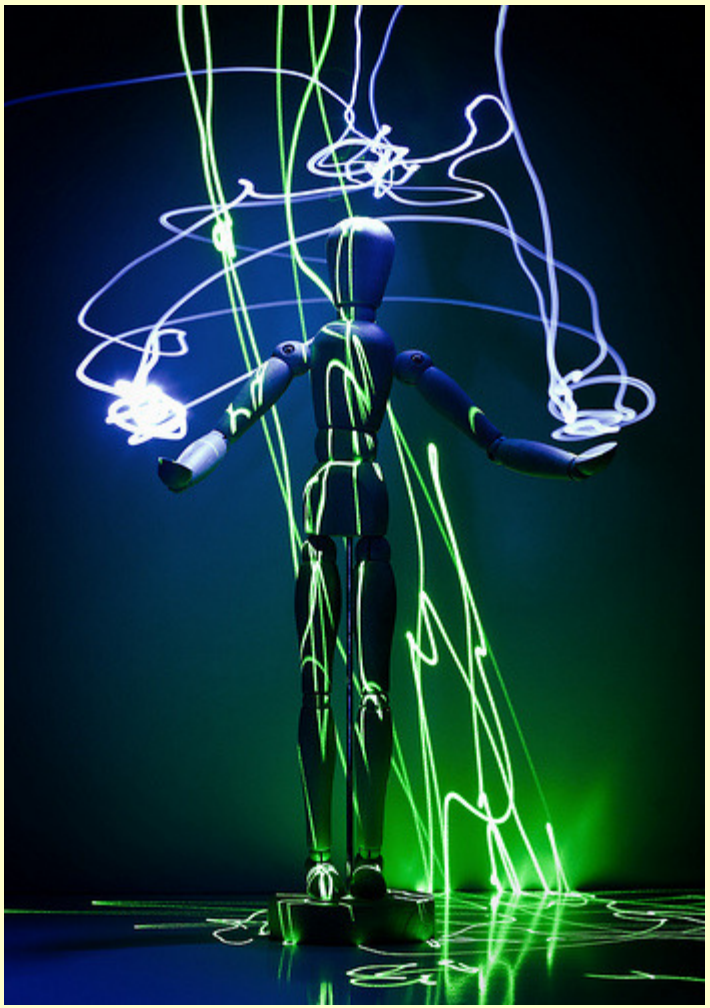
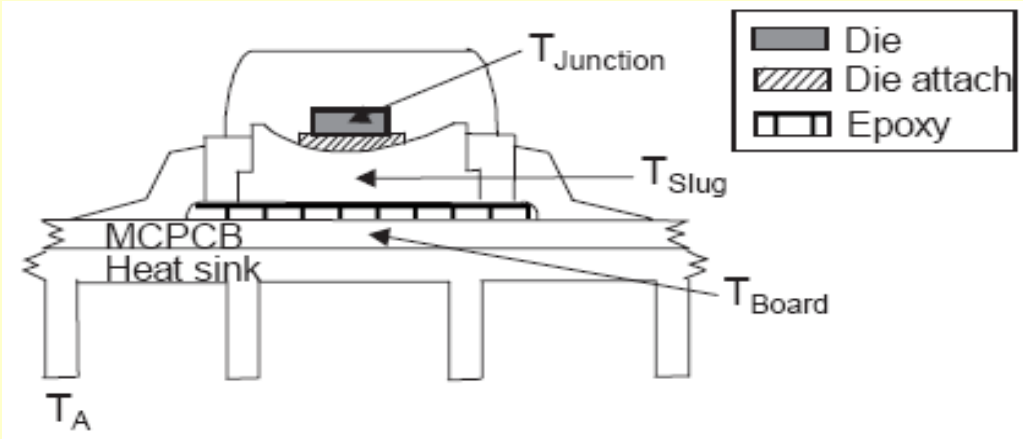


What's the Big Deal About Thermal Management?

What 'Heat' Are You Talking About?
I Thought That LED's Didn't Give Off Any Heat

When You Touch the Front of the LED There is Little if Any Heat. BUT if it is Generating Light and Consuming Energy THAT Produces Heat – But Where You Ask? Meet us at the Junction - the LED Junction (Tj)

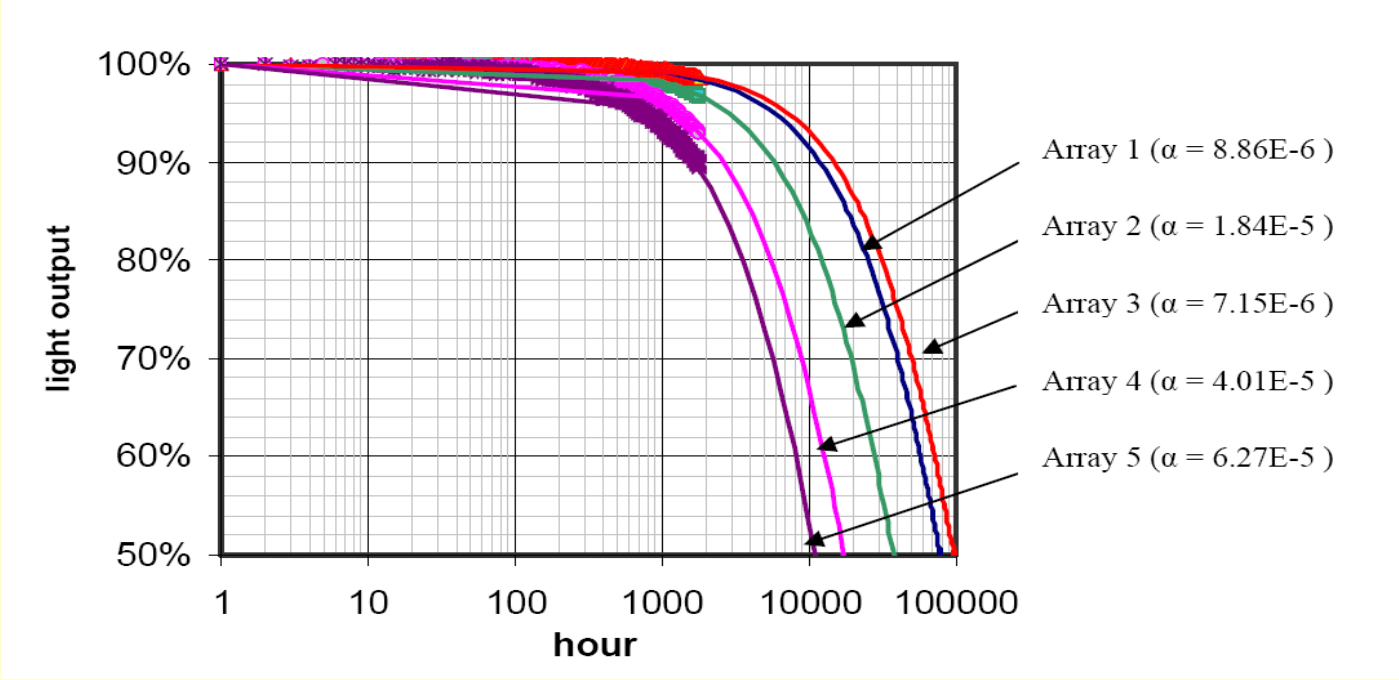
Thermal Management is 'Power Management'



- **Heat Transfer rate = Electric power in / Power converted to Light**
- Manufacturers task is to design a robust system to accommodate this heat transfer rate

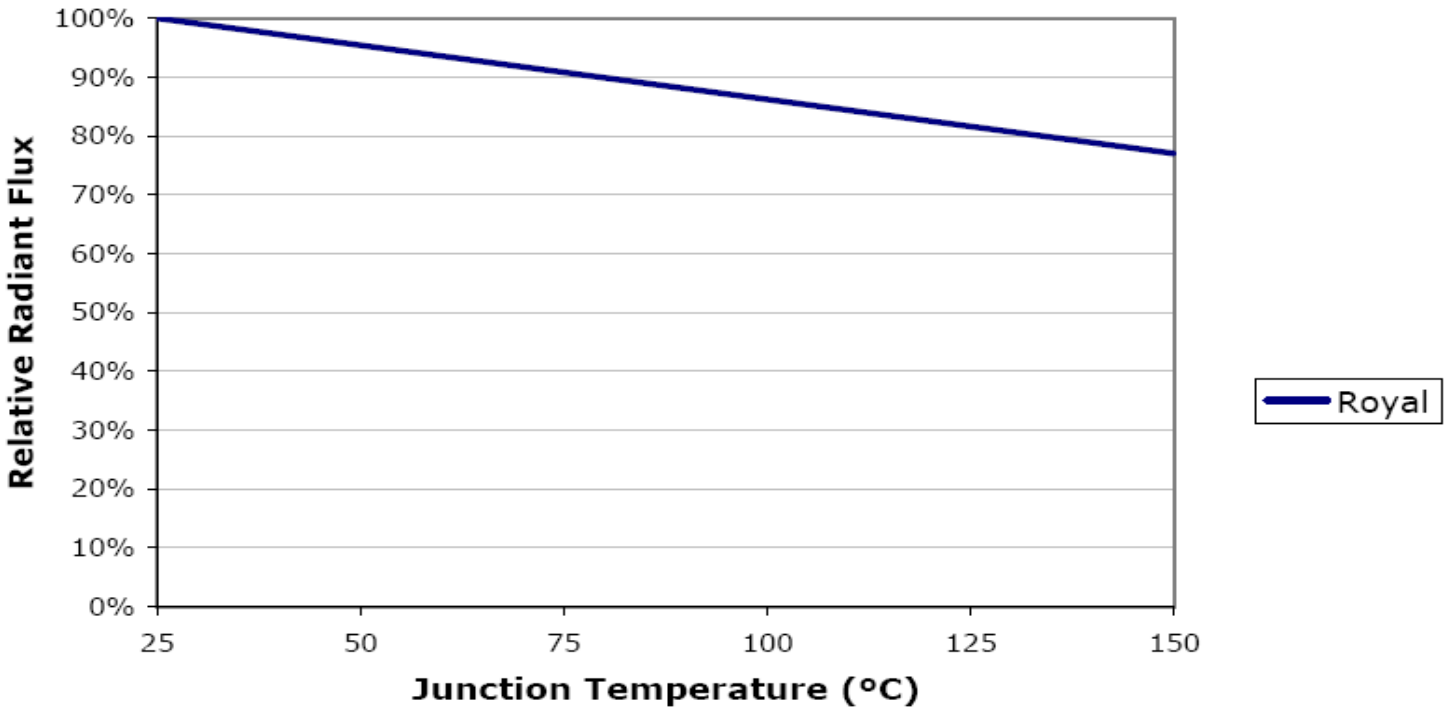
Impact of Heat on Life
(LED Life That Is)

An 11 degree C change in junction temperature reduces the life (L70)
From 45,000 hours to 15,000 hours*

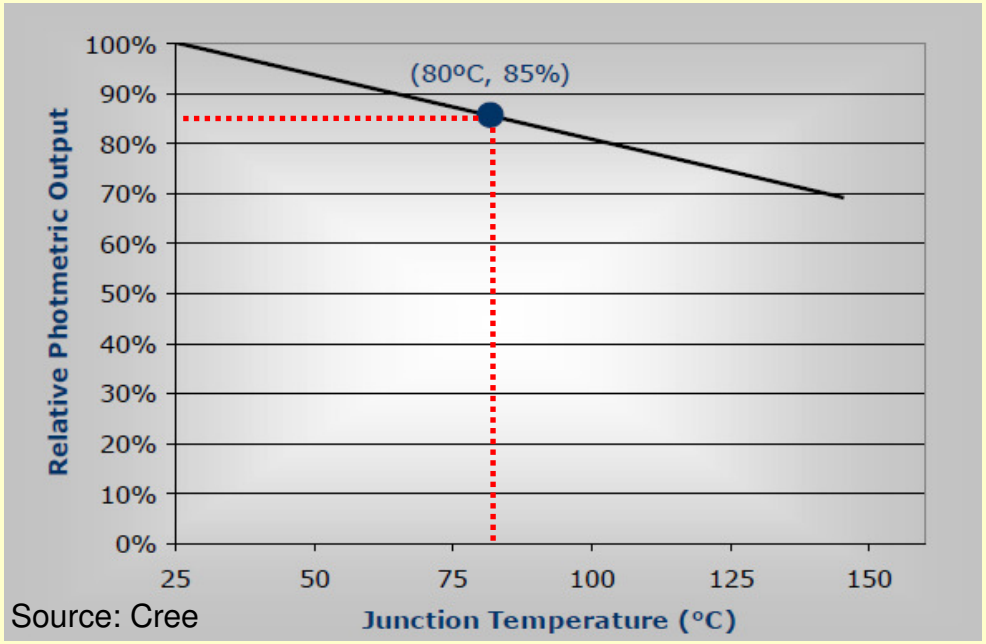


* Lighting Research Center

Junction Temperature 'Jt' Heat Impacts Light Output



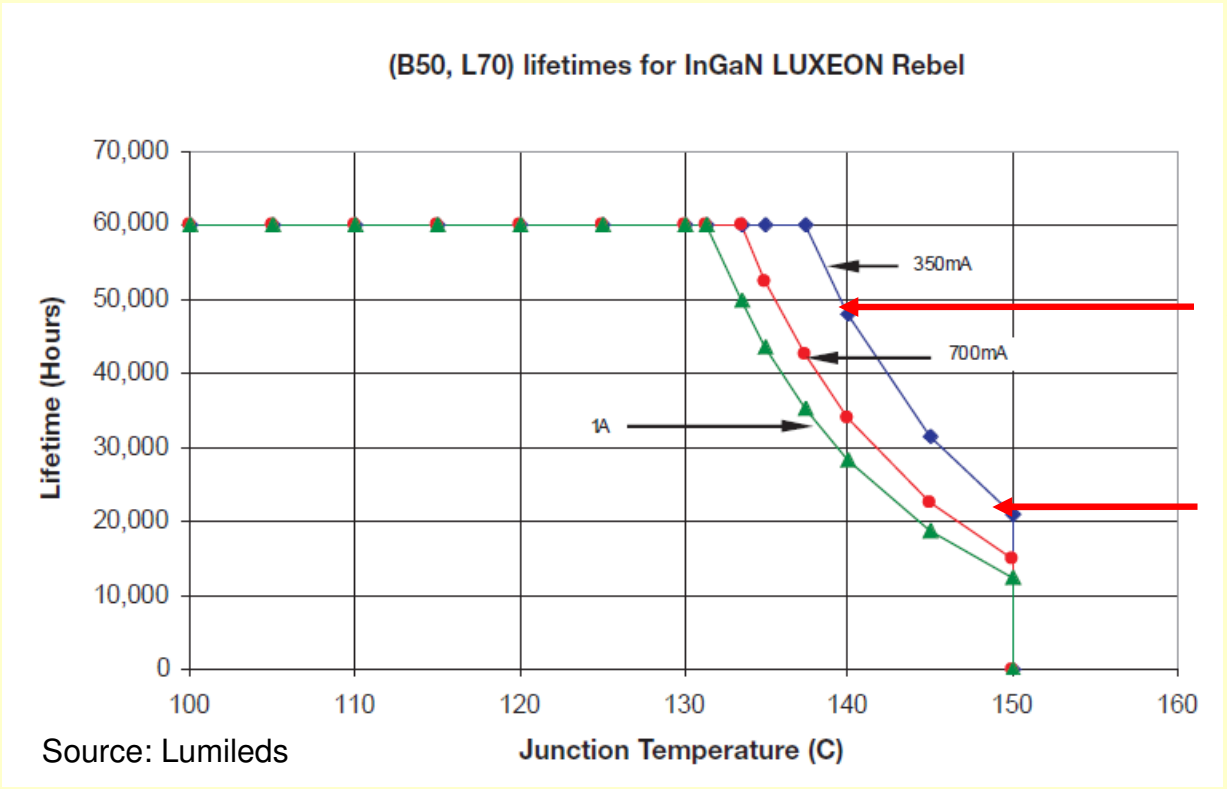
‘Jt’ Graph For Cree LED’s



Source: Cree

- Light output goes down as junction temperature goes up
- 100 lumens @ 25°C Tj goes down to 85 lumens @ 80°C Tj
- There is typically a 10-20° delta between the circuit board and junction
- That translates to about 65°C on the circuit board
- You can assume a 15-30% reduction in light output due to thermal losses

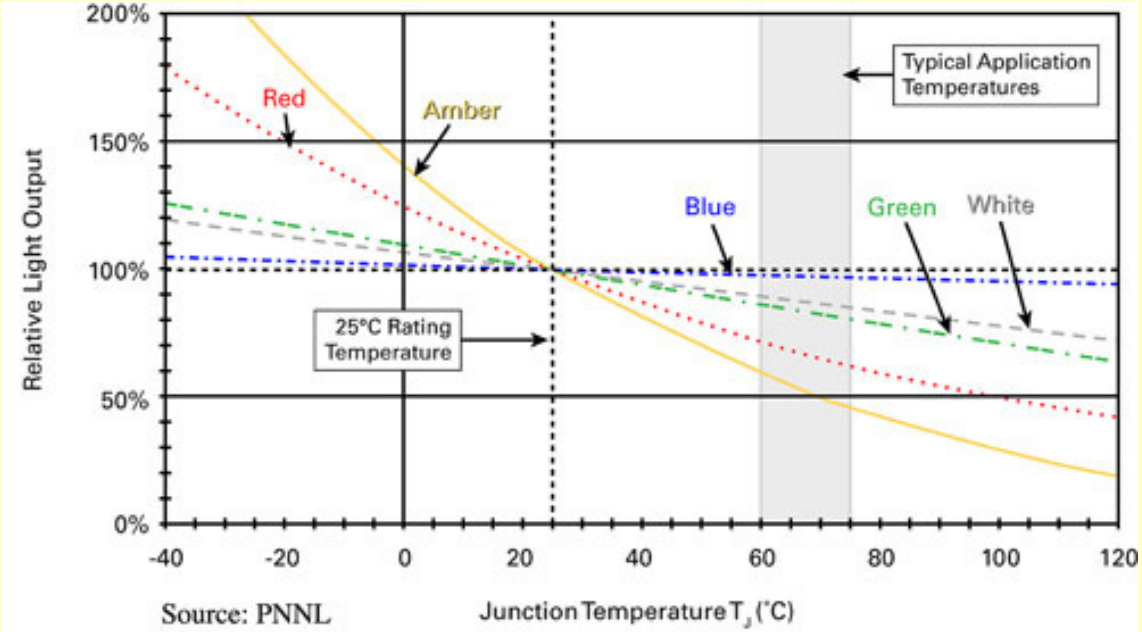
‘Jt Graph For Lumileds LED’s



Source: Lumileds

- Life is directly related to junction temperature
- Generally you can predict the life will be reduced by 50% for every 10° C rise in Tj

'Jt' Graph For Colored LED's



- Each color has a different sensitivity to temperature
- Each color degrades at a different rate
- In general, warmer colors are more temperature sensitive and degrade faster than cooler ones
- The degradation rate increases with increased junction temperature

OK, How do You Get Rid of Heat?

A responsibly designed LED luminaire takes into account all (yes, ALL) of the following modes of heat transfer:

- Conduction
  - Occurs in all substances and is energy transfer due to atomic vibrations
- Convection
  - Occurs whenever a moving fluid (AKA 'air') flows past a solid surface that is at a temperature different that the fluid.
- Radiation
  - Occurs in vacuums, transparent or semi-transparent materials and is energy transported by electromagnetic waves.

OK, OK Heat is The Enemy
Can We Wrap This Up and Move On?

Sure! In Summary:

- Lifetimes of 50,000 hours life or more are possible with a properly designed system
- Although failures are possible, LEDs typically do not burn out, light output degrades over time
- The degradation rate increases with increased junction temperature
- Phosphors degrade with time and temperature and encapsulate materials can yellow over time
- For general illumination, life is generally measured to 70% lumen maintenance (L70) or when light output decreases to 70% of initial lumens