Epigap FAQs

Part 2

2. Electrical and other parameters

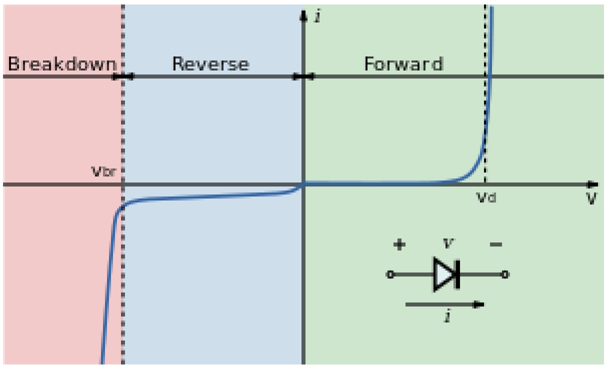
2.1. absolute maximum ratings

are a listing of the environmental and electrical stresses that may be applied to a device without resulting in short term or catastrophic damage. However, exposure to maximum ratings conditions for extended periods of time may adversely affect device reliability.

Maximum limit ratings must not be used simultaneously. Operation at one maximum limit may preclude the operation at the maximum limit of a different parameter.

Source: PerkinElmer.

2.2. I-U dependence diagram for LEDs



I-V diagram for a LED resembles I-V diagram for a diode. An LED will begin to emit light when the on-voltage is exceeded. Typical on-voltages are 1…2 V for infrared LEDs, 2…4 volts for visible LEDs and more than 4 V for UV LEDs.

Sometimes the axis of the I-U-dependence are shown in reverse order. In this case the graph shows the stabilized current and measured voltage.

2.3. typical tolerances of measured optical and electrical parameters

- typical tolerance of measurements of forward voltage is ± 0.05 V.
- typical tolerance of measurements of the luminous flux, luminous intensity, radiant flux and radiant intensity is ± 5…7 %.
- typical tolerance of measurements of the chromaticity coordinates is ± 0.01.
- tolerance of measurements of peak wavelength is typically ± 1 nm.

2.4. forward voltage of LEDs

is the voltage across the LED at a definite current. For standard infrared LEDs values of 20, 50 mA or 100 mA are typical, for power LEDs: 350 mA or more. In pulse mode at high pulse currents the forward voltage is significantly higher (for example, 5 V at 5 A).

2.5. temperature dependence of forward voltage

Forward voltage is temperature-dependent and decreases with increasing temperature. This dependence is not linear, but can be linearly approximated.

2.6. dependence of optical output of LED on forward current

Output power of LEDs rises with increasing forward current. The forward current generates heat inside the LED that causes an increase of junction temperature. As the junction temperature increases efficiency drops. Thus dependence of output power from forward current tends to saturation.

2.7. driver circuits for fast switching / modulation of LEDs

There are many driver circuits developed for laser diodes. They can be generally used for LEDs, too. The main difference between laser diodes and LEDs is the absence of threshold current for LEDs.

2.8. junction capacitance of LEDs

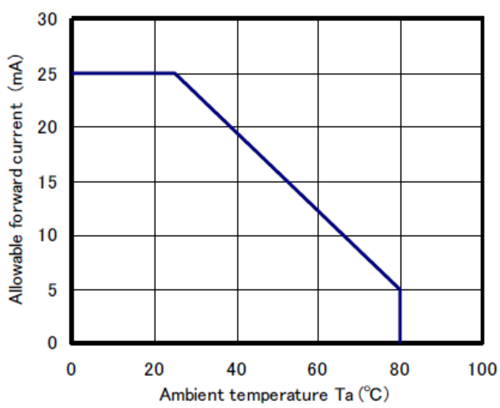
Typical capacitance of a small-chip LED (up to 400 x 400 µm^2) is 20…125 pF (measured at 0 V and 1 MHz). LEDs with larger chips have higher capacitance, roughly proportional to the chip area. The speed of LED is limited by the RC constant of LED itself and the external circuit.

2.9. maximum permissible forward current of LEDs

Max forward current of a LED-component is usually given in the data sheet. It is limited by the maximum current density of:

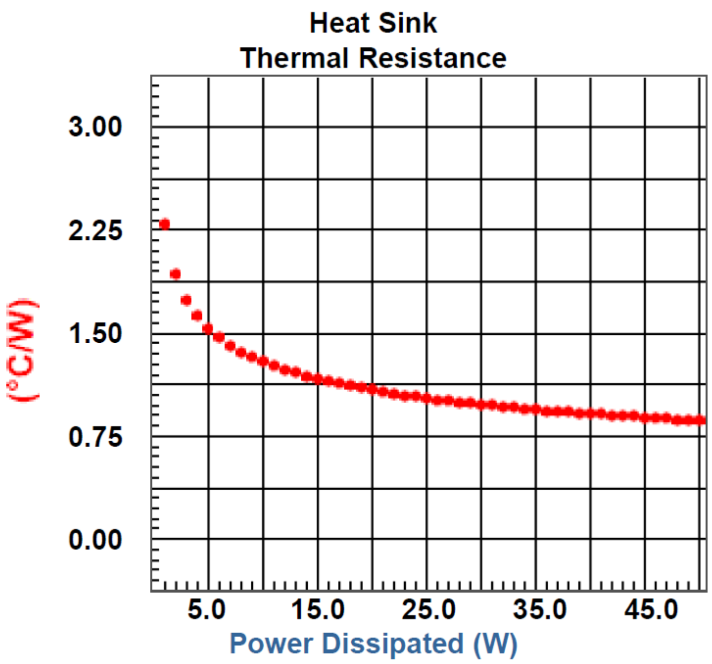
- the LED-chip itself,
- the wire interconnect (single or multiple wires)

and also temperature-dependent. The higher the temperature, the smaller the allowable forward current (derating rate).



2.10. thermal resistance of LEDs

Thermal resistance of LEDs weakly depends on the dissipated power. However in datasheets often a constant value of thermal resistance is provided at definite conditions.



source: Epigap-Optronic

2.11. pulse handling capability of LEDs

Permissible pulse handling capability is the dependence of allowed pulse current on pulse width and repetition frequency or period or duty cycle.
It is often shown in data sheets under maximum ratings.

2.12. thermal time constant of the LEDs

LED chip temperature stabilization time is typically 50…200 ms. LED component temperature stabilization time can be seconds and even minutes. Yellow LEDs have an especially long thermal stabilization constant.

2.13. parameter stabilization of LEDs during warm-up

LEDs are usually operated at a constant current. The emitted light is a function of the set forward current I_F and the compliance voltage U_F. Experiments show that the voltage is not stable instantly following the device energization. U_F comes to stabilization as the temperature of the (light emitting) diode junction stabilizes. The temperature rises due to electrical power consumed by the LED chip and then stabilizes at a temperature value $T_c > T_{Ambient}$ after a period of time. Because of this effect, the emitted light is not stabilized until a stable forward voltage is attained. Figure below shows the stabilization of a white LED over time.

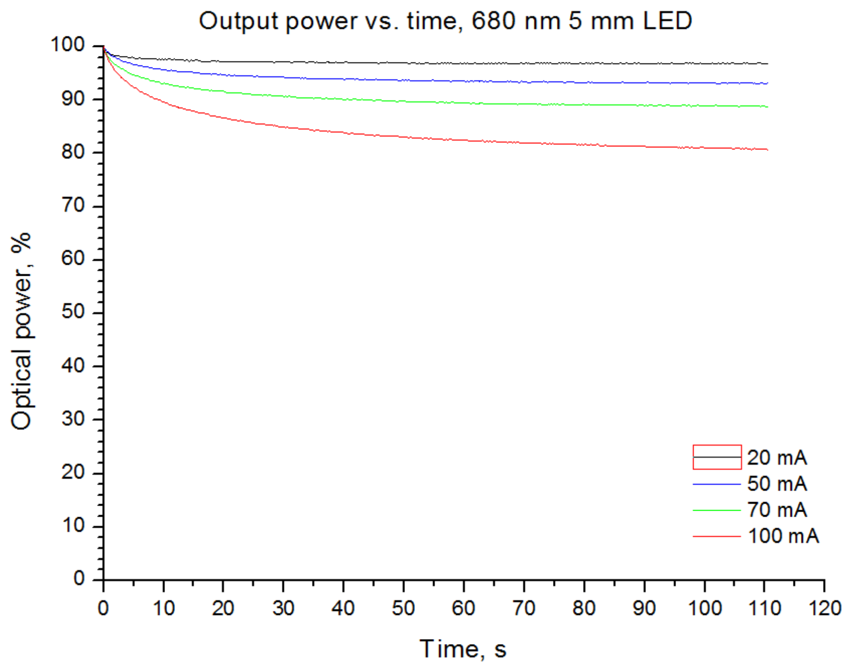


Figure: Output power stabilization of a 680 nm deep red LED at different currents.

Since the heat from the junction must be dissipated into the ambient, changing the ambient temperature affects the junction temperature and hence the emitted light. A typical temperature coefficient for the forward voltage at constant current is approximately –1.5 to –2.5 mV/K. At a given current, therefore, the measured forward voltage is lower at higher temperatures.

2.14. LED temperature stabilization for attaining constant spectral properties

If the LED chip temperature rises, the spectrum shifts towards longer wavelengths (except for blue LEDs). The shift of peak wavelength is typically about +0.1 to +0.3 nm/K. This effect has a negligible influence upon the photometric values of green, yellow or amber LEDs because their peak wavelength is at the flatter portions of the V(λ) curve. However, the peak wavelength for red and blue LEDs are on the much steeper slopes of the V(λ) curve and this can lead to significant changes in the photometric values. That's why current and temperature stabilization is important for attaining constant spectral properties.

LEDs operated with high pulse current may slightly change their spectrum during the pulse.

2.15. thermal resistance

Absolute thermal resistance Rth is a specific property of a component. Absolute thermal resistance is the temperature difference across a structure when a unit of heat energy flows through it in a unit of time. The SI unit of thermal resistance are Kelvins per Watt.

Low thermal resistance of materials and components is of great interest to electronic engineers because most electrical components generate heat and need to be cooled.

2.15.1. What are typical thermal resistances of LEDs?

for 3 mm package:
Junction/ambient 260 K/W
Junction/soldering point 300 K/W

for 5 mm package:

Junction/ambient 260 K/W
Junction/soldering point 230 K/W

for PLCC2 / PLCC4:

Junction/ambient 300…400…500 K/W
Junction/soldering point 180…280 K/W, 6.5…11 K/W for power SMD LEDs

for TO-46:

Junction/ambient 450 K/W
Junction/soldering point 160 K/W

for SMD 3020:

Junction/case 60 K/W.

Example: A LED is driven with a forward current of 20 mA DC. At this drive current the forward voltage of the LED is 1.5 V.

P_D = (0.02 A) x (1.5 V) = 0.03 W
ΔT = (400°C/W) x (0.03 W) = 12°C
(–0.9%/°C) x 12°C) ≅ -11%

> There is an 11% decrease in the amount of light generated by the LED when used without heatsink.

With good heat sinking: R_{thJC} ≅ 150°C/W,
where: R_{thJC} = thermal impedance, junction to case.

ΔT = (150°C/W) x (0.03 W) = 4.5°C
(–0.9%/°C) x (4.5°C) ≅ -4%

> There is only a 4% decrease in the amount of light generated by the LED when a heat sink is used.

Increasing the forward drive current will raise luminous flux of the LED. However, increasing the drive current also increases power dissipation in the device. This raises the LED's junction temperature resulting in a decrease in LED efficiency.

2.15. How can one achieve high LED reliability?

The smaller the thermal resistance the smaller is the temperature rise resulting in longer life time. That's why reliability of LEDs can be improved by using ceramic or metal-glass packages instead of plastic ones, using chip soldering instead of gluing, using multiple bonding wires and performing burn-in test.

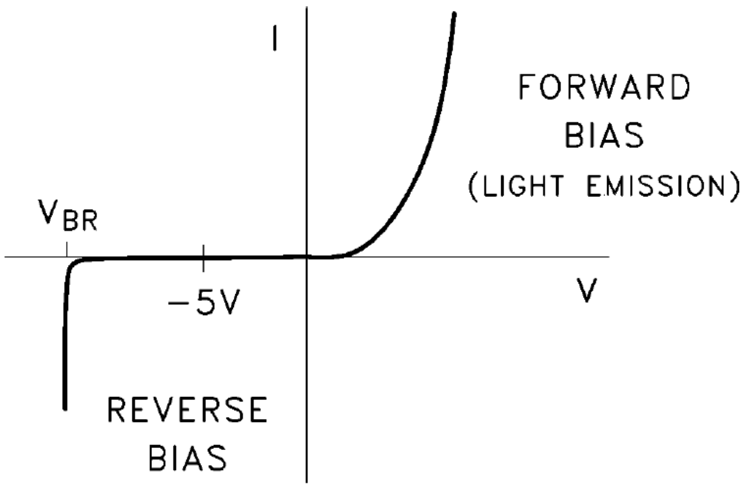
2.16. reverse bias to an LED
Any excess reverse voltage can cause immediate degradation and consequently total failure. 5 V is a typical "maximum reverse voltage" for ordinary LEDs but some special types (for example, mid-IR LEDs) may have lower limits. There are also power LEDs that are "not designed for reverse operation" and often have protective diode in reverse direction.

2.16.1 typical values for reverse voltage

The reverse voltage is measured at reverse current of 1…100 µA. Typical values are 5…12 V and more. For UV and mid-IR LEDs values of 1..2 V are typical.

2.16.2. Reverse breakdown voltage (V_{BR})

This is the maximum reverse voltage that can safely be applied across the LED before breakdown occurs at the junction. The LED should never be exposed to VBR even for a short period of time since permanent damage can occur. VBR is often given in data sheets under maximum ratings. Typical value are a few Volts.



2.17. surge current

Surge current is a peak allowable current in pulse mode, often at single pulse. It indicates the ability of an LED to withstand short time overloads.

2.18. calculation of power consumption / dissipation

for cw mode: P_D=I*U (mW)
for pulse mode: P_D=I*U*t/T (mW)

2.19. calculation of temperature rise

$\Delta T = \theta * P_D$
Rth –thermal resistance, P_D –power dissipation.

2.20. special features of InGaN-based LEDs

In contrast to commonly-used standard LED types, InGaN-based LEDs (UV, violet, blue, green, with or without white phosphor) often show non-uniformity of forward voltage. Consequently using these LEDs in a parallel circuit would cause different forward currents for each LED. This may lead to a remarkable variation in brightness and chromaticity coordinates.

To avoid any colour shift or recognizable brightness variation of InGaN LEDs the use of serial circuits resulting in equal current is recommended.