



Thermal Management of LCD-TV

CMO, LCD-TV HD

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➤ TFT-LCD

- Polarization
- Liquid Crystal
- Backlight

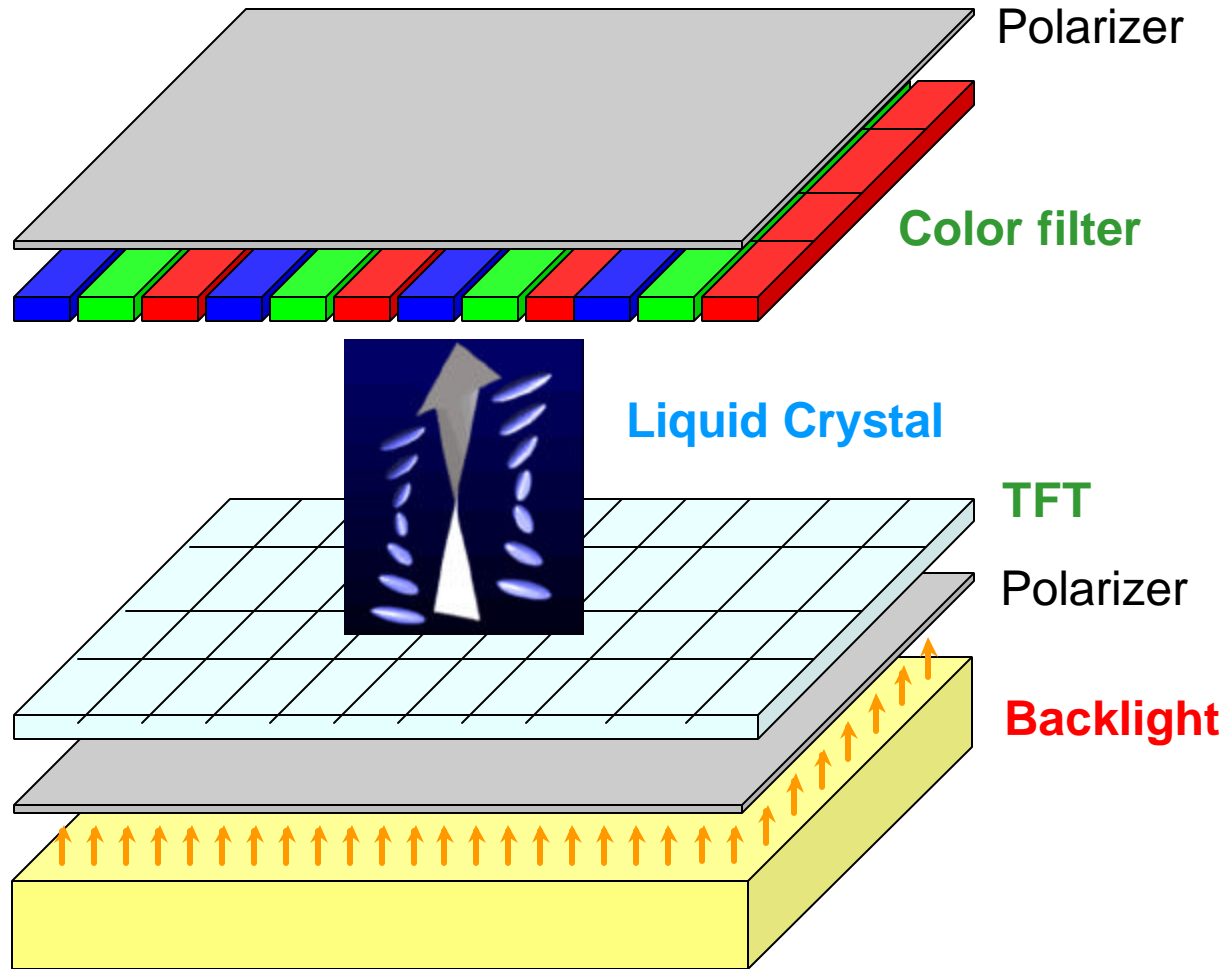
➤ LCD-TV

➤ Thermal Issues

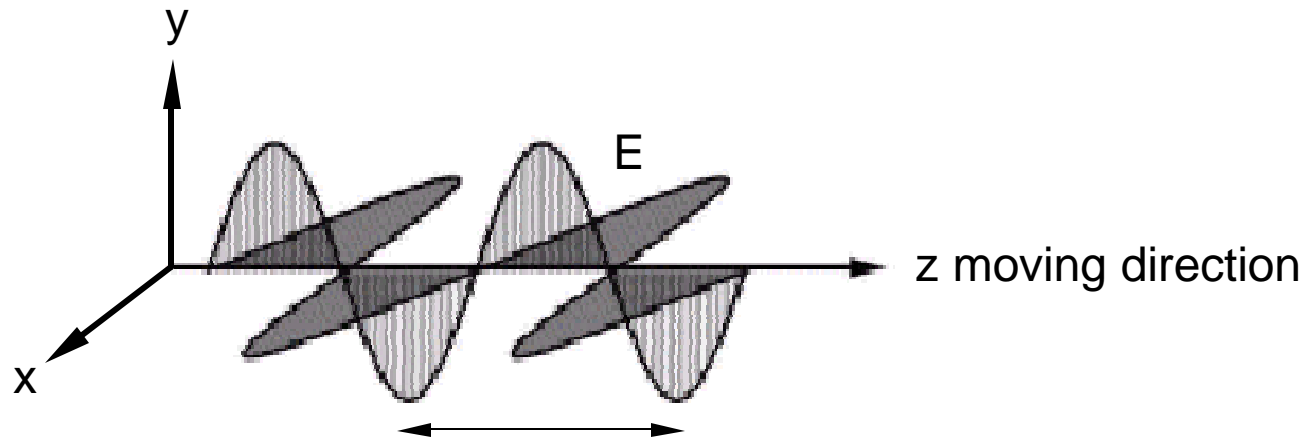
- LCD Module
- Backlight Unit
- Optical Films & Reflector
- **Light Source**



➤ **TFT-LCD**



▪ Polarization



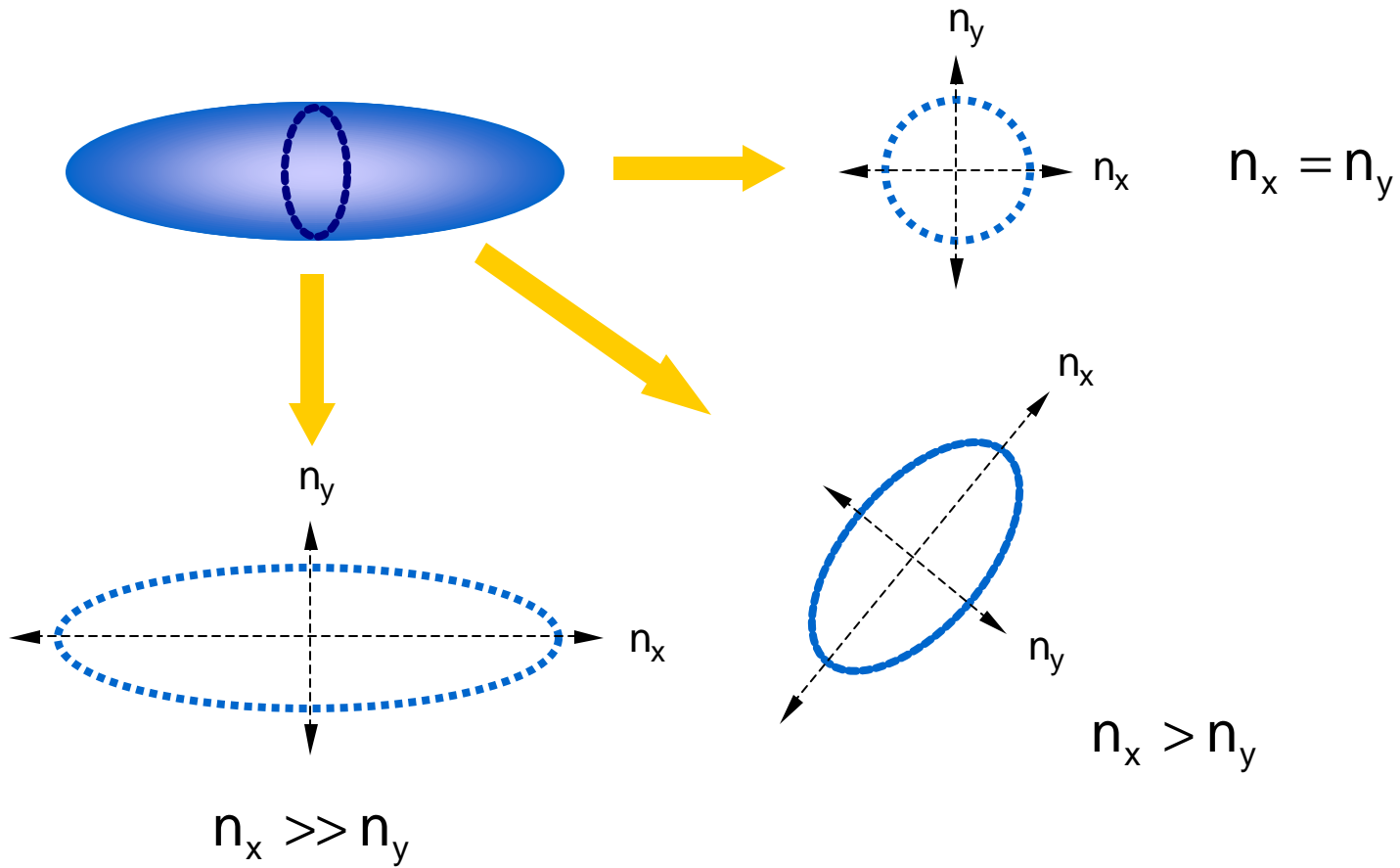
$$E_x = A_x \cdot \cos(\omega t - k \cdot z + \delta_x)$$

$$E_y = A_y \cdot \cos(\omega t - k \cdot z + \delta_y)$$

where

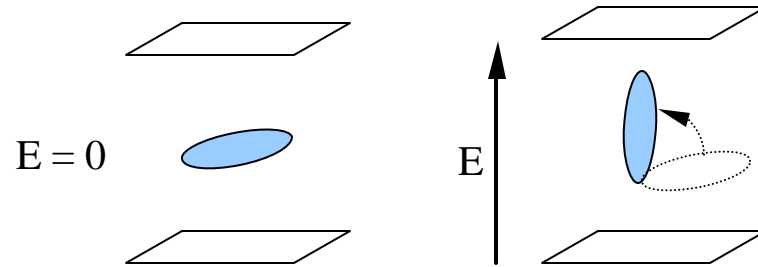
$$\omega = 2\pi f, \quad k = n\omega/c, \quad \underline{n \text{ is refractive index}}$$

- Liquid Crystal



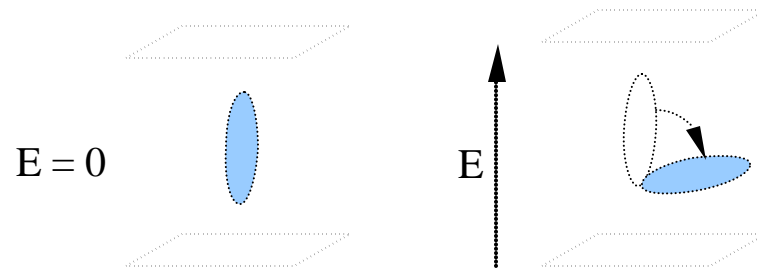
TN mode

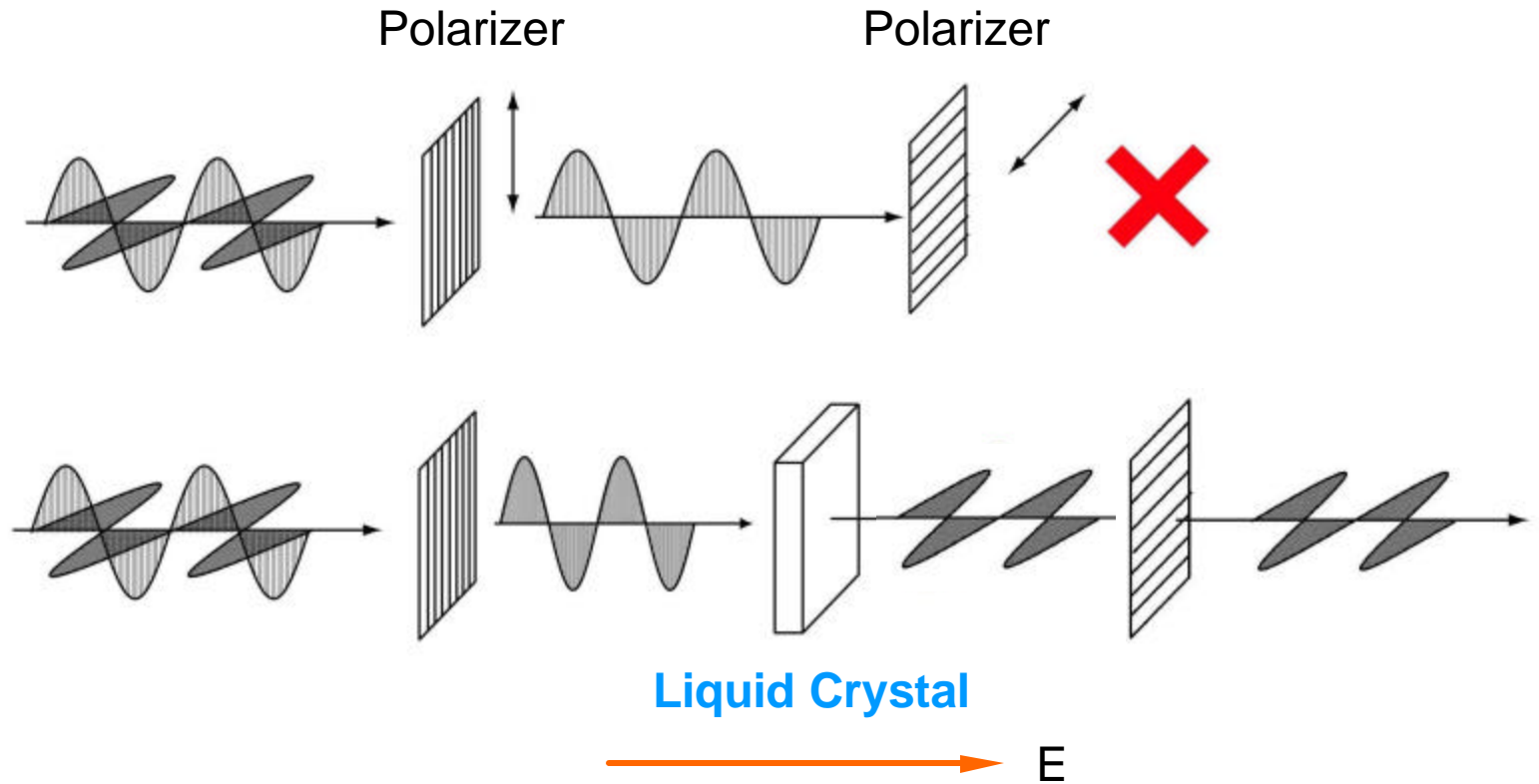
$$\begin{aligned} \rightarrow e_{//} > e^{\wedge} \\ \rightarrow \quad \quad = e_{//} - e^{\wedge} > 0 \end{aligned}$$

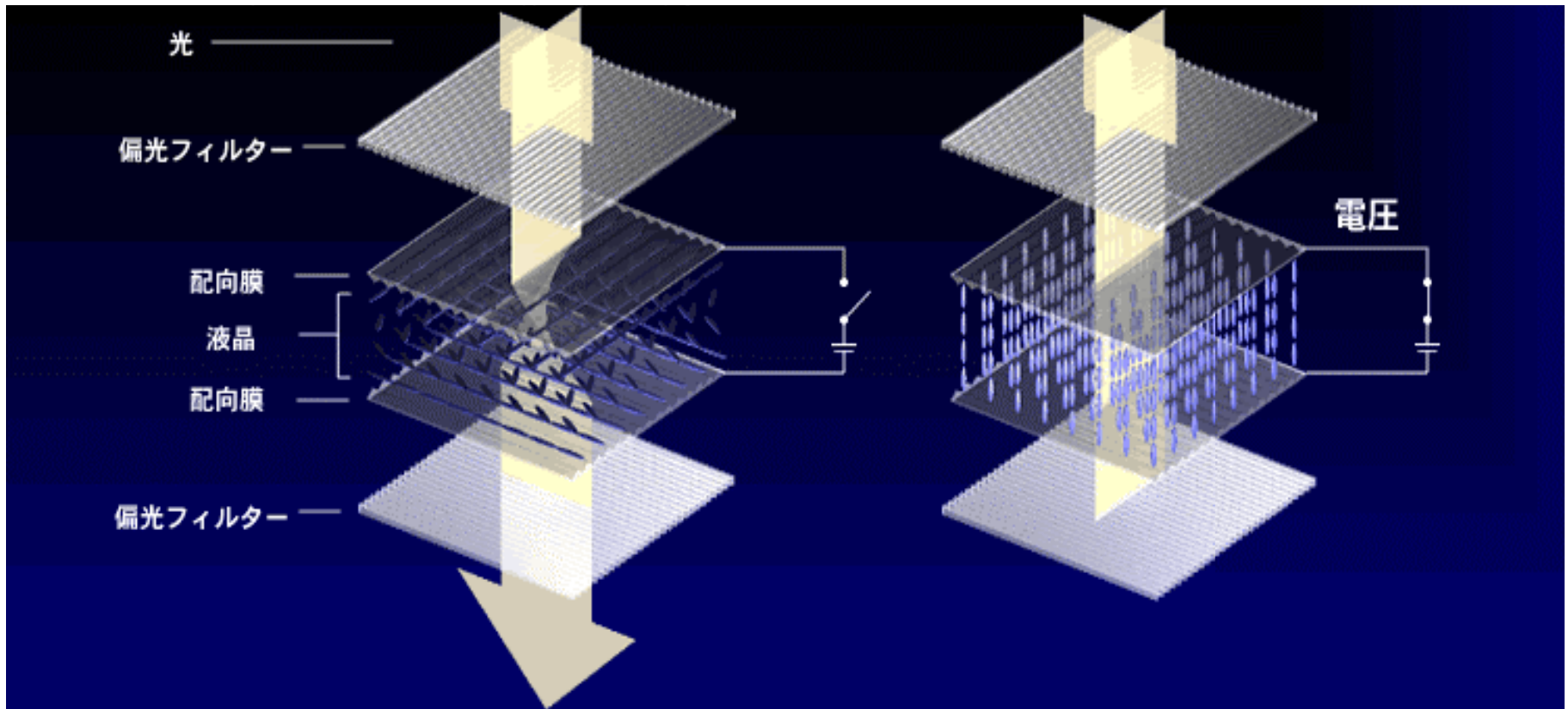


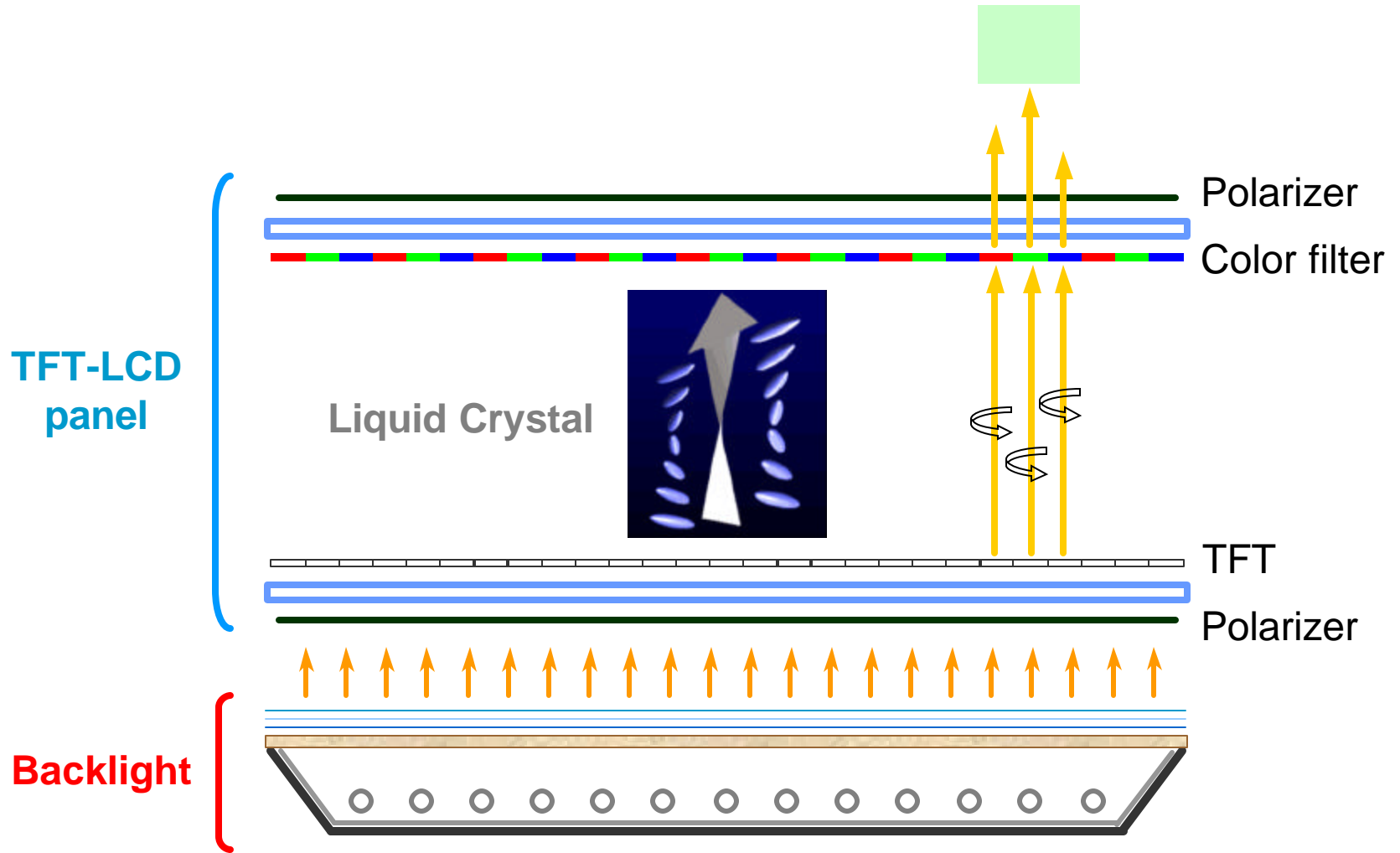
VA mode

$$\begin{aligned} \rightarrow e_{//} < e^{\wedge} \\ \rightarrow \quad \quad = e_{//} - e^{\wedge} < 0 \end{aligned}$$

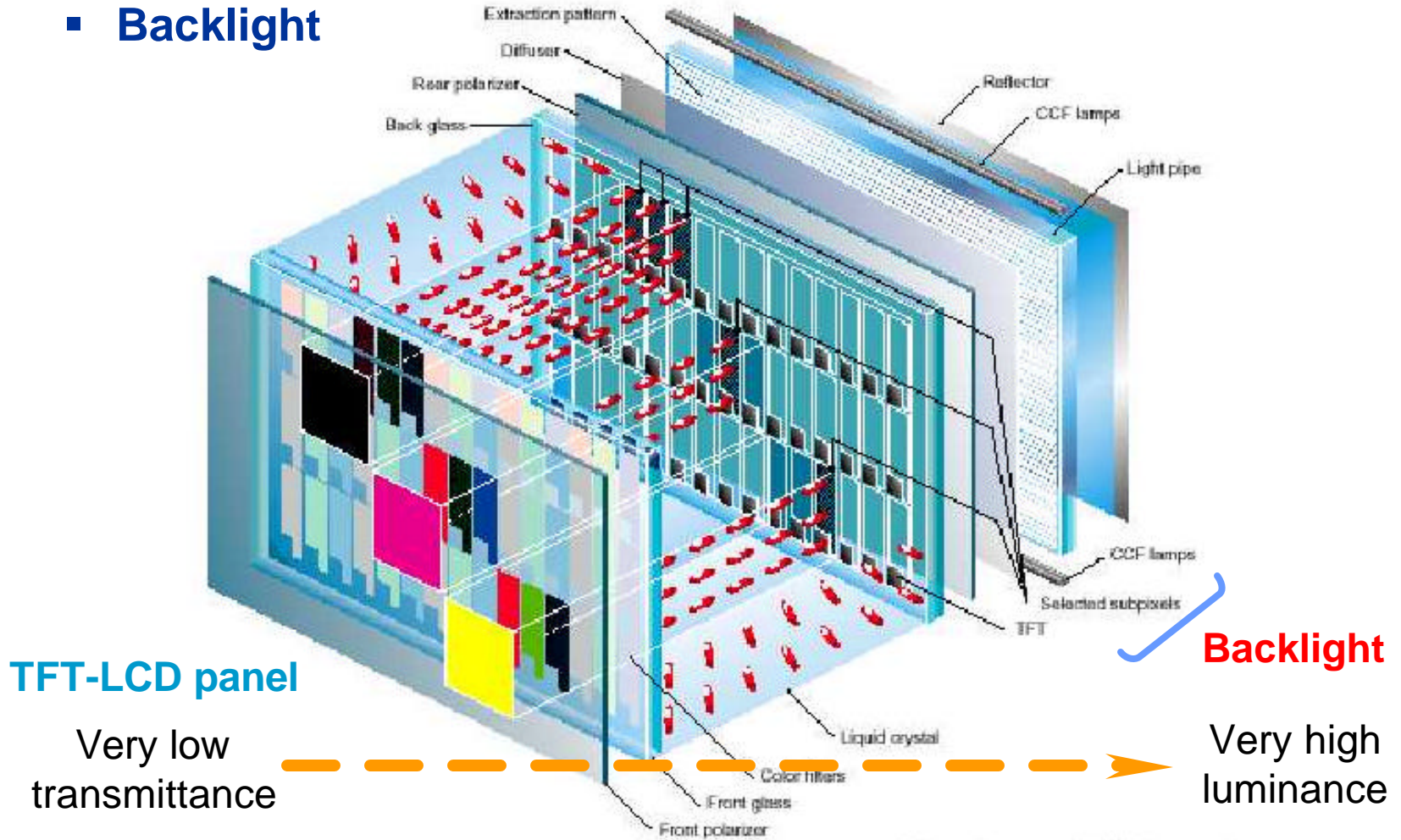


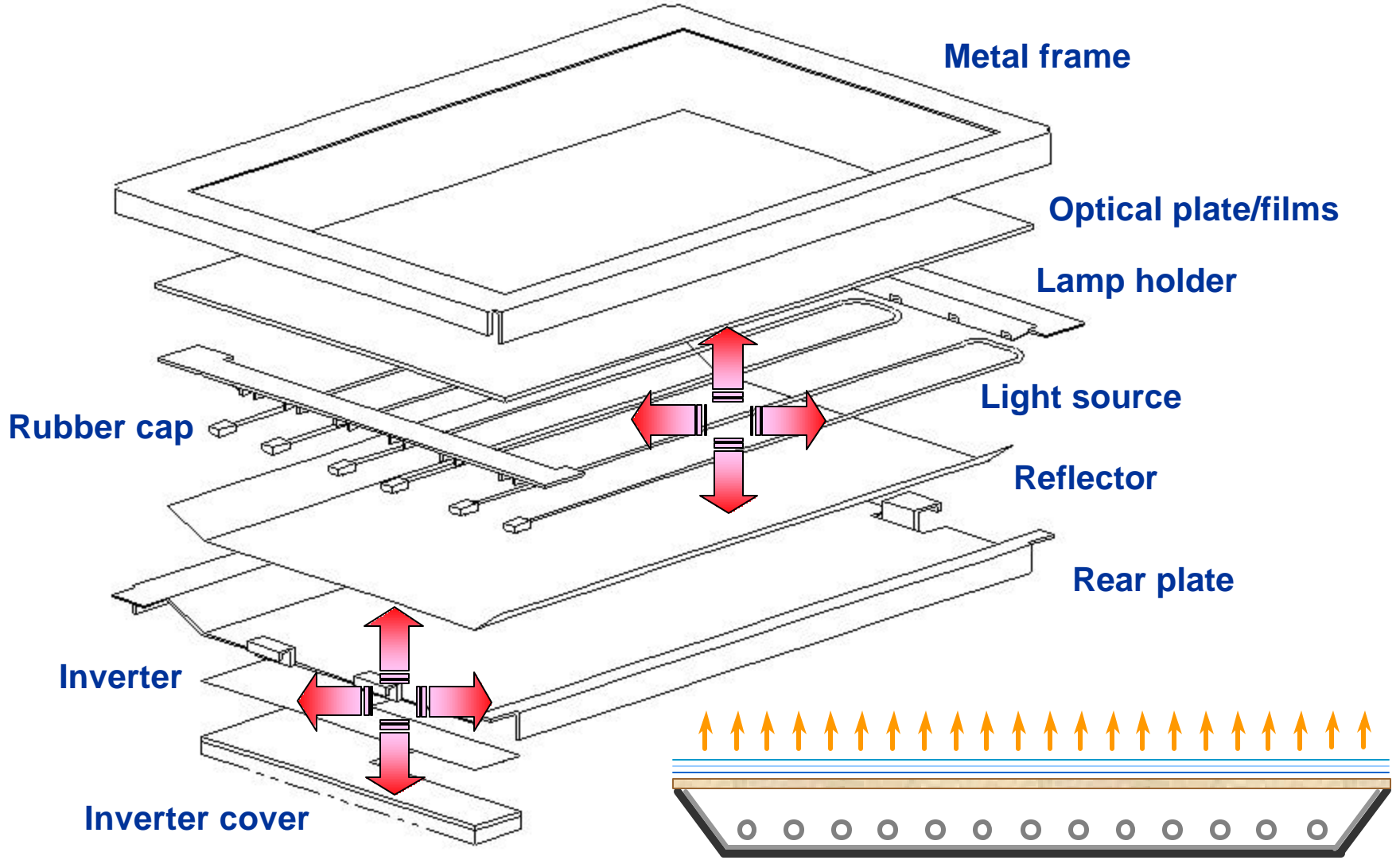


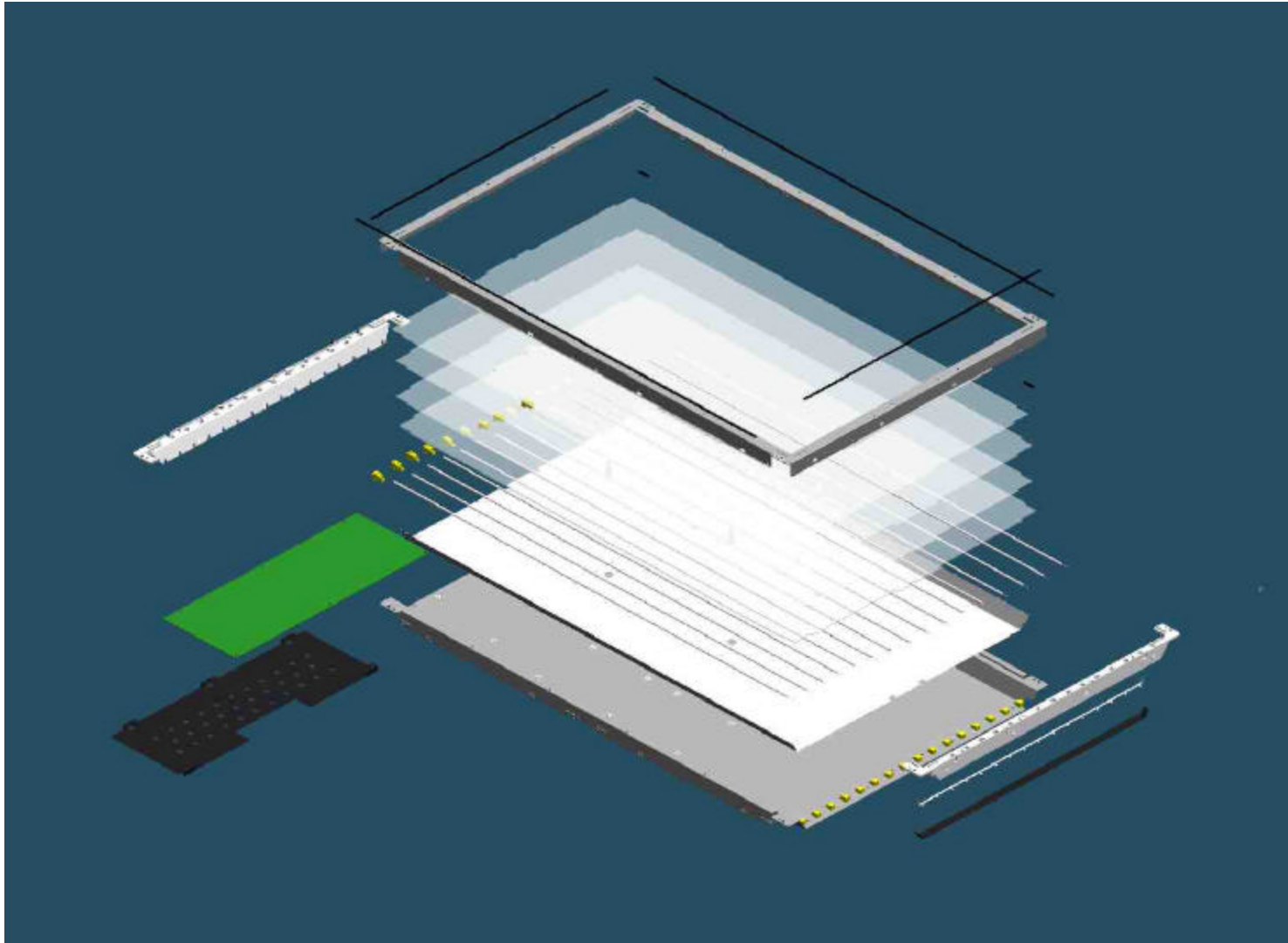




▪ Backlight







➤ **LCD-TV**



- 1) High brightness
- 2) High resolution
- 3) High color saturation
- 4) High contrast ratio
- 5) Wide viewing angle
- 6) Large display area
- 7) Long life time
- 8) Fast response time
- 9) Multiple functions



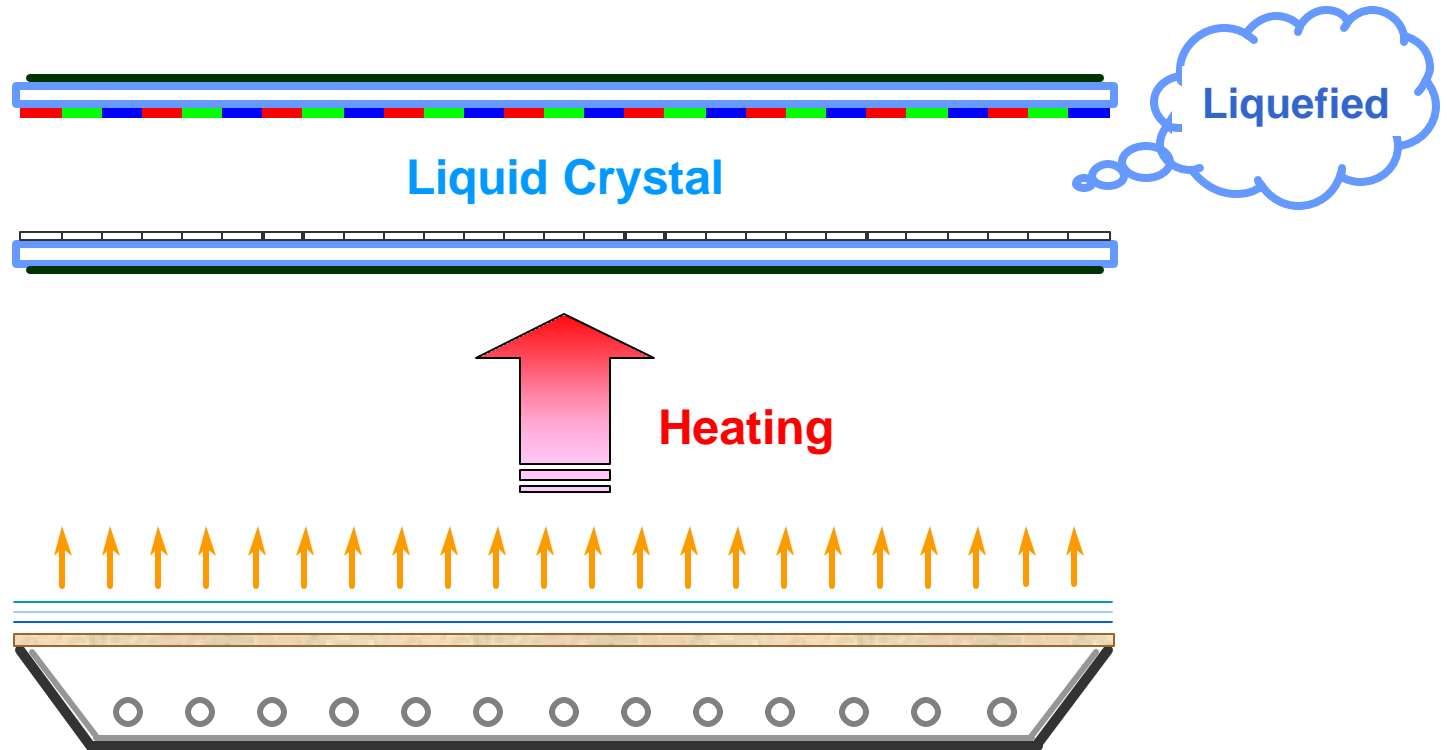
More energy, more elements



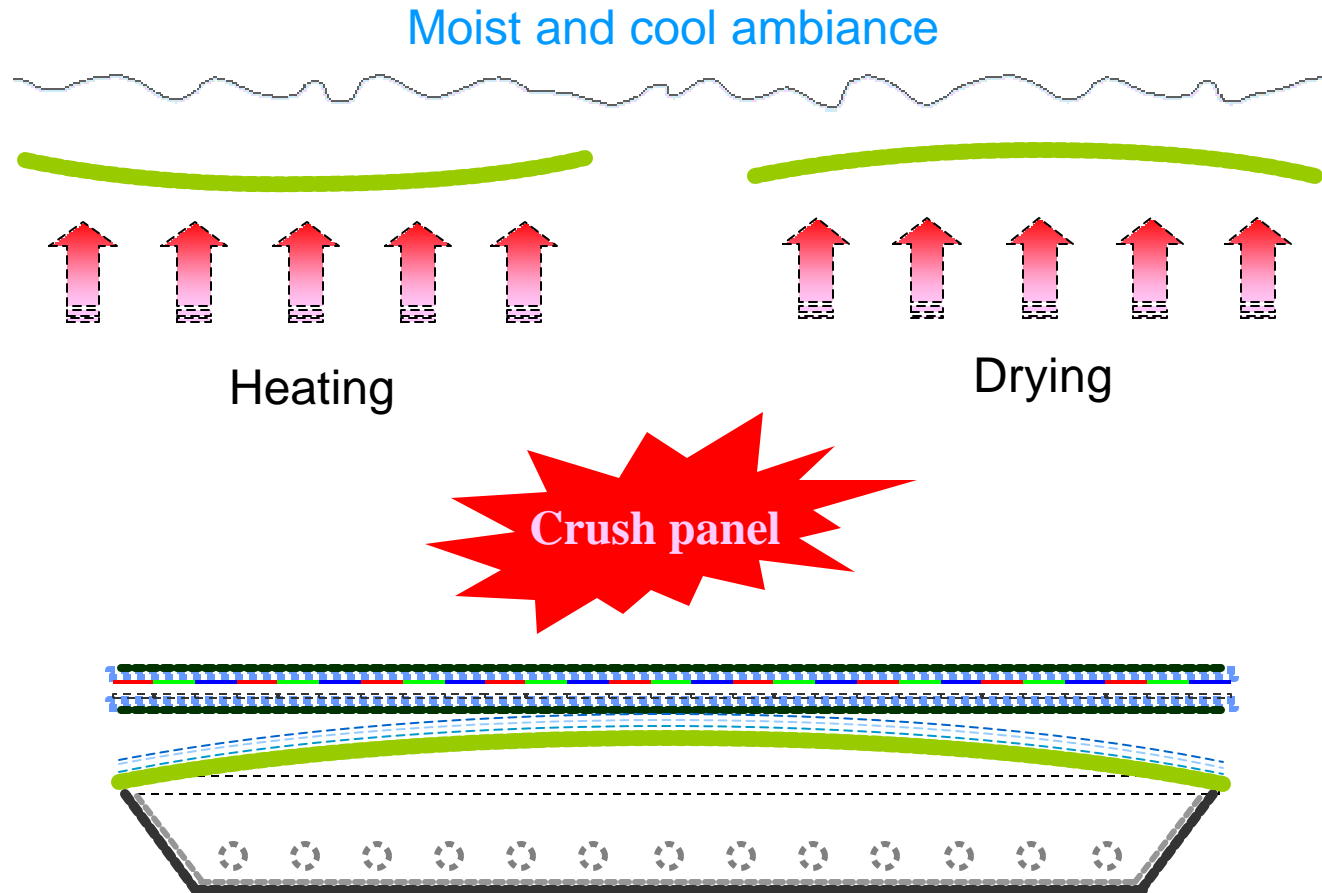
Thermal management !!

➤ **Thermal Issues**

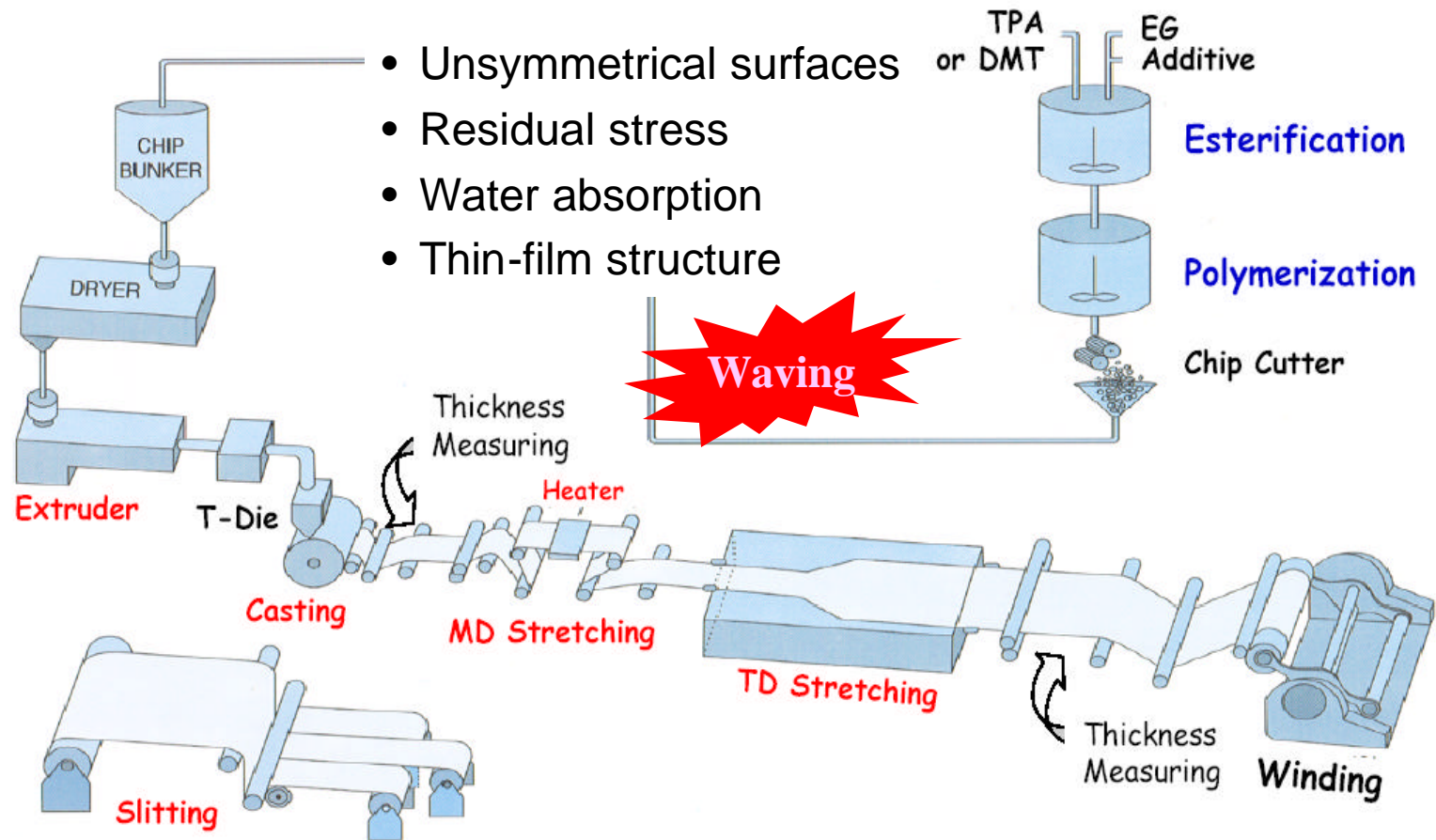
- **LCD Module**

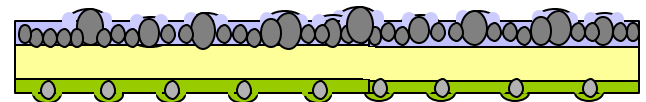
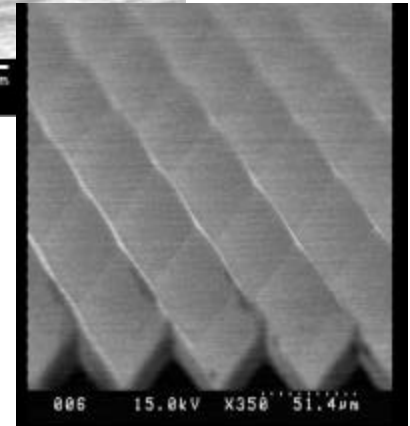
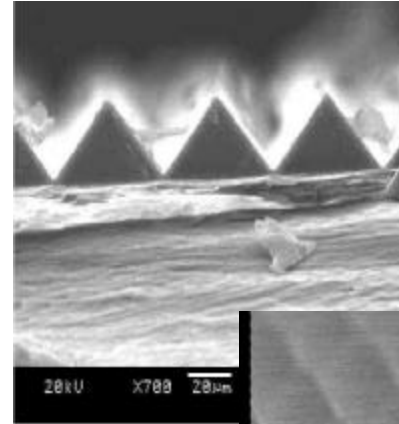
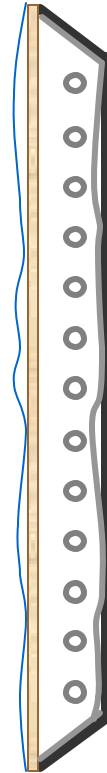


▪ Backlight Unit

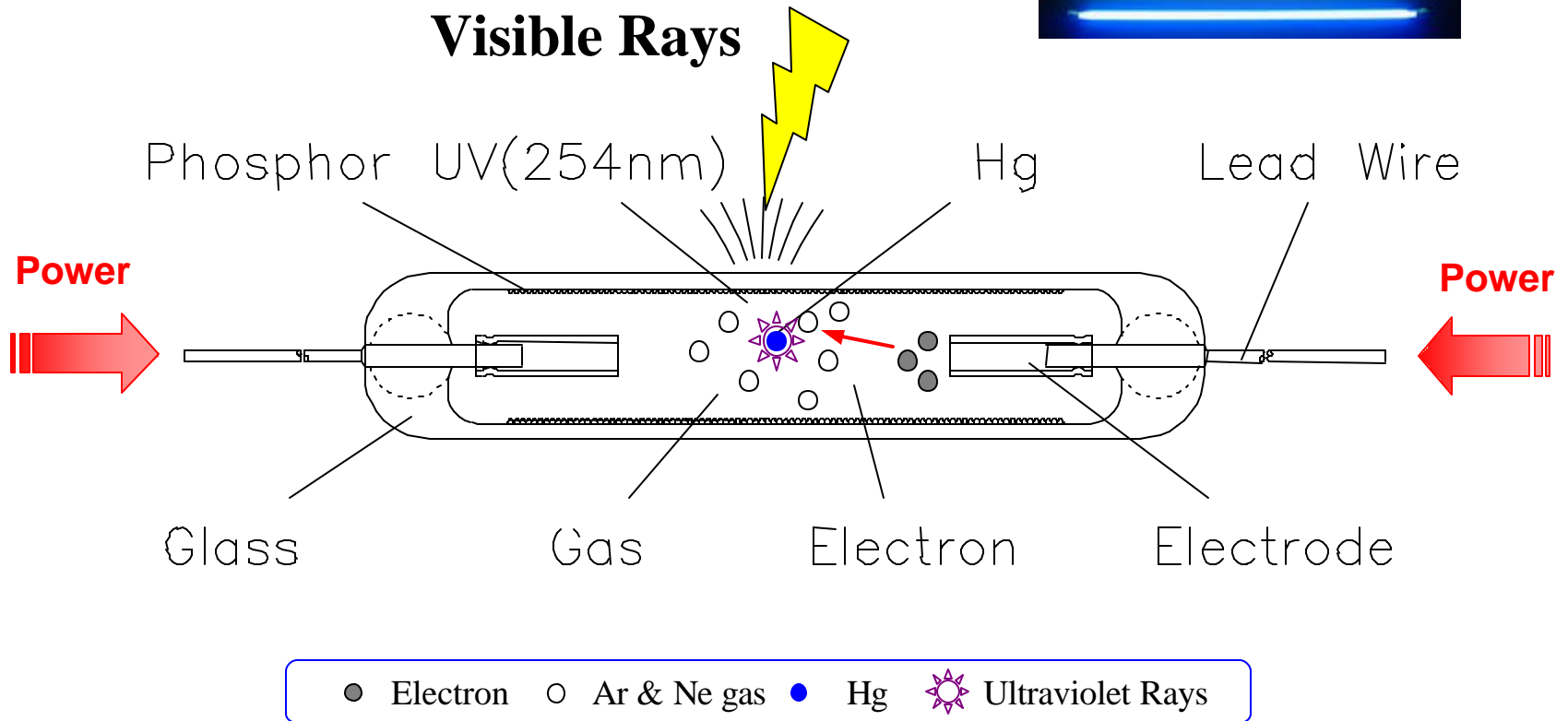


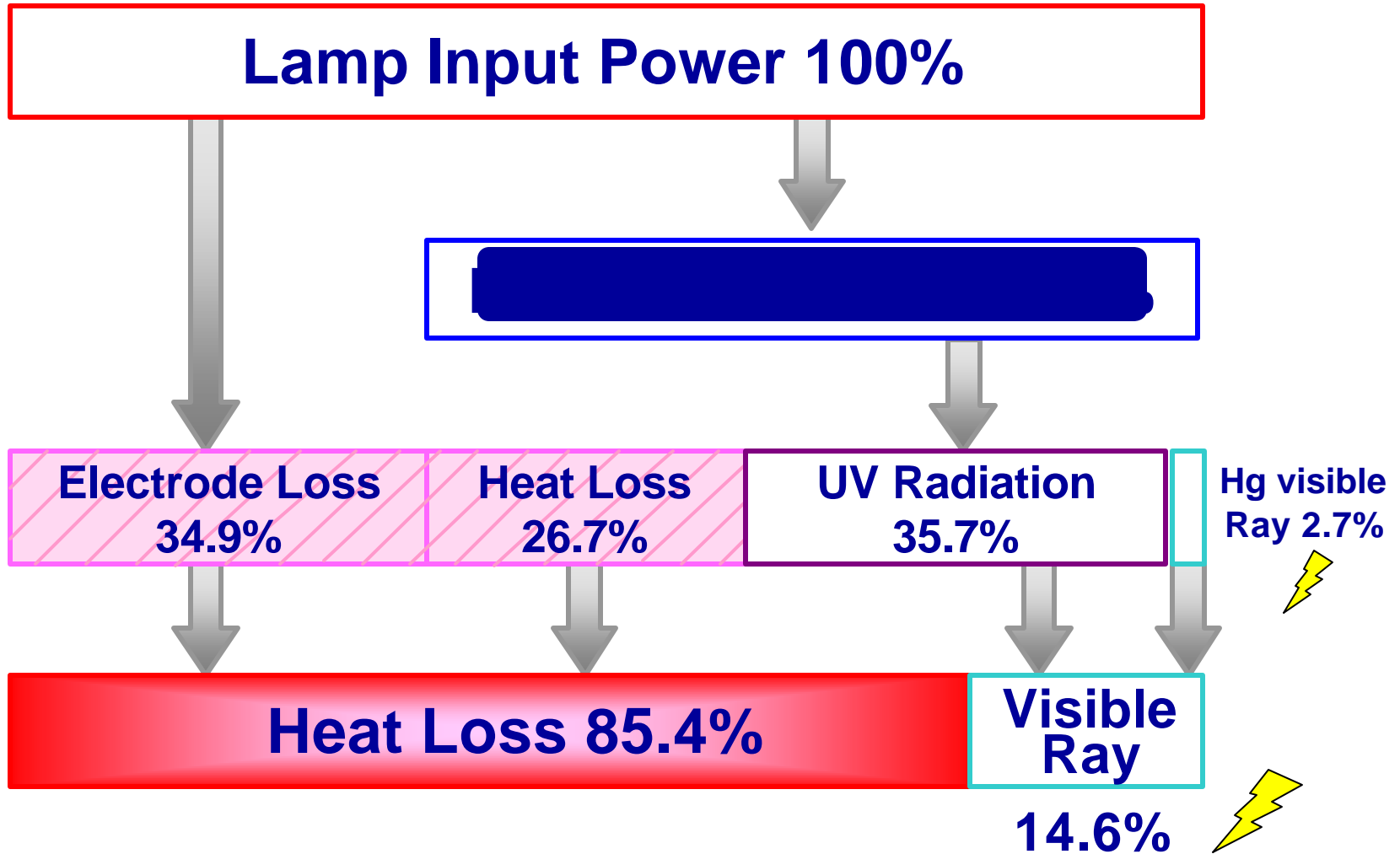
Optical Films & Reflector



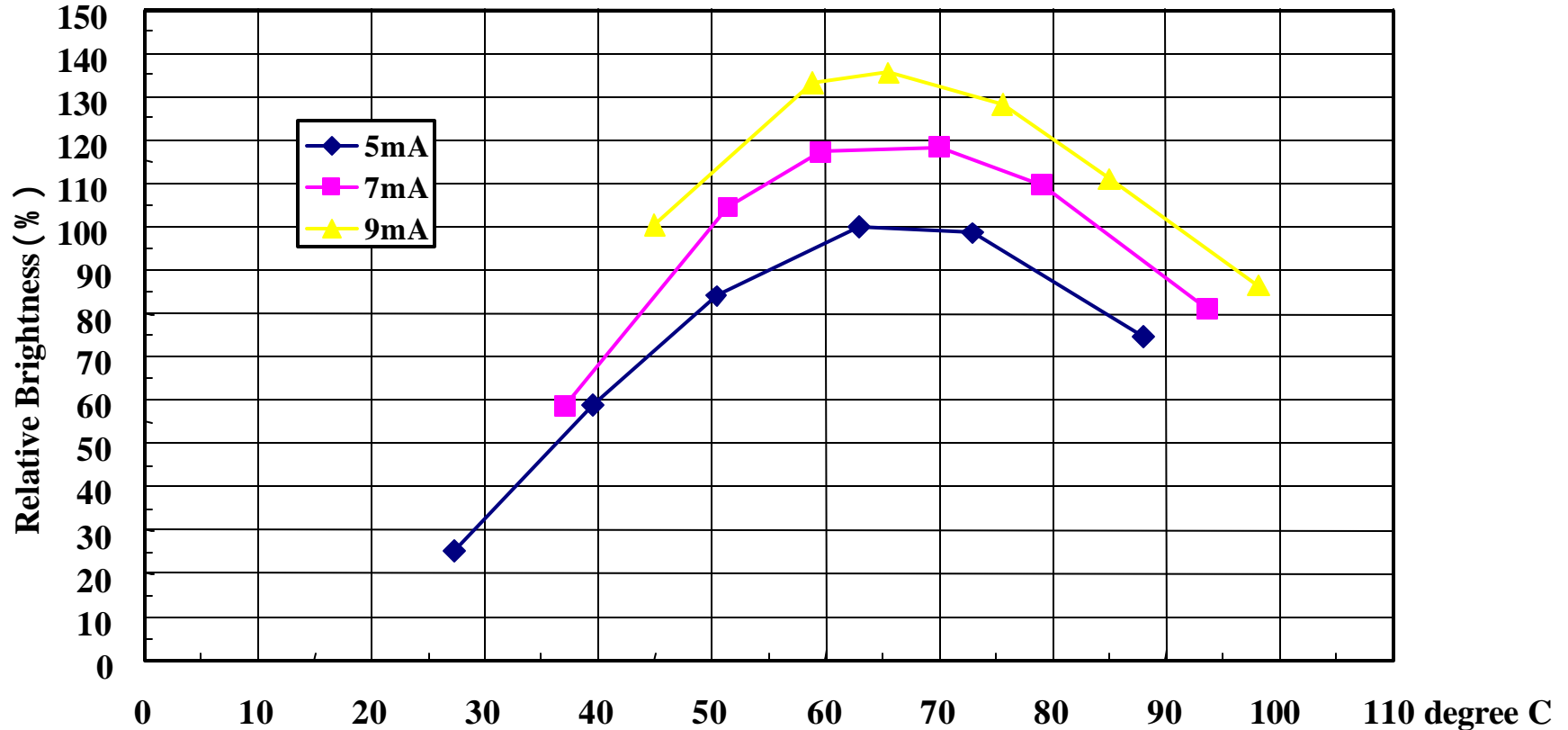


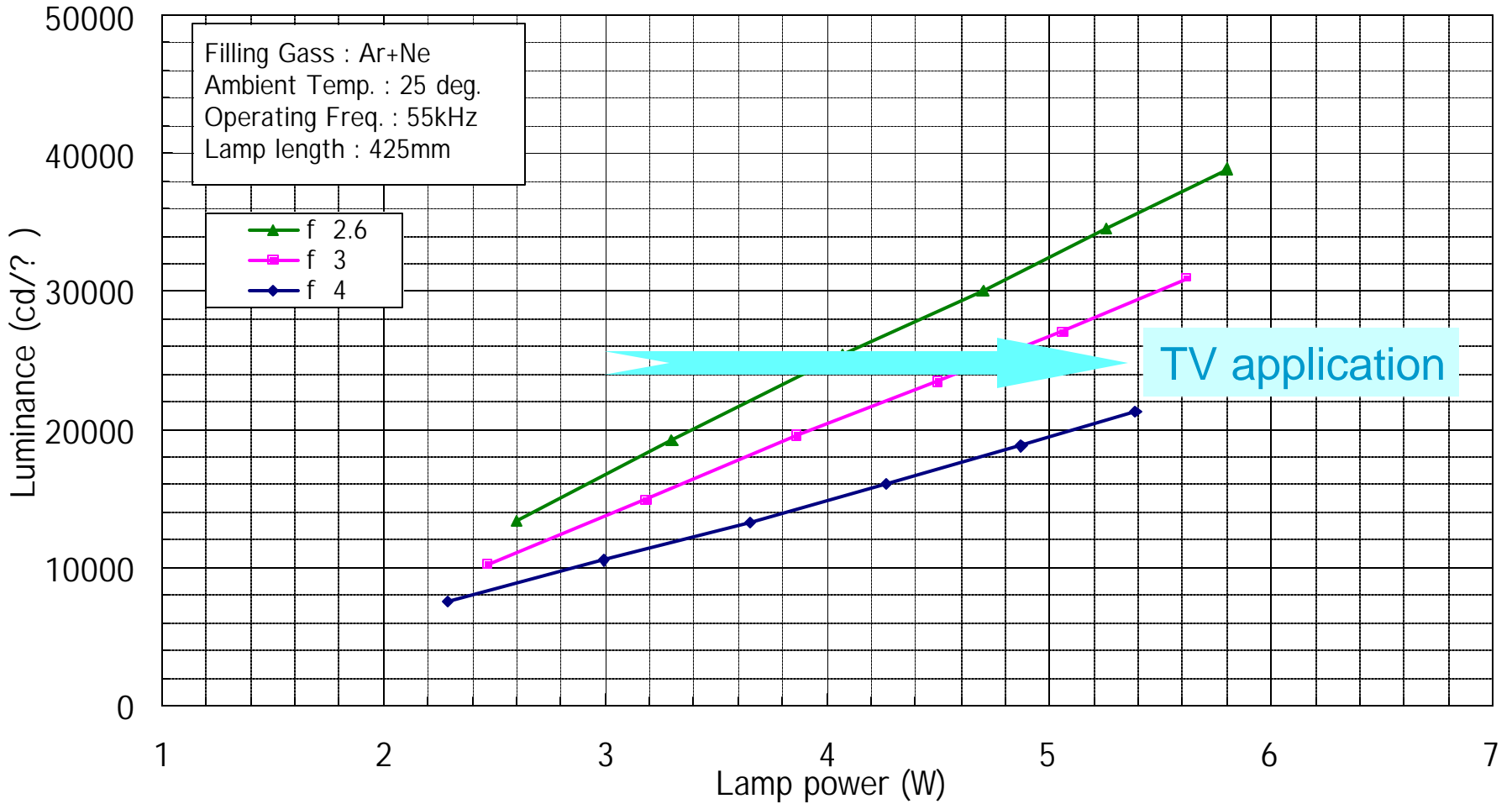
▪ **Light Source**
: Cold Cathode Fluorescent Lamp

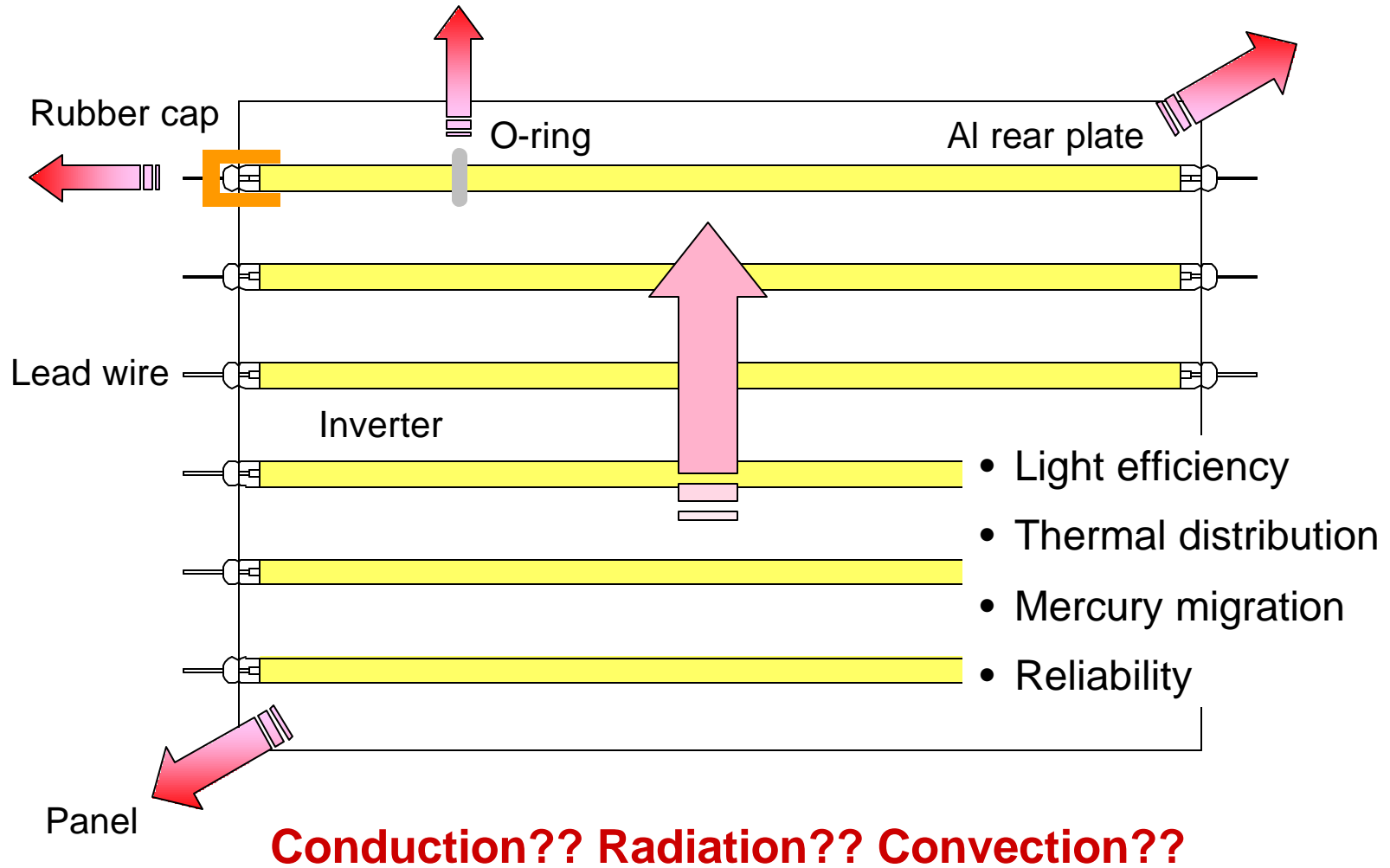




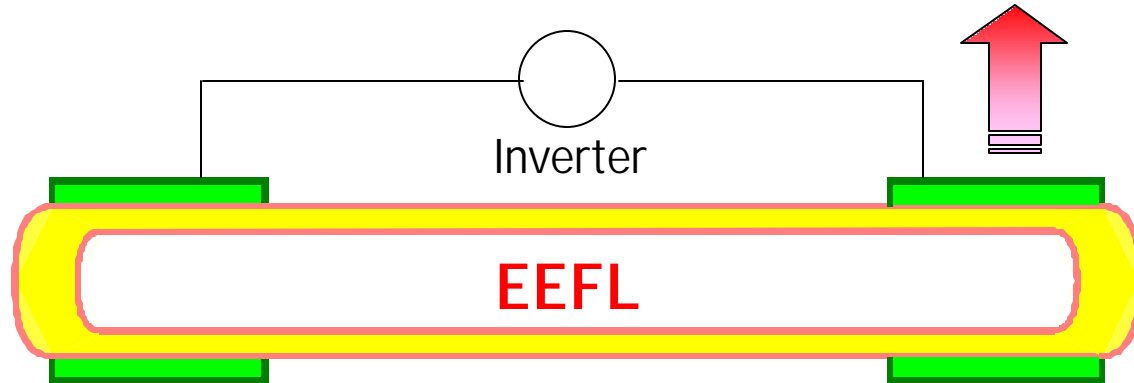
Lamp wall temp. Vs Brightness





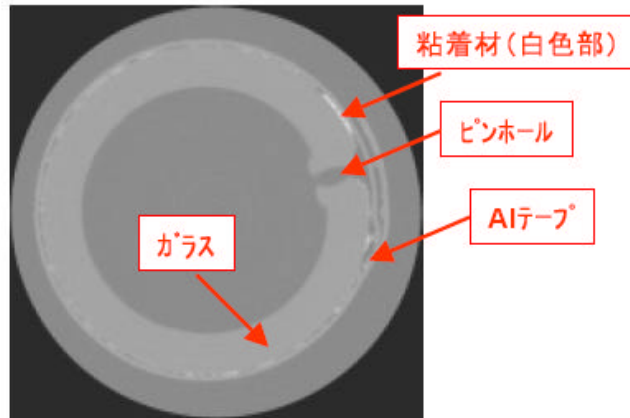


- Light Source
: External Electrode Fluorescent Lamp



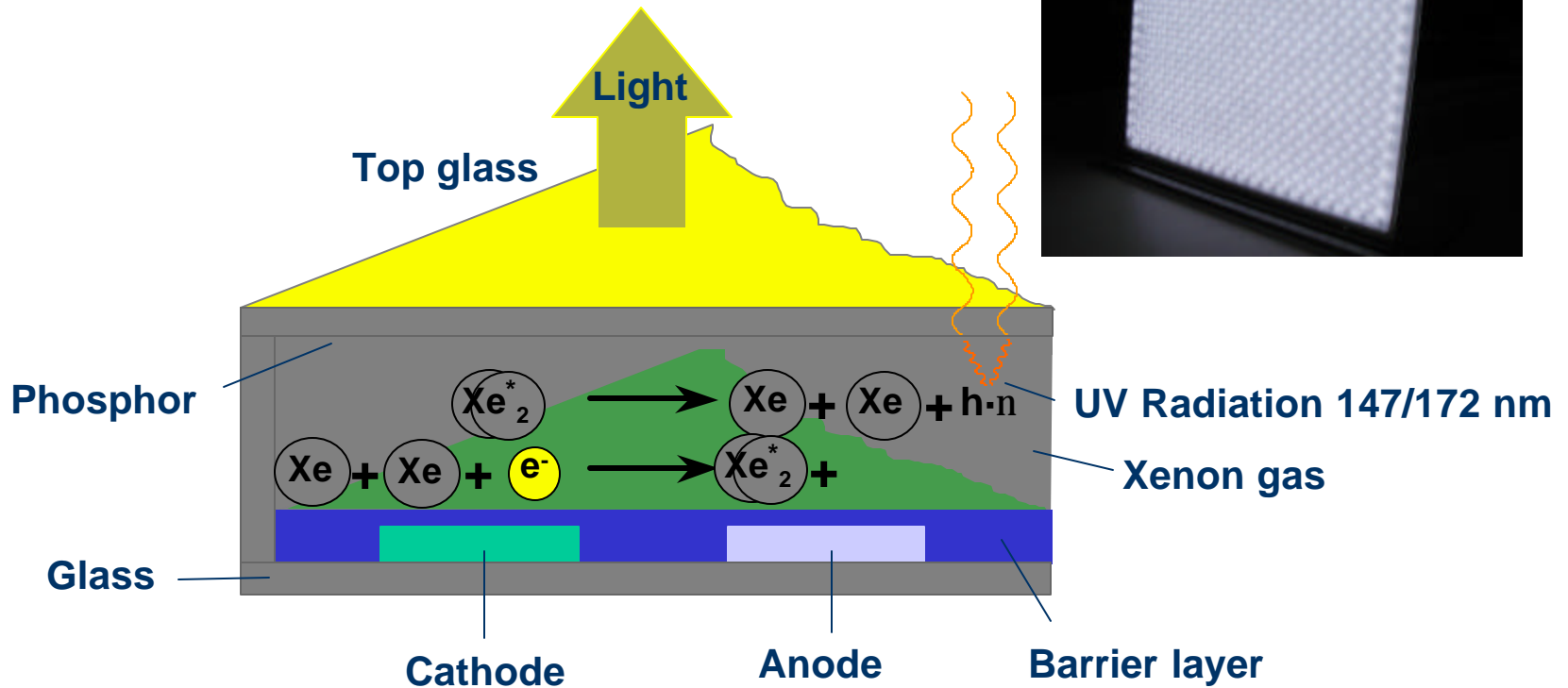
Electrode (Al tape)

Electrode (Al tape)



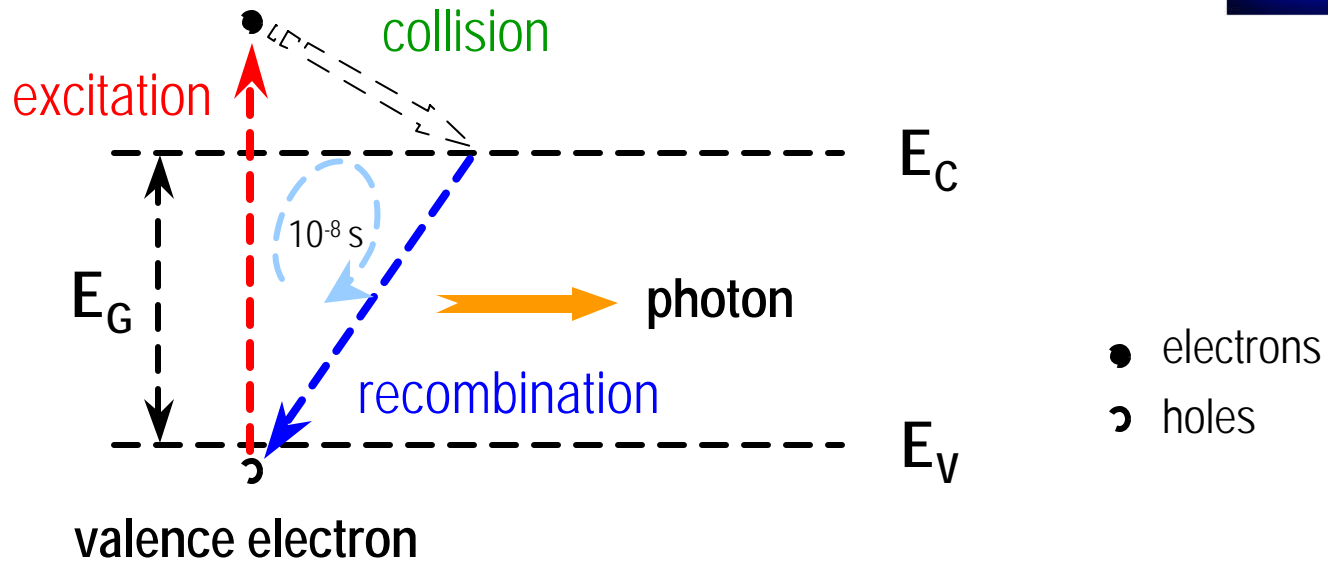
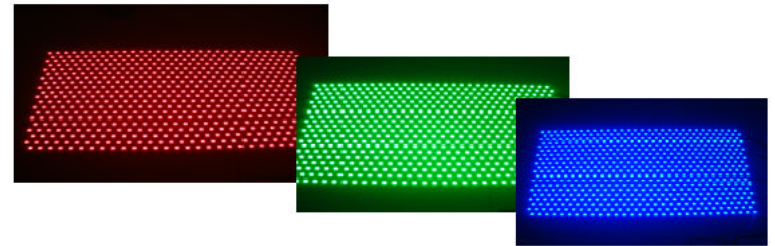
High temperature
(electrode > 180 °C)
yields pin-hole.

- Light Source : Flat Fluorescent Lamp



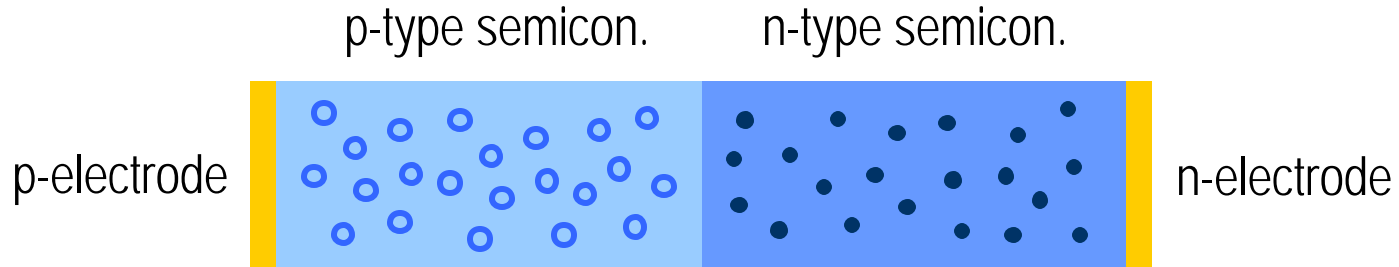
Due to bad efficiency, thermal management of FFL is much more critical than CCFL/EEFL.

▪ Light Source
: Light-Emitting Diode

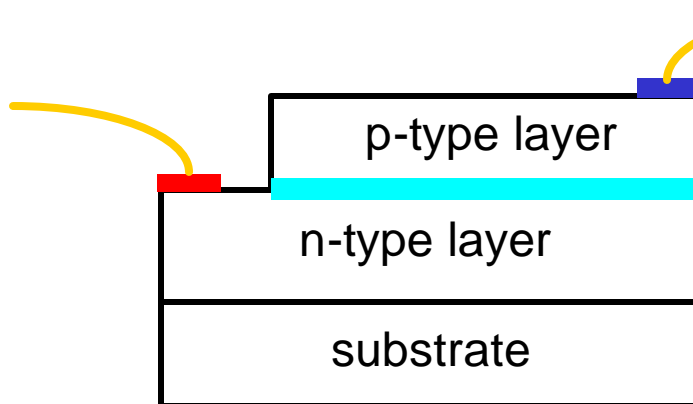


E_C : energy at conduction band

E_V : energy at valence band



- **Direct band-gap semiconductor: GaN, ZnSe...**
- **Indirect band-gap semiconductor : SiC...**

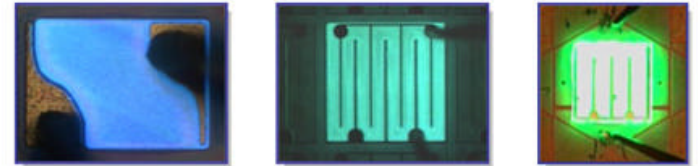


Benefits of LED backlighting

- 1) Long life (100k hrs.)
- 2) Vivid saturated colors
- 3) Solid-state devices
- 4) Dynamic color control
- 5) Mercury-free
- 6) No UV or heat in the light beam
- 7) Cold and quick start capable
- 8) Low-voltage DC operation

Concerns about LED backlighting

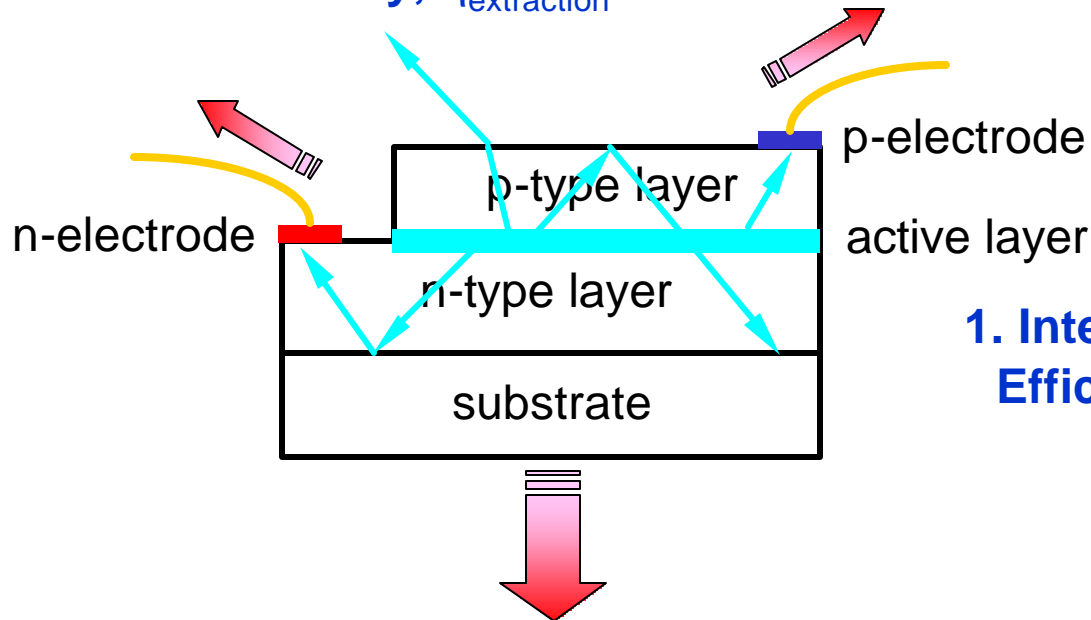
- Heat generation
- Color uniformity
- Distinct RGB decaying rate
- Power consumption
- High cost



Refractive index of GaN ~2.5

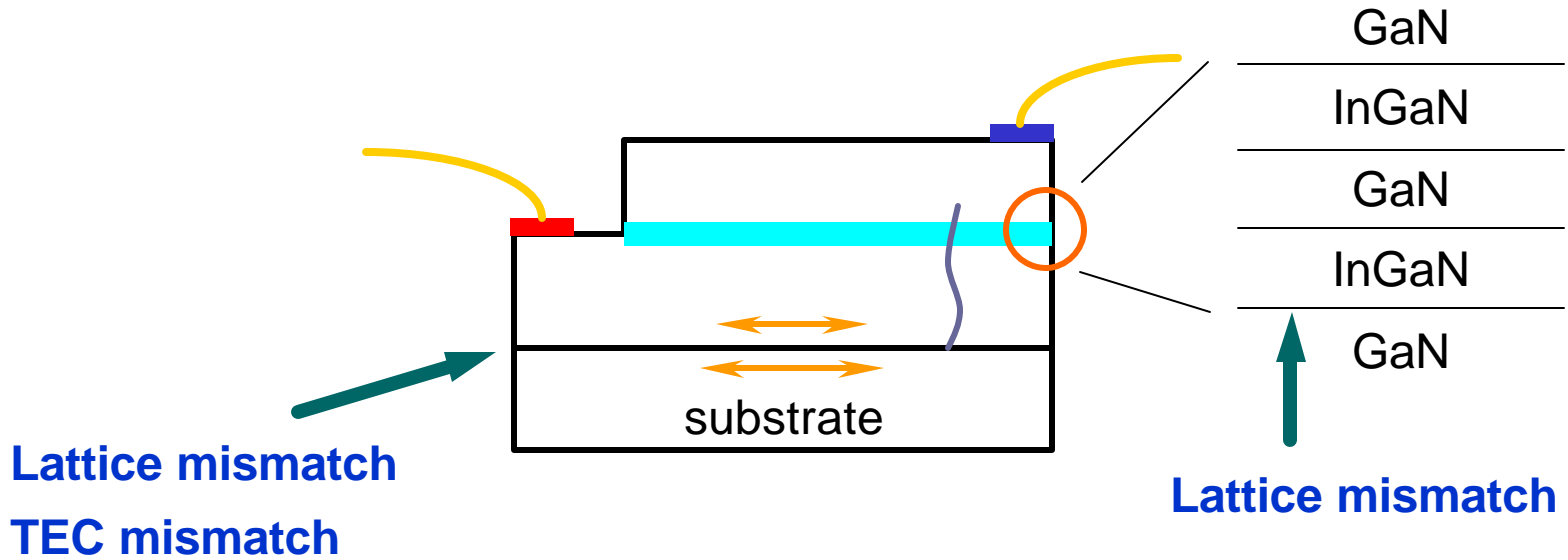
→ Critical angle ~24 °

2. Extraction efficiency, $\eta_{\text{extraction}}$

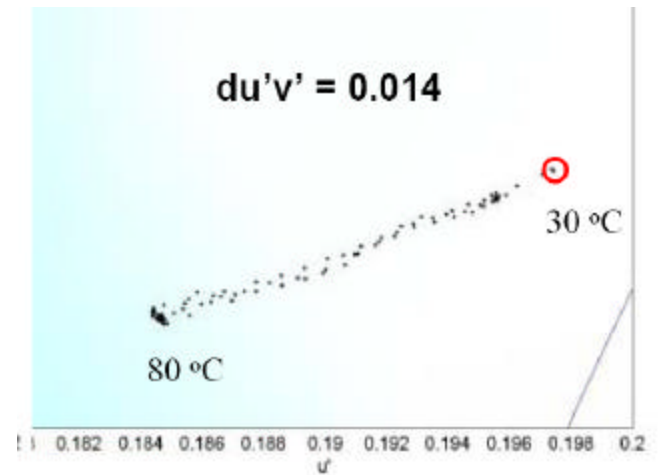
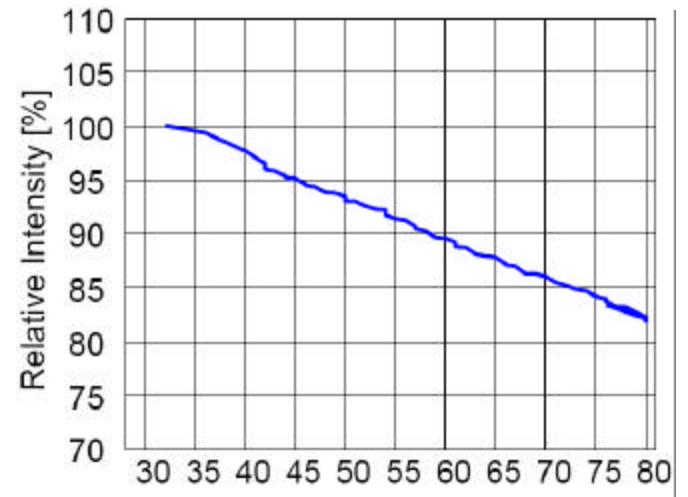
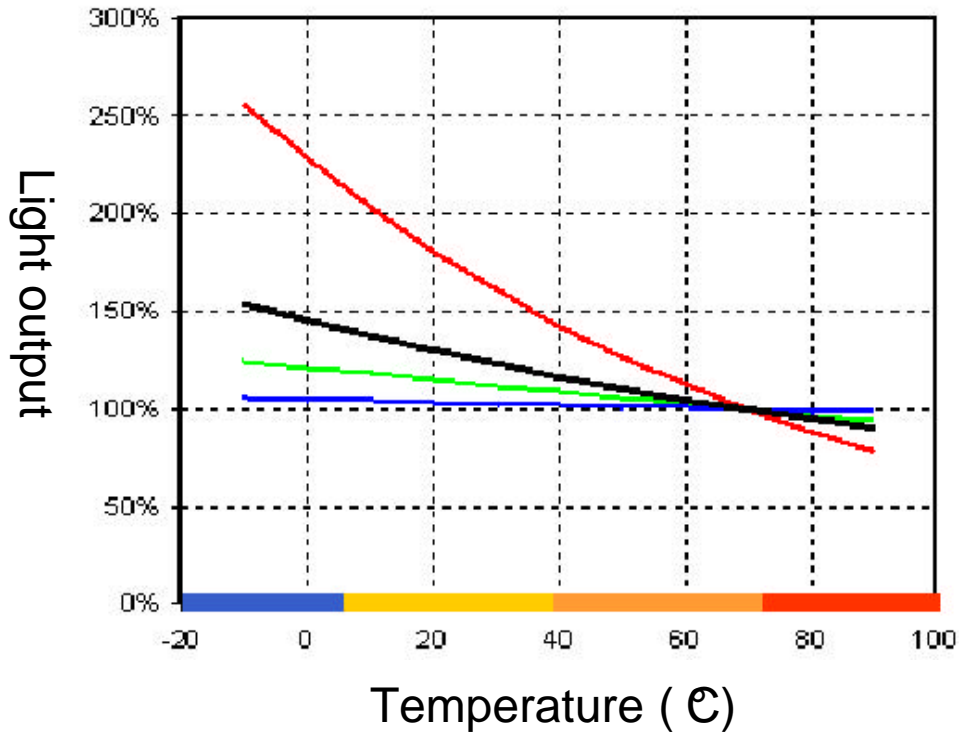


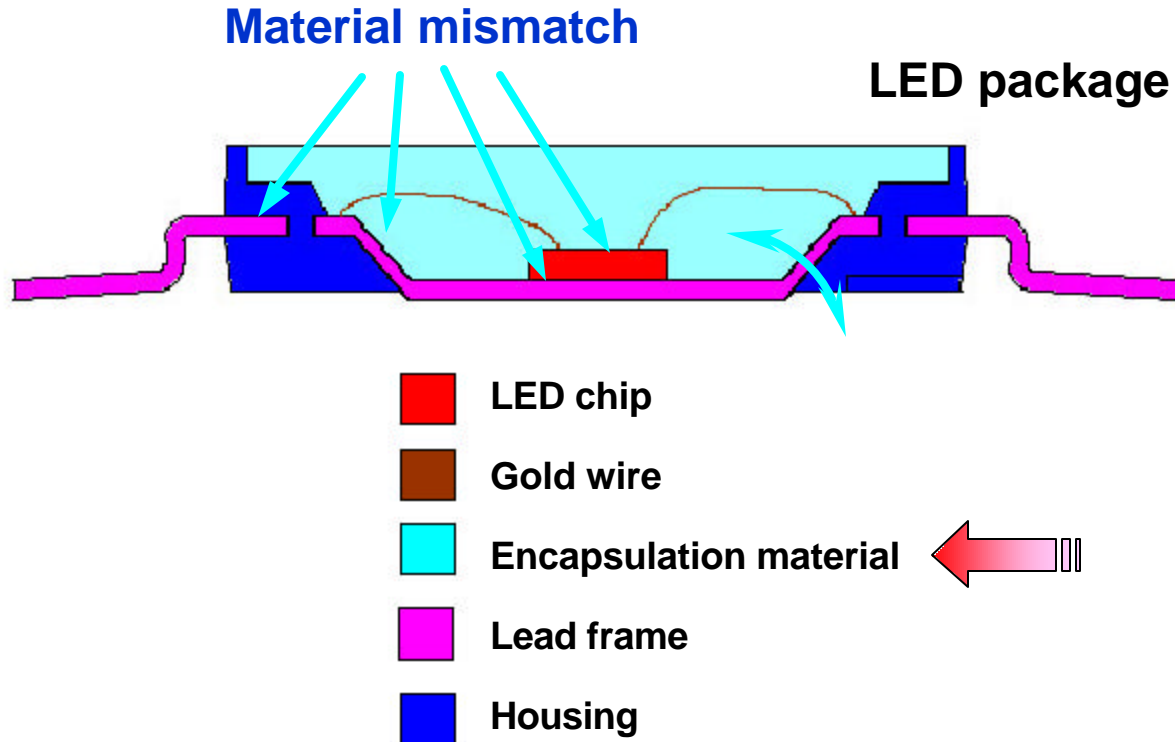
1. Internal Quantum Efficiency, η_{internal}

Since external quantum efficiency ($= \eta_{\text{internal}} \times \eta_{\text{extraction}}$) is poor, a lot of heat is generated.



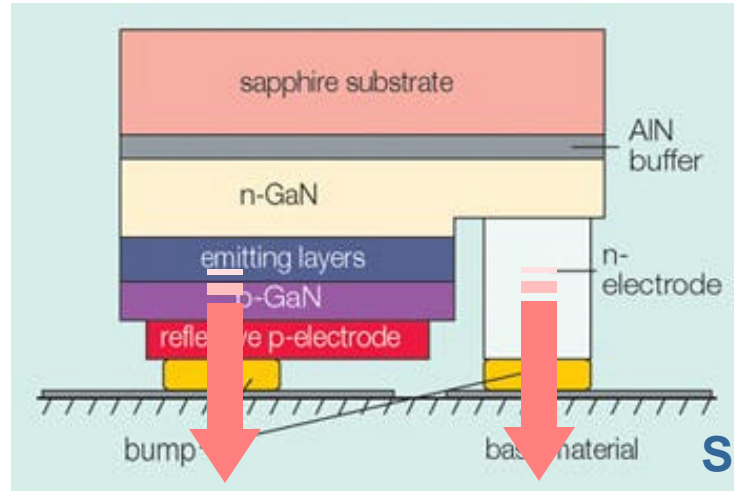
Material	GaN	Sapphire	SiC
Structure	Hexagonal	Hexagonal	Cubic
Lattice constant (Å)	3.189	4.758	5.431
Thermal expansion coefficient (10 ⁻⁶ /K)	5.59	7.5	3.59



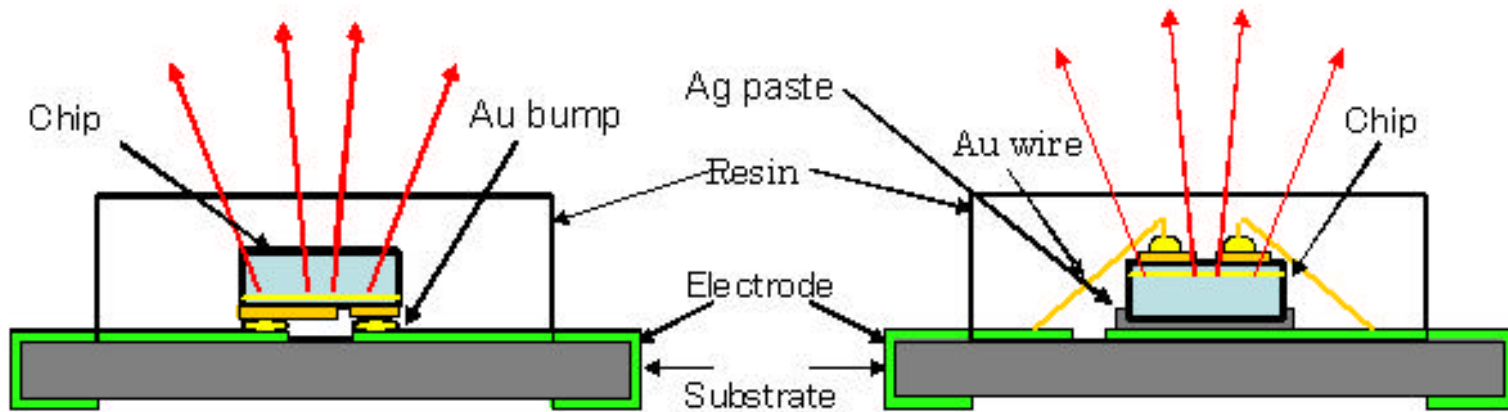


LED chip

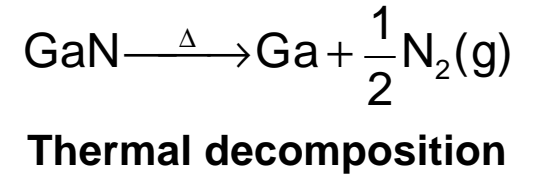
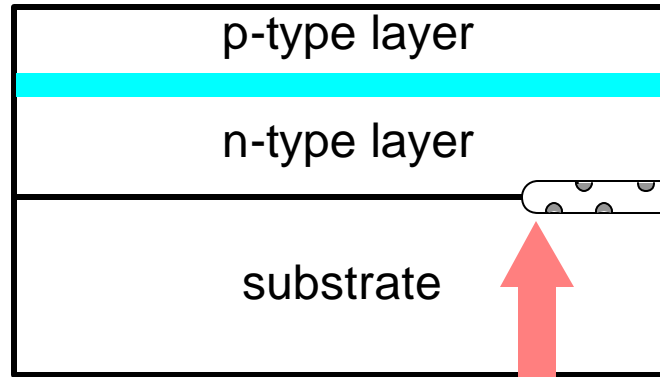
Flip-Chip



Si-Submount

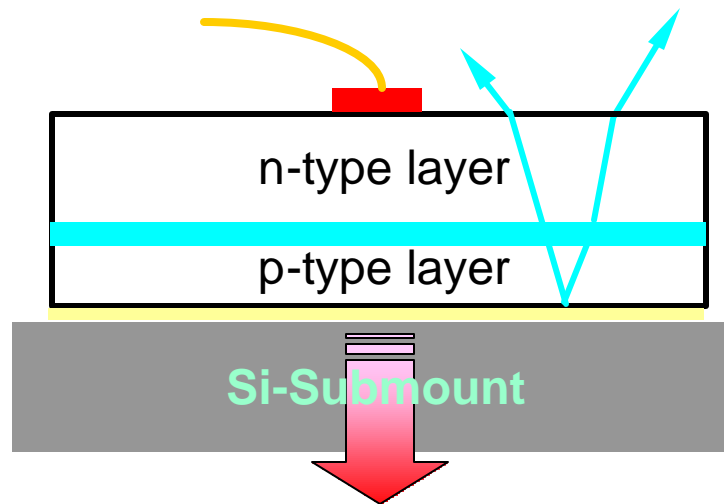


LED chip

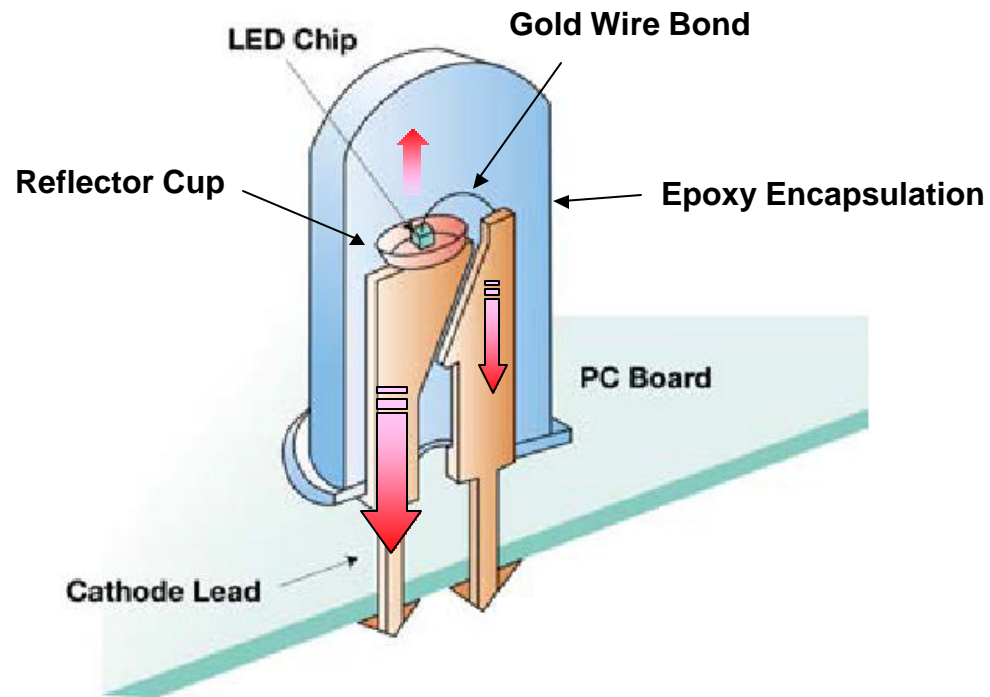


Laser lift-off

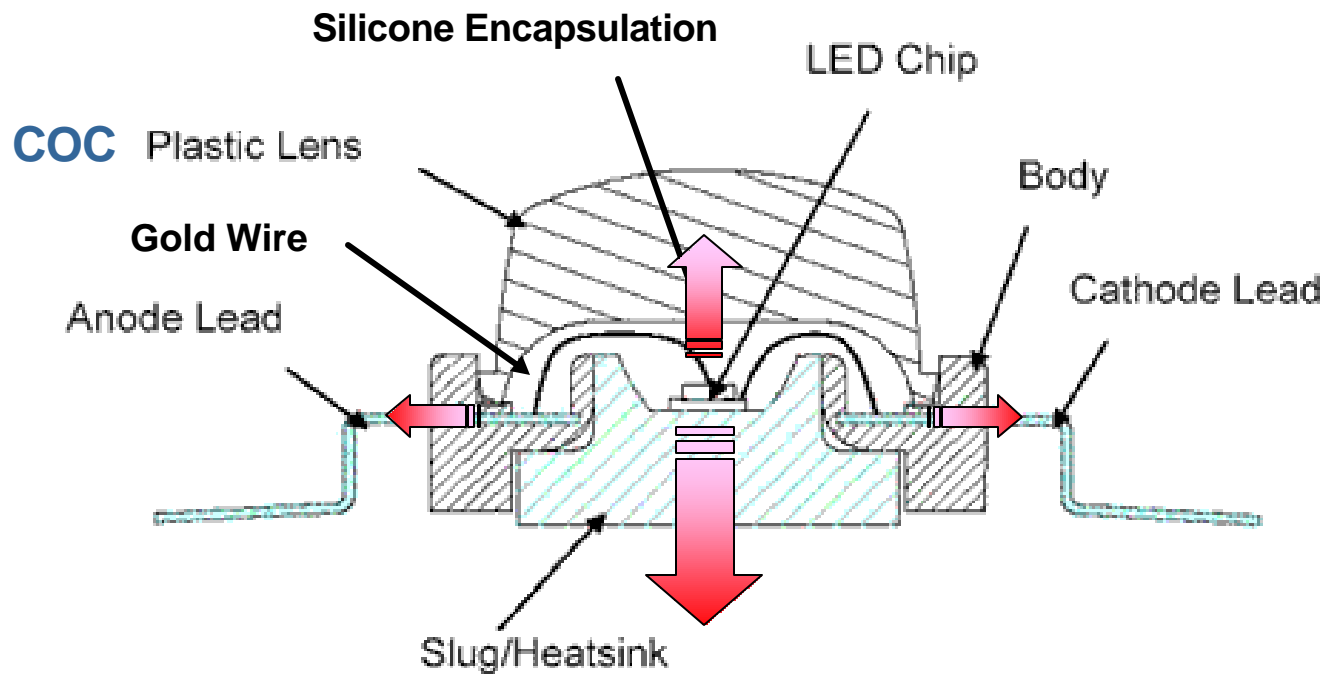
Thin-GaN



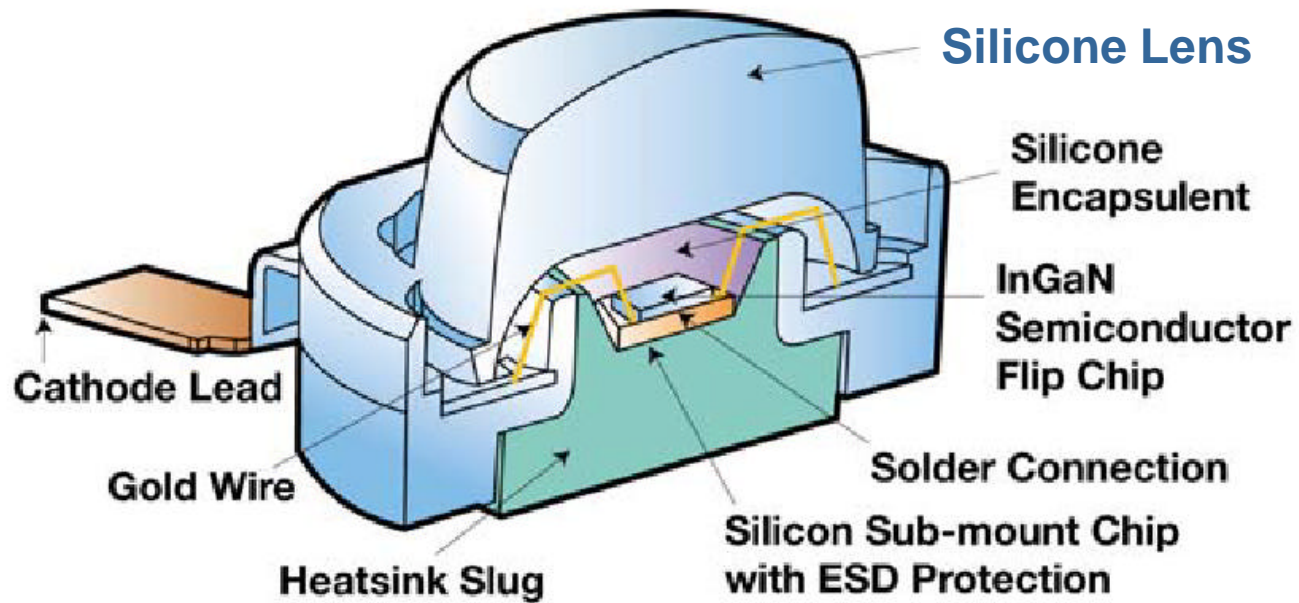
LED package

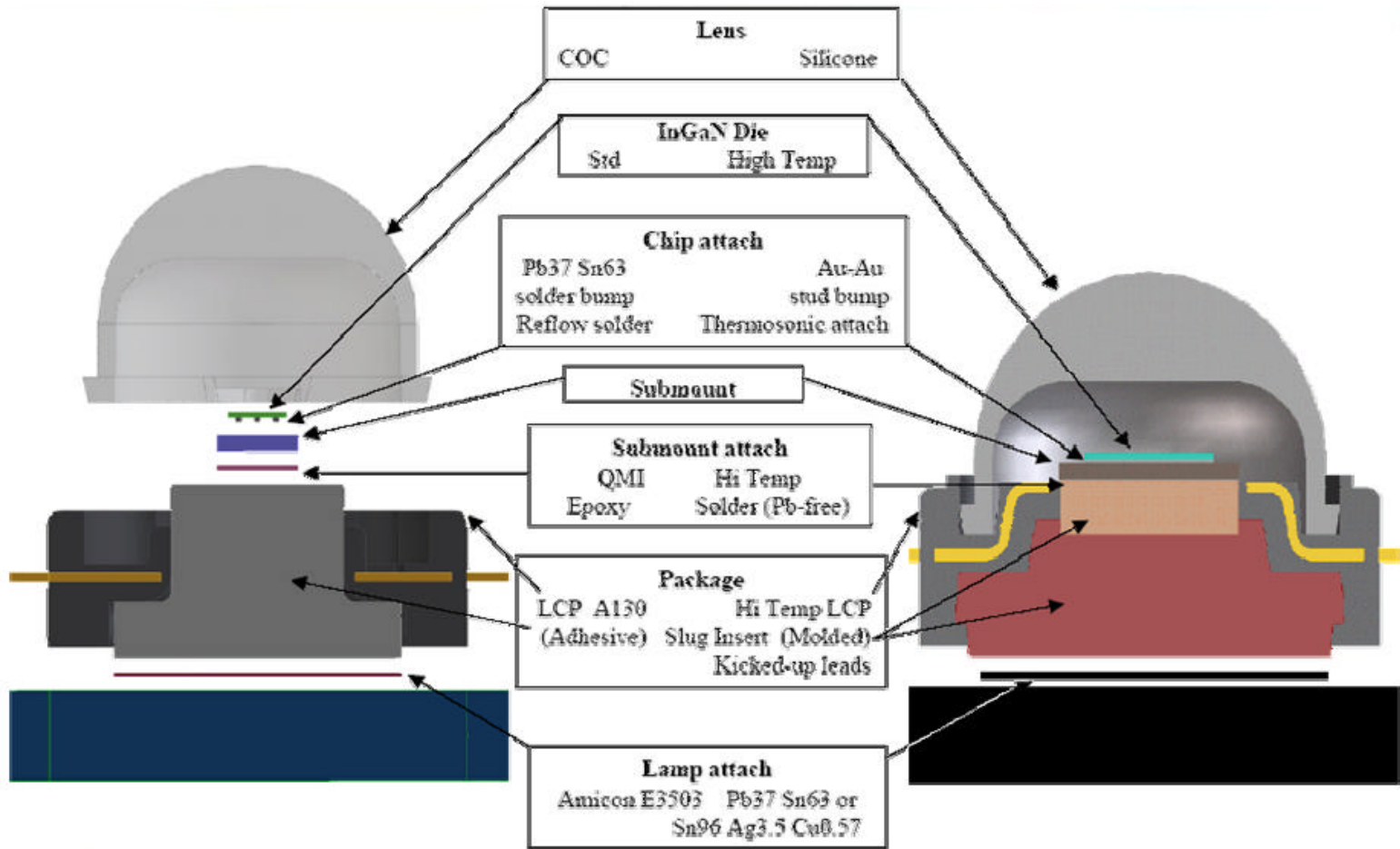


LED package

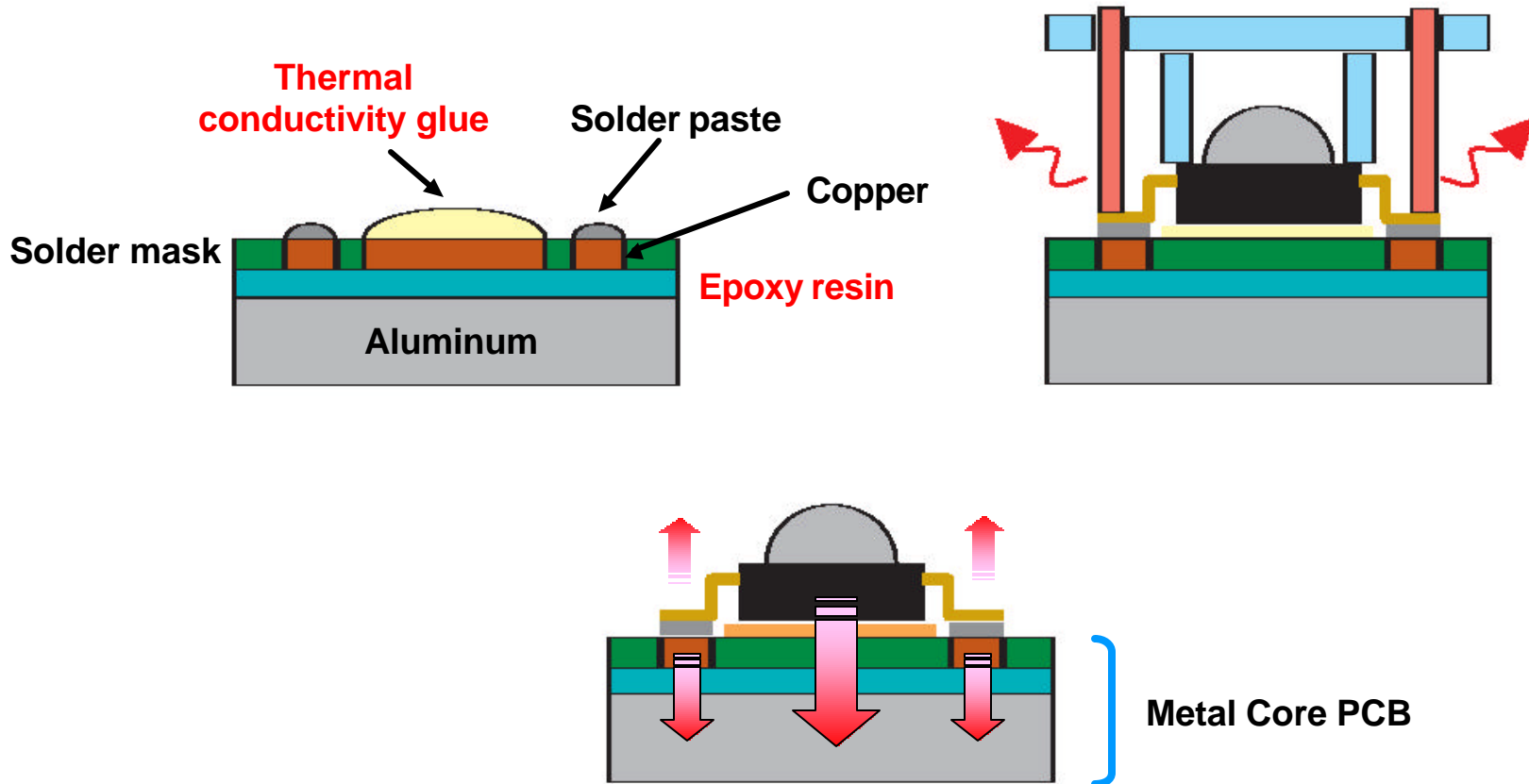


LED package

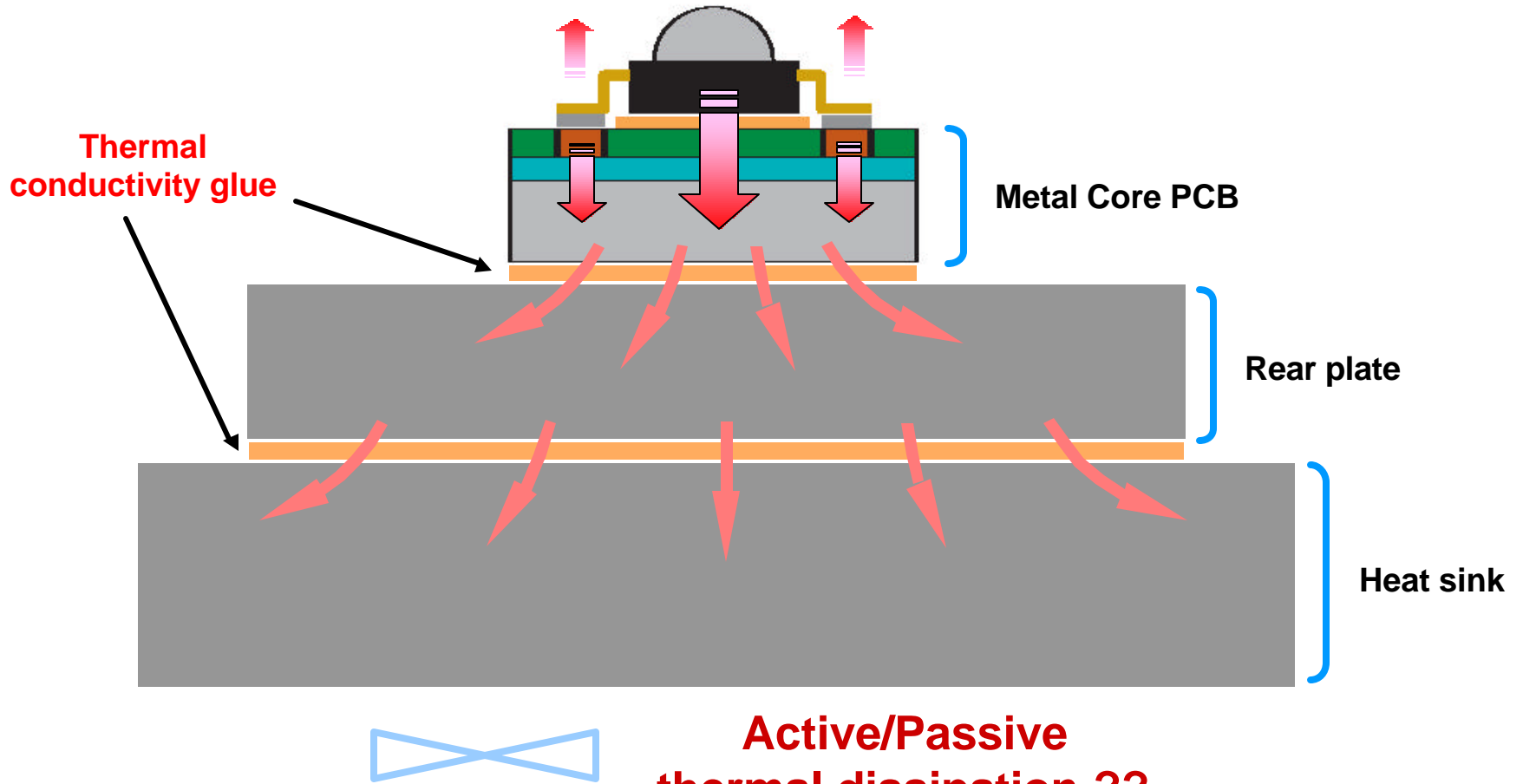




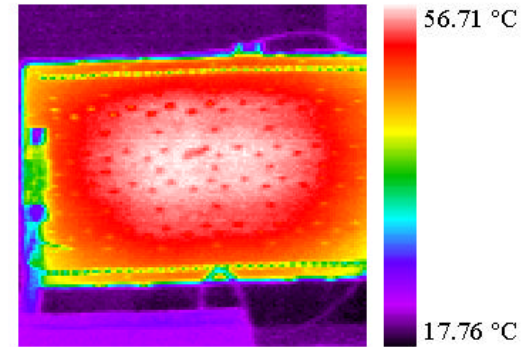
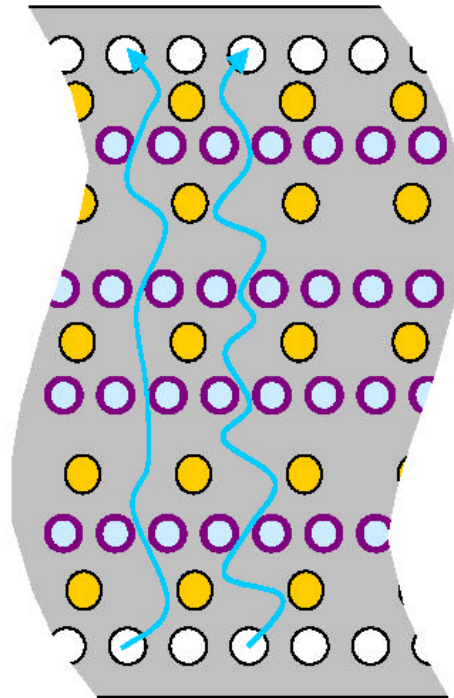
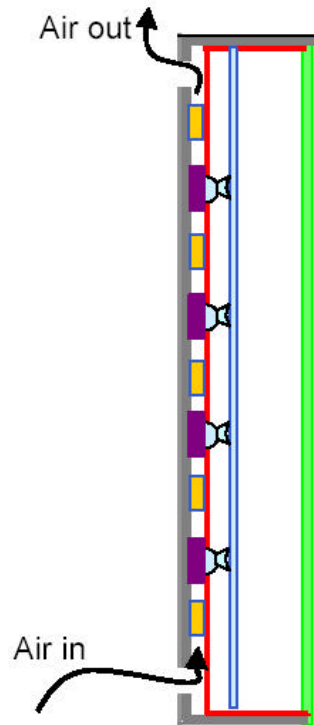
LED package-to-PCB



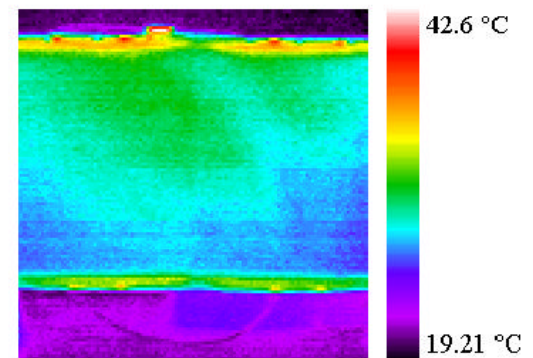
LED package-to-Module



TV-set System



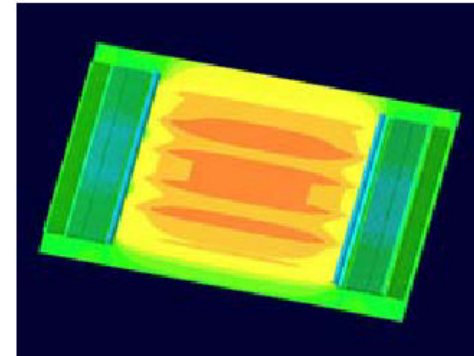
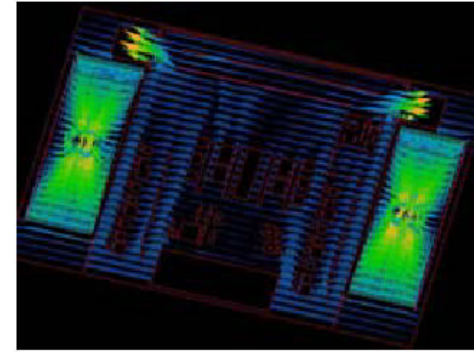
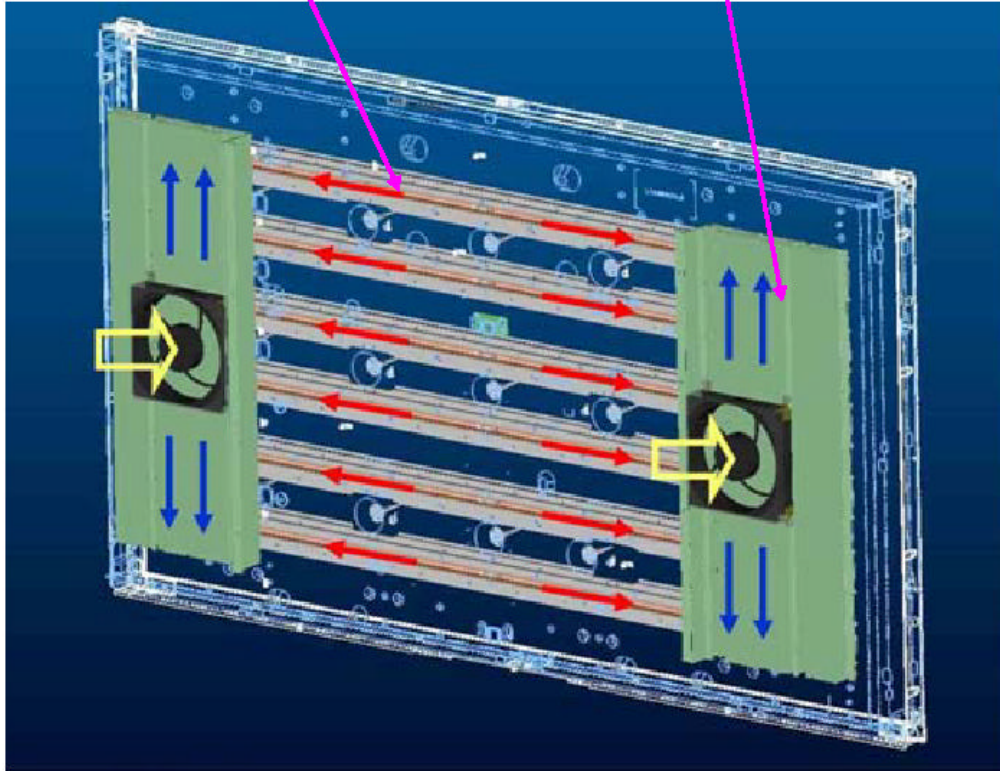
CCD image of back

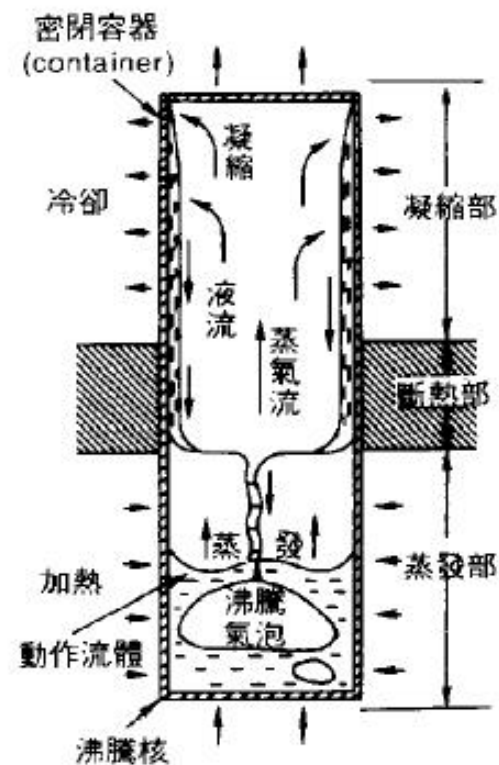
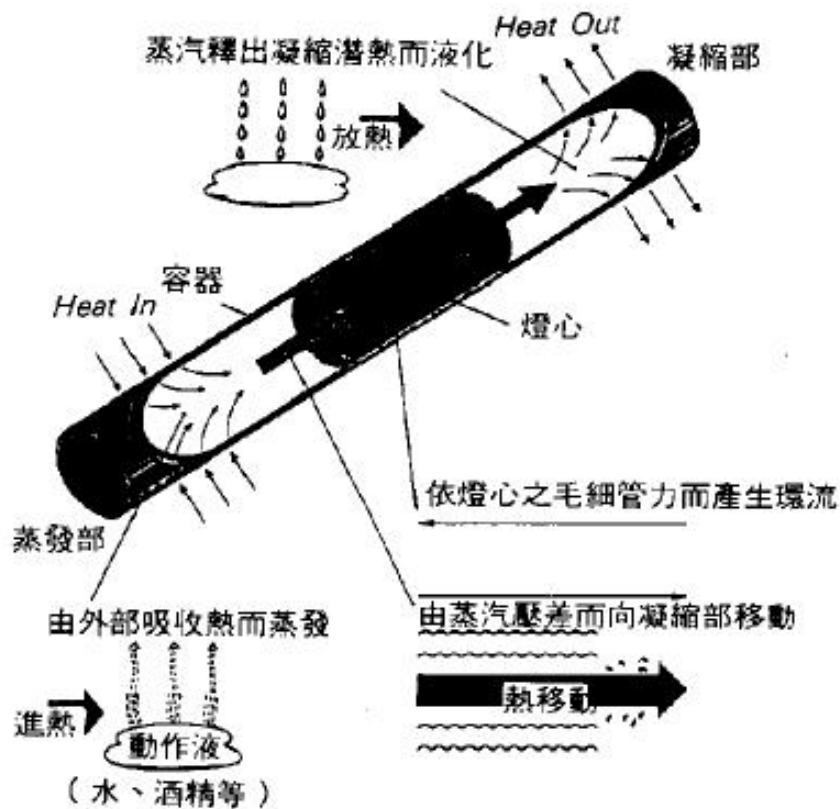


CCD image of front

Heat pipe

Heat sink







Thank You for Your Attention !!

