Why LED is Successful

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California Polytechnic University
Pomona, CA May 8, 2014

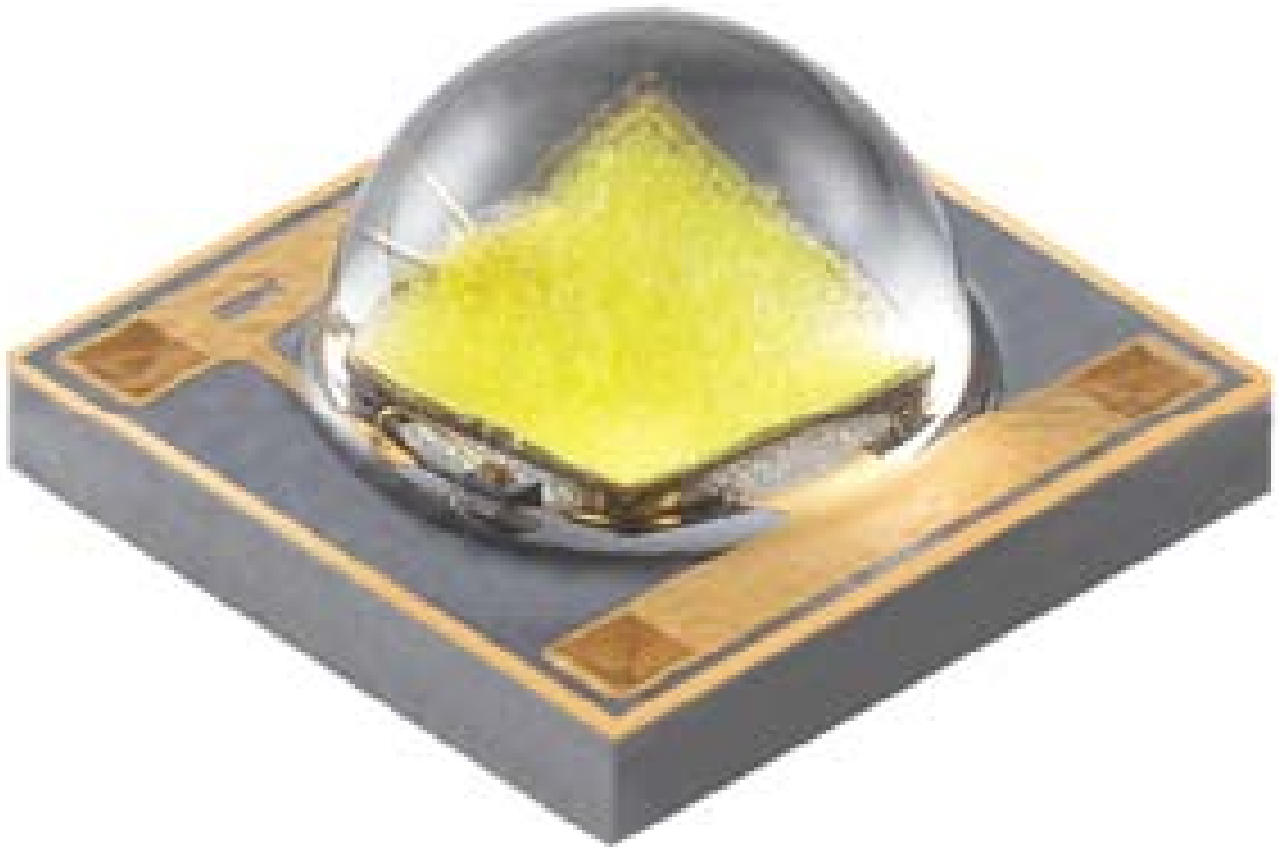
Headlines Of Session I
"Why LED Is Successful"

- What is LED
- Why use LED
- LED Market Data
- Who makes it successful
- The bottom line is: LED System
- Headlines of Session II on May 20th

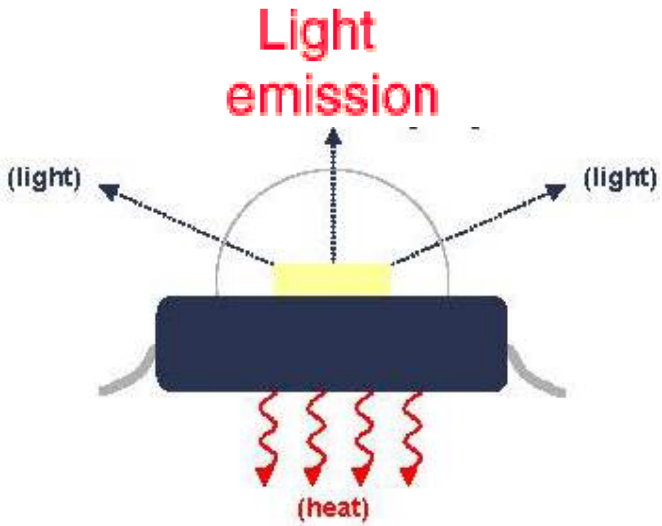
Session I

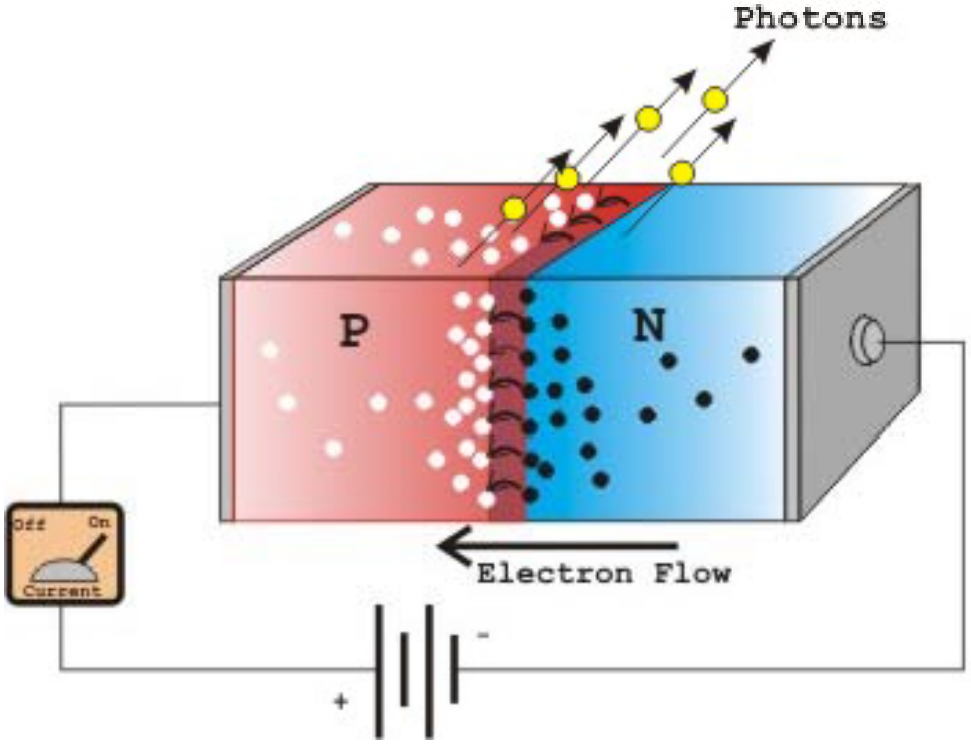
What is LED

Light Emitting Diode



PN Junction / Light / Heat



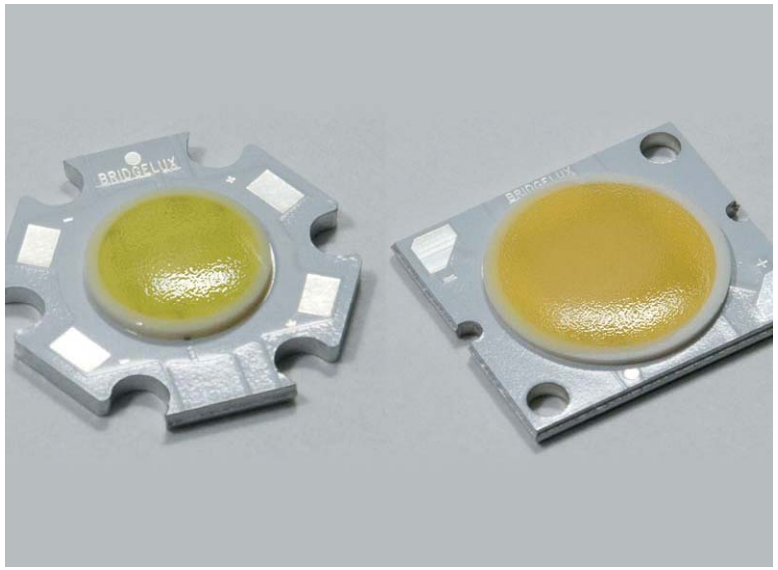


Forward Biased

Indication to Illumination

- Ray Malki Hi Tech Architect Glendora, CA CalPoly May 8, 2014

Indication to Illumination



Indication to Illumination

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Phasing Out Old Lighting

Still have some job to do

Why Use LED

- This is a Phenomena
- Saving Energy
- Enhanced Color
- Long Life
- Low Heat
- Low Maintenance
- Made the PLC “Product Life Cycle” Economically
- Save the Planet

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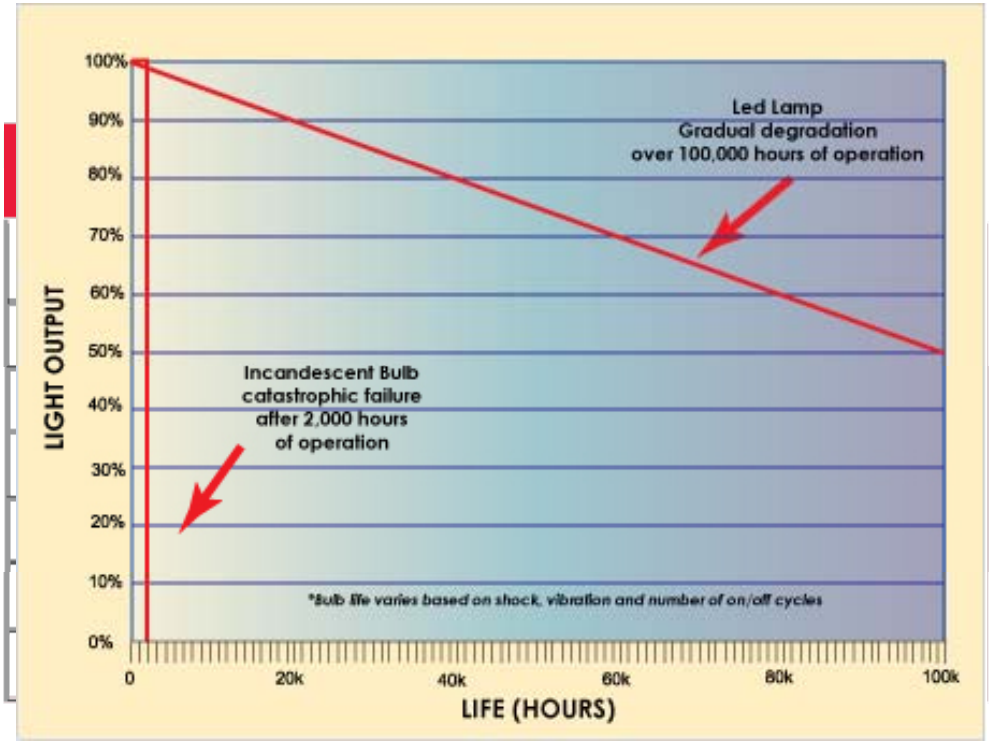

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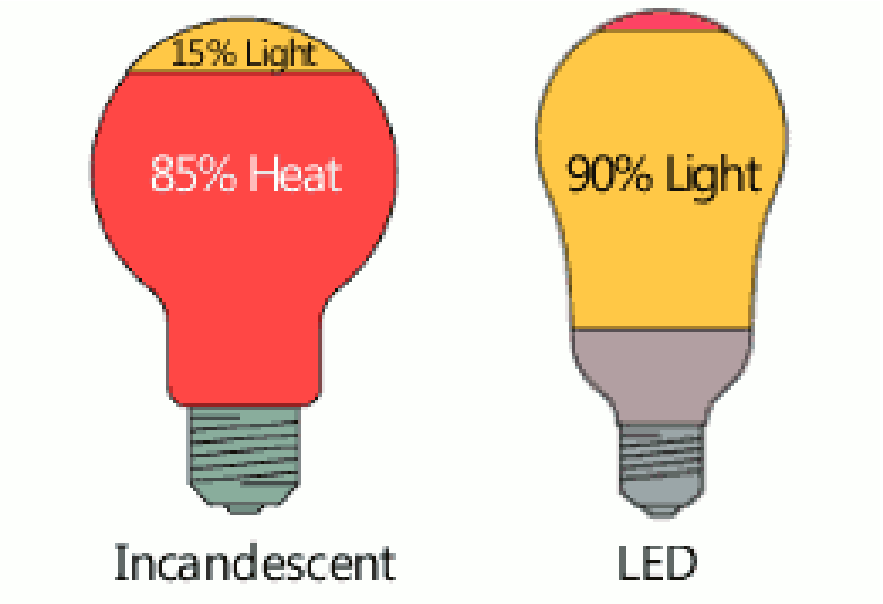
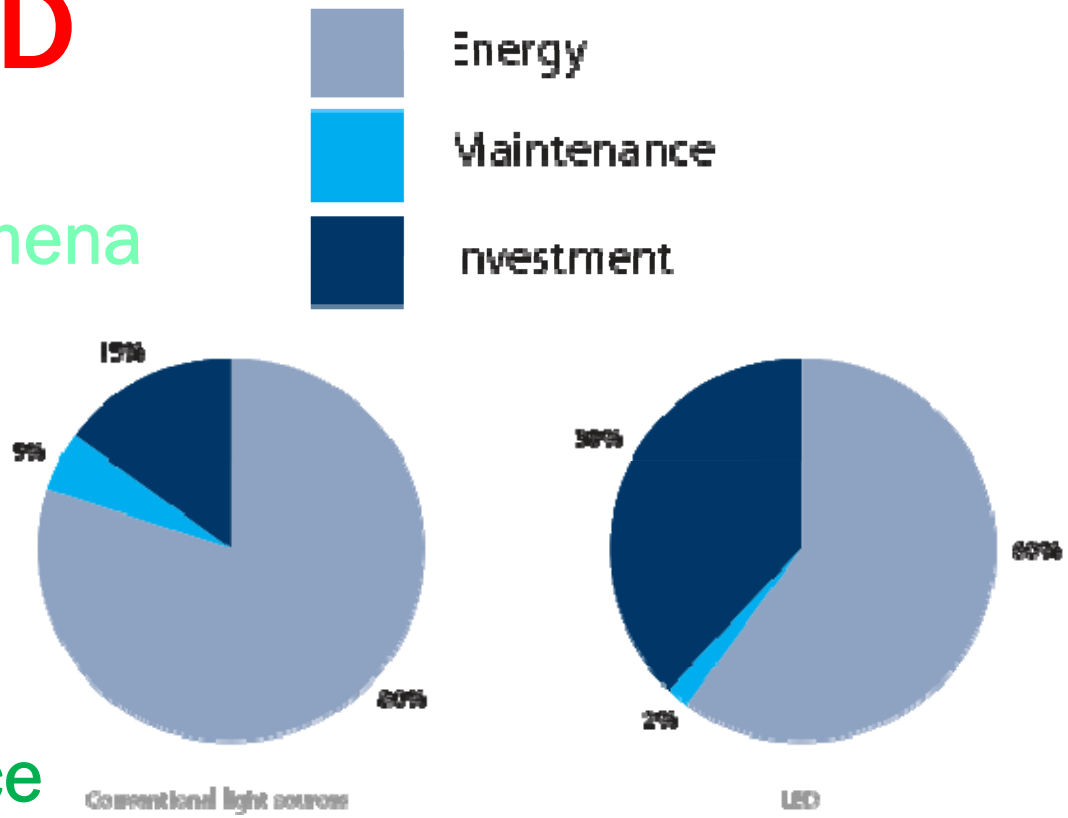


Why Use LED



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LED RETROFIT	$70,000.00
Rebate	$10,966
Investment After Rebate	$59,035
Basic KWH	$261,752
Replacement KWH	$42,442
Annual Savings	$26,413
Maintenance	$4,500
Savings 1st Year	$30,913
ROI	52.36%
ROI/Years	1.91

The Future

Reno Nevada Main Post Office

A $300,000 renovation in the facility's lighting system, produced a little over $50,000 annual savings ($22,400 in direct energy savings and $30,000 in reduced maintenance)

That same renovation resulted in major reductions in operator errors (to 0.1%) as well as a 6% improvement in employee productivity which was worth an additional **$400,000** annual savings

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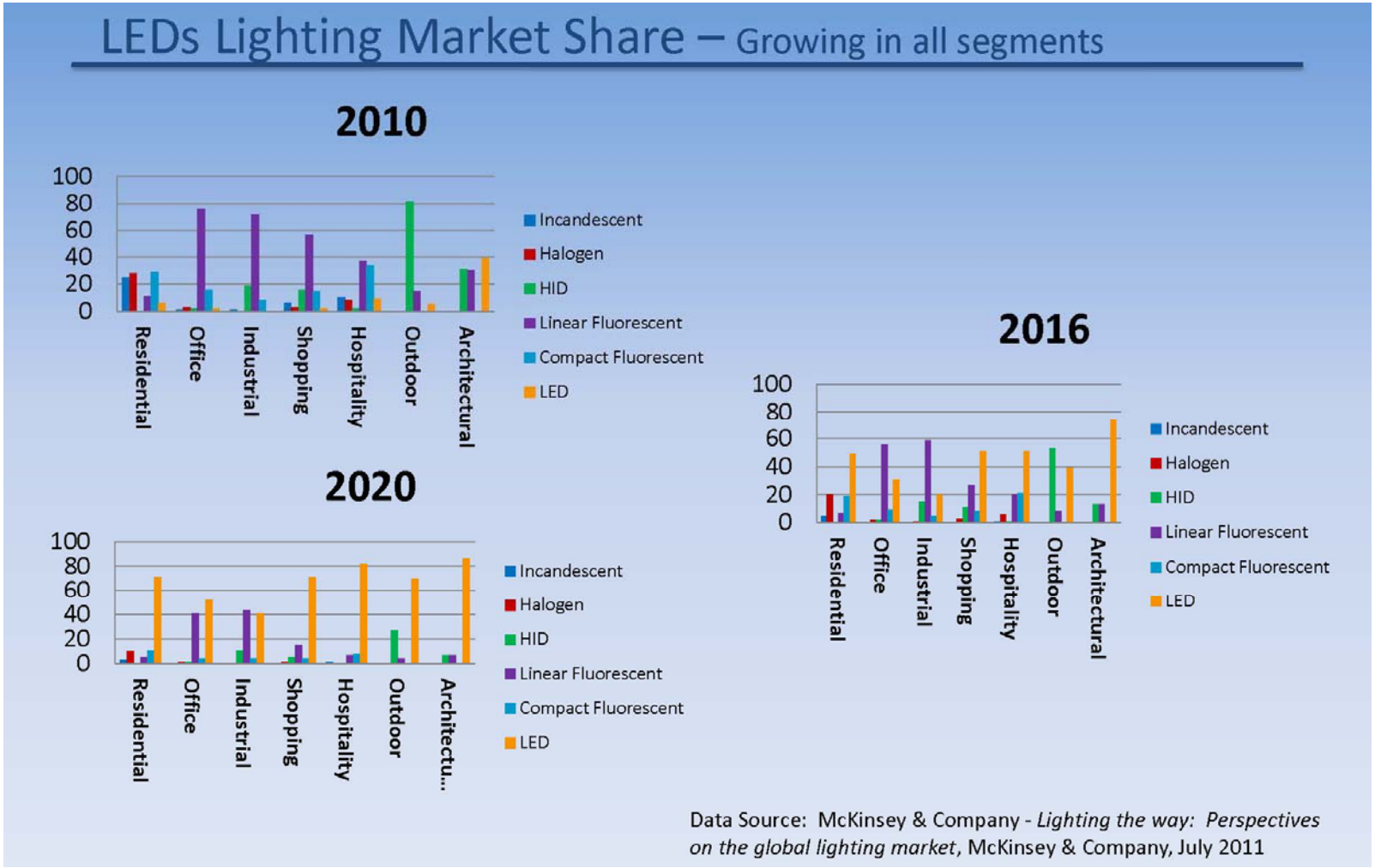
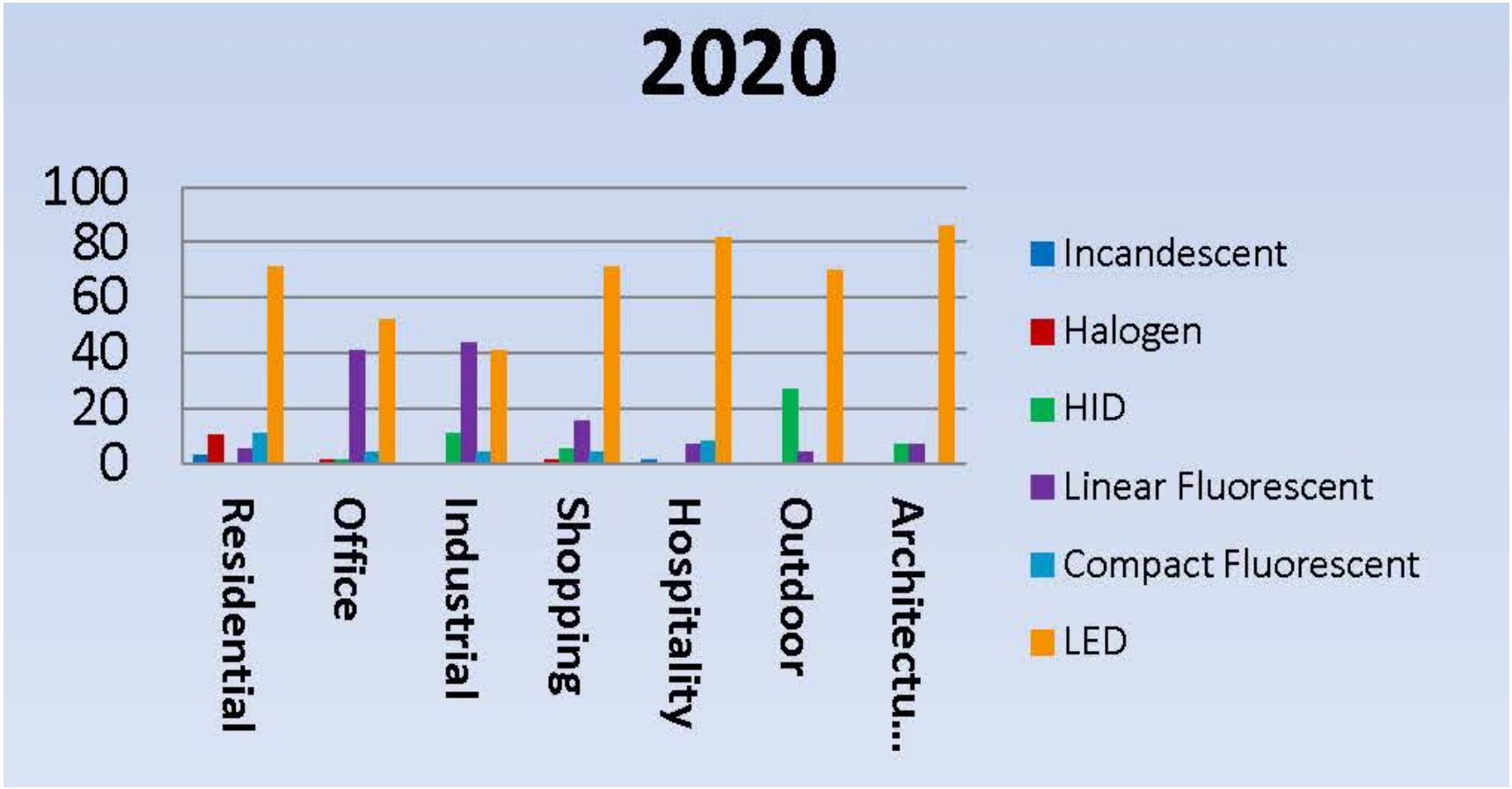
LED Market Evolution

Growing ALL Segments



LED Market Evolution

Game over! LED light bulbs win in ALL Segments



$Dollar / Lumen (LM)

$Dollar / LPW Lumen Per Watt

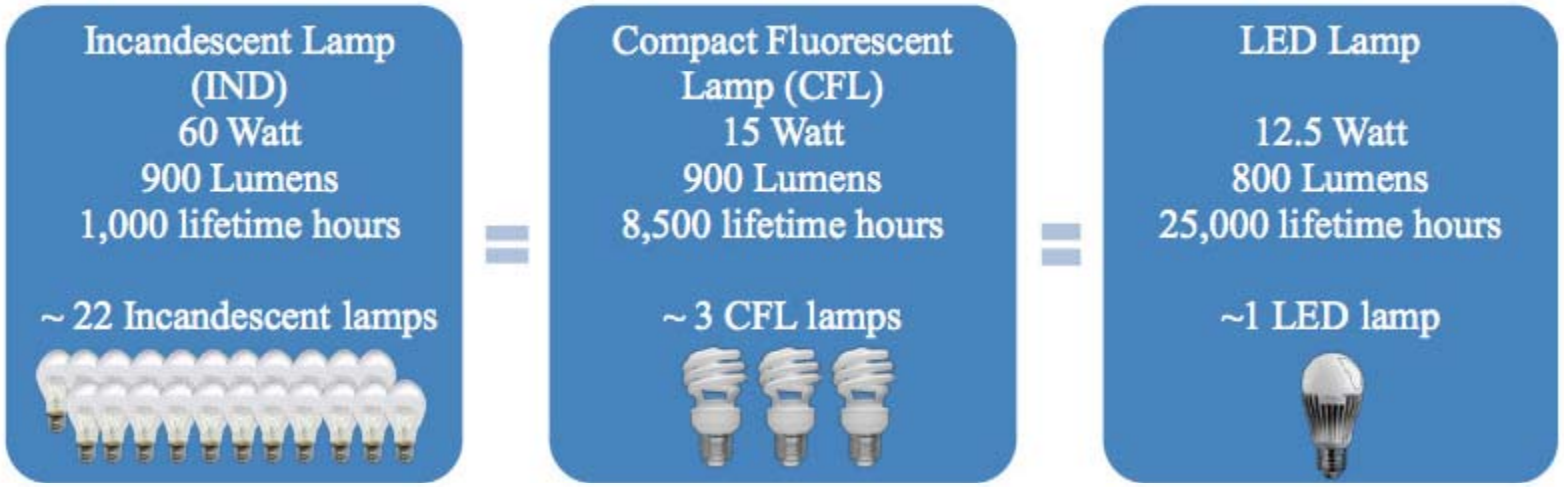
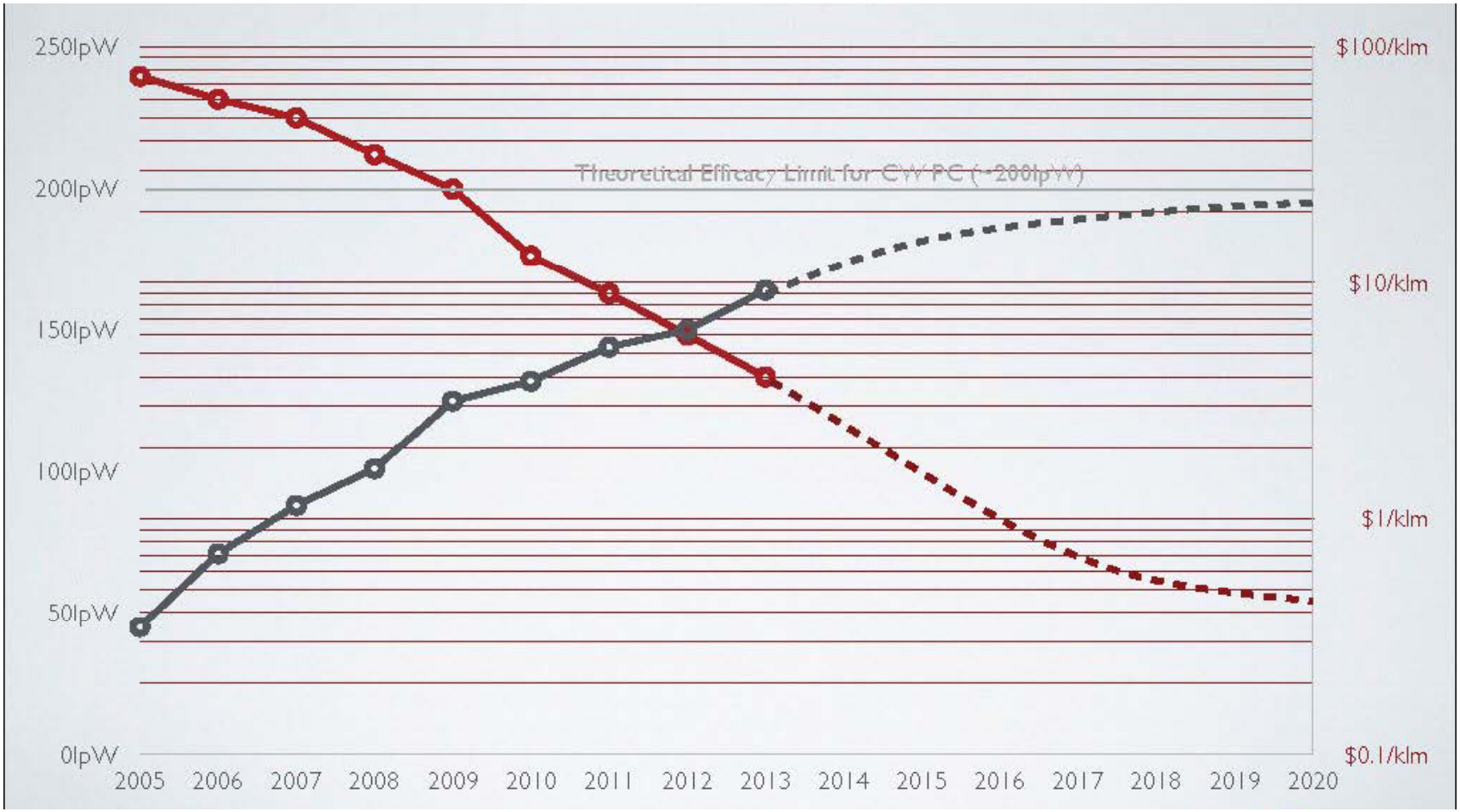
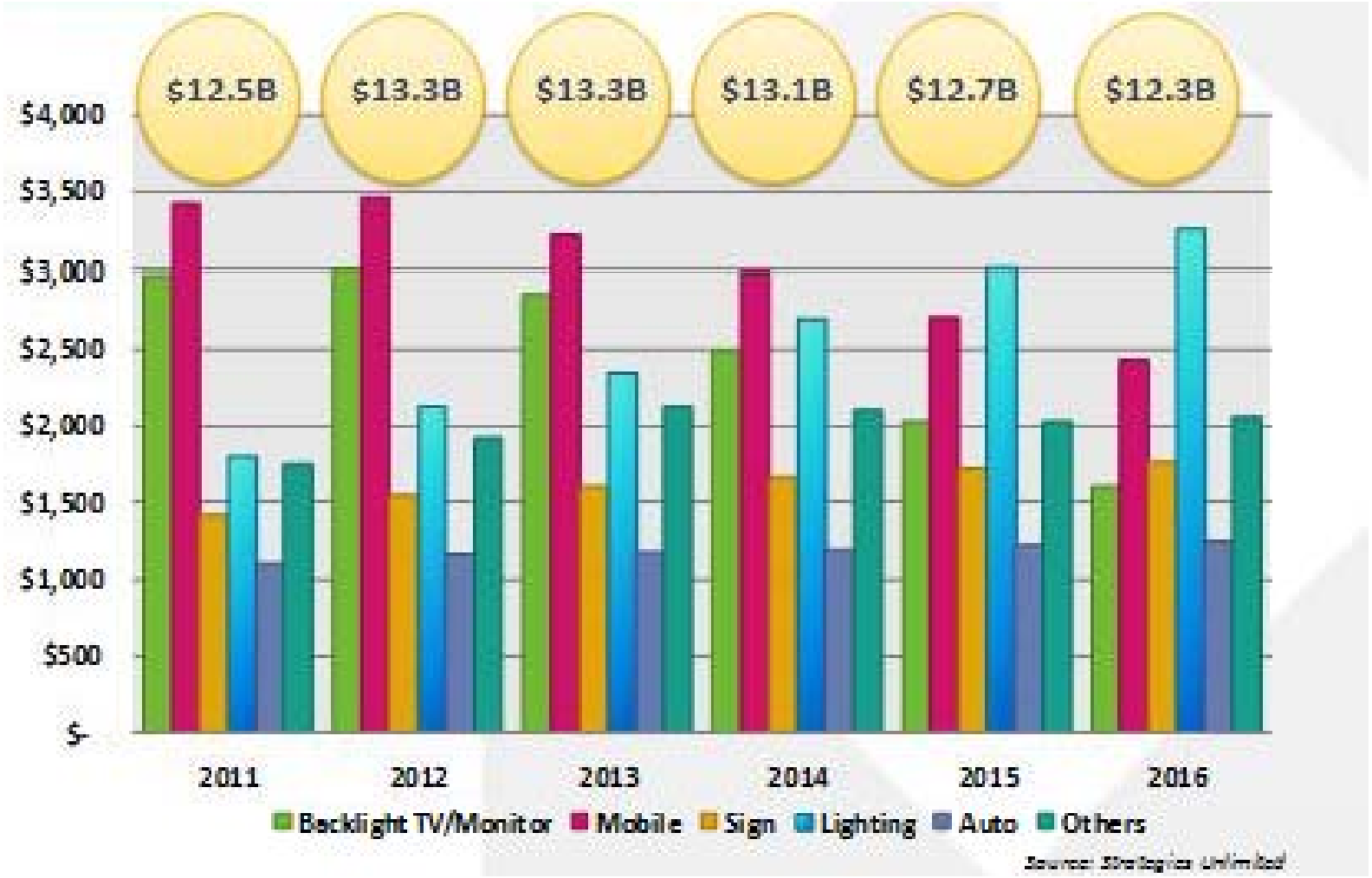


Figure 4.1 Number of Lamps Needed to Supply 20 Million Lumen-Hours[6]

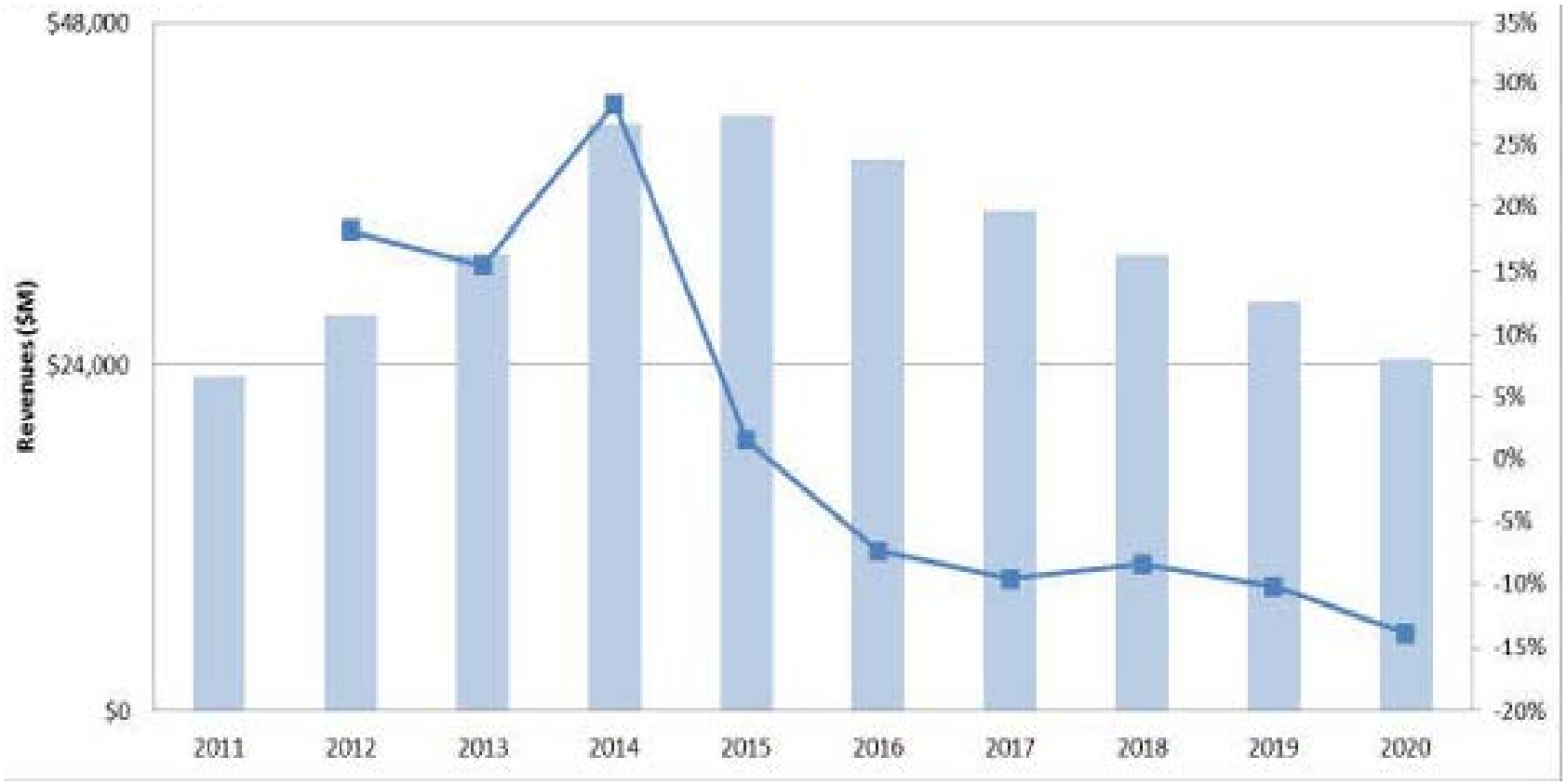
Technology Evolution



LED Market 2011-2016



World Market For Lamps 2020



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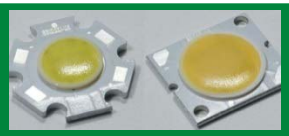
Who Makes LED Successful

- Semiconductors / Chip

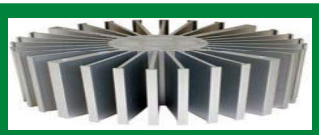


- Packaging / Module

- Color

- Driver

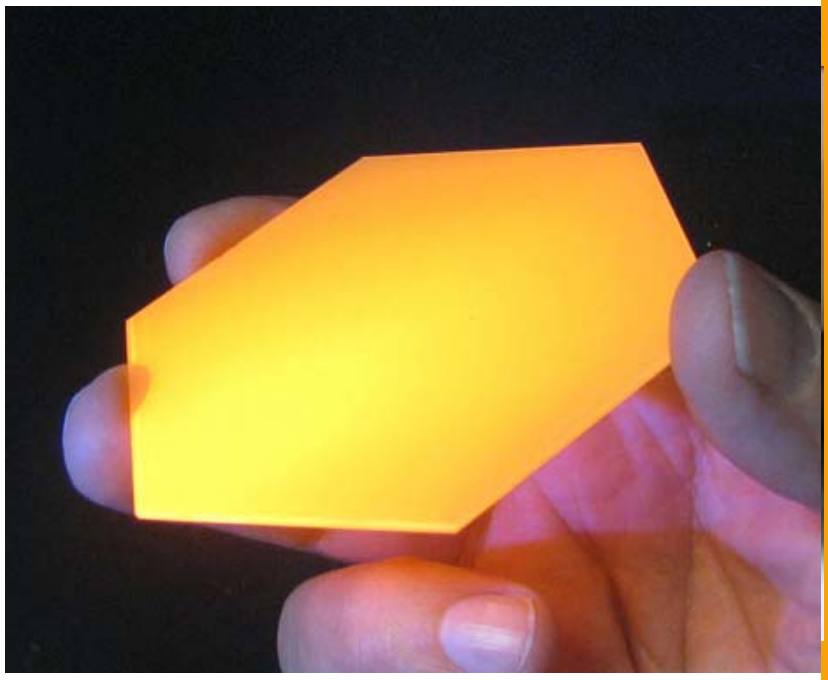
- Optics



- Thermal Management

Semiconductors

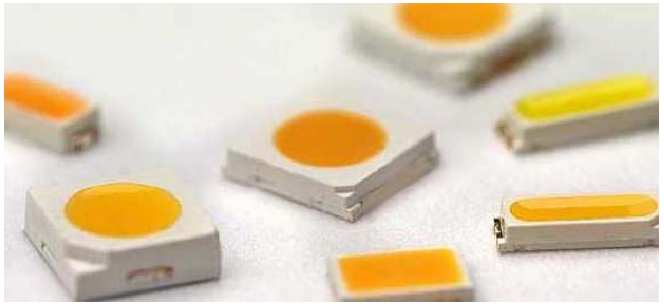
- Since 1965, evolution of Electroluminescent Materials
- 2002, High Power using InGaN “indium Gallium Nitride/GaN “Gallium Nitride”.
- Wafer size is 72-200mm. LED Die Size is 1mm2 Thickness: 350 µm +/- 25
- OLED: Printable, Foldable, Flexible & Transparent
- Quantum Dot LED



Chip / Package

New Chip Package:

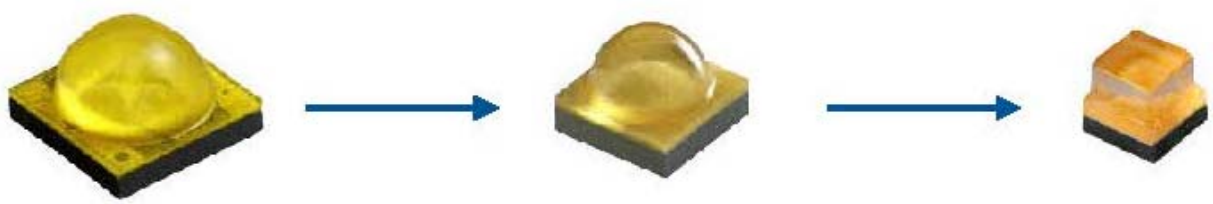
- Smaller and Cooler Operating Packages
- Multi Chip Packages COB
- Specialty Packages



Package, Evolution

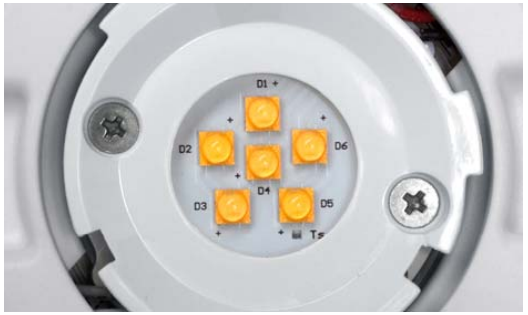
Package requires New Metrics

- Combined Power Density: W/mm2
- Efficacy = Lumine / W
- Shrinking in Size



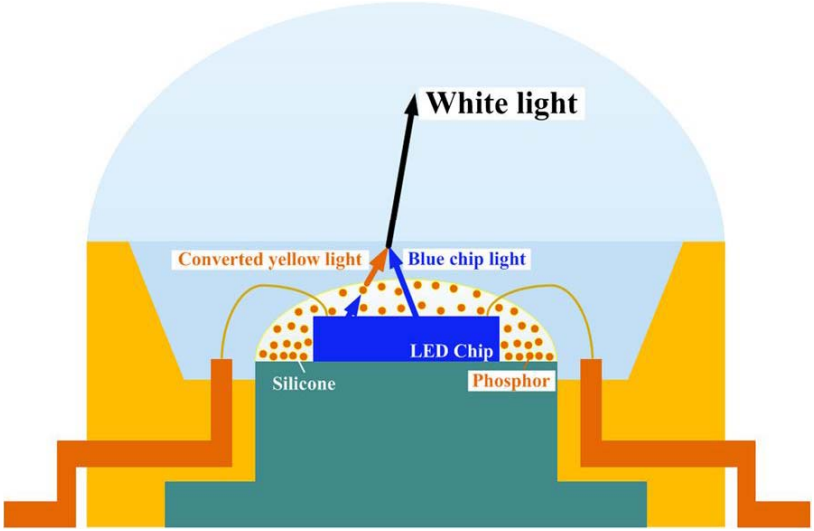
- Multiple Chip
- High V Package

Module

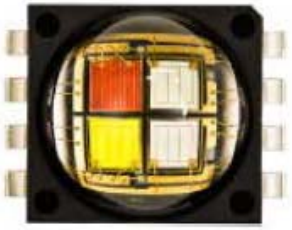


Color

- LED Color is Blue
- Layer of Phosphors
- White Color
- Binning

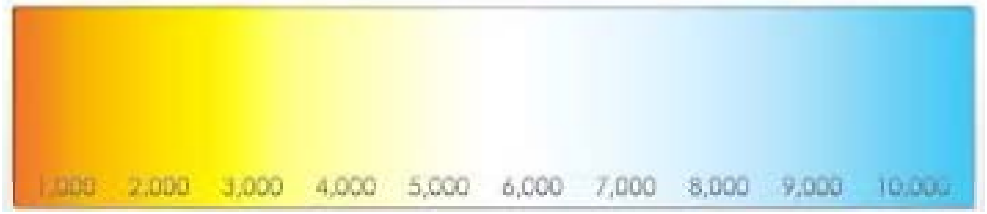


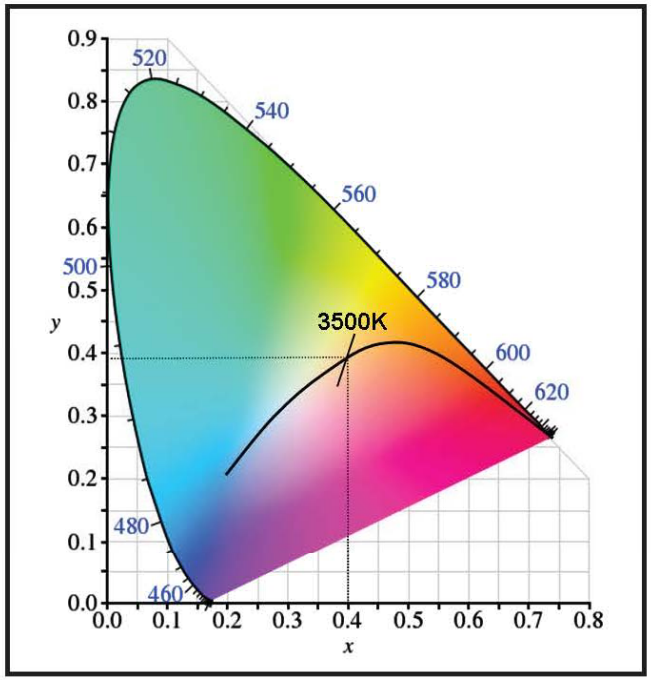
- Hybrid dots – Color Mix
  Different chip on Different strings

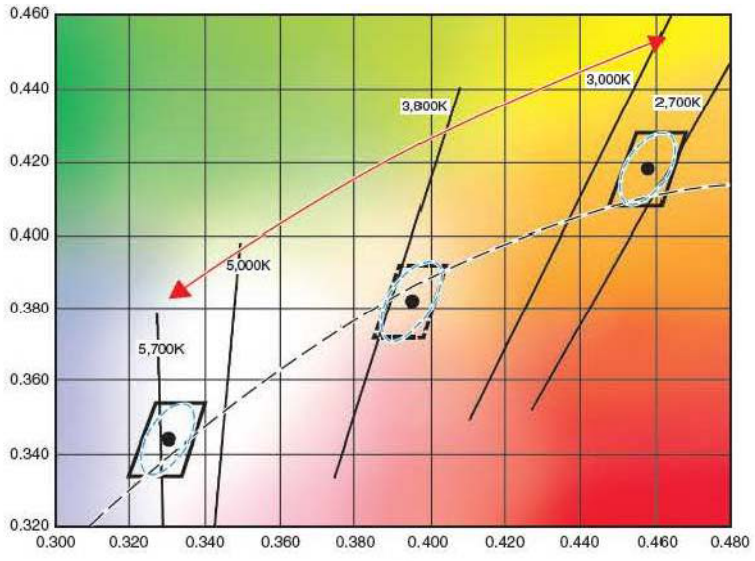


Correlated Color Temperature

- CCT Range between 1000 – 10000







CRI Color Rendering Index

CRI = 62

CRI = 93

CRI = 80

CRI = 92

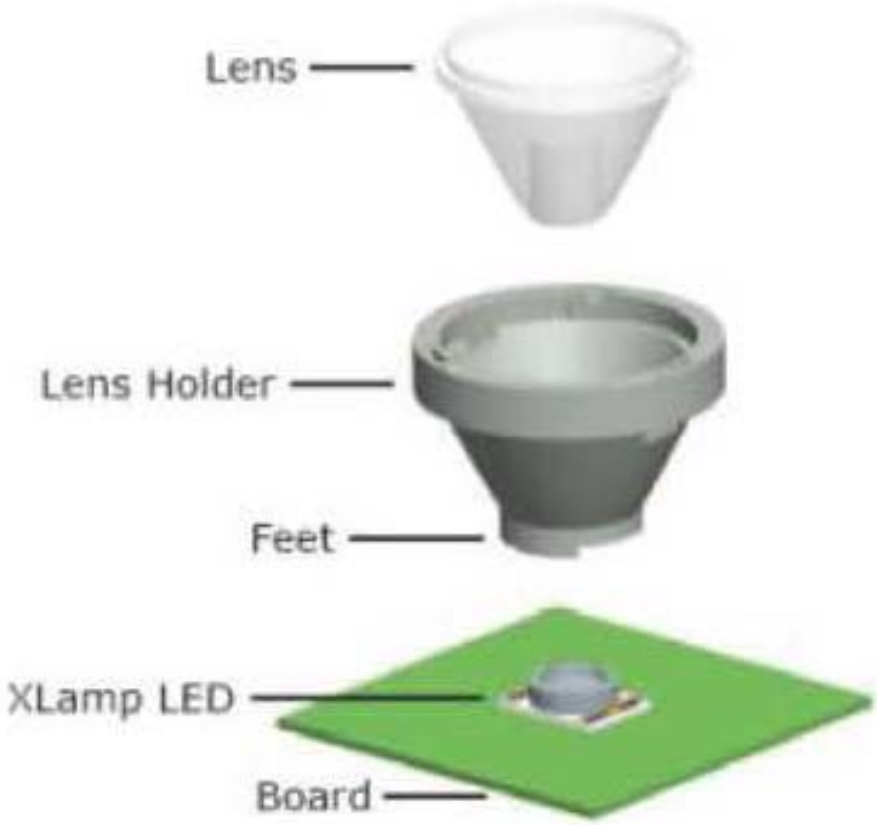
- How close to real life
- 100% is under the Sun (Full Spectrum)
- Industry Today: ~95

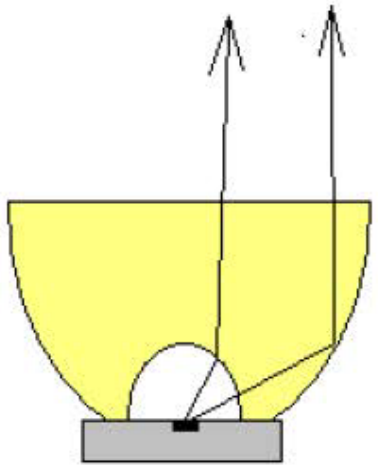
The Future Of Color

Lighting Scenes from the Boeing 787 Dreamliner

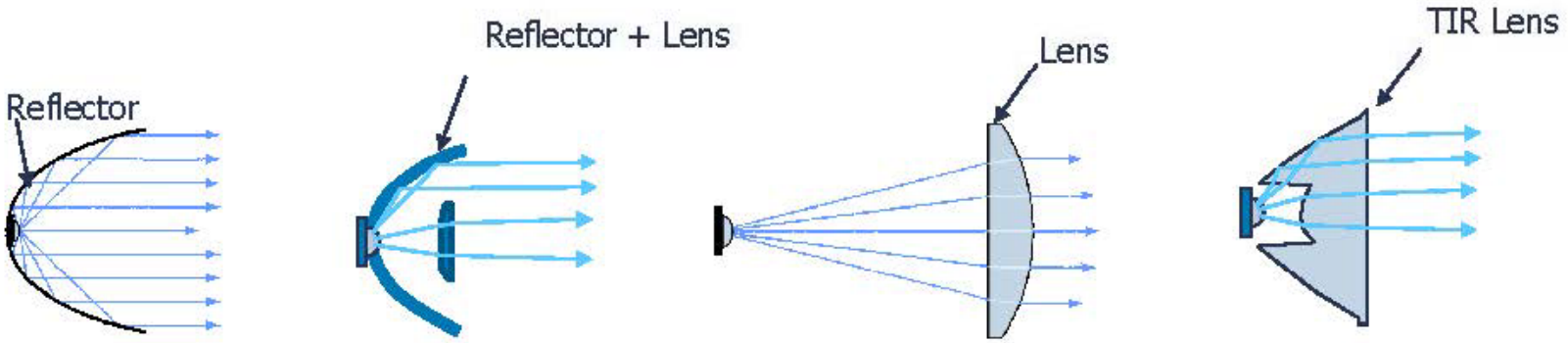
Boarding Cruise Relaxation Meal Service Sleep Prelanding

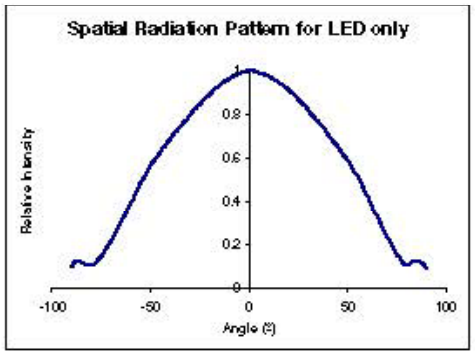
Optics / Secondary Optic



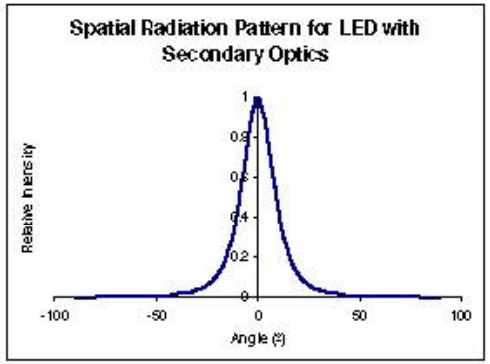


Optics / TIR Lens

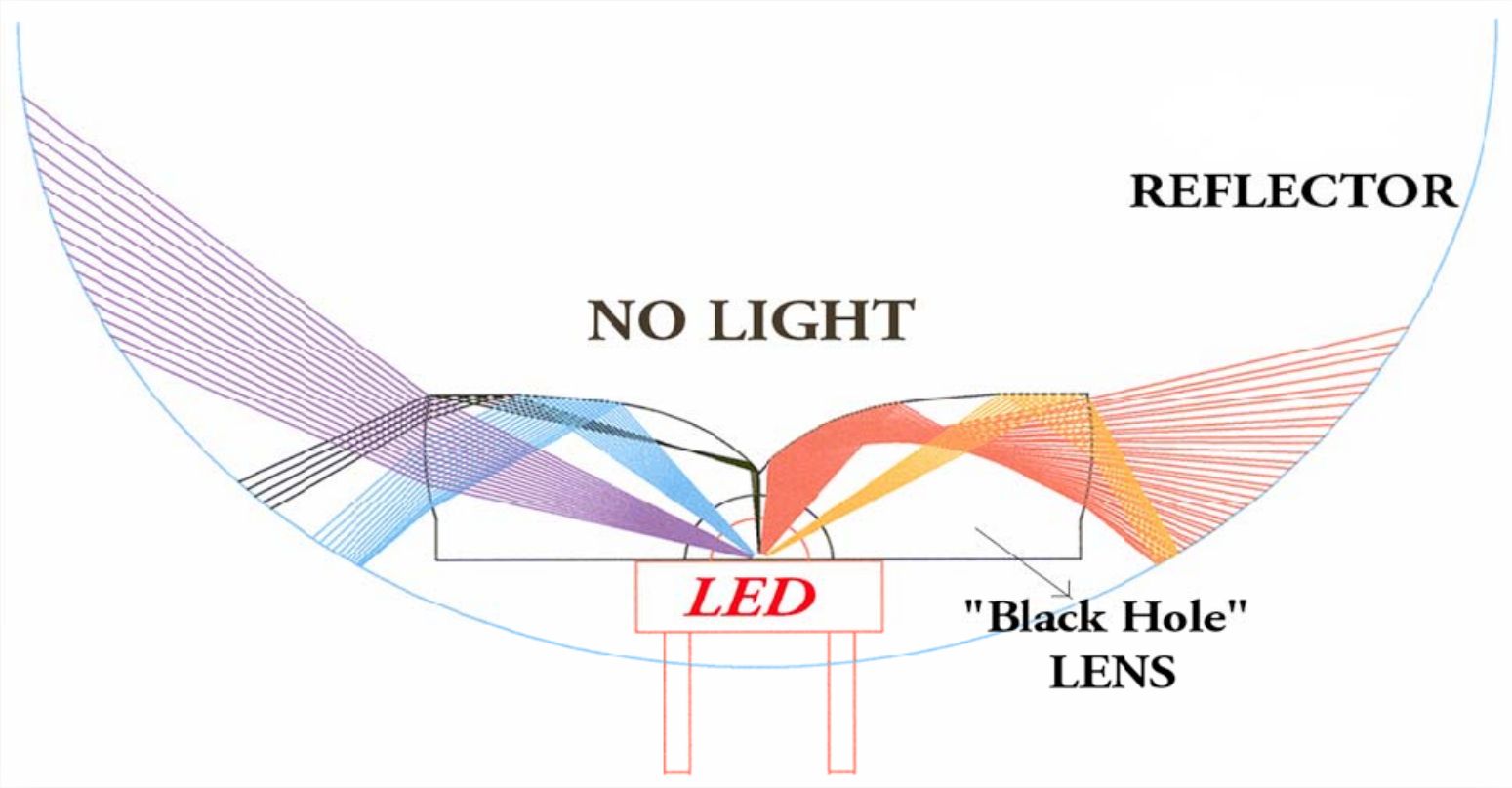




LED with secondary optics



Optic / No Light



12 Degree

25 Degree

Angle & Shape

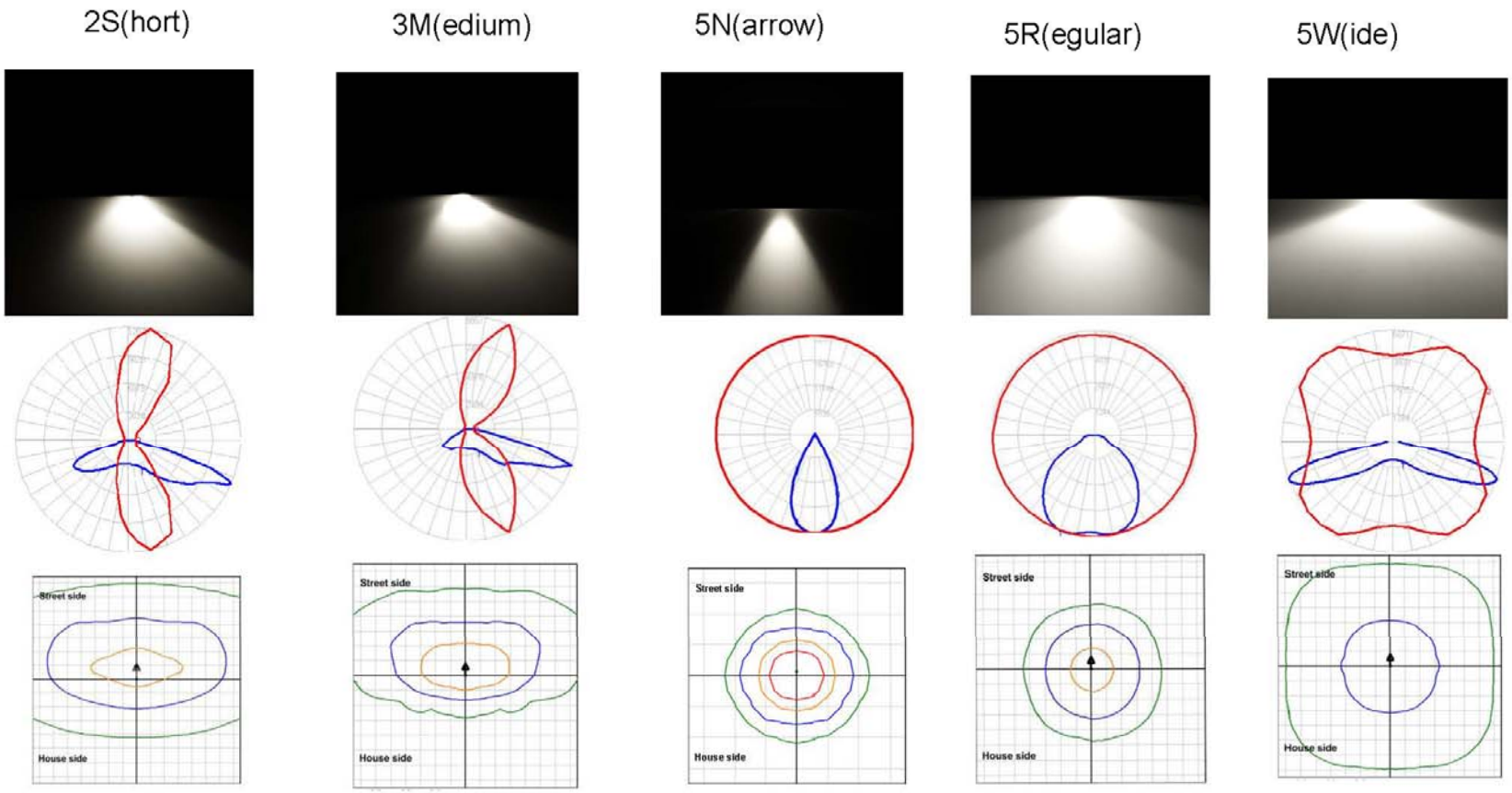
Beam Angle 20˚- 30˚

MR 16

Oval Beam

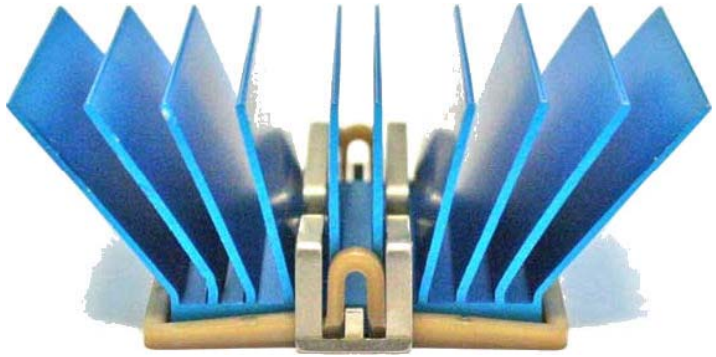
Street Light & High Bay

Optics / LENS

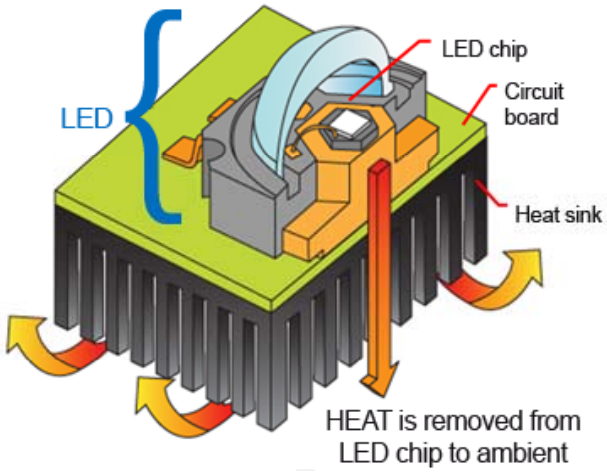

2S(hort)
3M(edium)
5N(arrow)
5R(egular)
5W(ide)
Street side
House side
Street side
House side
Street side
House side
Street side
House side
Street side
House side

Thermal Management

- Heat Sink Disbursement

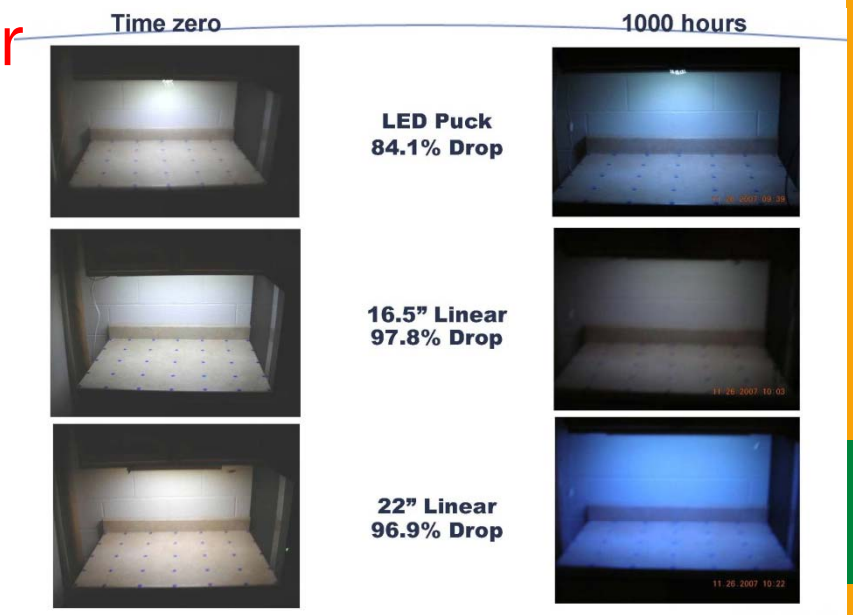


- Heat Disbursement Gel

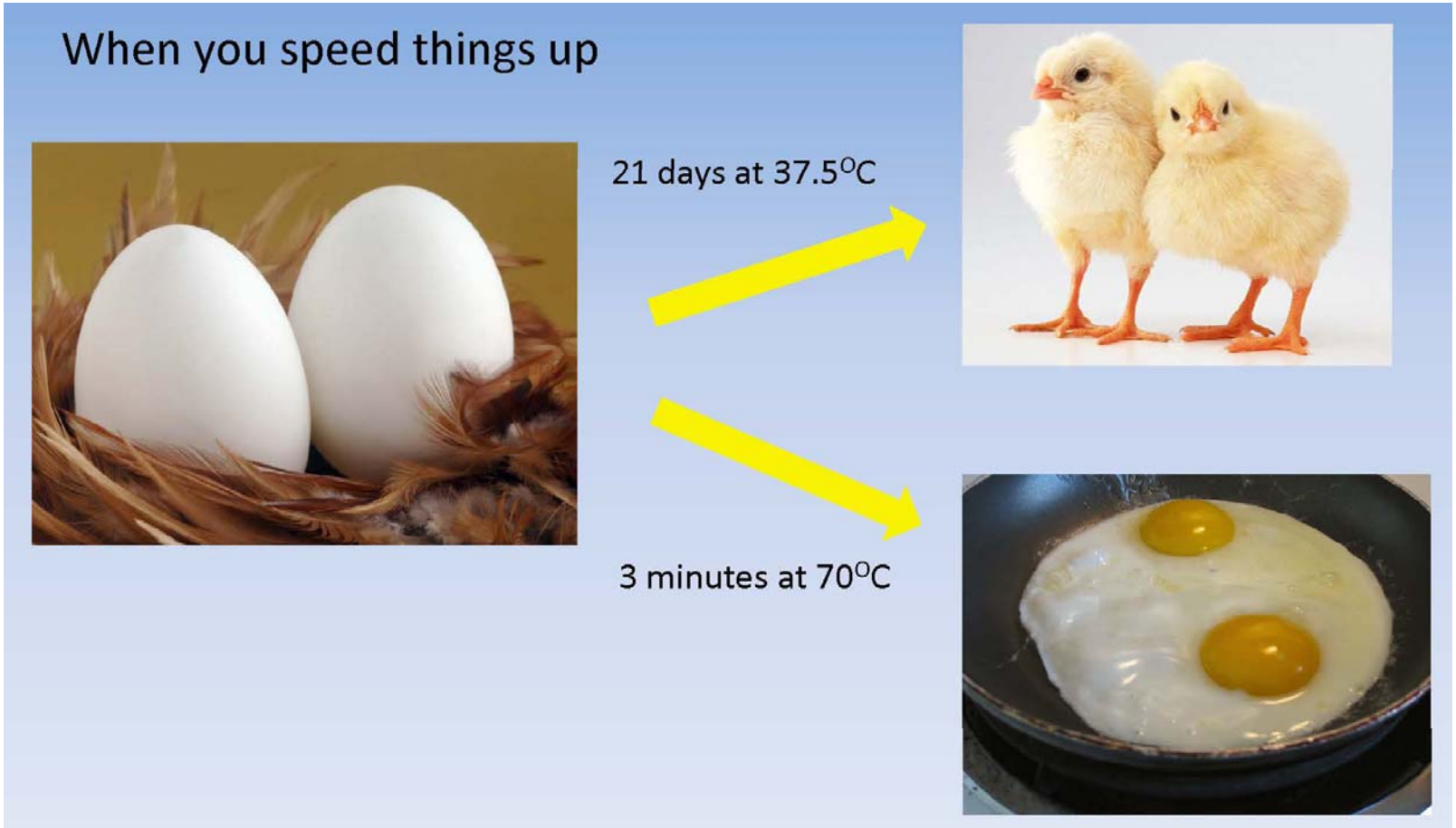


Temperature can have drastically different effect On Lumen and Color

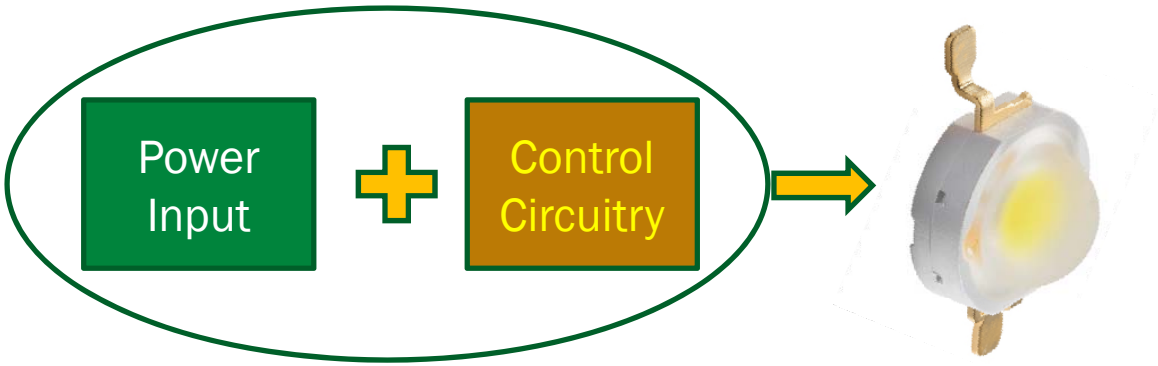
- Lumen Maintenance, LM78
- Color Shift /Color Stability
- Standard Measure Color Stability: LM80
- Efficiency



Testing Time / Temperature can have drastically different effect



Driver



- DC-DC, Regulator
  LV AC-DC, Convertor + Regulator
  AC Line High Power, Convertor + Regulator
  Driver, Constant Current
  LED is Current driven
- Diming function
  Triac Or Transistor
  Step Dimming: 0 - 25% - 50% - 75% - 100%
  Variable Volt input: 0-10V
- Programmability

High Efficiency Driver

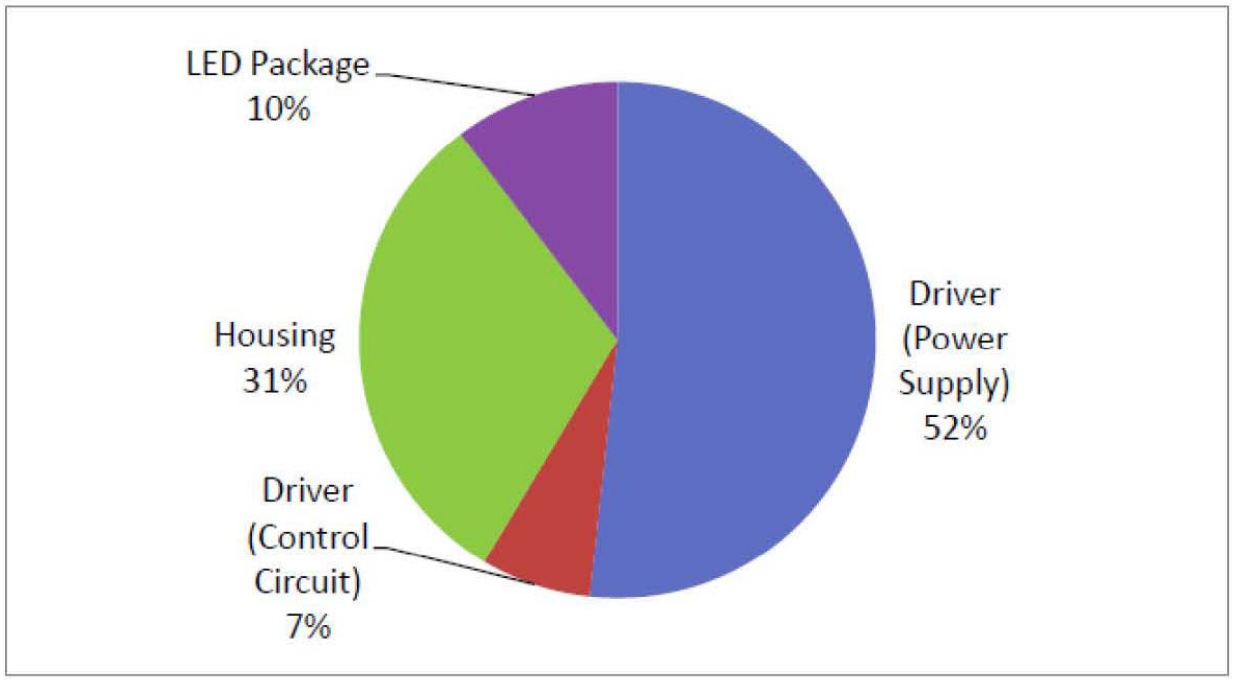
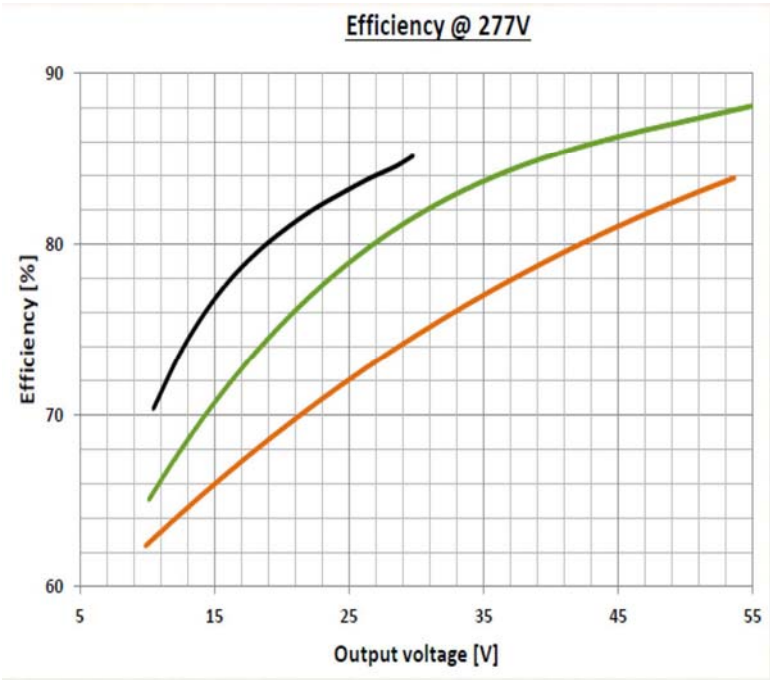


FIGURE 3. DISTRIBUTION OF FAILURES IN 34M OPERATING HOURS FOR A FAMILY OF OUTDOOR LUMINAIRES. TOTAL NUMBER OF FAILURES WAS 29, OR 0.56% OF INSTALLED BASE OF APPROXIMATELY 5,400 FIXTURES.
SOURCE: APPALACHIAN LIGHTING SYSTEMS, INC.

- Life of Driver

High Efficiency Driver



More Than Component, it is System Design

Failure Of any Component can Cause the Entire System to stop Functioning

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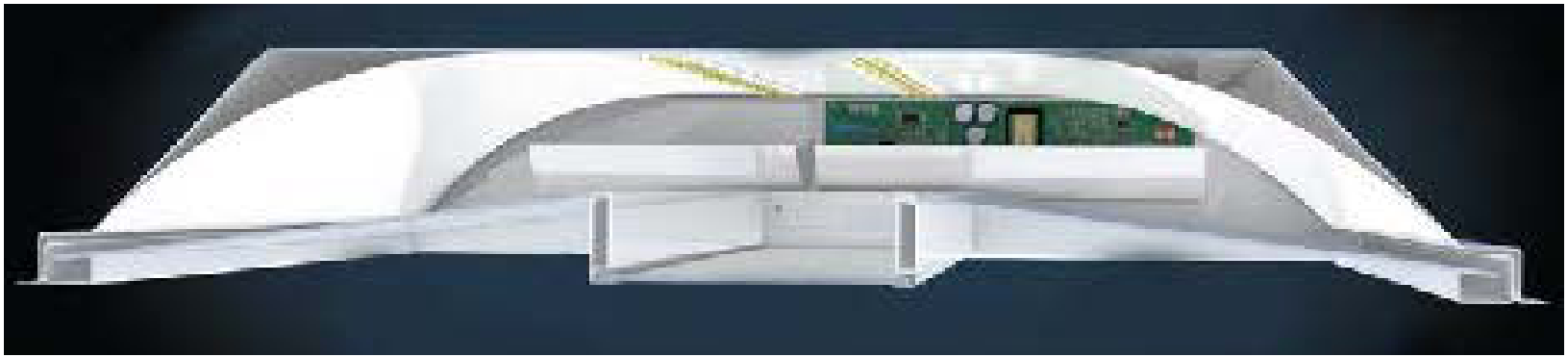

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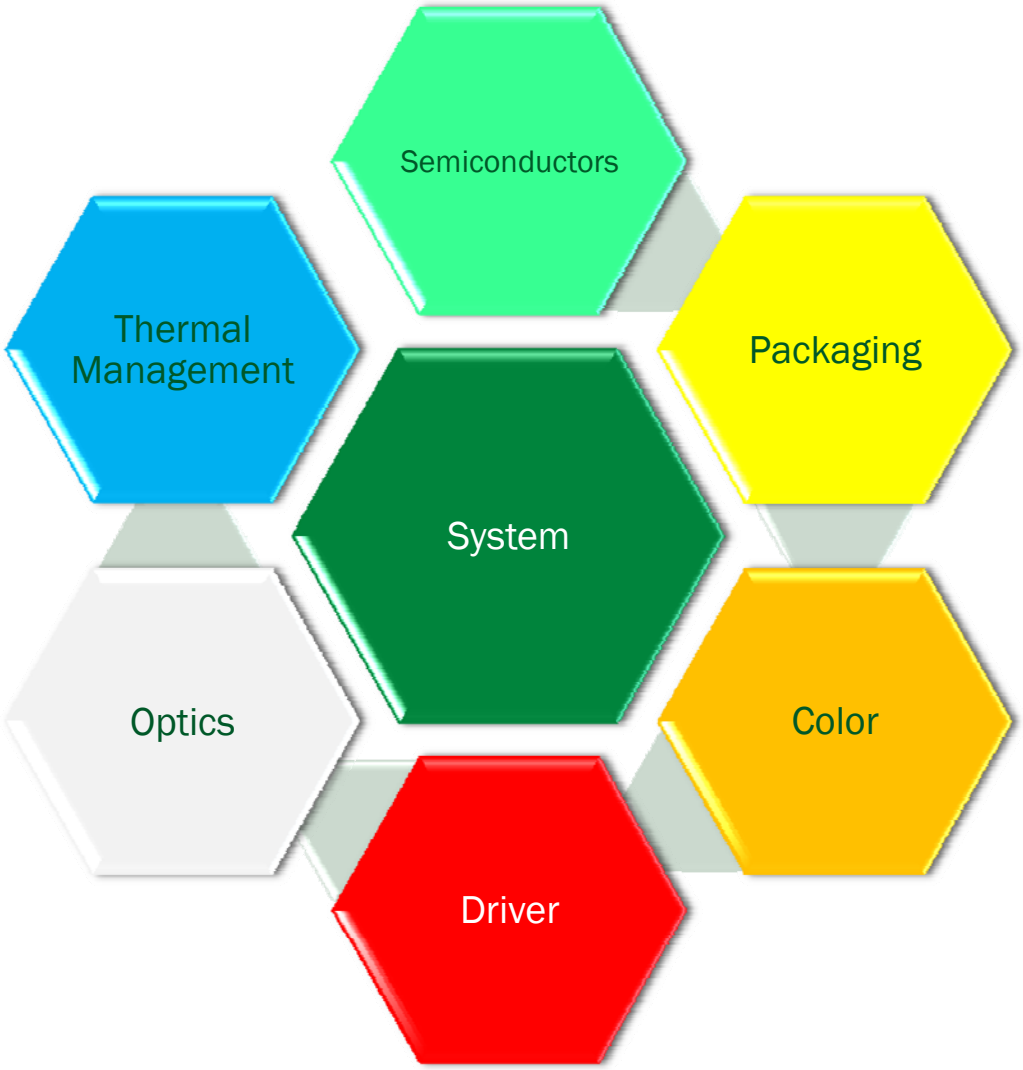
System Design



Measure Your LED Performance

LED Lighting Facts® label:

- Light Output (Lumens)
- Lumens per Watt (Efficacy)
- Watts (Measured Power)
- Color Rendering Index (CRI)
- Correlated Color Temperature (CCT)
- Warranty (optional)
- LED Lumen Maintenance as a percentage of initial light output at a fixed time (optional)
- * Luminaire measurements have been standardized with the issuance of the IESNA Standard LM-79-2008 test procedure.

Example:
LED Lighting Fa

Litecontrol Cove-15

LED lighting facts®
A Program of the U.S. DOE

Light Output (Lumens)	**1950**
Watts	**32**
Lumens per Watt (Efficacy)	**61**
Color Accuracy Color Rendering Index (CRI)	**81**

Light Color Correlated Color Temperature (CCT) **3500 (Bright White)**

Warm White | Bright White | Daylight

2700K 3000K 4500K 6500K

All results are according to IESNA LM-79-2008: *Approved Method for the Electrical and Photometric Testing of Solid-State Lighting*. The U.S. Department of Energy (DOE) verifies product test data and results.

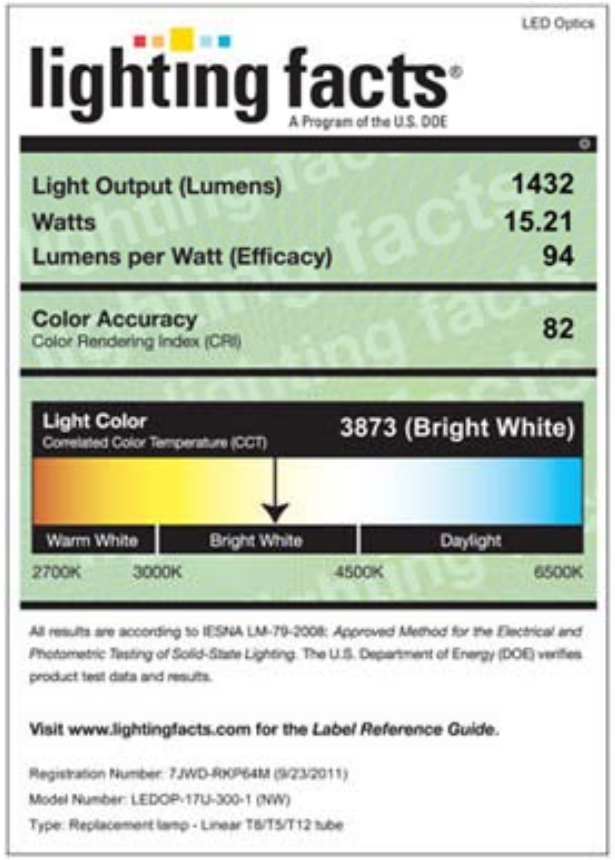
Visit www.lightingfacts.com for the *Label Reference Guide*.

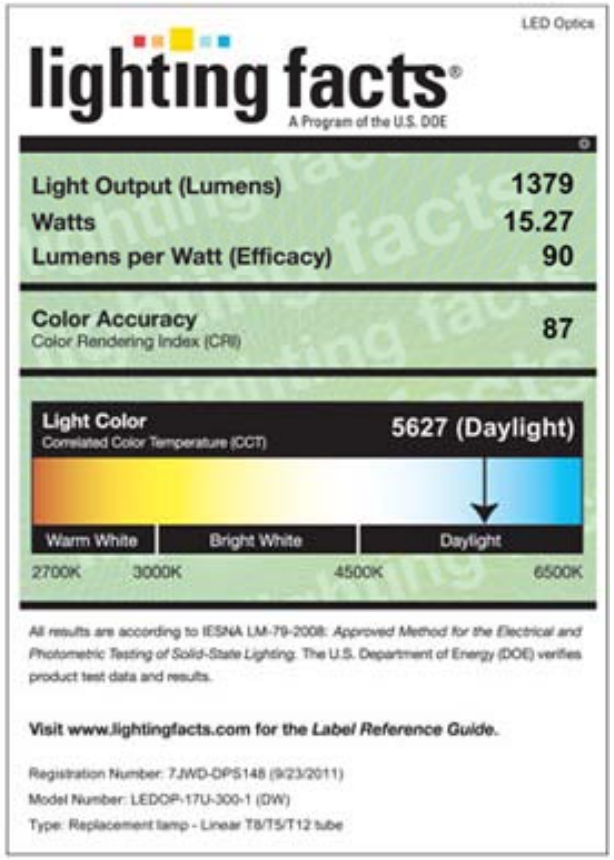
Registration Number: 56A7-2PLEZB (2/24/2012)

Model Number: CC-AI-L1504-MO-35K-LHI

Type: Cove light

Example: LED Lighting Facts





Example: LED Lighting Facts

- **Optic :** Type VW
- **Lumen:** 15,400LM
- **Color:** 5000
- **CRI:** 80
- **Electrical:** 120 –277V, 347V, or 480V @ 700 mA, 20 to 300w models available
- **Mechanical:** Aluminum housing, 12” W x 13-30” L by 2 ¼” high, powder coated
- **Certifications/Ratings:** CETL/CUL, ROHS, IP65 rated, DLC Listed
- **Reliability:** “EncapsLED” heat sink for superior cooling and durability (patent pending)
- **Warranty:** 5 years
- **Options:** Dimming (D); Motion Sensor (M); Twist Lock (T)

Headlines Of Session II
LED Lighting & More
Tuesday, May 22, 2014

- Light Control
- Power LED
- Applications
- Fixtures, Category
- Design
- Color Changing, RGB
- More Than Lighting
- Smart Lighting

Thank You

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References

- EIS Engineering Illumination Society
- DOE Department Of Energy
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