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Anatomy of LED Lighting

By Michael Grzywacz

What Is an LED?

An LED — or light emitting diode — is a semiconductor chip that generates light when current is applied in the right conditions, which is very different from any other technology currently used in lighting. These chips (known as dies), are assembled in a structure that helps support and protect the dies and the electrical connections. This structure is generally known as a package. Depending on the type of LED package and the desired characteristics, there may be one or more LED dies per package.

The different types of LED packages have different strengths and weaknesses that affect the package's applicability in lighting. Of note, LEDs are more sensitive to operating temperature than other types of lighting, and anything from lifetime to acceptable current to chromaticity can be impacted by the operating temperature.

Operating Characteristics

LED chips run on a very low voltage (3V – 4V) and need a well-regulated voltage and current. Integrated LED products are made with integrated drivers (appropriate to the application) in order to safely drive the LED components and achieve a long lifespan. The low voltage products are designed for 12VDC current, and will operate on 90% of 12VAC applications. Some low voltage fixtures operate lamps on 12VAC electronic transformers, which can cause problems with any LED product not working properly due to incompatibility related to differences in frequency.

Lighting Characteristics

Directionality

To direct light coming from an LED, products use what is called a secondary optic. This is a lens (although there are reflectors available) that attaches to the chip holding the LED package mechanically or through adhesive and directs the light into a different pattern (such as a narrow or a wide flood pattern). The quality of this optic affects the optical efficiency, or the amount of light that is actually projected, compared to the amount of light generated by the LED. By taking advantage of the directional characteristic of LEDs, and using high quality optics, effective general lighting can be achieved with LED lamps.

Light Quality

There are no true-white LEDs that are commercially viable. Every type of material used in the chip part of the LED that produces light generates color, but none of those colors are white. All LEDs produce red, green, yellow or blue (note that IR and UV LEDs do exist as well). The two methods for generating white light are to either use multiple LED chips and mix the light, or to use a phosphor with a single color light (usually blue) to generate white light. Most common in today's lamp technologies is phosphor coatings. These phosphors are what produce the various color temperatures of the lamp. Warm white 2700K to cool white 5000K, for example.

Where to Use LED Products

LED products, at their current state of development, do have some limitations, and are expensive compared to some other technologies, so where can the advantages of LED products best used?

Lifespan

The long life of properly designed LED products makes them ideal for a situation where light failure can cost a lot of time, effort, and money. Examples of such are high-mounted recess and track lighting, where changing the bulb could be both dangerous and time consuming (such

as in a hotel lobby or in the atrium of a building). With landscaping projects, any return trip to the job can be expensive and frustrating to both installers and owners.

Energy Savings

Today as few as 2- to 3-watt LED lamps are replacing 20-, 35- and even 50-watt halogen lamps. For systems that run each night from dusk to dawn, that's as much as 4,300 hours annually. It's easy to determine that an LED lamp consuming one-tenth the power of its halogen equivalent can save hundreds of dollars each year in most applications.

Safety

There is no glass in most LED lamps to break, they produce very little heat, and they do not contain mercury. A lamp that won't be in the landfill for years, won't poison drinking water, and won't shatter sending slivers of glass flying.

Fixture Requirements

All LED products come with a mention of not using them in totally enclosed fixtures, which causes some confusion and concern. To clarify, the term "totally enclosed" in this instance means that there is no airflow around the LED lamp, and the reason goes back to thermal management. LEDs do generate some heat, and while not as much as any of the other types of light, in a fixture with zero airflow, the aluminum body is unable to act as a heat sink, and reduces the life of the electrical components in the LED lamp.

LED Drawbacks

The aforementioned benefits of LED-based lighting products do not come without a price.

One of the largest drawbacks of LED based products is initial price. High quality LED packages, with predictable and reliable color quality and output, are still more expensive when considering their initial cost on a lumen-per-watt basis. Their long life requires a different approach to considering cost, where cost of ownership over time considering energy and maintenance should be taken into account the true price of the lamp.

The second main drawback of LED-based products is that they are much more sensitive to heat buildup than many other technologies. One must ensure that the LED lamp and fixture are properly paired so that heat degradation is minimized to guarantee proper performance. Reputable lamp and fixture manufacturers will have done the testing needed, and will back their products with strong warranties.

Despite the drawbacks or challenges in LED lighting technology, they have significant potential to change the landscape of lighting forever, and in dramatic ways that far exceed the flexibility of any other commercially available lighting technology.

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