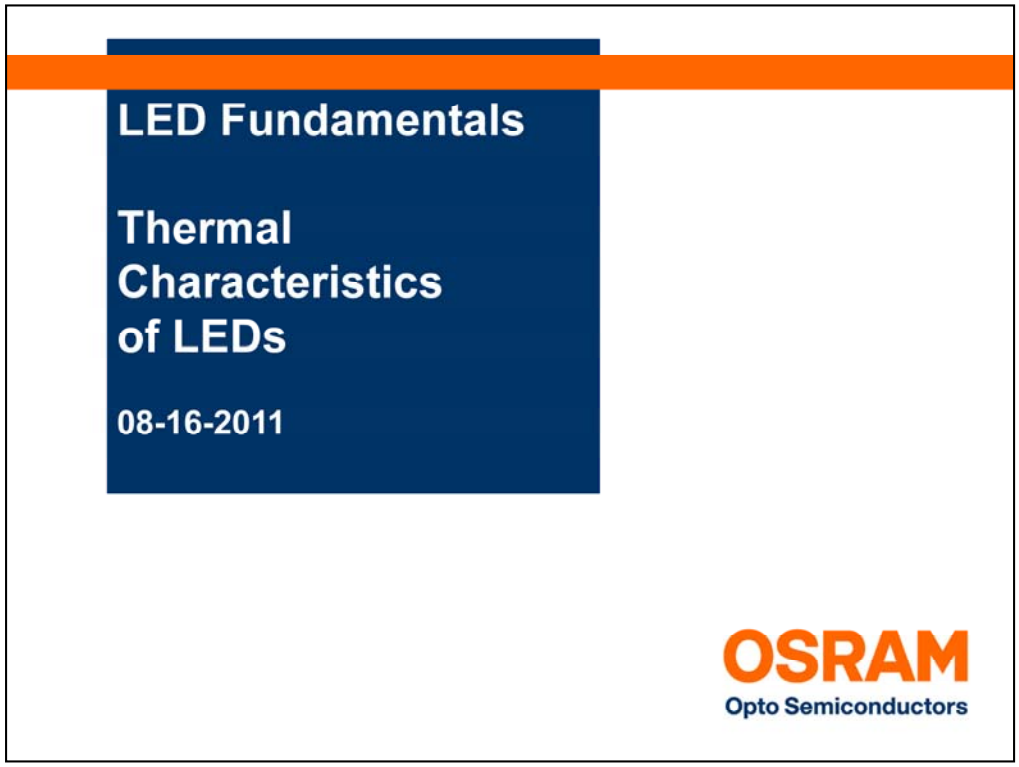
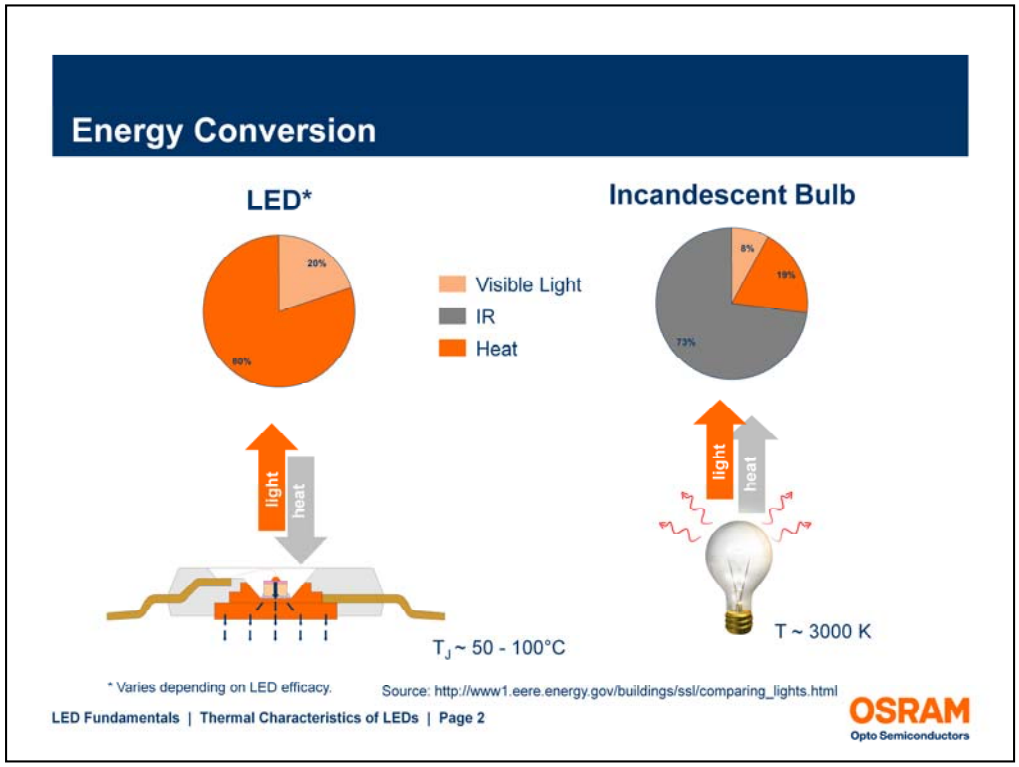
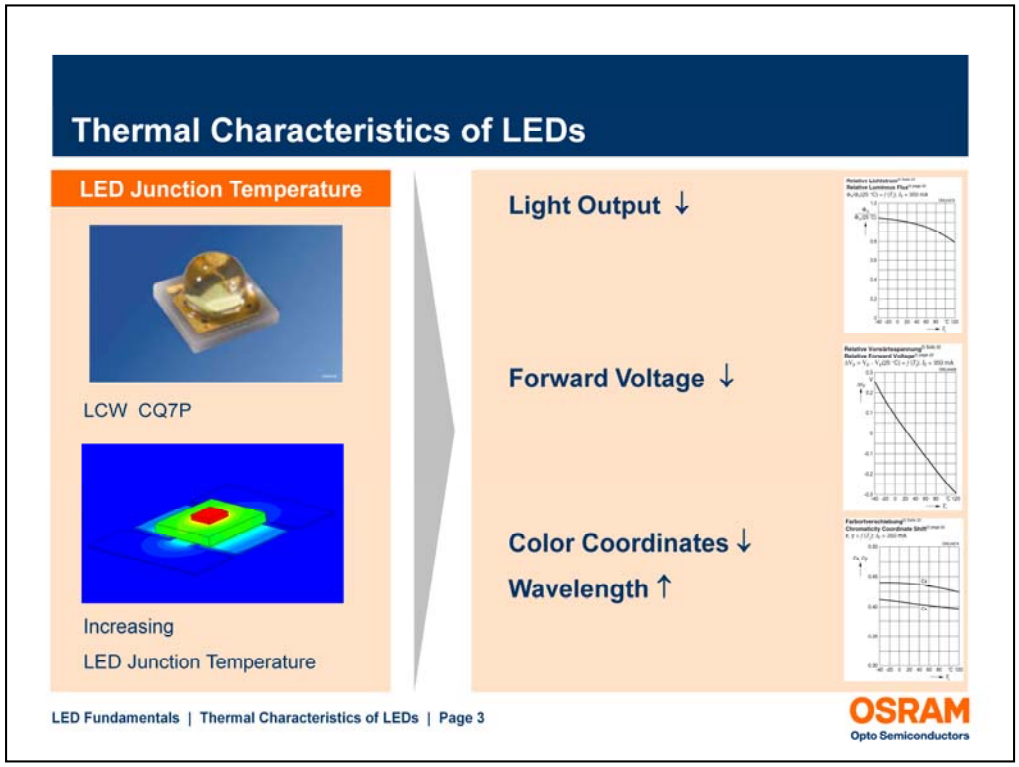


Welcome to this presentation on Thermal Characteristics of LEDs, part of OSRAM Opto Semiconductors‘ LED Fundamentals series.

In this presentation we will look at the basics of thermal management in LED devices.

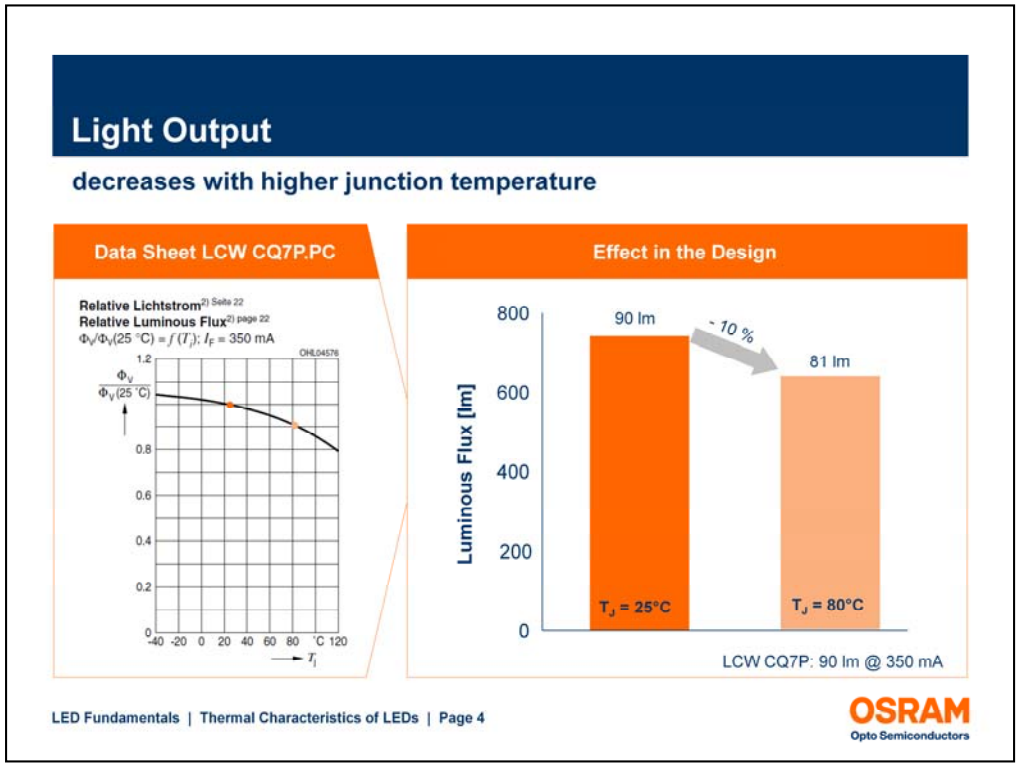


This slide captures the contrast in energy conversion between an LED and a conventional lighting source, such as an incandescent bulb. In an incandescent bulb approximately 8% of the supplied electrical energy is converted into visible light and about 19% is conducted in the form of heat. Most of the supplied electrical energy (about 73%) is radiated in the form infrared light. In sharp contrast, in an LED approximately 80% of the supplied electrical energy is dissipated through the LED package as heat and about 20% is converted into visible light. Therefore, thermal management in LED devices is extremely critical for performance and reliability as compared to conventional lighting sources.



This slide summarizes the impact of rising junction temperature, which is the temperature on the LED die, on the performance characteristics of the LED. An increase in the junction temperature of the LED has an adverse effect on the light output and the forward voltage of the LED. The rising junction temperature results in a decrease of light output from the LED package and also reduces forward voltage of the LED at a specified current. In the case of a white LED, the chromaticity coordinates would change with rising junction temperature.

For a monochromatic LED, the dominant wavelength in the LED spectrum would increase, causing a shift towards higher wavelengths. Let's look at each of these effects in detail with an example in the following slides.



Here we have an example of the light output characteristics of an OSLON SSL LED with rising junction temperature. The graph on the left, taken from the datasheet of the OSLON SSL LED, indicates the light output has dropped by 10% as the junction temperature increases from 25º C to 80º C.

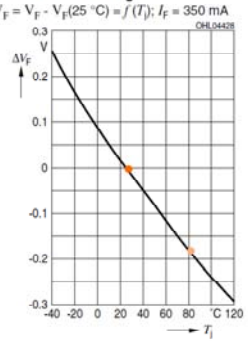
For example, if the LED produces 90 lumens at 25º C it would produce 81 lumens at a junction temperature of 80º C.

Forward Voltage

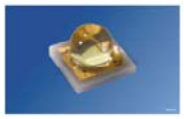
drops down with higher junction temperatures

Data Sheet LCW CQ7P.PC

Relative Vorwärtsspannung[2) Seite 22]
Relative Forward Voltage[2) page 22]
$\Delta V_F = V_F - V_F(25\ °C) = f(T_j)$; I_F = 350 mA



Effect in the Design



LCW CQ7P

- I_F = 350mA
- typ. V_F = 3.2 V

Durchlassspannung [4) Seite 23)]	(min.)	V_F	2.7	V
Forward voltage[4) page 23]	(typ.)	V_F	3.2	V
I_F = 350 mA	(max.)	V_F	3.7	V

T_J= 80°C: ΔV_F = -0.17 V

typ. V_F (350 mA; T_J = 80°C) = 3.03 V

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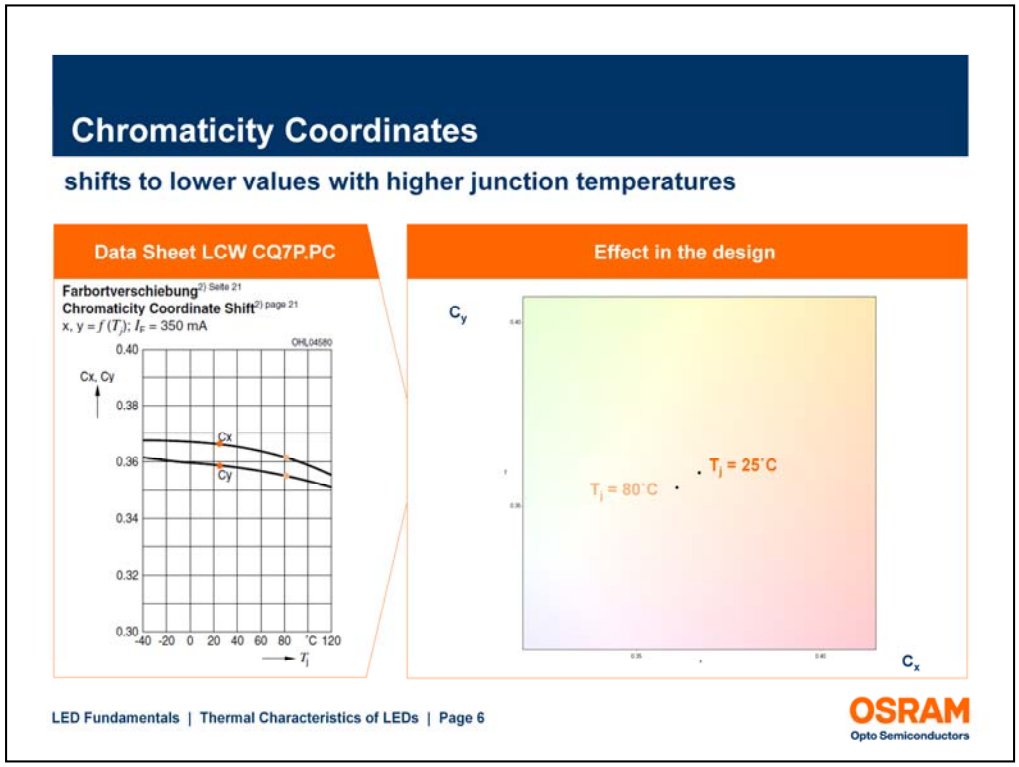
Similarly, looking at the characteristics of forward voltage with respect to rising junction temperature from the datasheet of the OSLON SSL LED, we can see that the forward voltage at a constant current of 350 mA decreases by 0.17 V as the junction temperature of the LED increases from 25º to 80º C. For a typical forward voltage of 3.2 V at a current of 350 mA at 25º C would decrease to 3.03 V at a junction temperature of 80º C.



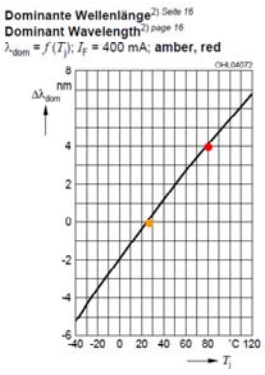
Looking at the graph of change in chromaticity coordinates with rising junction temperature for a warm white OSLON SSL LED we can see that as the junction temperature increases the chromaticity coordinates Cx and Cy decrease. (Note that for other LED types, the chromaticity coordinates could change differently).

Plotting the change in Cx and Cy coordinates with the rise in junction temperature of the LED from 25º C to 80º C, we notice a blue shift in the light output of the warm white LED package.

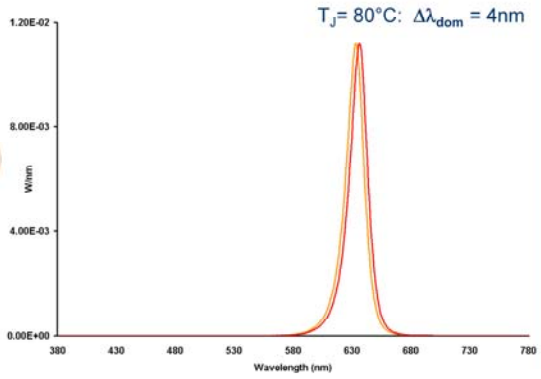
Dominant Wavelength

increases with higher junction temperature

Data Sheet LR CP7P



Effect in the Design



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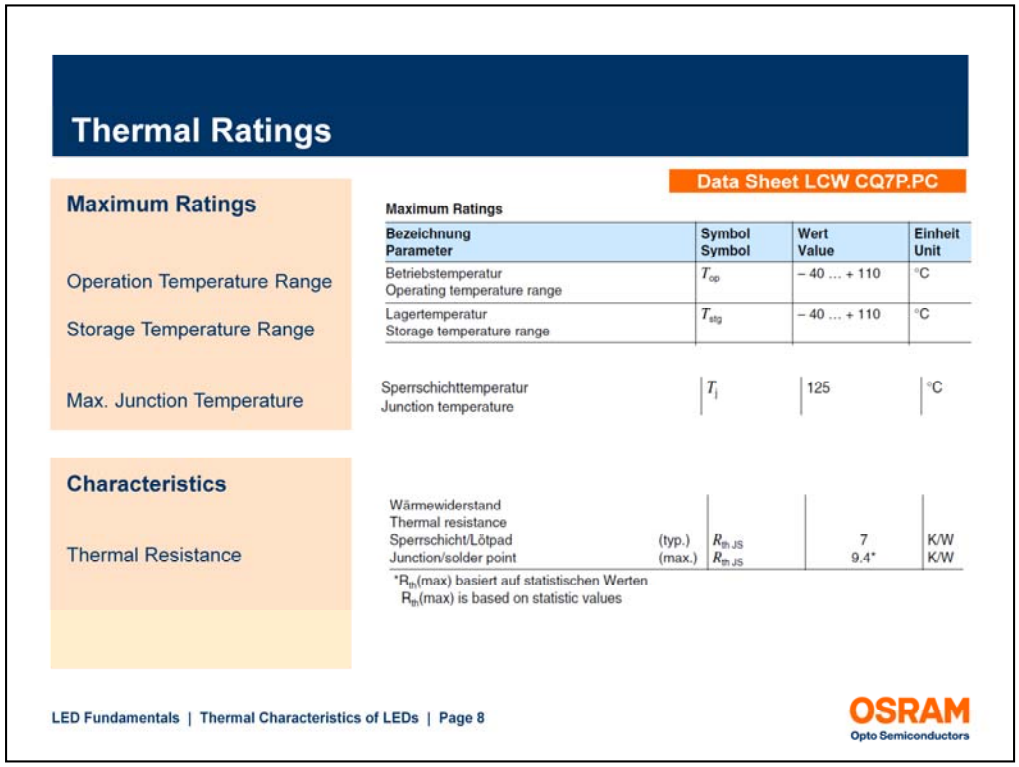
Finally, for a monochromatic LED such as a red OSLON SSL LED, we see the change in dominant wavelength in the LED spectrum as the junction temperature increases. From the graph of change in dominant wavelength versus junction temperature, we notice the dominant wavelength increases by 4 nm as the junction temperature of the LED rises from 25º C to 80º C.

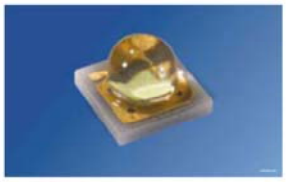


In addition to all the graphs indicating the performance of the LED with regards to the change in junction temperature, the datasheet also lists the minimum and maximum operating and storage temperatures of the LED and, most importantly, the maximum junction temperature of the LED. One must be cognizant of the maximum junction temperature of the LED and should not exceed this value in his or her system design.

An important tool to calculate the junction temperature of the LED is the internal thermal resistance of the LED, which is listed as the thermal resistance from junction to solder point on the datasheet of the LED. For the OSLON SSL LED, the datasheet lists the maximum junction temperature as 125º C and a typical value of the thermal resistance from junction to solder point as 7º K/W.

Designing with LEDs

"Grouping Environment"



- Each LED is measured in the production with specific conditions.
- LEDs are grouped into BINs according to the measured characteristics.

LED Characteristics

- Luminous Intensity
- Luminous Flux
- Wavelength
- Color Coordinates
- Forward Voltage
- Reliability

Application Environment

- The application environment differs from the grouping environment.
- The temperature dependent characteristics of the LED have to be taken into account in the design.

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Finally, each LED is measured in production and grouped or "binned" for specific characteristics such as luminous intensity, luminous flux, wavelength, color coordinates and forward voltage. But a real-world application environment varies significantly from these binning conditions. The temperature-dependent characteristics of the LED as discussed in the previous slides must be taken into account in the design of LED systems.

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