, Univ. Autónoma del Estado de Morelos (Mexico); Jorge Varona, Univ. Panamericana (Mexico) . . . . . [8512-15]

4:40 pm: **Study of atmospheric effects on infrared polarization imaging system based on polarized Monte Carlo method**, Zhenyue Chen, Xia Wang, Weiqi Jin, Beijing Institute of Technology (China). . . . . [8512-16]

Wednesday 15 August

SESSION 5

Room: Conv. Ctr. 9 . . . . . Wed. 8:30 to 10:30 pm

III-V and SL Detectors

Session Chairs: **Sumith Bandara,** U.S. Army Night Vision & Electronic Sensors Directorate (USA); **Arvind I. D'Souza,** DRS Sensors & Targeting Systems, Inc. (USA)

8:30 pm: **Growth and device performance of superlattice-based infrared detectors**, Arezou Khoshakhlagh, David Z. Ting, Alexander Soibel, Linda Höglund, Sam A. Keo, Sarath D. Gunapala, Jet Propulsion Lab. (USA) [8512-17]

8:50 pm: **Type-II InAs/GaSb superlattices grown by molecular beam epitaxy for infrared detector applications**, Amin Al Torfi, Cheng Yun Chou, Wen I. Wang, Columbia Univ. (USA). . . . . [8512-18]

9:10 pm: **Post growth annealing study on LWIR InAs/GaSb superlattices**, Heather J. Haugan, Gail J. Brown, Air Force Research Lab. (USA); Said Elhamri, Univ. of Dayton Research Institute (USA); Shanee Pacley, Air Force Research Lab. (USA); Benjamin V. Olson, Thomas F. Boggess, The Univ. of Iowa (USA) . . . . . [8512-19]

9:30 pm: **Study of the minority carrier lifetime in mid-wavelength infrared InAs/InAs1-xSbx type-II superlattices**, Elizabeth H. Steenbergen, Arizona State Univ. (USA); Blair Connelly, Grace D. Metcalfe, Paul H. Shen, Michael Wraback, U.S. Army Research Lab. (USA); Dmitri Lubyshev, Yueming Qiu, Joel Fastenau, Amy W. K. Liu, IQE Inc. (USA); Said Elhamri, Univ. of Dayton (USA); Oray O. Cellek, Yong-Hang Zhang, Arizona State Univ. (USA). . . . . [8512-20]

9:50 pm: **Infrared photodetectors based on MWIR and LWIR InAs/InAsSb superlattices**, Ha Sul Kim, Oray O. Cellek, Hua Li, Shi Liu, Zhiyuan Lin, Elizabeth H. Steenbergen, Yong-Hang Zhang, Arizona State Univ. (USA) . . . . . [8512-21]

10:10 pm: **Design and development of low dark current SLS detectors for IRFPA applications**, Ashok K. Sood, Roger E. Welser, Magnolia Optical Technologies, Inc. (USA); Nutan Gautam, Sanjay Krishna, Ctr. for High Technology Materials (USA); Eric A. DeCuir, Jr., Priyalal S. Wijewarnasuriya, U.S. Army Research Lab. (USA); Nibir K. Dhar, Defense Advanced Research Projects Agency (USA) . . . . . [8512-22]

Coffee Break . . . . . 10:30 to 11:00 am

SESSION 6

Room: Conv. Ctr. 9 . . . . . Wed. 11:00 am to 12:20 pm

Si-based Detectors

Session Chairs: **Paul D. LeVan,** Air Force Research Lab. (USA); **Arvind I. D'Souza,** DRS Sensors & Targeting Systems, Inc. (USA)

11:00 am: **Antimony-doped silicon blocked impurity band (BIB) arrays for low-flux applications**, Vaikunth Khalap, Henry H. Hogue, DRS Sensors & Targeting Systems, Inc. (USA). . . . . [8512-23]

11:20 am: **Studies on transmittance of silicon with AR coating films for IR transparent window**, Myeongho Song, National Nanofab Ctr. (Korea, Republic of) and Chungnam National Univ. (Korea, Republic of); Eunmi Park, Moon Seop Hyun, Tae Hyun Kim, Hee Yeoun Kim, National Nanofab Ctr. (Korea, Republic of); Gawon Lee, Chungnam National Univ. (Korea, Republic of) . . . . . [8512-24]

11:40 am: **Silicon PIN diodes for remote sensing**, Ernest W. Robinson, Arvind I. D'Souza, DRS Sensors & Targeting Systems, Inc. (USA). . . . [8512-25]

12:00 pm: **Development of large area nanostructured antireflection coatings for EO/IR sensor applications**, Ashok K. Sood, Roger E. Welser, Adam W. Sood, Yash R. Puri, Magnolia Optical Technologies, Inc. (USA); Jaehee Cho, Samsung Advanced Institute of Technology (Korea, Republic of); E. Fred Schubert, Rensselaer Polytechnic Institute (USA); Nibir K. Dhar, Defense Advanced Research Projects Agency (USA); Priyalal Wijewarnasuriya, U.S. Army Research Lab. (USA); Martin B. Soprano, U.S. Army Research, Development and Engineering Command (USA). . . . . [8512-26]

Lunch/Exhibition Break . . . . . 12:20 to 1:50 pm

SESSION 7

Room: Conv. Ctr. 9 . . . . . Wed. 1:50 to 3:10 pm

Medical Applications

Session Chairs: **Priyalal S. Wijewarnasuriya,** U.S. Army Research Lab. (USA); **Paul D. LeVan,** Air Force Research Lab. (USA)

1:50 pm: **Research on application of spectral imaging technology in determining on thermal burn degree**, Yongquan Luo, Li Xian Huang, China Academy of Engineering Physics (China); Junjie Yang, Jun Wu, Third Military Medical Univ. (China); Dayong Zhang, China Academy of Engineering Physics (China) . . . . . [8512-27]

2:10 pm: **Er^{3+}-doped fibre laser sensor for structural health monitoring applications design**, Maria Guadalupe Pulido-Navarro, Grethell Perez-Sanchez, Dalia Cisneros-Chable, Jose A. Alvarez-Chavez, Ctr. de Investigación e Innovación Tecnológica (Mexico) . . . . . [8512-28]

2:30 pm: **A fiber loop ringdown urine glucose sensor**, Malik Kaya, Chuji Wang, Mississippi State Univ. (USA); Charlotte Wang, The Mississippi School for Mathematics and Science (USA) . . . . . [8512-29]

2:50 pm: **SU-8 photoresist microstructure with cytochrome c protein as a sensing pixel for microbolometer**, Jian-Lun Lai, Guo-Dung Su, National Taiwan Univ. (Taiwan) . . . . . [8512-30]

Coffee Break . . . . . 3:10 to 3:40 pm

SESSION 8

Room: Conv. Ctr. 9 . . . . . Wed. 3:40 to 5:20 pm

Lasers and THz

Session Chairs: **Ashok K. Sood,** Magnolia Optical Technologies, Inc. (USA); **Priyalal S. Wijewarnasuriya,** U.S. Army Research Lab. (USA)

3:40 pm: **Range profile by using compressive sensing in a chaotic lidar**, Berenice Verdin, Ricardo von Borries, The Univ. of Texas at El Paso (USA) . . . . . [8512-31]

4:00 pm: **3D active imaging to see through adverse conditions**, Nicolas Riviere, Laurent Hespel, Erwan Bernard, Romain Ceolato, ONERA (France); Mathieu Renaudat, SAGEM SA (France); Bernard Tanguy, ONERA (France) . . . . . [8512-32]

4:20 pm: **Terahertz and millimeter-wave plasmonic photoresponse of grating-gated InP and graphene-based HEMT devices**, Nima Nader Esfahani, Solid State Scientific Corp. (USA); Robert E. Peale, Univ. of Central Florida (USA); Walter R. Buchwald, Solid State Scientific Corp. (USA); Justin W. Cleary, Air Force Research Lab. (USA); Christopher J. Fredricksen, Univ. of Central Florida (USA); Joshua R. Hendrickson, Air Force Research Lab. (USA); Masahiro Ishigami, Ben Dawson, Univ. of Central Florida (USA) . . . . . [8512-33]

4:40 pm: **Single-cycle pulse generation in the course of four-wave mixing in the filament**, Vera Andreeva, Nicolay Panov, Olga G. Kosareva, Lomonosov Moscow State Univ. (Russian Federation); See Leang Chin, Ctr. d'optique, photonique et laser (Canada) . . . . . [8512-34]

5:00 pm: **Enhanced directionality of terahertz emission from a cluster of femtosecond filaments in gases**, Vera Andreeva, Olga G. Kosareva, Nicolay Panov, Lomonosov Moscow State Univ. (Russian Federation); T. J. Wang, S. Yuan, See Leang Chin, Ctr. d'optique, photonique et laser (Canada) . [8512-35]

Conference 8467 · Room: Conv. Ctr. 3

Wednesday-Thursday 15-16 August 2012 • Proceedings of SPIE Vol. 8467

Nanoepitaxy: Materials and Devices IV

Conference Chairs: **Nobuhiko P. Kobayashi,** Univ. of California, Santa Cruz (USA); **A. Alec Talin,** National Institute of Standards and Technology (USA); **M. Saif Islam,** Univ. of California, Davis (USA)

Program Committee: **Kristine A. Bertness,** National Institute of Standards and Technology (USA); **Albert Davydov,** National Institute of Standards and Technology (USA); **Shadi A. Dayeh,** Los Alamos National Lab. (USA); **Supratik Guha,** IBM Thomas J. Watson Research Ctr. (USA); **Jung Han,** Yale Univ. (USA); **Chennupati Jagadish,** The Australian National Univ. (Australia); **Mutsumi Kimura,** Ryukoku Univ. (Japan); **Takhee Lee,** Gwangju Institute of Science and Technology (Korea, Republic of); **Marina S. Leite,** California Institute of Technology (USA); **Francois Leonard,** Sandia National Labs., California (USA); **Samuel S. Mao,** Lawrence Berkeley National Lab. (USA); **Sanjay Mathur,** Univ. zu Köln (Germany); **Samuel Tom Picraux,** Los Alamos National Lab. (USA); **Sharka M. Prokes,** U.S. Naval Research Lab. (USA); **Zhifeng Ren,** Boston College (USA); **Atsuhito Sawabe,** Aoyama Gakuin Univ. (Japan); **Fred Semendy,** U.S. Army Research Lab. (USA); **Loucas Tsakalakos,** GE Global Research (USA); **Emanuel Tutuc,** The Univ. of Texas at Austin (USA); **Lionel Vayssieres,** National Institute for Materials Science (Japan); **Deli Wang,** Univ. of California, San Diego (USA); **George T. Wang,** Sandia National Labs. (USA)

Sunday 12 August

SYMPOSIUM-WIDE PLENARY SESSION

Room: Conv. Ctr. 6A . . . . . Sun. 6:00 to 7:25 pm

6:00 pm: **Introduction and Opening Remarks**

6:05 pm: **The Exciting Science of Light with Metamaterials**
Vladimir M. Shalaev, Purdue Univ. (USA)

6:45 pm: **Future of Optics and Photonics**
Bahaa E. A. Saleh, CREOL, The College of Optics and Photonics at the Univ. of Central Florida (USA)

See page 10 for details.

Monday 13 August

PLENARY SESSION

Room: Conv. Ctr. 6A . . . . . Mon. 8:30 am to 12:00 pm

NanoScience + Engineering

Session Chairs: **Satoshi Kawata,** Osaka Univ. (Japan) and **Manijeh Razeghi,** Northwestern Univ. (USA)

8:30 am: **The Light and Sound Fantastic: Radiation Pressure at the Nanoscale**
Oskar Painter, California Institute of Technology (USA)

9:15 am **Organics and Nanostructures for Nonlinear Optics**
Nasser Peyghambarian, College of Optical Sciences, The Univ. of Arizona (USA)

10:00 to 10:30 am: Coffee Break

10:30 am: **From Nanophotonics, to Metaphotonics, to Dynamic Photonics: Controlling Light Propagation and Light-Matter Interactions for Emerging Technologies**
Paras Prasad, University at Buffalo (USA)

11:15 am: **Global Activities in Novel-Nano Magnetic Materials for Magnetic, Optoelectronics Applications**
Misoon Mah, Asian Office of Aerospace Development (Japan)

See page 11 for details.

Wednesday 15 August

SESSION 1

Room: Conv. Ctr. 3 . . . . . Wed. 8:00 to 9:55 am

Nanowires I

Session Chair: **Nobuhiko P. Kobayashi,** Univ. of California, Santa Cruz (USA)

8:00 am: **Bio-functionalized Si, SiC, and GaN nanowires for sensor applications,** Elissa H. Williams, George Mason Univ. (USA) . . . . . [8467-01]

8:15 am: **III-V nanowires for energy applications** *(Invited Paper),* Silvija Gradecak, Massachusetts Institute of Technology (USA). . . . . [8467-02]

8:40 am: **Engineering new phenomena and functionality in complex oxide thin film heterostructures: highly strained $BiFeO_3$** *(Invited Paper),* Lane W. Martin, Univ. of Illinois at Urbana-Champaign (USA) . . . . . [8467-03]

9:05 am: **Novel combinations of III-V materials in ternary and heterostructure nanowires** *(Invited Paper),* Kimberley A. Dick, Lund Univ. (Sweden) . . . . . [8467-04]

9:30 am: **III-nitride nanowires: from the bottom-up to the top-down** *(Invited Paper),* George T. Wang, Qiming Li, Jonathan J. Wierer, Daniel D. Koleske, Jeffrey J. Figiel, Jeremy B. Wright, Ting S. Luk, Igal Brener, Sandia National Labs. (USA). . . . . [8467-05]

Coffee Break . . . . . 9:55 to 10:30 am

SESSION 2

Room: Conv. Ctr. 3 . . . . . Wed. 10:30 am to 12:20 pm

Low-Dimensional Materials I

Session Chair: **A. Alec Talin,** National Institute of Standards and Technology (USA)

10:30 am: **Selected topics in compound semiconductor research at Sandia National Laboratories** *(Keynote Presentation),* Robert M. Biefeld, Sandia National Labs. (USA). . . . . [8467-06]

11:05 am: **Patterned nanopillar optoelectronic devices** *(Invited Paper),* Diana L. Huffaker, Univ. of California, Los Angeles (USA). . . . . [8467-07]

11:30 am: **AFM-assisted deposition and etching of nanoscale electronic materials on silicon and related materials** *(Invited Paper),* Massood Tabib-Azar, The Univ. of Utah (USA). . . . . [8467-08]

11:55 am: **Core-shell heterostructures for advanced catalysis, diagnostics, and energy conversion** *(Invited Paper),* Ivano Alessandri, Univ. degli Studi di Brescia (Italy). . . . . [8467-09]

Lunch/Exhibition Break . . . . . 12:20 to 1:40 pm

SESSION 3
Room: Conv. Ctr. 3 . . . . . Wed. 1:40 to 3:10 pm

Low-Dimensional Devices I
Session Chair: **Silvija Gradecak,** Massachusetts Institute of Technology (USA)

1:40 pm: **Comparison of radial junction fabrication methods for Si micro/nanowire array solar cells** *(Invited Paper)*, Joan M. Redwing, The Pennsylvania State Univ. (USA). . . . [8467-10]

2:05 pm: **MOCVD growth of GaN nanopyramid and nanopillar LED with emission in green to orange color** *(Invited Paper)*, Hao-Chung Kuo, National Chiao Tung Univ. (Taiwan); Yuh-Jen Cheng, Academia Sinica (Taiwan)[8467-11]

2:30 pm: **III-V compound semiconductor nanowires for optoelectronic device applications** *(Invited Paper)*, Chennupati Jagadish, The Australian National Univ. (Australia) . . . [8467-12]

2:55 pm: **Indium phosphide nanowire network's growth and characterization for thermoelectric conversion**, Kate J. Norris, Junce Zhang, Timothy J. Longson, David Fryauf, Andrew J. Lohn, Nobuhiko P. Kobayashi, Univ. of California, Santa Cruz (USA) . . . [8467-13]

Coffee Break . . . 3:10 to 3:40 pm

SESSION 4
Room: Conv. Ctr. 3 . . . . . Wed. 3:40 to 5:00 pm

Atomic Layer Deposition
Session Chair: **Albert Davydov,** National Institute of Standards and Technology (USA)

3:40 pm: **Novel optical properties of Ag films deposited by plasma-enhanced atomic layer deposition** *(Invited Paper)*, Sharka M. Prokes, U.S. Naval Research Lab. (USA) . . . [8467-14]

4:05 pm: **Principles and applications of atomic layer deposition and self-assembled monolayers** *(Invited Paper)*, A. Bertuch, R. Bhatia, M. Dalberth, L. Lecordier, G. Liu, M. Sowa, G. M. Sundaram, Jill Becker, Cambridge NanoTech Inc. (USA) . . . [8467-15]

4:30 pm: **Plasma-enhanced atomic layer deposition of silver thin films for applications in plasmonics and surface-enhanced Raman scattering**, Erin Cleveland, U.S. Naval Research Lab. (USA) and American Society for Engineering Education (USA); Joshua D. Caldwell, Edward E. Foos, U.S. Naval Research Lab. (USA); Jaakko Niinisto, Mikko Ritala, Univ. of Helsinki (Finland); Orest J. Glembocki, Sharka M. Prokes, U.S. Naval Research Lab. (USA) . . . [8467-16]

4:45 pm: **Electrical properties of epitaxial $LaAlO_3/SrTiO_3$ devices fabricated using atomic layer deposition**, Nick M. Sbrockey, Eric J. Gallo, Gary S. Tompa, Structured Materials Industries, Inc. (USA); Andrew Akbashev, Guannan Chen, Jonathan Spanier, Drexel Univ. (USA) . . . [8467-17]

Thursday 16 August

SESSION 5
Room: Conv. Ctr. 3 . . . . . Thurs. 8:00 to 9:55 am

Nanowires II
Session Chair: **Joan M. Redwing,** The Pennsylvania State Univ. (USA)

8:00 am: **Enhanced field ionization current enabled by gold induced surface states to silicon nanowires**, Hakan Karaagac, M. Saif Islam, Univ. of California, Davis (USA) . . . [8467-18]

8:15 am: **Nanoscale effects on heterojunction electron gases in core/shell nanowires** *(Invited Paper)*, Francois Leonard, Sandia National Labs., California (USA) . . . [8467-19]

8:40 am: **Graded nanowire deep ultraviolet LEDs without impurity doping by polartzation engineering** *(Invited Paper)*, Roberto C. Myers, The Ohio State Univ. (USA) . . . [8467-20]

9:05 am: **Ordered array of III-V nanowire growth by MOCVD and applications in nanoelectronics** *(Invited Paper)*, Xiuling Li, Univ. of Illinois at Urbana-Champaign (USA). . . . [8467-21]

9:30 am: **Thermal stability of gallium nitride: nanowires versus films** *(Invited Paper)*, Albert Davydov, National Institute of Standards and Technology (USA) . . . [8467-22]

Coffee Break . . . 9:55 to 10:30 am

SESSION 6
Room: Conv. Ctr. 3 . . . . . Thurs. 10:30 am to 12:20 pm

Low-Dimensional Materials II
Session Chair: **M. Saif Islam,** Univ. of California, Davis (USA)

10:30 am: **Towards nanoscale control of semiconductor nanostructure architectures using focused ion beam templating** *(Keynote Presentation)*, Robert Hull, Rensselaer Polytechnic Institute (USA). . . . [8467-23]

11:05 am: **Engineering nanostructures in active regions for high-efficiency III-nitride light-emitting diodes: epitaxy and physics** *(Invited Paper)*, Nelson Tansu, Lehigh Univ. (USA). . . . [8467-24]

11:30 am: **Growth structure and work function of monolayer and bilayer graphene on Pd(111)** *(Invited Paper)*, Suneel Kodambaka, Yuya Murata, Hoi Sing Mok, Univ. of California, Los Angeles (USA); Shu Nie, Sandia National Labs., California (USA); Abbas Ebnonnasir, Colorado School of Mines (USA); Norman C. Bartelt, Kevin F. McCarty, Sandia National Labs., California (USA); Cristian V. Ciobanu, Colorado School of Mines (USA) . . . [8467-25]

11:55 am: **VLSI-ready strategy for heterogeneous integration of epitaxial nanostructures** *(Invited Paper)*, Chi On Chui, Univ. of California, Los Angeles (USA) . . . [8467-26]

Lunch/Exhibition Break . . . 12:20 to 1:40 pm

SESSION 7
Room: Conv. Ctr. 3 . . . . . Thurs. 1:40 to 2:45 pm

Nano Characterization
Session Chair: **Sharka M. Prokes,** U.S. Naval Research Lab. (USA)

1:40 pm: **Imaging carrier transport in nanowires using integrated SEM/NSOM** *(Invited Paper)*, Nancy M. Haegel, Naval Postgraduate School (USA) . . . [8467-27]

2:05 pm: **In-situ TEM observations of electrochemical reactions of individual nanowire or nanoparticle electrodes in lithium ion batteries** *(Invited Paper)*, Jianyu Huang, Sandia National Labs. (USA) . . . [8467-28]

2:30 pm: **Study on indium phosphide nanowires grown by metal organic chemical vapor deposition and coated with aluminum oxides deposited by atomic layer deposition**, Andrew J. Lohn, Univ. of California, Santa Cruz (USA); Noel M. Dawson, The Univ. of New Mexico (USA); Robert D. Cormia, Foothill College (USA); Kate J. Norris, Nobuhiko P. Kobayashi, Univ. of California, Santa Cruz (USA). . . . [8467-29]

Coffee Break . . . 2:45 to 3:15 pm

SESSION 8
Room: Conv. Ctr. 3 . . . . . Thurs. 3:15 to 4:55 pm

Low-Dimensional Devices II
Session Chair: **Nobuhiko P. Kobayashi,** Univ. of California, Santa Cruz (USA)

3:15 pm: **New epitaxial metallic nanostructure materials for photonic devices** *(Invited Paper)*, Seth R. Bank, The Univ. of Texas at Austin (USA) . . . [8467-30]

3:40 pm: **Characterization of AlGaN/AlN/GaN high-electron mobility transistor structure with a nano-scale AlN interlayer**, Shih-Chun Huang, Wen-Ray Chen, National Formosa Univ. (Taiwan); Yu-Ting Hsu, National Chiao Tung Univ. (Taiwan); Jia-Ching Lin, Kuo-Jen Chang, Wen-Jen Lin, Chung-Shan Institute of Science and Technology (Taiwan). . . . [8467-31]

3:55 pm: **Fully functional Li-ion nanobatteries**, A. Alec Talin, Dmitry Ruzmetov, Vladimir Oleshko, Henri Lezec, Paul M. Haney, National Institute of Standards and Technology (USA). . . . [8467-32]

4:10 pm: **3D silicon micro-pillars/-walls decorated with aluminum-ZnO/ZnO nanowires for opto-electronic device applications**, Hakan Karaagac, Logeeswaran Veerayah Jayaraman, M. Saif Islam, Univ. of California, Davis (USA) . . . [8467-33]

4:25 pm: **Contact metal effects in indium phosphide nanowire transistors**, Jin-Woo Han, NASA Ames Research Ctr. (USA); Andrew J. Lohn, Univ. of California, Santa Cruz (USA); Meyya Meyyappan, NASA Ames Research Ctr. (USA); Nobuhiko P. Kobayashi, Univ. of California, Santa Cruz (USA) . [8467-34]

4:40 pm: **Investigation of indium-tin oxide based nonvolatile memory**, Nitish Padgaonkar, Michael M. Oye, Nobuhiko P. Kobayashi, Univ. of California, Santa Cruz (USA). . . . [8467-35]

附件二

SPIE Optics + Photonics
14 - 16-August 2012
San Diego, California, USA

Exhibitors by Company Name

Return to Search

Featured All 0-9 A B C D E F G H I J K L M N O P Q R S T U V W X Y

1-Material Inc.
4D Technology Corp.
ABET
Abet Technologies, Inc.
AccuCoat Inc.
Accumold
Acharya Narendra Dev College at University of Delhi
ADIT Electron Tubes
AdlOptica GmbH
Aerotech, Inc.
Agilent Technologies, Inc.
Air Force Institute of Technology
ALIO Industries
Analog Modules, Inc.
Andover Corp.
ASE Optics
Hitachi High Technologies America, Inc.
Infinite Optics Inc.
Inrad Optics, Inc.
Institute for Atomic Physics
Instrument Technology Research Ctr.
International Laser Centre
IntraAction Corp.
IOP Publishing Ltd.
IRCameras, LLC
Iridian Spectral Technologies Ltd.
ISP-CELOS
Isuzu Glass, Inc.
ITT Exelis
J.A. Woollam Co., Inc.
JENOPTIK Optical Systems, Inc.
JiLin University
piezosystem jena, Inc.
Poggi software
Polymicro Technologies, A Subsidiary of Molex Incorporated
Precision Glass & Optics
Precision Optics Gera Corp.
Proto Labs, Inc.
Qioptiq S.A.S.
Quartus Engineering Inc.
Radiant Zemax, LLC
RPMC Lasers, Inc.
Ruhr-Univ. Bochum Chapter
Samara Student Chapter
Sandia National Labs.
SCHOTT North America, Inc.
Seiwa Optical America Inc.

ASML Optics
attocube systems AG
Avantes, Inc.
B&W Tek, Inc.
B.P. Poddar Institute of Management and Technology
Bach Research Corporation
Beijing Institute of Technology
Beijing Jiaotong University
Beijing University of Posts and Telecommunications Club
BGU
BMSTU
Boulder Nonlinear Systems
Breault Research Organization, Inc.
Cambridge NanoTech Inc.
Cambridge Univ. Press
Capítulo Estudiantil Universidad de Antioquia (CEUdeA)
Carl Hanser Verlag GmbH & Co. KG
Cascade Optical Coating
Charles Univ. in Prague
Checkpoint Technologies, LLC
Chroma Technology Corp.
Chulalongkorn University
CICESE
College of Optical Sciences, The Univ. of Arizona
CRC Press
CSIR
Ctr. de Investigaciones en Óptica
CVI Melles Griot
Davidson Optronics, Inc.
DCE at Delhi Technological University
Deposition Sciences, Inc.
Diateq Labs, LLC
Diverse Optics Inc.
e2v
Ecole Polytechnique - ParisTech - SCOP
Edmund Optics Inc.
Elcon Precision LLC
Electro Optics Magazine
Element Six Technologies U.S. Corp
Energetiq Technology, Inc.
Katholieke Univ. Leuven
KETEK GmbH
Kharkov National Univ. of Radio Electronics
L-3 Communications Corp. - Tinsley
Lake Shore Cryotronics, Inc.
Lambda Research Corp.
Laser Focus World
LEONI Fiber Optics, Inc.
Lumetrics, Inc.
Mad City Labs., Inc.
Materials Today
Meadowlark Optics
MediVision Optics
Micro Laser Systems, Inc.
MICRONIX USA, LLC (formerly MICOS USA, LLC)
Mildex, Inc.
Mindrum Precision, Inc.
Minus K Technology Inc.
Moscow Institute of Physics and Technology
MOXTEK, Inc.
Naked Optics Corp.
National Aperture, Inc.
National Central University
National Chiao Tung University
National Reconnaissance Office
National Research Univ. of Information Technologies, Mechanics and Optics
National Taiwan Univ.
Nature Publishing Group
Navitar
New Focus™, a Brand of Newport Corporation
Newport Corp.
NiPro Optics, Inc
NITT
Nitto Optical Co., Ltd.
NKT Photonics
Noren Products Inc.
Northwestern Univ.
Novotech, Inc.
Ocean Optics, Inc.
Ocean Thin Films, Inc.
Ohara Corp.
SEMICORE Equipment, Inc.
Sensors Unlimited-Goodrich ISR Systems
Shanghai Institute of Optics and Fine Mechanics
Shinano Kenshi Co., Ltd.
Sierra Precision Optics
Silesian Univ. of Technology
Singapore Student Chapter
Siskiyou Corporation
Southwest Research Institute
Special Optics, Inc.
Spectral Evolution
Spectral Instruments, Inc.
Spectrogon US, Inc.
Spectroscopy Magazine
SPIE Career Center
SPO Inc.
St. Petersburg State Univ. of Aerospace Instrumentation
StellarNet, Inc.
Stellenbosch University
Sutter Instrument Co.
Synopsys, Inc.
Syntec Optics
Syntronics - Night Vision Systems Division
Taurida National VI Vernadsky Univ.
Taylor Hobson
TDK-Lambda Americas Inc.
tec5USA, Inc.
Technical University of Denmark
Teledyne Judson Technologies
The Optronics Co., Ltd.
The Pennsylvania State Univ.
Thermo Scientific - CIDTEC
Thorlabs Inc.
Three Rivers Community College
Trillium US Inc.
TRIOPTICS GmbH
Tsinghua Univ.
TwinStar Optics, Coatings & Crystals, Inc.
U.S. Army Research, Development and Engineering Command
UCLA

Engineering Synthesis Design, Inc. (ESDI)
Entegris, Inc.
Epner Technology Inc.
ETA International
Federal Laboratory Consortium for Technology Transfer
Fianium, Inc.
Filmetrics, Inc.
Flexible Optical BV (OKO Tech)
Fotofab
Gdansk University of Technology
Gentec Electro-Optics Inc.
Georgia Tech Research Institute / SENSIAC
GIKI
GPD Optoelectronics Corp
G-S Plastic Optics
Gulf Photonics, Inc.
Hamamatsu Corp.
Harbin Institute of Technology
Hardin Optical Co.
Harvard Photonics
Heidelberg Instruments Inc.
Hellma USA, Inc.
Heraeus Quartz America LLC
Hinds Instruments, Inc.
Olympus America Inc.
Ontar Corporation
Ophir-Spiricon, A Brand of Newport Corporation
Optical Perspectives Group, LLC
Optical Reference Lab., Inc.
Optical Support, Inc.
Optics Technology, Inc.
optics.org
Optiforms, Inc.
Optikos Corp.
Optimax Systems, Inc.
OptiPro Systems
Optofluidics
OptoSigma Corp.
Oriel® Instruments, A Brand of Newport Corporation
OSKar
PerkinElmer, Inc.
Photon Engineering LLC
Photon etc. Inc.
Photonics Media
Photonics Online
Physics Today
PI (Physik Instrumente) L.P.
UGent
UNCC
Univ. Autonoma de Nuevo Leon
Univ. College Dublin
Univ. College Dublin
Univ. de Buenos Aires
Univ. de Guadalajara
Univ. Laval
Univ. Nacional de Colombia - Medellin
University of Dayton
University of Latvia
University of Notre Dame
University of Rochester
University of Sydney
VG Scienta Inc
Vilnius University
Vincent Associates
Vinnitsa National Technical Univ.
Vrije Univ. Brussel
Warsaw University of Technology
Wells Research, Inc.
Wordingham Technologies
Xenics
Xonox Technology GmbH
Zygo Corporation

附件三

IRCameras 與 Xenics 兩家公司之紅外線熱像產品資料

IRCAMERAS

IRC900 Series MWIR InSb Infrared Cameras

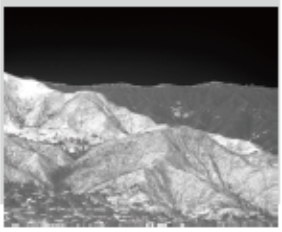
Closed cycle cooled IR camera with advanced digital focal plane array

Digital FPA Technology from Santa Barbara Focalplane

- 4X higher frame rates
- High speed data output
- Ultra low noise
- No electrical cross talk
- Lower power
- Immune to external noise
- Impervious to solar exposure
- Sharp integration time on & off
- No blooming or image retention

Applications

- Target signature analysis
- Spectroscopy
- Materials evaluation
- Long range surveillance
- Quality assurance
- Range phenomenology
- Scientific imaging
- Process analysis
- Medical imaging



Based on the most advanced infrared focalplane technology available today, the IRC900 series of high performance infrared cameras provide the superior performance of an InSb sensor with a choice of detector resolutions. Utilizing the latest in all-digital FPA technology, the IRC900 series offers unmatched sensitivity, ultra low noise, no blooming and no crosstalk.

With superior sensitivity and NEdT, greater than 99.5% operability, and extremely high uniformity, the IRC900 is the perfect choice for the most demanding MWIR imaging applications. The IRC900 series cameras operate at high frame rates, and support subwindowing and triggering for even faster throughput and synchronization with external events

Super-framing allows the camera to switch among different integration times on a frame by frame basis to image rapidly changing scenes over a wide dynamic range. Full rate image data is available via Camera Link, and simultaneous Gigabit Ethernet is also available.

A bayonet mount optical interface or standard bolt pattern is provided to allow the use of commercially available infrared optics. An optional embedded motorized warm filter wheel allows the use of multiple spectral filters. IRCameras offers several data acquisition and software packages to acquire, display and analyze data from the IRC900 series cameras. An SDK is also available for users who wish to create their own applications.

Key Product Features

- All digital InSb focal plane array
- Choice of 320x256, 640x512, 1024x1024 or 1280x1024 format sensors
- f/2.3 or f/4 coldshield standard
- Custom dewar configurations available
- Closed cycle Stirling cooler
- 3.0µm - 5.0µm spectral response standard, CO_2 and custom filters optional
- Optional motorized warm filter wheel
- NEdT <20mK (<30mK for 1280x1024)
- High frame rate operation
- User defined subwindows
- External triggering & synchronization
- 14 bit digital data (13 bit for higher frame rates)
- Uncorrected or corrected data, bad pixel replacement
- Twelve on board NUC tables
- Super-framing dynamic range enhancement

IRC900 Series MWIR InSb Infrared Cameras

System Specifications

Detector	IRC903	IRC906	IRC906HS	IRC910	IRC912
Detector type	Indium Antimonide (InSb)				
Spectral response	<1.0µm to 5.3µm				
Resolution (pixels)	320 x 256	640 x 512	640 x 512	1024 x 1024	1280 x 1024
Pixel pitch	30µm	20µm	20µm	25µm	12µm
Imaging Electronics					
Frame rate @ max window size	478 Hz	119Hz	478 Hz	76Hz	119 Hz
Integration time	<150 ns to full frame				
Dynamic range	14-bits with 13-bit option to increase frame rate at small window sizes				
Windowing	User defined in 4x1 increments; min width=320, min height=32				
Integration type	Snapshot, automatic selection of integrate while read or integrate then read				
Ultra low latency sync	Sync I/O, integration out				
Image data	Simultaneous Camera Link & Gig-E				
Communications	Serial over Camera Link & Gig-E				
Software control	Cross platform GenICam compliant				
Performance					
NEdT	17mK/25mK (Lo/Hi gain)	18mK	18mK	18mK	<30mK
Well capacity (electrons)	20M/4M (Lo/Hi gain)	7M	7M	10M	2M
Operability	99.8%	99.8%	99.8%	99.6%	99.6%
Optics					
Camera f/#	f/2.3, f/3.0 & f/4.0 standard; custom coldshields available on request				
Cold filter	3.0µm - 5.0µm or no cold filter standard, optional CO_2, SWIR or custom filters on request				
Lens mount	Bayonet	Bayonet	Bayonet	Bolt hole pattern	Bayonet
Optional filter wheel	Motorized four position warm filter wheel; 12.5mm diameter x 1.0mm thick filters				
General					
Power @ 24 VDC	16W	20W	25W	35W	28W
System weight	<7 pounds	<7 pounds	<7 pounds	<10 pounds	<7 pounds
Closed cycle cooler	Rotary	Rotary	Rotary	Linear	Rotary
Size	5.1" x 5.8" x 8"	5.1" x 5.8" x 8"	5.1" x 5.8" x 8"	6" X 6" X 9"	5.1" x 5.8" x 8"
Operating temperature range	-40C to +55C (-40°F to +131°F)				
Storage temperature range	-55C to +80C (-67°F to +176°F)				
Environmental rating	IP-51				
Mounting holes	2x 1/4-20 & 4x #10-24				

Specifications/features subject to change without notice

IRCameras, LLC
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www.IRCameras.com Web

IRCAMERAS

Xenics
Infrared Solutions

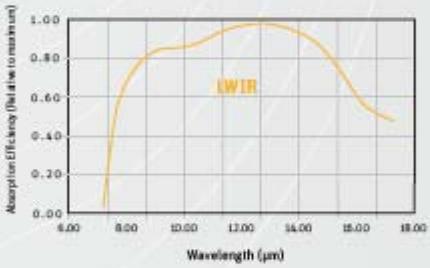
Imagine the invisible

Scientific

Gobi-640-GigE

High resolution uncooled thermal camera

Fast data transfer of high definition thermal images

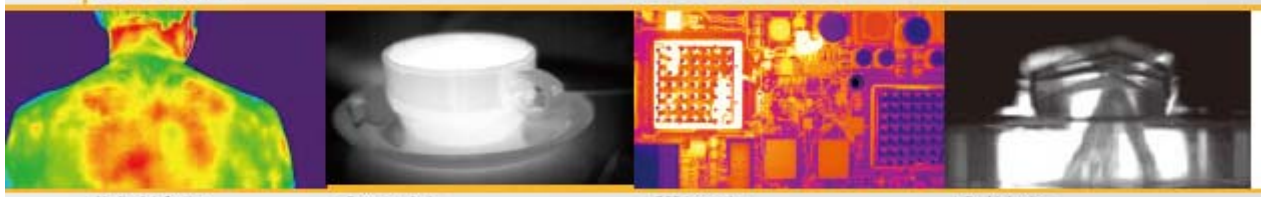


You will enter a new era of easy, fast, efficient and comfortable connectivity with the Gobi-640-GigE. The advantages of a high quality infrared camera are now combined with the power of a GigE interface. Excellent image quality, high thermal resolution (0.05°C) and accurate thermal analysis capabilities guarantee the most versatile R&D tool on the market.

This combination makes it ideal for instant, accurate and cost-effective evaluation of your thermal imaging. Using the Gobi-640-GigE will bring your analysis to the next level of accuracy!

Need for customization?
A variety of industry standard accessories is available.

Designed for use in



- Medical: Infection
- Stress analysis
- PCB inspection
- Fuel injection

Applications

- Medical imaging
- Non-Destructive Testing: Lock-in thermography
- Temperature measurement
- Quality control and quality assurance
- Real-time process control and process monitoring

Benefits & Features

- Realtime
- High sensitivity
- Small pitch (17 µm)
- Power over ethernet
- High image resolution
- Complete infrared system

Broad range of accessories available to simplify your research

Lens & filter options

Inputs

Software

- Xeneth radiometric
- Xeneth SDK
- Thermography studio (optional)

Outputs

Specifications

Camera Specifications	Gobi-640-GigE
Lens (included)	
Focal length	18 mm f/1, HFOV 33°, standard manual focus
Optical interface	Multiple lens mount
Imaging performance	
Frame rate	Max 25 Hz
Window of interest	Minimum size 160 x 120
Temperature stabilization	No thermoelectric cooling required (TEC-less)
Integration type	Rolling shutter
A to D conversion resolution	16 bit
Interfaces	
Camera control	GigE Vision
Video out	GigE Vision
Trigger	In or out (Configurable)
Operating mode	Stand-alone or PC-controlled
Power requirements	
Power consumption	4.5 W
Power supply	12 V
Physical characteristics	
Shock	70 G, 2 ms halfsine profile (without shutter)
Vibration	4.5 G, (5Hz to 500 Hz)
Ambient operating temperature	0°C to 50°C
Dimensions	49 W x 49 H x 77 L mm³ (without lens)
Weight camera head	220 g (Lens not included)

Array Specifications	Gobi-640-GigE
Array Type	Uncooled microbolometer (a-Si)
Spectral band	8 µm to 14 µm
# Pixels	640 x 480
Pixel Pitch	17 µm
NETD	< 50 mK @ 30°C with F/1 lens
Array Cooling	Uncooled
Pixel operability	> 99%

Product selector guide

Part number	NETD	Frame rate (Hz)	Interface
XEN-000065	50 mK	25	GigE Vision

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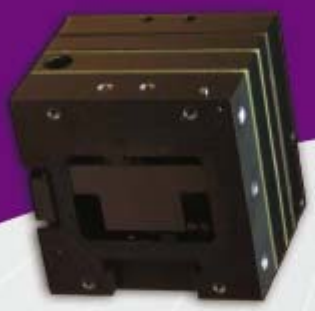
Modules & components

XTM-640

High resolution uncooled thermal infrared module



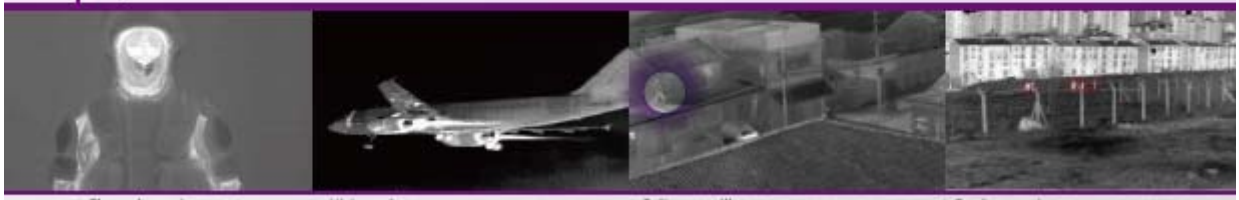
Ready-to-integrate thermal infrared module consuming ultra-low power

Xenics' XTM-640 is an extremely compact and versatile thermal camera module with unique image quality and stability for a broad range of OEM applications. These applications include security, night vision, firefighting, airborne and land-based reconnaissance and surveillance.

We guarantee you unparalleled uniform and crisp thermal images thanks to our XTM's powerful readout and processing electronics.

You can easily integrate our XTM-640 into your system with the universal QTE connector, providing digital video out or raw digital data. This allows you immediate connection, data acquisition, command and control.

Designed for use in



- Thermal security
- Vision enhancement
- Police surveillance
- Border security

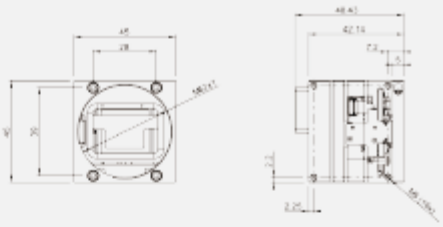
Key features

- Small size
- Low power
- Made in Europe
- High resolution
- Easy connectivity
- Small 17 µm pixel pitch

OEM applications

- UAV
- Gimbal
- Night vision
- Thermal sights
- Border security
- Fire Fighting
- Driver assistance
- Police surveillance
- Search & Rescue (SAR)

Ready-to-integrate



Specifications

Array Specifications	XTM-640
Array type	Uncooled microbolometer (a-Si)
Spectral band	8.0 to 14.0 µm
# pixels	640 x 480
Pixel pitch	17 µm
NETD	~ 50 mK @ 30°C with F/1 lens
Pixel operability	> 99.5 %

Module Specifications	XTM-640
Lens (not included)	
Optical interface	Multiple lens mount
Imaging performance	
Frame rate	50 Hz
Shutter	Yes
A to D conversion resolution	16 bit
Interfaces	
Connector type	Samtec 40 pin QTE
Digital output	Digital output following BT.601-6/BT.656-5 standard Parallel uncompressed video data
Digital control	Serial LVCMOS 3 V interface using XSP protocol
Trigger	In and out
GPIO	Extended GPIO via I2C
Power requirements	
Power consumption	2.0 W
Power supply	3.3 V
Physical characteristics	
Shock	70 G, 2 ms halfsine profile (without shutter)
Vibration	4.5 G, (5Hz to 500 Hz)
Ambient operating temperature	- 40 °C to 70 °C
Dimensions	45 W x 45 H x 48 L mm³
Weight module	95 g

Product selector guide

Part number	NETD (mK)	Frame Rate (Hz)	Selfstarting
XEN-000064	50	50	Yes

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