# LED Binning

Light Emitting Diodes or **LEDs** are unique in many ways compared to traditional lighting technologies such as incandescent, fluorescent, or High Intensity Discharge (HID). One example is **binning** which is a process where the LEDs are tested and sorted. Understanding how LED specifications differ from traditional technologies will help prevent comparing "apples to oranges". To optimize LED and luminaire performance and longevity, it is imperative that LEDs be used according to their binning.

## LED manufacturing

LEDs are manufactured millions at a time using high-speed processes. Each LED manufacturer has its own particular "recipe", but there are some commonalities. It all starts with the **epitaxial or "epi" wafer** which is the baseline material that is grown. More layers are then grown on the epi wafer, the wafer is diced into **chips**, and these chips are **packaged** with electrical leads, mechanical supports, lenses, and in the case of white LEDs **phosphors** are added for the different **CCTs or Correlated Color Temperatures** (e.g. 4100K, 3000K, etc.).

Just like any natural growth process such as crystals, diamonds, plants, or even people, no two LEDs are alike. Therefore, every single LED needs to be tested and sorted. As they come off the production line LEDs are tested, typically for 20 milliseconds – faster than you can snap your fingers. The testing occurs quickly to prevent the LEDs from heating up since there are no heat sinks. In that short time LEDs are tested for their **color or CCT, lumen output and forward voltage**. The LEDs are then sorted or **binned and marked per these three parameters**. The goal of LED manufacturers is freedom from binning, as binning is as much a hassle for them as it is for the luminaire manufacturer. Much effort is put into material technologies and process controls for epi growth, phosphor application and packaging to reduce process variations and reduce the number of bins available.

Binning parameters can be thought of as an "oversized Rubik's Cube" – see *Figure 1*. LED manufacturers produce this myriad of binning combinations (what they call **full distribution**), but using all of these many bins together would result in a wide range of performance. Imagine the possibilities in color and lumen output of luminaires if we used all of these bins. To optimize consistent long-term performance, LED luminaire manufacturers zero in on only the bins they need and we design our LED luminaires accordingly.

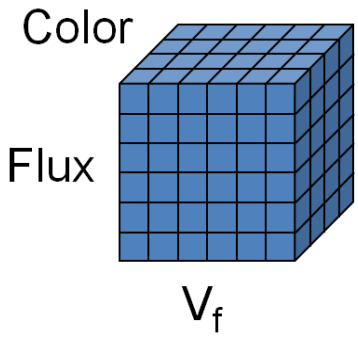


*Figure 1. 3-D representation of binning.*
*Illustration courtesy of Philips Lumileds Lighting Company.*

It should be noted that traditional technologies also differ in their color and lumen output which is typically expressed as a tolerance. We have grown accustomed to accepting these variations and we design our luminaires and our lighting accordingly. A key advantage of LEDs over traditional technologies is that we can now be **more precise with matching** LED to LED and, therefore, LED luminaire to LED luminaire.

## Color or CCT binning

Perhaps the best known parameter – and what people think about when you mention LED binning – is LED color as typically measured in Correlated Color Temperature or CCT. At the heart of white LEDs are blue chips or "pumps". To make white light **phosphors** (typically yellow or yellow-green) are used. For more on this topic see the Information Brief 'Making White Light with Blue LEDs'. For an example of LED construction, see *Figure 2*.

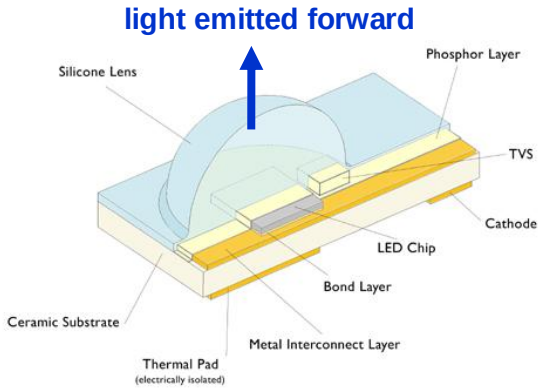


*Figure 2. Cross-section of a LUXEON® Rebel LED.*
*Illustration courtesy of Philips Lumileds Lighting Company.*

Correlated Color Temperature is a relative measure of the color of light produced by a light source, including LEDs. Not all white light is the same so CCT is used to differentiate the "shades" of white. Higher CCTs correspond to cooler white light; conversely, lower CCTs correspond to warmer white light. Early white LEDs had broader CCT binning. As advancements in blue LED chip, phosphor and phosphor deposition technologies are made the CCT binning gets tighter resulting in more consistent color from LED to LED.

As the binning improves from LED manufacturers, so does the ability of LED luminaire manufacturers to provide luminaires with more consistent white light. CCT binning improvements also enable LED luminaire manufacturers to offer different white CCTs including those similar to traditional technologies. Tighter binning enables greater CCT consistency; specifically, **ANSI (American National Standards Institute) binning**[1] as required by ENERGY STAR®, the Designlights Consortium and the Lighting Facts™ label is the key to world class CCTs. See *Figure 3*. Compare the smaller ANSI quadrangles on the right versus the larger quadrangles on the left.

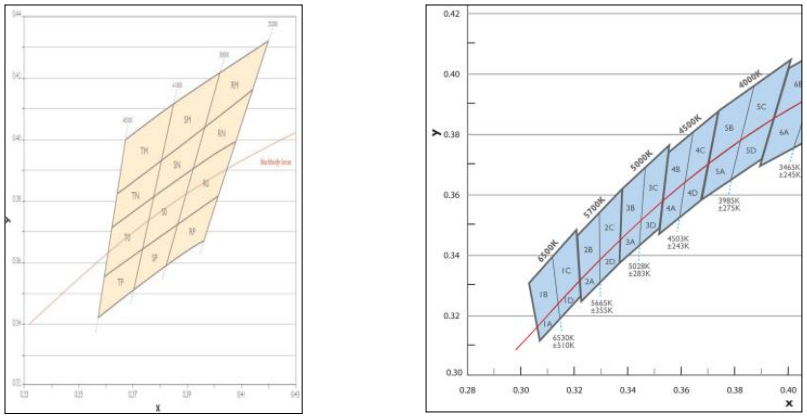


*Figure 3. Older (left) versus newer (right) LUXEON® Rebel LED ANSI CCT binning.*
*Charts courtesy of Philips Lumileds Lighting Company.*

## Lumen output binning

In addition to CCT, LEDs are also binned for lumen output. If we did not bin this parameter we would have unacceptable variations in the lumen output of our LED luminaires. We design our LED luminaires to provide the precise lumen output required to meet lighting needs, so it is imperative that we use precise lumen output binning. As LED design and manufacturing technology improves LED manufacturers will continue to raise the bar on LED lumen output. This enables us to continuously improve the lumen output of our LED luminaires.

## Forward voltage binning

Perhaps the most often overlooked parameter is forward voltage binning. This is because it is a consideration for LED luminaire manufacturers with regard to how we design LED arrays and the LED drivers we use. Specifiers and installers of LED luminaires with integral LED drivers do not have to concern themselves with this parameter.

## Summary

Unlike traditional lighting technologies, LEDs use binning to classify performance regarding three parameters – color or CCT, lumen output and forward voltage. This is due in part to the natural growth process LEDs go through as well as the lack of ANSI standardized classification for LEDs like there is for traditional lamps. As a world class LED luminaire manufacturer we understand binning and we design our luminaires to optimize long-term peak performance based upon tighter binning.

## References

1. American National Standards Institute, *Specifications for the Chromaticity of Solid State Lighting Products*, ANSI_NEMA_ANSLG C78.377-2008, Virginia: American National Standard Lighting Group, 2008.

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