

2006: A Revolutionary Year for Architectural Lighting

Unique Solid-State Lighting (SSL) technologies have emerged as leaders of a revolution that are beginning to displace conventional light sources and quietly change the architectural lighting landscape forever. There is an exciting new era for lighting engineers, architects and designers.

LEDs are perhaps the most significant advancement in illumination since the invention of the light bulb by Thomas Edison more than a century ago. LEDs are a truly disruptive technology offering lighting engineers, architects and designers new opportunities to explore their creativity and imagination.

Unlike promising lighting technologies in the past, LEDs are here to stay and have begun to revolutionize the next generation of architectural lighting fixtures. The challenge for the architectural lighting community is how to keep up with the rapid pace of change and to understand how best to capitalize on the tremendous opportunities that are provided by high-efficiency Solid-State Lighting.

The LED Technology Advantage

LEDs have considerable advantages over traditional lighting sources such as extremely long life, high durability and low energy usage, but it is their color-generating abilities that define them as totally unique (see figure 1). In addition to producing millions of vivid colors and providing white light in a variety of colour temperatures, LED light engines are fully dimmable and can be controlled to create the perfect atmosphere. Existing technologies simply cannot compete with the huge number of design, control and display possibilities available with LEDs.

Additional Advantages of LEDs:

- Long life times (20,000 to 100,000+ hours)
- Small form factors for improved design flexibility
- Robust to thermal and vibrational shocks
- Environmentally friendly - no Hazardous materials
- Rapid-on and restrike times (<100ns)
- Digital control with 100 percent dimming capability
- Highly energy efficient - 130 lm/W +
- No IR or UV in beam output
- Low DC voltage operation
- Directed light output for increased system efficiency
- Lower overall total cost of ownership (TCO)
- Vivid saturated colors without filters
- Dynamic color control - CCTwhite point tunable and variable CRI
- Cold start capable down to -40°C
- High temperature operation up to 185°C junction temperature

It is predicted that the use of LED technologies within the US lighting industry could save more than \$120 billion in energy costs through to 2025 and defer more than 100 power plants (1,000 MW capacity each) contributing to a cleaner environment and provide a strong economic growth driver for the architectural lighting sector over the next decade.

Today, the total cost of ownership (TCO) for lighting systems is not seen as a strong selling point, however, with the rapid increase in energy costs during 2006, predicted energy shortages and issues of global energy security it is inevitable that TCO will become a major factor in

specifying and choosing future architectural lighting installations.

Further environmental factors that favor LED lighting technology:

- Reduction in carbon dioxide emissions
- Lower consumed wattage
- Defined beam patterns reduce light pollution
- Ability to control power to optimise efficiency
- Automated and intelligent lighting - switch off when not needed
- Elimination of hazardous environmental wastes (RoHS and WEEE compliant)
- Increased product lifetimes - reduced recycling

You now understand the factors of how and why LEDs are revolutionizing architectural lighting but where is the catch, why do we not see LEDs everywhere right now?

Factors Effecting the Adoption of LED Technology

There are five crucial factors to the general adoption of LED technology within the architectural lighting market:

1. Luminous efficacy - ratio of lumen light output to electrical power input
2. Cost per lumen - cost of the LED package for each lumen light output
3. White light performance characteristics - CCT, CRI and light output consistency
4. Measuring the photometric output of LED fixtures
5. LED lighting standards

Architectural lighting has been dominated by various traditional light source technologies providing significant performance challenges that white LEDs in the past have struggled to match. However, figure 2 demonstrates the progress of white LEDs efficacies compared to common light sources. Today, the very latest white LED specifications have exceeded incandescent, halogen and compact fluorescent light sources and are now starting to compete with fluorescent, mercury vapour, metal halide and sodium lighting.

The phenomenal rate of LED development in 2006 has witnessed the leading LED manufacturers (Nichia, Cree, Philips-Lumileds and Osram) vie for first position and during 2006 the most efficient white LEDs have increased from 110 to 131 lumens per watt. At this pace it should be possible to see the first 200 lumen per watt LED light source within

research facilities by December 2008.

The cost for generating white light using LED technology is seen as a major barrier to the adoption of LEDs within general architectural lighting applications and it is suggested that costs must be reduced by 5 to 10 times that of current LED prices.

However, increased competition amongst manufacturers, an ever increasing supply chain, improvements in material technologies and production yields will ensure price/performance ratios will be consistently achieved over the next few years. Japanese lighting leaders Toshiba Lighting predict that costs for LEDs could reduce to 1 Yen per Lumen by 2010 making costs comparable to those of halogen and fluorescents.



Figure 1: A typical example of the use of LED architectural lighting fixtures (courtesy of Dialight-Lumidrive)

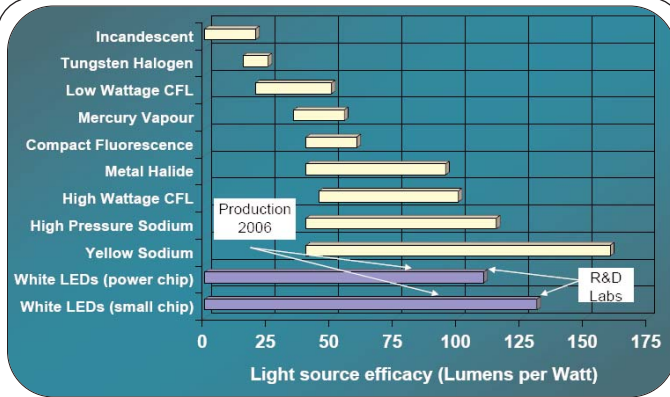


Figure 2: Efficacy comparisons for conventional and white LED light source technologies

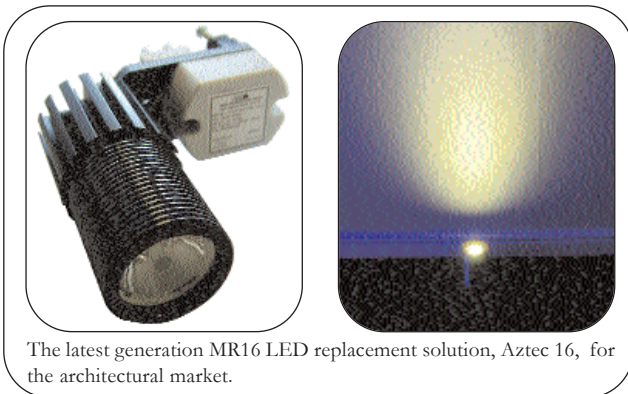
Generating White Light with LEDs

Currently, there are three methods commonly used for LED-based white light generation: individual multicolored LED combinations that additively mix to generate white light, Blue LED chips encapsulated in phosphor(s) to generate a mix of light and near-UV LED (380 nm to 410 nm) with several phosphors to generate a mix of light.

The multicolored LED approach requires at least three LED channels covering RGB colors and each color channel must be controlled precisely to balance the emission intensity for correct white light generation. This approach currently yields the best overall efficiencies and with the addition of extra colors, such as amber, may also produce high color rendering index (CRI) values >85. However, the technology faces considerable color mixing challenges including:

- Variation of color mixing with temperature
- Variation of color mixing with time and brightness
- Homogeneous beam color mixing
- Reproducibility under production tolerances
- Reproducibility under fixture maintenance or replacement

In order to ensure color, CCT and CRI are maintained within acceptable tolerances and intelligent electronic fixture control driver is required.



The latest generation MR16 LED replacement solution, Aztec 16, for the architectural market.

The LED industry currently mass produces a white solid-state lamp based on a blue LED chip combined with a yellow broadband phosphor. LED manufacturers have managed to produce warm-white LEDs with CCT as low as 3,000°K and CRI >85 by utilizing a mixture of red and green phosphors however the devices currently have an inferior efficacy performance compared to yellow phosphors. This approach not only has the same challenges as the RGB system but

additionally has issues with:

- Color deviation over viewing angle
- Tolerances in efficiency, CCT and CRI
- Large CCT variations due to narrow absorption spectrum of phosphor
- Variations of CRI with minor changes in LED wavelength

The final technique is a recent technology advancement and utilizes a near-UV LED (violet) with multi-part phosphors to generate a high quality white light making it highly suitable for lighting fixture design; however the light generated is much less than the other techniques.

Further LED Lighting Challenges

LED lighting has considerable advantages over traditional light sources, but there are still many challenges facing widespread architectural adoption including:

- Standardization of HB LED packages will improve system designer options
- Still relatively expensive and may require multiple LED arrays
- Requires new fixture design techniques and disciplines
- Technology is still rapidly developing - difficult to design for
- LED arrays with higher total lumen package output
- Improvement in LED cost-effectiveness
- Consistent and reproducible white light, CRI & CCT beam control
- New sales channels and stable SSL value chain
- Widespread adoption of reliable and intelligent LED drivers

Conclusion

HB LEDs have emerged as an unstoppable revolution that is creating new opportunities to replace conventional light sources for architectural lighting applications. Such LEDs are available in a variety of vivid colors and varying white light versions bringing exciting new opportunities for lighting engineers, architects and designers.

Demonstrated energy efficacies by leading LED companies means that LEDs are already more efficient than incandescent and halogen light sources and within a few years will be the most efficient light sources known to mankind.

Improvements in CRI and CCT properties for the latest generation of white LEDs now enable LEDs to access new markets while supply chain cost pressures will continue to make LEDs more cost effective and accelerate their adoption within the general lighting market.

The creation of a new set of LED lighting standards within the next few years will further enhance the adoption and utilization of LEDs by specifiers and architects and ensure that conventional lighting fixtures are consigned to the history books.

Architectural lighting is defined by its ability to be creative and stimulate imagination - LED lighting enables it to boldly go where no-one has been before.

About the Author

Dr. Geoff Archenhold is currently the Business Development director of Aston Science Park in Birmingham, UK, and has more than 10 years experience within the stage, TV and architectural lighting industry. In 1998 he founded Integrated System Technologies Ltd and more recently Radiant Research, where his research work concentrated on the development of novel LED lighting fixtures leading to worldwide patents covering intelligent LED closed-loop feedback driving techniques, lighting fixture designs and nanophotonics diffusers.



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