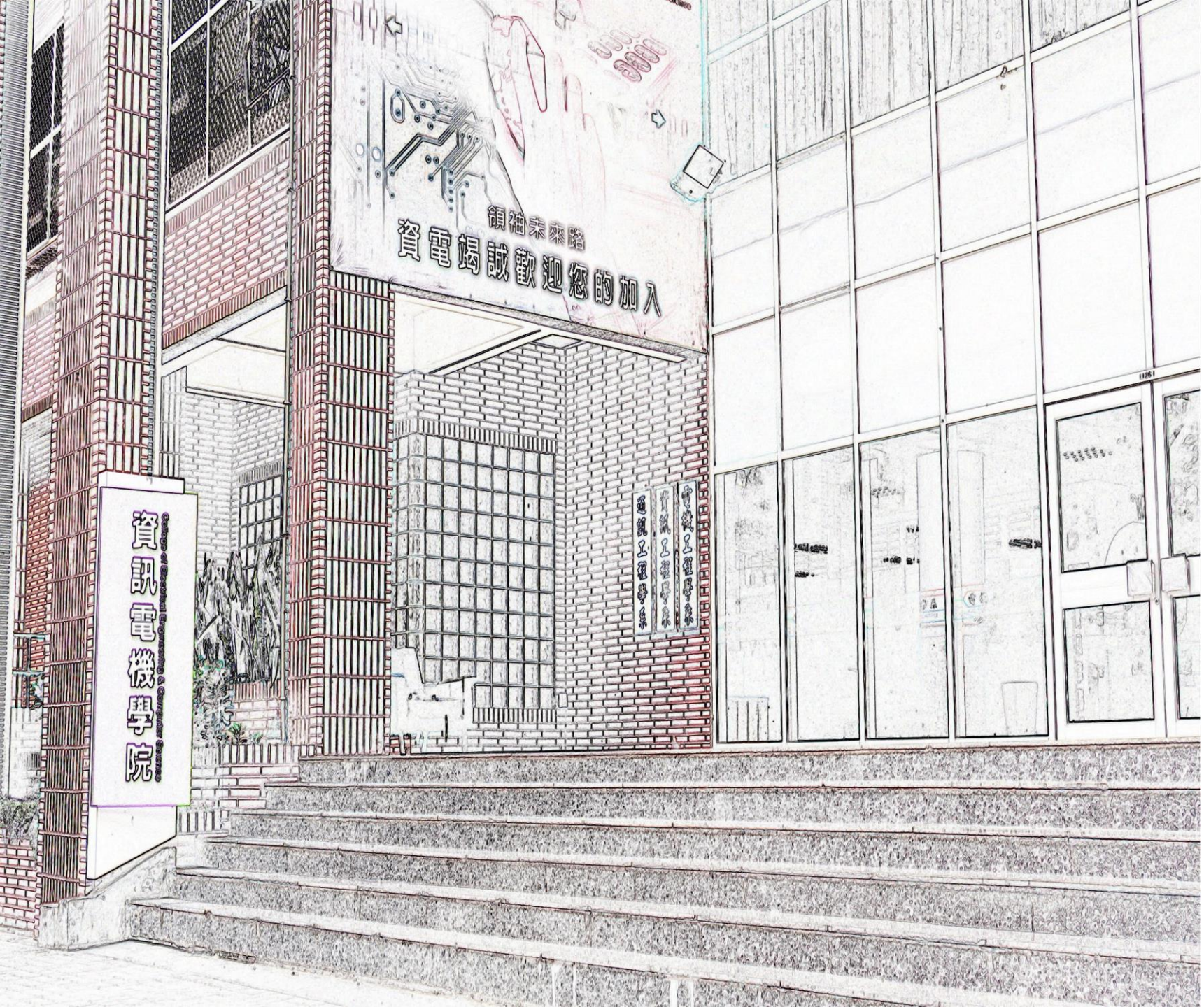

生產力4.0 與 電機系的未來發展

中央大學電機工程學系
李柏磊教授

NCU, TAIWAN

什麼是工業4.0?

工業4.0，或稱**第四次工業革命**、**生產力4.0**，是一個德國政府提出的高科技計劃。2013年德國聯邦教育及研究部和聯邦經濟及科技部將其納入《高技術戰略2020》的十大未來專案，投資預計達2億歐元，用來提昇製造業的電腦化、數位化和智慧化[2]。德國機械及製造商協會（VDMA）等設立了「工業4.0平台」

未來工廠

https://zh.wikipedia.org/wiki/%E5%B7%A5%E6%A5%AD4.0

http://topic.cw.com.tw/2016industry4.0/article.html

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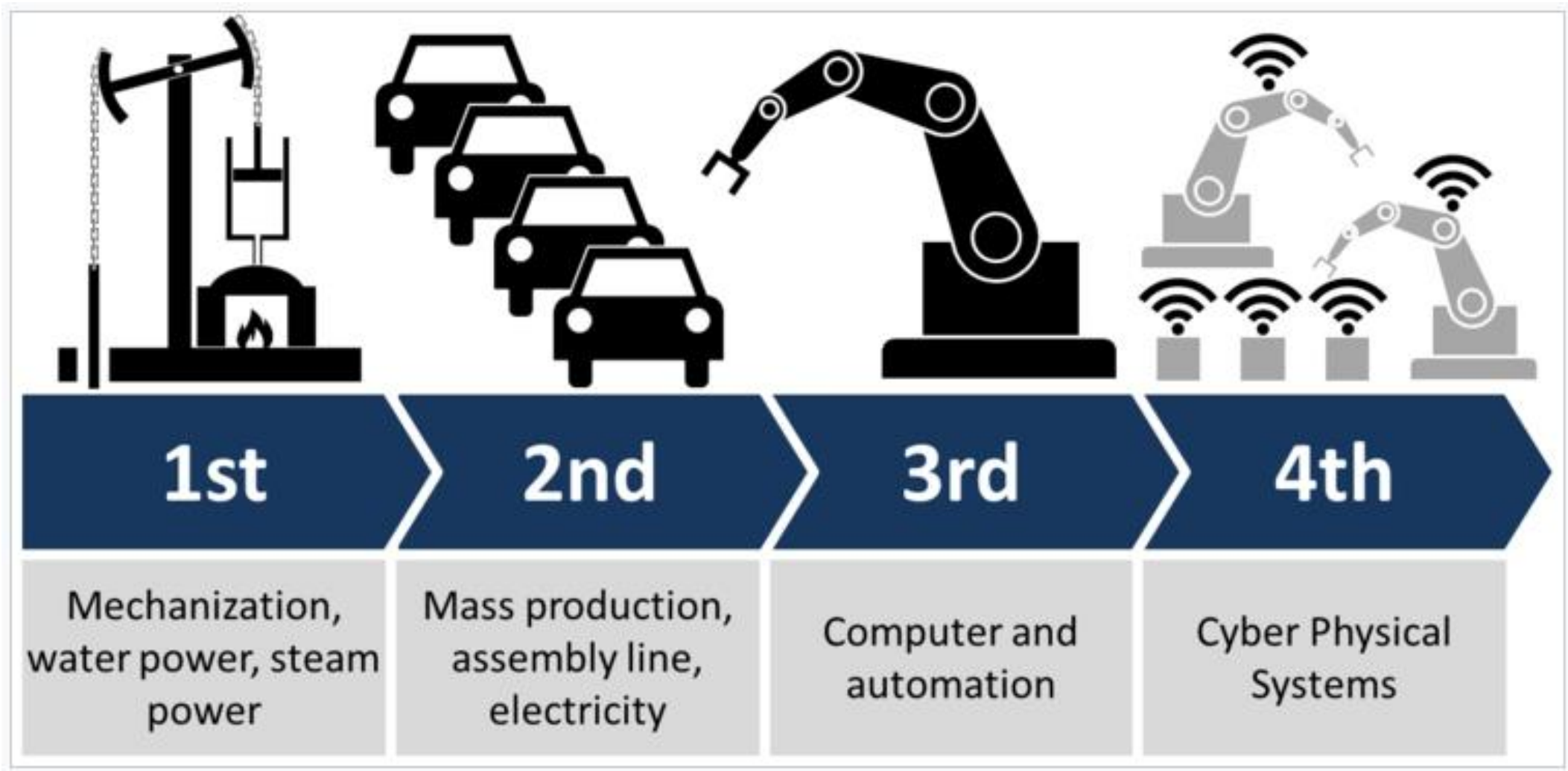
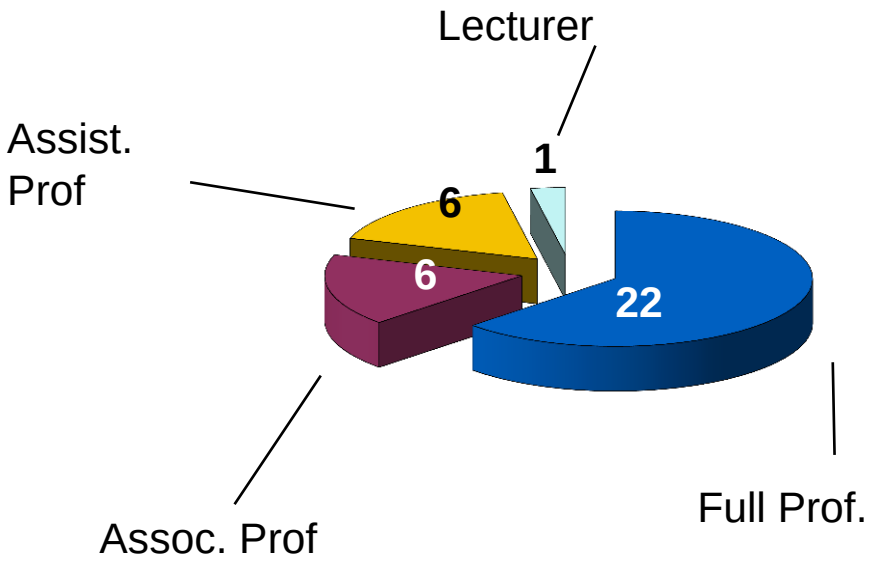
工業4.0簡單的說，就是大量運用自動化機器人、感測器物聯網、供應鏈互聯網、銷售及生產大數據分析，以人機協作方式提升全製造價值鏈之生產力及品質。

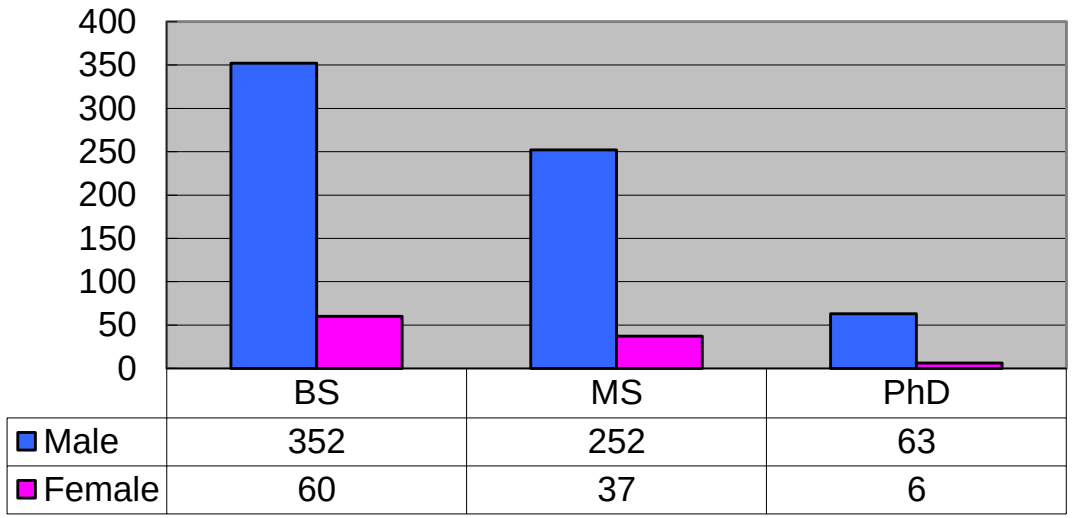


https://en.wikipedia.org/wiki/Industry_4.0

EE Facts & Figures

- The Department
  - Established in 1980
- Faculty and Student





	BS	MS	PhD
Male	352	252	63
Female	60	37	6

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EE Facts & Figures

- Faculty Awards & Honors
  - 3 IEEE Fellows
  - 2 IET Fellows
  - 4 MOST Distinguished Research Awards
  - 4 Ta-You Wu Memorial Awards, MOST
  - 5 MOST Distinguished Young Researchers
- Research funding (2016)
  - MOST: USD $2,120,000
  - Other: USD $36,500

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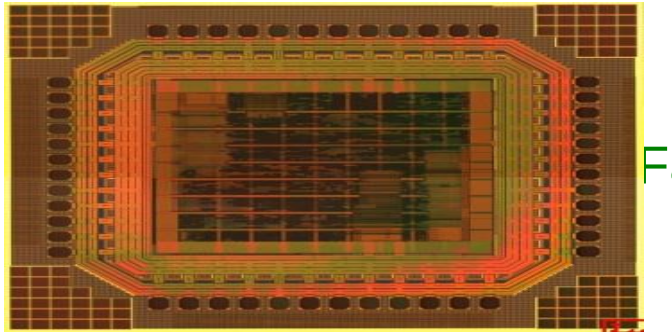
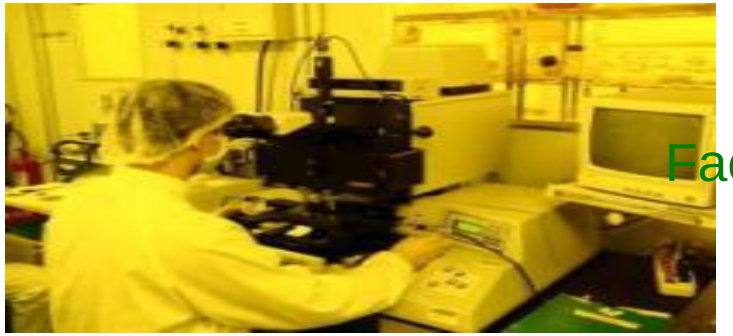
Research and Teaching Groups

- Electronic Circuit Design Group



Faculty: 10

- Solid State Group

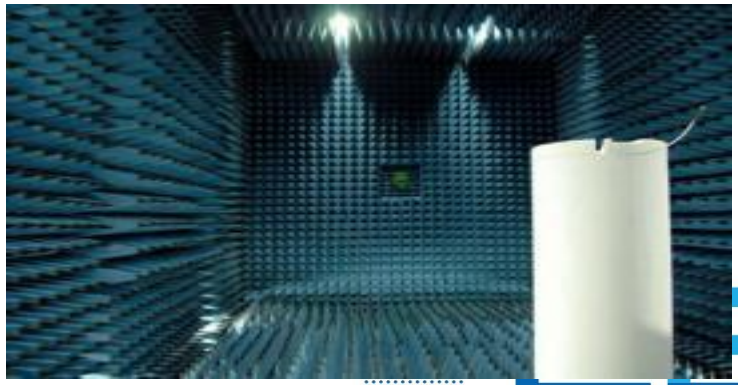


Faculty: 8

- System and Biomedical Engineering Group

Faculty: 10

- Electromagnetic Waves Group



Faculty: 7

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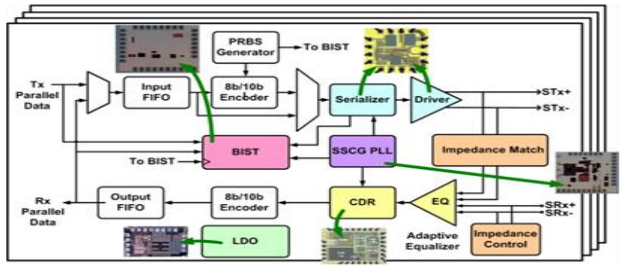
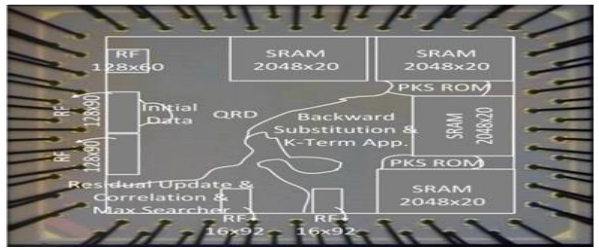
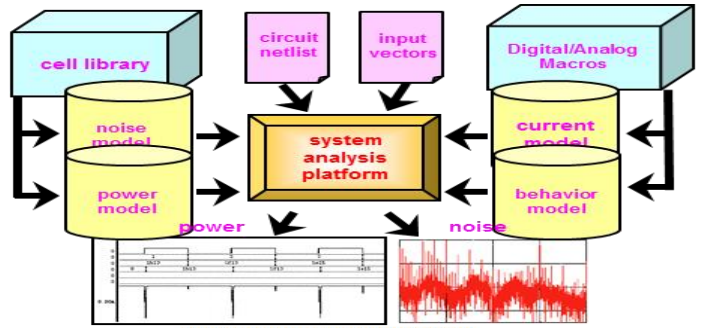
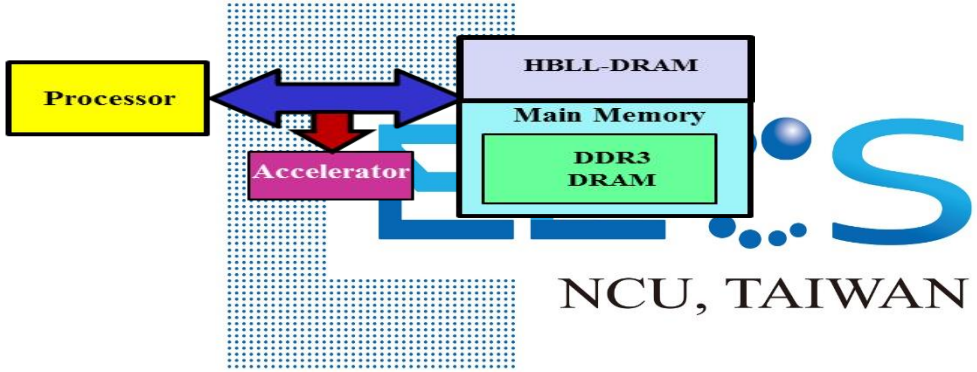
Electronic Circuit Design Group

- Research areas
  - Design of Intelligent Electronic Systems
  - Circuit and System Design of Advanced Communication and Network Systems
  - Design and Computer-Aided Design of SoCs
  - Design of Mixed-Signal and High-Speed Ics
  - Design of Bio-electronic Systems and Circuits
  - Testing and Design Automation of Integrated Circuits and Systems
  - Internet of Things
  - Near-Data Processing



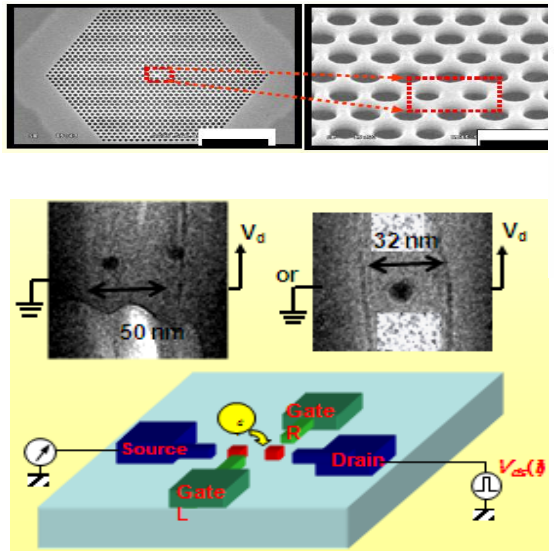


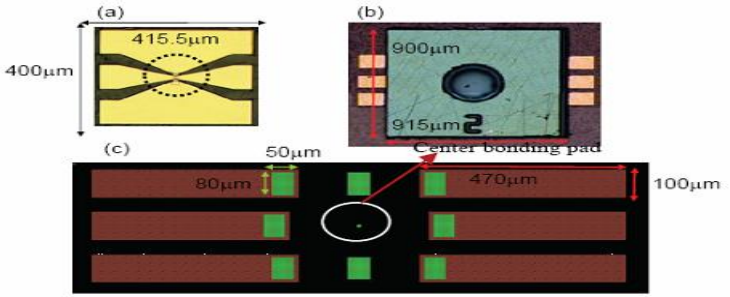


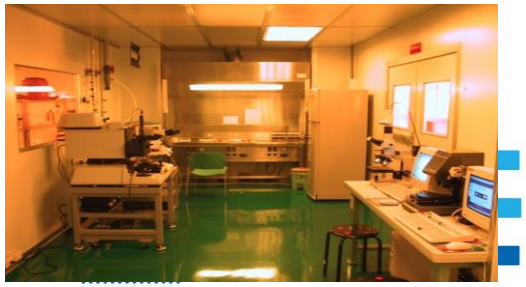


Solid State Group

- Research areas
  - Semiconductor Material and Device
  - Optoelectronics Device, High Speed Device, and Device Modeling
  - High-speed Optical Communication Device and Measurement System
  - GHz Optoelectronic Transceiver and Applications







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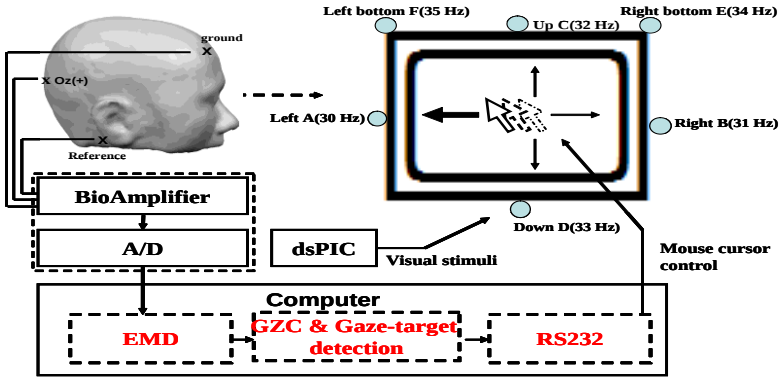
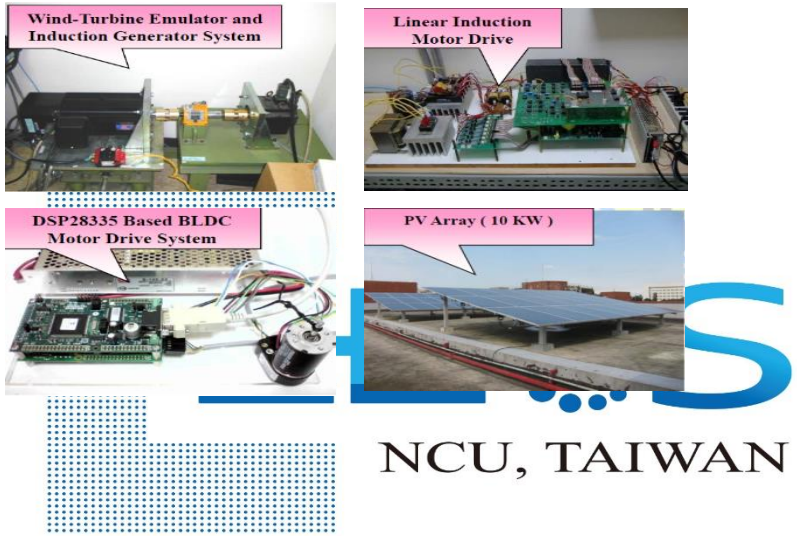
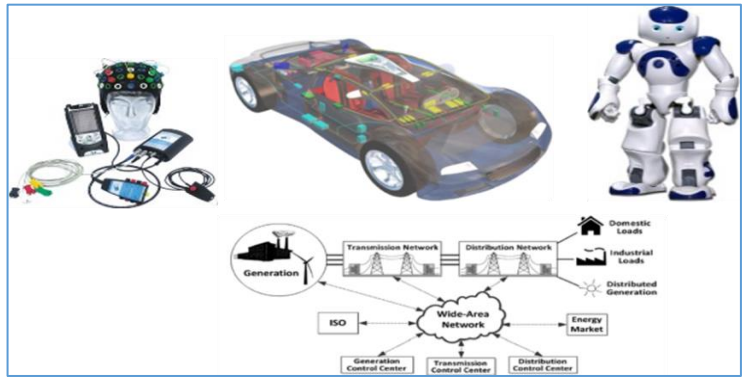
System and Biomedical Engineering Group

- Research areas
  - Fuzzy Theory, Control System, and Robot
  - AC and Ultrasonic Motor Drives, Nonlinear Control Theories, Micro Mechatronics
  - Power Electronics
  - Biomedical Instrumentation Design, Signal Processing, and EEG Processing
  - Biomedical Sensor Chips and Speech Production Mechanism





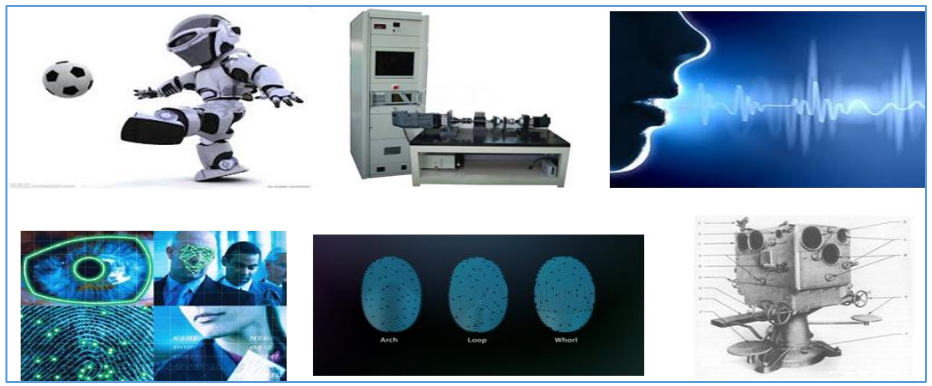
System and Biomedical Engineering Group



智慧型控制理論與應用研究
機器人
機電系統設計及應用
生醫工程及高科技輔具
語音處理與辨識
電力電子與電動機控制應用
智慧電網
穿戴式裝置

醫療電子(侵入式、非侵入式測量儀表技術、人體診斷資訊系統、醫療輔具監控系統等)

環境監控(溫溼度、光度、空間、氣體濃度、聲音、震動、水質、土質結構等監控議題)



電機控制與辨識(機器人、交直流馬達、控制理論、語音及影像辨識等)

能源監控(電力品質、節能技術、再生能源、智慧電網、電力電子等)

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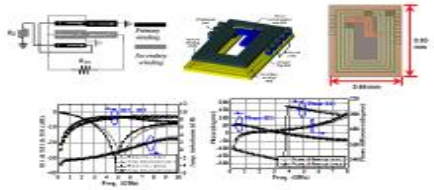
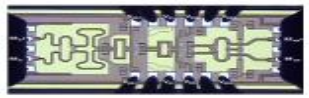
Electromagnetic Waves Group

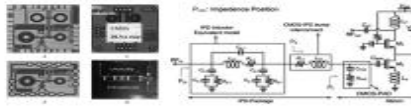
High Performance Passives in Si-based and GIPD RFICs



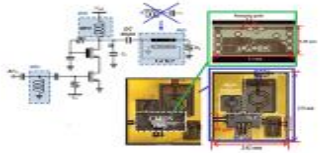
State-of-the-arts Transmission Line Transformer in Silicon Based Technology



K-band 24.1% PAE Wideband CMOS PA with Differential TLT

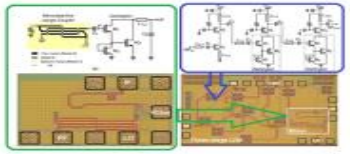


5.2 GHz CMOS LNA using Wafer-leve Integrated Passive Device Technolog

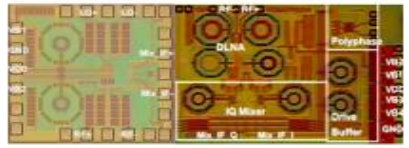


Broadband and High-Efficiency Pow Amplifier that Integrates CMOS and IPD Technology

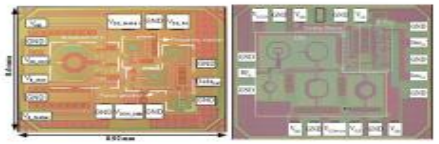
High Integration RFICs and MMWICs



5 to 65 GHz Gate-pumped Down-conversion Mixer Using Darlington Cell for 60-GHz CMOS Receiver

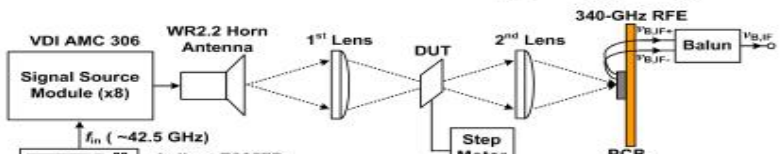


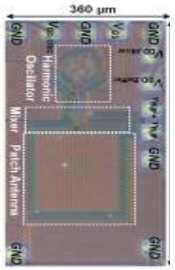
1-V 5-GHz self-bias folded-switch mixer in 90-nm CMOS for WLAN receiver

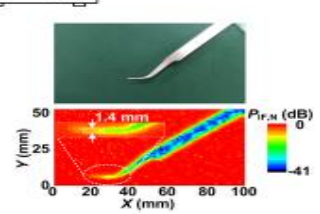


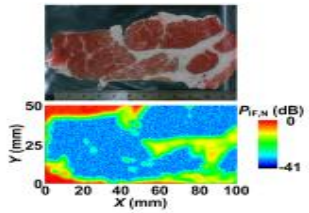
Fully integrated 24 GHz OOK Transceiver

THz Biomedical Imaging System

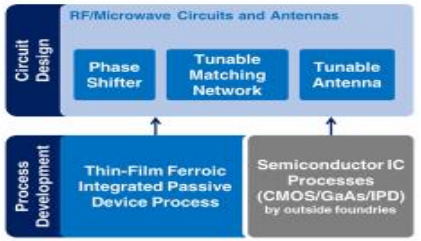








Integrated Passive Device (IPD) Process Incorporating Ferroic Thin-Films



Integrated passive device (IPD) fabrication process incorporating ferroic thin-films for RF/microwave circuit and antenna design

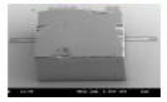
開發一引入鐵性材料薄膜的積體被動元件製程，應用於射頻／微波電路及天線設計

Microwave phase shifter based on the thin-film ferroelectric IPD process

使用鐵電薄膜積體被動元件製程所製作之微波相位偏移器

Tunable slot-loop antenna using ferroelectric varactors

使用鐵電可變電容之可調式環形槽孔天線



CMOS chip flip-chip bonded onto a home-made carrier substrate by gold-gold thermo-compressive bonding

以金-金熱壓合方式將CMOS晶片覆晶鍵合至自製的載板上

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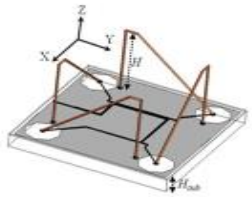
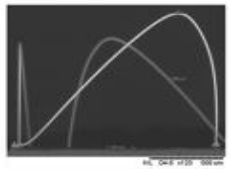
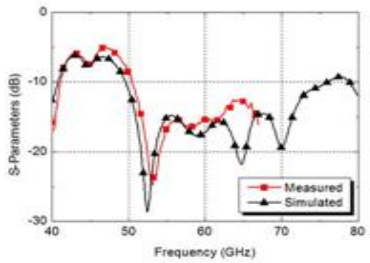
Electromagnetic Waves Group

MMWave and Reconfigurable Antennas

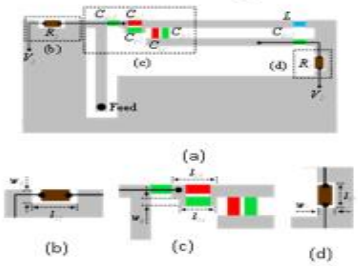




V-Band Circular-polarized Antenna Based on IPD and Wire-bonding Technology

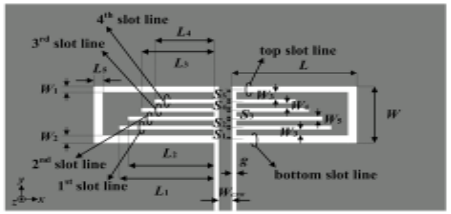


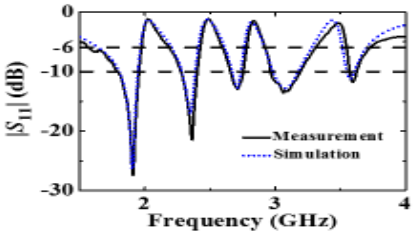
Dual-band Reconfigurable Antenna Design



Multiband Antennas

CPW-fed penta-band antenna

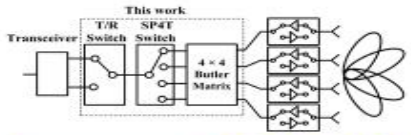


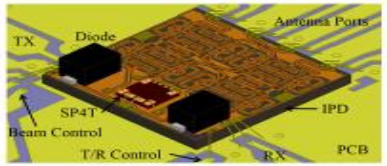


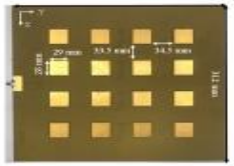
The multiple slot lines cut out by the two embedded comb-like sheets play an important role for frequency control, and each frequency could be tuned based on the slot lengths. The measured return loss is greater than 10 dB in each band. Stable antenna gain between 5.3 and 6.46 dB are observed in the operational bands.

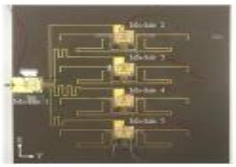
Miniature Beamformer Module and 2D Scanning Antenna Array

Miniature 2.4-GHz Switched Beamformer Module

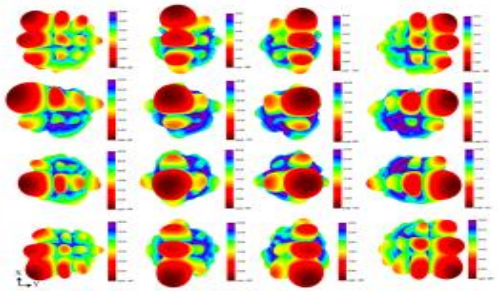


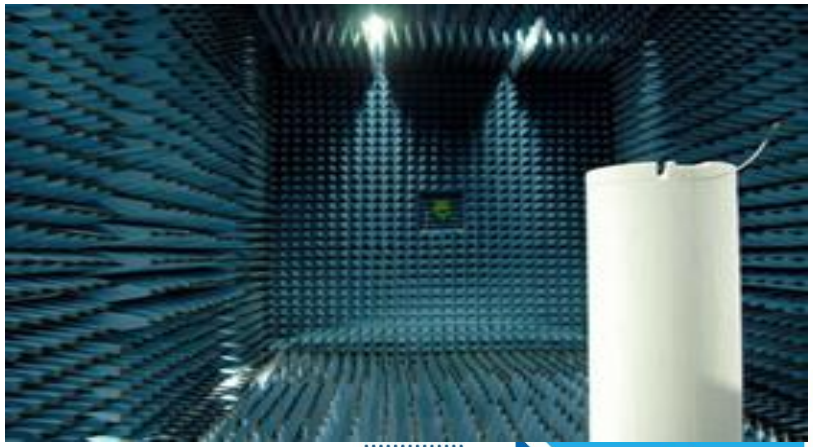






Very-Low-Profile 2.4 GHz Scanning Antenna Array with 2D Beam-Steering Capability





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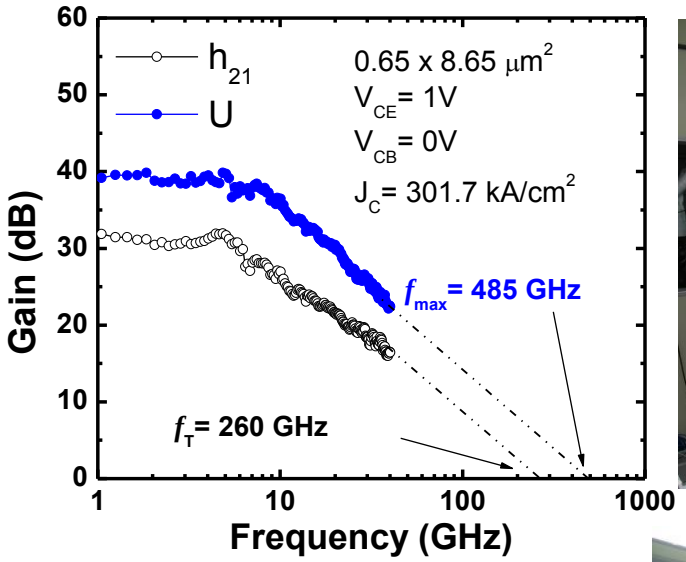
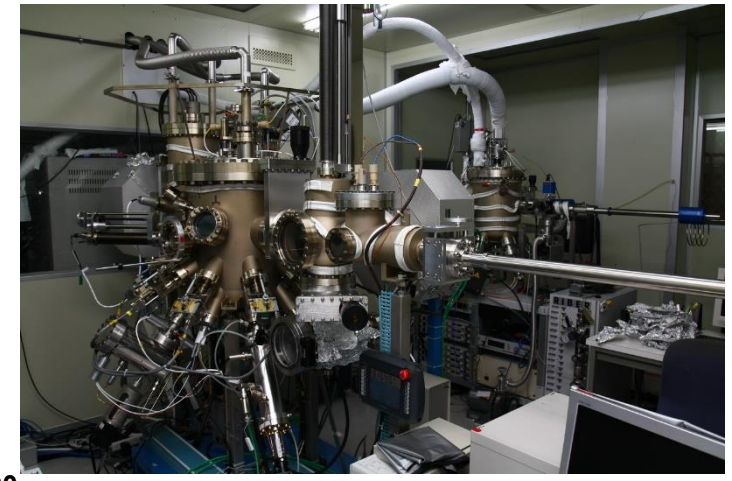
中央大學電機系固態組

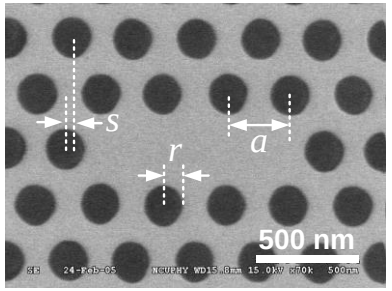
綦振瀛

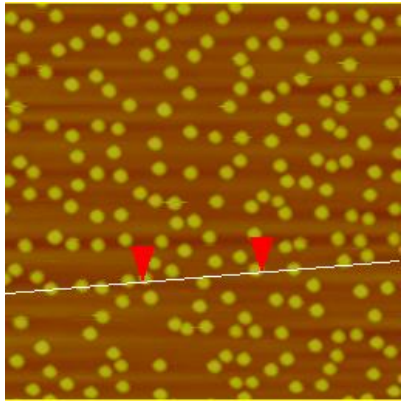
III-V族化合物半導體材料與元件

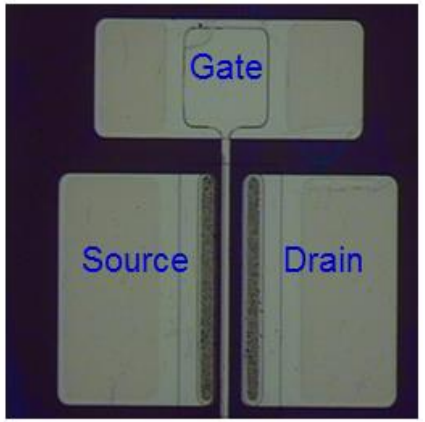
- 氮化鎵功率元件
- 氮化鎵毫米波功率電晶體
- 氮化鎵紫外光發光二極體
- 砷化銦鎵鰭式場效電晶體
- 砷銻化銦鎵高速雙極性電晶體
- 量子點光電元件







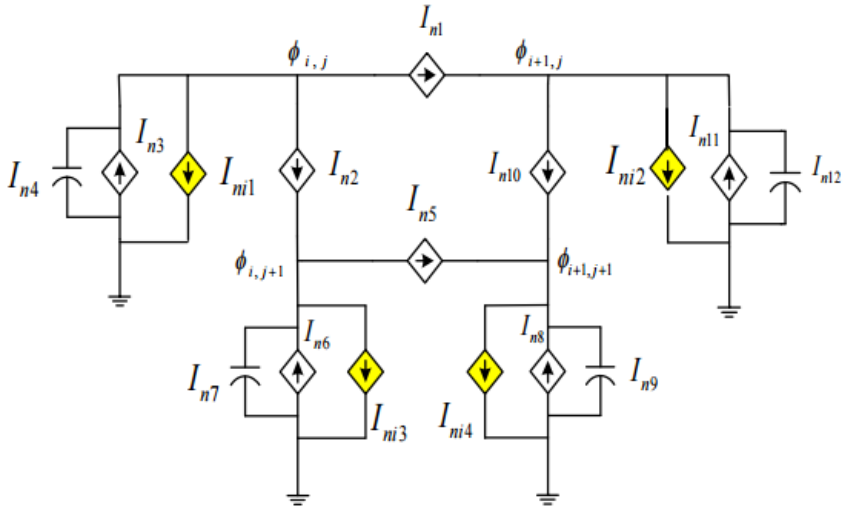


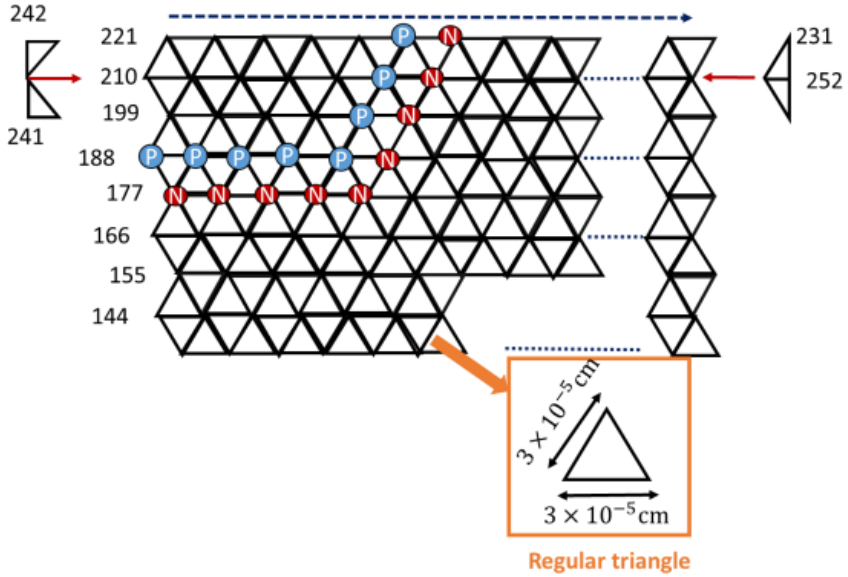


中央大學電機系固態組

研究領域–蔡曜聰

- 半研究領域–導體元件
- 元件模擬
- 電路模擬
- 高速計算





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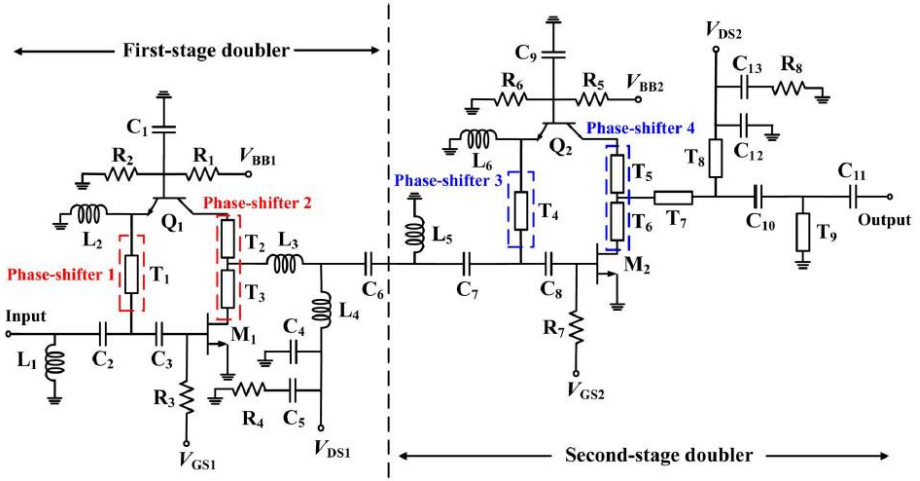
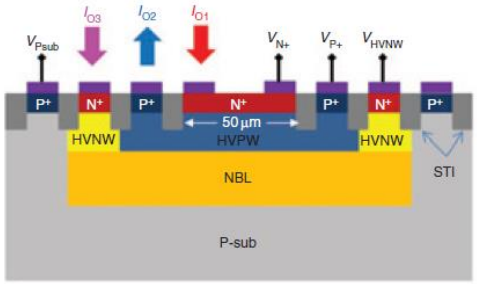
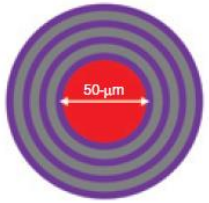
中央大學電機系固態組

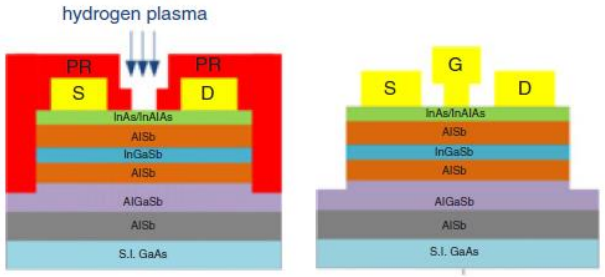
研究領域和特色-辛裕明

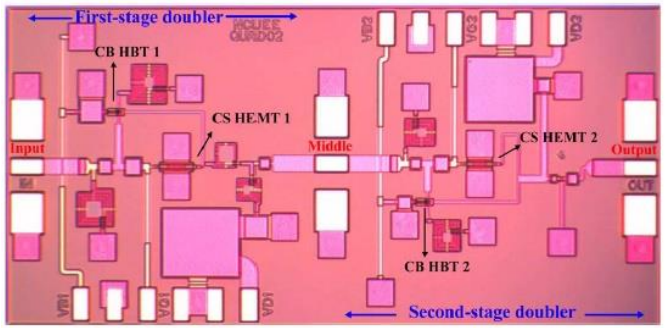
- 高速電晶體和電路應用
- 高功率高壓電晶體和電路應用
- 光通訊接收器

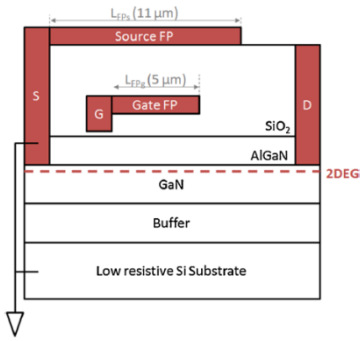


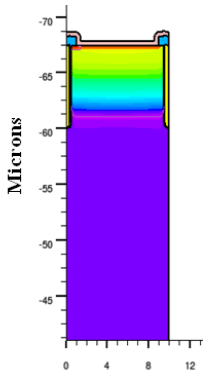


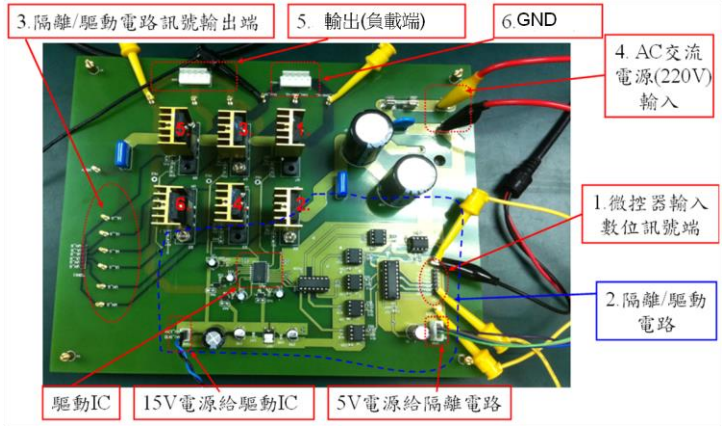












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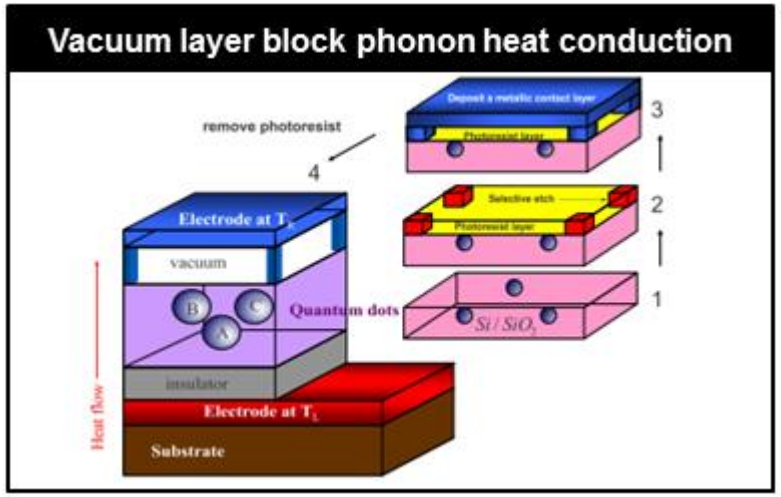
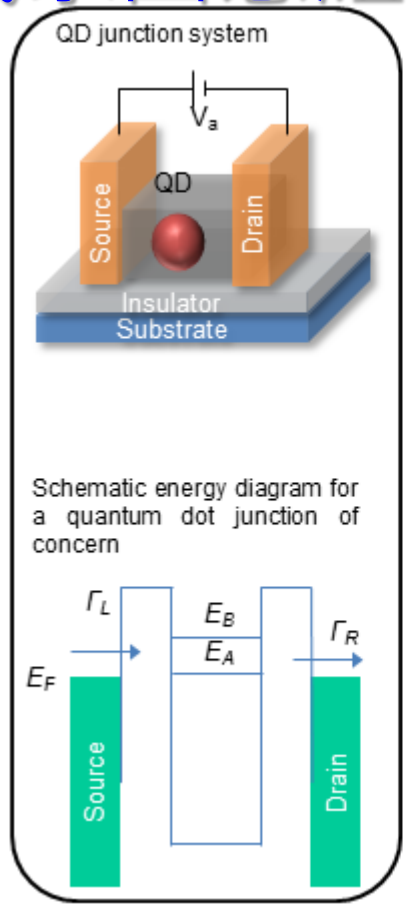
中央大學電機系固態組

研究領域-郭明庭

- 奈米元件
- 量子資訊





We obtain the following close-form solution

$$G^r_{\ell,\ell} = \prod_{i=1}^{M-1}(\hat{a}_{j_i} + \hat{b}_{j_i} + c_{j_i})G^r_{2M} \Big/ \prod_{j\neq\ell} c_j$$

$$\equiv N_\ell \sum_{m=1}^{3^{M-1}} \frac{p_m}{\mu_\ell - U_\ell - \Pi_m},$$

$$G^r_\ell = (\hat{q}_\ell + 1)G^r_{\ell,\ell}$$

$$= N_\ell \sum_{m=1}^{3^{M-1}} \left[\frac{q_\ell p_m}{\mu_\ell - \Pi_m} + \frac{p_m}{\mu_\ell - U_\ell - \Pi_m} \right],$$

Tunneling current of QD junction

$$J = \frac{-2e}{\hbar} \sum_\ell \int \frac{d\epsilon}{2\pi} \frac{(f_L - f_R)\Gamma_{\ell,L}(\epsilon)\Gamma_{\ell,R}(\epsilon)}{\Gamma_{\ell,L} + \Gamma_{\ell,R}} \mathrm{Im}G^r_\ell,$$

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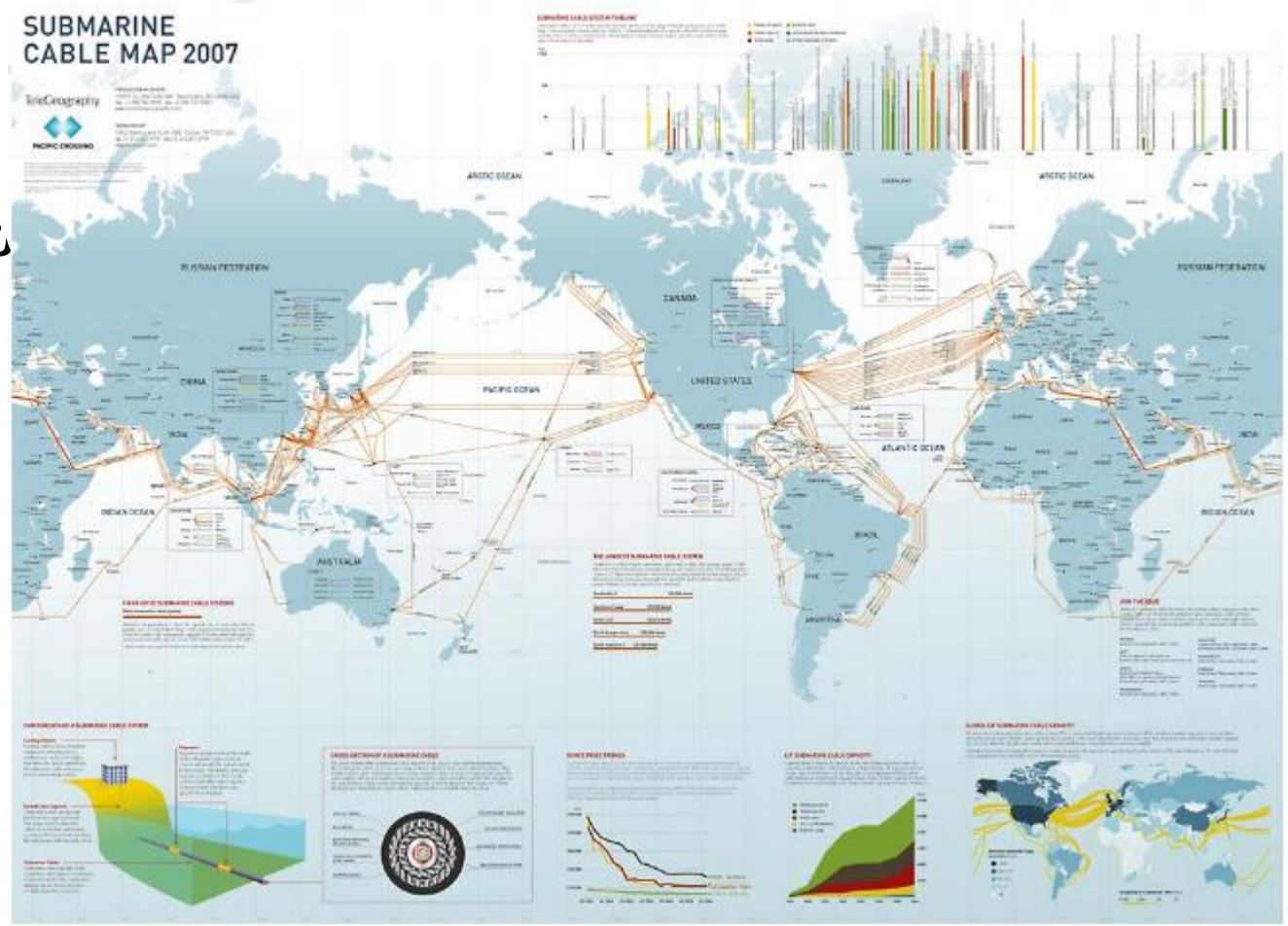
中央大學電機系固態組

研究領域-許晉瑋

- 超高速光通信元件與量測系統
- 高速矽鍺光電元件
- 兆赫波光電發射器和應用

◦ 跨洋海底光纖通訊



◦ 毫米波兆赫波 - 光纖無線通訊

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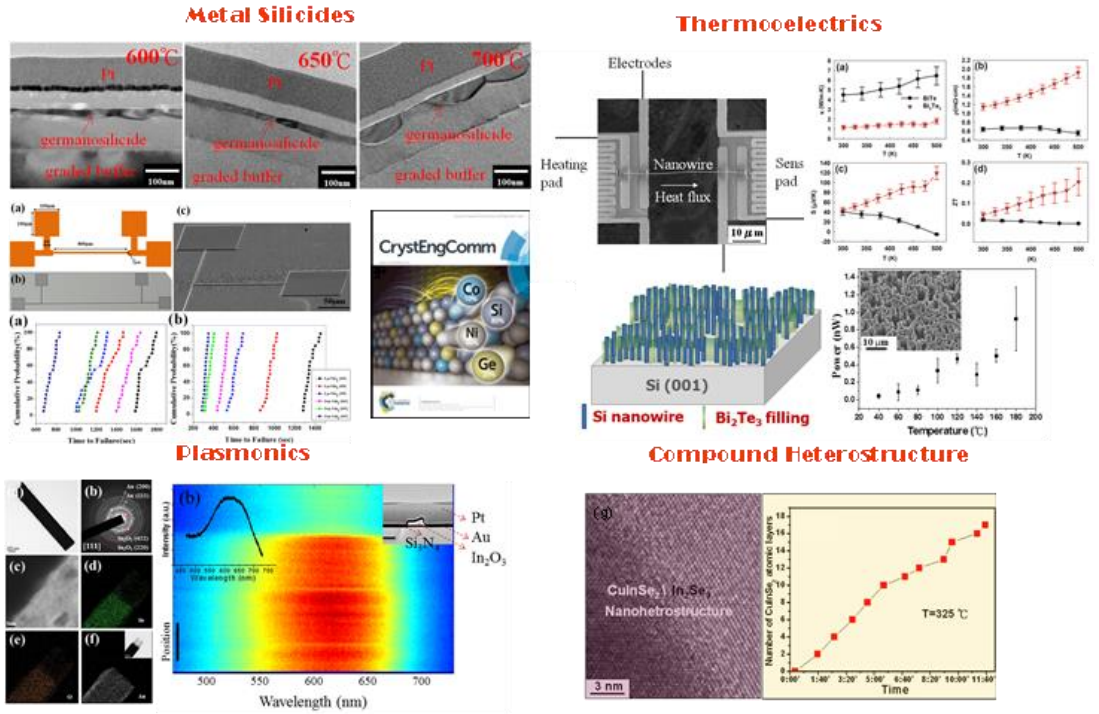
中央大學電機系固態組

發展特色-辛正倫

- 半導體材料及元件結構設計
  金屬矽化物、銅製程及可靠度、鍺磊晶成長、光偵測器及特性量測。
- 熱轉換傳輸及元件致冷研究
  熱電材料合成、元件製作、優值係數量測、熱偵測器。
- 表面電漿子
  奈米材料表面電漿共振現象觀察
- 臨場觀測穿透式電子顯微術
  觀察熱/電影響下之結構變化動力學



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中央大學電機系固態組
發展特色-胡璧合

矽及三五族材料前瞻奈米元件 Silicon and IIIV-based Nanoelectronics

- Emerging devices including Si/Ge/IIIV-OI MOSFETs, Tri-Gate FET, and FinFET etc.
- Steep Subthreshold Slope Devices including Tunneling FET, and Negative Capacitance FET etc.

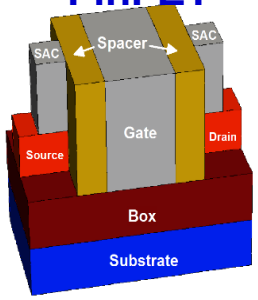
靜態隨機存取記憶體設計 SRAM Design with Emerging/Post CMOS Devices

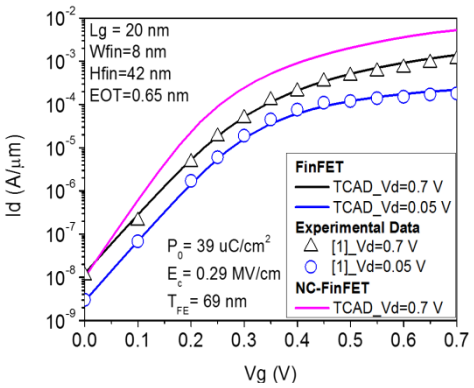
- High-Performance and Ultra-Low-Power SRAM Design
- Variability and Reliability Tolerant SRAM Design
- Monolithic 3D SRAM Design

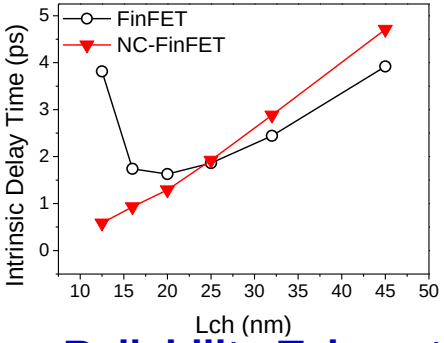
先進奈米元件與電路最佳化設計 Circuit and Device Interaction

- Impact of Future Device Structures on Circuit Design
- Technology-Design Co-optimization

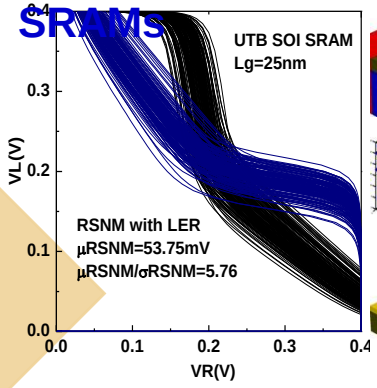
Intrinsic Delay Analysis of Negative Capacitive FinFET

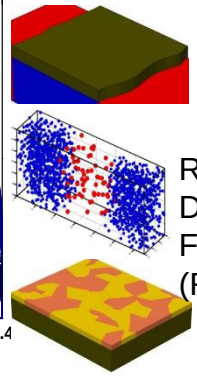






Variability Analysis of UTB SOI SRAMs



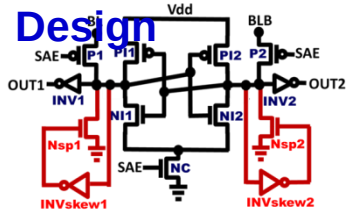


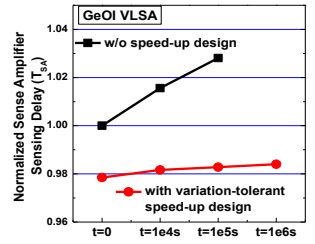
Line-edge roughness (LER)

Random Dopant Fluctuation (RDF)

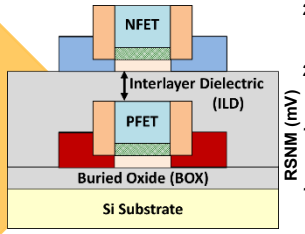
Work Function Variation (WFV)

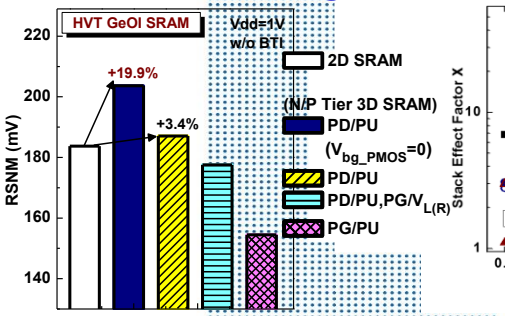
Reliability-Tolerant Sense Amplifier Design



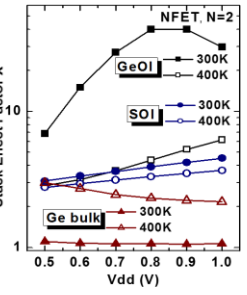


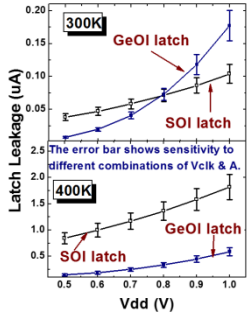
Monolithic 3D SRAM Design





GeOI Logic Circuit

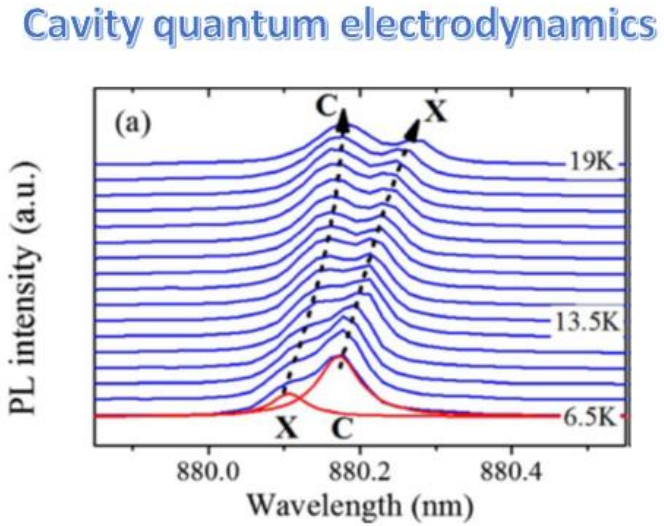


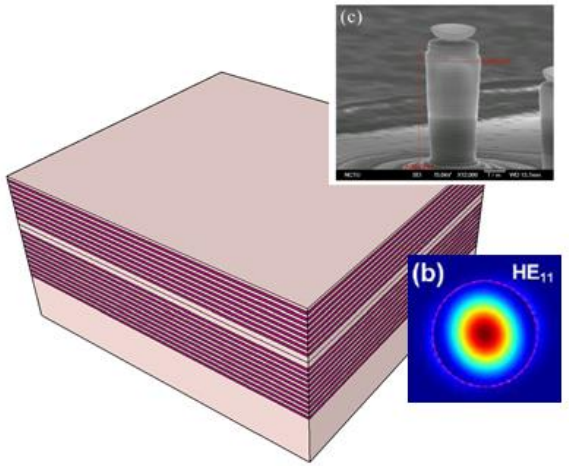


中央大學電機系固態組

發展特色-李依珊

- 分子束磊晶成長技術：三五族半導體量子點、半導體量子井、光電元件
- 單光子偵測器：元件結構與電路設計
- 單光子源：量子點柱狀共振腔結構分析
- 共振腔量子電動力學





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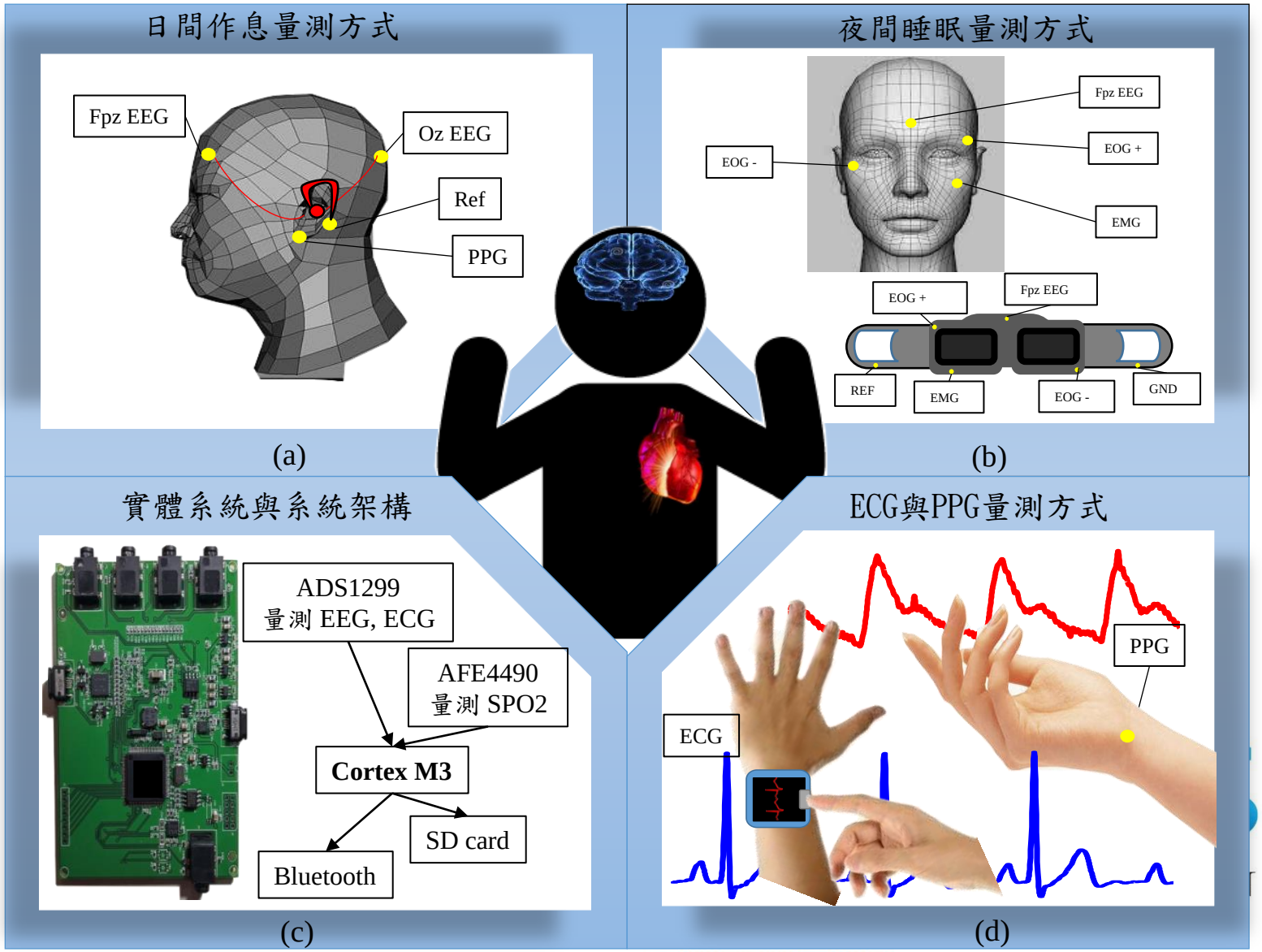
中央大學電機系系統與生醫組

徐國鎧、李柏磊教授-穿戴式生理感測系統 (Wearable Bio-sensing system)

1. 穿戴式生理量測裝置（生物特徵vital sign：非加壓式血壓量測、反射式血氧量測SPO2、睡眠腦波、穿戴式心電圖ECG Holter、動能感知 On-body activity、超寬頻生理監控雷達系統)
2. 生物指標開發（精神壓力指數、睡眠品質、呼吸中止症、血管硬化指數、心率異常、自主神經異常、高血壓風險、認知障礙）
3. 智慧生活照護感測網路、綠能電子



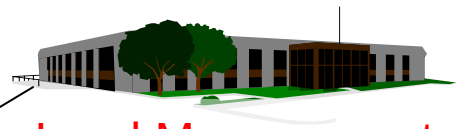
中央大學電機系系統與生醫組

林法正、陳正一教授-智慧電網與能源資通訊技術

- **電能轉換與控制**
  - 可程式化電力品質訊號產生器
  - 分散式電源轉換系統
  - 動態電壓調整器
  - 主動式電力濾波器
  - 靜態型無效電力補償器
  - 智慧電網/微電網
  - 電力電子應用
- **電力電子訊號技術**
  - 能源資通訊
  - 系統監控與診斷
  - 主動保護應用
- **量測儀表系統開發**
  - 電力分析儀
  - 閃爍分析儀
  - 電壓變動事件檢測器
  - 整合型監控系統
  - 智慧電表

Substation

Distribution System



Load Management

Distributed Generation

Smart PQ Analyzer and Controller

- Development of smart real-time PQ analyzer and controller
- Identification and tracking of power quality disturbances and faults in the modern power systems
- Control of voltage in transmission system and enhancement of power quality

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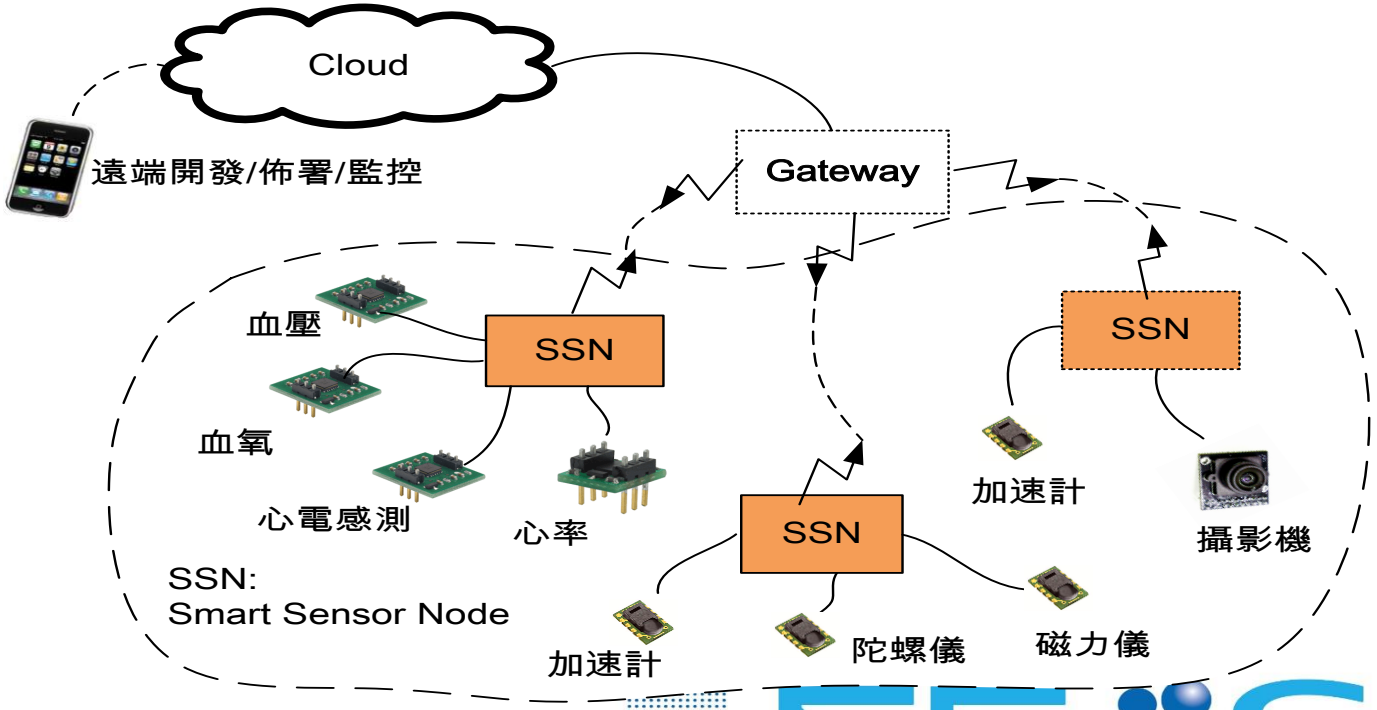
- Smart Sensor Node (SSN)
  - 智能影像擷取、處理與壓縮
  - 可適性生理訊號擷取
  - 感測壓縮與頻譜感知技術
- SSN節能無線感測網路
  - 感測器工作模式調節
  - 智慧電源時脈管理
  - 無線供電



Green Sensor Network (GSN)

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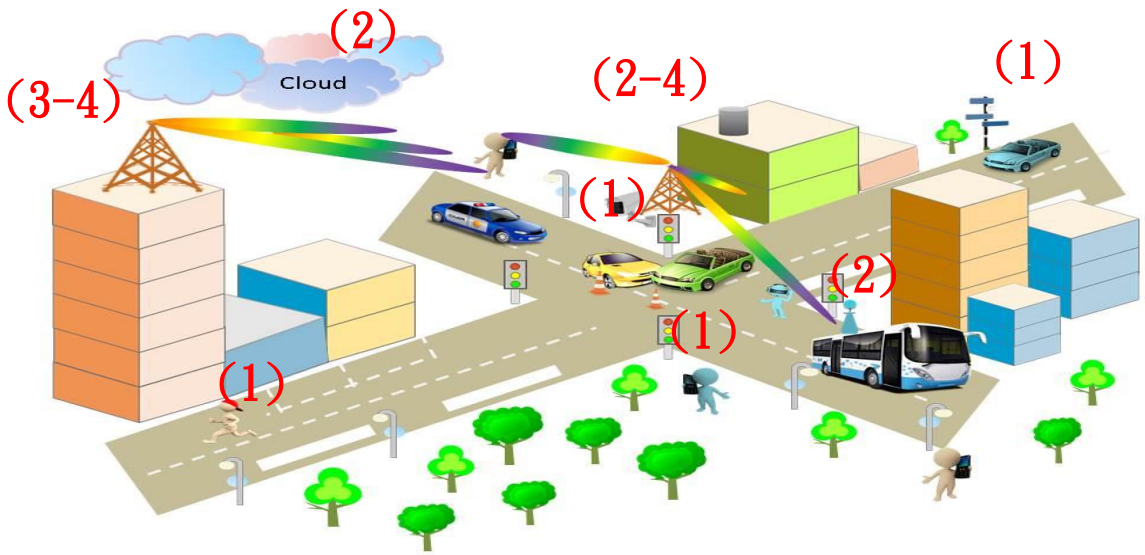
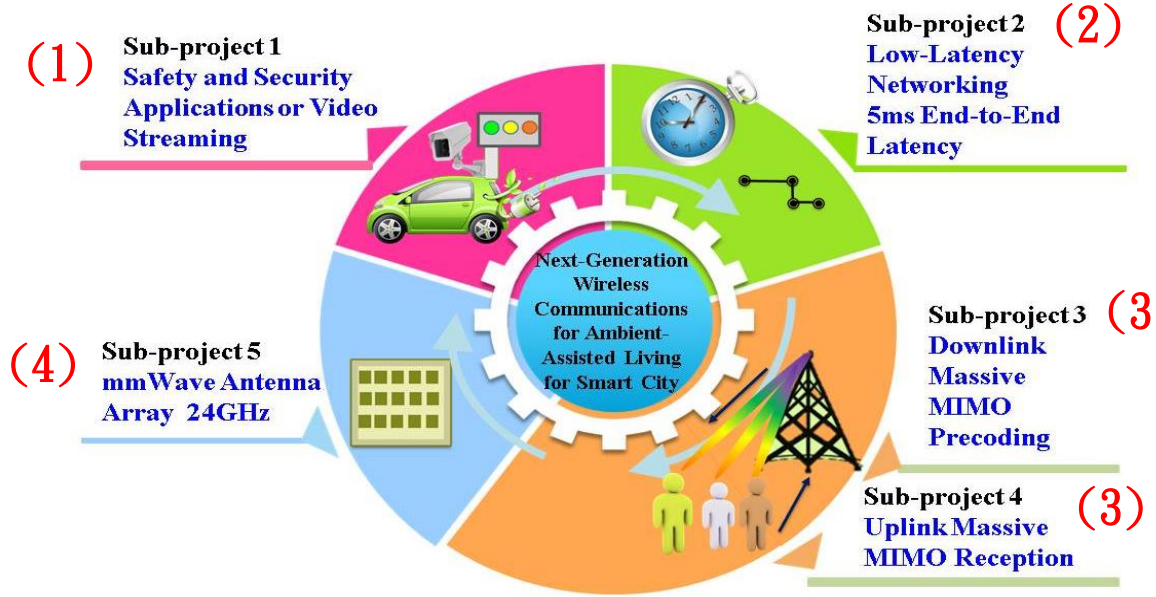
中央大學電機系電子組
蔡佩芸、傅家相、黃琴雅教授-Smart City

Next-Generation Mobile Communications for Ambient-Assisted Living in Smart City

- 應用於智慧城市的物聯網、雲端資料傳輸系統之技術開發，使物聯網各種感測資訊能低延遲、高速之傳送到雲端做即時互動之應用，如環境安全監控、交通運輸管制等
  - 主要相關關鍵技術開發:
    - (1) 城市環境感測、即時高畫質影像互動技術
    - (2) 低延遲之高速無線網路傳輸技術開發
    - (3) 高頻寬、巨量天線之關鍵技術開發
    - (4) 巨量天線陣列傳輸技術開發





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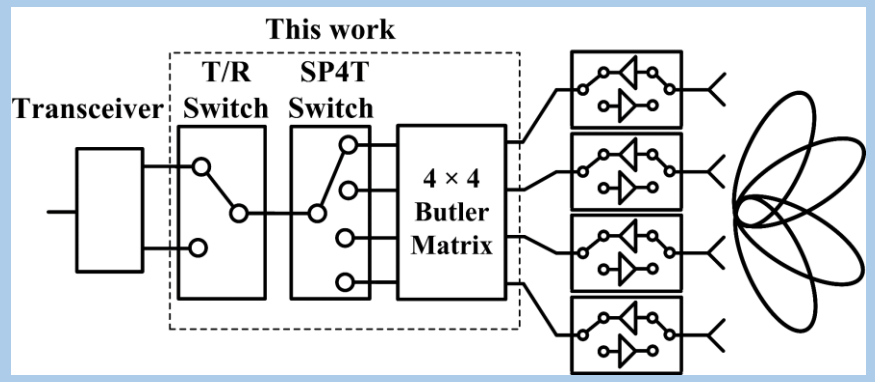
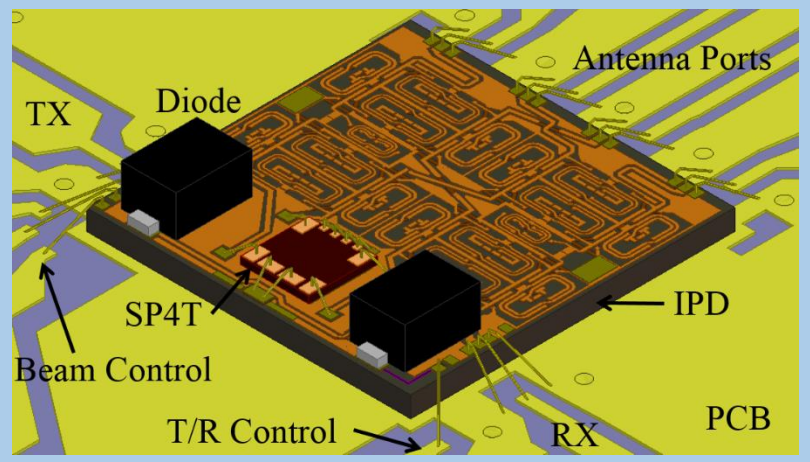
中央大學電機系電波組

林祐生教授 - 射頻智慧型天線系統設計技術

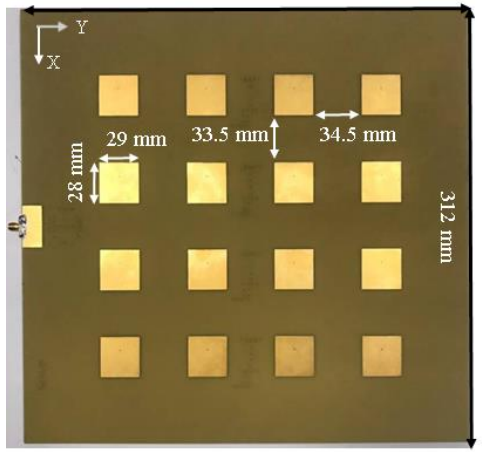
2.4-GHz微型化切換式波束成型模組

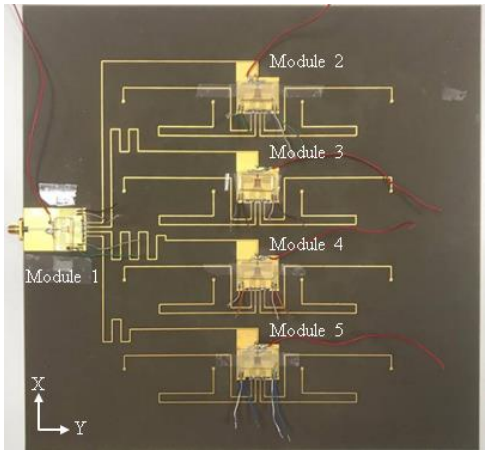


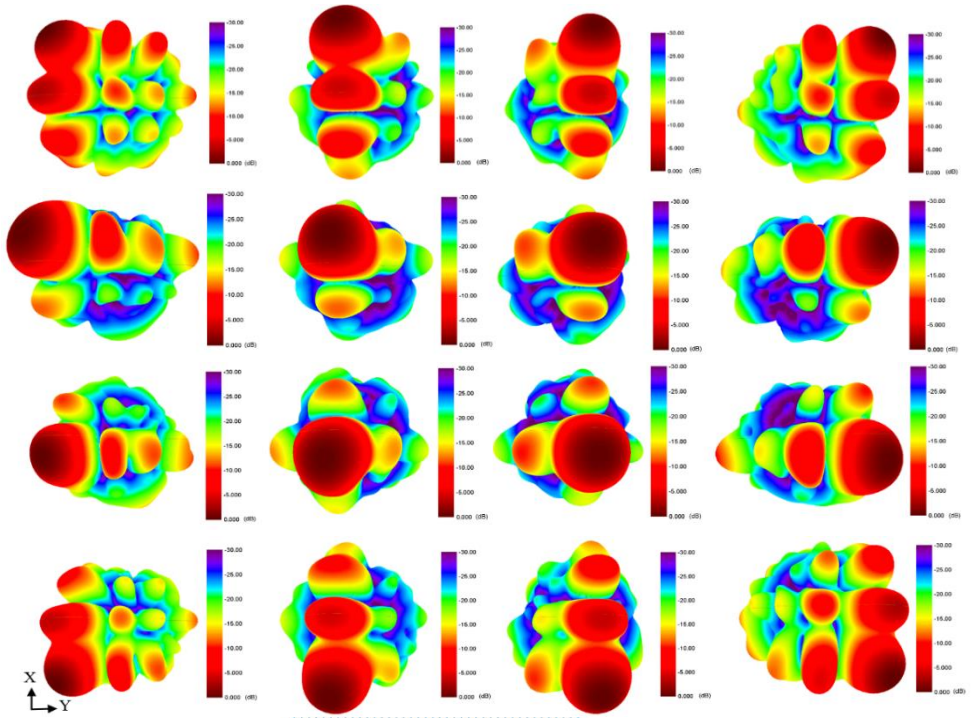


模組體積：5.0 mm×4.9 mm×0.9 mm

薄型化2.4-GHz二維波束掃描陣列天線







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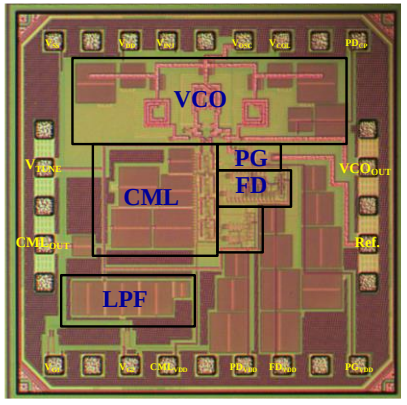
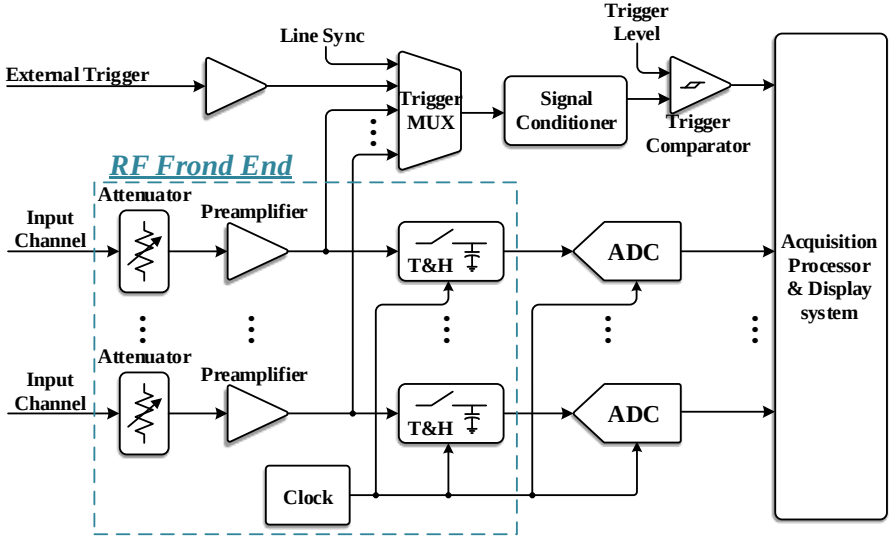
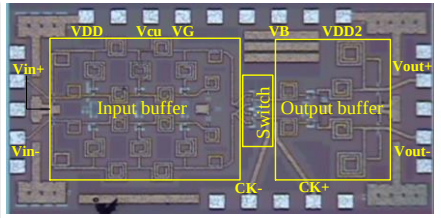
中央大學電機系電波組

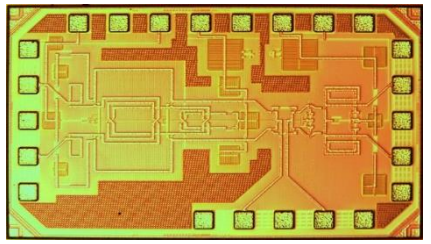
張鴻埜教授-毫米波感測系統

- 應用於小型無人飛行載具，輔助空拍照相錄影、遙測、環境監測及攜帶小型貨物等用途。
- 感測系統分析平台建立、毫米波積體電路設計和模組構裝技術開發。
- 使用先進製程研製，具高速、體積小、低耗電及高性能優勢，提升國內毫米波、電子量測儀器技術能量及開發能力。









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106年電機系所發展特色領域與亮點(至多4點即可)

- 電子組研究領域：智慧電子系統設計、前瞻通訊與網路電路與系統設計、單晶片系統（SoC）設計與電腦輔助設計、混合信號或高速積體電路設計、生醫電子電路與系統設計、積體電路系統測試與設計自動化、物聯網、鄰近資料處理（near-data processing）設計。
  - 應用於智慧電子系統之高速及低功率電路設計技術
  - 應用於前瞻通訊系統之high-throughput電路設計技術
  - 有效降低前瞻單晶片晶片及堆疊式晶片系統設計與測試成本之設計自動化與可測性設計技術
  - 前瞻智慧電子系統關鍵類比及混合訊號電路設計技術
- 固態組研究領域：奈米結構物理及量子資訊、半導體材料及前瞻奈米元件、超高速光電元件、高電壓高功率電晶體。
  - 呈現世界紀錄的高速光檢測二極體和雪射二極體，應用在雲端大資料光通訊。
  - 氮化鎵發光二極體和毫米波功率電晶體開發，適用綠能光電產業。
  - 矽及三五族材料前瞻奈米元件研究，突破傳統邏輯矽材電子元件，減少功率耗損。
- 系統與生醫組研究領域：智慧型控制理論與應用研究、機器人、機電系統設計及應用、生醫工程及高科技輔具、語音處理與辨識、電力電子與電動機控制應用、智慧電網、穿戴式裝置。
  - 智慧型電能轉換及監控技術，得以全自動穩定智慧電網/微電網供電系統品質與提升能源效率。
  - 穿戴式生理非加壓式血壓量測、反射血氧手環、創新生命特徵量測技術，獲宏達電（HTC)技術轉移。
- 電波組研究領域：
  - 以CMOS與IPD製程實現微波被動元件如巴倫(Balun)、傳輸線變壓器(TLT)，實測特性超越世界級大廠Murata，極具商業化價值；並以IPD+CMOS製程進行異質整合，實現高效能之射頻系統級封裝設計，有效降低成本與電路面積。
  - 開發低成本、微小化之兆赫茲影像系統，可應用於機場安全、食品安全及生物醫學影像檢測。
  - 開發一引入鐵性材料薄膜的積體被動元件(IPD)製程，並應用於可調式射頻／微波電路及天線設計。
  - 開發射頻乃至毫米波頻段之多頻與可重組式(Reconfigurable)天線，以及射頻波束掃描陣列天線系統。

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系所推薦榮譽事項

- 陳正一助理教授榮獲科技部103年度吳大猷先生紀念獎
- 李進福教授榮獲IEEE VLSI Test Symposium 2013---Best Special Session Award
- 徐國鎧教授榮獲中華民國自動控制學會會士
- 辛正倫教授於台灣電子材料與元件協會榮獲傑出青年獎
- 李進福教授榮獲104年度中國電機工程師學會「傑出電機工程教授獎」
- 鍾鴻源榮獲IETI Distinguished Fellow。
- 為促進海峽兩岸資訊及電機技術，特別是電腦網路及其應用方面的學術交流，中央大學盛邀兩岸的專家學者於2015年6月3日~6日參加在桃園市中壢區舉辦的第十七屆海峽兩岸資訊技術（CSIT2015）研討會，主題是「雲端電腦，大數據，與電子科技生活應用」。
- 郭明庭教授榮獲Joseph Wang Award 2015。
- 綦振瀛教授榮獲財團法人潘文淵文教基金會 2015 年研究傑出獎
- 林法正教授榮獲105年度中國工程師學會傑出工程教授獎
- 陳正一教授榮獲2016年度潘文淵文教基金會考察研究獎
- IEEE 中央大學學生分會榮獲 2015 IEEE台北分會績優學生分會獎

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