OPTO
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From Calculators to Street Lights, the Future of LED's

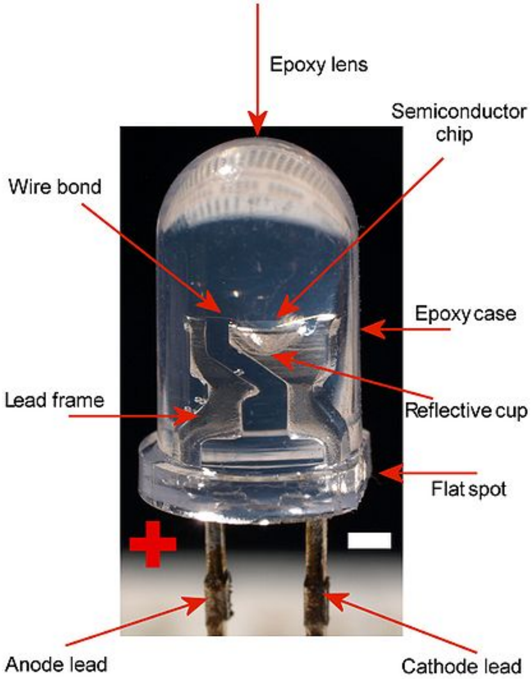
May 2009

IEEE

From Calculators to Street Lights

Light Emitting Diode (LED)

- **1957** - LED invented by RCA
- **1968** – First economically mass produced LEDs made by Monsanto Corp & Litronix
- **1972** - HP introduces the HP35 calculator using an LED display
- **1993** - Nichia Corp produces the first high brightness LED using phosphor conversion to create white light
- **2009** - European Union bans most incandescent light bulbs



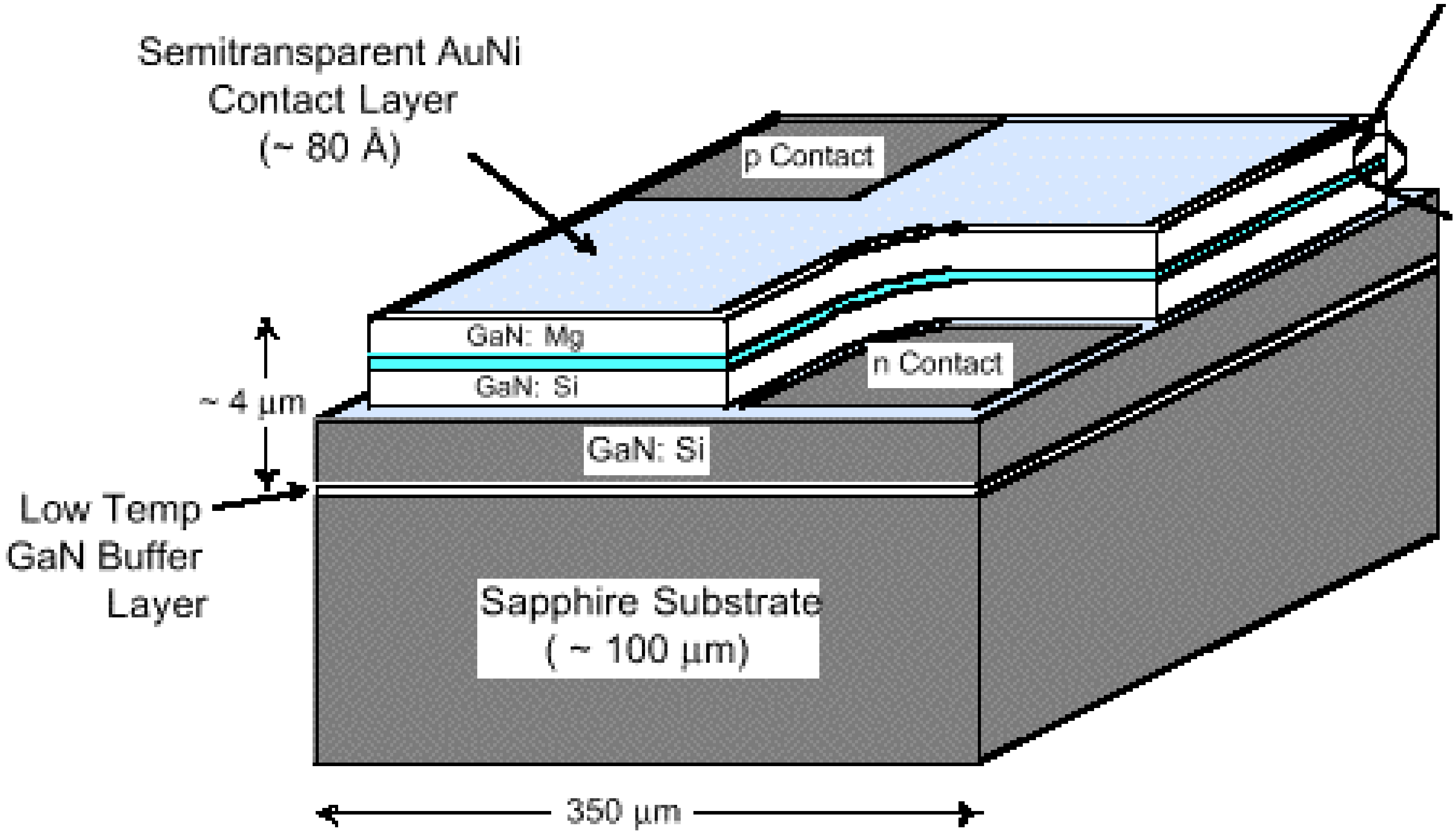
LED's – The Early Years

Low Operating Voltage made the LED ideal for battery powered equipment

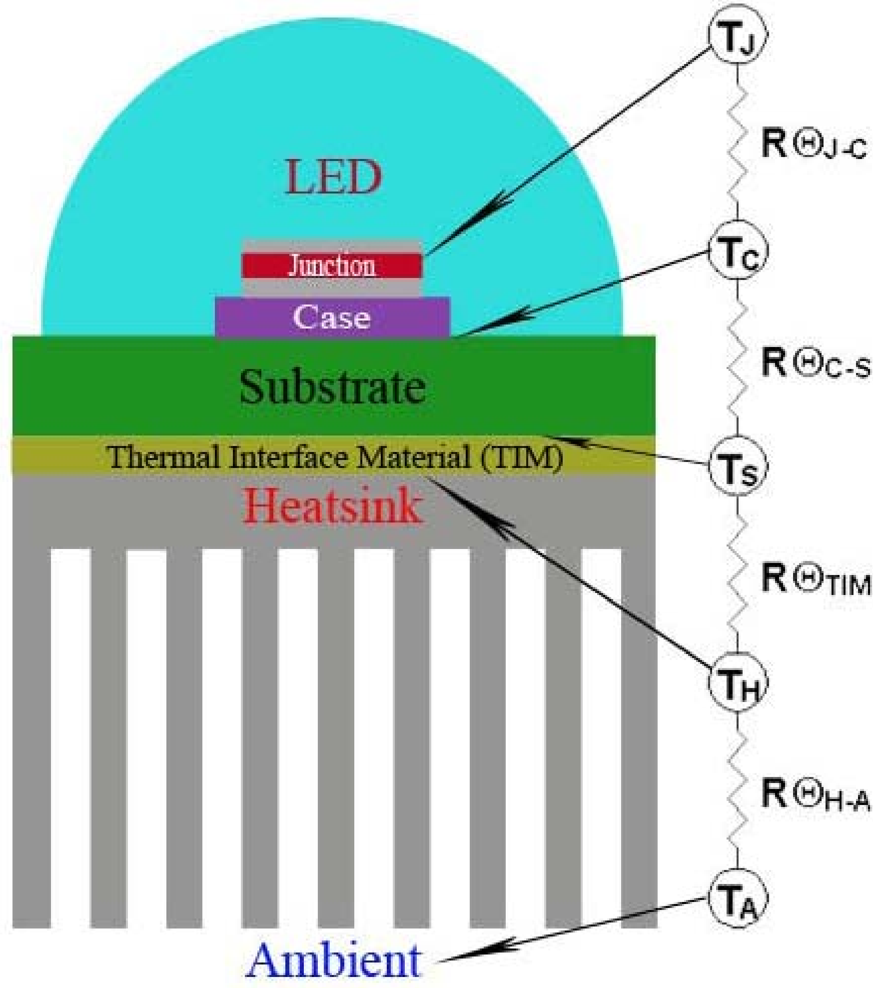
High Brightness LED

- Blue emitter with white conversion phosphor (InGaN)
- Micro lens for radiation pattern control
- Approx forward voltage 3 VDC
- Current device
- White LED’s produce no IR
- ~75% of power converted to heat!
- ~5x more efficient than incandescent

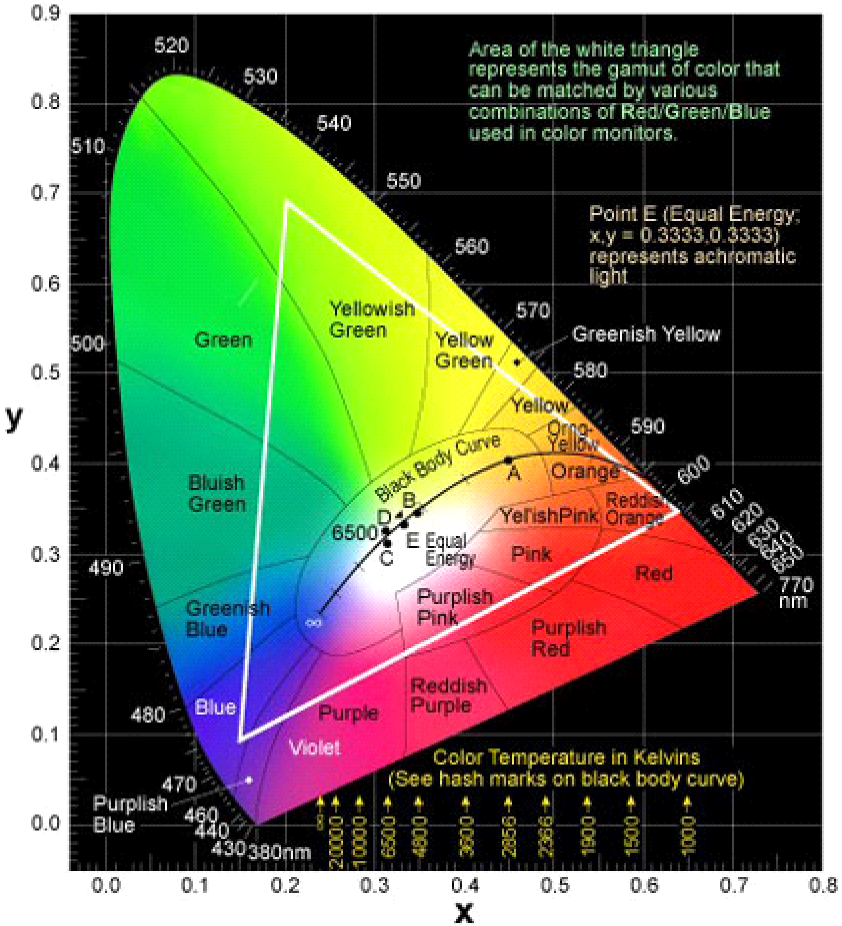
Where does the light come from?

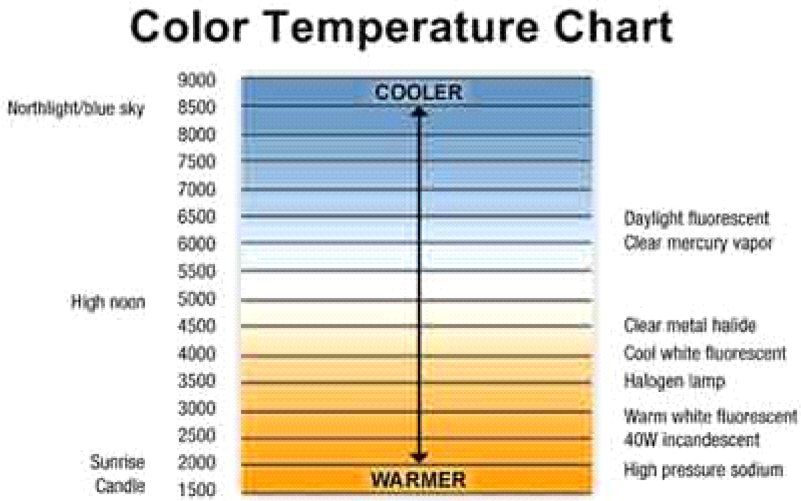


Where does the light come from?



LED's Can Make Colored Light!





LED Flashlights - 2001

- ARC introduced the first LED flashlight in 2001
- LED's are more efficient than ordinary light bulbs.
- LED flashlights, in some cases have a battery life of hundreds of hours.
- LED's can survive shock that often break conventional light bulbs.
- LED flashlights are electronically regulated to maintain constant light output independent of battery voltage.
- Incandescent flashlights becomes progressively dimmer as the battery voltage drops

Why LED’s Now?

- Global Warming
- Exponential consumption of electricity
- Fossil Fuel / Peak Oil
- Government Mandates
- European ban on Incandescent bulbs
- Mercury in Florescent bulb, now a hazardous material. Against the law in California to put in your trash
- No new power plants in California

Chart courtesy OSRAM

Compact Florescent Lights (CFL)

- Took 20 years to catch on
- Required subsidies to get consumers to purchase
- Early products were low quality
- Not dimmer compatible
- High color temperature
- Now classified as hazardous material!

Why LED's Now?

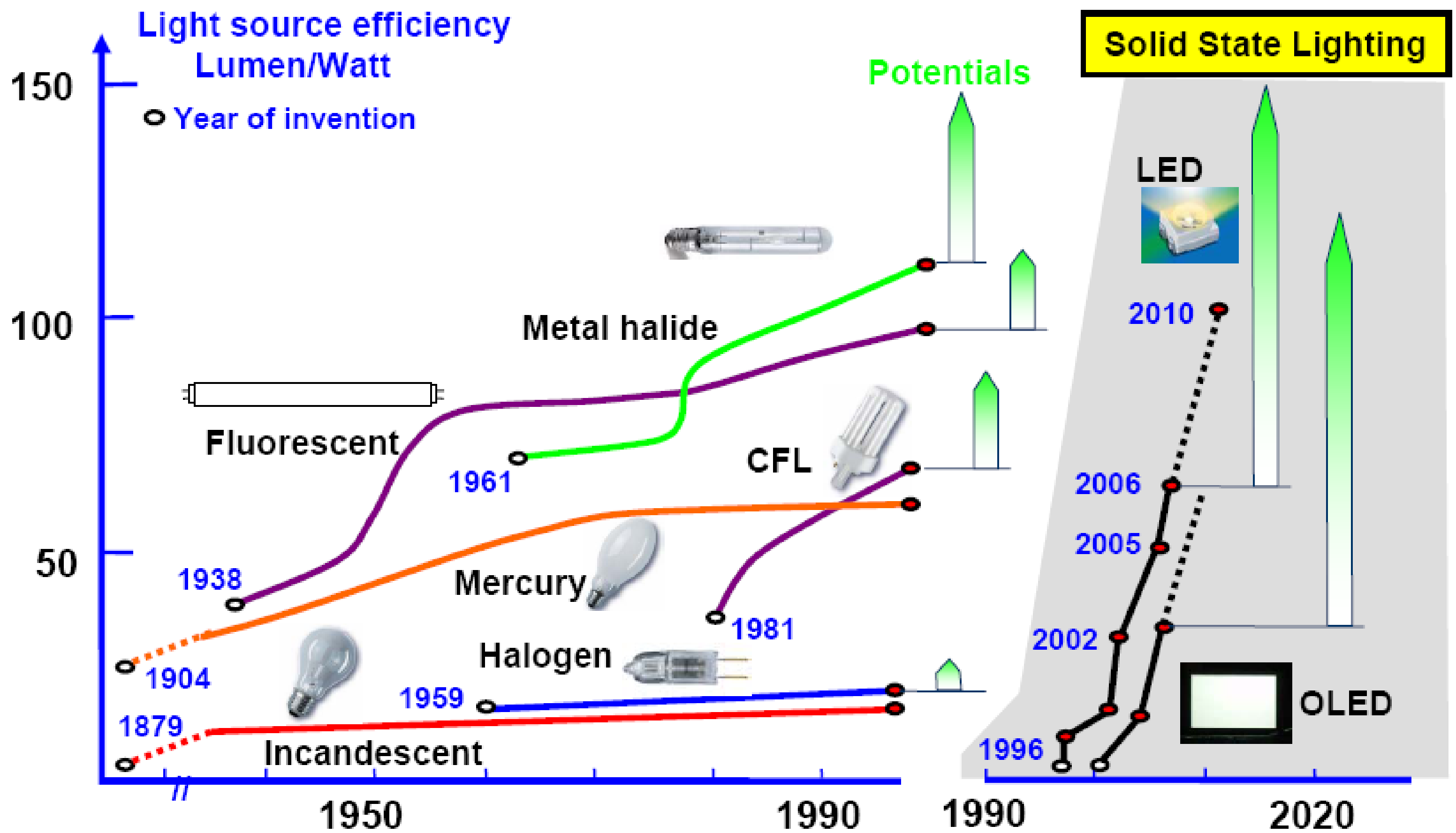
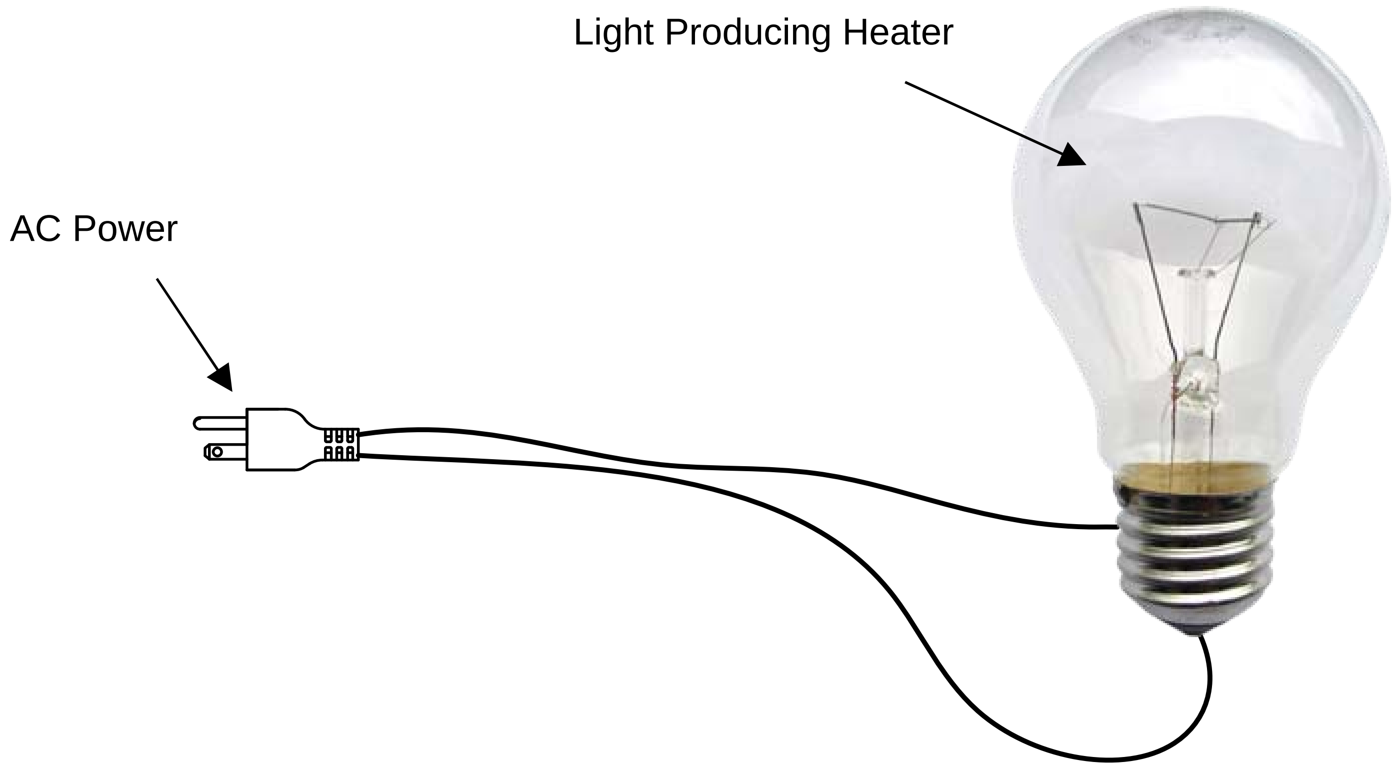


Chart courtesy OSRAM

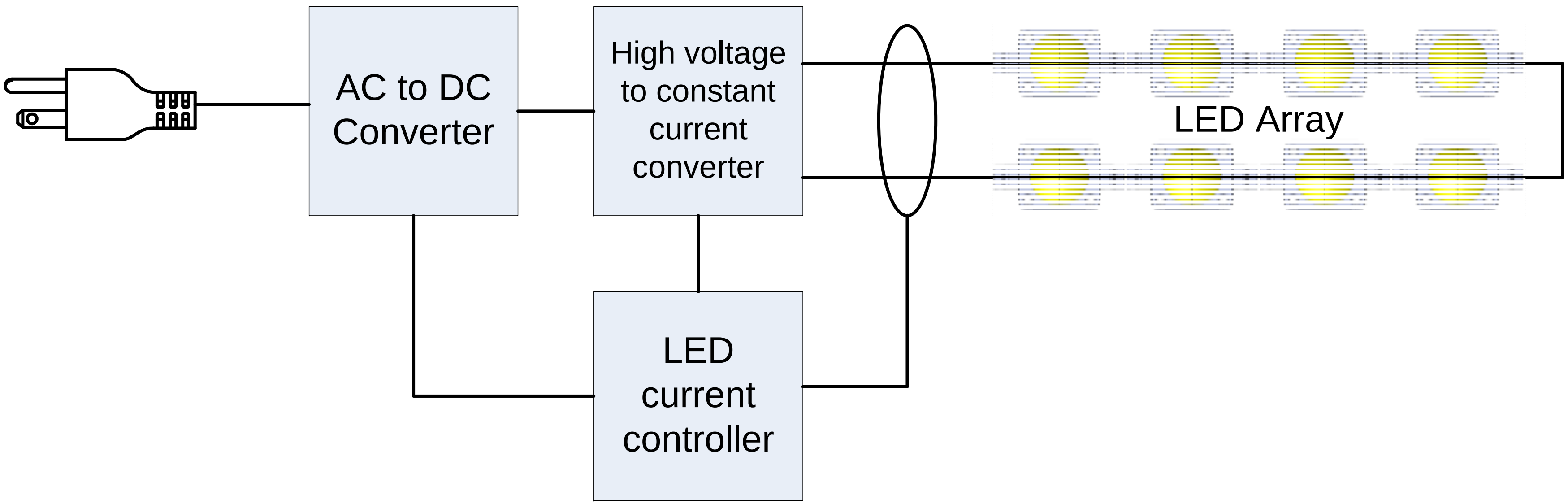
Incandescent vs. LED

Same Shape, same light output but very different under the hood!

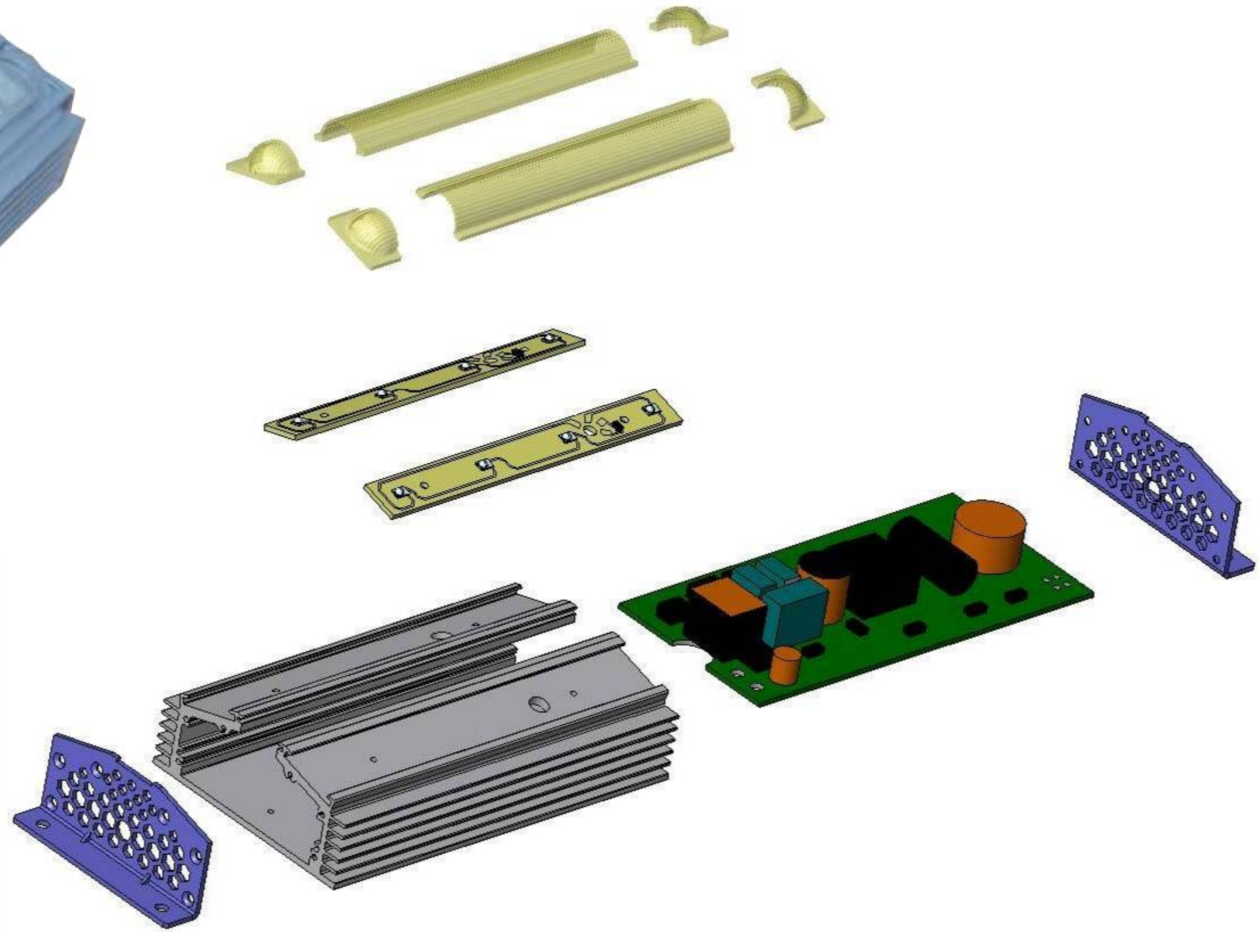
Incandescent light system



LED light System

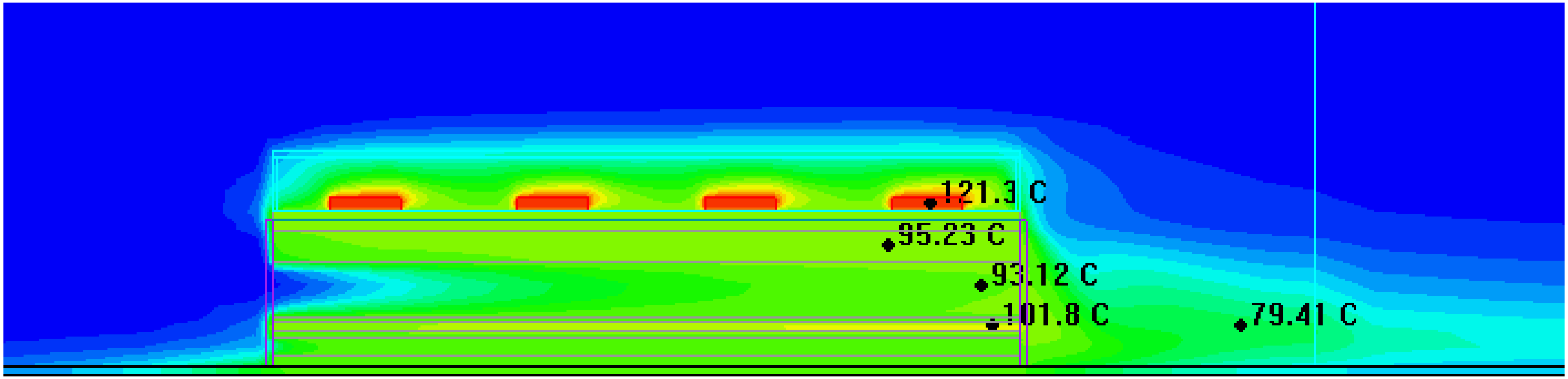


Anatomy of a Light Engine



Heat is bad!

- LED's can not tolerate the high temperatures that bulbs can
- LED light design requires significant thermal design and analysis
- Light output is inversely proportional to operating temperature



How to tell good from bad?

- Performance
  - DOE – Energy Star
  - CALiPER
  - NIST
  - L70
- Safety
  - Underwriters Lab
  - CSA
  - TUV

Standards finalized in 2008

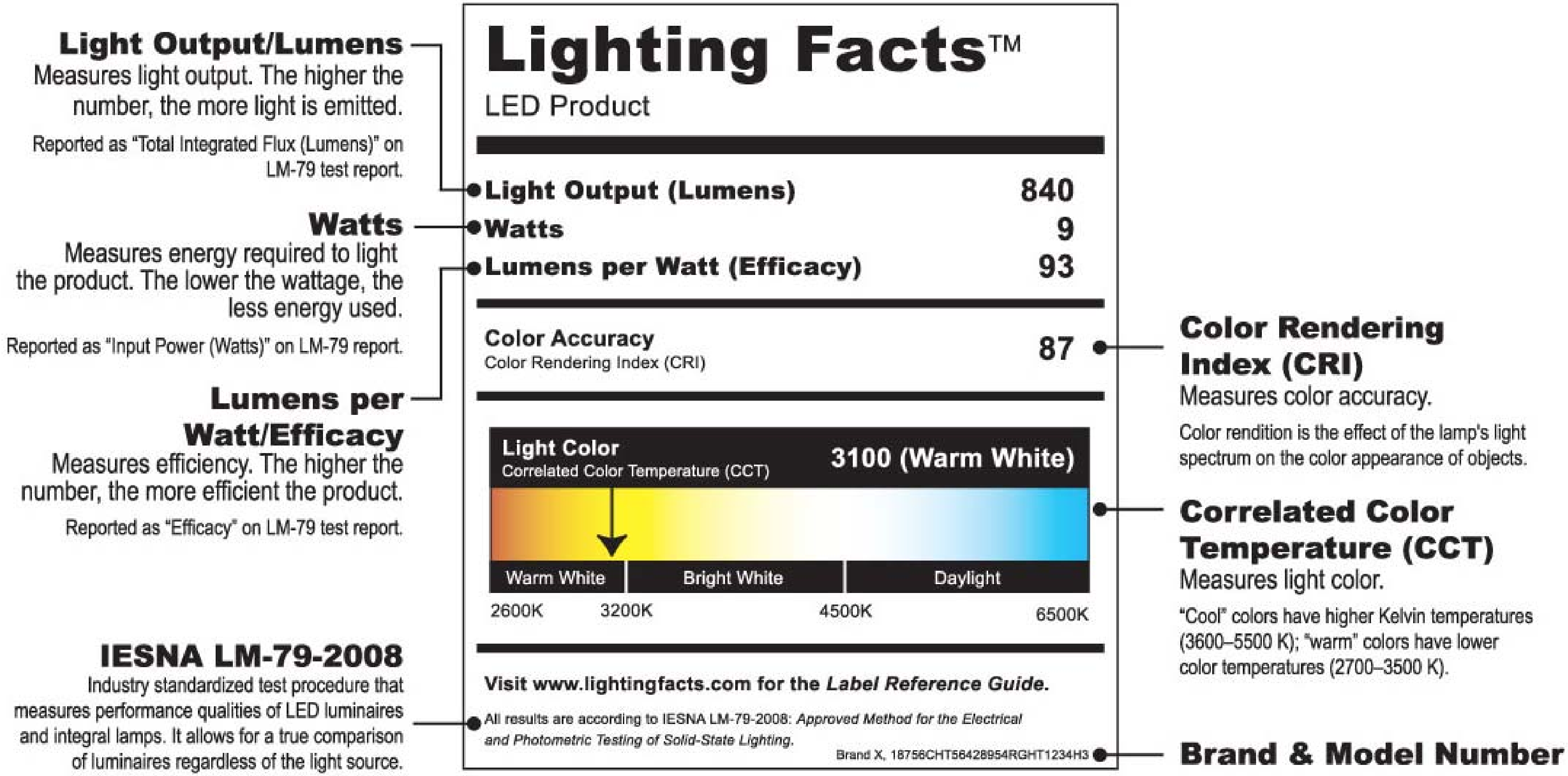
Chromaticity: **ANSI C78.377-2008**
"Specifications for the Chromaticity of Solid State Lighting Products"

Luminous Flux: **IESNA LM-79**
"Electrical and Photometric Measurements of Solid-State Lighting Products"

Lumen Maintenance: **IESNA LM-80**
"Measuring Lumen Maintenance of LED Light Sources"

Definitions: **IESNA RP-16 Addendum A**
"Nomenclature and Definitions for Illuminating Engineering" ◄

Low Fat Lighting

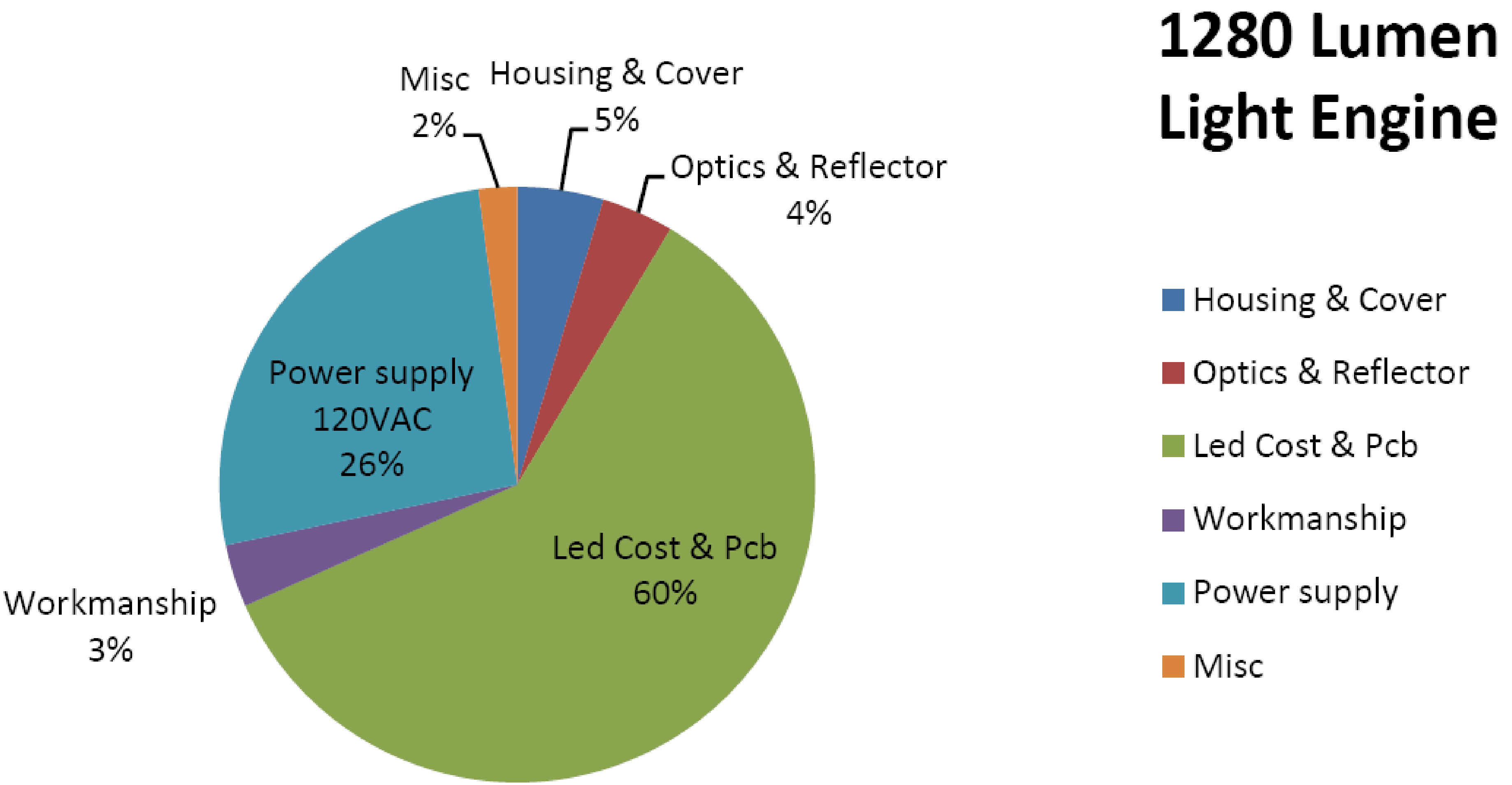


Measuring Light Output

- Integrating Sphere to measure total flux output $$$$
- Spectrometer to measure color temperature $$
- Spectromoeter & Integrating Sphere to measure color rendering index (CRI)
- Goniometer to measure radiation pattern $$$$

Methods that have typically only been used by light bulb manufacturers.

LED System Cost



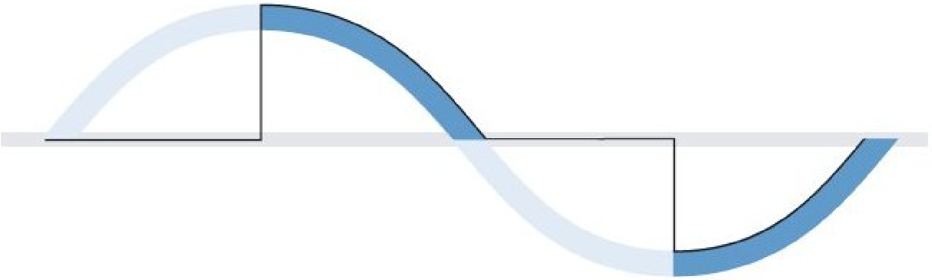
Dimming with Triacs

Triac dimmers cut the AC phase angle.

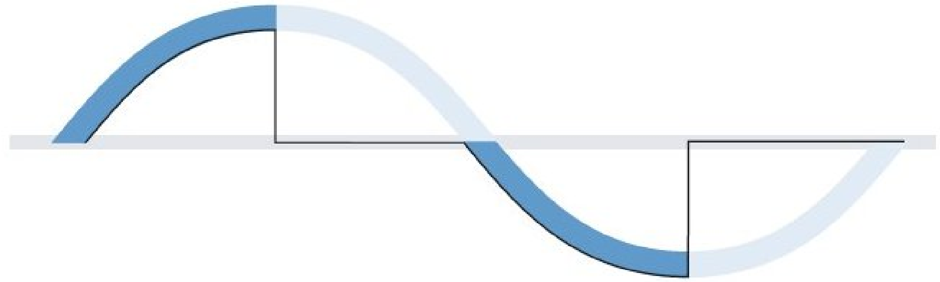
Very good for blowing up bulk capacitors!

Power supply needs to convert AC phase angle to PWM LED current.

Dynamic inrush current limiter required for fast rise time on leading edge dimmers.

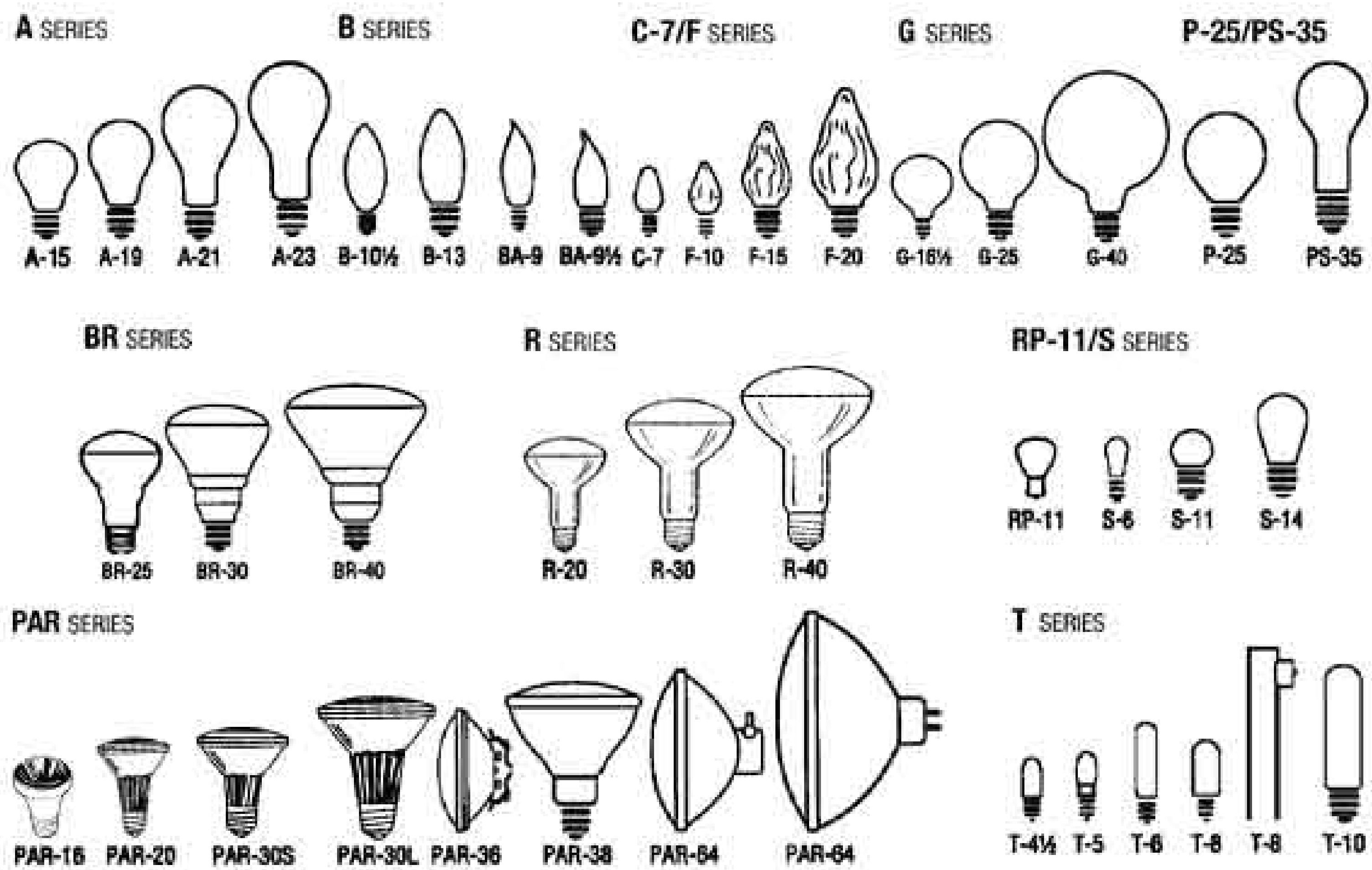


Leading-Edge, Triac Dimmer



Trailing-Edge Dimmer

Light Bulbs come in many shapes and varieties



Bulb Replacement

Its not easy to make quality incandescent bulb replacements!

Image Credit: GBL LED Lighting

Image Credit: GeoBulb™

Some LED bulbs don’t work so good

- White versions of the old style T1¾ LEDs
- LED’s die if they get too hot
- Be suspicious if no heatsink

Case Study (courtesy Cree)

Case Study (courtesy Cree)

LED's are DC Devices!

Great opportunity for integrated control systems!

- Motion Sensing
- Network Control
- Energy Harvesting
- Ambient Sensing
- Dynamic color changing

Where LED’s Shine!

- Street Lights, Office Lighting, Parking Garages, Grocery Stores, Schools
- Solar Powered; parks, streets, other
- Locations where light output can be reduced based on need.
- Locations where bulb replacement is not practical
- Automotive
- Medical applications for high intensity or specific wavelengths of light.

More Information

US Department of Energy - www.lightingfacts.com

California Lighting Technology Center - www.cltc.ucdavis.edu

Nichia - www.nichia.com

*Bridgelux - www.bridgelux.com

*OSRAM - www.osram-os.com/osram_os/EN

*Philips Lumileds - www.philipslumileds.com

Cree - www.cree.com

Luminus Devices - www.luminus.com

LED bandage to enable outpatient skin cancer treatment

A plastic strip embedded with Polymertronics' LEDs can reportedly destroy skin cancer cells by bathing cream-applied skin with red light.

According to a recent article in the British national newspaper the *Daily Mail,* "a strip of bendy plastic" embedded with LEDs by Polymertronics "can patch up wounds and destroy skin cancer cells by zapping them with light." Stephen Clemmet, managing director for the company, told *BioOptics World* that the LEDs match the absorbance spectra of aminolaevulinic acid (ALA), which is approved by the U.S. Food and Drug Administration (FDA) for treating skin carcinomas. So an ALA-based cream applied to the skin enables photodynamic therapy when the LED-encrusted patch bathes the area in red light.

While current skin-cancer treatments are big, expensive and require long stretches of inactivity, Polymertronics' light bandage is faster-acting and unobtrusive enough to allow patients to follow their normal routine. The LED bandage connects to a power pack worn on a patient's waist or tucked into a pocket. Clemmet explained that his company has two prototype versions of the same bandage, one based on LEDs and one OLEDs. Each has specific advantages. "We have tested both our LED solution and organic LED solutions in a controlled laboratory experiment," Clemmet told *BioOptics World*. "The LED killed 100% of head and neck cancer cells in less than half an hour, whilst our organic LED solution did the job in 2.5 hours. For a wearable product this is very acceptable." Because LED technology is more established and better understood, and especially because the FDA has already approved LEDs for medical use, the LED-based version of the bandage will be the first to appear as a product. Polymertronics will begin clinical trials in the next few months and expects to receive approval in early to mid 2011. In the meantime, the company will continue to develop its OLED technology and is seeking further investment. For more information see the Daily Mail article and Polymertronics' website. Reported by Barbara G. Goode from BioOptics World magazine