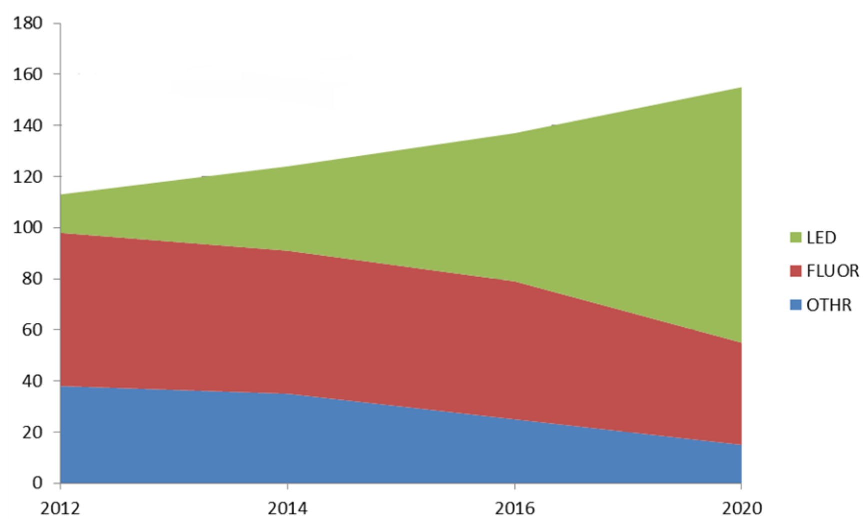
***Why LED Light Engine Design is Critical in Lighted Magnifiers used for Professional Close Proximity Viewing and Quality Control Inspection***

By Stan Hogrebe, President, Dazor Lighting Solutions

LED lighting is rapidly replacing many traditional sources of artificial lighting in a wave of change that may be second only to Thomas Edison's patent of the incandescent light bulb.

The acceleration of change is being fueled by continued technology advancements in LED efficiency, reduction in payback, and its commercial viability. Additionally, there are environmental and sustainability benefits compared to fluorescent and other legacy lighting technologies. Governments around the world recognize these benefits and are incenting both production and consumption of energy-efficient lighting. By converting to LED technology, the US would cut lighting electricity requirements by roughly 50%, or 10% of our total electricity consumption. This would reduce energy demand and help close an efficient energy supply gap.

**Global Lighting Product Trends**
*In Billions*




Early on, "LED lighting" became a curiosity and term used by consumers when purchasing bulbs or lighting fixtures of all types. Lighting manufacturers recognized this market demand and quickly adapted product offerings to include "LED lighting" alternatives.

But in many lighting applications, energy efficiency and conservation are only a part of the consideration. All LED lighting solutions are not created equally. And perhaps in no single application is this more evident or important than in close proximity viewing for critical assembly tasks, inspection and quality control.

**Color and Color Quality of Light**

In artificial lighting, there are 3 terms to know that are fundamental to understanding differences in the color and color quality of light. They are:

- Correlated Color Temperature (CCT). CCT correlates "color" to thermal temperature (a black body radiator). A candle flame is yellow in color and emits a "soft" or "warm" light. Great for creating a mood and making skin look smooth. A gas flame is hotter and emits a "blue white" light. This makes for good lighting in an operating room where contrast is important, or in making small defects easier to see during inspection tasks.

- Kelvin (K). Kelvin is the actual thermal temperature scale that correlates to CCT correlates.

- Color Rendering Index (CRI). Color rendering index is a scale by which artificial light renders color the most accurately in relation to a known source. The sun is a known. Light produced from the sun covers all spectrum of visible light. It has a CRI of 100. The higher the CRI, the better.

In the marketplace, manufacturers specify both CCT and CRI when selecting LEDs. The following are commonly specified colors and color quality of LEDs, and their best suited application:

- 4100K 80CRI LEDs. This light is generally used in settings where flesh tones are most important. "Red" colors are highlighted. It's used to create a "warm and laid back" atmosphere; not to highlight contrast and defects. Rather, it tends to blend surface differences. This light color would generally NOT be preferred for quality control inspection environments.

- 5000K 80CRI LEDs. This light is used in general office overhead lighting. It is a soft white light with yellow undertones, similar to outside lighting on a cloudy day. It is a commonly available LED color and sometimes selected for cost savings purposes. A better choice than a 4100K color, but still misses the correct color temperature for quality control tasks requiring high contrast to identify defects quickly over prolonged inspection task times.

- 6500K 95CRI LEDs. This light is specific for inspection applications requiring a high degree of visual discernment. Defects are identified more quickly and are less likely to be missed. Diamond graders use this lighting because it produces the best environment to create contrast, to see defects and perceive color the most precisely. It is light color which promotes alertness.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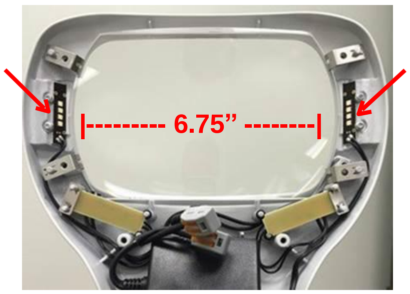
**LED Light Engine Design and Board Layout**

In addition to LED color selection, the layout and design of the LED board are equally critical to achieving optimal viewing in close proximity under magnification. Below are three examples of LED light engine designs and board layouts in commercially available magnifiers.

1




4pcs High-Powered LEDs populated on 2 boards

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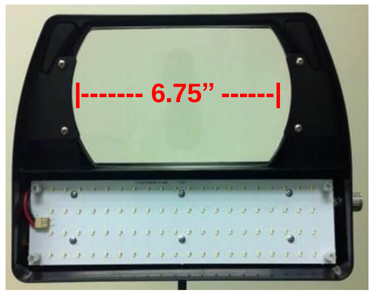



80pcs Wide-Angled LEDs densely populated on 1 board

2


2pcs on 6 boards (Note the wide, collimated spacing between LEDs)

*Point Source*

Light emitted from a single source is considered a “point source” of light. An incandescent bulb and a fluorescent bulb are both point sources of light – they are considered “omnidirectional”; that is they emit a lot of light in all directions (inefficient). LEDs are point sources too, but are more directional. To produce enough light over a large enough area, you usually need more than 1 (unlike an incandescent or fluorescent bulb).

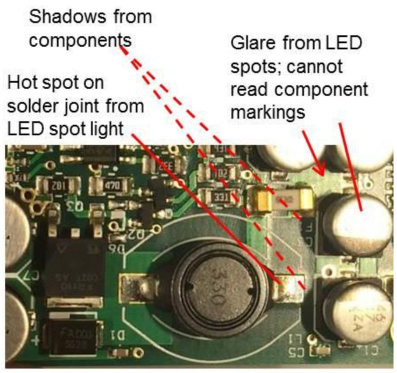
*High Powered*

“High powered” LEDs seem like they should be better. “High powered” must equate to brighter, and “brighter is better”, so high powered LEDs must be better, right? Well, not so much. High powered LEDs may be great for certain applications like overhead lighting or theatre spot lighting or medical exam lighting. But they are NOT good to use in close proximity viewing applications, especially those involving specular or reflective surfaces. Using fewer, high powered LEDs in bench magnifiers increases glare, “hot spots” and even worker eye-strain by washing out subtle details. This makes defect identification more difficult and slows down inspection tasks.

*Low Power Wide Angle is Better*

Using more low-powered wide-angled LEDs populated on a board closely together, and not driving them hard electrically, does some beneficial things. First, it allows the maximum amount of lumen “mixing” to occur just beyond the surface of the LEDs. Secondly, by running the LEDs at a lower electrical drive current, they operate cooler and last their full rated life. Light engines that are designed with fewer LEDs and that are driven harder electrically to save component part cost produce an undesirable light pattern for close-up work. Additionally, they are at greater risk for premature failure.

1




Hot spots and shadowing from 2 high-powered, side mounted LED "spot" lights. Note yellowish color from 4100K LEDs

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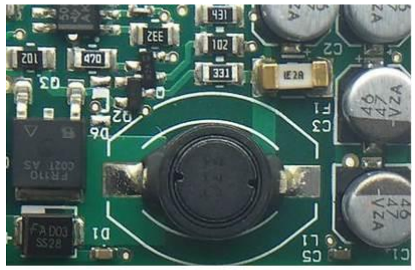
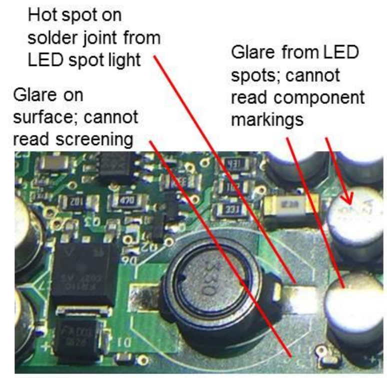


With many wide-angle LEDs, view glare free, no hot spots, no wash out, high color accuracy.

2

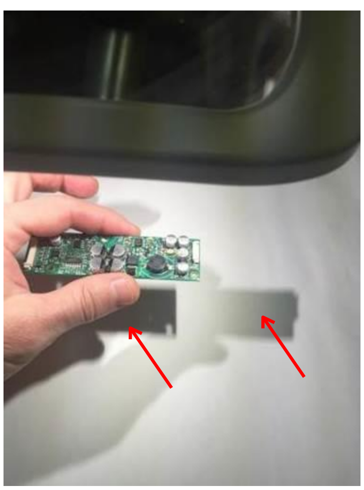



Hot spots and glare from collimated, widely-spaced, undiffused high-powered LEDs

**Multi-shadowing**

Multi-shadowing is directly related to the selection and layout of LEDs on a board, plus how the emitted light is diffused as part of the total light engine design. Multi-shadowing occurs when directional point sources of light create their own individual shadows. *This is **a BIG deal** when light is used for close proximity inspection viewing.* Multi-shadowing can be a viewing distraction, potentially causing defects to be overlooked, reducing productivity and even causing eye fatigue.

1



2 hard shadows from each directional LED source

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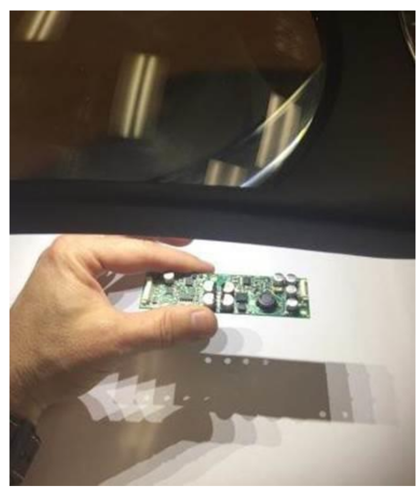
Single shadow from wide-angle, diffused LEDs, similar to fluorescent source

2



Multiple hard shadows from each collimated LED for each object: fingers, board

**Diffusers**

Diffusers are a very important part to an LED light engine design and unfortunately are frequently a design afterthought. Big mistake. Without a well thought out diffuser, the light pattern emitted from the light engine will not be mixed properly, creating multiple shadows, as depicted above. Or if a piece of opaque plastic is used for diffusion, it can absorb up to 50% of the light, forcing the fixture manufacturer to over-drive the LEDs which in turn, shortens their life.

A complete LED engine design considers the diffuser as integral to the total light system. An optical grade material specifically designed for high light transmission in LED applications should be used. With proper material, 85 - 90% of the lumen emitted passes through the diffuser. This means less power to the LEDs which in turn run cooler and extends their life while properly mixing the light. The appearance of light emitted from this style of light engine design is a smooth, diffused and even "glow".

**Modularity and Field Serviceability**

Making components accessible and replaceable by the user is critical to servicing an LED magnifier for years. There is no benefit to the claim of 50,000+ hours of LED lifetime if the entire fixture has to be thrown away when a single electronic component fails somewhere in the design and it cannot be accessed for replacement. "Field service". "Environmentally friendly". "Sustainability". Each important terms that have to be backed up by product design.

Components within a LED Lighted Magnifier that should be easily accessible and replaceable by the user:

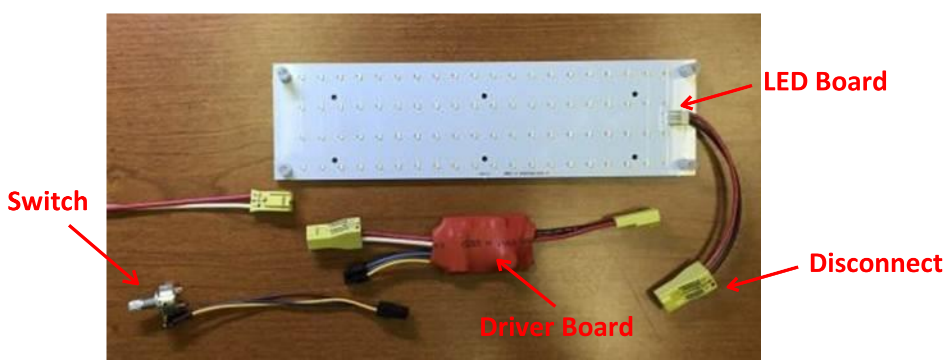
- Power Adapter. Converts AC to DC power for most LED designs. Should be located outside of the fixture with a barrel type connection.

- Driver Board. Electronic components that forward the correct amount of current to the LEDs, based upon their type and layout. Some designs combine the LEDs and electronic components together for a "driver on board" design. If any component fails before the LED, the entire engine fails.

- LED Board. If separated from driver components and properly thermally managed among other variables, LEDs will likely last their rated life.

- Switches. Powers unit on/off and/or may provide dimming capability depending on design.

For field serviceability, components must not be soldered together. Rather, use of quick disconnects allows users to access and replace components should the need arise. The following is an example:




In combination with a high quality mechanical fixture, an LED light engine designed with modularity for field serviceability, the full benefit of a 50,000 hour LED lifetime can be realized.

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*Dazor Lighting Solutions is a USA designer, integrator, and manufacturer of customized lighting and magnification solutions that professionals rely on to improve work efficiency, accuracy and visual comfort.*