ELECTRICITY + CONTROL *Reprint from the November 2011 Issue*

Lighting the way with LEDs

The Eneref institute reports on how lenses are being replaced by reflectors in LED light systems to provide greater Light Output Ratios (LOR) and reduce glare in different applications

We've come a long way since the days when LEDs were used almost exclusively as device indicators or in handheld calculators. Today's LEDs are powerful light sources that use lenses to protect us from glare. But lenses are inherently inefficient as a solution for controlling glare.

The lighting industry has never seen a lighting technology gain so much interest, so quickly. It is true that one can expect to see the fastest growth in LEDS within the retail market, with retailers, like Wal-Mart entering the South African retail market, designing stores with a number of LED fixtures.

However, does the LED, a point source of light, pose a special threat to visual comfort in commercial spaces when lighting design is ignored; and will an ageing population, more sensitive to glare, find spaces lit with poorly-designed LED luminaires especially challenging? Is there a better solution for controlling glare from increasingly powerful LEDs than with increasingly diffused lenses?

The solution to glare may come in the form of reflectors designed to shield us from the LED light source. Well-designed reflector systems made from highly reflective materials can offer greater light output ratios (LOR) than a typical lens system while reducing or eliminating glare. Lenses, on the other hand, by their very nature reduce light output.

Standardisation

As LED modules grow more standardised, the standardisation offers opportunities to combine the LED light source with a variety of reflectors; where the same LED modules can be combined with different reflector systems to tailor light distribution to a specific application. Only the light source would need to change, not the complete optical system.

Modularity will offer specific advantages as LEDs become more prevalent in the market. Electronic component parts can fail. Modularity can help reduce maintenance costs and modular systems offer greater and easier supplier options.

Interchangeable systems will also dramatically reduce production costs while increasing light distribution options. As raw materials grow in cost, replacing modules will not only become more cost effective, but will reduce material waste.

Reflectors

The reflector market already has made significant advances in reflector materials and reflector design. Alanod Aluminum's Miro Silver comes with a 98% total reflectivity, and has found its way into many advanced designs beyond simple linear luminaires explains Sean Stewart, of Arcona International, South Africa's leading supplier of highly reflective optical materials. For example, more and more, luminaire designers are developing segmented reflectors to optimise efficiency.

For years, HID reflectors have taken advantage of segmented optics and increased light output ratio (LOR) to nearly 90%.

Can the next generation of LEDs take advantage of what we have learned about reflectors in fluorescent and HID systems? Certainly, reflector design offers new potential for LEDs, explains Sean Stewart, of Arcona International, South Africa's leading supplier of highly reflective optical materials.

Initially, the bar has been set too low for optical design in LED luminaires. That is probably because the roots of LEDs are not in the lighting industry, but in electronics industry. However that trend is clearly changing.

In a traditional HID outdoor lighting system, the reflector design and material determines light distribution, glare control and system efficiency. The luminance of the lamp is hidden within the luminaire and the light is distributed over a wider area. In this case, any light loss is dependent on the reflector design and material.

Quality of lense

In many of today's LED outdoor lighting systems, the quality of the lens determines light distribution and efficiency. Avoiding glare can be difficult, especially since manufacturers want to

maximise lumens per watt. The light is beamed in one direction, leading to unwanted high luminance spots and increased glare.

Certainly lenses can reduce glare, however they do so at a cost – reducing light output anywhere from 10 to 30% depending on various factors. Lenses are therefore a balance between efficiency and visual comfort: between high transmission rates and reduced glare.

And lenses can tend to increase maintenance. For one thing, lenses are unlikely to hide the appearance of a single LED failure that would need to be replaced. And as lenses age they tend to become opaque, losing transparency, and thereby reducing illuminance.

While lenses can offer a low-cost solution to glare, their low average efficiency remains a disadvantage. Beyond reduced illuminance, lenses can also add thermal resistance, chromatic aberration and aging. Glass lenses avoid some of these downsides, but at higher development and production costs, leading to higher fixture costs.

The solution is to instead shield the light source with a reflector – pointing the LEDs directly into a reflective material and bouncing the lumens off of the reflector in a controlled photometric distribution of light. With a highly reflective material such as Alanod's MIRO-SILVER, with 98% reflectance, for example, the light output ratio of such a system can be much greater than with a typical lens solution, provided the reflector is designed with a minimal number of bounces, or reflections.

Naturally, if no lens is used, the problem of lens aging is also eliminated. High quality reflective materials, such as Miro, do not dull over time.

Certainly, a white-painted reflector would seem to offer the advantage of a diffused distribution; however distribution control is essentially lost. Whereas a white painted surface may allow less than 10% directional control, a Miro-type product would offer over 90% directional control.

Directional control

How important is directional control? Placing all the lumens where you want them may be the most cost-effective road to energy efficiency. While a white painted surface can offer the same total reflectance of nearly 100% as a specular material, a white painted surface, by its very nature, will offer no way to place lumens where they are needed. Painting light on surfaces where light is not needed is an enormous waste of energy.

High quality luminaires requires reflective materials that offer a complete spectrum of visible light, which includes reflectors made from platinum, silver and aluminum.

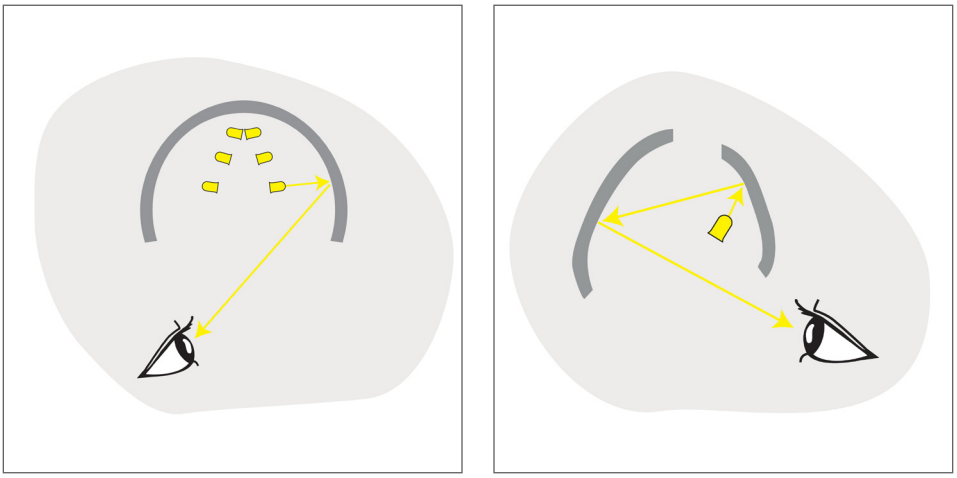
Directed light can offer additional visual rewards over a more diffused light from lenses. Studies have shown that diffused or less directed light can result in the kind of fatigue often associated with poor lighting design. Overly diffused light reduces perception. Well-designed directed light on the other hand can add to visual comfort with better contrast and colour rendering because visual details would have more dimension and structure.

and color mixing without chromatic aberration. All of which results not only in higher user acceptance but higher efficiency as well.

Several manufacturers have developed outdoor street lighting using one single small reflector for each LED; however such solutions cannot take advantage of LED modules that can be easily changed.

It seems that the future of LED luminaires will likely use one reflector to control the LED group while avoiding a direct view of the LEDs.

Still, controlling the LED light distribution with two reflector component parts opens the door to some innovative luminaire design options. With a second reflector, the reflector surface distribution can be increased. Or different surfaces can be mixed. Designed intelligently, the reflector will hide the impression that individual high-power LEDs are the light source.



A specular reflector in a LED system distributes the light evenly resolving the high luminance of the point LED light source

When luminaires shield a direct view of the LEDs with either a single mirror as the primary reflector or with secondary mirrors certain benefits are assured. Most obviously, the system presents no visible point light sources, thereby reducing glare. Reflectors can also offer improved light distribution

Primary and secondary reflectors

A few companies have come to market with an LED luminaire system that incorporates a primary and secondary reflector. The systems are offered for low installation heights without the glare of a traditional spot or down lights.

The first reflector hides the direct view into the LEDs and directs the light to the second reflector, which controls light direction. Visual comfort is assured because no point luminance is seen, only a ring of constant luminance. And aging or colour problems associated with lenses are eliminated as well.

Conclusion

No one doubts that LEDs will grow more common in workplaces and retail environments. Will tomorrow's luminaires expose more glare or offer a more visually comfortable environment?

Bruce Waddell, director of South African based lighting manufacturer, Lighting Innovations, recalls seeing the accumulative effect of glare from the LED streetlight displays during Light+Build, the world's largest lighting exhibition, held in Frankfurt, Germany. In his opinion, a long street of such light would be disturbing; using a reflector system to shield and direct LED light simply offers better control.

Seth Warren Rose, founder of the Eneref Institute (www.eneref.org) writes regularly on successful green building projects. This article is part of an ongoing initiative by the Eneref institute to assess impediments to building zero-energy urban communities in the U.S