LEDs

(Light Emitting Diodes)

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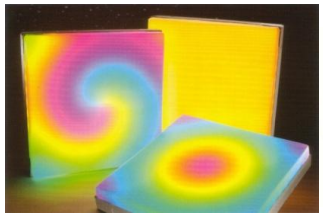
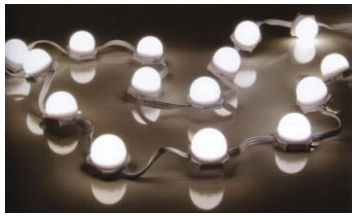


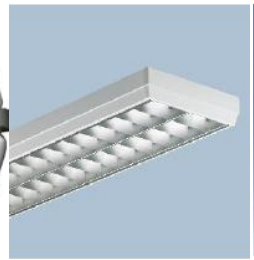




What do we want from lighting?

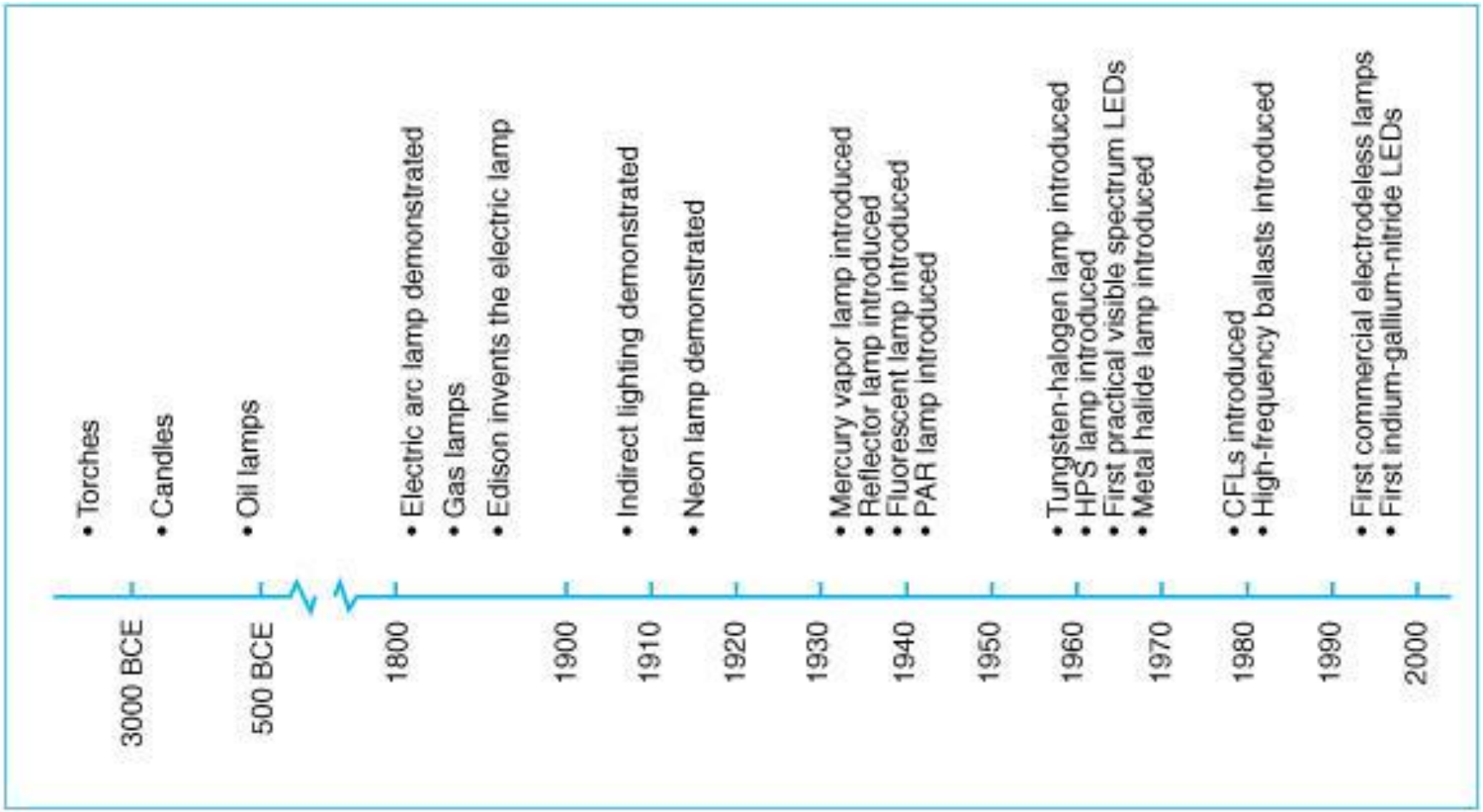
Meet our lighting needs

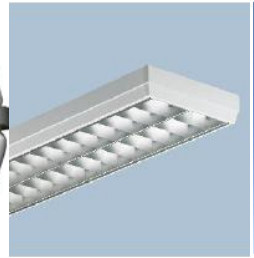
- Easy on the eye (no eye strain)
- Right level of illumination (not too little, not too much)
- Right colour (objects appear in natural colours)
- Easy to install and operate (can I change the bulb?)
- Tried and tested products (high reliability)
- Energy efficient (low energy consumption)
- Reasonable cost (low capital cost)





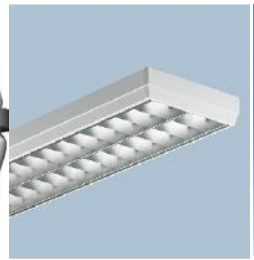

History of Light Sources





LED is the Newest Technology

- For over a century, the incandescent lamp and the gas discharge lamp have ruled the world of artificial lighting.
- Solid state light sources has now become powerful enough to replace these traditional light sources.
- However they are still not competitive in price.

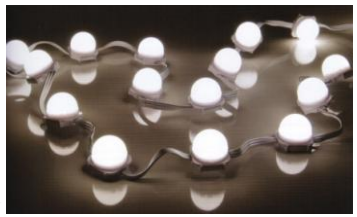


Advantages of LEDs

- Potential for Energy savings.
- Potential for lower lifetime cost.
- Rugged and durable.
- Unique lighting solutions (highly adaptable in form, intensity and colour).
- Low ultraviolet and infrared radiation.
- No mercury (environmentally friendly).





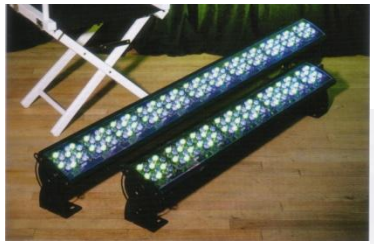



Applications

From 1990 to about 2000

From 2000 to about 2005

About 2005



LED Lighting

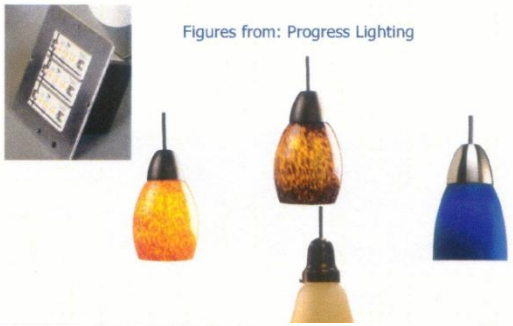
Decorative Lighting with LED Colour Changing Technology

LED Lighting

Customised lighting solution for a hotel lobby. The colour of the tiles changes with Time.

LED Replacement Lamps

Replacement Light Engines



Figures from: Progress Lighting

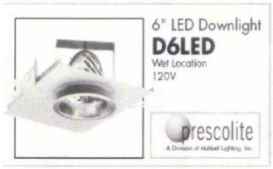
Figures from Prescolite

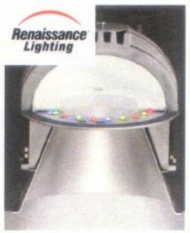
Down Lighting

Cree and Zumtobel Announce Strategic Agreement for LED Downlights in Europe

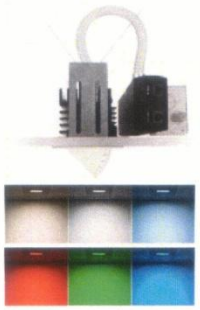
Global Adoption of Solid-State Lighting Accelerating At a Rapid Pace

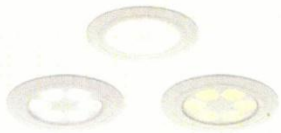
Last update: 2:00 a.m. EDT Oct. 8, 2008





Lightolier's ColorWash





Sharp Corporation will introduce into the Japanese market six new LED Downlight Lightings, including three that deliver a light intensity equivalent to a 150-watt incandescent lamp, an industry first for downlight models.

Global trend.....

Interior Lighting with LED

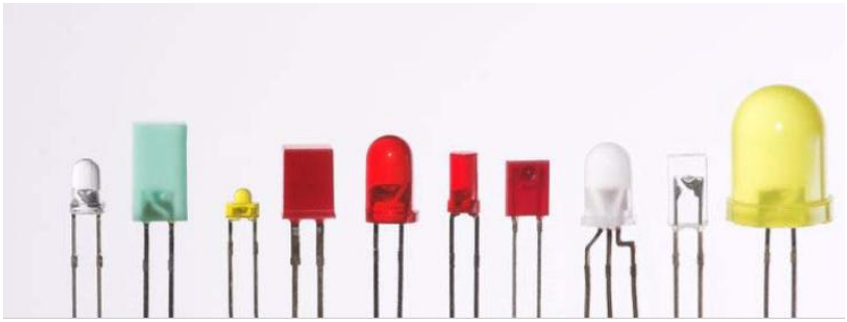
Interior Lighting with white LEDs

Future

- White light applications are now well advanced.
- Prices are coming down.
- Office and household LED lighting applications are beginning to be cost effective.
- However, there still are some issues,
  - Only some products can meet the lighting requirements of a modern office environment and be cost effective.
  - Reliability is unknown.

History

- Light Emitting Diodes (LED) were first developed around 1960's.
  - The principles were known much earlier for infrared LEDs.
  - First practical visible spectrum LED (red) was developed in 1962 by Nick Holonyak Jr.
  - M. George Craford, invented in 1972 the first yellow LED and 10 times brighter red and red-orange LEDs.
  - Practical blue LED lamps were developed recently (late 1990s), leading the way to white LEDs.



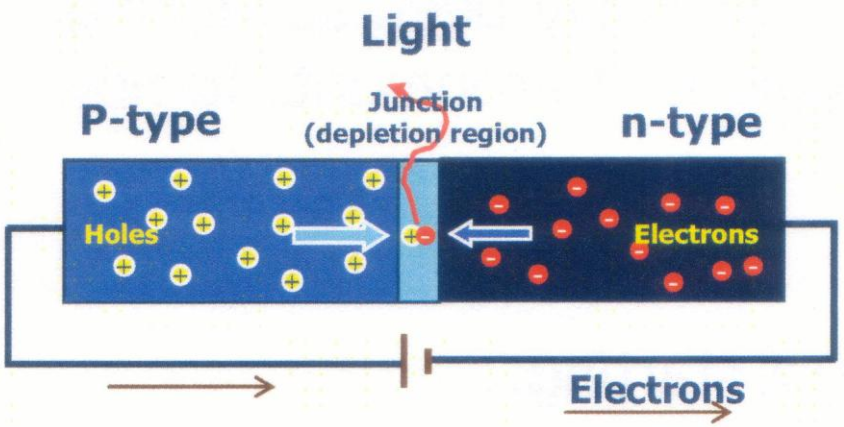
Principle of Operation

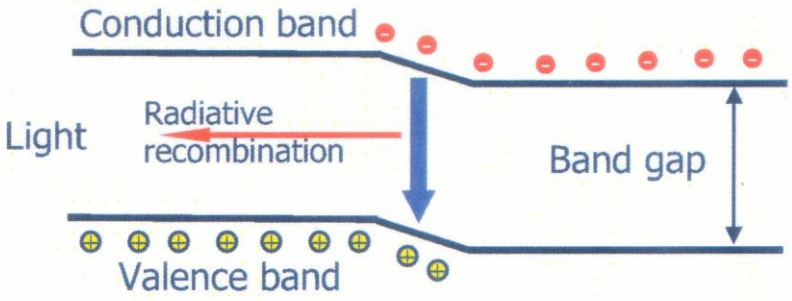
The p-n Junction

- The wavelength of the light emitted, and therefore its color, depends on the energy gap of the materials forming the p-n junction.
  - energy band theory of semiconductors.
- The semiconductor materials used for an LED creates a band gap with energies corresponding to near-infrared, visible or near-ultraviolet light.

P-N Junction

- Not all electron-hole recombination results in light.
- Charges trapped in defects results in heat.
- Colour of the output light depends on the bandgap energy.





Colour by Material

- Aluminium gallium arsenide (AlGaAs)
  - red and infrared
- Aluminium gallium phosphide (AlGaP)
  - green
- Aluminium gallium indium phosphide (AlGaInP)
  - high-brightness orange-red, orange, yellow, and green
- Gallium arsenide phosphide (GaAsP)
  - red, orange-red, orange, and yellow
- Gallium phosphide (GaP)
  - red, yellow and green

Blue LED

- Blue LEDs are based on the semiconductors GaN (gallium nitride) and InGaN (indium gallium nitride).
  - These materials produce a wider energy gap.
- With AlGaN and AlGaInN, even shorter wavelengths are achievable.
- Ultraviolet and Near-UV LEDs are already available on the market.
  - e.g., as black light lamp replacements for inspection of anti-counterfeiting UV watermarks in documents and currency notes.

White LED

- A combination of red, green and blue LEDs can produce white light. However due to low efficacy, white LEDs today rarely use this principle.
- Most white LEDs in production are modified blue LEDs:
  - Blue LED is covered with a yellowish phosphor coating. Part of blue emission is efficiently converted to a broad spectrum centered at about 580 nm (yellow) by the coating.
  - The resulting mix of blue and yellow gives the appearance of white.
  - By varying thicknesses of the phosphor, light with different color temperatures, from warm yellowish to cold bluish, can be made.

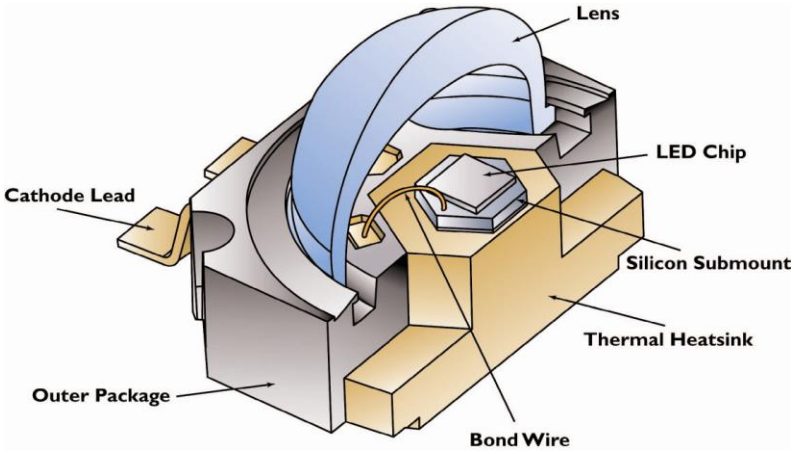
White LED

- Another method used to produce white LEDs uses no phosphors at all.
- Which simultaneously emits blue light from its active region and yellow light from the substrate.
- Recently, many other methods of producing white light from blue LEDs have been developed.
- These methods produce white light with different colour properties.

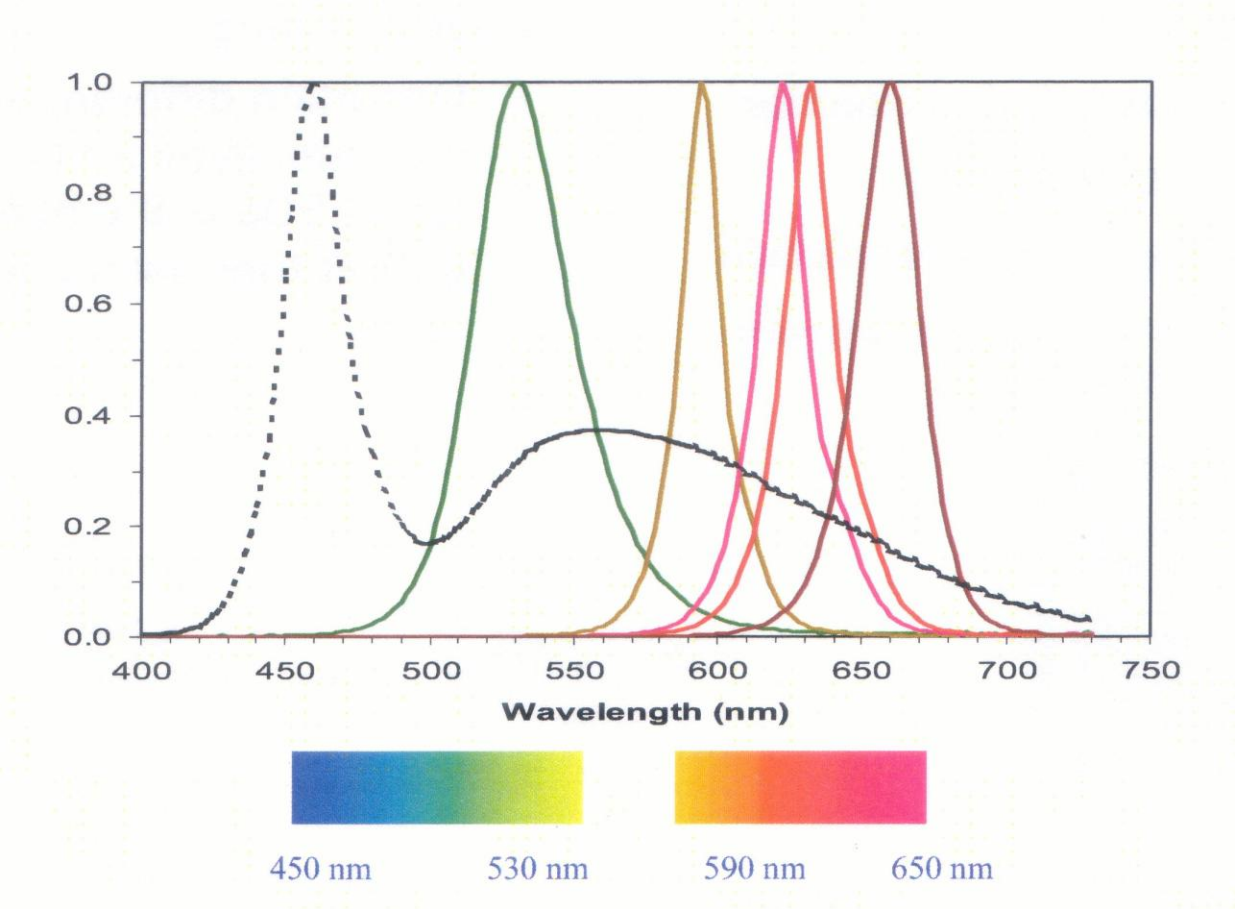
LED Construction

High power illuminator type

- Die size is 1.0mm square.
- Power levels are 1W to 3W.
- Colour consistency and thermal effects are extremely important.
- Proper thermal management needed.
- Light is emitted through all six sides of the LED chip.



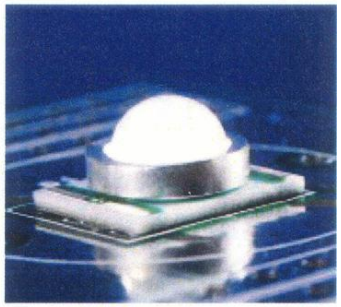
LED Spectrum



Commercial High Flux LEDs

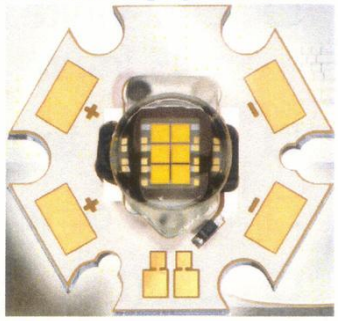
- High lumen output per lamp (above 100 lm).
- Better colour properties of white LEDs.
  - Good colour rendering.
  - Smaller colour variation between lamps.
  - Stable colour over time.
- Longer life.
- e.g. Cree – XRE
  - 350mA, 95 lm/W, 107 lm
  - Colour temp. of 2600K to 10,000K
  - Drive current up to 1000mA
  - Life at 700mA is 50,000h

Cree – XRE

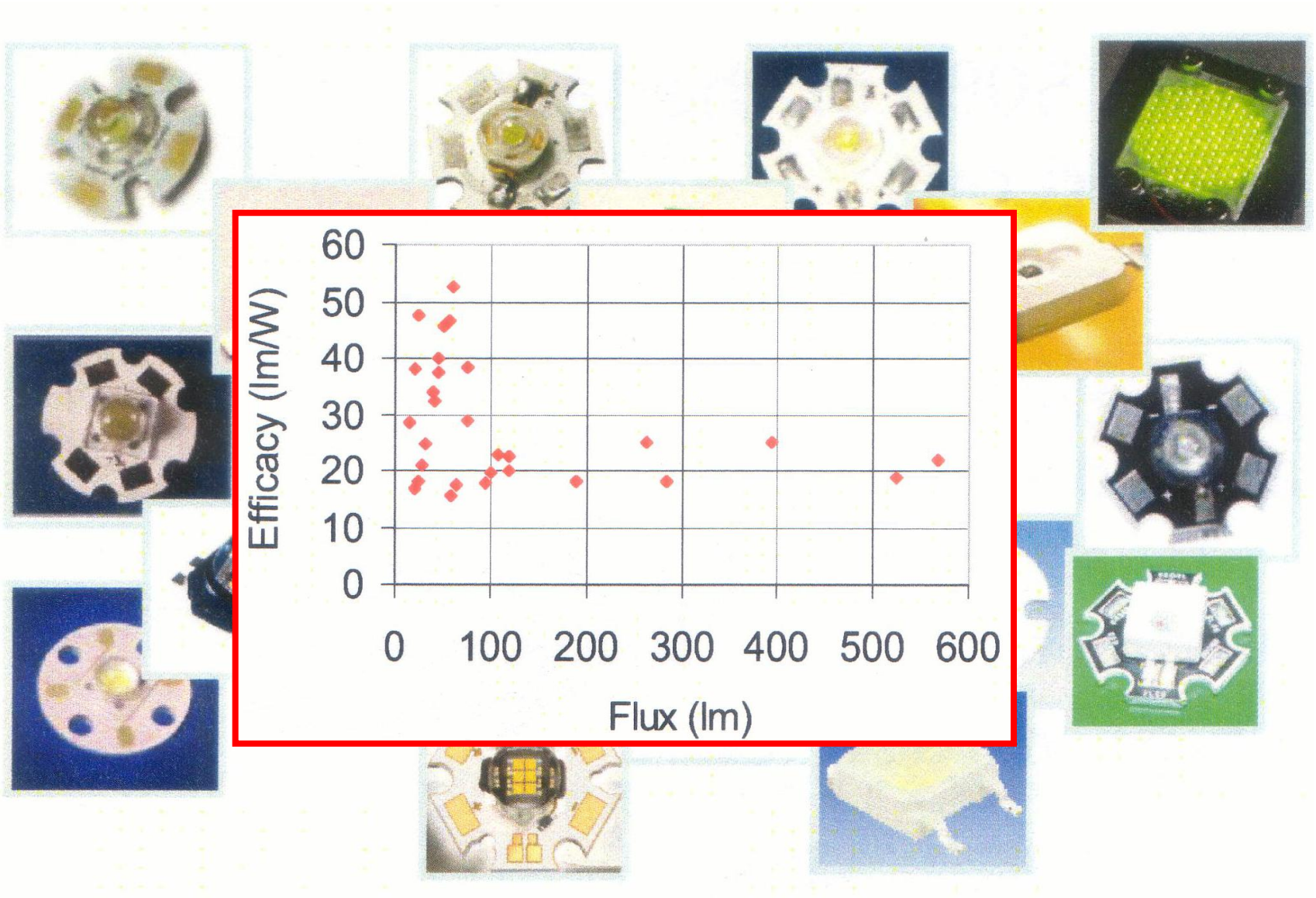


Osram's high-power Ostar

420 lm
700mA
15W
28 lm/W

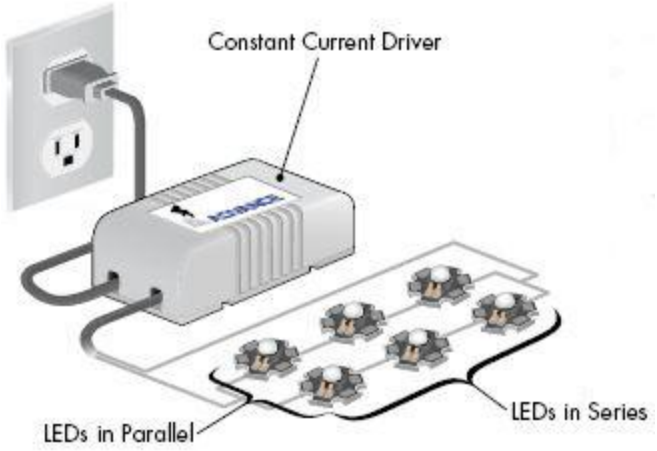


Not All LEDs are Created Equal



Lamp Systems

- An LED system consists of
  - LED package, with its own optics and thermal management.
  - Secondary optics to re-shape the beam.
  - Heat sink for thermal management.
  - Mechanical housing.
  - Electrical connection grid.
  - Power supply.
  - Controls.



LED Systems

- For the end user, the most important consideration is the system efficacy.
- Typically about 55% of LED efficacy.
- Commercial white LED systems in 2008 are about 15 to 60 lm/W.
- Heat affects light output, colour and life.
- LED products for replacement of traditional PAR/MR16 incandescent/halogen systems are frequently appearing on the market.
- Marketed as one-to-one equivalents.

The End.