

LED未來應用與照明之發展趨勢

Presented by Carson Hsieh

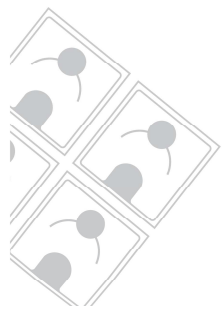
2021/12/16

Outline

- 回顧來時路-Since 1996
- 創意是想像力之果
- LED未來的發展方向
- 結語

EPISTAR

Actualize LED Potential

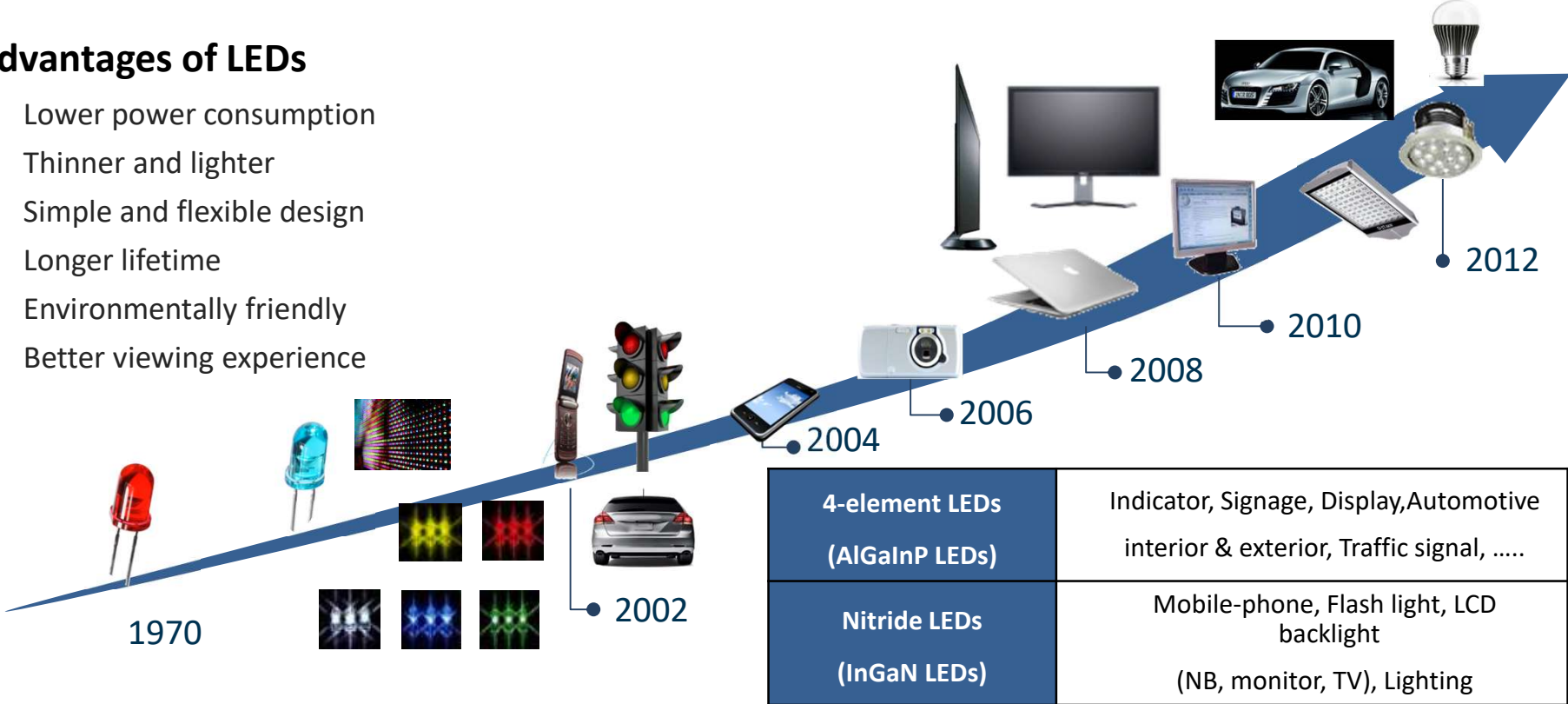


- Co-activation Service Model
- Full Spectrum LED Chips Portfolio
- Chip Solution for Various Applications

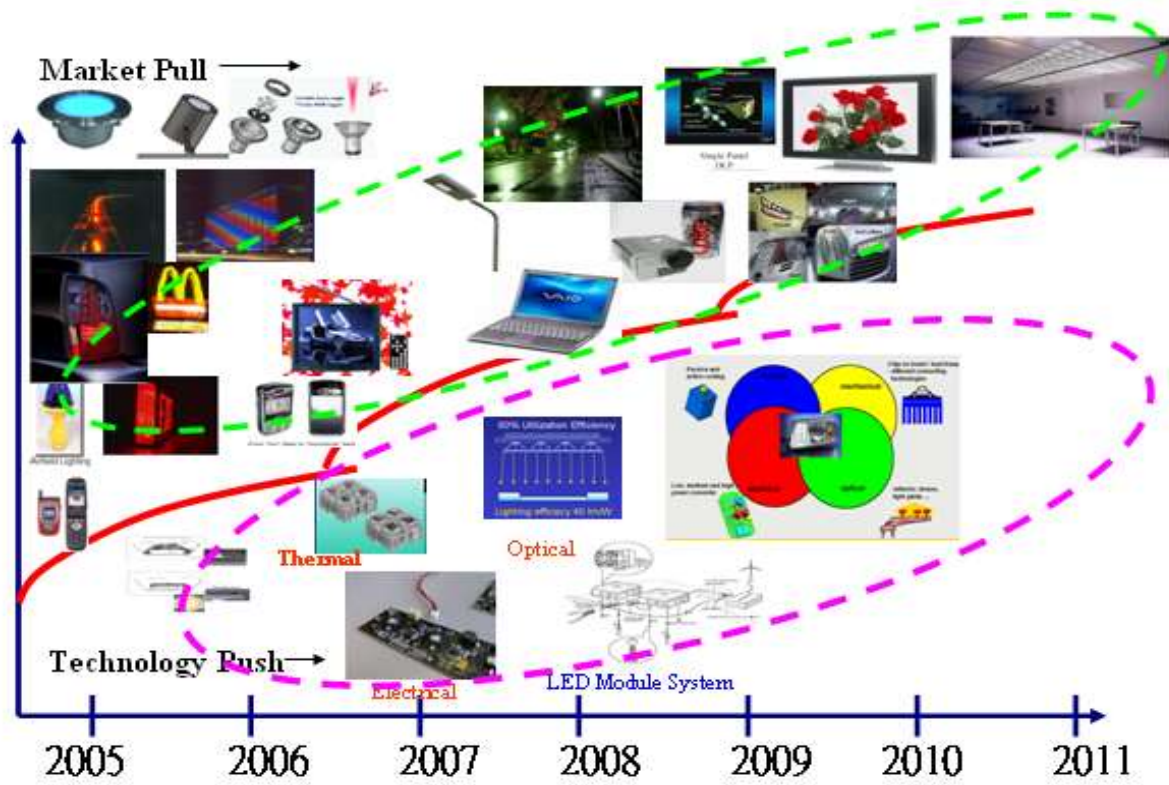
Lighting Your Life Through Diode Emitting

Advantages of LEDs

- Lower power consumption
- Thinner and lighter
- Simple and flexible design
- Longer lifetime
- Environmentally friendly
- Better viewing experience



照明-LED未來的想像 @ 2007



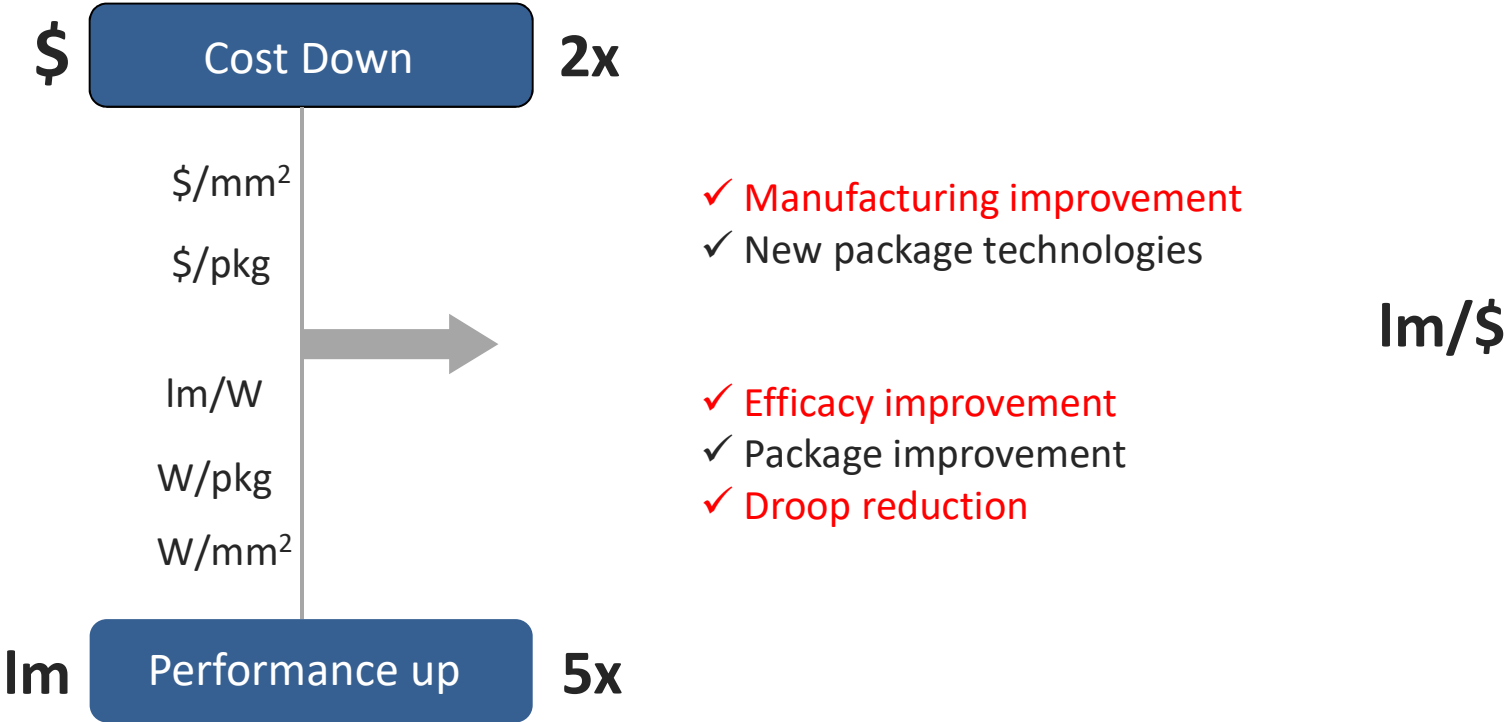
LED Efficacy (lm/W) and Price (\$/klm) Roadmap

Next: ~200 lm/W; 500 lm/\$ vs. ~150 lm/W; 1,000 lm/\$ @2015 ??

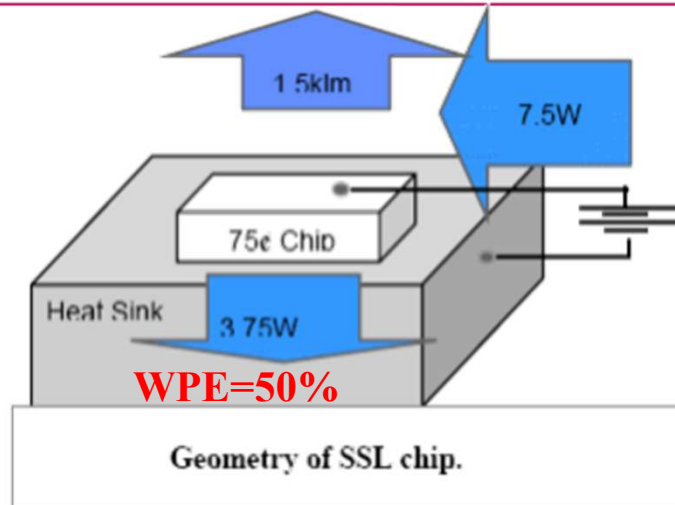
Same performance for cool white and warm white @2020 ??

Metric	Unit	2010	2012	2015	2020
LED Efficacy (warm white)	lm/W	96	141	202	253
LED Price (warm white)	\$/klm	18	7.5	2.2	1
LED Efficacy (cool white)	lm/W	134	176	224	258
LED Price (cool white)	\$/klm	13	6	2	1
OEM Lamp Price	\$/klm	50	23	10	5

How to Achieve 10x Im/\$ Improvement... ..



LED照明應用、散熱不是問題



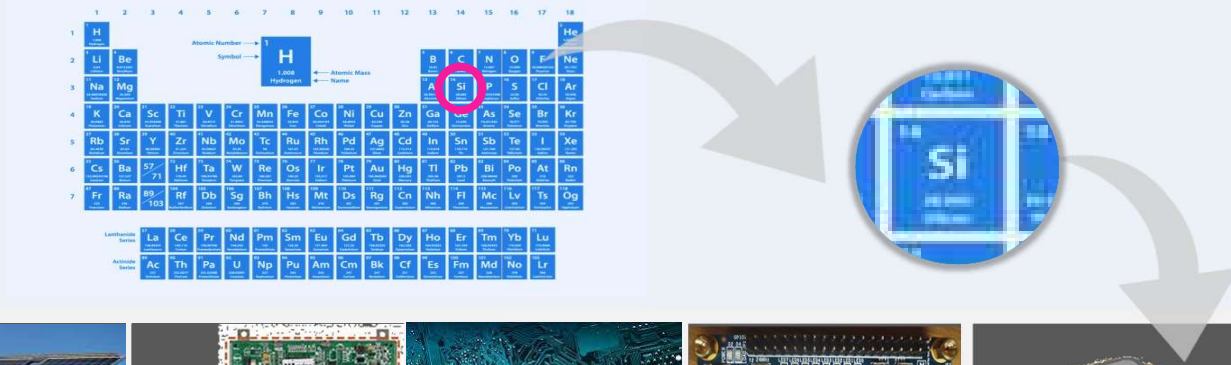
IEEE Circuits & Devices Vol 20 No 3 pp 28-37 May/June 2004

Page 1 of 12

50 lm/W	100 lm/W	150lm/W	200 lm/W
WPE~25%	WPE ~50%	WPE~75%	WPE ~100%
Blue	Blue	Blue	Blue

回歸問題本質: 重要的是提昇LED效率, 減少發熱

Application Field for Silicon Materials



Photovoltaic
Solar Module
.....

Display
Thin-Film
Transistor
.....

**Integrated
Microcircuits**
Motherboard
.....

**Transistor
Diodes**
Memory
Digital Circuit
.....

Processors
CPU
.....

Application Field for III-V Materials



LED
 Illumination
 Signals
 Automotive
 Mobile Application

Laser Diodes
 Optical Storage
 Industry Medical
 Projector
 3D Sensing

Power
 PFC / Power Supply
 PV Inverter/
 EV / HEV/UPS

RF Front End
 5G PA
 BAW Device

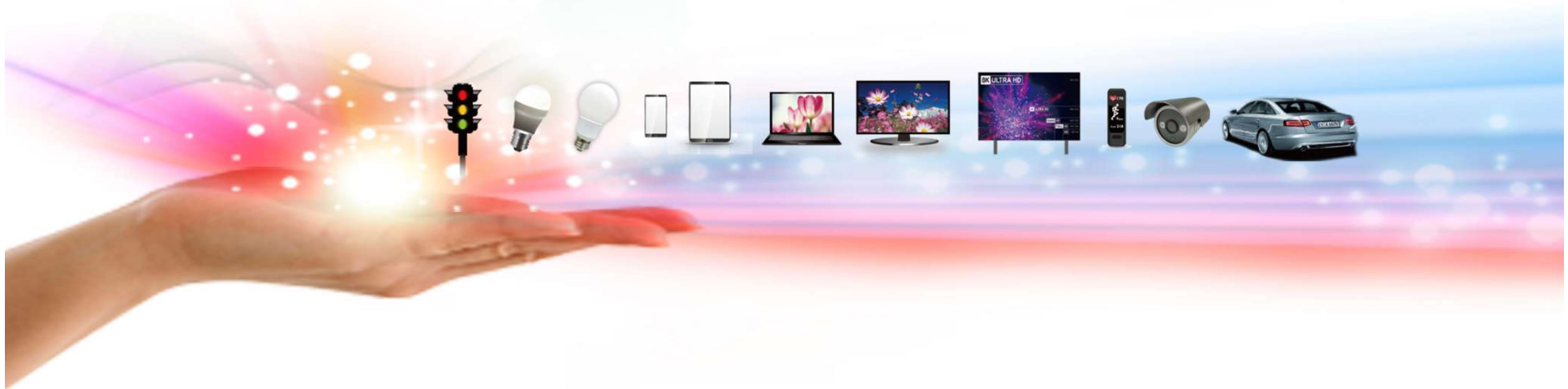
Acoustic Wave
 Mobile Phone

Actualizes LED Potential



Core Technology
Demand pull

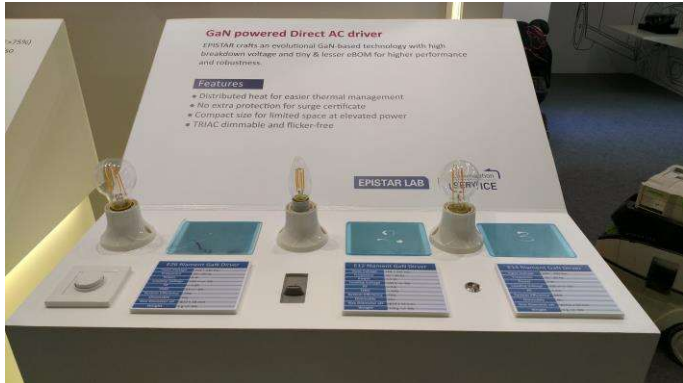
Actualizes III-V semiconductor Potential



Power Device GaN Driver
In
Frankfurt Light and Building (2017)

EPISTAR: Frankfurt Light and Building

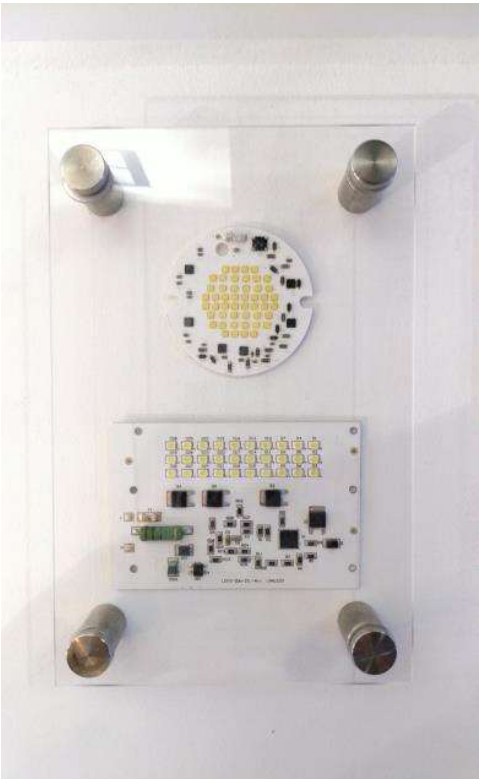
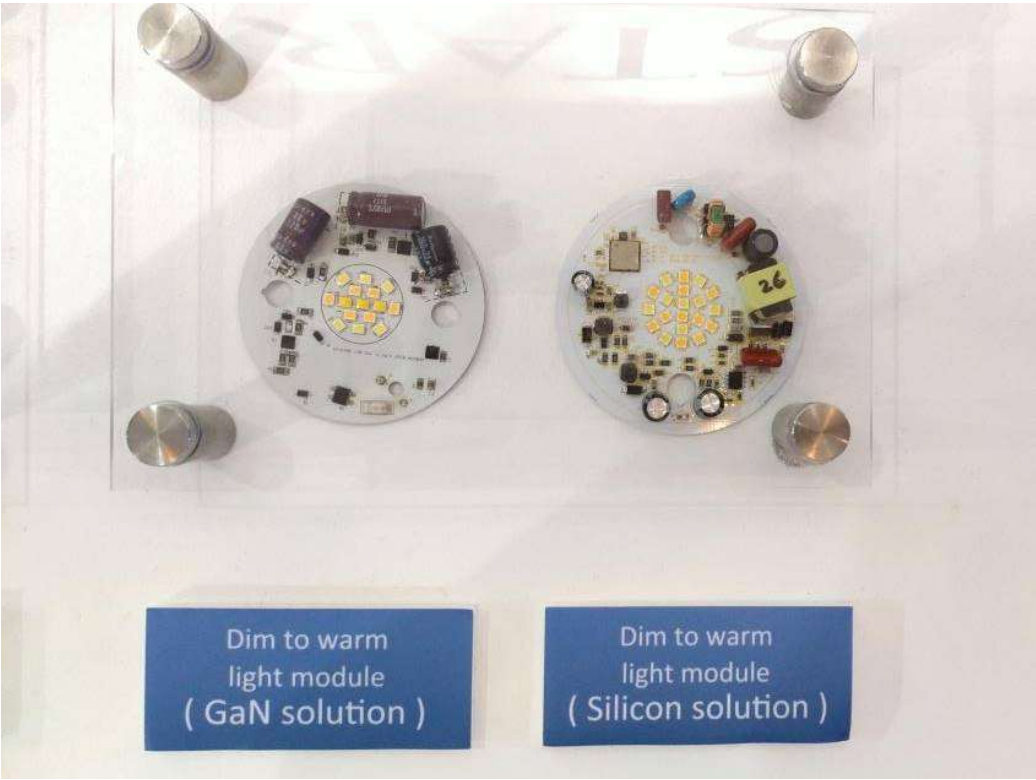
EPISTAR LAB



EPISTAR

EPISTAR: Frankfurt Light and Building

EPISTAR LAB



What is next for EPISTAR? → Ennostar

EPISTAR LAB

Power Electronic/ RF



RF

White/R/G/B LED & Laser Diode



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Core Value: III-V



Sensor



動作感應控制/遙控



Actualizes III-V Semiconductor Potential

EPISTAR

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- LED未來的發展方向
- 結語

- 創意是想像力之果
- 創意複雜後的簡單
- 創意、以直覺導航、以知識續航
- 透過創意，另一個世界是可能的
- 創意兼具頑固與幽默、就能解決問題
- 創意、像新鮮的空氣，一定既要新鮮又要為人所知
- 創意家：要有本事大膽夢想、又能逐夢踏實、才不會淪為走唱江湖的賣藥郎中



Revolution of Display technology

CRT



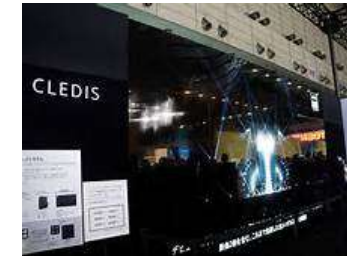
TFT-LCD



AM-OLED



Micro LED



輕、薄、體積小

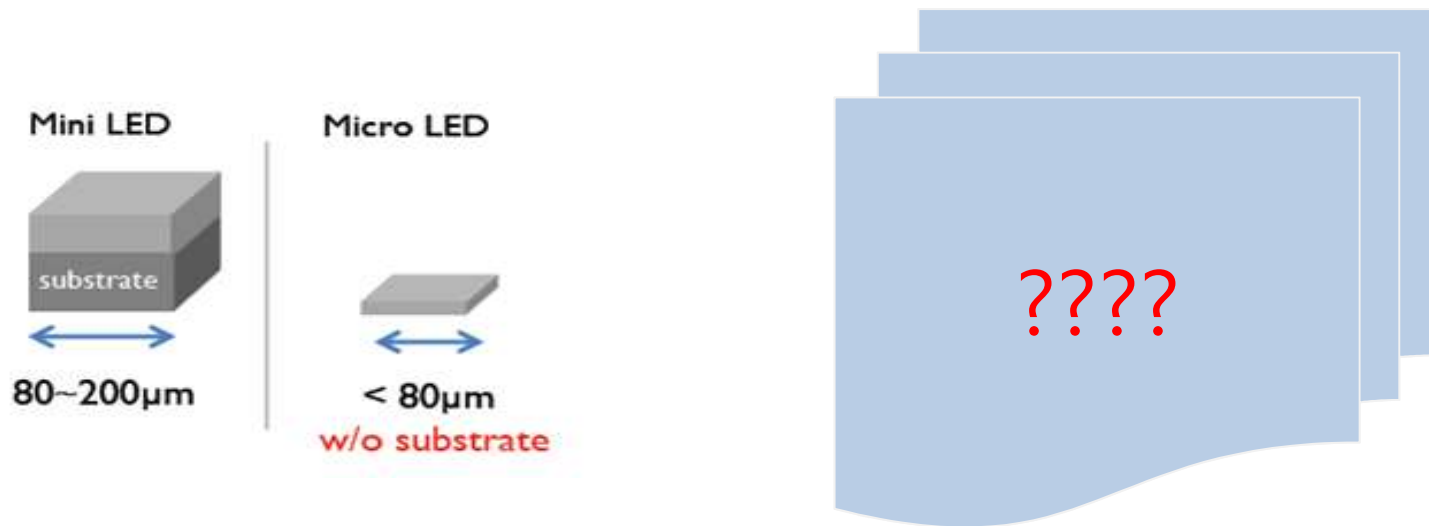
色彩飽和度 DCI-P3, REC2020
CCFL → White LED → +KSF → QD

色彩飽和度、軟性

反應速度、省電

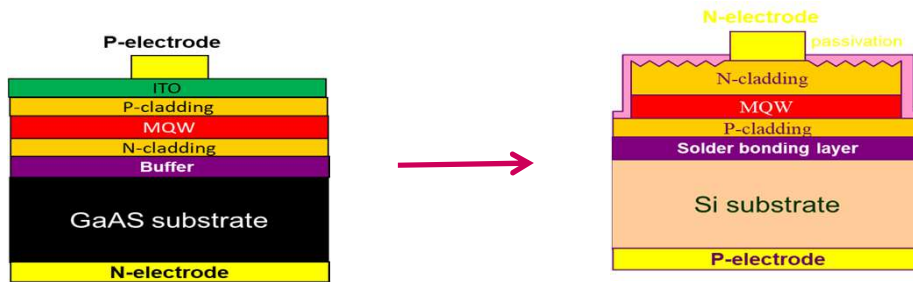
Mini / Micro LED基本的定義

- **Micro LED Definition**



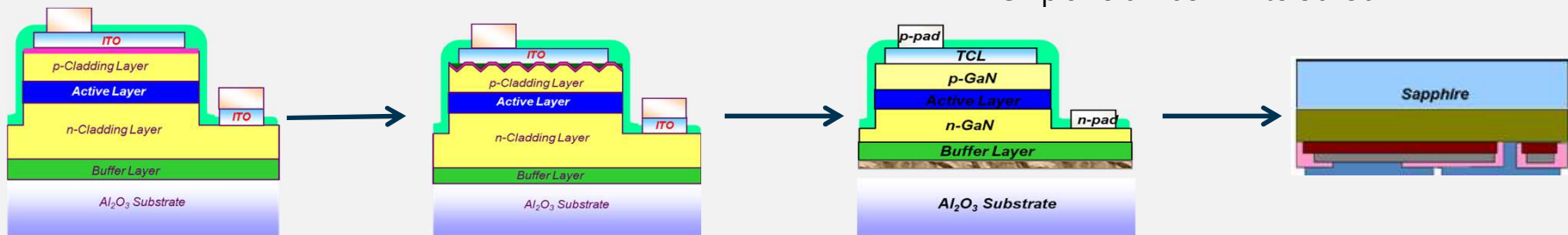
LED 晶粒型態演變

- Vertical :GaAs Conductive Substrate (red ;yellow ...)



- Dicing Saw
- Chip size 4 mil to 50 mil

- Horizontal Sapphire Insulate Substrate(Green; blue; UV...)



- Laser scribe and break
- Chip size 04x08 mil to 50x50 mil

- 1. Epitaxy: lattice constant match <0.1%
- 2. wavelength depend on bandgap energy E_g

$$\lambda = 1240 / E_g \text{ (nm)}$$

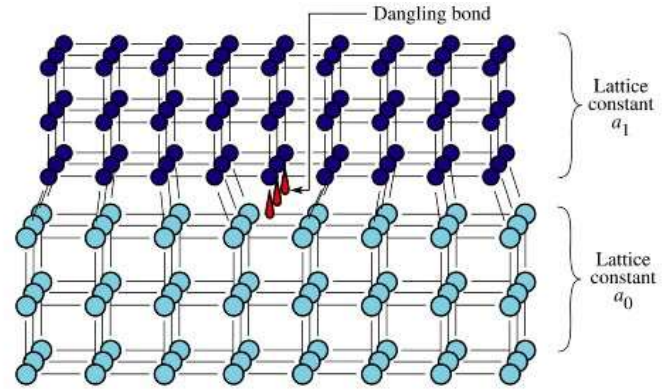


Fig. 5.12. Illustration of two crystals with mismatched lattice constant resulting in dislocations at or near the interface between the two semiconductors.

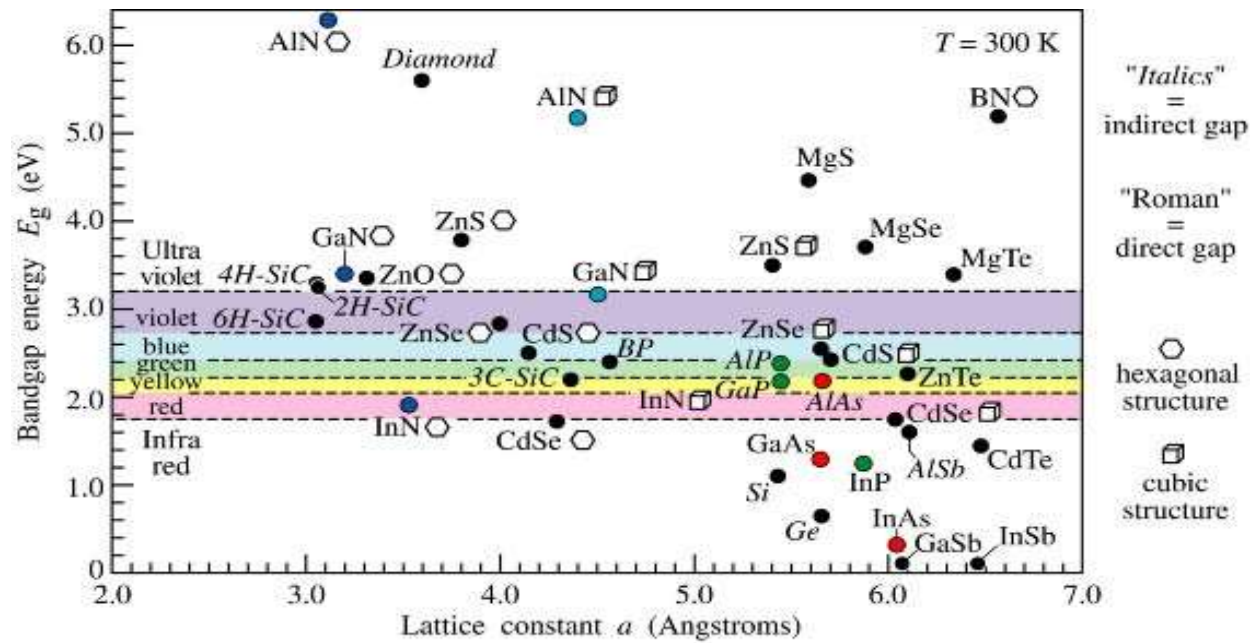
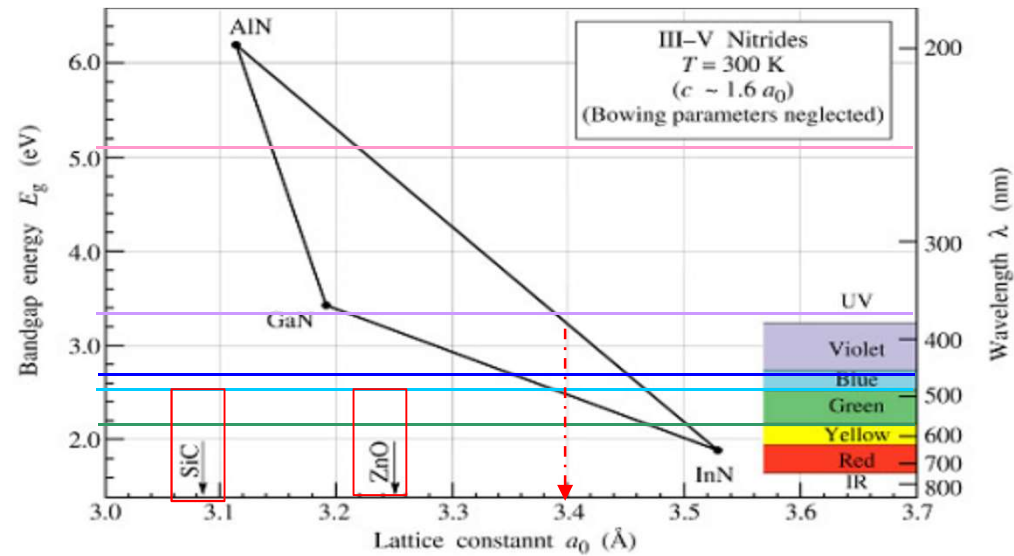


Fig. 11.4. Room-temperature bandgap energy versus lattice constant of common elemental and binary compound semiconductors.

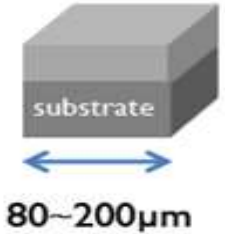
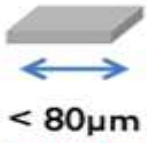


Bandgap energy versus lattice constant of III-V nitride semiconductors at room temperature.

- 沒有基板 meet : Sapphire 透過創意，另一個世界是可能的!
- Sapphire Substrate; but.....

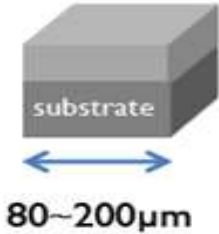
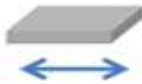
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- Micro LED Definition

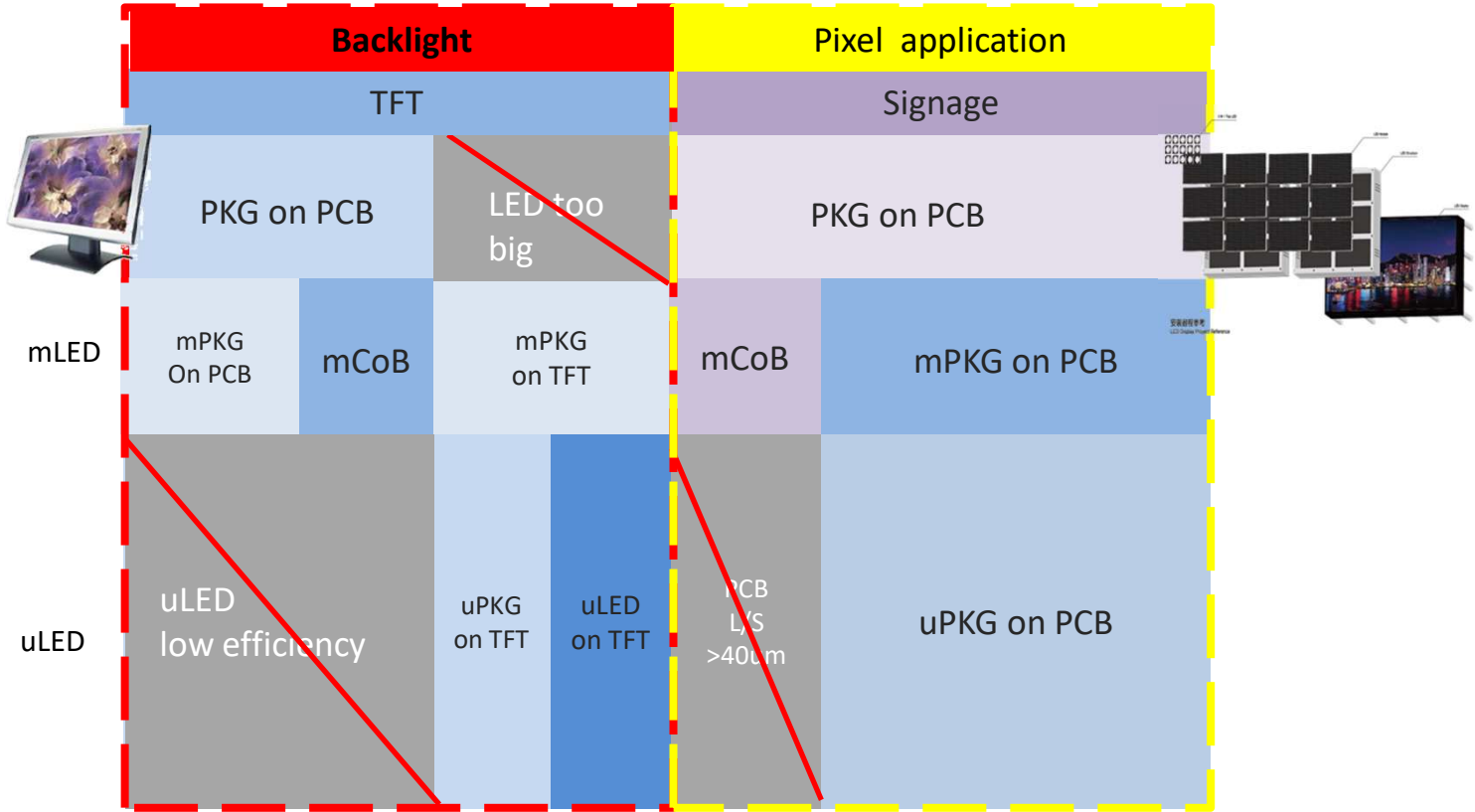
<ul style="list-style-type: none">• Local dimming backlight chip size 1012 to 0509• Signage chip 0509; 0408; 0406; 0305; 0204 ? ..  <p>80~200µm</p>	<p>Micro LED</p> <ul style="list-style-type: none">• Signage ; TV chip 3458; 2454; 2040; 1530; 1020 ..  <p>< 80µm w/o substrate</p>
<p>Mini LED: (mil)</p> <ol style="list-style-type: none">1. Flip chip2. With substrate	<p>Micro LED: (um)</p> <ol style="list-style-type: none">1. Flip chip or Vertical2. Without substrate

Mini / Micro LED基本的定義

- Micro LED Definition

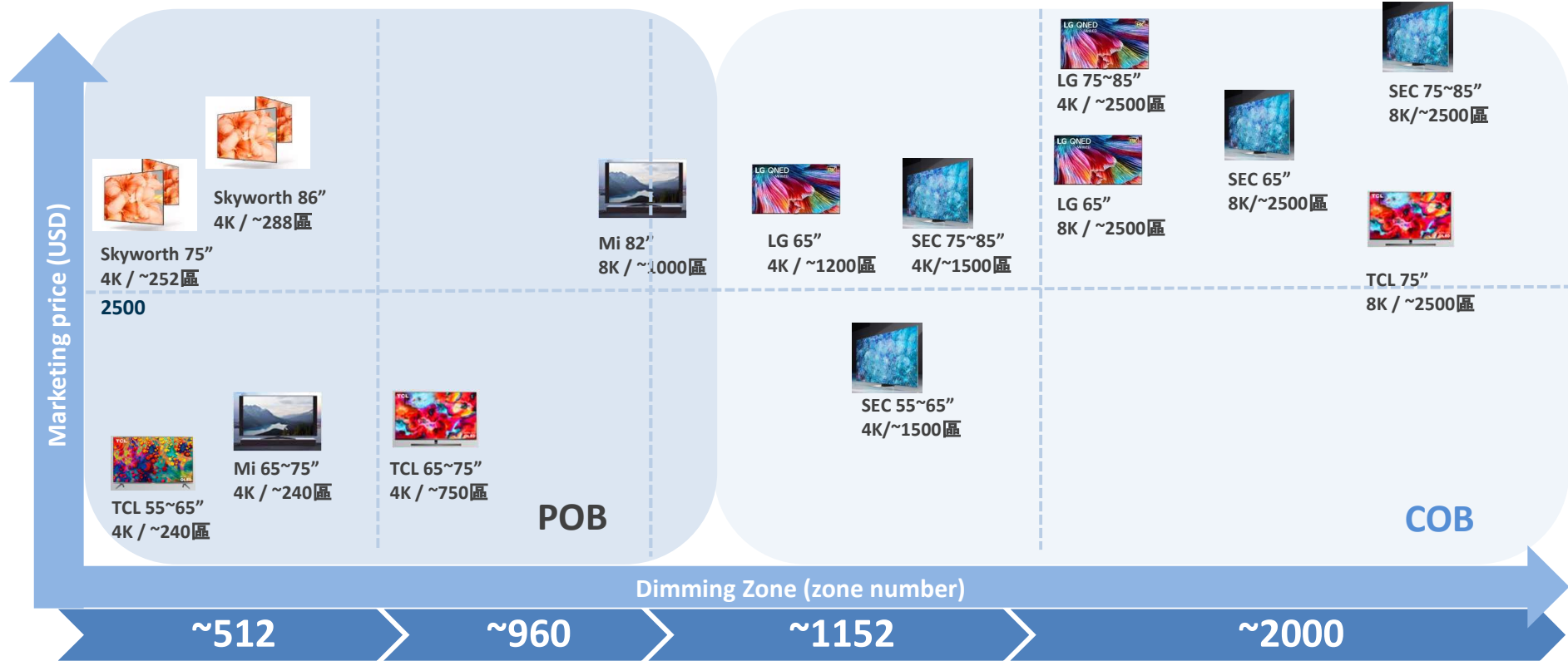
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<p>Mini LED: (mil)</p> <ul style="list-style-type: none">• 基板支撐 Epilayer stress• 可大chip size• Sapphire 基板切割研磨不易(現在只能勉強到 0305)• 傳統打件設備可操作	<p>Micro LED: (um)</p> <ul style="list-style-type: none">• 沒有支撐基板、基本60um以上無法支撐應力而 crack• 只能做小於60um之下的尺寸、但最小尺寸也不可以小於 Epilayer 厚度• 沒有sapphire 不必切割研磨• 傳統打件設備無法操作

LED顯示器應用趨勢




Mini LED TV in the Pricing Trend

EPISTAR LAB



Micro LED的應用

TV/Cinema/PID



Main Application

First Target Market of most customers/competitors
...but may not be profitable

Transparent Auto AR/VR/Wearable



Special Application

- AUTO → The most likely profitable market
- AR/VR/Wearable → next generation

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Definition of Illumination

Illumination -- Cambridge Dictionary

1: the act of supplying with light (**any lights**).

2: an observable property and effect of light, may also refer to Lighting, the **use of light sources**

Definition of illumination – Merriam Webster

1 : the action of illuminating or state of being illuminated:

a : spiritual or intellectual enlightenment

b (1) : a lighting up

(2) : decorative lighting or lighting effects

c : decoration by the art of illuminating

2 : the luminous flux per unit area on an intercepting surface at any given point

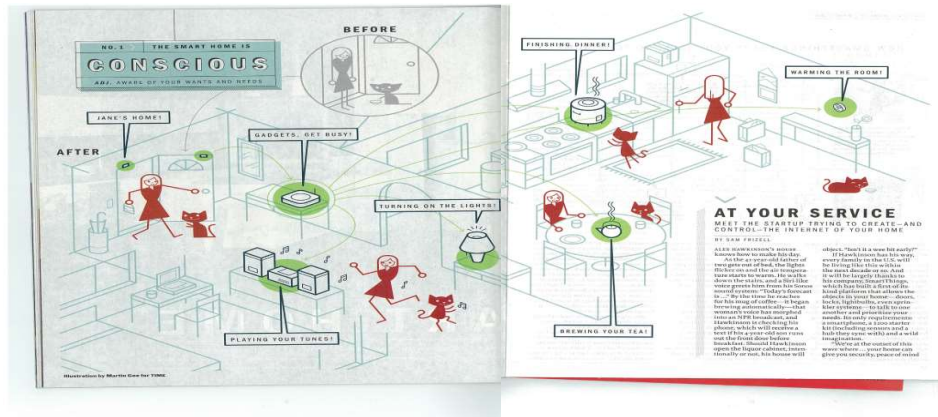
*光源 照亮他物 或 物體 被照亮 都屬於 Illumination.

Smart Lighting Application



多功能整合型照明

智慧照明
雲端通訊
醫療保健
便利的生活



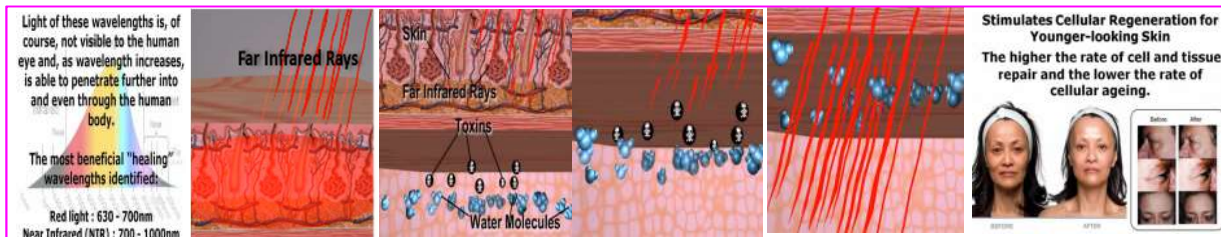
隨需求自動啟閉並調整亮度



與無線通訊整合或再進階至光通訊



與醫療保健用途整合



Ideal product

- 具學習及記憶功能
- 自動啟閉並調整亮度
- 自動感應環境照度
- 可依所在位置局部照明達到省電效果
- 調整色溫符合情境需求
- 提供通訊功能
- 遠端控制家電、燈光及空調
- 腦波偵測功能

只要擁有一組多功能智慧照明燈具
便利的生活從此為您敞開！！

應用與原理-汽車照明應用

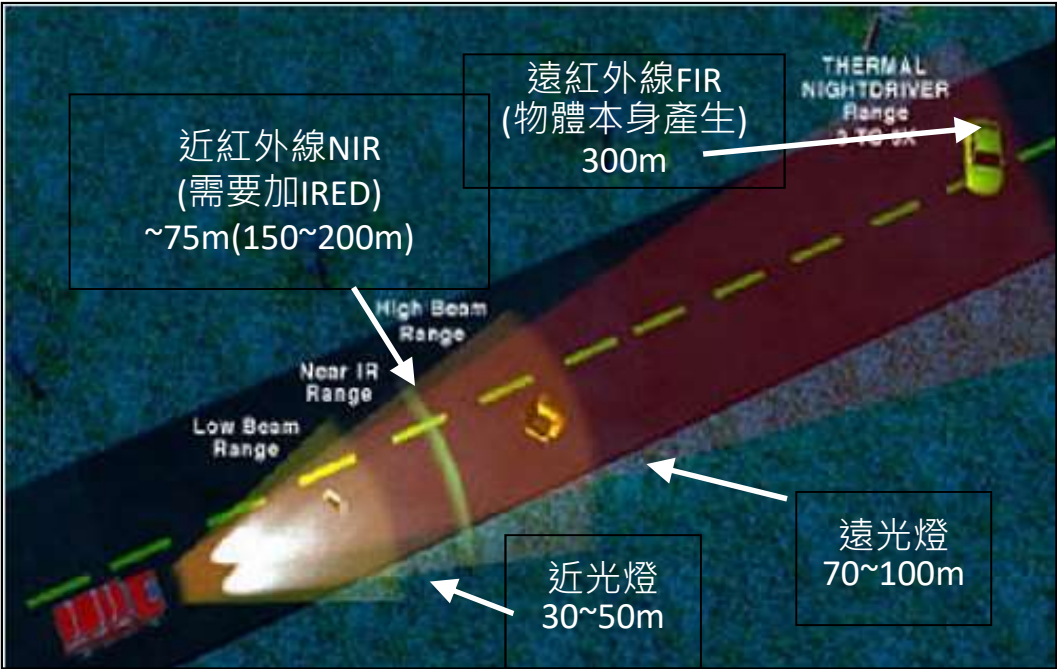
LED優點:

- 色彩多樣化，體積小→造型設計容易
- 反應快→加速後方車輛煞車反應時間(縮短煞車距離)
- 多顆並聯→避免死燈不亮
- 使用壽命長→安全



→品牌識別





太陽光併用型(半人工)-花卉

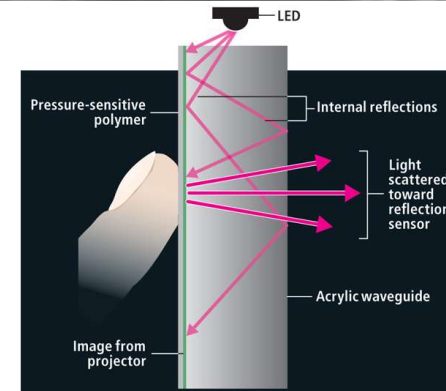
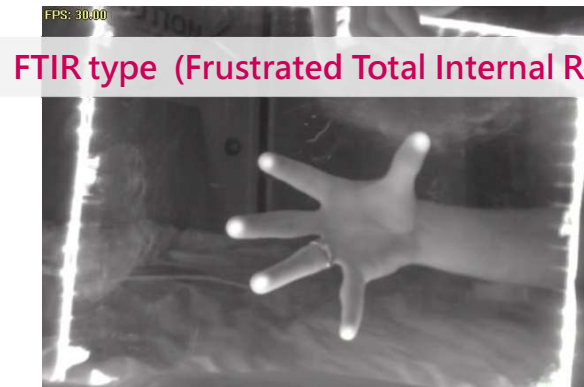
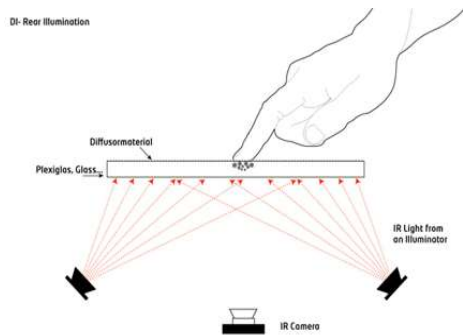
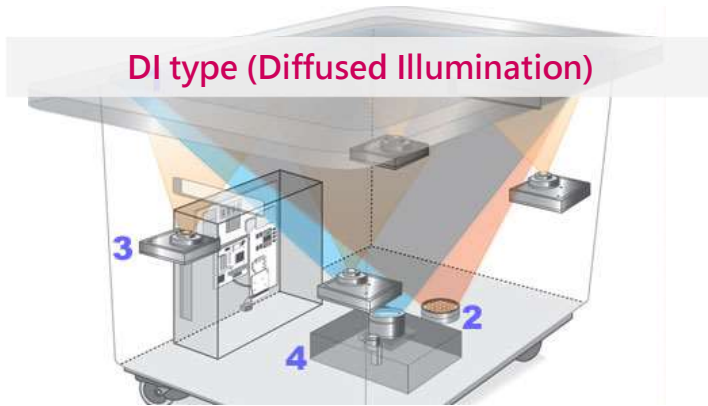


控制或加速植物生長週期，提高產能與品質

全人工型-蔬菜(植物工廠)

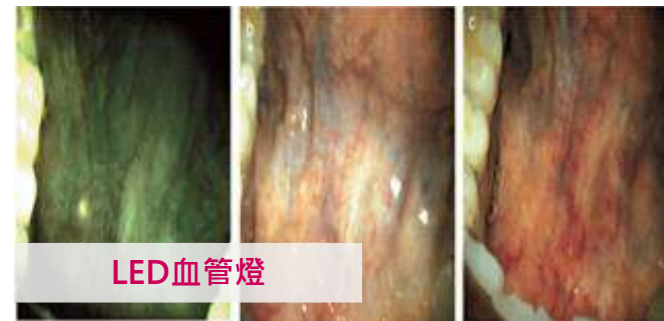
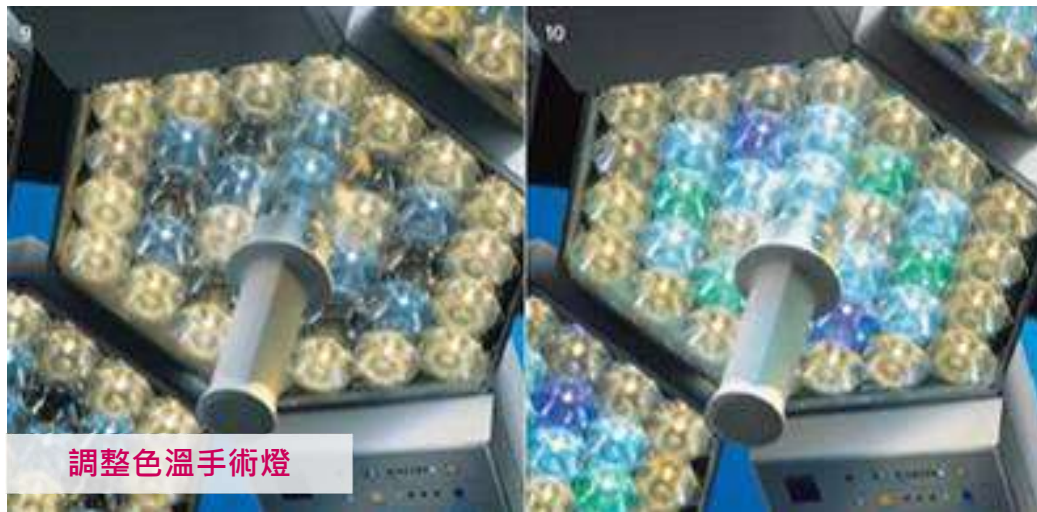


應用與原理-光學觸控系統(紅外線)

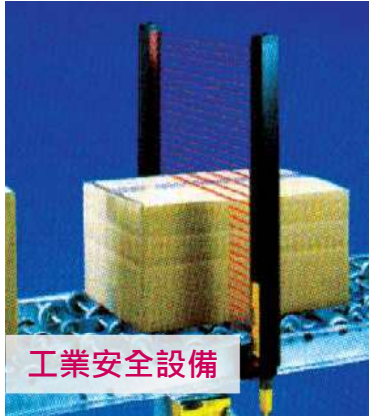


應用與原理-醫療應用

一般檢驗燈、手術燈、手術頭燈、牙科診療燈、
光筆、殺菌燈、光療照明及血管照明...等



應用與原理-其他應用



應用與原理- 體感遊戲/手勢動作感應

1) TOF技術(Time of Flight)-3DV

彩色影像 立體(深度)影

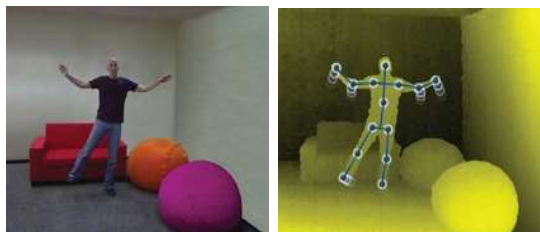


SONY PS MOVE

LED光球

動作感應控制/遙控

2) Light Coding技術-Prime Sense



LED 在生醫/美容方面的應用

EPISTAR LAB



UV殺菌



生理偵測



時差調整



美容/美白



體內偵測/造影



醫療

LED 波長/生醫應用整理

	UV-C	UV-B	UV-A	Blue	Green	Red	Deep Red	IR	
Products\Wavelength(nm)	100-280	280-315	315-400	410-470	510-550	610-640	660	740-1100	1100-1550
A. UV光殺菌機/UV光淨水器	V	V	V						
B. 攜帶式脈搏/血氧偵測							V	V (880,940)	
C. 血糖監測機							V	V (880,940)	V (1550)
D. 時差/生理調整器				V	V	V			
E. 生理影像監測							V	V	V
E. 皮膚保養				V	V	V	V	V	
F. 禿頭光療機 (光療帽)				V (415)			V (660)		
G. 治療青春痘				V (415)			V (660)		
Epistar 產品	D	X	O	O	O	O	O	O	D

UV LED 選擇未來哪個市場與應用?

美甲機

Prints

Coating

Adhesives

Others

殺菌LED燈

浴廁殺菌光

手動消毒棒

露營水壺 Pure

水系統殺菌器

UV LED殺菌水, 奶瓶

UV LED水龍頭殺菌器

UV LED隨手清

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5年LED的應用場景

由感知透過網路結合大數據分析而生成總體應用架構。

- Automotive自駕車成為廣泛的移動平台
- Mobile Device結合感測器匯集多方資訊
- Display即時高度整合與同步訊息的顯示

移動/Automotive



- 駕駛偵測系統
- 後座偵測系統
- ADAS系統
- LiDAR系統

健康/Mobile Device



- Proximity感測
- 心率偵測
- 血氧偵測
- 血糖偵測
- 眼球追蹤

資訊/Display



- 高對比顯示技術
- 車用 HUD
- AR/VR HMD
- 透明顯示器

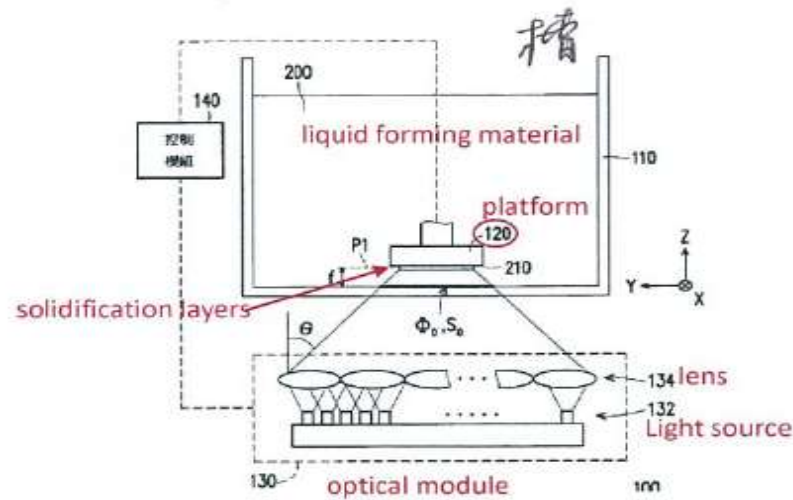
Micro LED 未來應用於照明之趨勢

- **General lighting?**
Concerns: Efficiency, P&P, Interconnection yield, probing cost,
- **3D printing (Stereo Lithography Apparatus)?**
Concern: Converging optics, heat dissipating
- **i-Line lithography?**
Concern: Collimating optics, heat dissipating
- **UVC direct writing (Maskless Lithography)?**
Concern: Collimating optics, heat dissipating
- **IR image sensor array?**

New Packaging Concept for General Lighting

EPISTAR LAB

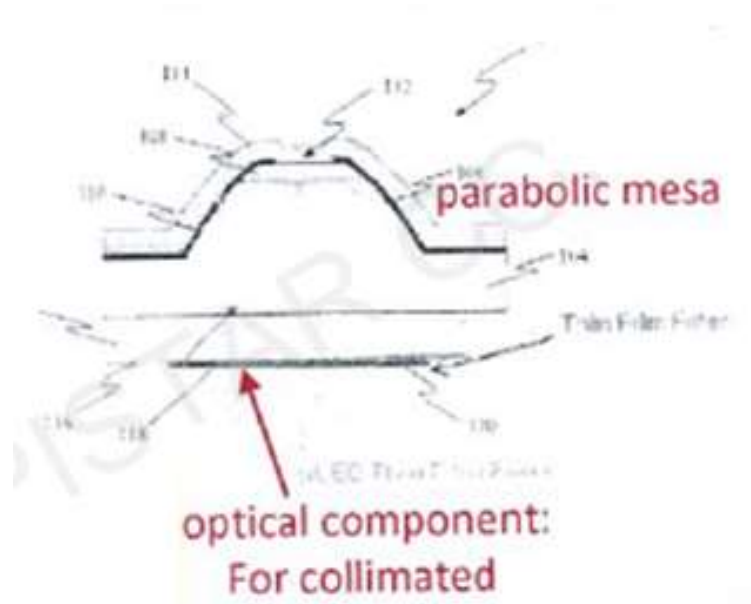
- No probing
- PCB is no longer available
- Wire bonding is no longer applicable
- Panel level Massive Packaging
- Mass transfer
- Panel level encapsulation
- Allow NGs
- Requires micro lens array



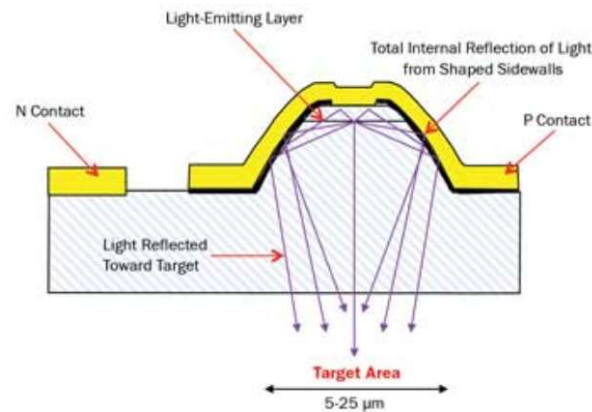
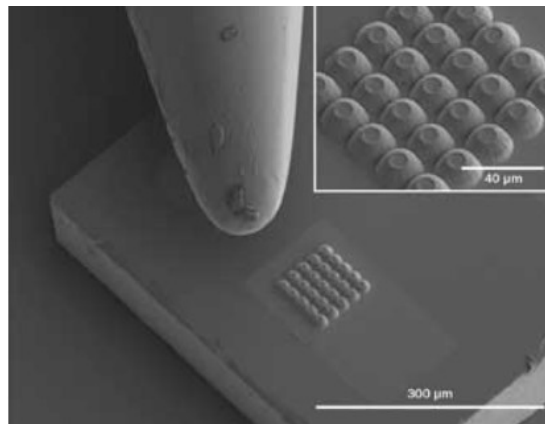
- 1. Input image via LED
- 2. Focus light by lens and light spot differentiate at different depth
- 3. Cured position away from the light source
- 4. Throughput increased

i-Line UVA Light Source

- Micro LED array with embedded parabolic lens for collimated rays

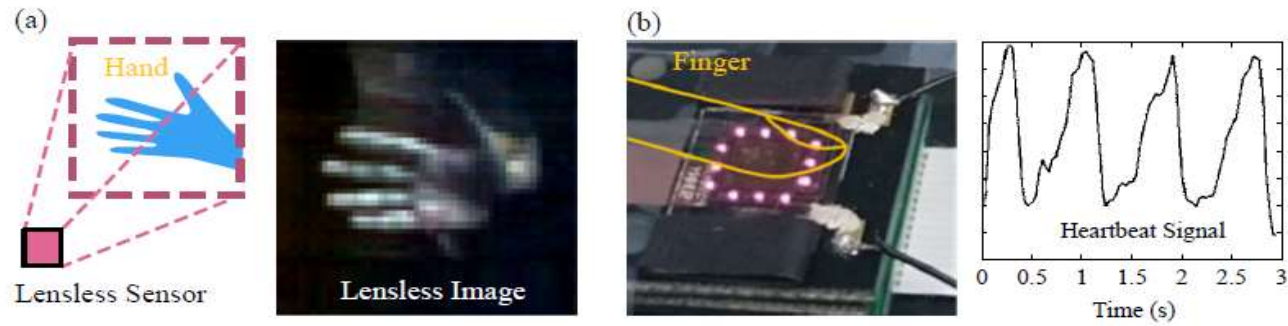


u-Collimated LED Array for Maskless Application



The emission angle from the chip is 4x improved over a standard LED (**half-angle of 60° vs. 15°**). The control of light generated is essential for the fabrication of high-density arrays. The Lambertian emission from a standard LED structure results in overlap between the light produced by pixels.

Micro LED 未來應用於照明之趨勢



無透鏡成像系統架構與實驗結果(a) Remote Sensing : (b) Contact Sensing

Institute	ITRI	Rice Univ.	Hitachi	
Modulation	Amplitude	Amplitude	Amplitude	
Focal Length	<1 mm	0.5 mm (VIS)/5 mm (NIR)	~2 mm	
Reconstructed Image				

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- 回顧來時路-Since 1996
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- 結語

- LED 未來應用是想像力之果
- EPISTAR 一本初衷

Provide Full Spectrum Products

Integrate LED Chip for Every Application

Actualize LED Potential

EPISTAR

EPISTAR LAB

Thank You!

CONFIDENTIAL SECURITY C

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