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Where are we going to land with LED?

Richard Larivée, ing., P. Eng.

Avia Rupta Solutions Inc.

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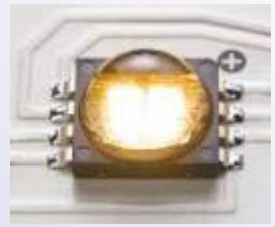
GOALS



- Have a good understanding of various pieces of this new technology and the impact of using it
- Have some guidance to make sounded choice
- Have an idea of what you can expect from the future
- Understand the context of lighting industry in general and the **metamorphosis** happening

PAR 38 - Cree

1050 lumens

Bulbrite 3W LED = 25 W incandescent
130 Lm 30000 hours

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AGENDA

- Introduction & Background
- Challenges
- Today
- Standards & Research
- Applications
- Conclusion

Introduction

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A NEW REVOLUTION!

Do you remember Polaroid and Kodak?

Lighting industry is changing

The big three should be ***worried!***

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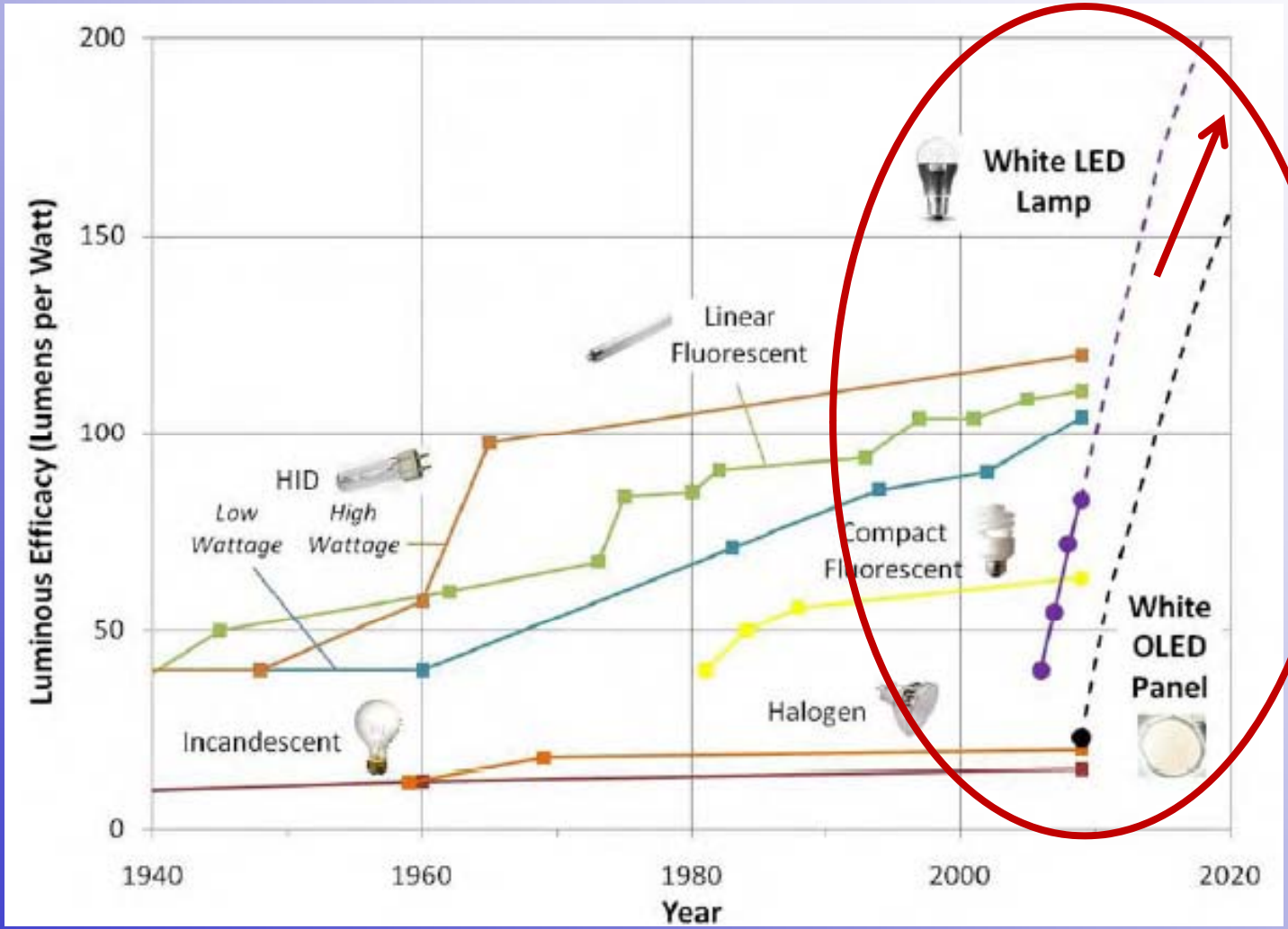

Historical and Predicted Efficacy of Light Sources

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LED lighting is now define by:

<u>Solid-State Lighting</u> (SSL)

- Semiconductors convert electricity into light
- Researchers believe the maximum achievable light output for packaged LED devices is **160–230 lm/W**

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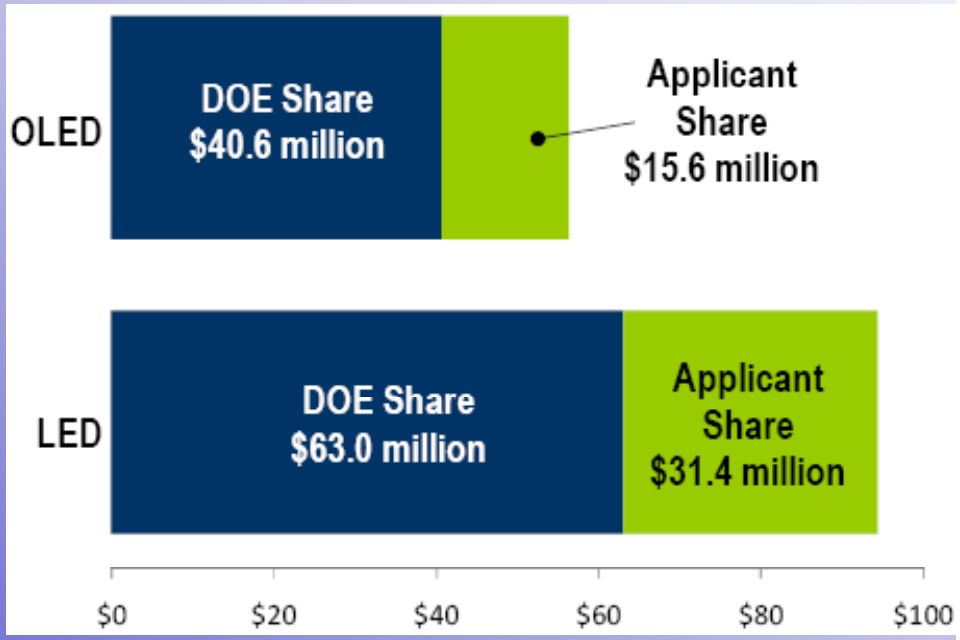
- U.S. Department of Energy (DOE) is the lead federal agency for all research, development, and commercialization efforts to systematically **accelerate this groundbreaking technology**
- Energy Policy Act of 2005
  - From 2007-2013, in SSL

R&D $350 million

- Europe

PHOTONICS 21



R&D Project Portfolio, February 2010

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Background Info

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Background Info

Global lighting fixtures market $94 billion (for 2010)

- In 2009, LED lighting sales were **$636 million (**12% of high-brightness LEDs lighting industry - $5.3 billion)
- **Expected** sales for 2010 to be **$1 billion**

Lamp type	Annual need (billion of units)	Life (year)	Existing (billion of units)
Incandescent	11.5	1	11.5
Halogen	0.8	2	1.6
Fluorescent	3.2	5	16.0
Compact fluo	0.6	5	3.0
HID	0.2	3	0.6
Total	**16.3**		**32.7**

From www.iaeel.org/2005 - World lighting lamp quantity

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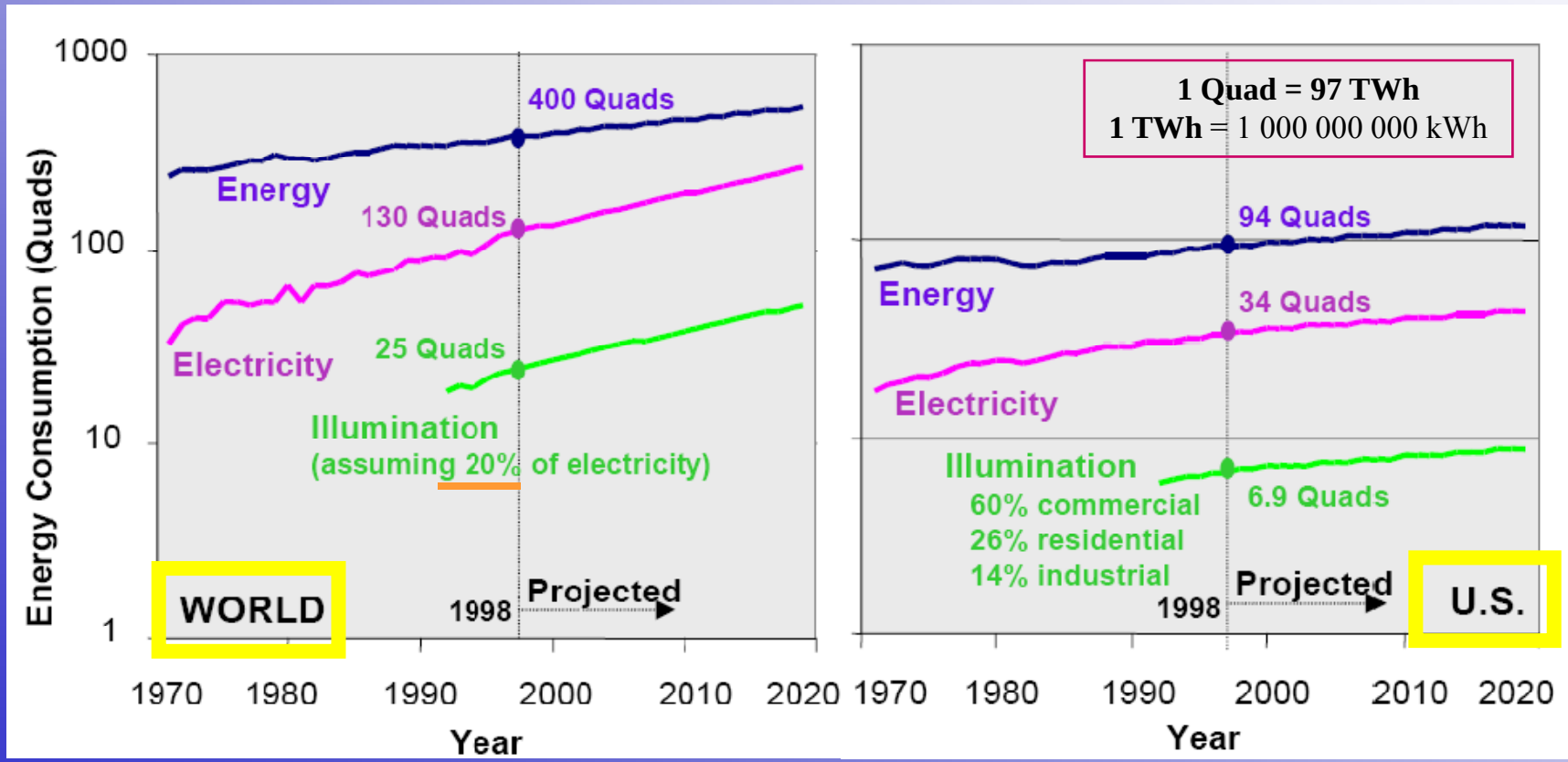
Why Solid-State Lighting?

Worldwide lighting consume **2 651 TWh** yearly



*The case for a national program research on semiconductor lighting - **1999***

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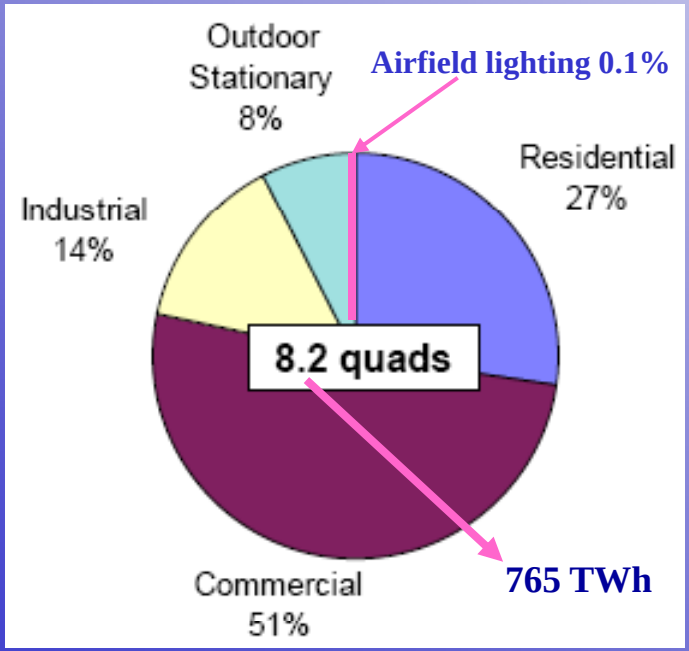
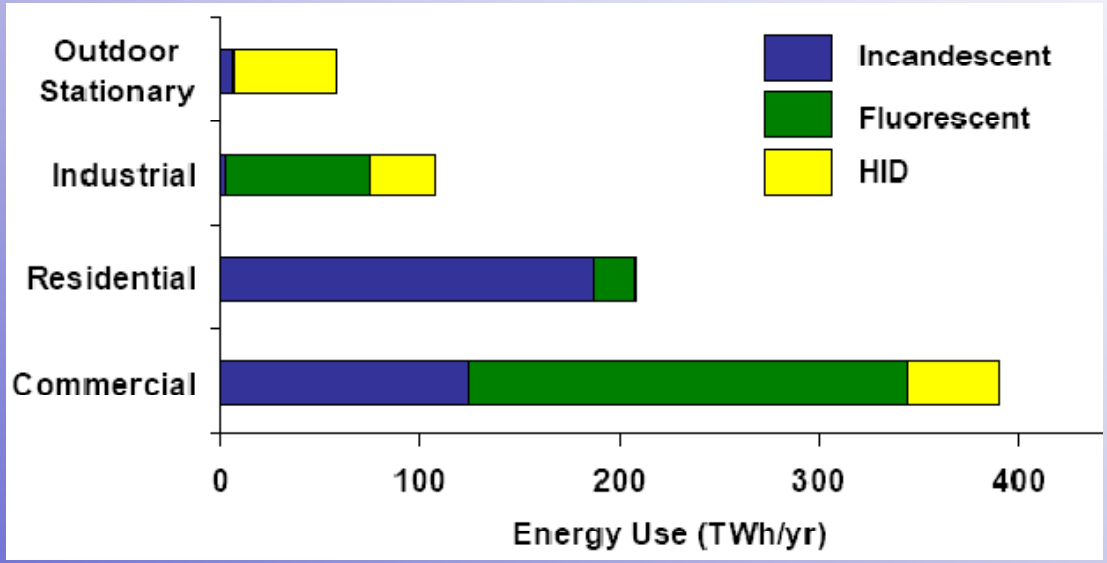
Lighting Industry in United States



Total U.S. Primary Energy Consumption for Electricity for Lighting by Sector 2001



2001 US Lighting Energy Consumption by Sector & Source

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Background Info

tdoor
tionary
egory

	Number of Installations	Installed Wattage per Installation (W)	Operating hours per Installation (h/day)	Lighting Energy Use per Installation (kWh/yr)	Total Lighting Energy Use (TWh/yr)
Billboard	**Displays**				**0.5**
8 Sheet	140,000	279	7.3	747	0.1
30 Sheet	200,000	557	7.3	1,493	0.3
Bulletin	56,000	836	7.3	2,240	0.1
Traffic Signal	**Intersections**				**3.6**
Ball Signal	300,000	3,568	7.3	9,549	2.9
Turn Arrow	300,000	248	2.2	201	0.1
Pedestrian	225,000	991	7.5	2,713	0.6
Aviation	**Lit runways**				**0.5**
Approach	720	36,000	6.0	78,840	0.1
Touchdown	5,000	10,800	6.0	23,652	0.1
Centerline	5,000	14,400	6.0	31,536	0.2
Taxiway/Runway	7,500	8,400	6.0	18,396	0.1
Roadway	**37,850,000**	**187**	**12.0**	**818**	**31.0**
Parking	**22,670,000**	**269**	**10.0**	**983**	**22.3**
Total					**57.8**

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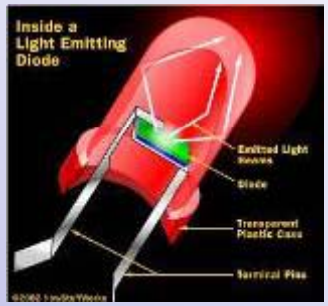
Background Info

In 1962, the first practical visible-spectrum light-emitting diode (LED) **was invented** at the Advanced Semiconductor Laboratory of General Electric.

Late 1960s, commercial product release of red LEDs (efficacy - 0.1 lm/W).



Acriche is the world's first

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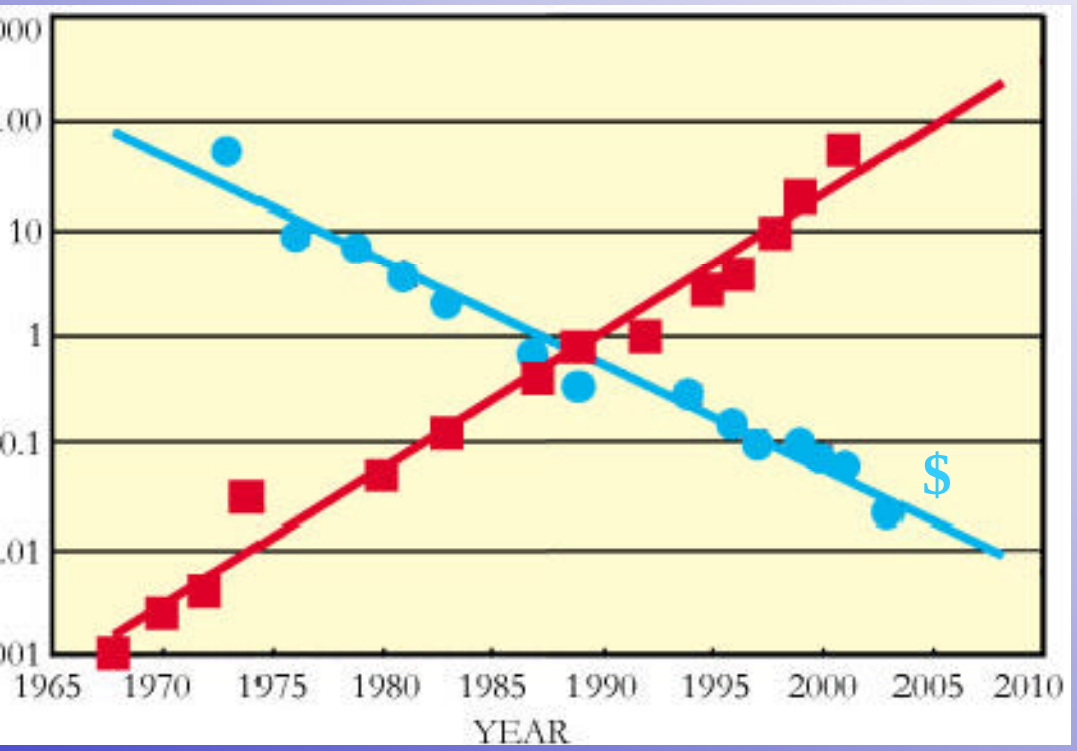
Background Info



▲ **Flux** 30X / 10 Years

▼ **$** 10X / 10 Years

z's Law *''LED brightness double every 18 to 24 months*
2001 Haitz)" – from LED Lighting Technologies and

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Challenges

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Challenges

- Constant technology update, need **$$$** for R&D
- More component and interconnection for one fitting
- Lighting characteristics
- Electrical network & power quality
- Dimming compatibility
- Failure mode – failure of 1 LED in array of 5 or 10?
- New industries not familiar working among themselves
  - Electronic components – **is shortage an issue?**
  - LED package susceptibility
  - Driver suppliers – too many, low production, high prices

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Challenges

- Manufacturer claims
  - Accuracy of data – ‘’*lifetime luminaire*’’
- Light measurement
- EMI/EMC
- Spare parts!
- Why can’t I replace the LEDs?
- Cost (Incandescent lamp cost < 7.5¢ to make)
- Expect a shakeout in the industry
- Hazardous material restriction http://www.rohs.eu/english/index.html

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Today

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Why Solid-State Lighting?

- **Long life** - LEDs can provide 50,000 hours or more of life.
- **Reduce maintenance costs**
- **Energy savings** - The best commercial white LED lighting systems provide more than ***five time the luminous*** efficacy (lumens per watt) of incandescent lighting.
- **Smaller flexible light fixtures** - The small size of LEDs makes them useful for lighting tight spaces.
- **Colored LED** - Advantageous for colored lighting applications (no filters needed).
- **Better quality light output** - LEDs have minimum ultraviolet and infrared radiation.
- **Durable** - LEDs have no filament to break and can withstand vibrations.
- **Intrinsically safe** - LED systems are low voltage and are generally cool to the

Definitions

ight Emitting Diode (LED) refers to a pn junction semiconductor

ED package refers to an assembly of **one or more LEDs**, including the mounting ubstrate, encapsulant, phosphor if applicable, electrical connections, and possibly ptical components along with thermal and mechanical interfaces

ED array or module refers to **several LED packages** that may be assembled on a ommon substrate or wiring board (possibly with additional optical components and echanical, thermal, or electrical interfaces) to be connected to the LED driver.

ED driver refers to a power source with integral control circuitry designed to operate n LED package or module or lamp.

ED luminaire refers to the complete lighting unit, intended to be directly connected o an electrical branch circuit.

ED lamp

- **non-integrated** refers to an assembly with an ANSI standardized base but *without* a built-in LED driver. Non-integrated LED lamps are designed for connection to LED luminaires.
- **integrated** refers to an assembly that is integrated with an LED driver and has an

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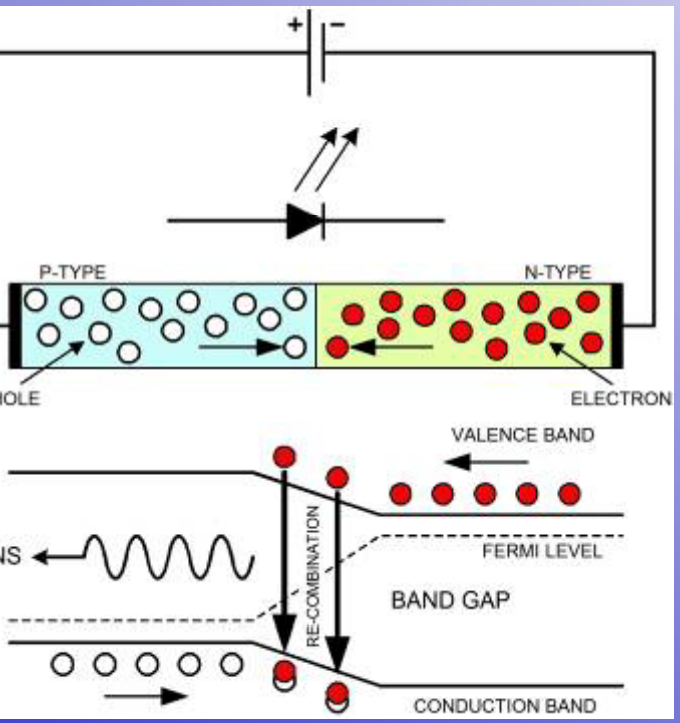
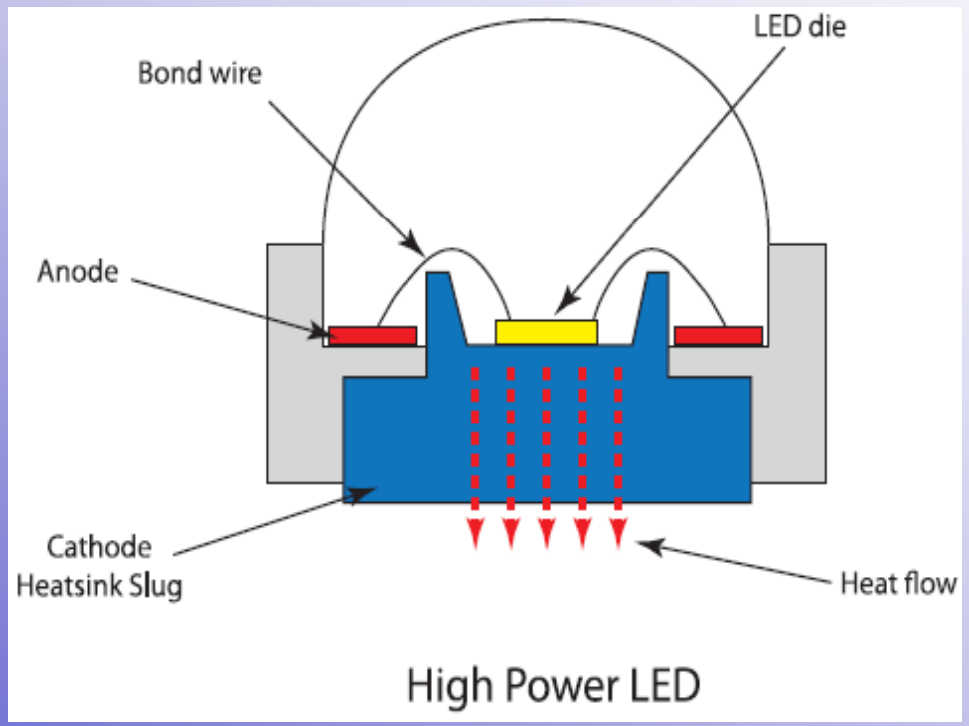
Light Emitting Diode (LED) is a semi-conductor





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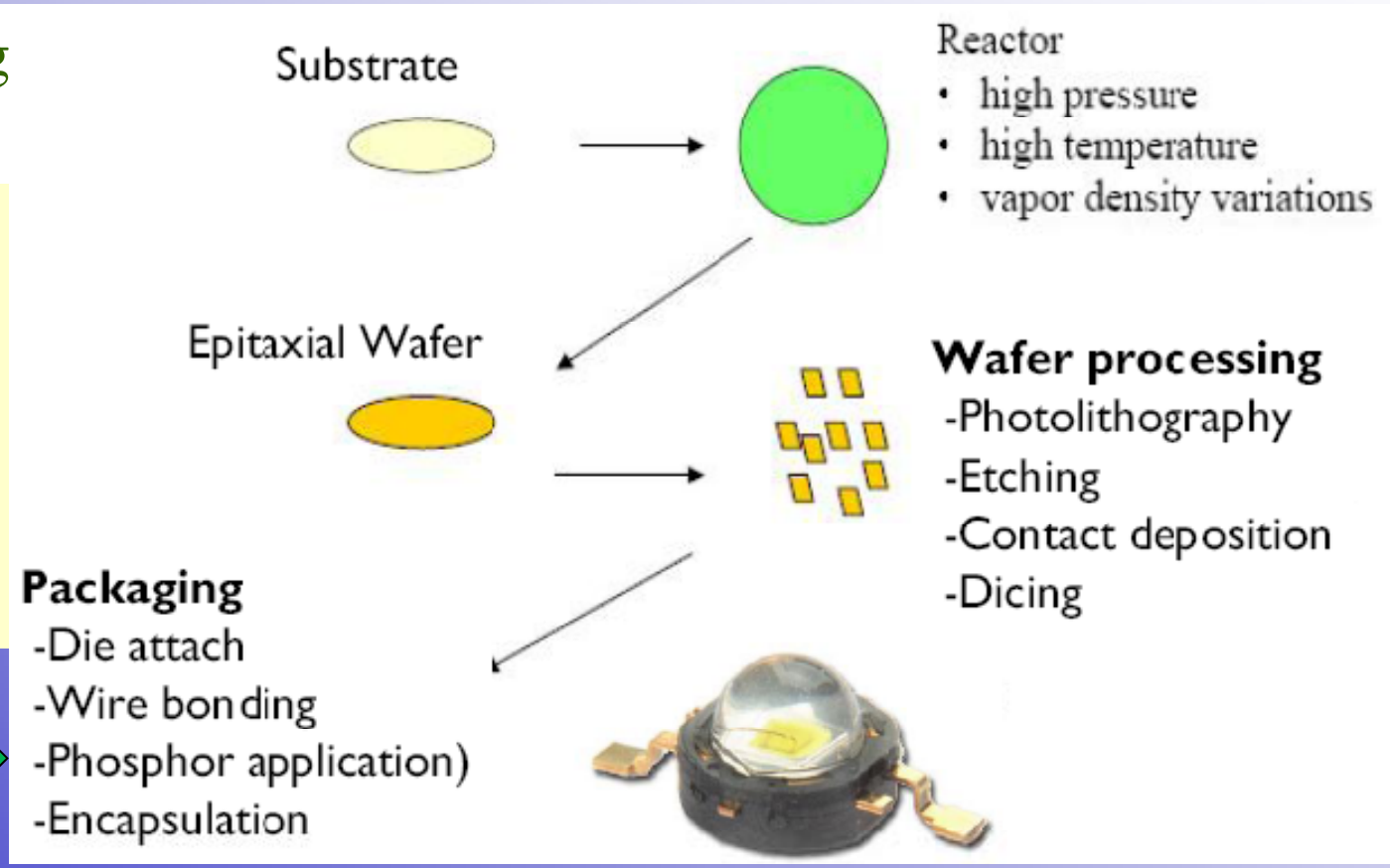

http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/bhandarkar_world_sanjose2010.pdf

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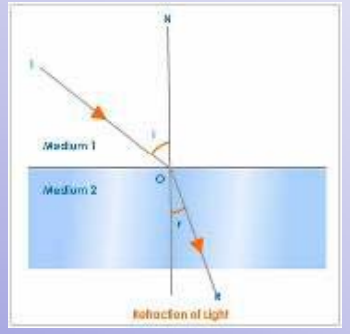
Light and Optics

Snell law



Secondary optic - **10 to 15%** losses of flux

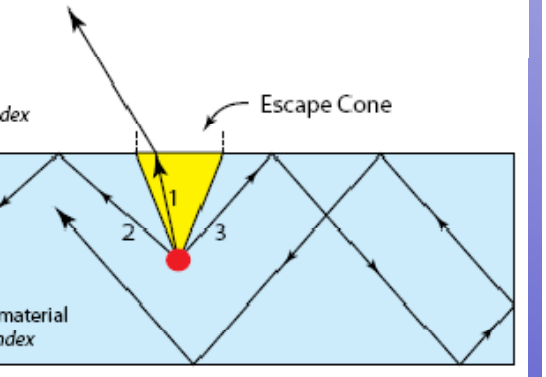
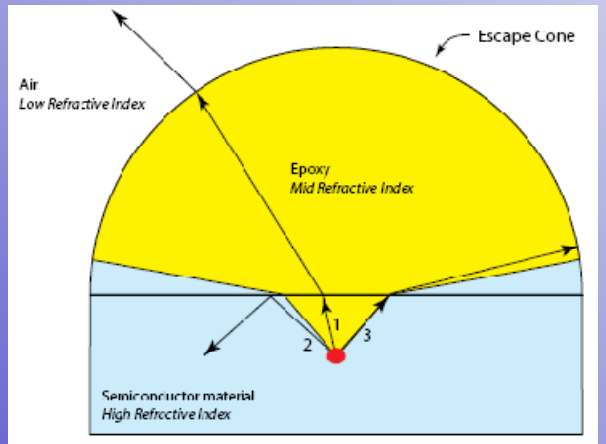
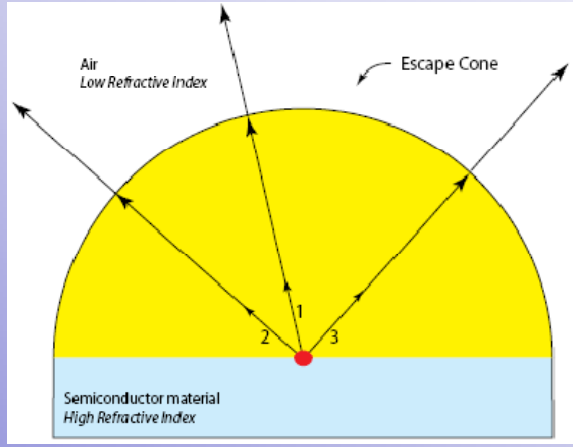


Figure 2 – TIR in a rectangular LED die



Epoxy encapsulation of the LED die



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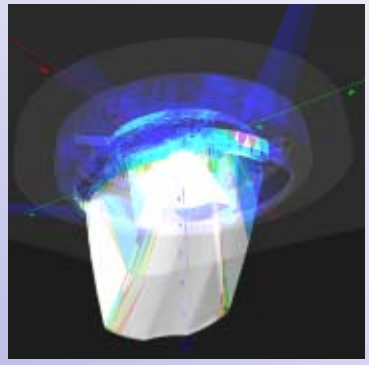
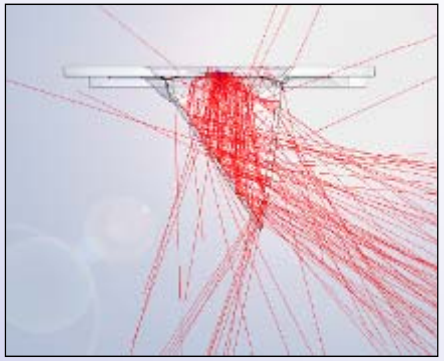
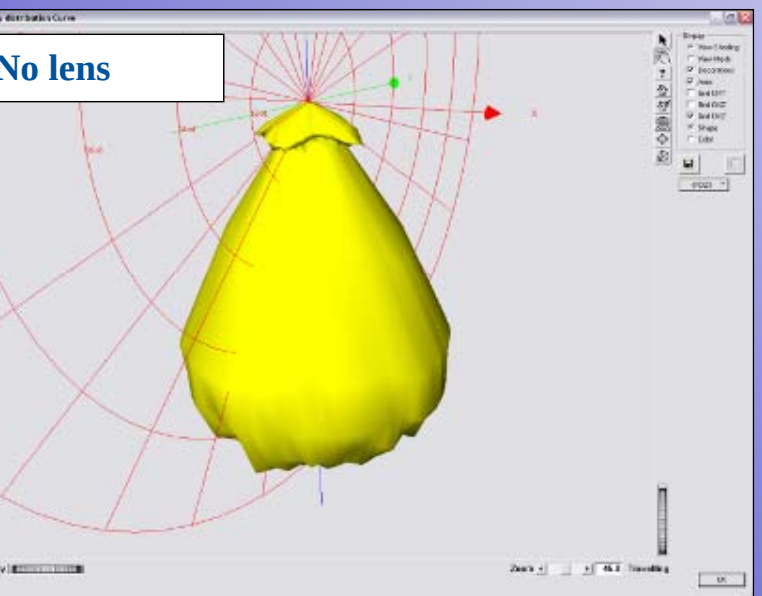
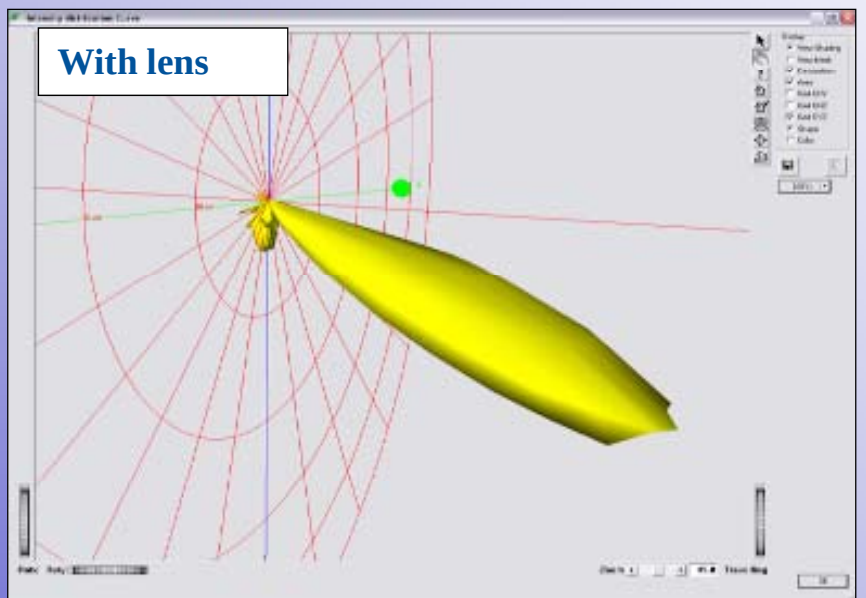
Light and Optics

Photometry









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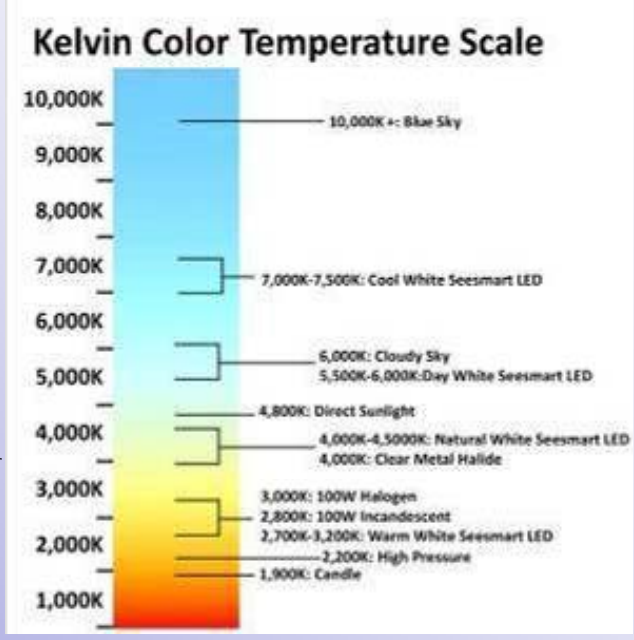
Today



orrelated Color Temperature (CCT)

A measure of the color appearance of a white light source.

CCT based on fluorescent + 4500 & 5700 K

olor Rendering Index (CRI)

It measure the spectral power at several discrete wavelengths

- Ra(8) - **8 wavelengths** (Standard) Ra(14) – 14 wavelengths

Found to be inaccurate for RGB (red, green, blue) LED systems.

Color Quality Scale (CQS)

– New metrics required for White LED – 15 saturated colors evenly span

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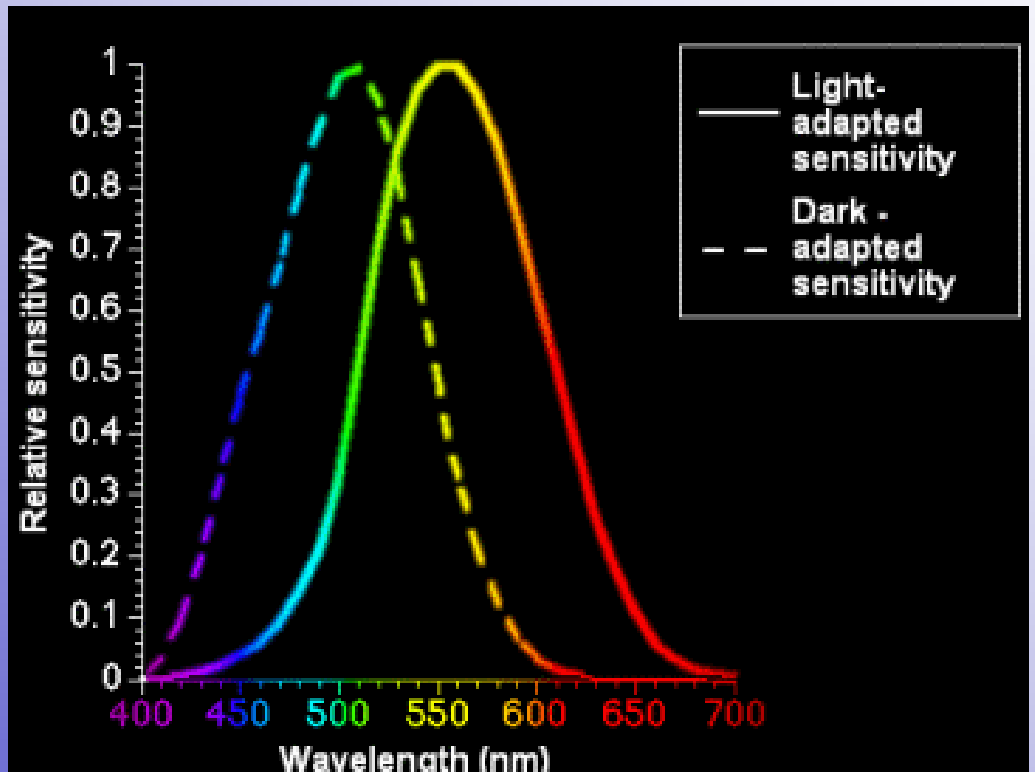
Eye sensitivity

Scotopic vision is the vision of the eye under low light conditions

Photopic vision is the vision of the eye under well-lit conditions



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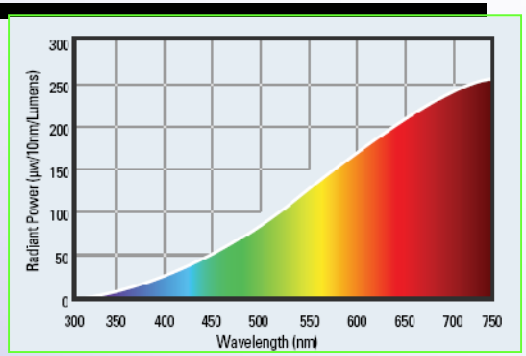
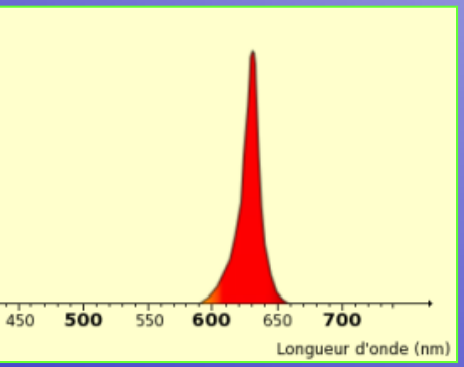
Spectral Power Distribution

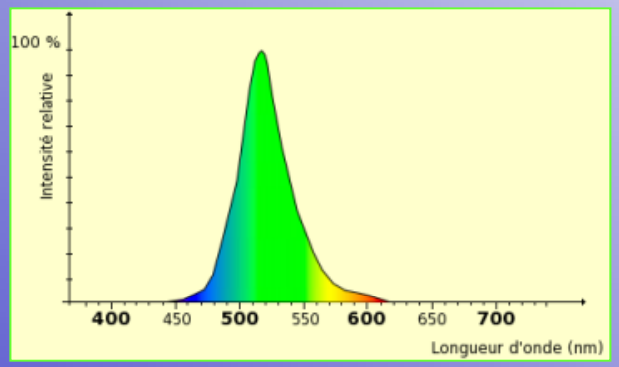
- White LED
  a. Short wavelength λ1 + phosphor larger wavelength λ2
  b. Near ultraviolet, coupled with one several phosphors
  c. Blue LED and Quantum Dots
  d. Combine **3 diodes** different visible wavelength



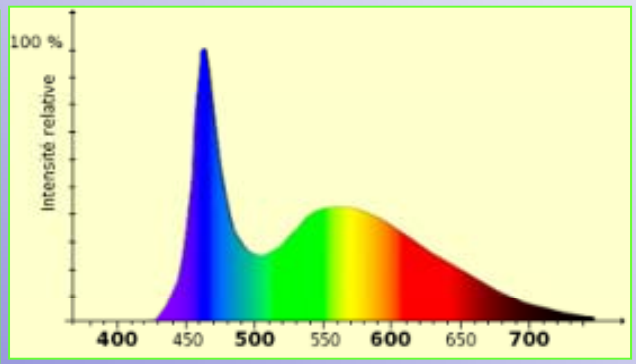
Typical Incandescent



Red LED



Green LED



White LED

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Today

Lumen maintenance

- Useful life
  - light output has declined to **70% of initial lumens (L70)**
  - **50% losses (L50)** for LED's used for decorative purposes.
- Life time of LED
  - IES **LM-80** : test LED package, arrays & modules (6000 hrs-250 days)
  - IES **TM-21**, *''Method for Estimation of LED Lumen Depreciation as a Measure of Potential LED Life''* is under development. It will use data from IES LM 80 test at multiple

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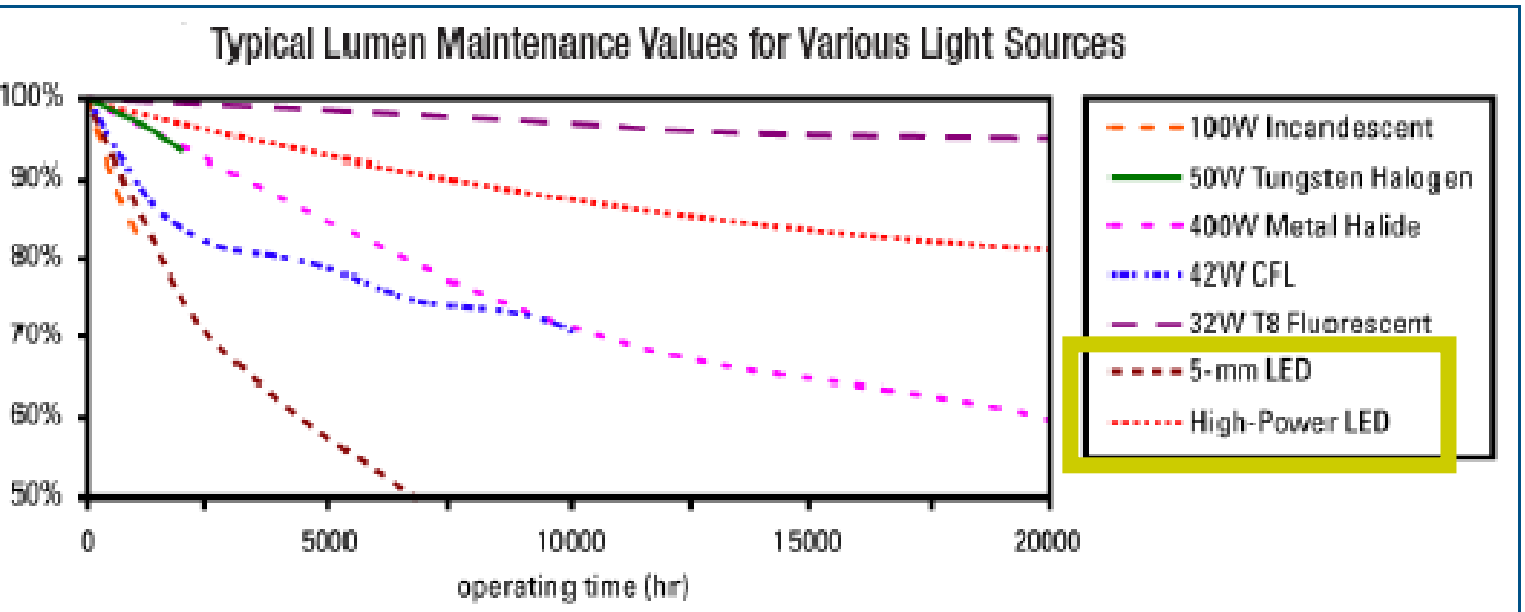
Today

Lumen maintenance



urce: Adapted from Bullough, JD. 2003. *Lighting Answers: LED Lighting Systems.* Troy, NY. National Lighting Product Information Program, Lighting Research Center, Rensselaer Polytechnic Institute.

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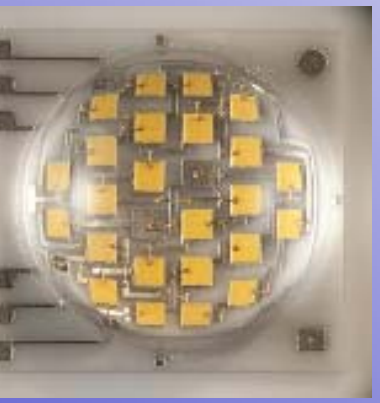
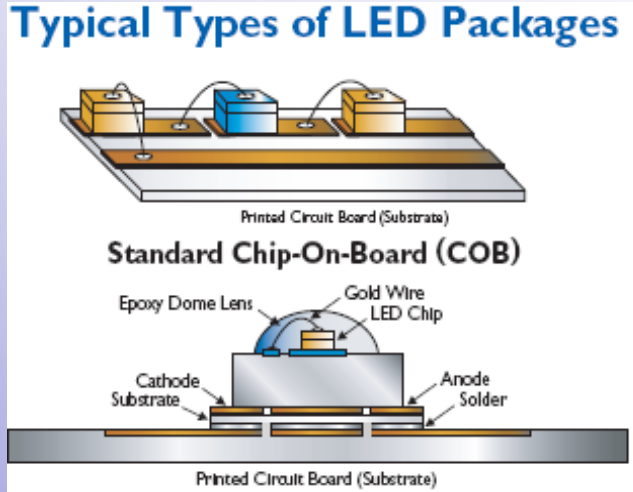
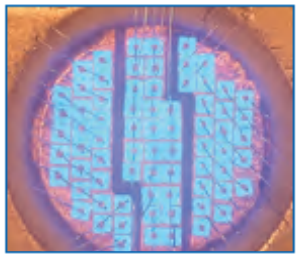
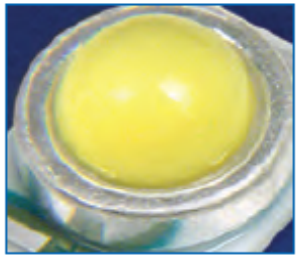
D on board!









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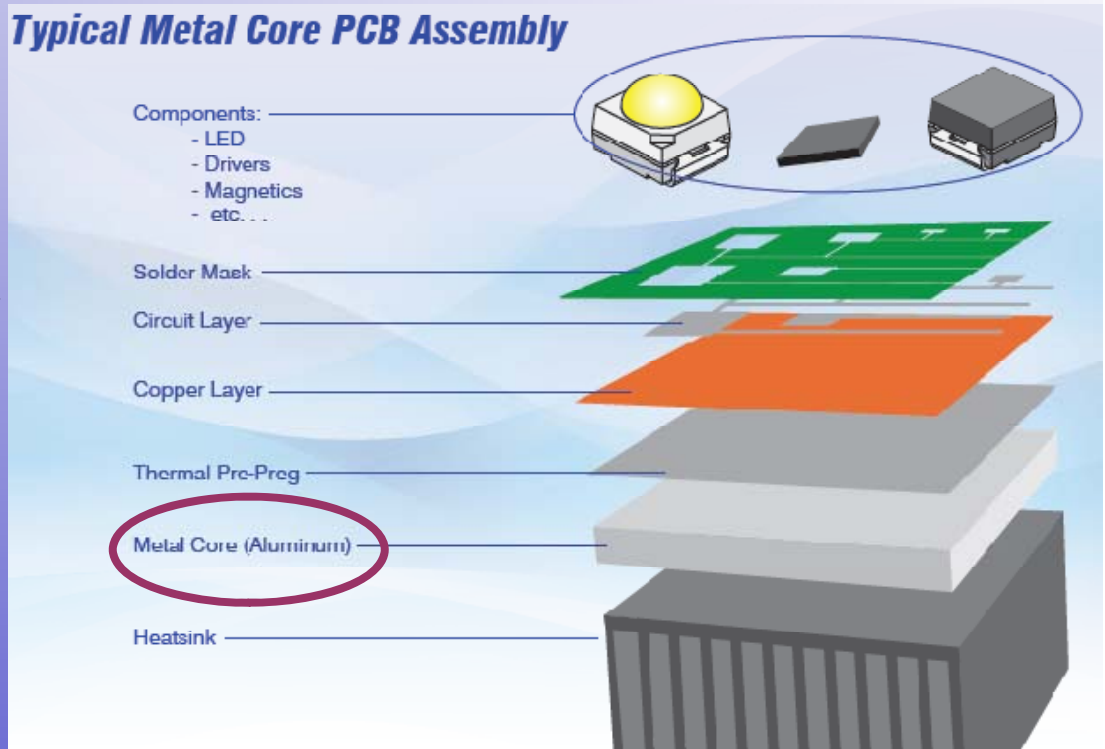
FR-4

- Glass fiber reinforced epoxy
- Not well suited to eliminate heat
- Low heat conductivity

MCPCB

- Aluminum and/or copper alloy
- Low coefficient of thermal expansion



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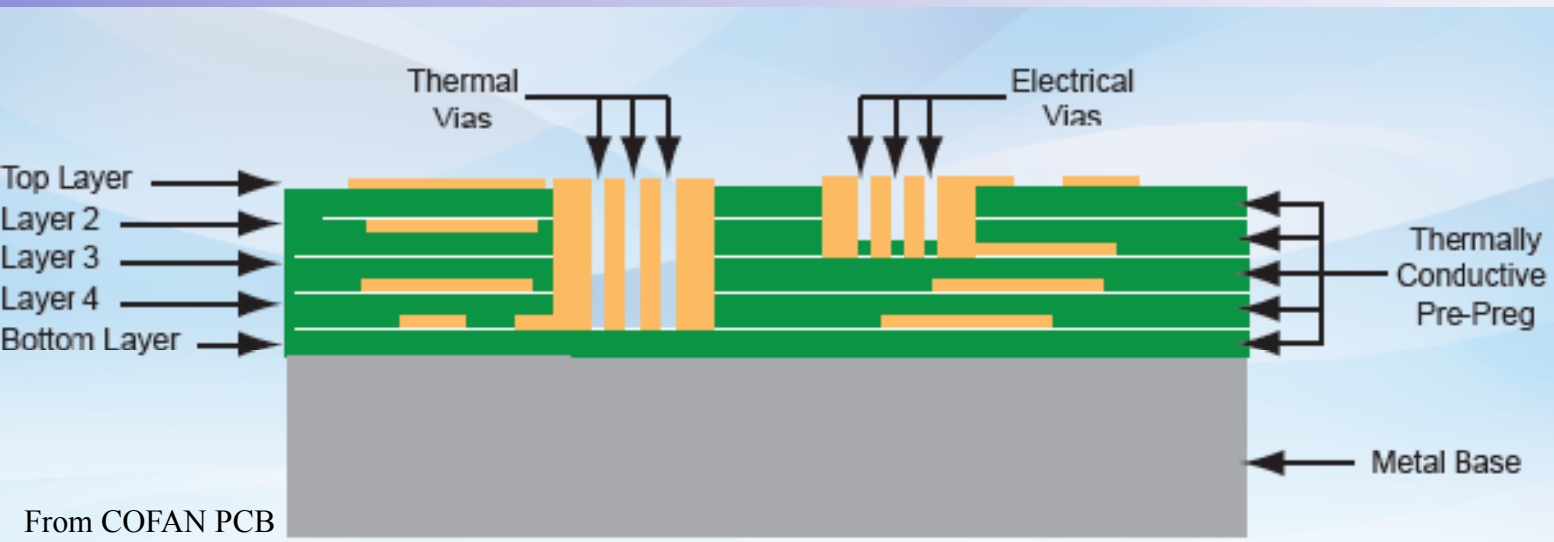
Four Layers Construction MCPCB - example



From COFAN PCB

- Single side SMT with Metal Base
- Surface Mounting on Top Layer
- All Connectivities are being done on Layer 2 & 3. EMI on Layer 4

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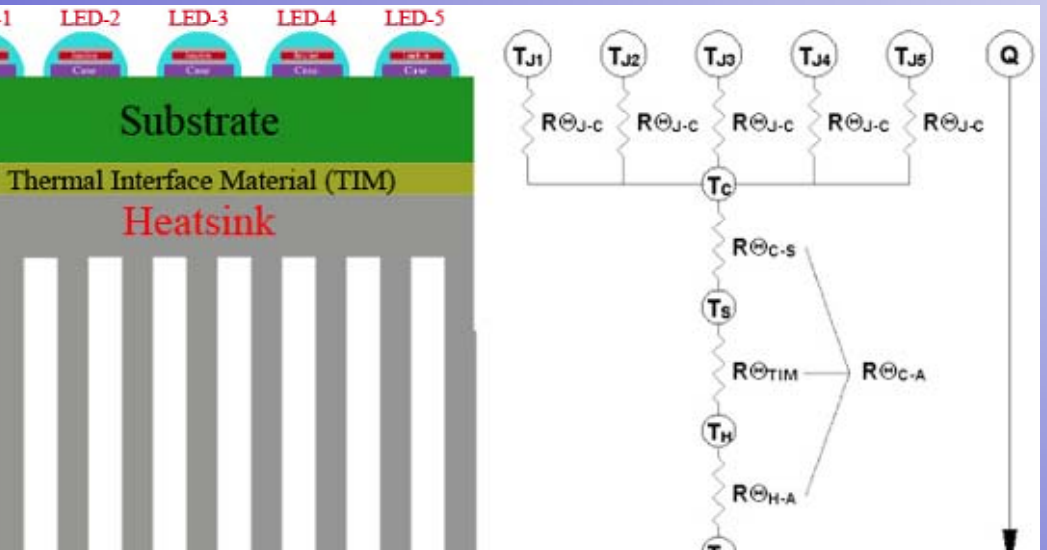
Today

Designated Temperature Test Point

Thermal Model

Surface area & thermal resistance
Substrate material (PCB)
Ambient temperature



Pin Fin

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Today

Why thermal management is so important?

0 lumens source

W incandescent
sipate 3 Watts
nduction.

LEDs.
VF (forward
tage) 3.2V
rent of 350mA
3.4 Watts

Source	Efficiency (%)	Efficacy (lumens/ watts)	Heat Loss (%)		
			Radiation	Convection	Conduction
Incandescent	2	15	90	5	5
Fluorescent	15	90	40	40	20
High Intensity Discharge	20	100	90	5	5
LED	20	75	5	5	90

Heat conduction comparison of various light sources

Tyco Electronics – Application Note

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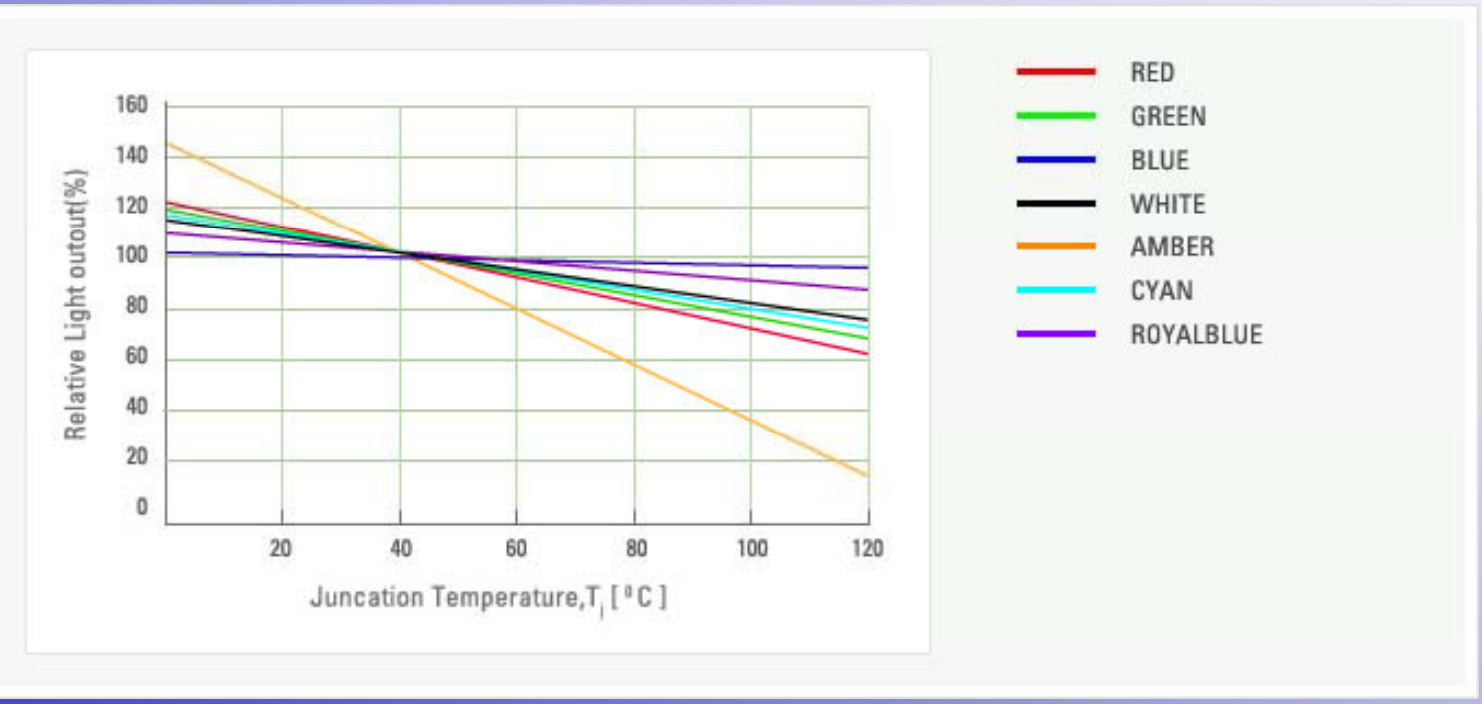
Today

Why thermal management is so important?



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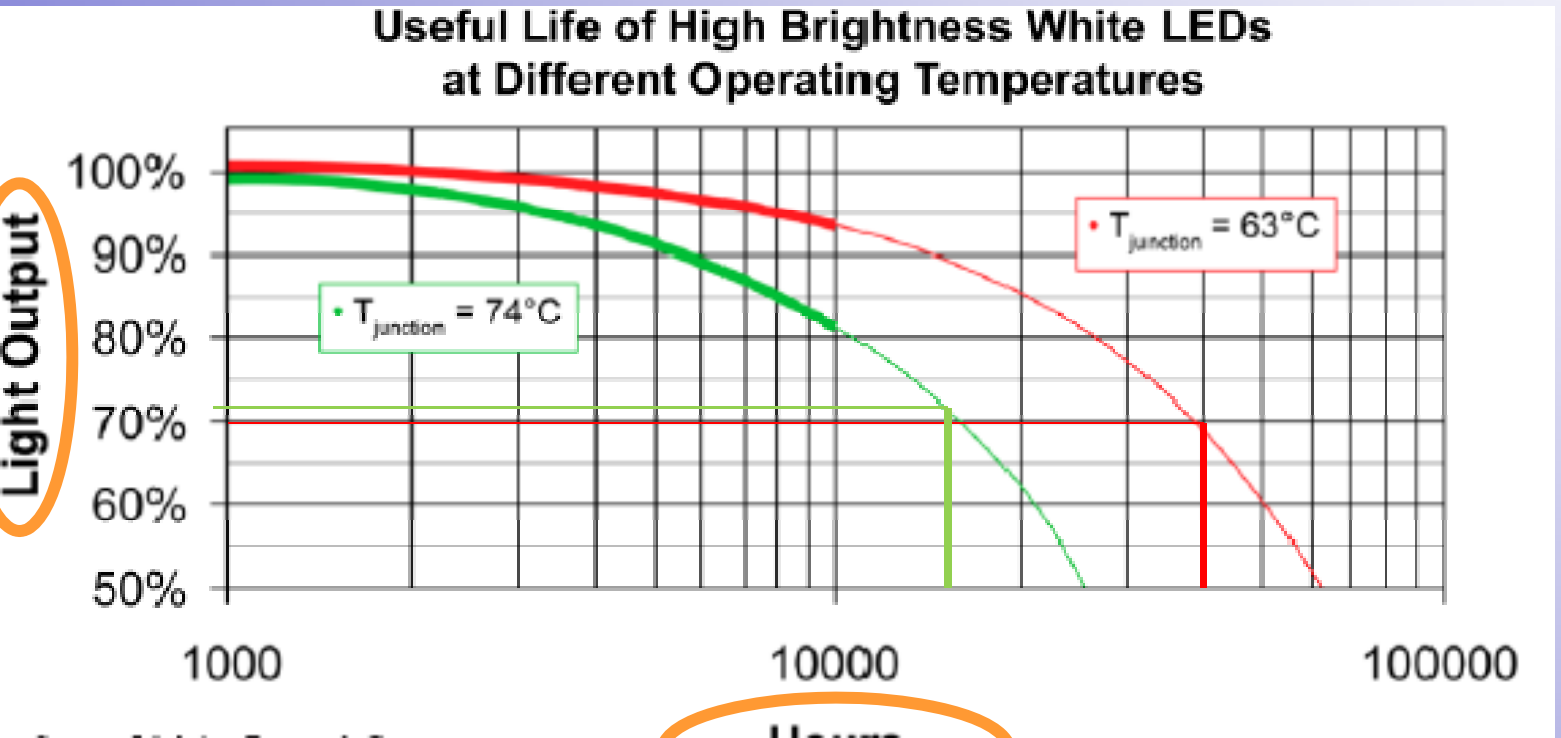
Today

Why thermal management is so important?



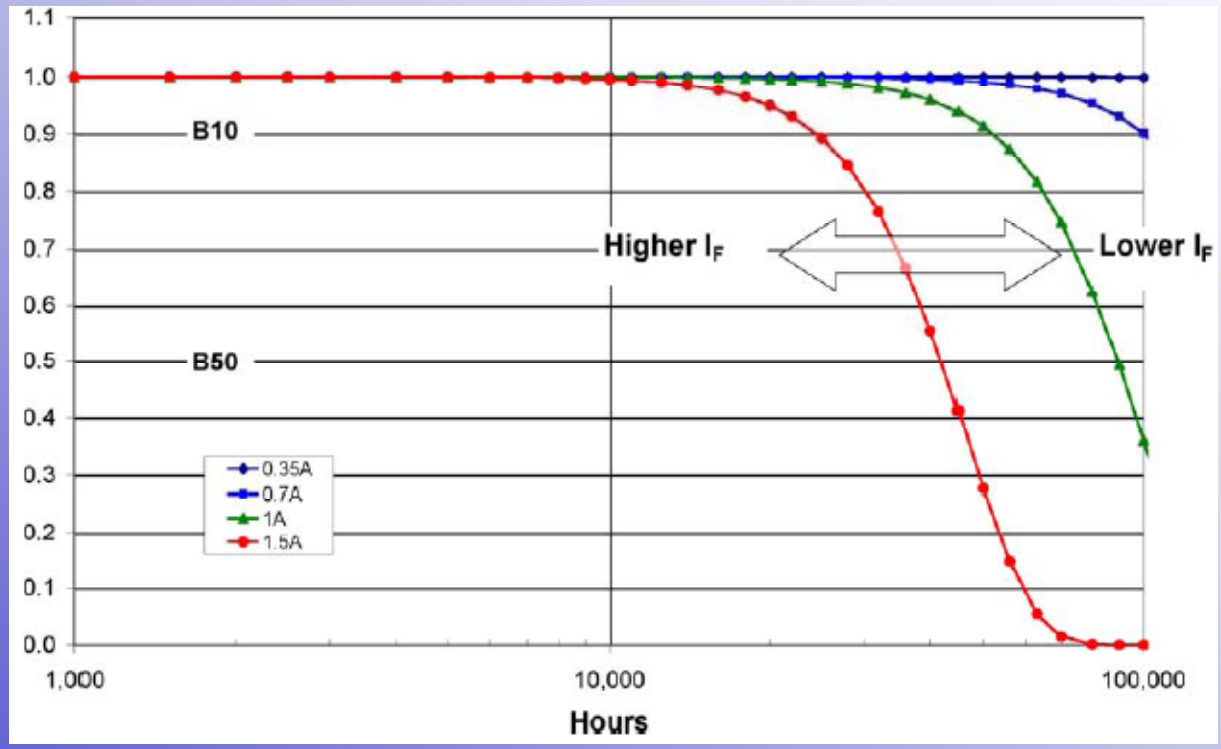
Today

Why thermal management is so important?

Current at

- 350 mA
- 700 mA
- 1000 mA
- 1500 mA
- Many others!

Based on pure DC



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Today

Driver

- Similarity with SMPS
- Product interfaces have **not been standardized**
- Drivers, dimmers, controls are difficult to navigate
  - **Capacitor** are susceptible to **temperature** cause high **failure rate**

Integrated Power Module
Discrete Controller

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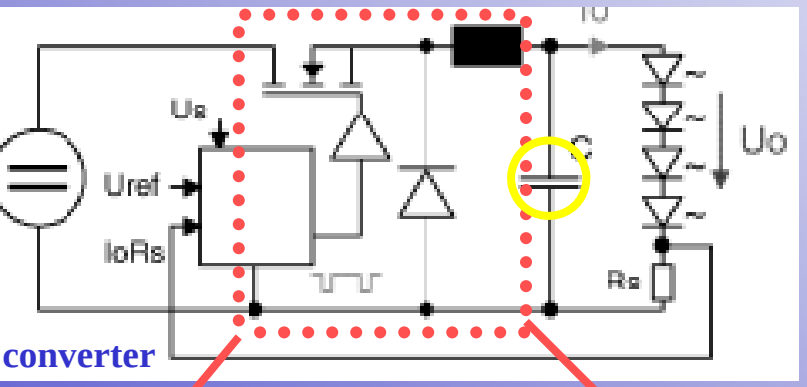
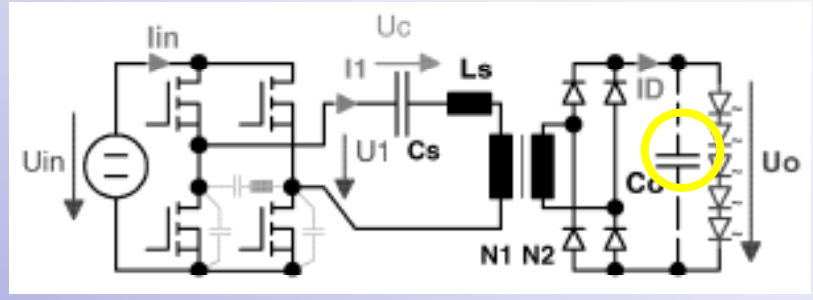
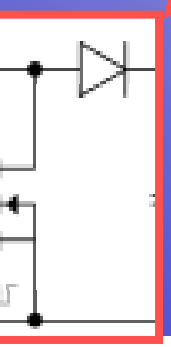
Driver and topologies

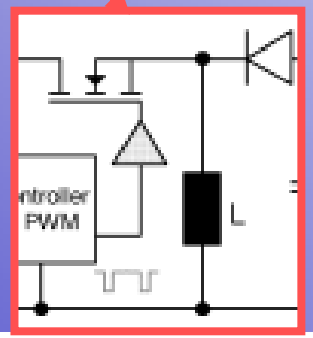
– Use of standard DC to DC power supplies

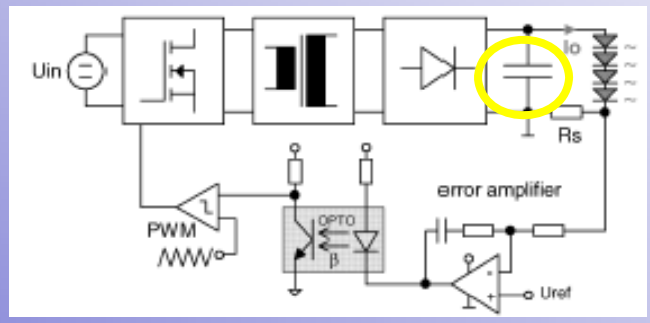




Resonant converter for LEDs







Galvanic isolating LED driver

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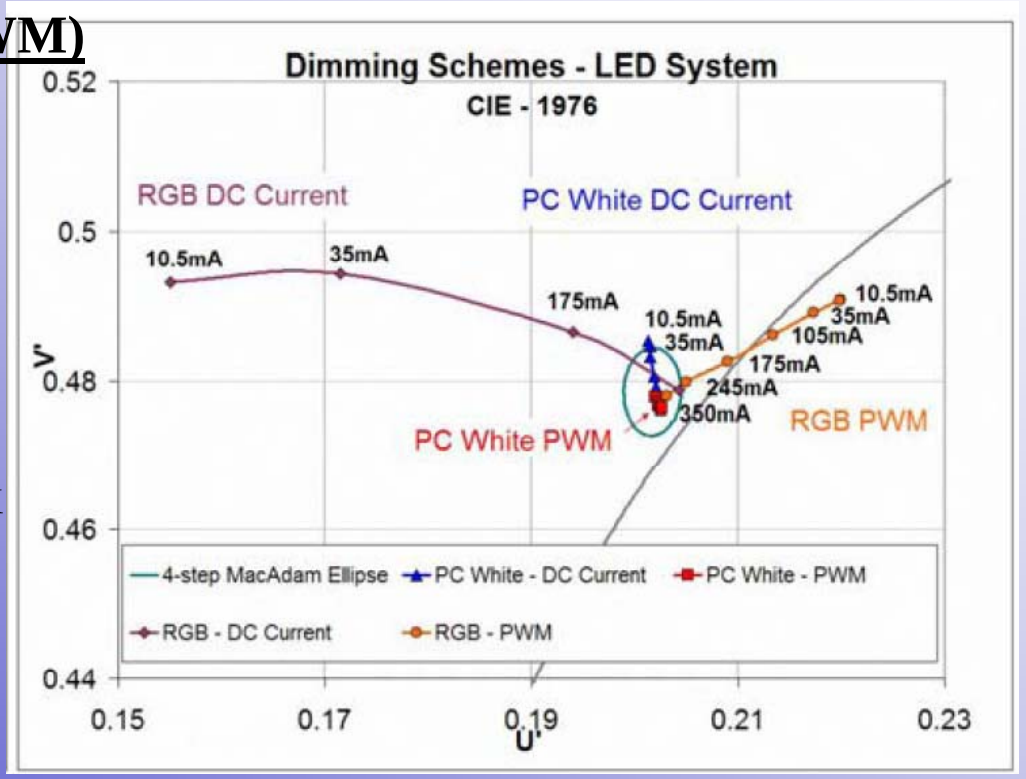
Driver and dimming method

Chromaticity shifts of under two types of dimming,

<u>continuous current reduction (DC)</u> and

<u>pulse-width-modulation (PWM)</u>

- Phosphor-converted (PC)
- RGB mixed-color LED



Perceivable color changes

- 1% of amplitude
- 1 nm shift of wavelength peak

PWM > 100 Hz not visible to human eye

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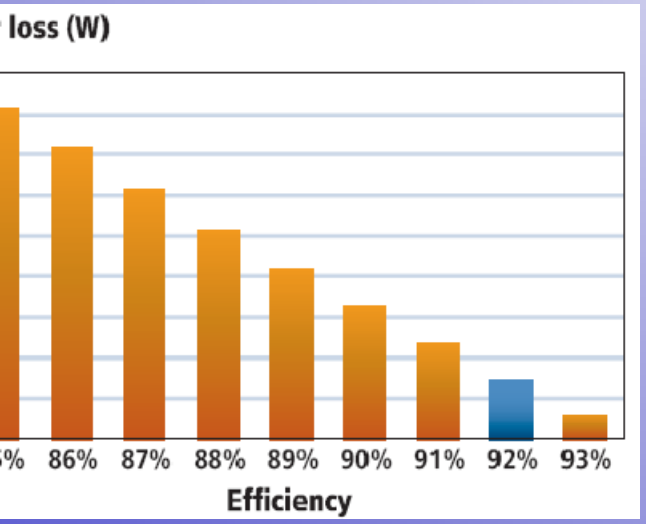
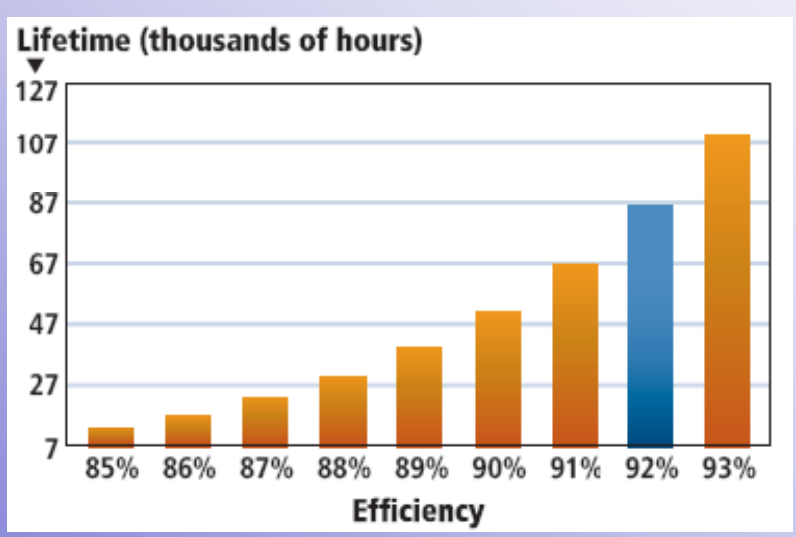
Driver and efficiency



r loss vs. efficiency of a 150W LED driver

If efficiency goes from 95% to 85%, heat is increase by a factor of 3.3



Lifetime vs. efficiency of a 150W LED driver

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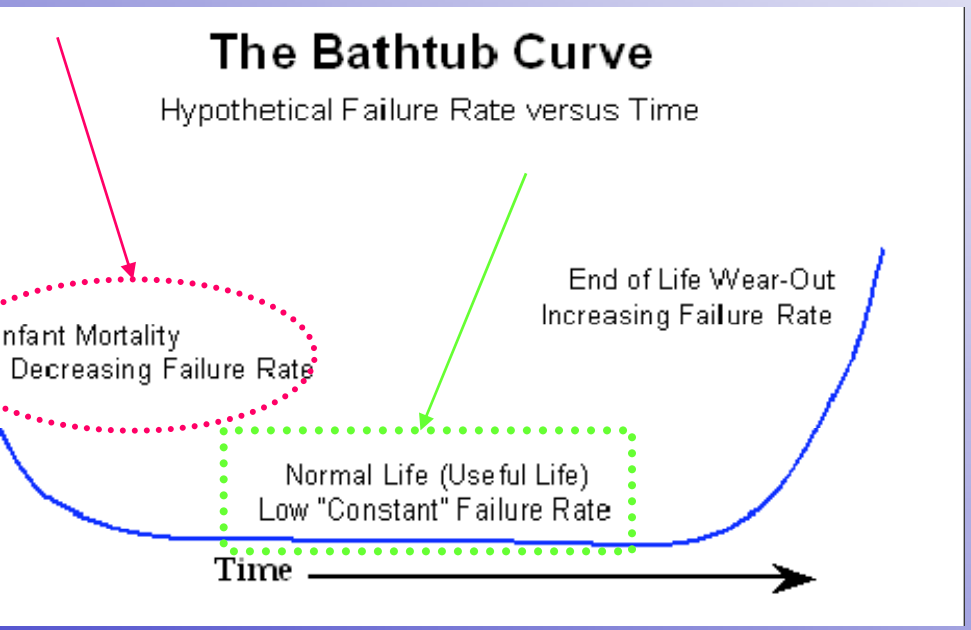
Driver and reliability



MTBF = Total Time/ Failures

Capacitor
a) Temperature
b) Ripple current

$$Lx = k \cdot Lo \cdot 2^{(Ts-Ta)/10}$$

- *Lx = lifetime*
- *Lo = lifetime tested in standard condition*
- *K = factor RMS ripple current*
- *Ts = rated case temperature*
- *Ta = operating case temperature*

Temperature rise of 10ºC reduce lifetime by 50%

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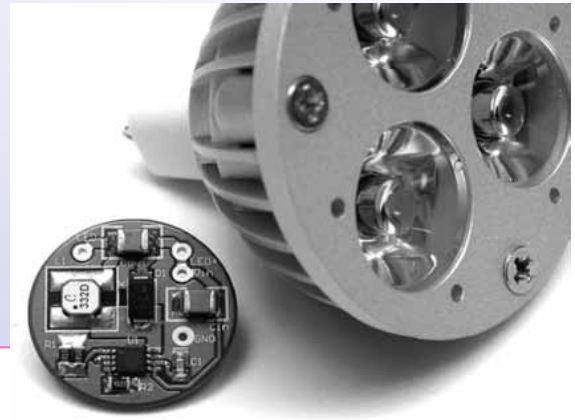
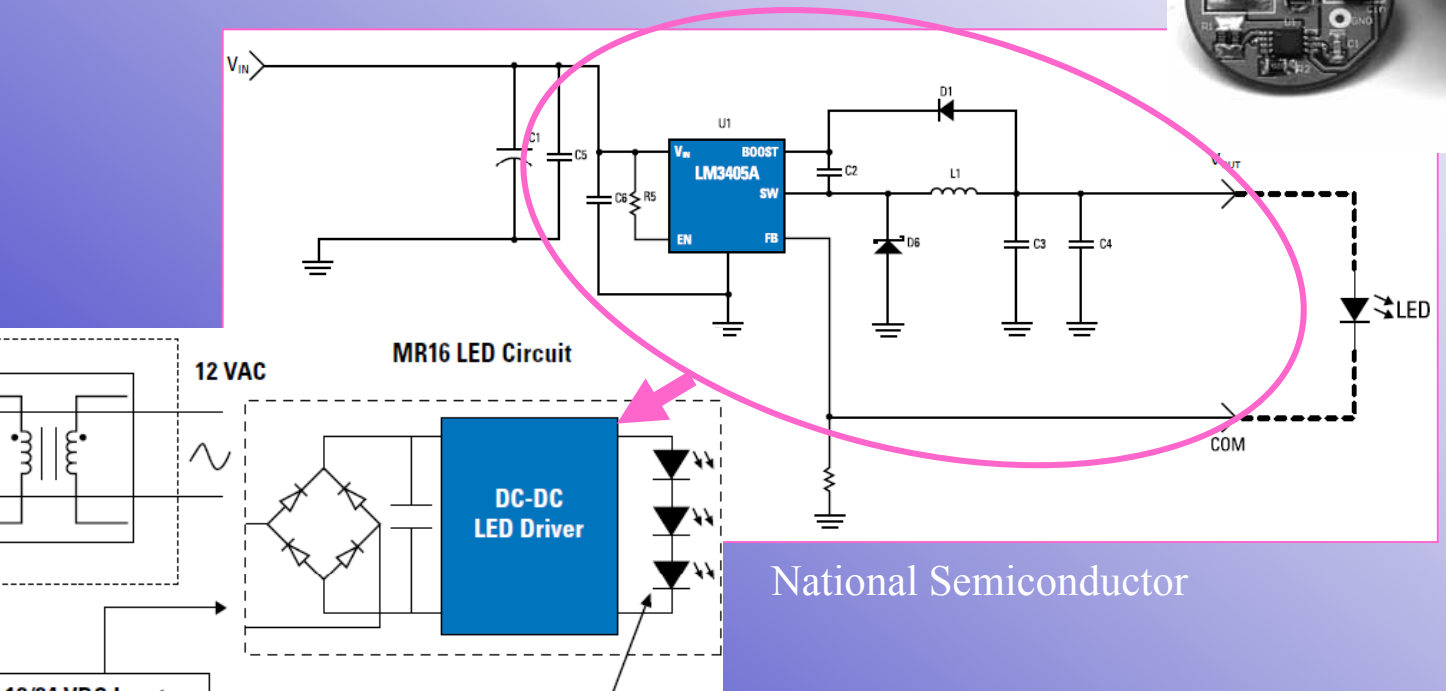
Today



MR16 driver concept



National Semiconductor

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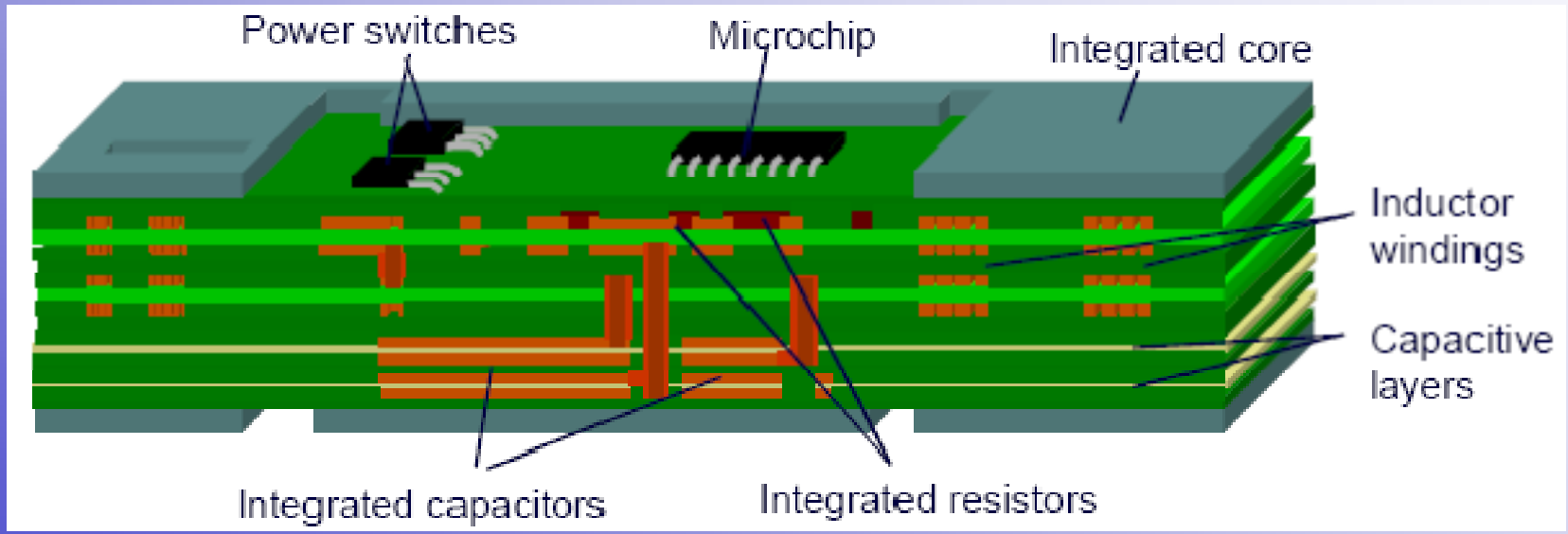
Driver and integration

– Use of embedded passives integrated circuit



Philips Research Laboratories Aachen, Germany

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Driver - Power Factor & Harmonics

ANSI C82.77 – Harmonic Emission Limits – Related Power Quality Requirements for Lighting Equipment

- Commercial indoor & roadway
  Requested : **PF > 90%**, Maximum **harmonic 32%** of I, + max of:
  2nd harmonic 5% , 3rd harmonic 30% , Individual harmonics>11th 7% ,
  Odd Triples (3rd, 9th, 15th, 21th,) 30%
- Or Point of Common Coupling IEEE 519-1992

IEEE 519 – 1992 Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

CBEA LED Site Lighting Performance Specification – PF > 90%,

New rules from **ENERGY STAR** program

Compact fluorescent (CFL) experience and important impact on electrical network

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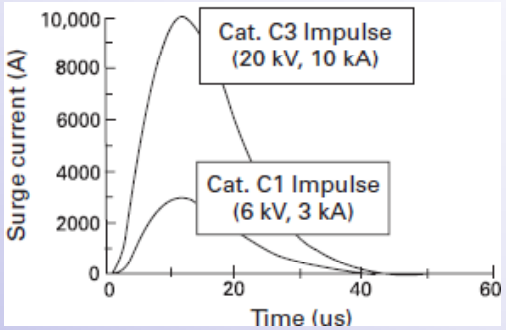
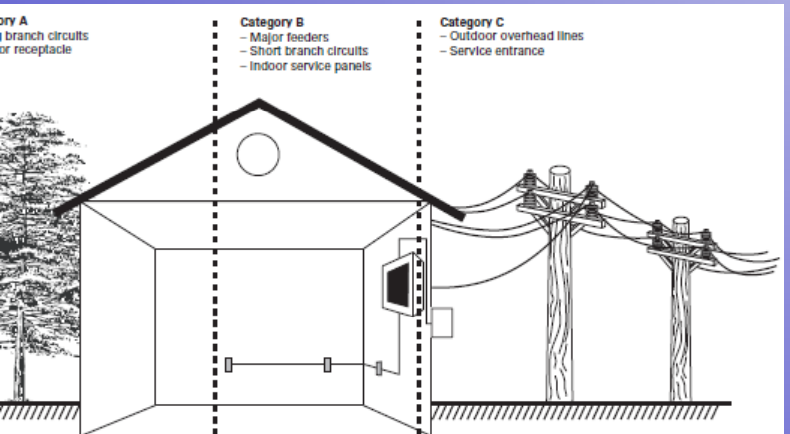
Today

rotection Devices for Outdoor and Standards

- ***IEEE Std. 1100 (2005) -*** *Recommended Practice for Powering and Grounding Electronic Equipment*
- ***UL 1449: Transient Voltage Surge Suppressors***
- ***ANSI/IEEE C62.41-2002 -*** *Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits*
- ***NEMA, IEC, Others***





CAT.	LEVEL	VOLTAGE (KV)	0.5μs X 100 KHZ RING WAVE CURRENT (A)	1.2 X 5μs (V) 8 X 20μs (A) COMBINATION WAVE CURRENT (KA)
A1	Low	2	70	—
A2	Medium	3	130	—
A3	High	6	200	—
B1	Low	2	170	1
B2	Medium	4	330	2
B3	High	6	500	3
C1	Low	6	—	3
C2	Medium	10	—	5
C3	High	20	—	10

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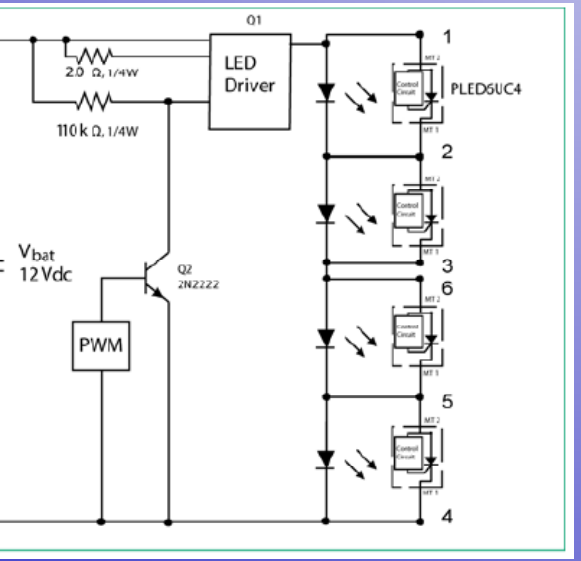
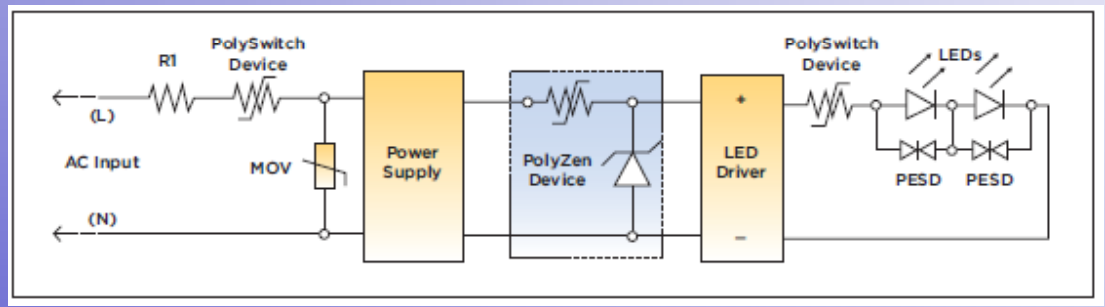
Protection Devices

– Open LED and keeps strings lighted if a single LED fail



mension up to 4.5 x 2.5 x 0.5 mm
Littelfuse

– Over voltage, current and temperature protection device



Resettable PPTC (polymeric-positive-temperature-coefficient)

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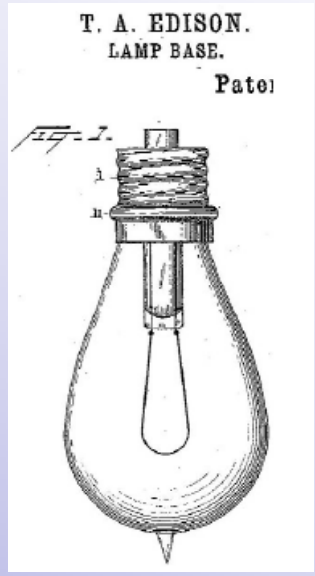
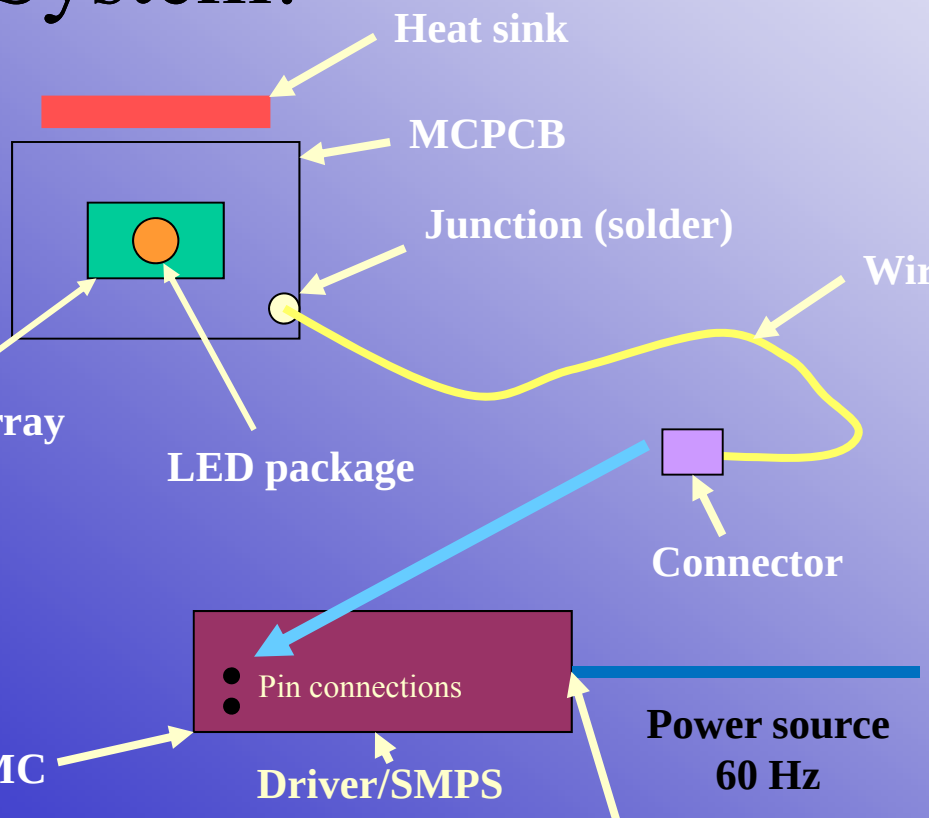
Today



System!



<u>Simplicity</u>, no longer exist!

- Behaviour of LED Systems
- Connection and susceptibility
- Lifetime

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Standards

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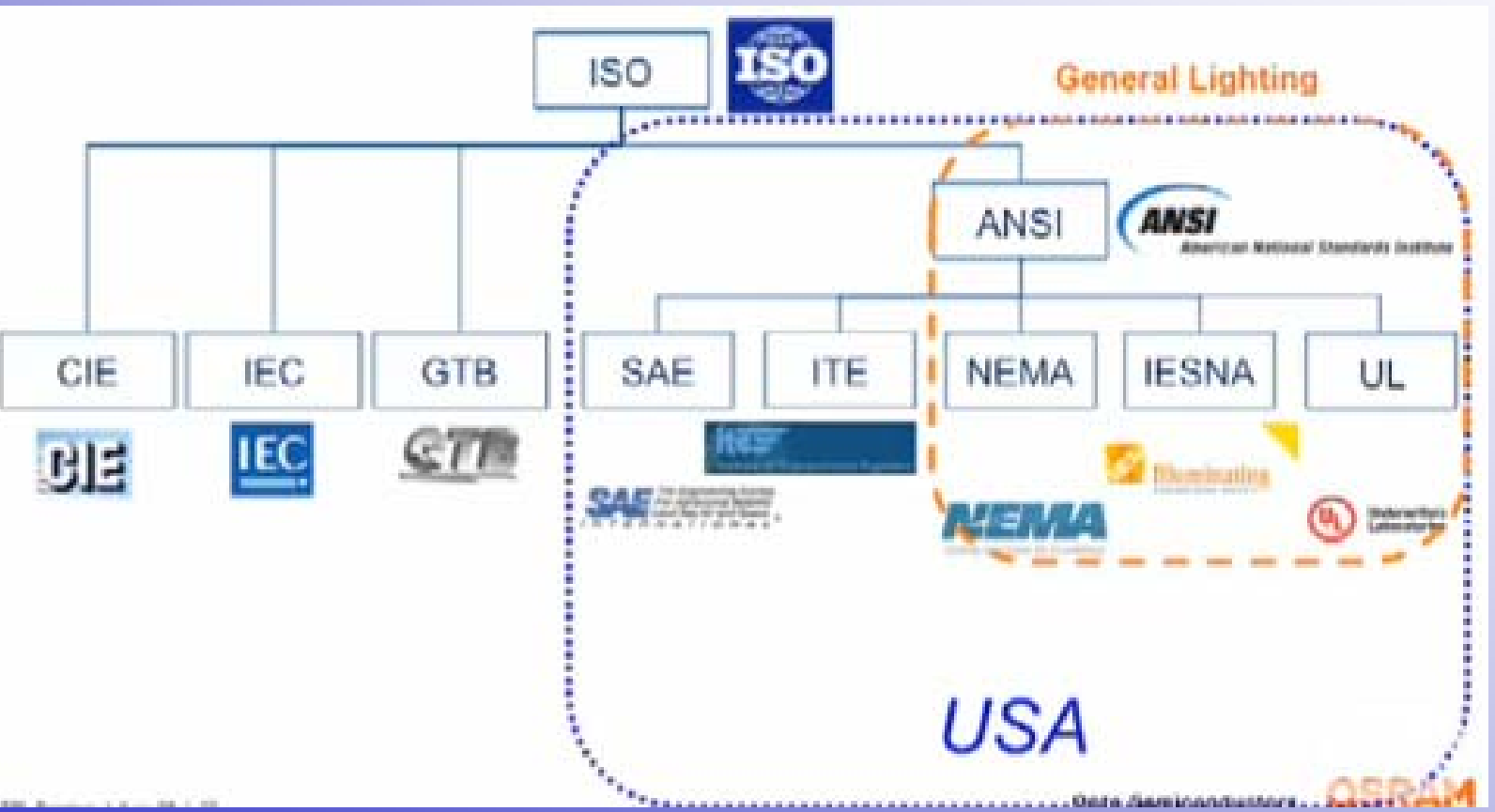
Standards



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Standards

rent

NSI C78.377-2008, Specifications for the Chromaticity of Solid-State Lighting roducts

ESNA G-2-10 , Guideline for the Application of General Illumination (White) LED

ESNA LM-79-2008, Approved Method for the Electrical and Photometric Testing f Solid-State Lighting Devices

ESNA LM-80-2008, Approved Method for Measuring Lumen Depreciation of LED ight Sources

ESNA RP-16 Addenda a and b, Nomenclature and Definitions for Illuminating ngineering

EMA LSD 45-2009, Recommendations for Solid-State Lighting Sub-Assembly terfaces for Luminaires,

EMA LSD 49-2010, Solid-State Lighting for Incandescent Replacement—Best ractices for Dimming

EMA SSL 3-2010, High-Power White LED Binning for General Illumination

L 8750, Safety Standard for Light Emitting Diode (LED) Equipment for Use in

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Standards

ivities and material **under development**

NSI C78-09, Working Group – SSL Light Sources

NSI C82-04, Working Group – SSL Drivers

ESNA TM-21, Method for Estimation of LED Lumen Depreciation as a leasure of Potential LED Life

ESNA LM-XX1, Approved Method for the Measurements of High Power EDs

ESNA LM-XX2, LED "Light Engines and Integrated Lamp" Measurements

EMA SSL-1, Electric Drivers for LED Devices, Arrays, or Systems

IE TC1-69, Color Quality Scale

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Research

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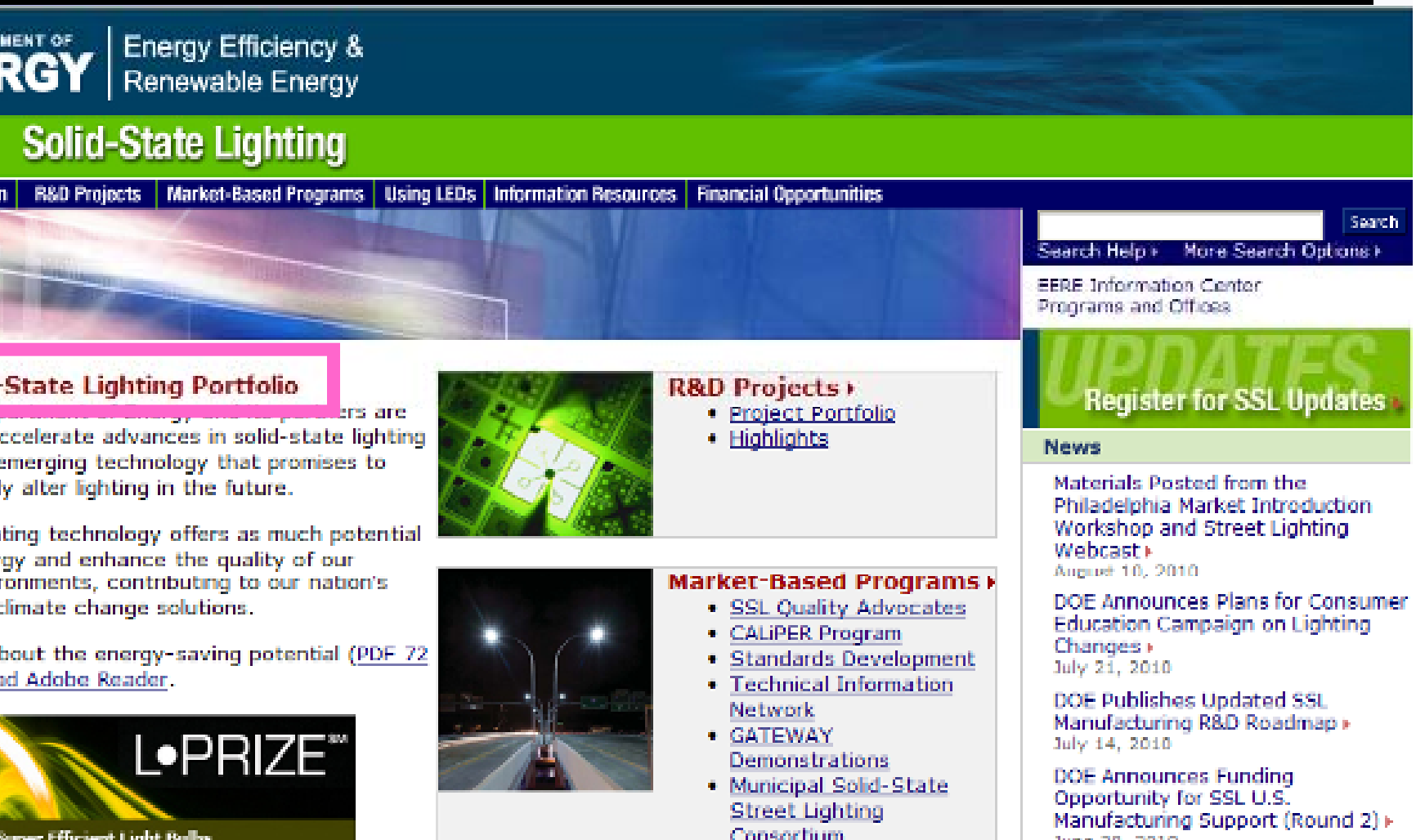

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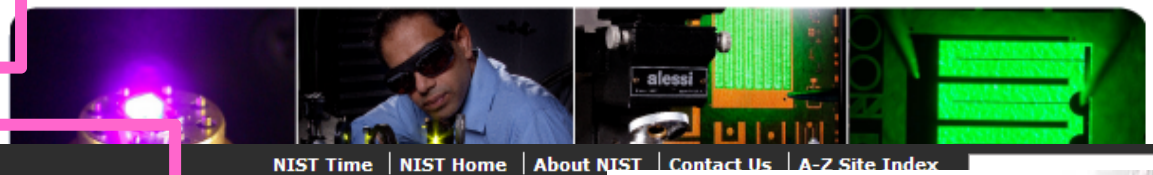

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Color rendering of light sources

A Color Quality Scale (CQS) is being developed at NIST with input from the indu
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BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY

STRATEGIC DIRECTIONS

Strategic Directions | Scientific Divisions

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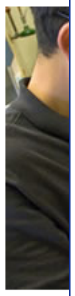
- Photon Science: X-Rays for Discovery
- Climate Change and Environmental Sciences
- Matter and Force in the Universe
- Energy Efficiency and Sustainable Energy
- Computational Science and Networking
- Biological Sciences for Energy Research

Energy Efficiency and Sustain

There's enough power in an hour's worth of global sunlight to supply an entire year's worth of human energy demands with no carbon emissions to exacerbate global warming. But until we are able to make full and effective use of this bounty, energy efficiency remains the most readily available means of reducing our dependence on foreign oil.



Batter

Energy efficiency

Contrary to popular belief, the terms "energy efficiency" and "energy conservation" are not sy

Advancing the effective use of light for society and the environment

Lighting Research Center

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Research Areas | Educational Opportunities

LEDs

LEDs (light-emitting diodes) are semi-conductors that convert electricity into light. Once used just as indicator lights for electronics, LEDs have evolved into a major lighting technology that may change the future of general illumination. LEDs are highly regarded for their long life, energy efficiency, non-toxicity, durability, and flexibility. Yet as a fairly new and rapidly changing lighting technology, much research is still needed in order to fully realize the energy and cost savings potential of LEDs.

The Solid-State Lighting Program at the LRC
educational programs to enhance this technology, overcome barriers to effective use, and help it to gain acceptance for general illumination purposes.

Download the LRC Solid-State Lighting Program brochure

Related Programs

- Solid-State Lighting - Improving, using LEDs
- Light & Health - Visual, circadian systems

Education Programs

Lighting Education Online is an interactive, Internet-based education program for building, design, and facility management professionals who want to learn more about light and lighting. Available courses include:

- Lighting Terminology (free of charge)
- Lighting Technology
- Residential Lighting

The LED Lighting Institute is a three-day, hands-on workshop for people who want to learn more about this quickly evolving lighting technology in a small-class setting.

Projects

Lighting Supermarket Freezers with LEDs - A field study investigating the use of white LED lighting inside supermarket freezers, including energy comparisons with fluorescent, sales analyses, and shopper preferences.

LEDs: Saving Energy in Retail Display Windows - A field study using LEDs as colored background lighting

Applications

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Applications

Residential and commercial building

– Lamp replacement

2.3 Watt – 250 lux
beam angle: 40°
LEDs .com

7.4W - 200 lumens
narrow beam
Digilin

7 Watts LED = 25W A19
Incandescent Bulb

ENERGY STAR® Program Requirements for Luminaires

Eligibility Criteria – Version 1.0, DRAFT 2

Note: This specification replaces the ENERGY STAR Residential Light Fixtures and Solid State Lighting Luminaires specifications.

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Applications

Office & public spaces

- Alignement
- Cost
- Retrofit

Will create 96 shadow lines
Not good for task light

- Design & integration
- Warranty

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Applications

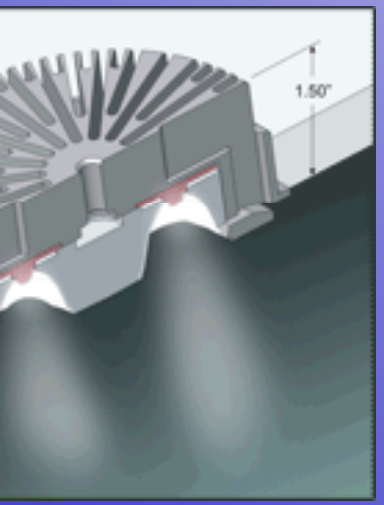
Retail area (7 years cycle!)

- Heat (IR)
- Discoloration
- Compatibility
- Color choice
- Replacement
- Pay back

Applications

Low-profile in elevators

- Cooler temperature, more efficient, better light control, lower profile, height of cabin, …



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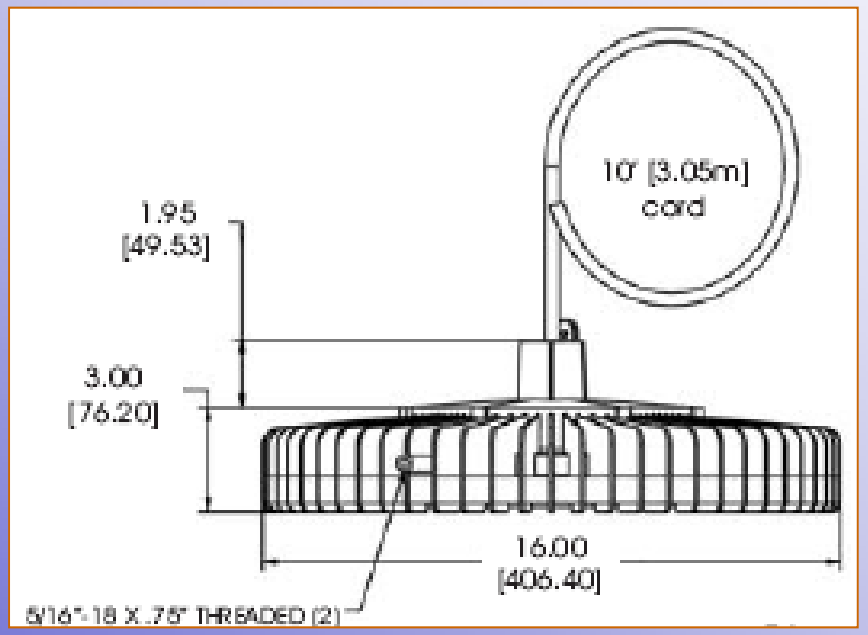
Applications

Hangar & industrial installation

- Thickness, weight, dust accumulation?



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Applications

Hazardous location

master - Appleton

LED Mercmaster - Appleton

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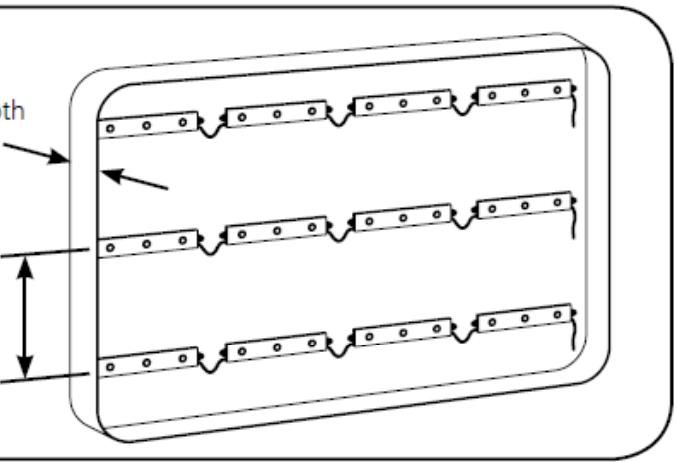
Applications

Sign

- Flexibility and shape
- Ingress protection



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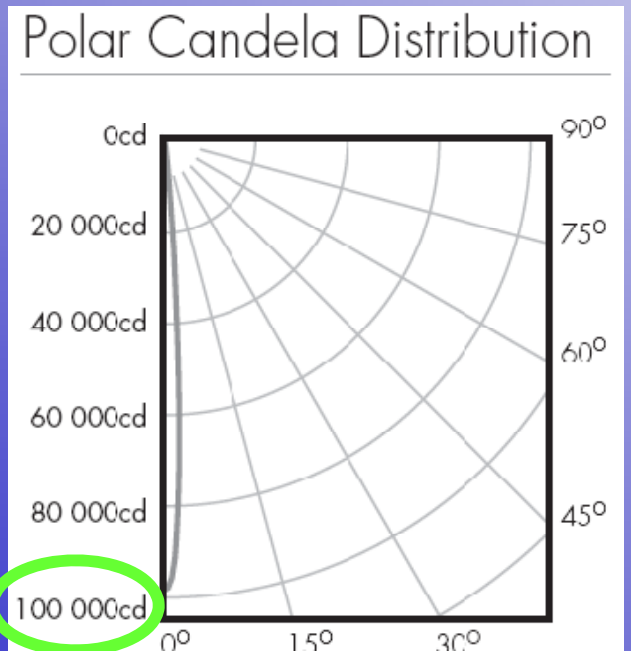
Applications

Architectural

- Outdoor fitting



Lamping	44 W
Lumens	2413
Efficacy	55.3 lm/W

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Applications

Parking

- Debris accumulation
- Dual driver option
- Surge protection

HOLOPHANE

ditional criteria's

NSI 136.31 – **Vibration**
00 000 cycles, 2 G, 3 axes

STM B117-97 - **Salt spray fog**

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Applications

Roadway

– Lamp source compatibility

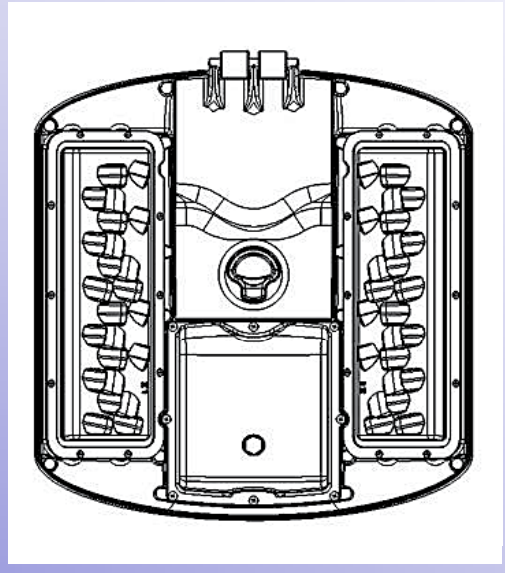
Lumec

HID

Induction

LED

LED arrays model



LED Roadway Lighting

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Applications

High Mast

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Applications

L-864 Red Medium Intensity Beacon

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Applications

Airfield lighting

- PAPI, REIL, Wind Direction, Approach Light, Edge Light, In-Pavement light (higher power!)

LED Green Threshold Lamp

LED MALSR System
FAA trial

L-849 LED REIL - ADB

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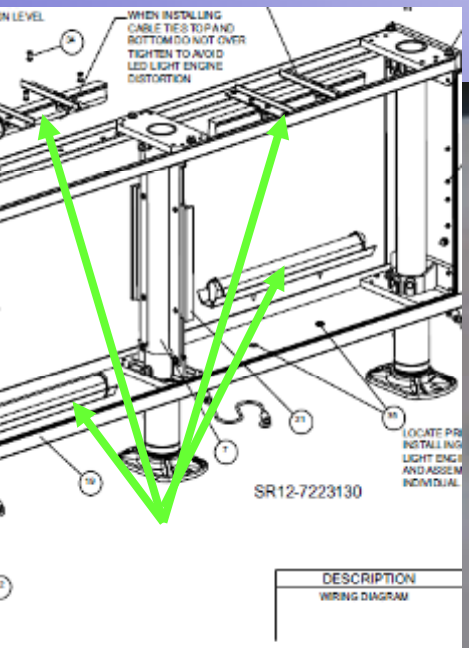
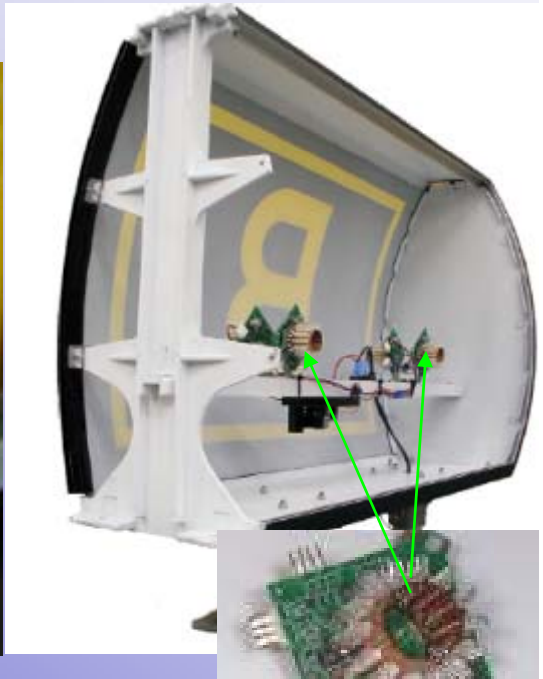
Applications

Airfield lighting – Signs and various possibilities





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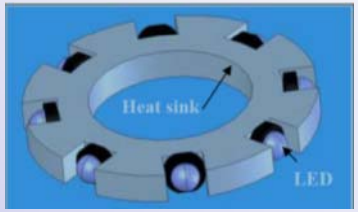
Applications

Other things that LED brought in airfield lighting?

Solar Elevated Runway Guard Light - Carmanah

Aveo Engineering

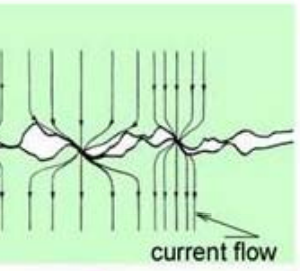


Investigation of Thermal Management Technique in Blue LED

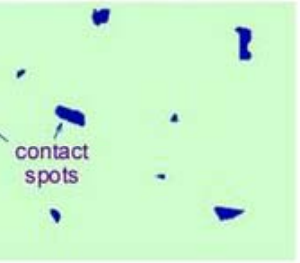
Applications

Other things that LED (will) brought in airfield lighting?

- How connection behave with lower current?
- Traditionally, 1 amp or less & under 10C temperature rise is consider a signal. Contacts often use gold to reduce resistance.



side view



top view

Is it the time to change the type of connection?

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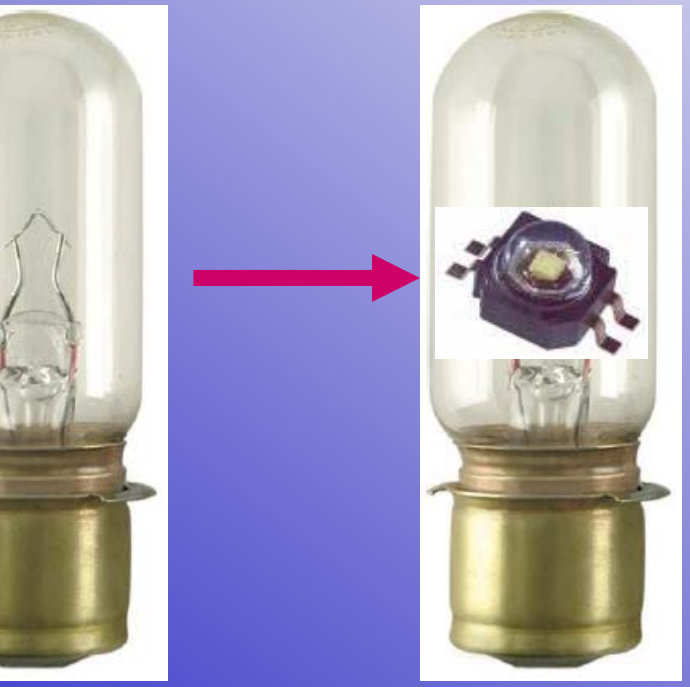
Applications

Airfield lighting – what if ?



lumens

For this one?

400 to 5200 lumens

And this one?

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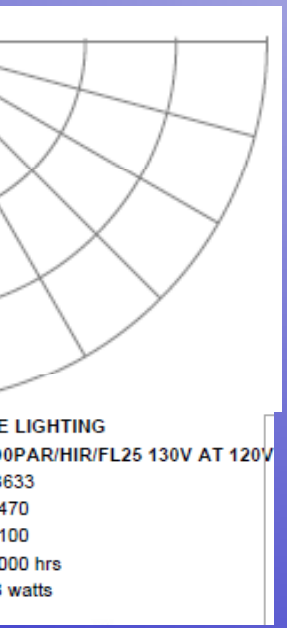
Applications

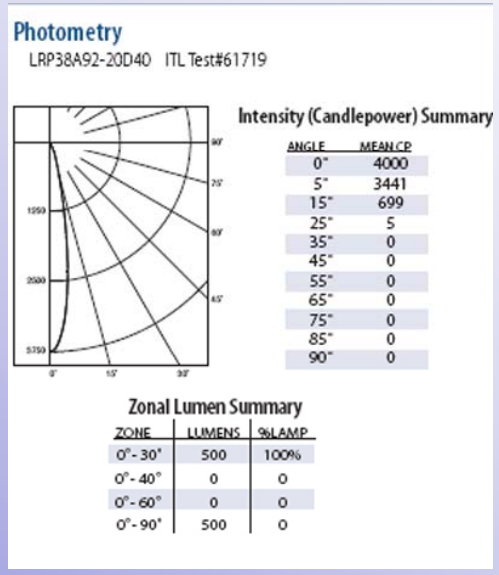
Airfield lighting – what if ?



LIGHTING

1470 lumens
6000 hours
PAR 38 – 88 watts

1200-1560 lumens
50000 hours
36 watts ***dimmable***
Green Lighting LED



LED PAR 38 Lamp With GU-24
Base (12 Watt)

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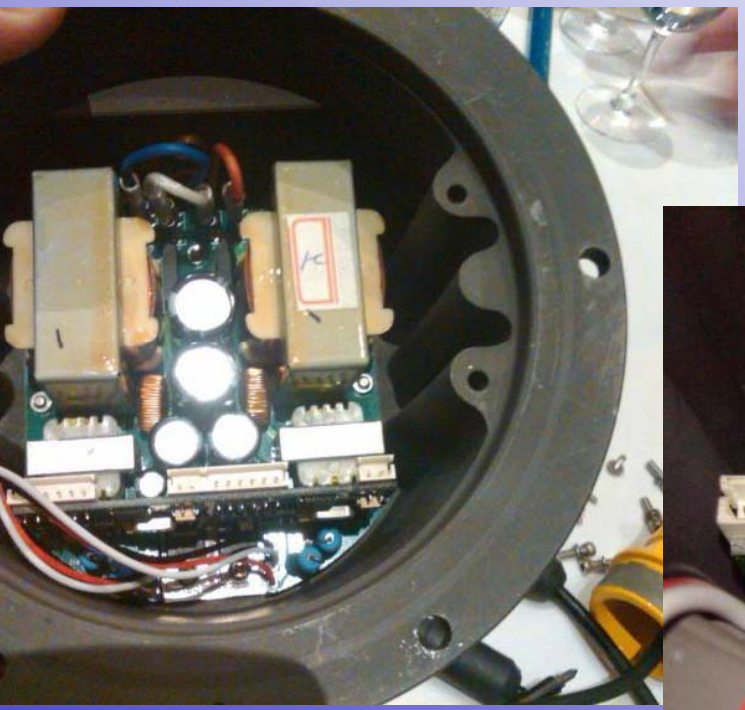
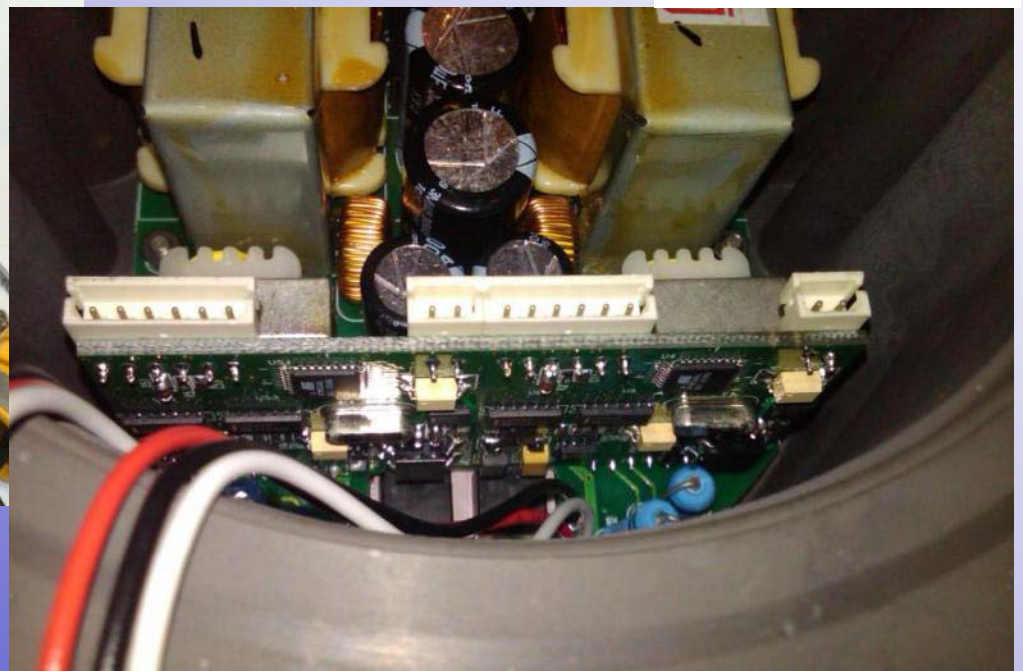
Applications





yang Airport Lighting Equipment

Conclusion

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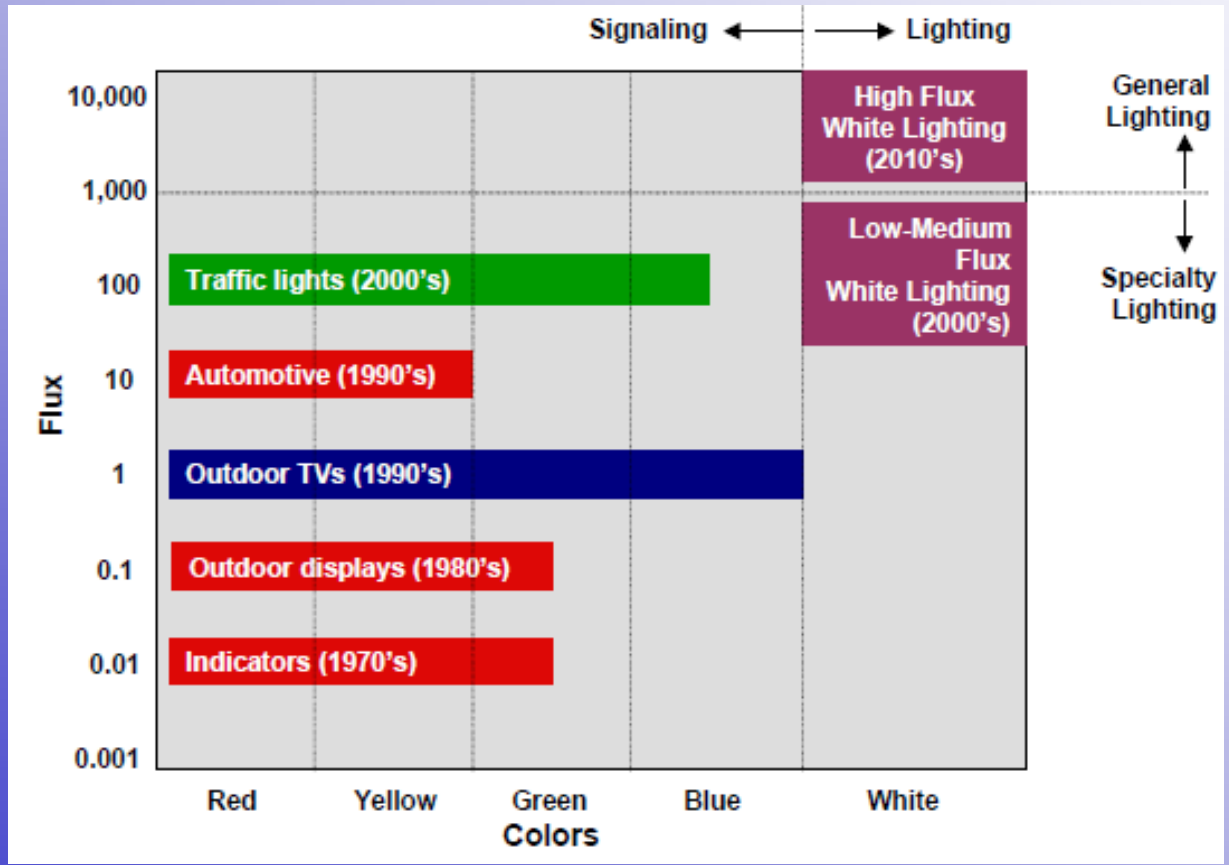
Conclusion



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Conclusion

Metric	2009	2010	2012	2015	2020
age Efficacy-Commercial White (lm/W, 25 C)	113	134	173	215	243
mal Efficiency	87%	89%	92%	95%	98%
ency of Driver	86%	87%	89%	92%	96%
ency of Fixture	81%	83%	87%	91%	96%
tant luminaire efficiency	61%	64%	71%	80%	90%
naire Efficacy- Commercial White (lm/W)	69	86	121	172	219

Summary of LED Luminaire Performance Projections

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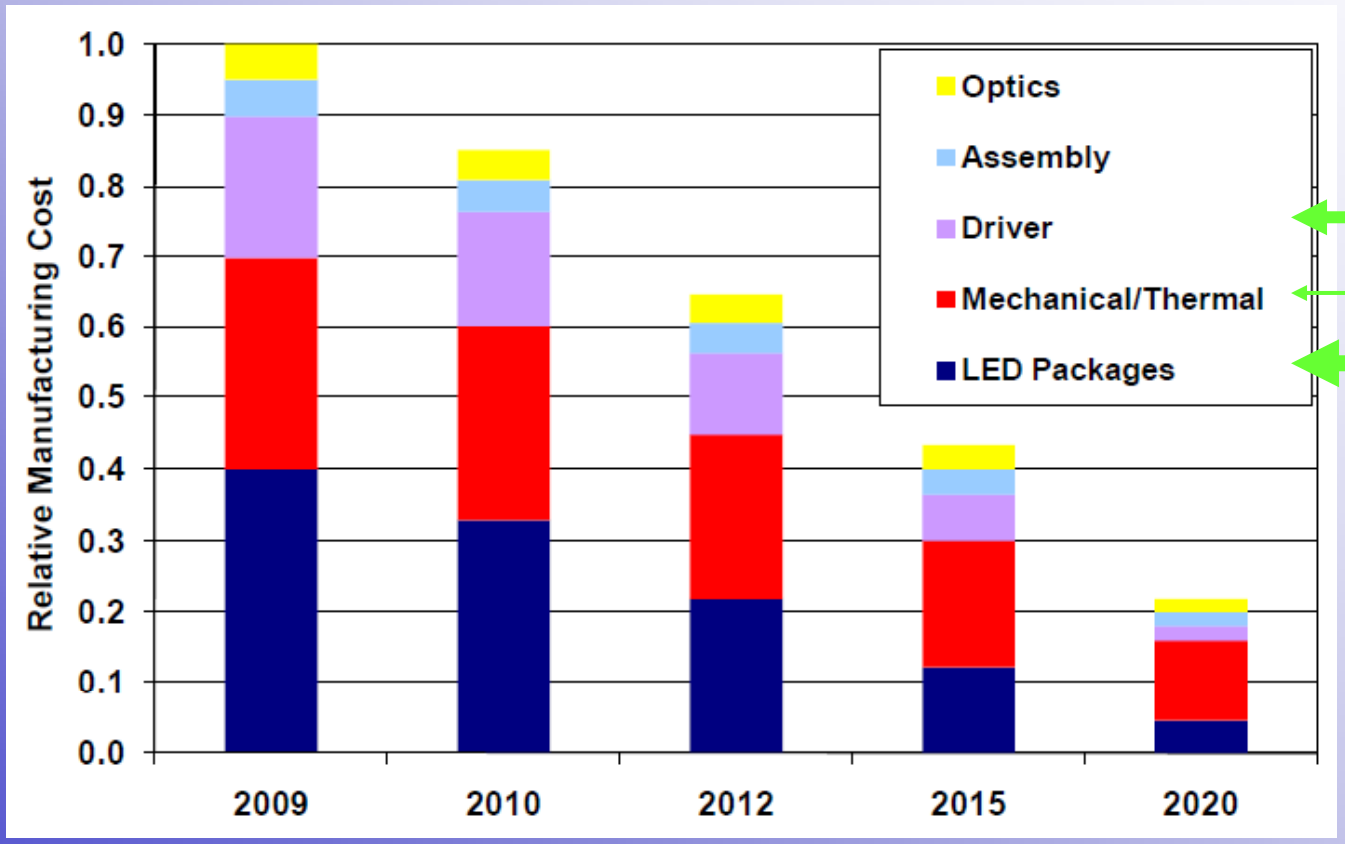

Projected LED Luminaire Cost Track

DOE Manufacturing Workshop consensus - Solid-State Lighting Research and Development: Manufacturing Roadmap July 2010

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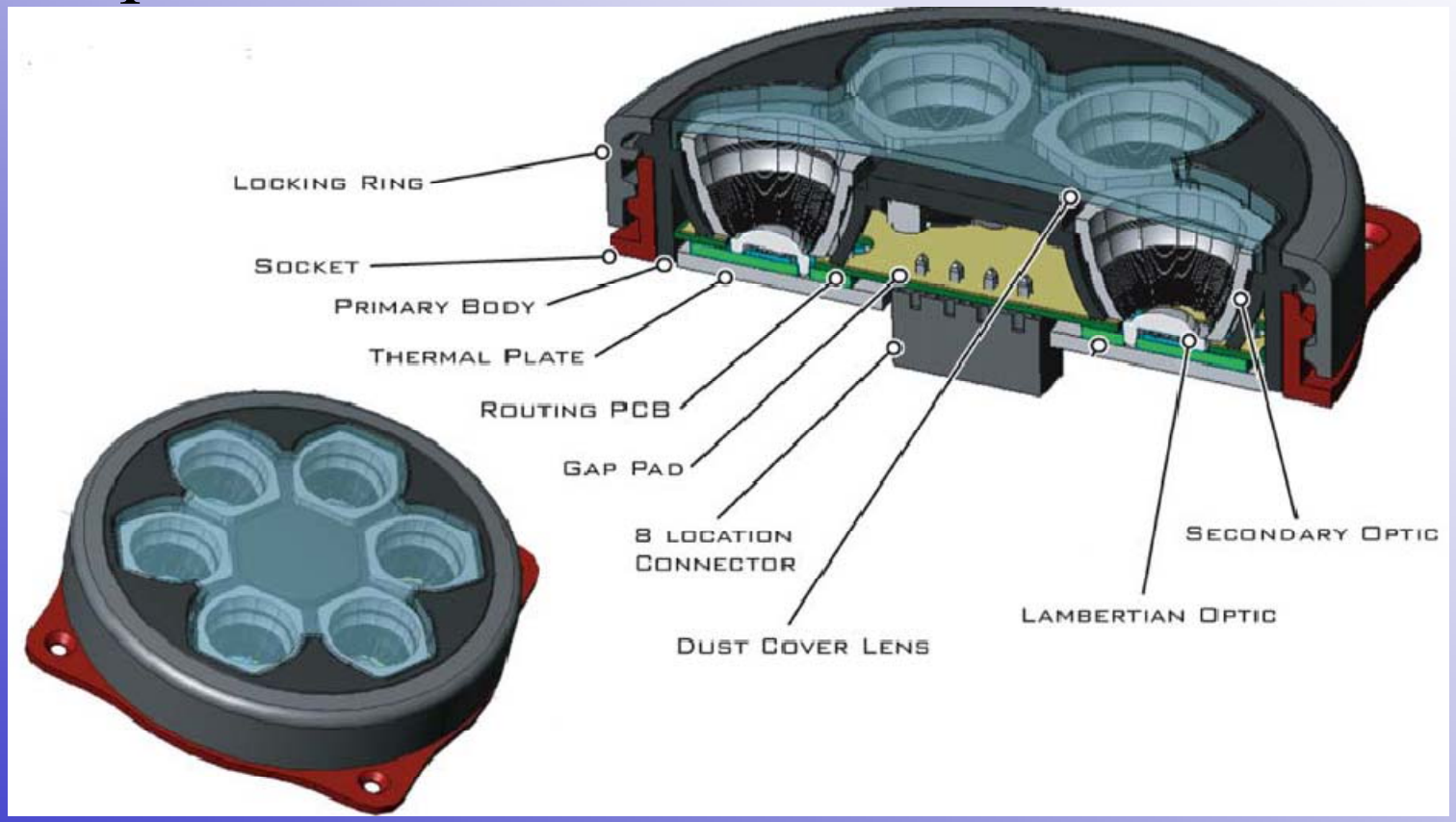
D replacement



Cutaway drawing of an example lamp showing various elements of an

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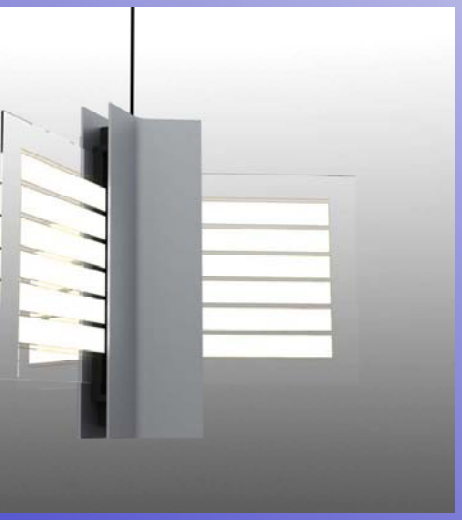
ED



rsal Display Corporation

See http://www.digitaltrends.com/

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ANGES

bal standard for
roperability USB port

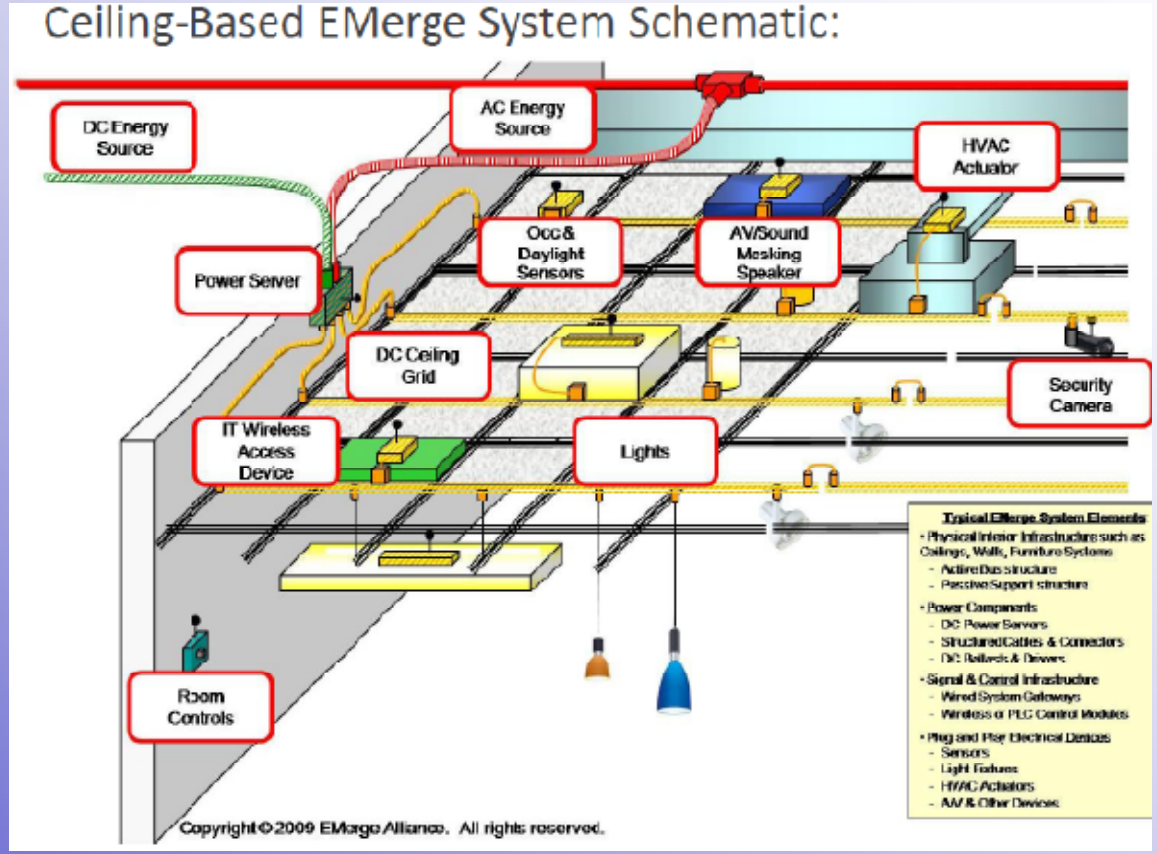
w infrastructure to deliver
ver – Emerge Alliance
ative

, open standard for room-
l DC Microgrids in
mercial buildings

minate 120V AC to 24V DC
er conversion (15% loss!)

2577 Suspended Ceiling Grid
Voltage Lighting Systems

ow voltage power supply operating at 30 V (42.4 V peak) or less



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Conclusion

jection

– **By 2030**, SSL could potentially **reduce lighting** electricity use by **1/3 -** the annual equivalent to **saving** (US):

- 348 billion kWh = **$30 billion** (in today's dollars)
- Output of **44, 1,000-megawatt** power plants
- Greenhouse gas emissions equivalent to **47 million cars**

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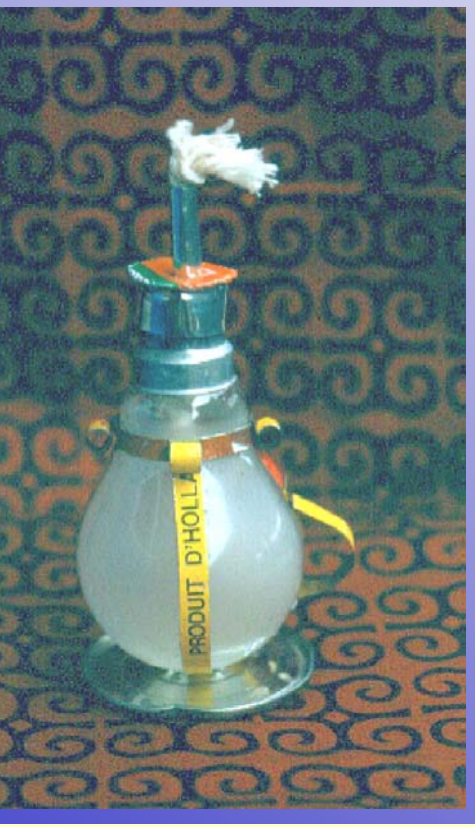

andescent bulb converted to a fuel-
ed lamp. Ghana marketplace
Photo credit: Rick Wilk).

‘’According to the world bank, ***24%*** *of the* ***urban population*** *and* ***67%*** *of the* ***rural population*** *in developing countries are without electricity today’’*

Is the LED a possible solution?

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Conclusion

To land safe.

Be aware and understand characteristics of

Solid State Lighting

- Assembly
- Quality of light & Optics
- Thermal management
- Lumen maintenance & end of life mechanism
- Driver functionalities and protection devices
- Testing, light measurements and certification
- Warranty, suggest 5 years

You are now in control of your own destination!

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Thank you

Question?

Richard Larivée, ing., P. Eng.
Avia Rupta Solutions Inc.
Richard.larivee@videotron.ca

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References

olid-State Lighting Research and Development: Multi-Year Program Plan March 2010 - ghting Research and Development Building Technologies Program – US Department of Energy

he case for a national program research on semiconductor lighting - Haitz et al. -1999

nproving Energy Performance in Canada - Report to Parliament Under the *Energy Efficiency ct* For the Fiscal Year 2008–2009

.S. Lighting Market Characterization Volume II: Energy Efficient Lighting Technology ptions - Eugene Hong, L.C., Louise A. Conroy, Michael J. Scholand September 30, 2005 tp://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ee_lighting_vol2.pdf

.S. Department of Energy (DOE) - Solid-State Lighting Research Program tp://www1.eere.energy.gov/buildings/ssl/

nergy Savings Potential of Solid-State Lighting in General Illumination Applications 2010 2030, Navigant Consulting, Inc., February 2010 tp://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_energy-savings-report_10-3 0.pdf

ow do LEDs work ? Mike Wood web site

IO High Power White LED GE Lighting Application Notes Electrical 2009

olid-State Lighting Research and Development: Manufacturing Roadmap July 2010

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NEW JERSEY 2010

References

ll In 1 : Plug & Play Solutions Guide by Future Lighting Solutions June 2010

he $230-billion Global Lighting Energy Bill – Evan Mills, Ph. D LBNL June 2002

ED Lighting Technologies and Potential for Near-Term Applications - Ecos Consulting *port* #E03-114 June 2003

ighting industry at the edge of the unknown – Ankush Chopra LEDS Magazine – July 2010

EDs for Lighting Applications – Patrick Mottier ISTE & Wiley 2009

troduction to light Emitting Diode Technology and Application - Gilbert Held 2008

atus and Future of High-Power Light-Emitting Diodes for Solid-State Lighting – M. R. rames and al. June 2007

TS256-LED Tester – Light Analyzer for Luminous Flux & Illuminance Spectral Distribution & olor of Single LED, LED Modules, LED Luminaire and other Light Sources Gigahertz-Optik ne 2009

eveloping an Accelerated Life Test Method for LED Driver – L. Han & N. Narendran LRC

ED drivers for High-Brightness Lighting – solution guide – National Semiconductor

he Topologies of White LED Lams' Power Drivers – Liu Yu, Jimming Yang, 2009

river Electronics for LEDs G. Sauerlander and all – Philips Research Laboratories 2006

ED driver considerations – M day –Texas Instrument Inc. 2004

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References

yco Electronics – Applications Notes

ipple Current Capabilities – 2004 Kemet Technical Update – John Prymak

aton's Guide Surge Suppression - Applications Notes

npact of Dimming White LEDs: Chromaticity Shifts Due to Different Dimming Methods yble et Al. LRC 2005

raining videos: LED and SSL Standardization Regulations http://ledlight.osram-s.com/tools/standards-regulations/led-ssl-standardization/

BEA LED Site Lighting Performance Specification – Commercial Building Energy Alliances CBEA) Project, Version 1.2

ESNA G-2-10 , Guideline for the Application of General Illumination (White) LED

tp://www.ecse.rpi.edu/~schubert/Light-Emitting-Diodes-dot-org/

onnectors 101: What Lighting Designers Need to Know - Tyco Electronics

SL Luminaires must deliver reliable beam patterns in outdoor applications – LED Magazine . Wright Sept 2004

ED Traffic Signal Monitoring, Maintenance and Replacement issues – Institute of ransportation Engineers (ITE) 2006

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Background info

ting industry at the
of the unknown –
Magazine July 2010

LIGHTING MAJORS IN 2010 VS. KODAK IN 1980S

	Kodak 1980s	GE / Philips / Osram 2010
Market Position	Dominant	Dominant
Dominant profit driver	Consumable film replacement demand	Replacement demand
Current Key challenge	Low cost film from Japanese competition	Pricing pressure from low cost lighting + move to CFL
Technological change	Film camera to digital camera	Incandescent to solid state lighting
New capabilities needed	Present with many firms outside the industry + need to build in-house	Present with many firms outside the industry + need to build in-house
Impact of technology on business	Replacement demand eliminated	Expected to largely eliminate replacement demand
Technological response	Spent billions in 10 years	Investing in LED technology
Commercialization response	Dragged its feet	?
Key misses	Myopic view of the future	?

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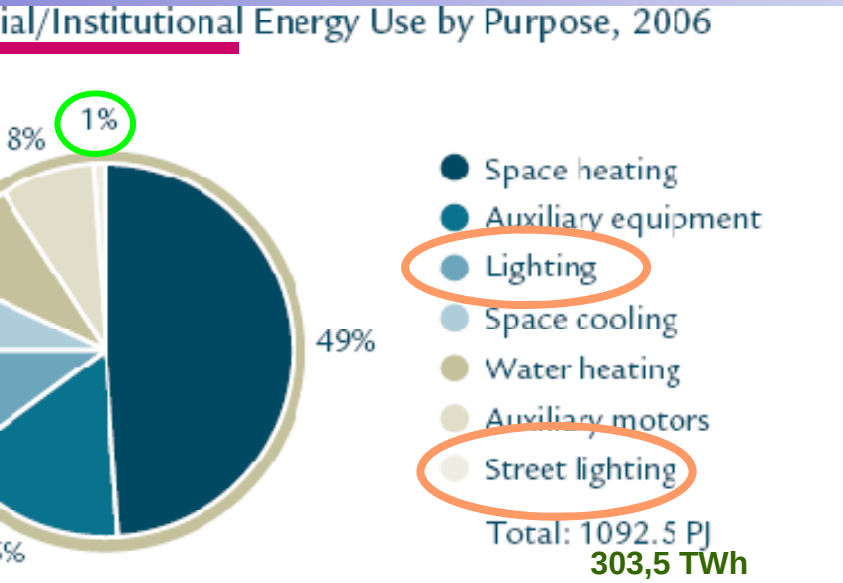
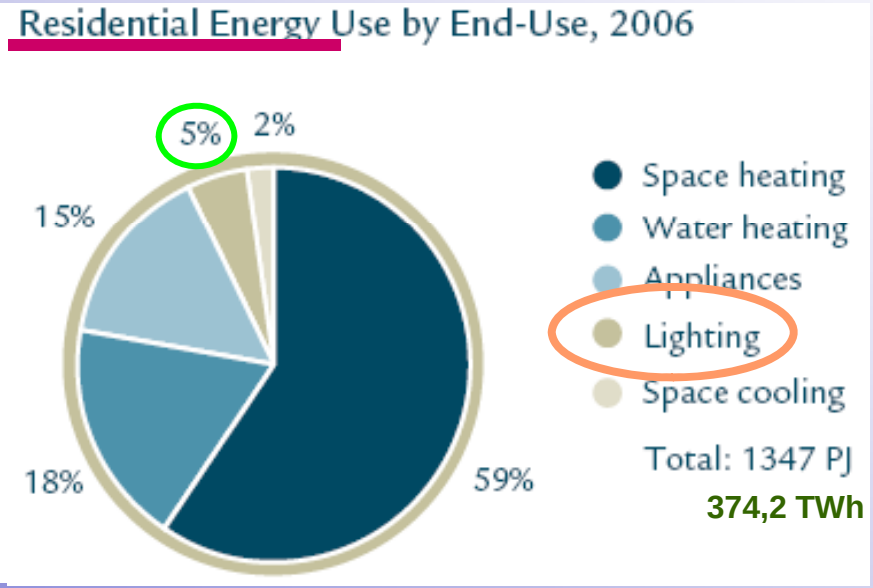
ergy Usage in Canada





http://oee.nrcan-rncan.gc.ca/publications/statistics/parliament08-09/pdf/parliament08-09.pdf

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Background info

Lamp type	EFFICACY (lm/W)
Incandescent – General service	15
Halogen - Reflector	25
Fluorescent - T5	95
Fluorescent - T8 - less than 4 ft	66
Fluorescent - T8 - 4 ft	83
Fluorescent - Compact - Plug-in	60
Fluorescent - Compact - Screw-in - reflector	55
Metal Halide	60
LED – cool White 4000K	75
High Pressure Sodium	100

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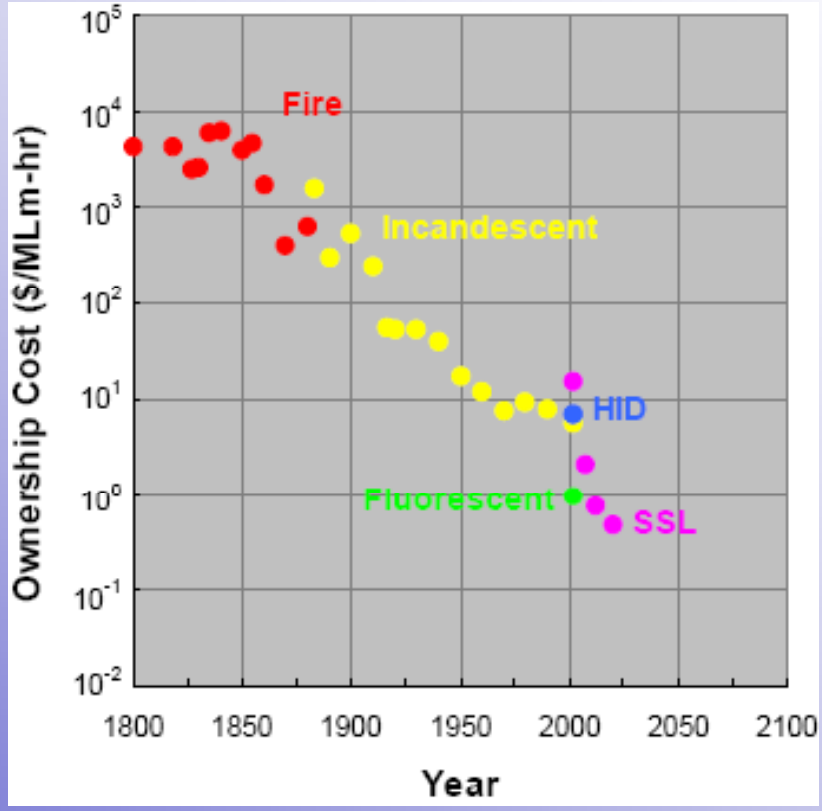
Background info

olid State the Future of Lighting?
Doug Kirkpatrick
RPA / ATO 2003

a for Fire and Incandescence modified
n W.D. Nordhaus, in T.F. Breshnahan
R.J. Gordon, Eds., The Economics of
y Goods (U of Chicago Press, 1997) pp.
70.

a for SSL-LEDs taken from 2002 U.S.
Roadmap.



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Background info

Year	LED Efficiency *(lm/W)*
2002	30
2005	40
2010	50

LED Lighting Technologies
and Potential for
Near-Term Applications -
Ecos Consulting - 2003

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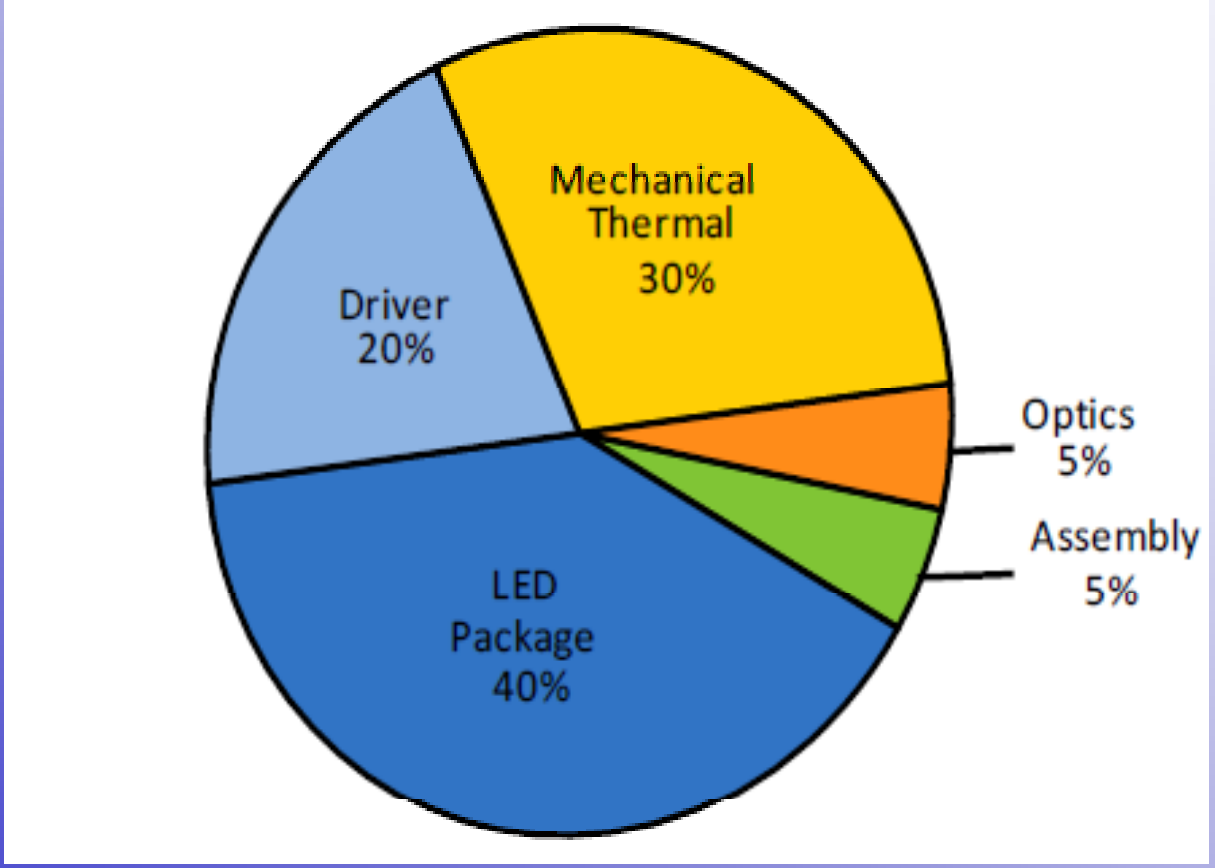
pproximate Cost Breakdown for LED Luminaire in 2009



Paul Pickard, Cree LED Lighting, "An Integrated Approach to SSL

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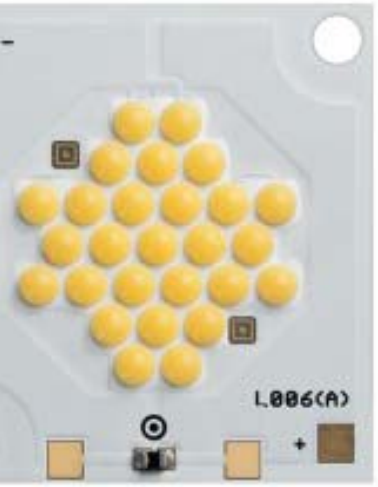
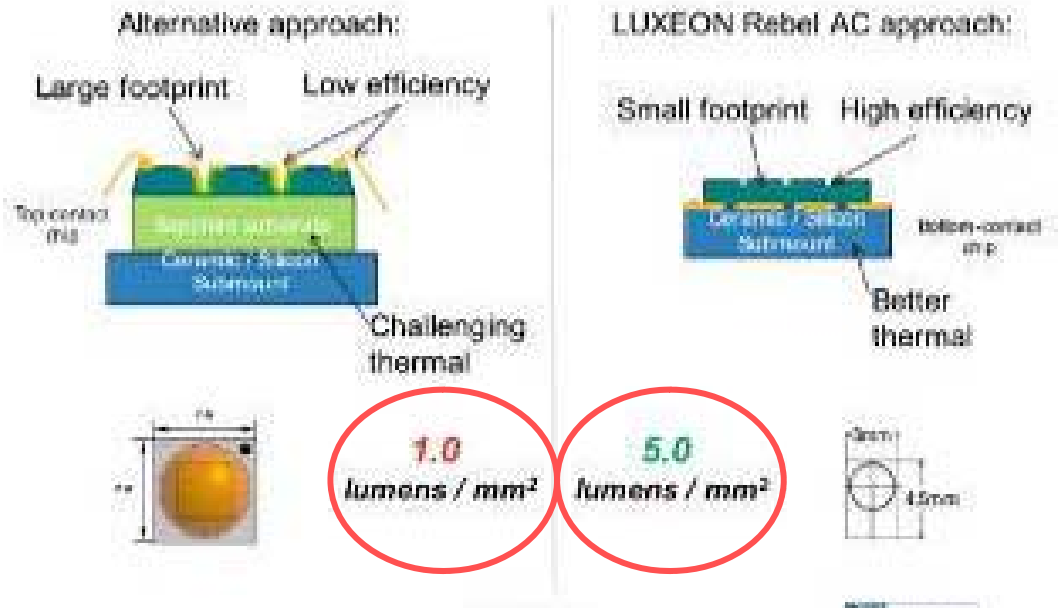
Today

Challenges of luminous flux & density of LED on chip



onic LEDs reach a high
us flux of **4.400 lumen**



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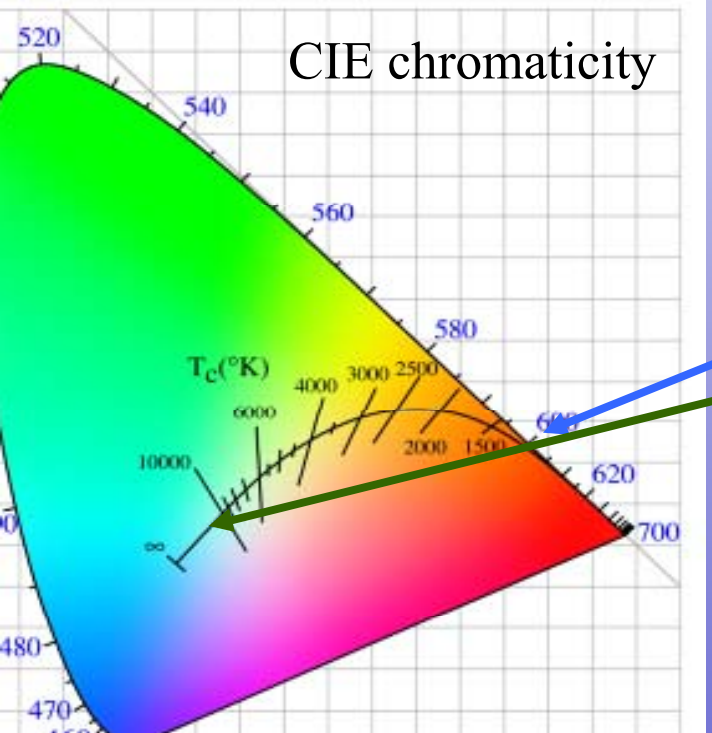
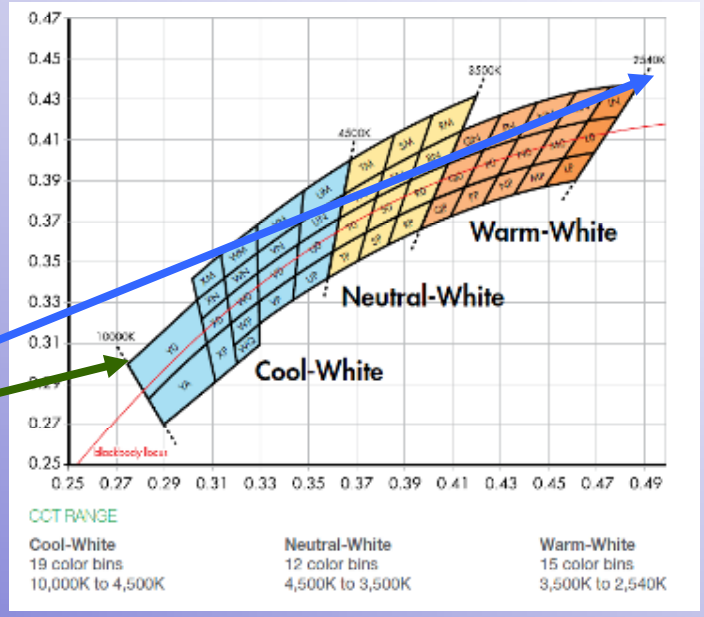
Today

CIE chromaticity & binning structure





LUXEON Rebel White Binning Structure

ANSI , CCT based on fluorescent +

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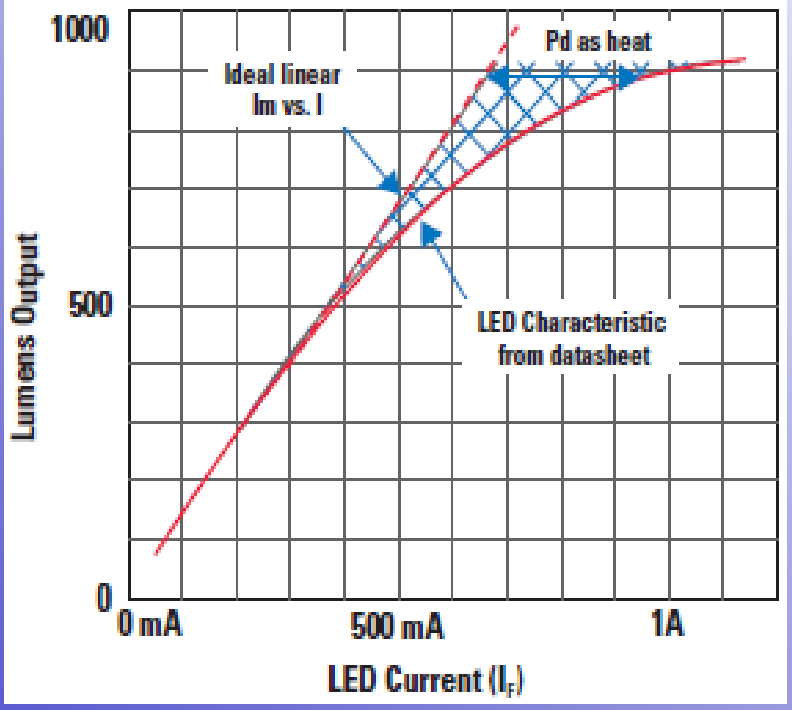
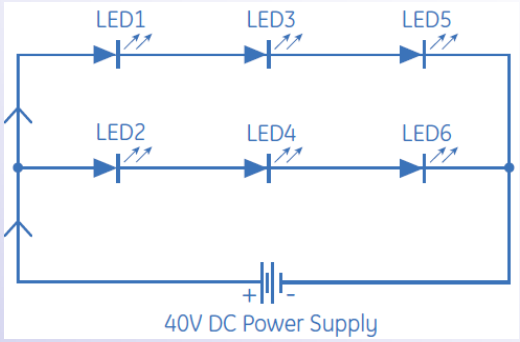
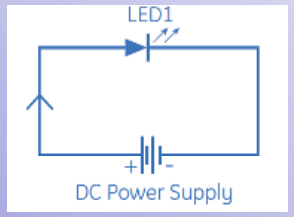
Today

Electrically connected





Series and parallel circuit



Serie LED GE Lighting

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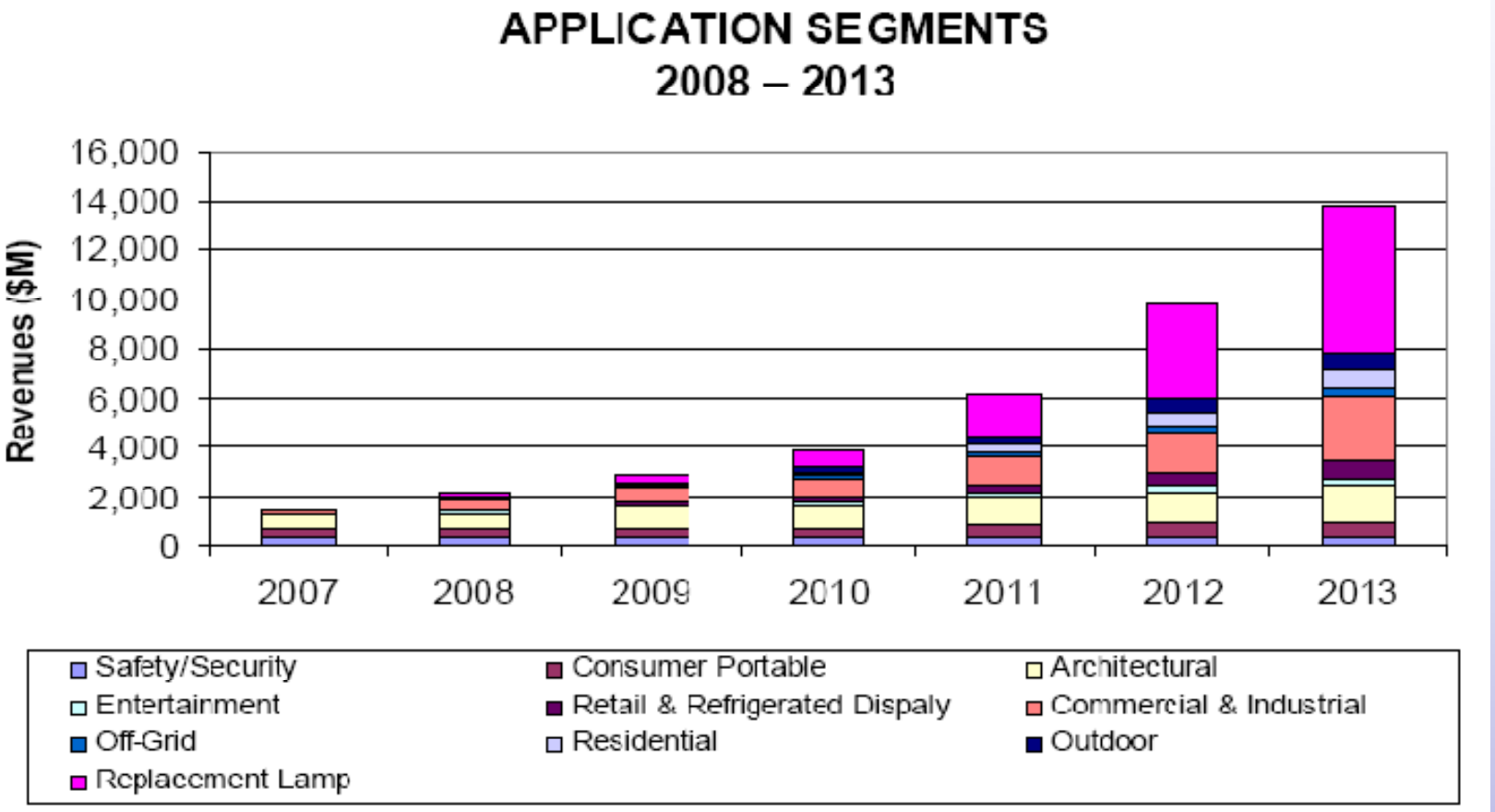
Outlook – LED Lighting Market



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Today

OURCE	Cost / kilolumen ($)
candescent	0.30
mpact Fluorescent	2.00
uorescent	4.00
ED Lamp	128
LED Panel	25 000

9 prices

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MENT OF RGY | Energy Efficiency & Renewable Energy

Solid-State Lighting

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EERE Information Center
Programs and Offices

Market-Based Programs

Printable Version

Solid-State Lighting GATEWAY Demonstrations

DOE GATEWAY Demonstration showcases high-performance LED products for general illumination in a variety of commercial and residential applications. Demonstration results provide real-world experience and data on state-of-the-art solid-state lighting (SSL) product performance and cost effectiveness. These results connect DOE technology procurement efforts with large-volume purchasers and provide buyers with reliable data on product performance.

The I-35W Bridge in Minneapolis, Minnesota, features LED roadway lighting on the main span, offering DOE the opportunity to study the use of LED lighting in a highly challenging environment over the course of three years.

Results

DOE shares the results of completed GATEWAY demonstration projects, publishing detailed reports and briefs on completed projects. The reports include analysis of data collected, projected energy savings, payback analysis, and user feedback.

New DOE Municipal Solid-State Street Lighting Consortium

To leverage the efforts of multiple cities pursuing

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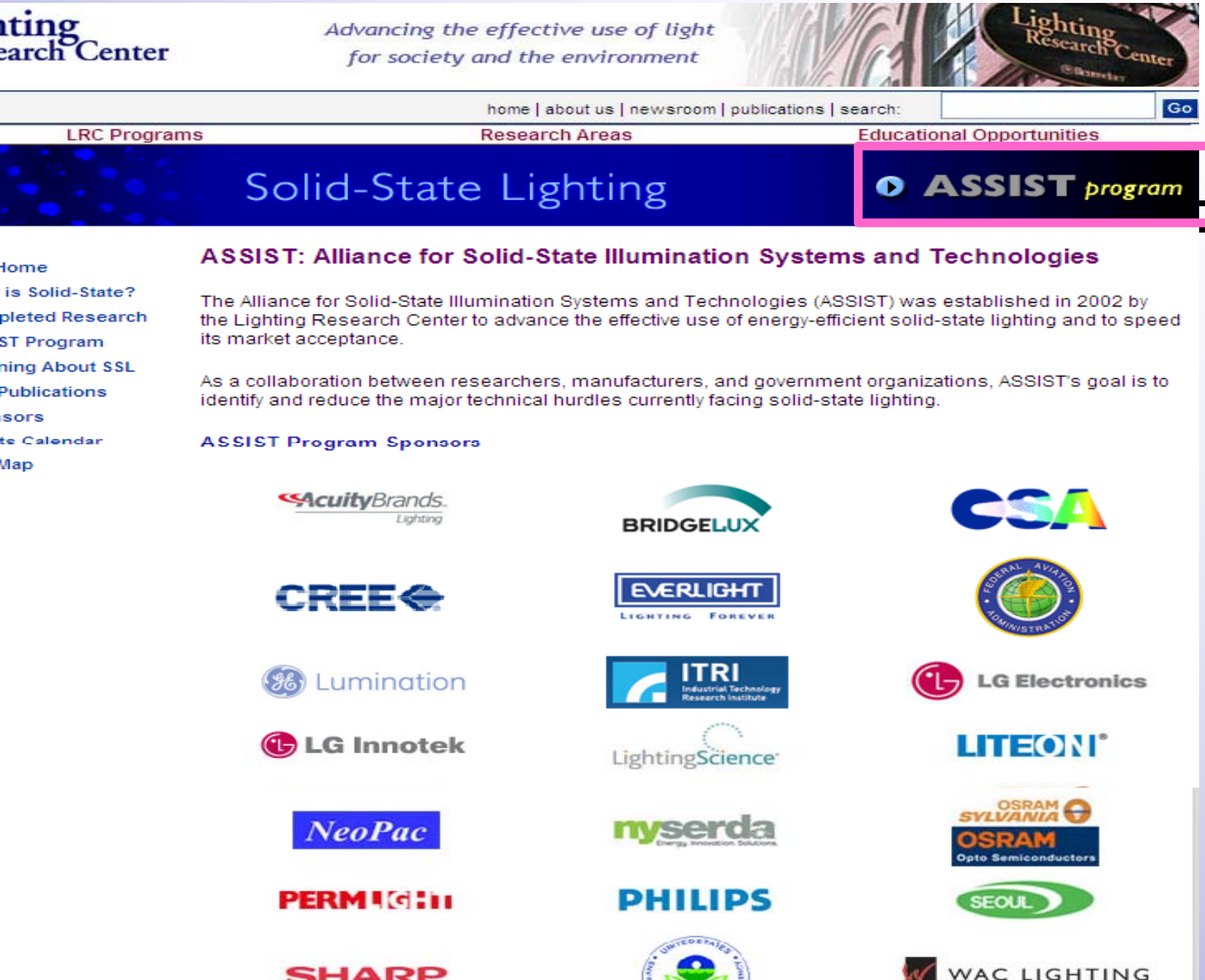
nting
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Advancing the effective use of light
for society and the environment
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ASSIST: Alliance for Solid-State Illumination Systems and Technologies
The Alliance for Solid-State Illumination Systems and Technologies (ASSIST) was established in 2002 by the Lighting Research Center to advance the effective use of energy-efficient solid-state lighting and to speed its market acceptance.
As a collaboration between researchers, manufacturers, and government organizations, ASSIST's goal is to identify and reduce the major technical hurdles currently facing solid-state lighting.
ASSIST Program Sponsors
AcuityBrands Lighting
BRIDGELUX
CSA
CREE
EVERLIGHT
LIGHTING FOREVER
FEDERAL AVIATION ADMINISTRATION
Lumination
ITRI
Industrial Technology Research Institute
LG Electronics
LG Innotek
LightingScience
LITEON
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OSRAM SYLVANIA
OSRAM
Opto Semiconductors
PERMLIGHT
PHILIPS
SEOUL
SHARP
WAC LIGHTING

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Applications

For your next

Christmas season!

Strawberry LED

zberry LED

Specifications: C9 Intermediate, E-17 Base, 5 LEDs Inside Unbreakable Plastic Cover, 120 Volt, 0.25 Watts, 0.016 Amps, 50,000 hour average life,

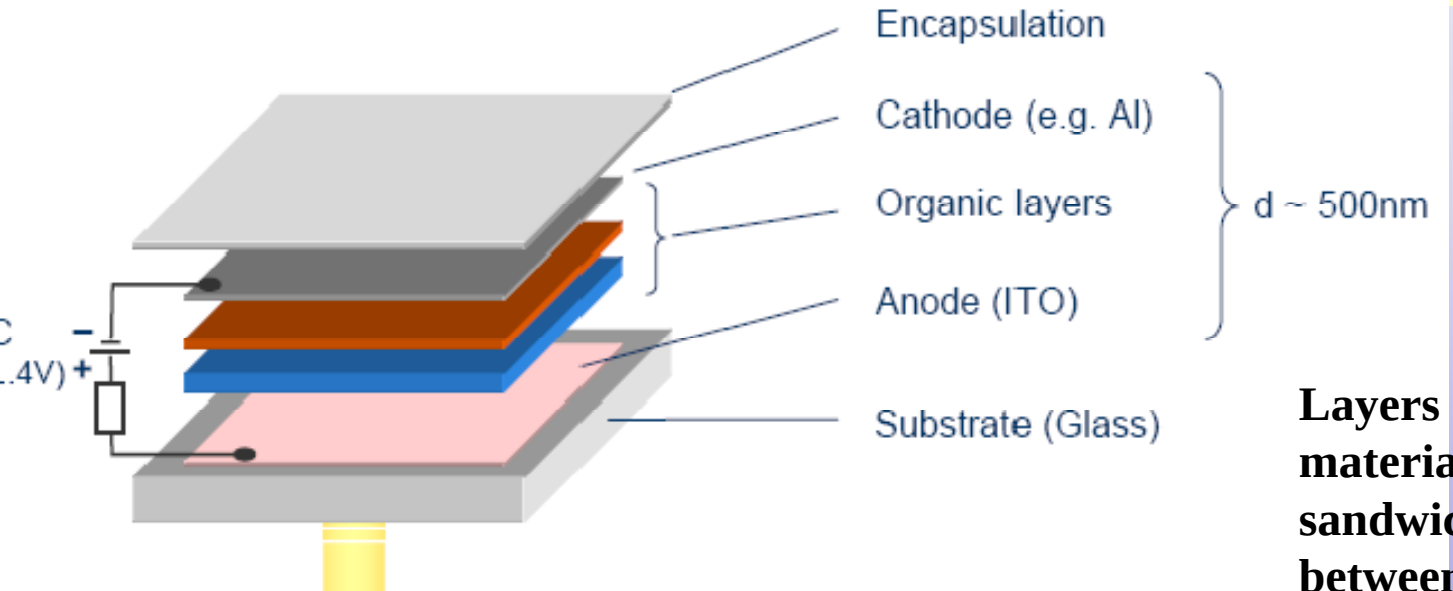
20 M5 Battery-Powered LED

Conclusion

ED technology (and soon PHOLED)

dimensional, flat light source, emitting diffuse light from a potentially large ctive area. Could be a flexible film.

LEDs create new lighting possibilities by enabling large area illumination ources, panels, ceilings, walls, partitions, fabrics etc.



Layers of organic materials sandwiched between anode and

Conclusion

hotonics21 is a voluntary association of industrial enterprises nd other stakeholders in the field of photonics in Europe. It nites the majority of the leading Photonics industries and elevant R&D stakeholders along the whole economic value hain throughout Europe. 1,400 stakeholders of 49 countries.

Development and deployment of Photonics in five industrial reas: Information and Communication, Lighting and Displays, Manufacturing, Life Science and Security

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