



LED Package & Die Attach Solder's Role

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Picture: Daktronics; MN, USA

Indium Corporation World Wide

- Indium is a World Class materials supplier for electronics manufacturing
- Founded in 1934
Solder Business Unit & Metals / Chemicals & Energy
- Over 350 direct Employees
- Manufacturing in
 - United States
 - United Kingdom
 - Singapore
 - China
 - Korea

Brief history of Light Emitting Diodes

- Developed in early 1960s
- First consumer applications in 1970s (red LED)
- New Colors introduced in 1980's but failure rates were high due to poor assembly methods.
- Today nearly 4 billion units a month are produced primarily in Taiwan, Japan and the United States...

LED Types



•Chip LEDs



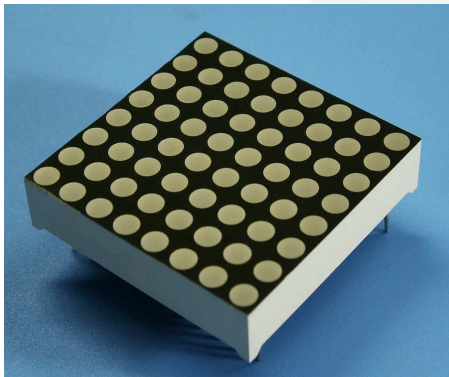
•Power LEDs



•Lamp LEDs



otics Ltd. WWW.SOLARBOTICS.COM



• Dot Matrix LEDs



•Digital Display LEDs



•Side View LEDs

High Power LED Applications

- Architectural and landscape lighting
 - Wall sconce
- Backlighting
 - LCD TV
- Video Projection
- Automotive
 - Head / Tail Light assemblies
- Displays & Signs
- Dental Curing
 - UV
- Mobile Devices
 - LED Flash



Source: gizmodo.com

Efficient Lighting

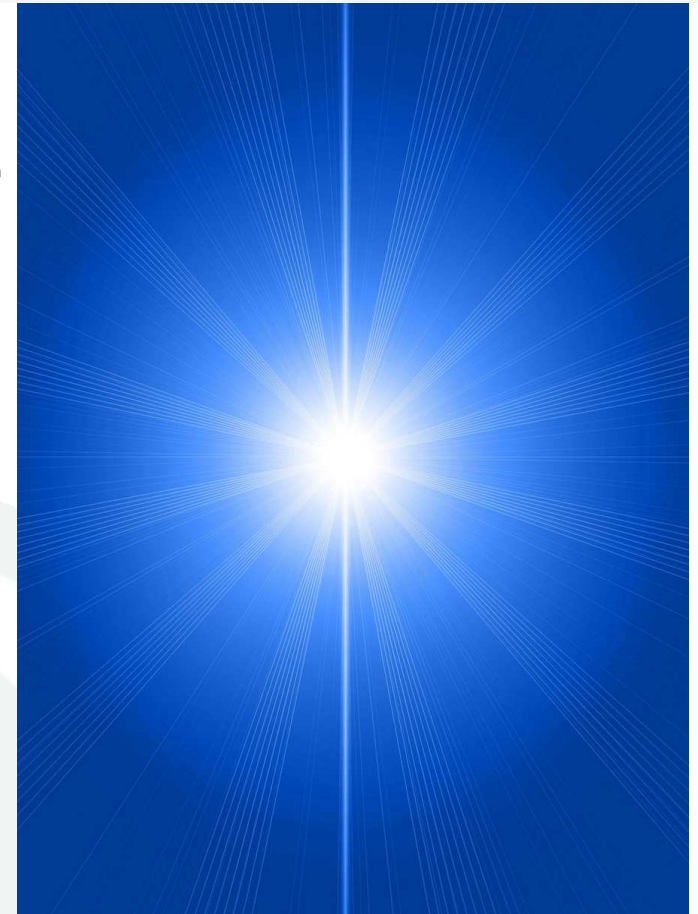
Statistics

- Lighting the World consumes 2 trillion kilowatt-hours annually (1/8 all electric power)
- LEDs have achieved 100 Lumens/ electric Watt with 200 in sight.
- Incandescent Bulbs Emit 15 Lumens/Watt and CFLs about 80 Lumens/Watt



High Quality Lighting

- Incandescent lights are rated for 1000 hours before the filament flakes out
- CFLs achieve 10,000 hours
- LEDs last 50,000 hours, 100,000 hours, even as high as 150,000 hours in outdoor applications.



Luminaire Design

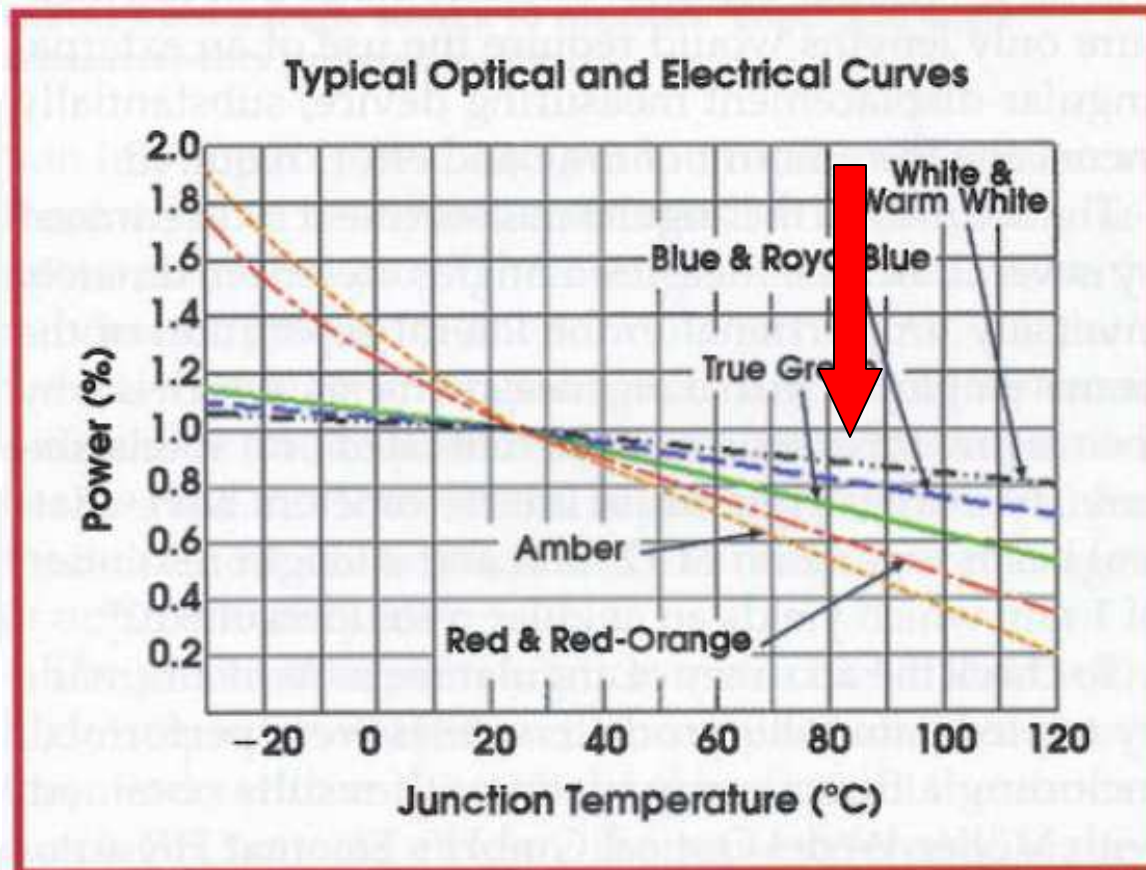
"The prediction of thermal performance of LEDs is becoming a necessity in reducing the time to bring products to market. However, with the increasing heat flux and package density, the heat dissipation of the LED package module is becoming a challenge, and the thermal analysis and design of the module is becoming even more important."

**Thermal Modeling for Application of High Power LED
White Paper**

By: Oon Siang Ling, Solid-State Illumination Division, Avago Technologies, Penang, Malaysia

Maximizing Thermal Output

- How hot the LED Chip gets during operation impacts the quality and lifetime of the light produced
- Typical junction temperature <80-90°C



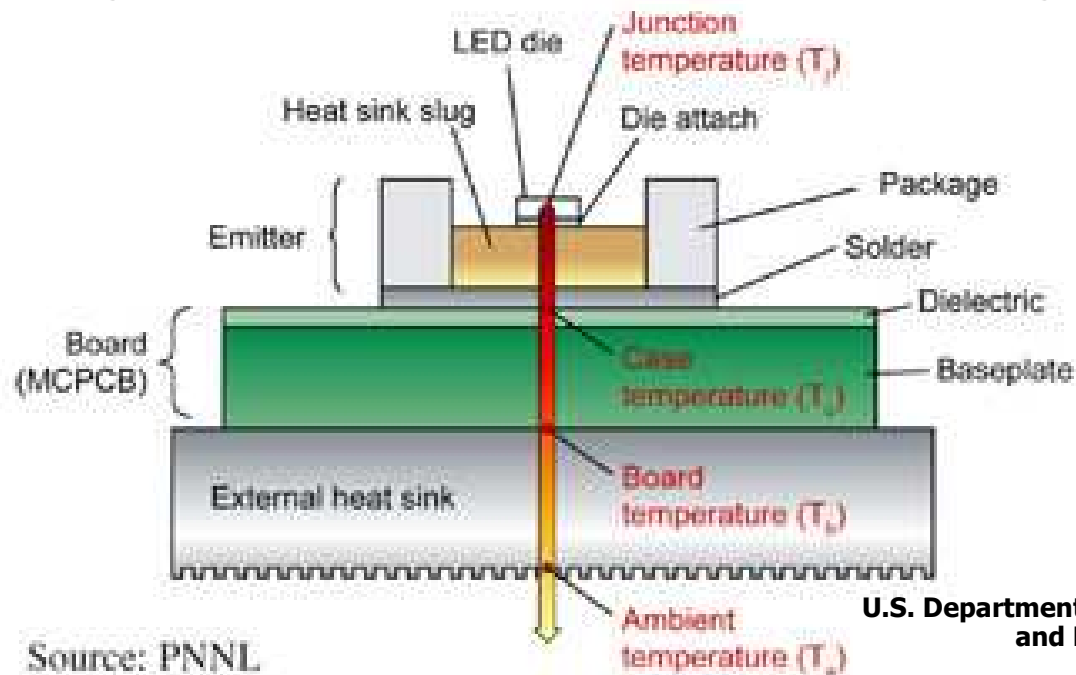
The relationship between output power and junction temperature in an LED is shown. Courtesy of Edison Opto.

What Determines Junction Temperature?

Three things affect the junction temperature of an LED:

Drive current, Thermal path, and Ambient Temperature

In general, the higher the drive current, the greater the heat generated at the die. Heat must be moved away from the die in order to maintain expected light output, life, and color. The amount of heat that can be removed depends upon the ambient temperature and the design of the thermal path from the die to the surroundings.

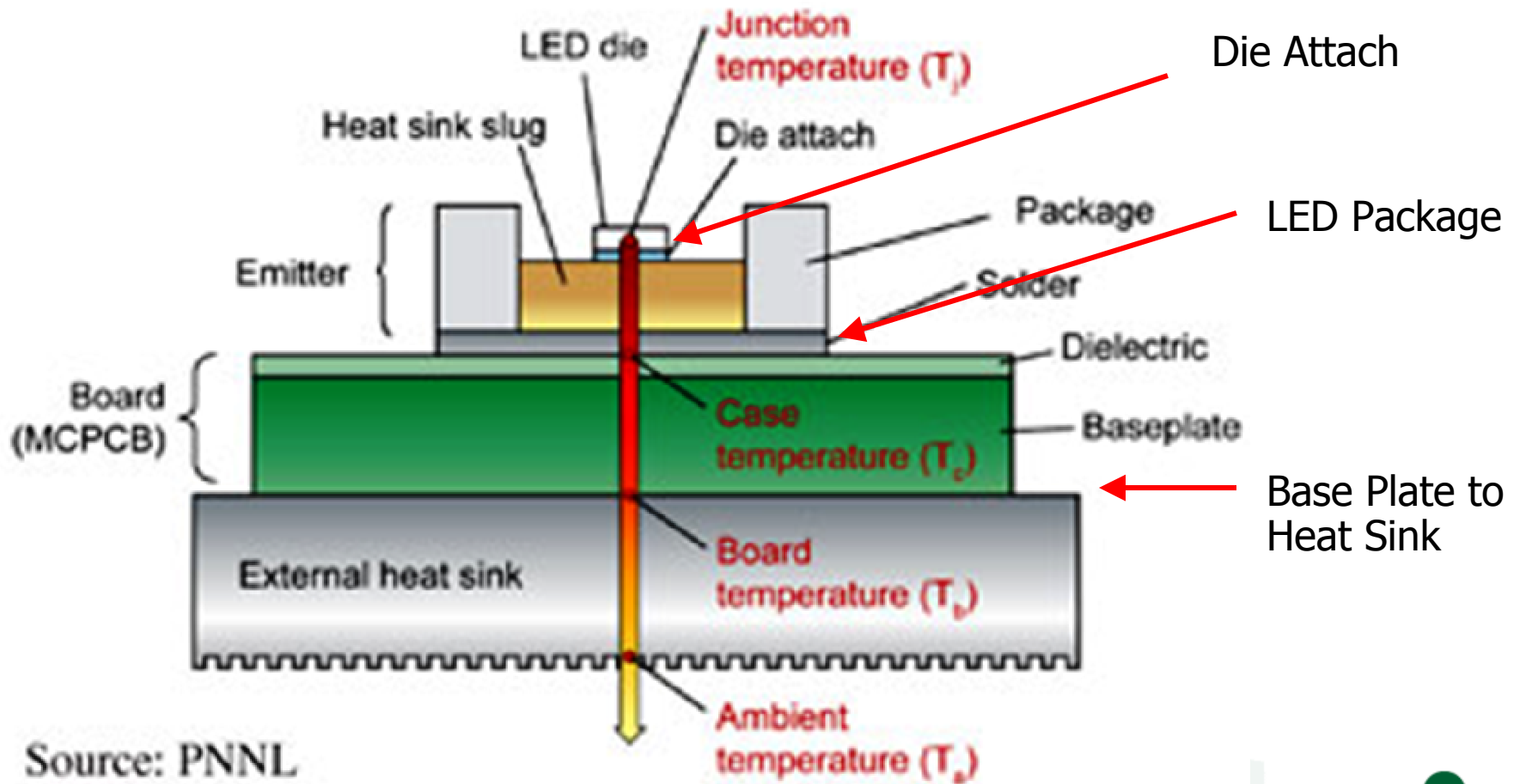


Source: PNNL

U.S. Department of Energy - Energy Efficiency and Renewable Energy

Solid-State Lighting

Solder Locations in HP LED



Die Attach

- **Methods:**

- Epoxy Die attach
 - Epoxy thermo-set resins
 - Acrylic thermo-plastic resins
 - Thermo-plastics (no cure) have higher thermal conductivity than Thermo-set (lower voiding)
 - Silicone resins
- Soft Solder Die Attach
 - Sn/Ag
 - Sn/Pb
 - 95Pb 5Sn
 - Pb/In/Ag
 - 65Sn 25Ag 10Sb
- HMP Eutectic Die Attach
 - Au/Sn
 - Au/Si
 - Au/Ge



Epoxy Die Attach

- **Benefits:**
 - Ease of application
 - Low curing temperatures
 - Reduced die stresses
 - Low cost
 - Wide range of die sizes
 - Special plated surfaces are not required
 - Rework is possible
- **Limitations:**
 - Out gassing
 - Voiding (in some cases)
 - Inferior thermal/electrical conductivity
 - Dimensional Changes during processing and service life
 - Harsh environment sensitivity

Soft Solder Die Attach compared to Eutectic Die Attach

- Benefits
 - Good CTE absorbing abilities
 - Lower temperature processing
- Limitations:
 - Requires solderable metallized surfaces on the die and substrate
 - Requires flux or inert atmosphere
 - Thermal fatigue of some alloys

HMP Eutectic Die Attach

- **Benefits:**

- Good Electrical/Thermal Conductivity
 - LED Color control
 - Longer LED Lifetimes
- Good Thermal Fatigue and creep resistance
- High Process/operational temperature ability
- Clean

- **Limitations:**

- High Stresses on Si Chip due to CTE mismatch on large dies
 - No Longer wire bonding with high temperatures-ultrasonic bonding with lower temperatures
- High temperature processing (>280C)
- If bare die are used, scrubbing action required to break down surface
- Difficult Rework

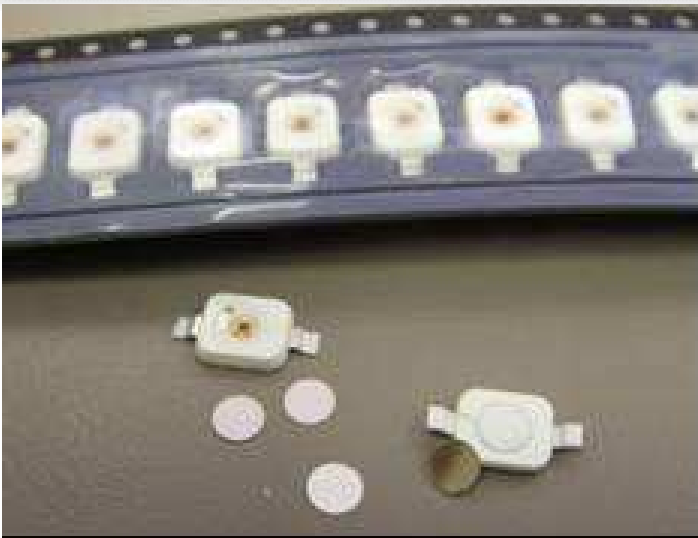
LED Package Attach

- Tin-plated NanoFoil
- Solder preforms
- Solder paste
 - Sn/Pb or Pb-free
 - Bi/Sn solder paste (step soldering)
- Epoxy material
 - Thermal interface; heavily loaded with silver (85%+)
- Mechanical attach (Phlatlite)

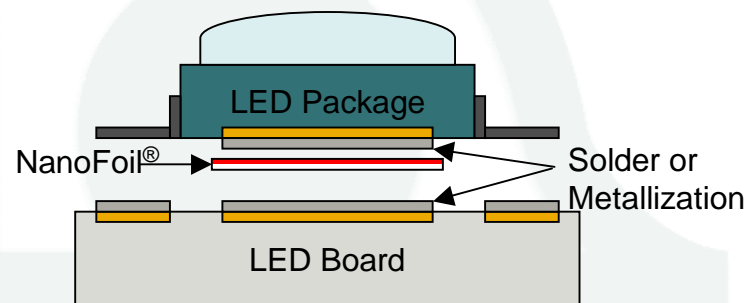
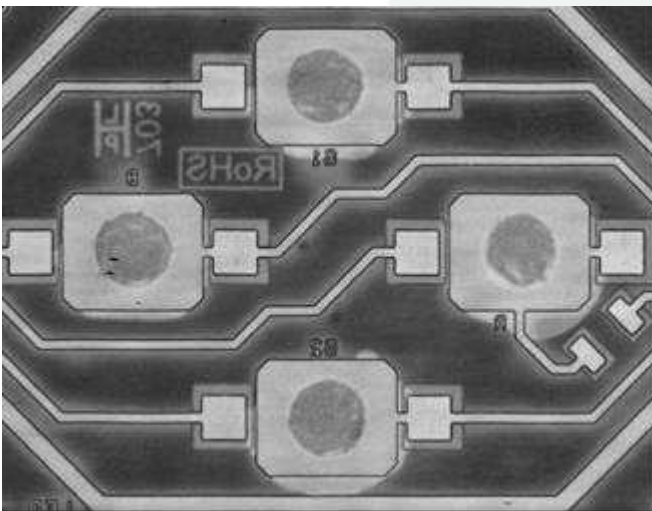


Picture: Daktronics; MN, USA

LED Package Attach NanoFoil



- No additional solder required
- Uniform and consistent bond line
- Superior thermal performance allows higher power, longer life



Methods of Heat Sink Attach

Solders

Benefits

- Creep Resistant
- Superior thermal conductivity (30-86W/m-°K)
- Voiding will not propagate over time
- High strength attach

Limitations

- Intermetallic growth can become problematic
- Solderable surface required
- Package can be exposed to heat during reflow
- Unacceptable voiding if process is not optimized

Methods of Heat Sink Attach

Thermal Grease / Gels

Benefits

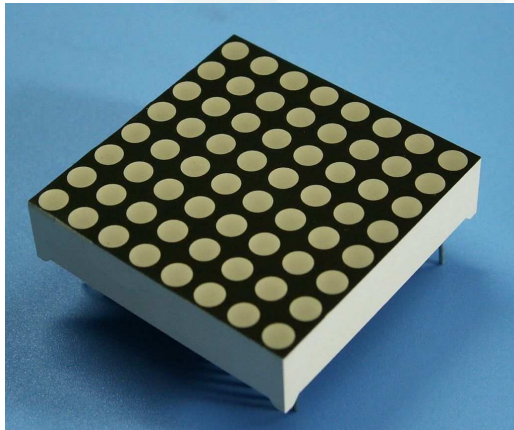
- Ease of application
- No Reflow required
- Lower Cost
- Good surface contact
- Gels are reusable

Limitations

- In high power applications thermal greases are more prone to drying out and bake out when exposed to extensive thermal cycling.
- Gels must be cured
- Thermal Conductivities in the range of (1-4W/m-°K)

Future of LEDs

- Hotter, Brighter LEDs if Haitz's Law continues
- Dot Matrix LEDs to maximize Lumens per area
- Active Cooling is not an option
 - Liquid cooling only viable for high end stationary applications
- "Greener" technologies



Questions?

Moore's Law:

In the history of computing, the number of transistors placed on an IC has effectively doubled every year since 1965.

Haitz's Law:

In the history of LED's, the cost per lumen has dropped by 10x, and light output has increased by 20x every year.

