

## Good Lighting = Good Color

Key components of high-quality LED lighting is color, desired color temperature and overall color consistency. Often overshadowed by desires for energy efficiency, color considerations can dramatically impact the function and aesthetics of lighting. This ALG Connections piece highlights an informative [white paper written by Xicato, Inc.](#) that emphasizes the importance of color in high quality LED lighting and how designers must consider the “right” color of white, check for consistent initial color, and ensure consistent color over the lifetime of the luminaire.

LED lighting has a very wide range of differentiation in the shades of white light it produces. LED luminaires are composed of a

problems introduced by a low-quality module. The materials used in LED modules can make a difference in their color consistency. With many modules, manufacturers make compromises with regards to plastics, silicones, and complex electronics. High-quality modules have a protective, long-lasting enclosure and carefully selected phosphors and LEDs. When considering an LED luminaire, it is important to make sure the modules inside are of high quality to get better initial color consistency.

### A high-quality light module is the most important element for consistent color.

Once consistent initial color is achieved, the stability of color is the next step. All lighting will experience some color change over time. To maintain the best possible lighting, the lighting should have consistent change across all the luminaires. This will give the appearance that is closest to the lighting originally installed, and is still visually consistent to the human eye. The LED technology used in the module, such as “cold” phosphor (remote phosphor) vs. traditional “hot” phosphor (phosphor at the diode), can dramatically impact the consistency of the color of the LED light source over time. This technology separates the phosphors that convert blue light to white light, from the blue LEDs themselves. The “cold” phosphor



Color temperatures of white light varying 2700K, 3000K, 3500K, and 4100K from left to right. Image courtesy of ALG Online and the Energy and Technology Center.

number of components including reflectors, heat sink, power supply and the light source itself. Of these, a high-quality light module is the most important element for consistent color. Even quality components in other parts of the system will not make up for the

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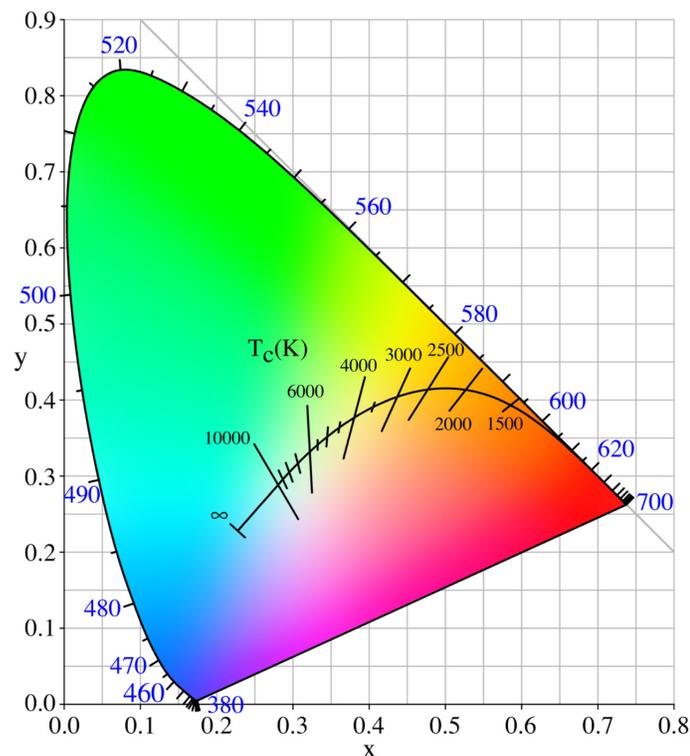
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approach mitigates the effects of high temperature over time on the phosphors and ensures a much more uniform and consistent light over the full life of the lamps.

For the best initial color, lighting designers need to look for LED modules that cluster LEDs from the same color "region." These regions are measured along two color axis. Manufacturers describe their starting region as a one, two or three step space (SDCM). Preference should be given to lights that are initially no more than one "step" apart on the vertical axis and two "steps" apart on the horizontal axis, since with these regions any variation between modules is imperceptible.

How lights vary on the color axis over time will determine how consistent the color remains. So, even if the initial color was evenly matched, these lamps could result in quite a wide range of color shift over time. To most closely



CIE 1931 Chromaticity Diagram with Planckian Locus.  
Image courtesy of Wikimedia.

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maintain the lighting originally specified, it is important to request LED light sources with demonstrated good color consistency along the same color axis. Complete specifications and data showing initial and maintained consistency over time should be available from light source manufacturers.

Careful selection of modules and luminaires can help assure color stability in LED lighting. For more on the importance of color and how it relates to LED lighting designs, read the [full article](#) written by Xicato, Inc., published in February 2013.

In addition, ALG Online has an entire section dedicated to [LED technology](#) that includes a detailed discussion of single and multi-color white LED systems, as well as LED binning. This chapter also features an ALG Snapshot that provides a list of [LED specification tips](#).

Several other recent articles have featured remote phosphor discussions. Review the following resources for added educational value:

- LEDs Magazine article on remote phosphor [system potentials](#) and
- Remote phosphor [overview](#) from the Digi-Key Tech-Zone lighting library.