

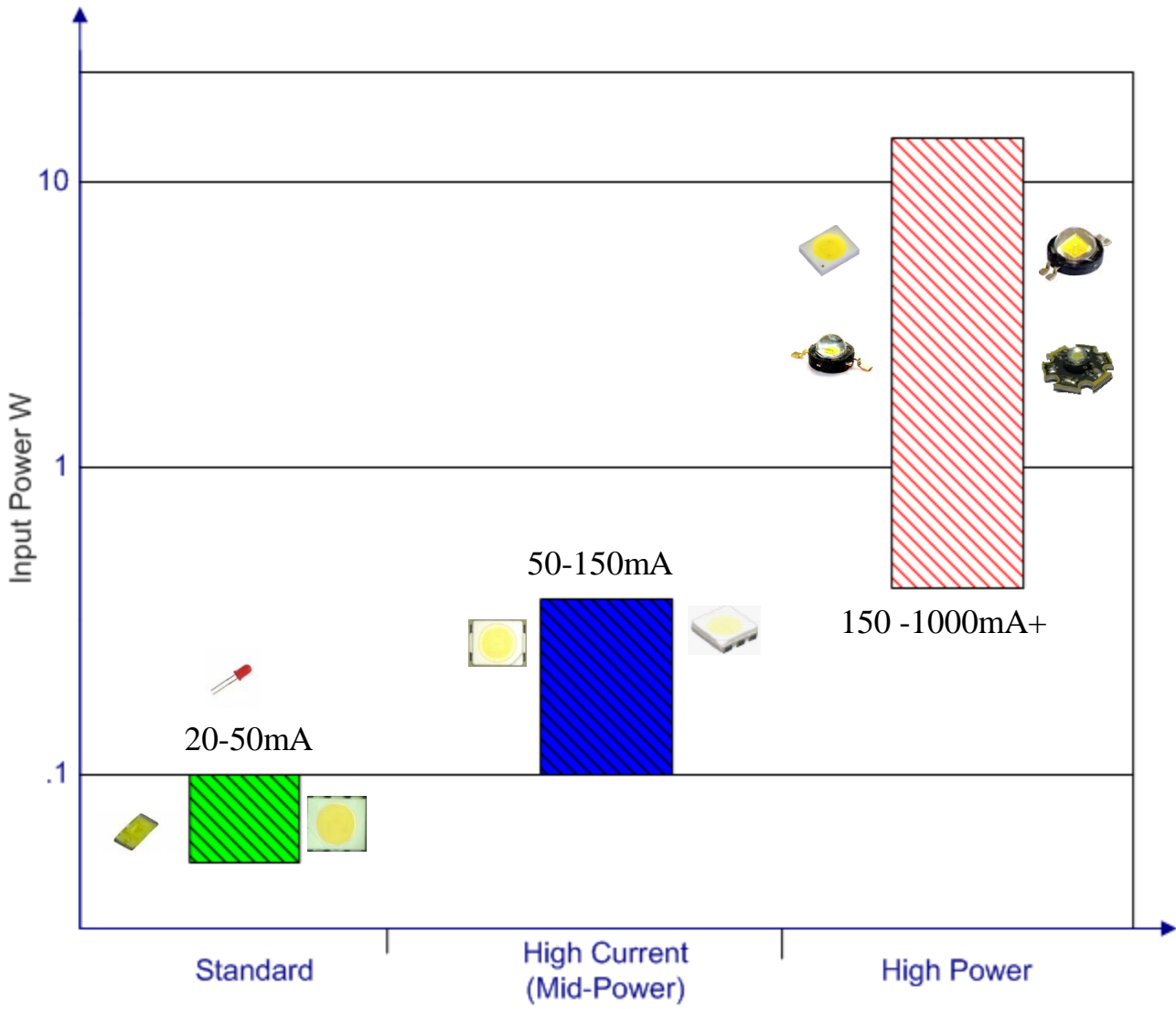
Seoul Semiconductor

Aug, 2011

- Agenda
 - Lighting Terminology
 - Solid State Lighting Concepts
 - Product Highlights – General Illumination

LED Lighting Terminology

Types of LEDs - Terminology



Standard LEDs

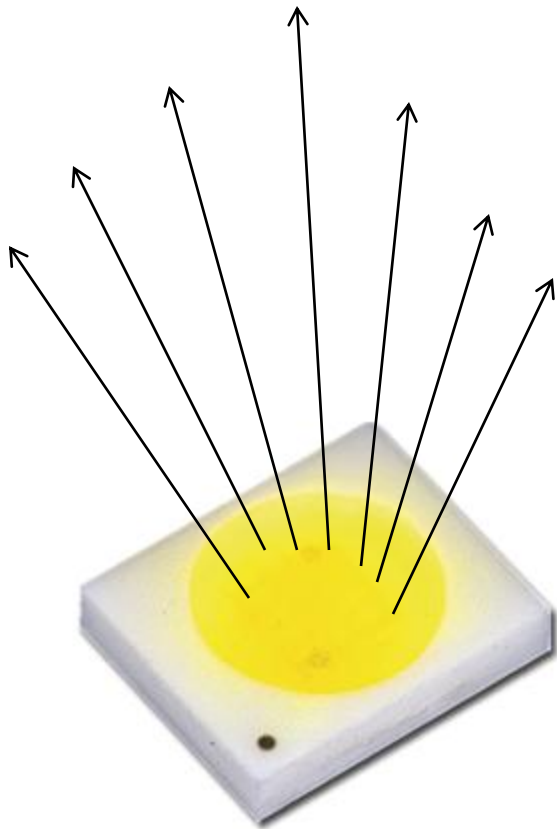
- Lamp LEDs
- Chip LED
- Top View LED
- Side View LED

Mid-Power

- Chip LED
- Top View LED (5630 / 5050)

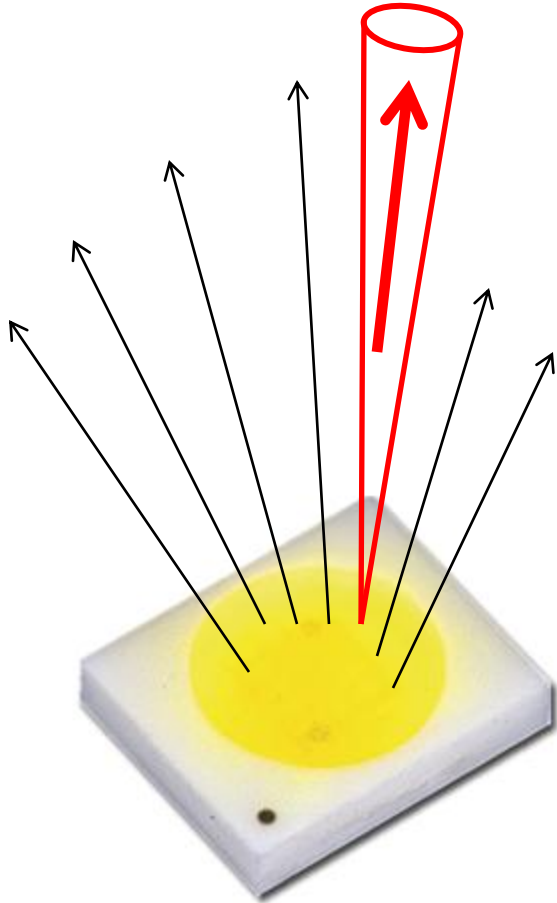
High Power

- Z1
- Acriche
- P4, P7, P5-II
- Z5, Z7



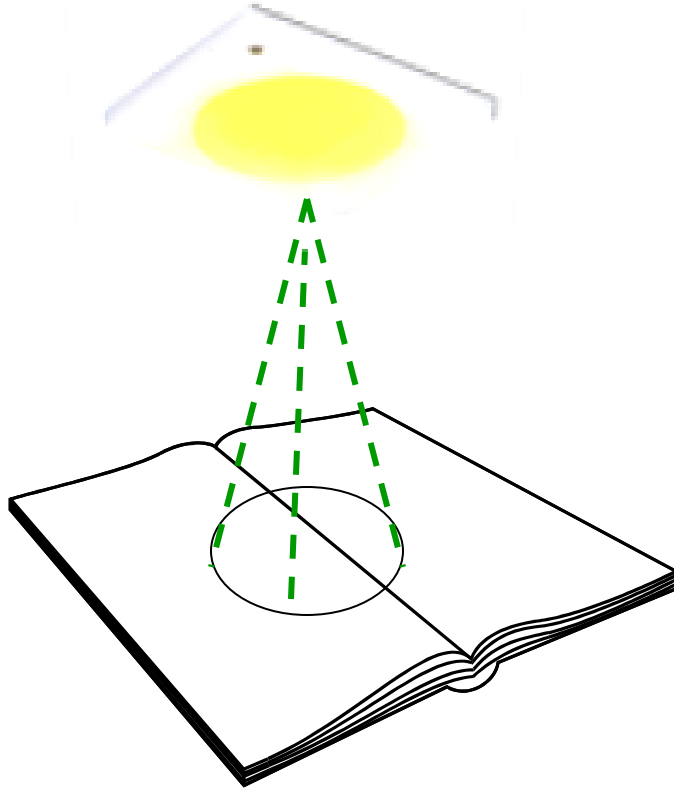
Luminous Flux (Flux) Φ

- ❑ Defined as the measure of the quantity of light. For a lamp, luminaire, or LED it refers to the total light emitted irrespective of the direction.
- ❑ Measured in an integrating sphere
- ❑ Units: Lumen (lm)
- ❑ Products measured by luminous flux
 - ❑ High Power LEDs (.5W and above)
 - ❑ Some mid-power (high current) LEDs
 - ❑ Lamps and Luminaires
- ❑ Commonly referred to as Light Output.
- ❑ Typical 100 Watt Incandescent Bulb = 1500lm



Intensity

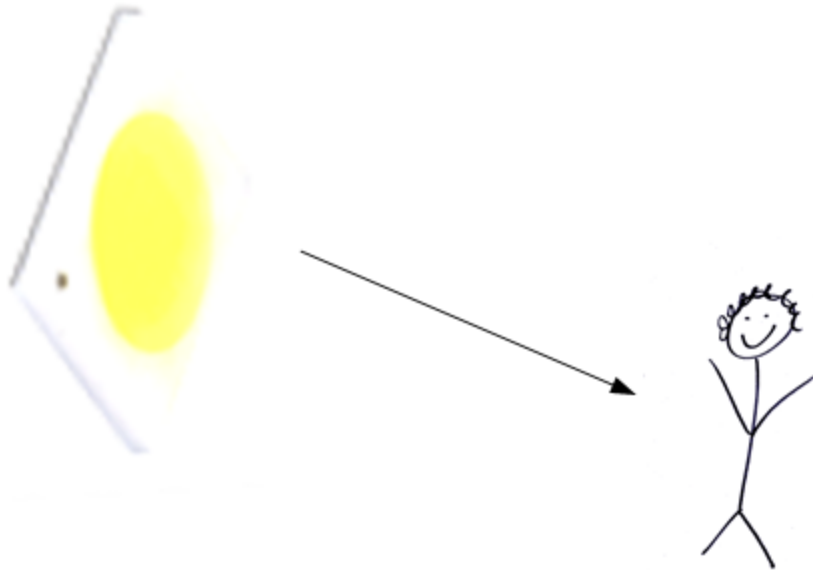
- ❑ Defined as the concentration of luminous flux emitted in a specified direction. Solid Angle.
- ❑ Units: Candela (cd), Millicandela (mcd)
- ❑ Products measured by luminous flux
 - ❑ Standard and Mid-Power LED
 - ❑ Lamps and Luminaires
- ❑ Function of Luminous Flux and Viewing Angle



Illuminance

- Defined as the light arriving at a surface, expressed in lumens per unit area; 1 lumen per square foot equals 1 foot-candle, while 1 lumen per square meter equals 1 lux.
- Units: lux (lm/m^2)
foot-candles (lm/ft^2)
- Products measured in Illuminance
 - Lamps and Luminaires (height is specified)

Luminance



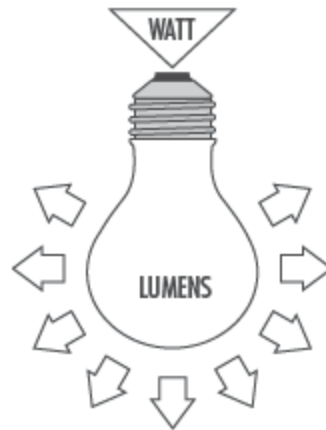
- Defined as the measure of the amount of light being emitted or reflected off a particular surface. This is the photometric quantity that our eyes react to and therefore governs our perception of brightness
- Units: cd/m^2 (nits), cd/ft^2 (foot Lamberts)
- Products measured in Luminance
 - BLU

Secondary Optics

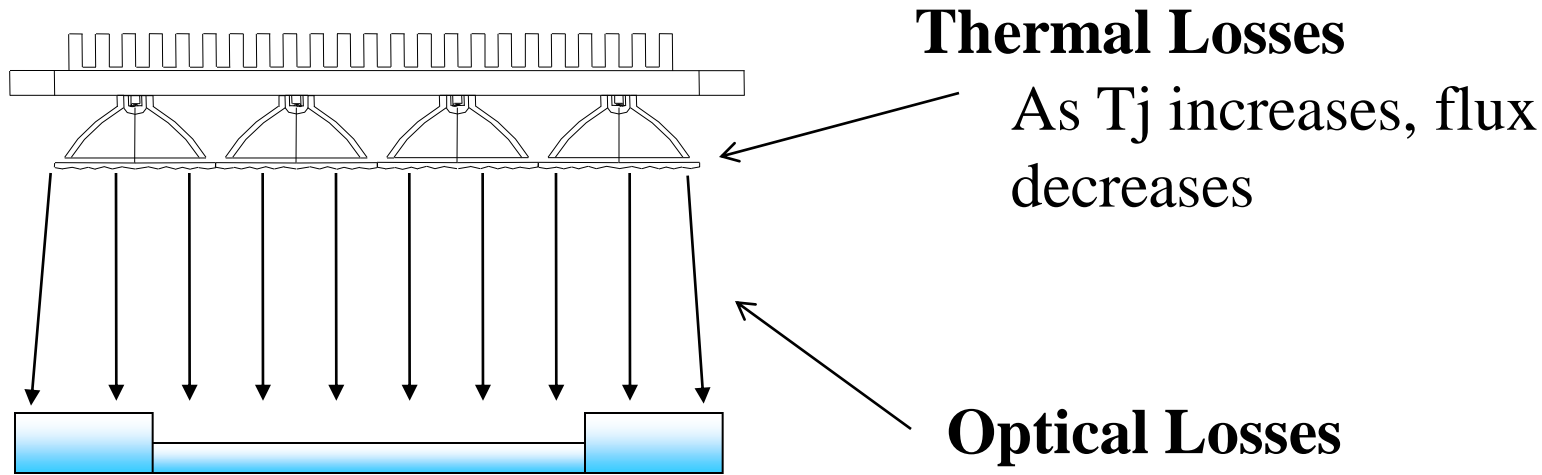


- ❑ No matter how many lumens are available in the LED, if they cannot be delivered effectively where needed, they serve no useful purpose
- ❑ Units: Angle
- ❑ Optic types
 - ❑ Simple lens
 - ❑ Reflectors
 - ❑ TIR optics (most popular)

- Luminous Efficacy (Efficacy)
 - The quotient of the luminous flux emitted by a source of radiation and the power it consumes, measured in lumens per watt (lm/W).



- ❑ System Efficiency (Efficiency)
 - Total system lm/W after thermal and optical inefficiencies.



Thermal Losses

As T_j increases, flux decreases

Optical Losses

Every time photons are “touched” there is loss

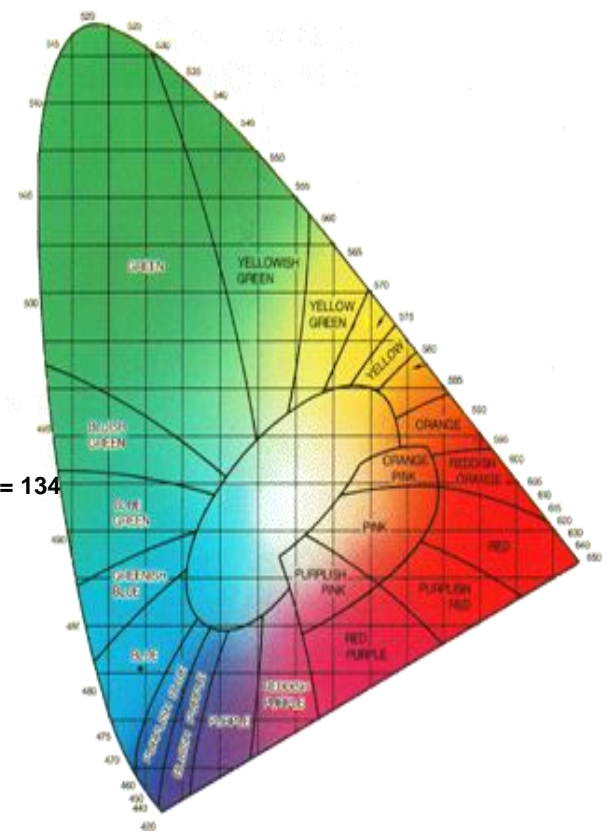
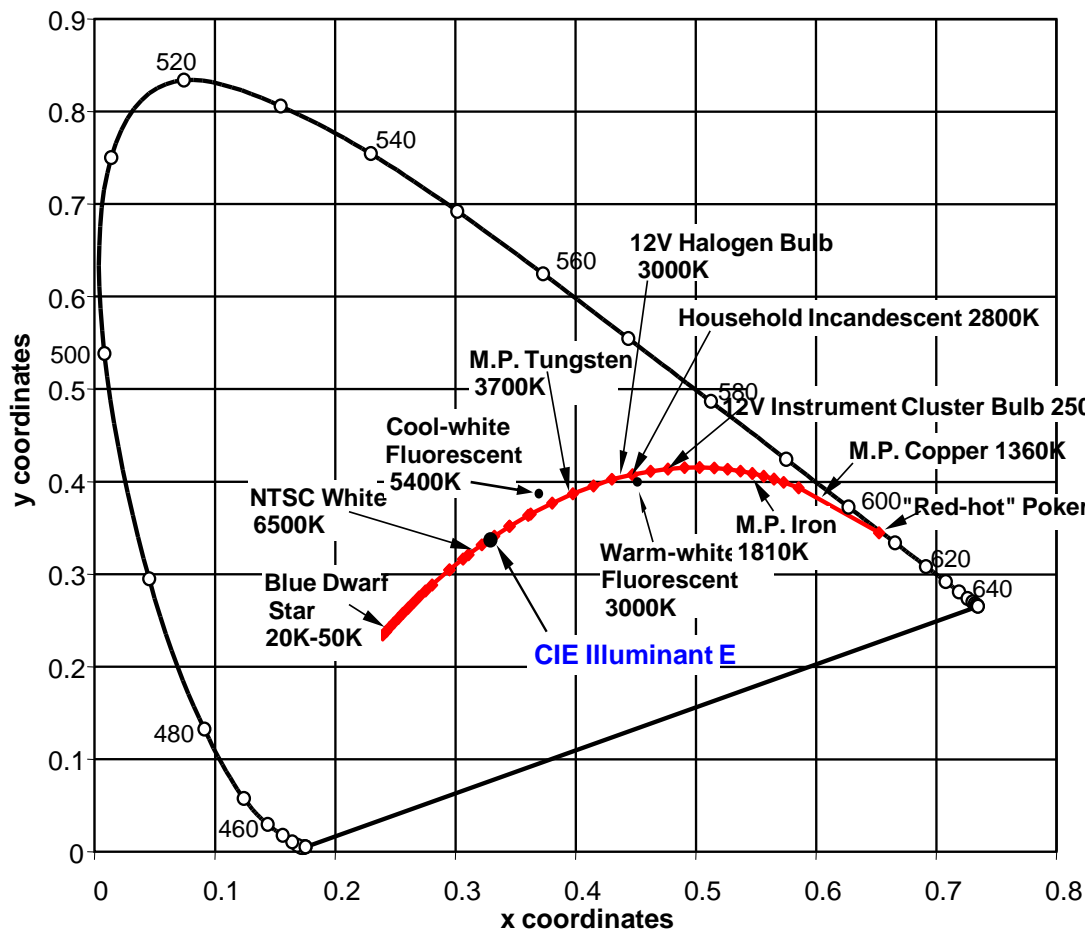
Example:

Luminous Efficacy = 80 lm/W

20% thermal loss, 15% optical loss

System Efficiency = 52 lm/W

CIE Color Chart – Planckian Curve



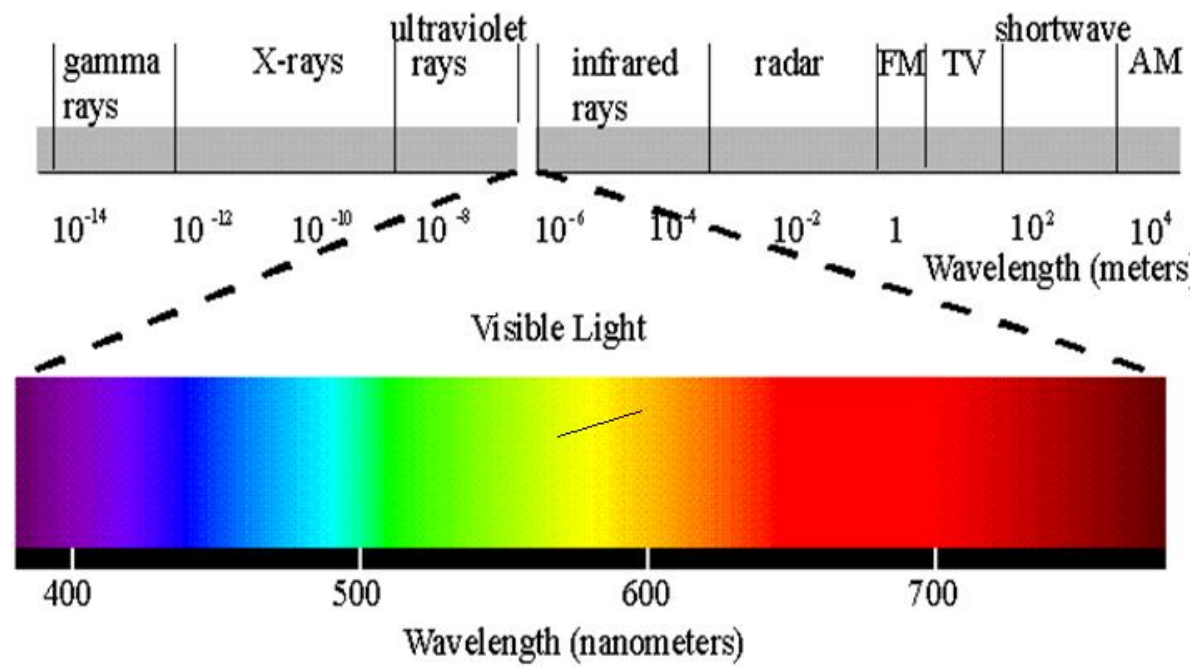
- **Color Temperature**
 - Characteristic of visible light that has important applications in lighting. The color temperature of a light source is determined by comparing its chromaticity with that of an ideal black-body radiator on the Planckian Curve
- **Correlated Color Temperature**
 - Nearly-Planckian light sources (LED's, Fluorescent) can be judged by their *correlated* color temperature (CCT); the color temperature of the Planckian black-body radiator that best approximates them.
 - Terms are often used interchangeably.

- **Pure White (Cool White)**
 - Refers to LED's with CCT of 4500 to 10000K

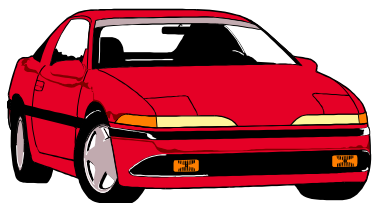
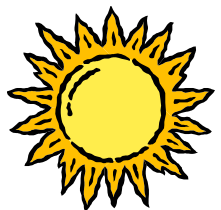
- **Natural White (Neutral White)**
 - Refers to LED's with CCT of 3500 to 4500K

- **Warm White**
 - Refers to LED's with CCT of 2650 to 3500K

- **Color**
 - a visual attribute of things that results from the light they emit or transmit or reflect
 - Units: Wavelength (nm)



- Color Rendering Index (CRI)
 - describes the effect of a light source on the color appearance of objects, compared to a reference (incandescent) source of the same correlated color temperature (CCT).

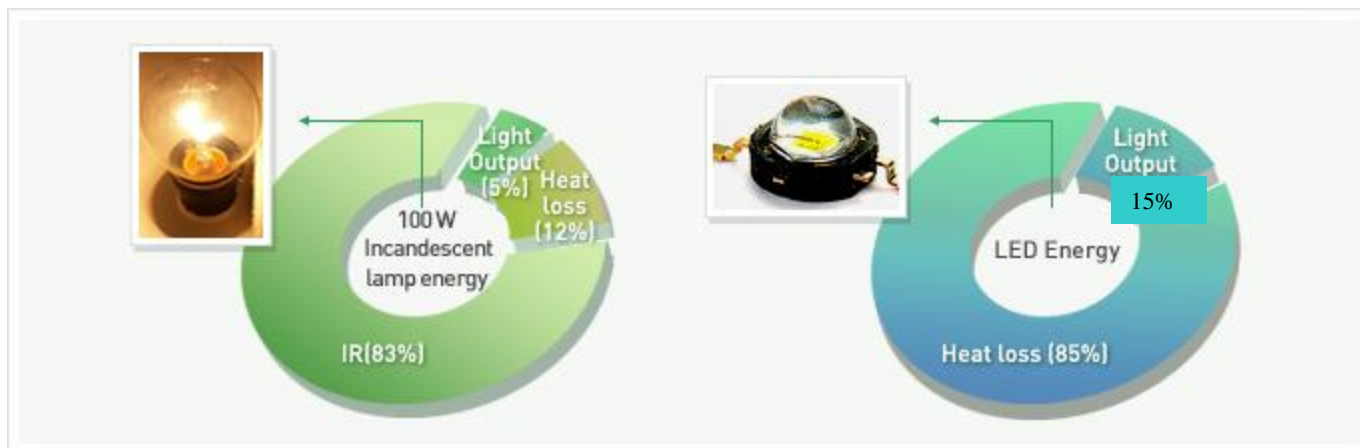


Sunlight Has a CRI of 100. When objects are illuminated with sunlight, all the colors look good

Light Source	Typical CRI
Tungsten incandescent	100
Tungsten halogen	100
Seoul Semiconductor Warm White	80-90
Seoul Semiconductor Pure White	70-80
SSC High CRI Top View	90+
T12 fluorescent tubes	75-85
T8 fluorescent tubes	75-85
Metal halide	70
High-pressure sodium	22
Low-pressure sodium	5

□ Thermal Resistance

- An indication of how effectively a unit rids itself of heat; a measure of temperature rise per watt; analogous to electrical resistance.
- Thermal resistance for an LED is used to determine the difference in temp between the package (heat slug) and the die (T_j-s).



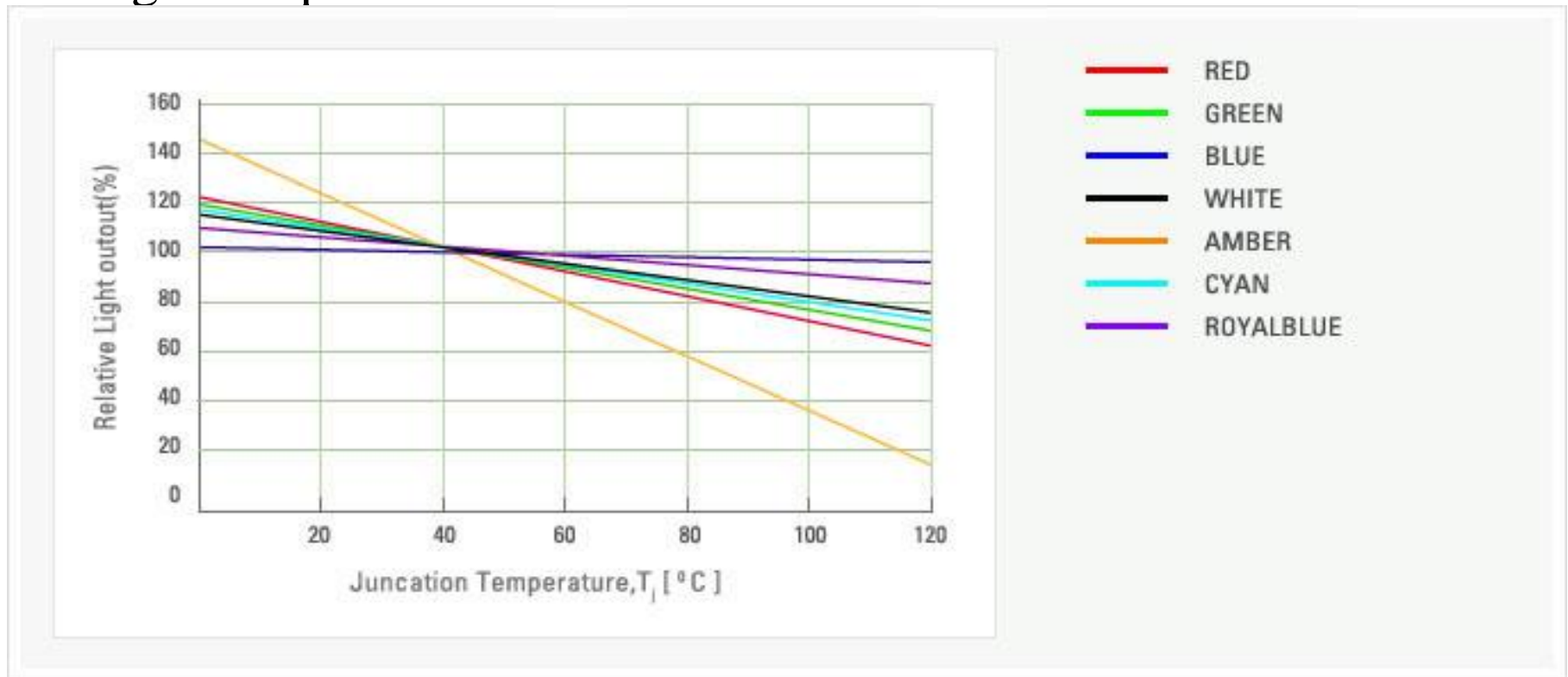
Solid State Lighting Concepts

- In LED's most of the electrical energy is converted into heat
 - Excessive heat will affect performance and lifetime
 - Overheating can cause permanent damage to the component
 - Heat has to be transferred to ambient (surrounding air)
 - Heat transfer from LED takes place primarily via conduction.

- An effective Thermal Management System conducts the heat from the LED die to ambient to minimize the T_j and maximize life.

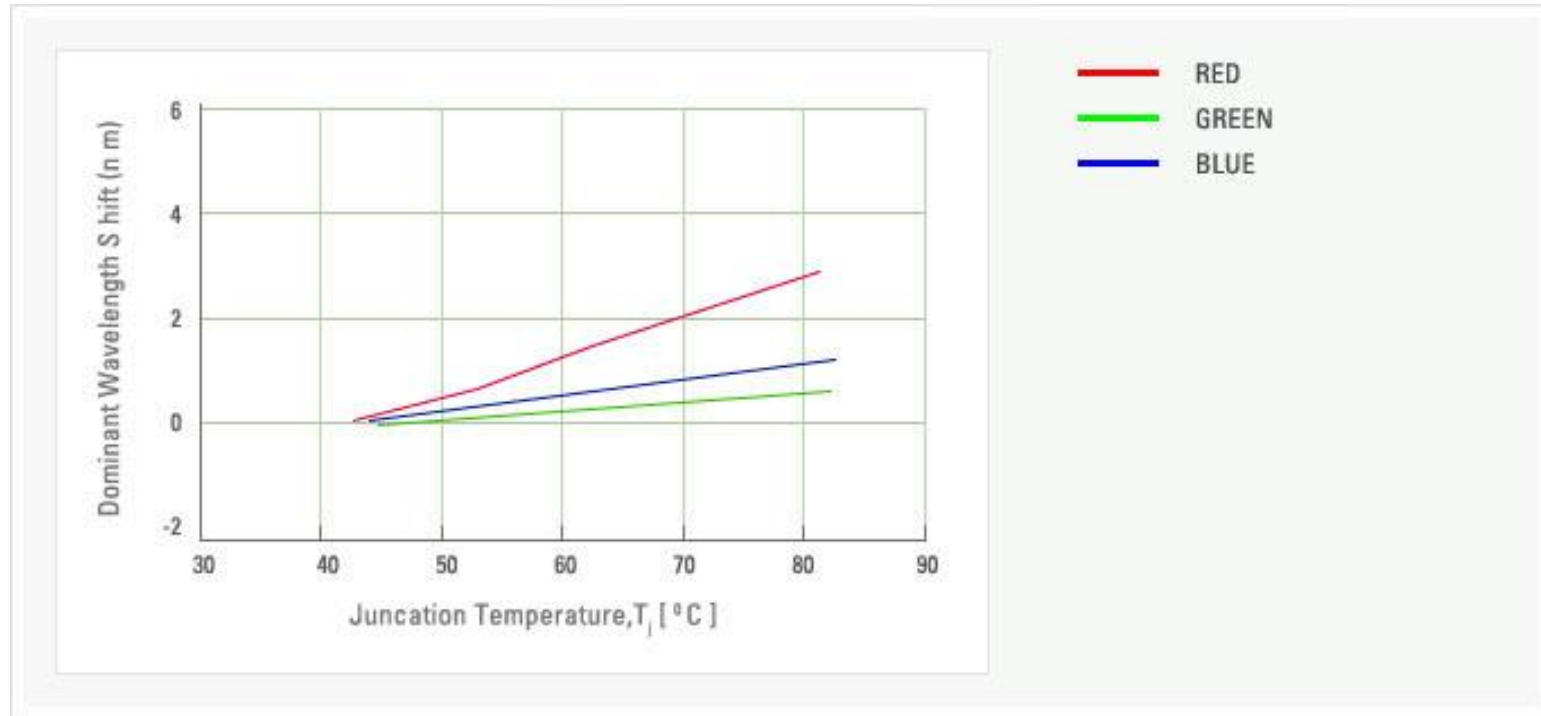
As temperature **rises**:

- Light Output decreases

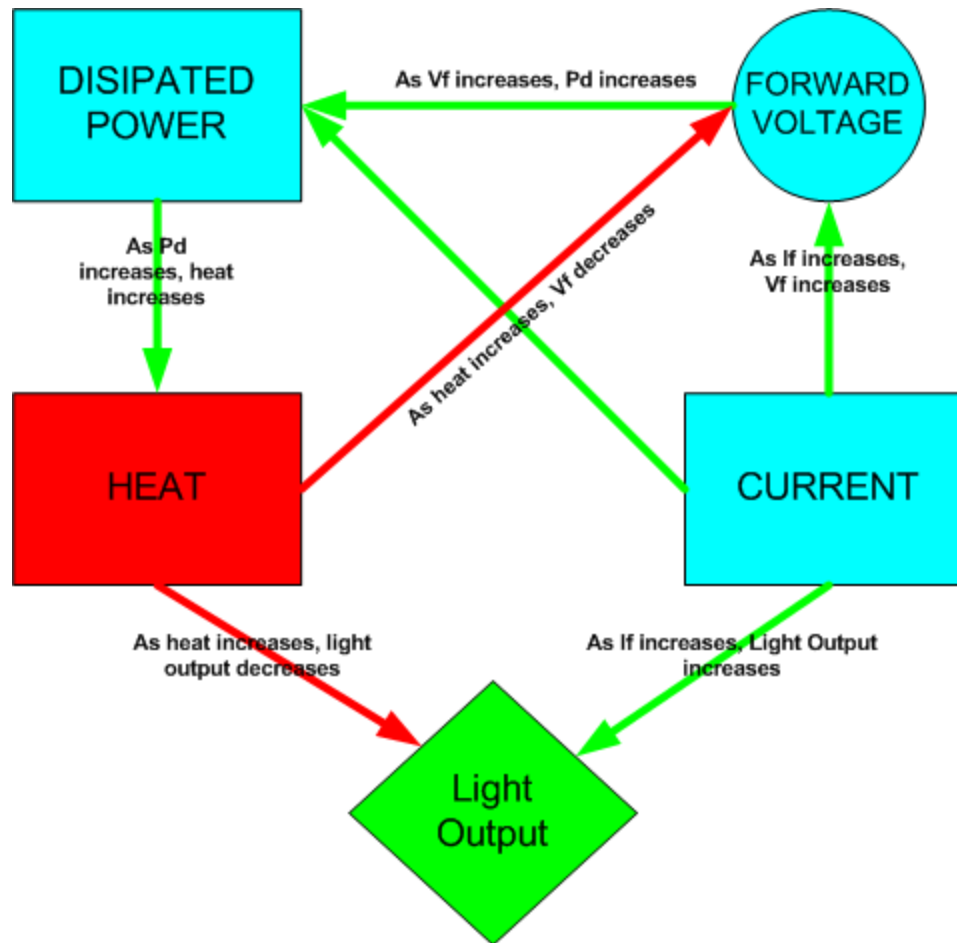


As temperature **rises**:

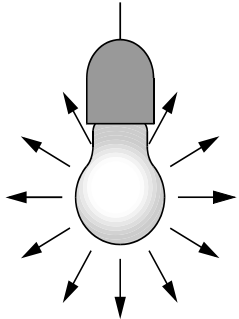
- Wavelength increases (towards red)



Interactions of current, heat and Vf and their effect on Light Output.

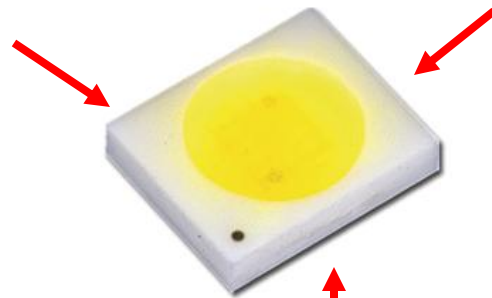


3 Variables

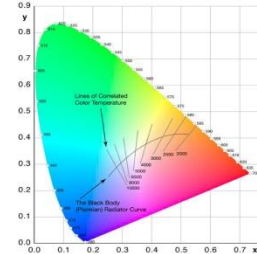


Luminous Flux (Lumens, lm)

Radiometric Power (MW)



Forward Voltage (V_f)



Color

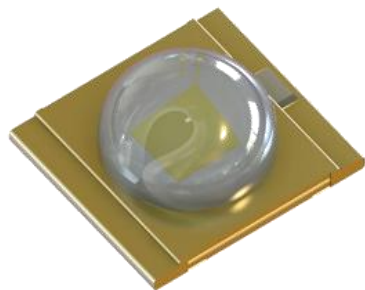
Whites LEDs

Correlated Color Temperature (Kelvin, CCT & x,y coordinates)

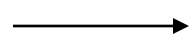
Colored LEDs

Dominant Wavelength (nm)

Understanding Binning



Finished LED

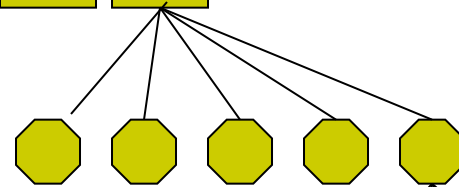


100% test

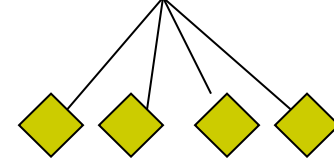
- Flux, Color, Vf
- Each LED sorted into like reels or bags and Labeled by bin



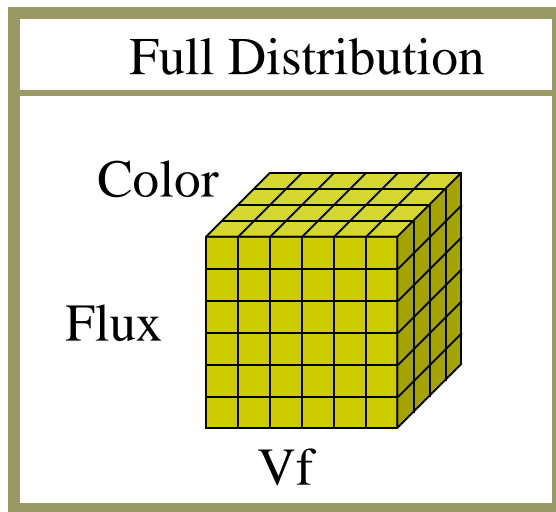
Flux binning



Color binning



Vf binning



1. Luminous Flux Bins

- Luminous flux bin structure for pure white, warm white, blue, cyan, green, amber and red Z-Power.

Bin Code		Luminous Flux [lm]
J		6 ~ 8.5
K		8.5 ~ 11.0
L		11.0 ~ 14.5
M		14.5 ~ 19.0
O		19.0 ~ 24.5
P		24.5 ~ 32.0
Q		32.0 ~ 41.5
R		41.5 ~ 54.0
S	S1	54.0 ~ 60.0
	S2	60.0 ~ 70.0
T	T1	70.0 ~ 80.0
	T2	80.0 ~ 91.0
U	U1	91.0 ~ 100.0
	U2	100.0 ~ 118.5
V		118.5 ~ 154.0
W		154.0 ~ 200.0
X		200.0 ~ 260.0
Y		260.0 ~ 340.0

2 -1 Blue, Green, Amber, Red

Bin Code	Color	Dominant Wavelength [nm]
BB1	Blue	455 ~ 460
BB2		460 ~ 465
BB3		465 ~ 470
BB4		470 ~ 475
GG1	Green	520 ~ 525
GG2		525 ~ 530
GG3		530 ~ 535
AA1	Amber	585 ~ 587.5
AA2		587.5 ~ 590
AA3		590 ~ 592.5
AA4		592.5 ~ 595
RR1	Red	618 ~ 625
RR2		625 ~ 632

Example: Z-Power Series

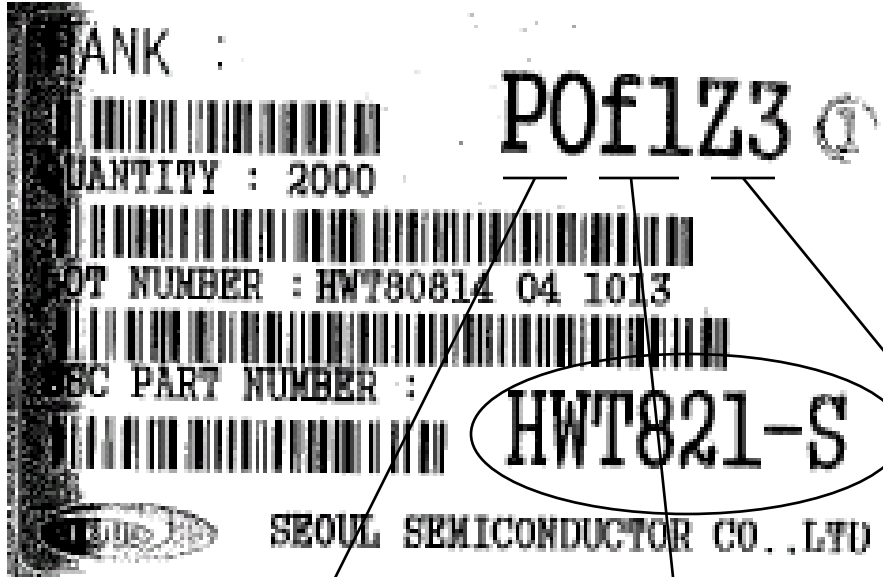
3. Code Labeling

- X_{10} : Luminous flux (or Radiant flux for royal blue)
- $X_{11} X_{12} X_{13}$: Dominant wavelength (or x,y coordinates rank code)
- X_{14} : Forward voltage

3. Forward Voltage Bins

Bin Code	Forward Voltage [V]
D	2.00 ~ 2.25
E	2.25 ~ 2.50
F	2.50 ~ 2.75
G	2.75 ~ 3.00
H	3.00 ~ 3.25
I	3.25 ~ 3.50
J	3.50 ~ 3.75
K	3.75 ~ 4.00
L	4.00 ~ 4.25
M	4.25 ~ 4.50

Reading B&L Documents



Sample Shipping Label

P/N HWT821-S

Forward Voltage Bin

Z3

Flux Bin

P0

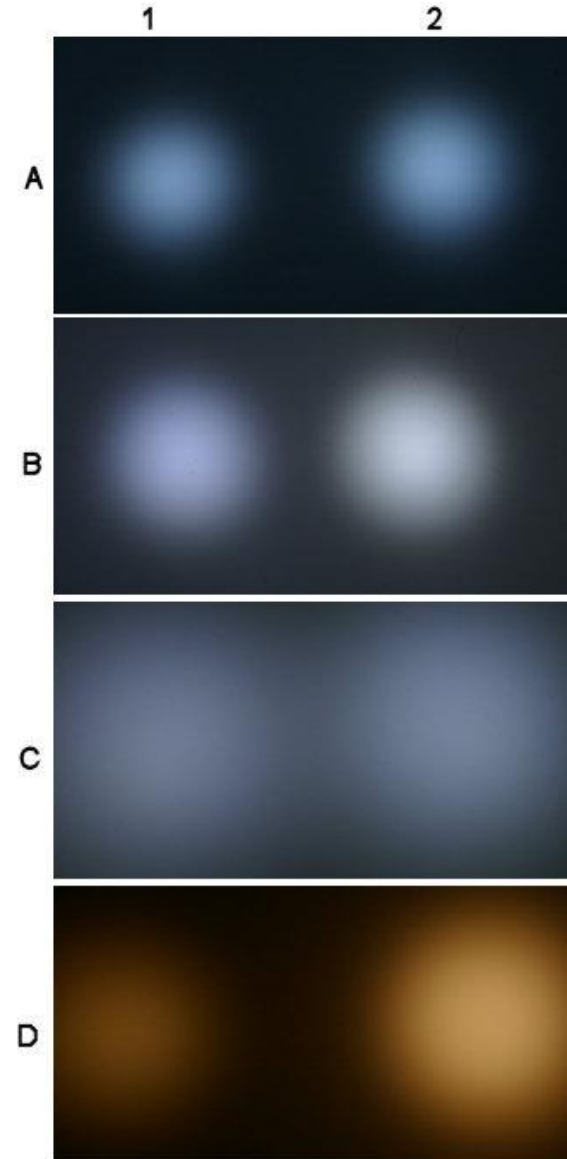
Color Bin

f1

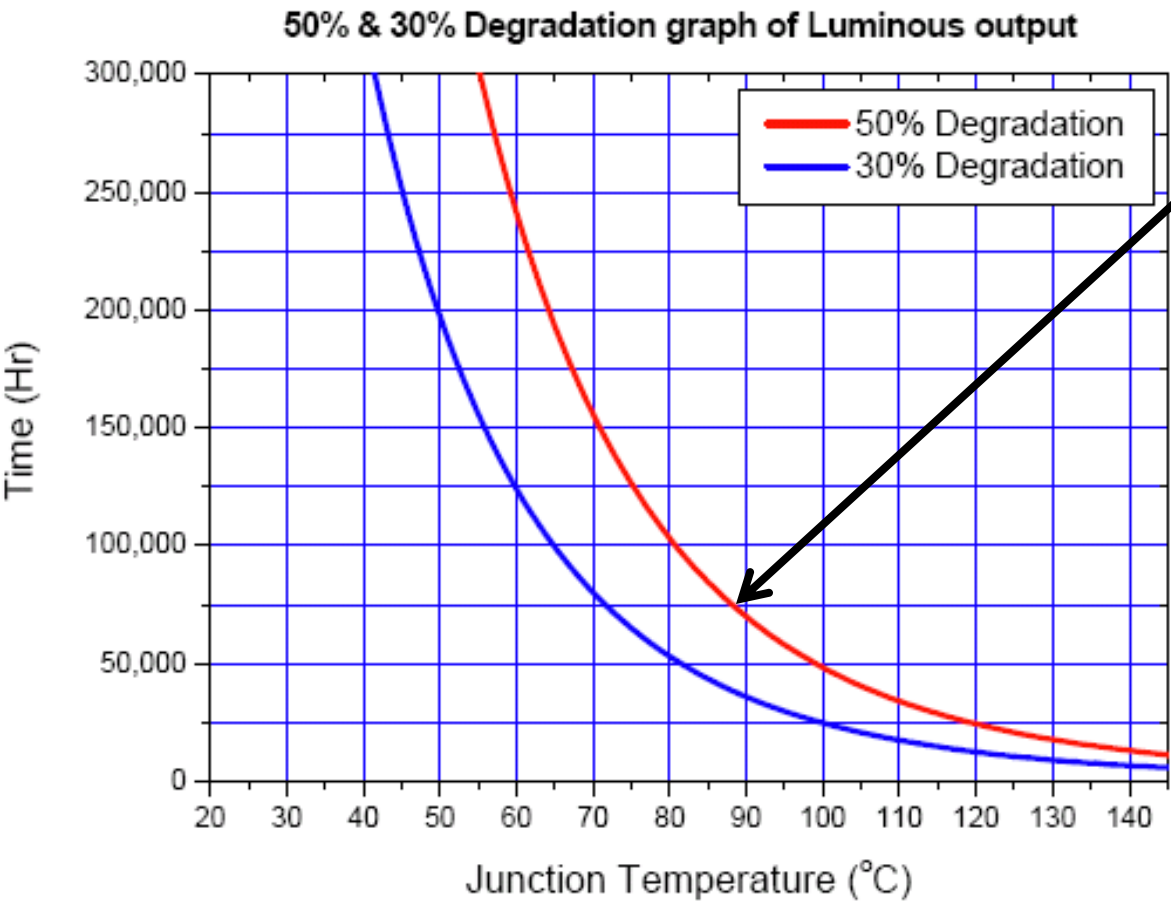
- All light sources experience decreases in light output over time.
- Generally, incandescent light sources fail catastrophically before the lumen depreciation is significant.
- LED technology, with much longer life times, demonstrates visible light depreciation prior to failure.
- Lumen Maintenance- A measure of how well a lamp maintains its light output over time. It may be expressed numerically or as a graph of light output vs. time.

- ❑ When operated within specified maximum ratings for current and T_j .
- ❑ LEDs light output will degrade over time as a function of Operating Junction Temperature
- ❑ Not all LEDs in a multi-LED system will degrade equally.

- ❑ LEDs will not burn out.



Tj vs. Life Time Graph of Z-Power P4 1W Pure White Series



Example:

SSC P4
At
 $T_j = 90 \text{ deg C}$

At 75,000 hours
light output will,
on average, equal
50% of initial
output.

To Determine Total System Lumen Requirements:

- 1) How many foot-candles or lux over what surface area and at what height?
- 2) How many lumens (net total losses) required for application?
- 3) How many candela and at what angle?

To Determine which LED is best fit:

- 1) First, need total system lumen requirements.
- 2) What is the size of the fixture?
- 3) What is the required angle?
- 4) Required system efficiency?
- 5) Budget for LED cost?
- 6) Is CRI an issue? If so, what are the CRI requirements?

To Determine Color requirements:

- 1) What color is the application?
- 2) If regulated by government or agency, what x/y coordinates are allowed?
- 3) What type of traditional bulb are you trying to approximate?

Thank you!