計畫編號：AN00-01

計畫名稱：分子金屬導線以及複合奈米基材的嶄新研究方向

計畫主持人：彭旭明

計畫摘要(中)：

自 19 世紀末以來，由於地不愛寶，地下出土的材料日多，其中以五大發現，最為世人所矚。而「羅、王之學」和《古史辯》亦先後問世。陳寅恪云：「一時代之學術，必有其新材料和新問題，取用此新材料，以研求問題，則為此時代學術之新潮流。」可見新出土與新發現，勢必隨之引發出新的學術轉變。

計畫摘要(英)：

Project 1-1 Syntheses, Characterizations and Applications of Molecular Metal Wires and Functional Nanomaterials

Fundamental understanding of the electron transport through a molecule between metal electrodes is essential for the development of the emerging technology of molecular electronics, such as molecular wires, voltage-activated switches, and single molecular transistors. This proposal, a continuous advancement from this long term collaborative team, will carry out (1) the synthesis of novel EMACs (extended metal atom chains or ligand-supported metal atom chains) with innovative experimental designs, (2) measurements of the electrical and energy transfer properties for unique compounds promising for molecular electronics and, in particular, (3) theoretical studies of the underlying physics controlling the electron transfer and transport processes. With these results from x-ray crystallography, magnetic susceptibility, electrochemistry, and I－V characteristics, the theoreticians in this team, employing the first principle calculations, will focus on modeling electron-transporting mechanisms which, in turn, will inspire our synthetic chemists to design molecules with better controllable I－V properties for further applications.

Project 1-2 Multifuncitonal Nanocomposites and Their Cutting-Edge Applications

This three-year-term research proposal is aimed to greatly expand our research quality and capacity stemming from our previous achievement in the field of nanoscience and phosphorescence materials. The goal is to strategically design and synthesize multifunctional nanocomposites suited for various cutting-edge applications. During the span of three years, three major research projects will be carried out, briefly specified as: (1) Nanocomposites for the biomedical application. (2) New generation of polymer bound nanomaterials for the solar energy devices. (3) Toward single chromophore anchoring nanoparticles for specific cutting-edge applications. Despite the difference in three research directions, the sameness lies in that they are all focusing on the exploitation of nanocomposites to the of-current-interest research territories. These three subprojects should be parallel in progress and are believed to spark an impact that, if successful, fits to the world-class frontier.

Project 1-3 Design and Characterization of Molecular Switch Material

This three-year-term research proposal is aimed to design and synthesize molecular switches based on chemical interactions; the change of the magnetic or of optical property of the material. These materials could have many potential cutting-edge applications, for example, as molecular motors, temperature sensors, as active elements of various types of displays, and information storage and retrieval. Three major orientations will be carried out in within the span of three years. (1) Toward high-order daisy chain polymers by rigid hermaphroditic monomers. (2) Molecular switches beyond catenanes and rotaxanes. (3) Generation of organic magnets and studies of their optical, magnetic, and electron paramagnetic resonance properties. (4) Generation of inorganic magnets and magnetic switch based on the transition metal complexes. These four venture subprojects are unprecedented in view of synthetic approaches. We thus expect to earn credit of worldwide leadership once the project is in positive progress.

Project 1-4: Physics of semiconductor nanocomposites

In this project, we intend to investigate various novel properties of semiconductor nanocomposites. Through our experiences, we strongly believe that the research on the composites consisting of semiconductor nanostructures and other materials is still in its infant stage. There exist many interesting properties awaiting for our exploration, which are quite attractive for both academic and industrial interests. Starting from physical principles, our future work includes material design, fabrication, characterization, as well as theoretical modeling. In the span of three years, the research direction will be focused on six topics briefly specified as: a)Generation and detection of spin polarized carriers, b)Manipulation of magnetoelectric effect at room temperature, c)Coupling between plasmonics and spintrenics, d)Electrical properties of mesoscopic semiconductor devices, e)Optical Aharonov-Bohm effect, and f)Theoretical modeling of nanoscale semiconductors.

計畫編號：AN00-02

計畫名稱：新穎紅外光元件及運用

計畫主持人：劉致為

計畫摘要(中)：

我們可以利用量子井、量子點、超晶格、量子環，及表面電漿和奈米晶體等表面奈米結構來製作新穎的紅外光元件。本計劃所提出的紅外光光源與偵測器波長範圍涵蓋近紅外光到遠紅外光，能應用於生物、醫學、以及國防等其他用途。李嗣涔教授、林浩雄教授、以及謝旭亮教授，將以 III-V 半導體建構高效能的紅外線元件，並研究其對植物生長的影響。劉致為教授將研究在矽鍺元件中引入錫材料，以求增加發光效率與拓展截止波長(超過 20 微米)。管傑雄將專注於矽/矽鍺/鍺元件的研究。，如下:

1. 紅外線電漿子發光源與 THz 偵測器 (李嗣涔) :我們所發明之室溫可操作的窄頻寬紅外線電漿子發光源已經成功地被應用在綠豆生長及基因表現的研究上。並首度發現，綠豆 GIR1 基因會受到尖峰波長從 3.9 到 4.5 m 範圍的紅外線所調制，其中以 4.5 m 對綠豆生長長度之抑制達 39.8%效果最為顯著。找出紅外線到底是哪一個小範圍的波長對基因有影響，有利於了解在植物細胞組織內，蛋白質、RNA 或 DNA 分子間以此段電磁波交換信息的機制。因此，尋求一個高功率、窄頻寬的紅外線發光源或雷射源，是我們研究的主要目標之一。在這個計畫，我們將擴展波長範圍來研究綠豆的基因表現，也會研究紅外光源對食物的抗氧化能力之影響。表面電漿子紅外線光源主要以週期孔洞銀/二氧化矽/銀三

層結構所製成，藉由增加二氧化矽厚度至 2 μm 時，Fabry-Perot 模態與表面電漿子會產生耦合效應，並可達到更窄頻寬之紅外線光源。在這計畫中，我們將利用這 FP 模態來製作紅外光源，亦會將此紅外線發光元件結構改良，直接加熱在上面三層結構，而非藉由矽基板傳熱，以增強熱傳遞效率並降低輸入功率以節約能源。兆赫電磁波藉由分子共振吸收特性而可以達到分子影像之鑑定，對於生醫、安全檢測研究上會有很大的幫助。過去的發展以 InAs/AlGaAs/GaAs 材料為主之量子點紅外線偵測器(QDIP)，其寬頻帶介於 3~20 μm 之間。由於量子點較量子井結構有更佳的侷限能力，故其具有較長的捕捉、鬆弛時間及較低的暗電流…等特性，惟無法操作在兆赫頻率。本實驗室製備之量子環紅外線偵測器(QRIP)，不僅響應強度可達 2.3 1011 cmHz1/2/W，且偵測頻率也可達 3 兆赫(THz)。本實驗室也利用電漿子特性，製作出一個窄波段且可選頻之表面電漿式量子點紅外線偵測器(plasmonic QDIP)。未來目標冀望可把 QRIP 偵測頻段降到 THz，並在同一片晶片上製做多頻道、高解析度且可高溫操作之量子環紅外線偵測器，以提供國防及生醫領域使用。

2. 矽/鍺/錫紅外光光源與偵測器 (劉致為) :矽鍺/鍺錫基底的光電元件因具有高載子遷移率，強烈的光子吸收，高放光性復合，以及與矽的整合可能性而有極佳的研究動機。錫的引用能進一步延伸目前矽鍺元件的發光與偵測波長。目前的發光二極體與雷射二極體將會使用絕緣層上矽/鍺與鍺/鍺錫/矽的結構。利用拉力應變，鍺將變成直接能帶材料。如果鍺錫材料中的錫成份高於 10 %，則其亦會形成直接能帶材料。利用鍺/鍺矽錫的能帶內躍遷與應變鍺的能帶間躍遷，我們可以達到更長波長的紅外光偵測。我們將會系統性的研究錫的含量與能帶不連續的大小關係。雜質能夠非常薄得引入間隔層中。有著雜質量子井與鍺/鍺矽錫量子井的混合運用，我們能大幅變寬偵測的範圍。聚亞醯胺上鍺元件是可撓性的並設計成可工作於光通訊波段。有著可撓性的基座，鍺能藉由撓曲變成直接能帶元件。利用鍺/鍺錫/鍺異質結構，我們能達成較佳的光學與載子侷限。玻璃上薄膜矽/矽鍺/矽可用於薄膜電晶體液晶顯示器和太陽能應用。聚亞醯胺上薄膜矽/矽鍺/矽則能運用在軟性電子上。既然只有薄薄的一層矽鍺材料是被聰明切於玻璃基板或塑膠基板上，成本能夠被有效的被降低。

3. InAsPSb/InAsSb 量子井發光二極體 (林浩雄)：本子計畫將以氣態源分子束磊晶法研製中紅外線(2-5 m)波段的新型材料包括低含氮 GaAsSbN 以及 InAsSbN 材料以及以 InAsSb 為基本材料的應變量子井與量子點。我們將有系統地研究這些材料的基本能帶電子結構、能帶排列方式與光學特性。並據以設計發光與偵測二極體元件。這種高感度、低成本、小型化、室溫操作的中紅外線光源將使中紅外線領域的應用有效地拓展。
4. 近紅外到中紅外線之光源及偵測器的研發 (管傑雄)：半導體元件操作波長為1-10μm的應用在過去10年來吸引了許多研究人員的目光，在這個計畫裡面我們將研究分為兩個範疇:第一個是 1~4μm 氧化層中嵌入鍺的奈米粒子的發光及偵測元件;第二為 7~12μm 應用在熱影像處理的量字井及超晶格紅外線偵測器。(a)1~4μm 氧化層中嵌入鍺的奈米粒子的發光及偵測元件: 以矽鍺為基礎的光偵測器在近紅外線的光學應用上有極大的潛力，根據我們之前研究的結果，我們已成功製造出不同型態的量子點紅外線偵測器，且其響應的波長為 2~4μm，但之前所使用的成長方式必須要利用昂貴的 MBE 或 UHVCVD 機台來長晶，有鑑於此，我們設計一個可當偵測及發光的元件，其結構為基本的金氧半元件並在氧化層中嵌入鍺的奈米粒子，響應的波長約為 1~4μm；此元件的製程方式相當的簡單，只需要 E-gun sputter 和 PECVD，先將鍺的的薄膜鍍在穿透氧化層上，再蓋上一層控制氧化層，經過高溫的熱退火後即可得到鍺的奈米粒子，可經由變換鍺薄膜的厚度控制的鍺奈米粒子大小，不同大小的奈米粒子會影響頻譜響應中的峰值位置，若是將穿透氧化層移除，直接將鍺薄膜鍍於矽基板之上，則鍺與矽會發生混合而形成矽鍺的合金，此矽鍺合金將提供波長短於 2μm 的響應。另外，藉由改變穿透氧化層的厚度，我們可以控制此元件的操作速度，穿透氧化層越薄則操作的速度越快，並且為了增加量子效率以及擴大頻譜響應的範圍，我們也可以堆疊數層的鍺與氧化層薄膜以形成多層量子點結構，目前我們已經觀察到此元件的電激發光頻譜。(b)7~12μm 應用在熱影像處理的量字井及超晶格紅外線偵測器: 為了要得到一個良好效能的偵測器，必須使元件”提高光電流”及”抑制雜訊”是無庸置疑的。而雙位能障超晶格紅外線偵測器可以提高光電流的效果，其結構是 15 週期的超晶格被兩個不同厚度的位能障所前後包夾，而原本

在第一迷你能帶的電子受到光激發可以在第二迷你能帶前後共振(如雷射共振腔)，其震盪的現象可以使得受激電子穿透能障的機率增加進而使響應提升，根據我們前面的研究，將超晶格偵測器與多重量子井整合以後可以得到更好的元件特性，在此多重量子井可以當成雜訊濾波器使用，因此我們將雙位能障超晶格紅外線與多重量子井整合可以得到一個高效能熱影像偵測器。

5. 阿拉伯芥紅外光訊息傳遞成員的遺傳篩選與功能性研究 (謝旭亮)：目前對植物光訊息傳遞所獲得的豐富資訊主要來自對可見光的大量研究；然而，波長大於 750 nm 的非可見光紅外光（IR）對植物生長發育的影響，則所知有限。植物能夠接收藍光與紅光的波長，啟動訊息傳遞，造成光形態發生；相對地，IR 則會穿透葉子的角質層與其柵狀組織，然後來到海綿組織的空隙，造成不是反射即是穿透。因此，IR 的反射力會隨著植物的種類與年齡而異。此現象與我們先前的結果是一致的，即綠豆受到 IR 照射時，具有 30%下胚軸延長的抑制性，比大豆與阿拉伯芥對 IR 的反應更加敏感。此結果暗示這些植物在葉部的葉肉細胞內的空隙可能不同。另外，我們從綠豆中利用差異性選殖法，分離出一個可受 2 至 5 μm IR 誘導的基因 VrGIR1，它與阿拉伯芥中的 GASA 基因家族的成員類似，同樣可受荷爾蒙 GA 的誘導表現。大量表現 VrGIR1 基因的阿拉伯芥轉殖株，具有對遠紅光（far-red light）不敏感的長下胚軸的外表型，並且影響 GA 生合成關鍵基因的表現；也造成一些開花基因如 GI、CO 與 FT 的表現量下降，因此造成延遲開花的現象。此點與目前所知「紅外光 IR 會影響植物開花」是一致的。為了進一步瞭解 IR 在植物中的訊息傳遞與植物對其反應的分子機制，我們打算利用阿拉伯芥的活化體標記的突變體族群（activation-tagging mutant pools），分離出對 IR 反應異常的突變體，這些可能是因 T-DNA 插入基因後，造成下胚軸或葉部構造的改變，此訊息傳遞的成員可能是光接受體或是中間訊息的傳遞者。因阿拉伯芥研究的豐富資源，應可加速獲得本計畫的研究成果。並且本計畫的執行完畢，定能促進阿拉伯芥中紅外光訊息傳遞的瞭解，有助於日後農作物的改良與產量的精進。

計畫摘要(英)：

Main Project:

The novel infrared devices can be fabricated using the quantum wells, quantum dots, superlattice, quantum ring, and surface nanostructures such as surface plasmon and nano-crystals. The proposed emitters and detectors cover near infrared to far infrared, even to Tera Hz region, which can be applied in biology, medicine, security and other applications. The III-V-based high performance infrared devices and the applications of plant growth will be investigated by Prof. Lee, Lin and Hsieh with the focus on narrow/wide band sources and modulation of growth condition. Prof. Liu will investigate the Sn incorporation into SiGe to increase the emission efficiency and to extend the cut-off wavelength more than 20 m. Prof. Kuan will focus on the Si/SiGe/Ge based devices.

Sub-project 1:

Room temperature operated narrow-bandwidth infrared plasmonic thermal emitter invented has successfully been applied to the study of the growth and gene expression of mungbean. It was discovered for the first time that the GIR1 gene of mungbean will be modulated by a range of infrared light with peak wavelength from 3.9 to 4.5 m. The 4.5 m light source showed the largest effect by suppressing the elongation of hypocotyl length of mungbean to 39.8 %. It is important to single out the infrared wavelength which is responsible for the gene expression or inhibition, because the information exchange mechanism between infrared light and the proteins, RNA or DNA molecules inside the plant cells can be understood. For this reason, it’ s our goal to develop an infrared light source or laser with high power efficiency and narrow bandwidth. In this project, we are going to extend the wavelength range to study the gene expression of mungbean and anti-oxidized ability of foods exposed to the narrow bandwidth infrared light. The infrared plasmonic thermal emitter is composed of tri-layer Ag /SiO2/Ag structure, and the top Ag layer is perforated with periodic hole arrays. The coupling effect between Fabry-Perot mode and surface plasmon was observed when the thickness of SiO2 exceeded 2 m, and this mode can be used in this project to achieve an even narrower bandwidth infrared light source. We are also going to modify the device structure by heating directly the top tri-layer instead of indirectly through the silicon substrate in order to enhance the output efficiency and reduce the input power.

Tera Hz electromagnetic wave is very useful in the area of the bio-medical science and security check because it can be used to analyze the image of molecules through their absorption spectra. The previous studies is based on InAs/AlGaAs/GaAs quantum dot infrared photodetectors (QDIP), and the detection range is between 3 and 20 μm. The confining characteristic in quantum dot is better than that in quantum well, so QDIP exhibits good performance like long relaxation time and low leakage current, but it can not be operated at THz. The quantum ring infrared photodetectors (QRIP) with high detectivity of 2.3 1011 cmHz1/2/W was fabricated successfully and the cutoff frequency can be extended to 3 THz (100 m). Utilizing the surface plasmon polariton (SPP), a plasmonic quantum dot infrared photodetectors with narrow bandwidth and tunable wavelength detection was successfully made. In the proposed project, we are going to develop a QRIP with operation frequency further lower to THz, and fabricate multi-channel photodetector in one chip with high sensitivity and high operation temperature for military and bio-medical applications.

Sub-project 2:

Due to the high carrier mobility, strong photon absorption, high radiative recombination rate, and possible integration with Si, SiGe/GeSn based optoelectronic devices attract great interest for scientific research and practical applications. The incorporation of Sn can further increase the emission wavelength and detection cut-off wavelength beyond the capacity of SiGe devices due to the bandgap reduction, band offset engineering, and strain optimization. The SnD4 precursor will be installed in the UHVCVD reactor for Sn incorporation. The LED/laser structures will be investigated using Si/Ge-on-insulator and Ge/GeSn/Si layers. With sufficient tensile strain, Ge becomes the direct bandgap material. The tensile strain of Ge can be fabricated by GeSn buffers or mechanical strain. The GeSn alloy can be the active gain medium (direct bandgap) if Sn content is more than 10%. The Fabry-Perot cavity can be formed by the pair of cleaved planes perpendicular to the junction plane. The intraband transition due to band offset between Ge/GeSiSn and the interband transition of strained Ge can have a much longer cut-off wavelength for infrared detection. The effects on the band offset via incorporation of Sn will be systematically studied. Deformation potential calculation shows that Ge/Ge0.65Si0.15Sn0.20 has type-I band alignment. The combination of transitions from Ge/Ge0.65Si0.15Sn0.20 QW/QD and the -doping can broaden the detection spectra.

The Ge/GeSn/Si-on-polyimide MIS devices are flexible/conformable and designed to operate in the telecommunication wavelength. The flexible substrate makes it easier to reach the direct-gap emission by bending. With the Ge/GeSn/Ge hetero-structure, better optical confinement and carrier confinement can be achieved. The thin film Si/SiGe/Si on glass for TFT/LCD and solar cell and the thin film Si/SiGe/Si on polyimide for flexible electronics can be fabricated by wafer bonding and smart-cut. Since only thin active layer is bonded on the glass substrate or the polyimide substrate, the cost should be effective.

Sub-project 3:

This subproject is aimed at the development of novel active media for infrared light emitters and detectors. The active media include dilute nitrides and Sb-based nano-structures. Dilute nitride alloys are well-known to have a large energy gap bowing which makes the energy gap reduce with the lattice constant in response to the incorporation of nitrogen. There is far less research on dilute nitrides for mid-infrared range. In the past, we have successfully fabricated InAsN quantum well laser on InP substrate with an emission peak at 2.4 m, which still holds the longest wavelength record among the nitride lasers.

In this proposal, we intend to investigate two dilute nitrides with narrow energy gaps, GaAsSbN on GaAs and InAsSbN on InAs, using molecular beam epitaxy (MBE). These alloys have only one group-III atoms, immunizing the dilute nitrides against the thermal induced atomic exchange, and can be grown either strained or lattice-matched to substrates. A very recently breakthrough on InAsN and InAsSbN showed that high quality epilayers can be prepared nearly lattice-matched on InAs substrates with photoluminescence from 3 to 4 m. We will focus on the growth and characterization on these dilute nitrides, and seek to the applications to detectors. The second media is the Sb-based compound semiconductor nano-structures including InAsPSb/InAsSb quantum wells and InAsSb quantum dots. In the past two years, we have systematically studied the basic band structure of this system. The most important finding is that the spin-orbit splitting energy of InAsSb is larger than the energy gap, which can inhibit the Auger recombination through spin orbit, a major problem for poor radiative efficiency in narrow gap semiconductors such as InAs. The energy gap and band alignment for InAsSbP/InAsSb and InAs/InAsSb are also defined. Based on these knowledge, type-II InAs/InAsSb room temperature light-emitting diode has been successfully demonstrated. The proposed project seeks to further enhance the efficiency of the light emitters. In order to break the limitation of lattice constant so as to combine alloys with different band alignment together, we will investigate the growth of InAsSb quantum dots on Sb-based alloys. The success of mid-infrared optoelectronic devices with the novel active media would be a real breakthrough.

Sub-project 4:

Some applications of the devices ranging from near to middle infrared wavelengths have been attractive in the past decade. In this sub-project, we divide our researches into two parts: (a) 1~4 μm MOS + Nanocrystals LED /detector, and (b) 7~12 μm Quantum wells + superlattice thermal imaging photodetector .

(a) 1~4 μm MOS + Nanocrystals LED /detector

SiGe based photodetectors are promising candidates for near infrared applications. According to previous research, the different types of QDIP are successfully fabricated by MBE and UHVCVD, and response wavelength arrived 2~4 m. However, this method needs expensive MBE and UHVCVD to grow the samples. In view of this, we design a photodetector/emitter with embedded Ge nanocrystals (NCs) in MOS structure, and the response wavelength is at 1~4 μm. The fabrication of this photodetector/emitter is quite simple. Only E-gun sputter and PECVD are necessary. The Ge NCs embedded in SiO2 are prepared by inserting Ge thin film between the tunneling and control oxides, and then thermally annealing it. Different Ge NCs sizes can be arose by varying the Ge thin film thickness. The Ge NCs sizes will affect the peak of response wavelength. As the tunneling oxide is removed and Ge thin film is deposited on the Si substrate directly, the Si and Ge will intermix to form SiGe layer. The response wavelength below 2 m is attributed to this layer. Furthermore, by changing the tunneling oxide thickness, we can control the operation speed of the detector/emitter. The thinner tunneling oxide will lead to the faster response. In order to increase the quantum efficiency and broaden the response wavelength, we will stack several Ge thin film and oxide to get the multi Ge layers.

(b) 7~12 μm Quantum wells + superlattice thermal imaging photodetector .

Undoubtedly, it is necessary to have "High Photocurrent" and "Low noise" for a good-performance detector. A double-barrier superlattice infrared photodetector (SLIP) is proposed to obtain high photocurrent. The 15-period SL was sandwiched in between the thick and thin barriers to enhance the SL's photocurrent. The photoexcited carriers excited from the first miniband can resonate in the second miniband. This oscillation phenomenon enhances the tunneling probability of the photoelectrons through the thin barrier and results in the higher responsivity. According to our previous work, we have successfully investigated a structure of a superlattice (SL) integrated with multiple quantum wells (MQWs) to operate at high temperature. The noise in MQWs is the generation-recombination noise and is given by , so MQWs can be used as noise filter since gn is much less than 1 at low biases .For this reason, a double-barrier SLIP can be integrated with multiple quantum wells for high-performance thermal-image detectors.

Sub-project 5:

All the fruitful information of light signal transductions is mainly derived from the intensive research on visible light (400-750 nm), whereas the effect of infrared (IR) light with a wavelength greater than 750 nm on plant development remains unknown. Plants can perceive the wavelengths of blue and red light to trigger signal transduction, leading to photomorphogenesis. In contrast, IR radiation passes through the cuticle and palisade tissues of leaves and is scattered by the air spaces in spongy cells, and then either reflected or transmitted. Thus, the reflectivity of IR radiation varies with plant species and plant ages, which appears to be consistent with our previous result showing that mungbean (Vigna radiate) with 30% reduction of hypocotyl elongation is more sensitive to IR irradiation than those in soybean and Arabidopsis. This implies that these plant species may have various air spaces in the mesophyll cells of their leaves. We have isolated one gene, gibberellic acid [GA]- and IR-induced gene 1 (VrGIR1), by differential display and found that its expression can be induced by 2 to 5 μm IR treatment and also inducible with phytohormone gibberellic acid (GA) implicated from its homology to a GASA (Gibberellic acid-stimulated in Arabidopsis) gene family in Arabidopsis that was induced by GA.

To further understand IR signal transduction pathway and the mechanisms underlying the sensitivity to IR radiation, we plan to use Arabidopsis, a model system of plant science research, and apply molecular genetics approach to identify signaling components involved in IR signaling pathway. The first year of the project aims to isolate signaling mutants responsible for IR signaling: Firstly, we will test whether the photoreceptor mutants in wavelengths of visible light, including phytochrome A and B, as well as cryptochrome 1 and 2 mutants, are responsible for the perception of IR. Secondly, we will screen for possible natural variation on IR response using different Arabidopsis ecotypes. Currently, 24 different Arabidopsis ecotypes are available in my lab, and display various flowering time. Thus, these ecotypes are good for examination of possible changes of IR responses in terms of hypocotyl elongation. Thirdly, we will identify possible signaling components and photoreceptors involved in IR signaling with changes of IR responses by screening activation-tagging mutant pools. This mutant pool contains gain-of-function and loss-of-function mutants, which may exhibit different lengths of hypocotyls upon IR irradiation. The second and third years of the project are to clone respective genes responsible for the mutants and perform functional studies by genomic approaches: Once the mutants are isolated, the flanking sequences of T-DNA inserted regions in mutants will be cloned by iPCR or related techniques. Further functional studies, including gain-of-function or loss-of-function transgenic lines, interactive partners, subcellular localization, and physiological examination will be carried out. In addition, we will apply microarray analysis to establish the differences of expression profiles between wild type and mutants under IR treatment. Because of fruitful genetic resources of the Arabidopsis research community, we believe that working on the Arabidopsis model system will speed up the accomplishment of the project. By the end of the project, it will definitely enhance our understanding of the IR signal transduction pathway in Arabidopsis and be beneficial to the crop engineering and yield improvement in the near future.

計畫編號：AN00-03

計畫名稱：奈米光電半導體材料研究

計畫主持人：楊志忠

計畫摘要(中)：

本群體研究中，我們將進行包括寬能隙氮化物及氧化物之新穎光電半導體奈米結構的生長、特性分析以及先導性應用研究，同時結合這些半導體奈米結構從事奈米光學研究。半導體奈米結構之研究乃基於有機金屬氣相沉積及分子束磊晶之樣品生長，包括四個課題：(1)氮化鎵奈米柱生長及其結合再生長；(2)氮化銦、富銦氮化銦鎵及相關量子井結構；(3)氧化鎘鋅鎂化合物及相關量子井結構；(4)氮化物及氧化物半導體混合生長。材料特性分析主要為瞭解其奈米材料、光及電之特性。先導性應用主要是嘗試高效率發光二極體及太陽能電池之製作。在奈米光學之探討，我們將著重在金屬及上述半導體奈米結構界面上表面電漿子之行為及表面電漿子與奈米結構耦合之新穎現象，同時也希望能實現表面電漿子雷射(表面電漿子類似光子雷射之行為)。我們將利用表面電漿子雷射的概念來進行生物檢測之先導性應用研究，同時表面電漿子與如量子井之耦合也可於發光二極體及太陽能電池內，以提昇他們的效率。由於上述氮化物與氧化物之材料及光電特性類似，本計畫中材料系統其實乃為一體，所有應用方向全與能源科技及生物醫學有關。全部共同九位具不同但互補專長(包括長晶、特性分析及元件設計與製程)之教師，共同為設定目標合作研究。

計畫摘要(英)：

In this research, we propose a team research for the growth, characterization, and preliminary applications of novel optoelectronics semiconductor nanostructures, including wide band-gap nitrides and oxides. Also, the combination of nano-photonics with such semiconductor nanostructures is studied. In the semiconductor nanostructure growth and characterization based on metalorganic chemical vapor deposition and molecular beam epitaxy, four issues are to be studied, including 1) the growth of GaN nano-columns (both self-organized and patterned substrate growths) and their coalescence overgrowth; 2) InN, indium-rich InGaN, and related quantum well structures; 3) CdZnMgO compounds and related quantum well structures, and 4) hybrid growth of nitrides and oxides. The characterizations include the understandings of the nano-material, electrical, and optical properties. The preliminary applications include the uses of those novel semiconductor nanostructures for the fabrications of efficient light-emitting devices and solar cells. In the study of nano-photonics, we focus on the behaviors of surface plasmons at the interfaces between metals and the aforementioned semiconductors, the novel phenomena of the coupling between the surface plasmons and the aforementioned semiconductor nanostructures, and the implementation of surface plasmon amplification by stimulated emission of radiation (SPASER). Preliminary bio-sensing application of SPASER and the use of surface plasmon coupling for enhancing emission efficiency of a light-emitting device and absorption efficiency of a solar cell will be realized. Because the material and optical properties of wide band-gap nitrides and oxides are quite similar, the proposed material systems are actually closely related. The targeted applications are all related to energy technology and health care. Nine faculty members of different expertise, including crystal growth, material analysis, electrical and optical characterizations, device design and process, work together for the targeted goals.