LEDiL Oy
Salorankatu 10
24240 Salo, Finland
www.ledil.com

SYMMETRIC VERSUS ASYMMETRIC OPTICS IN ROADWAY LIGHTING APPLICATIONS

Today, white LEDs are capable of delivering more than 150 lumens per watt (lm/w), which translates to significant energy savings and longer life than traditional filament-based lamps. For these and other reasons, the choice to use an LED light source is becoming more apparent every day.

While deciding to use LEDs is an easy decision, lighting designers face a number of challenging decisions when specifying solid-state technology. LEDs come in many different styles and from many vendors, from through-hole packaged, to single-die surface-mount packages with primary lenses, to multi-die surface-mount packages and chip-on-board (COB) array packages without primary optics. Many similar LEDs do not share the same footprint or physical dimensions. Designers must properly design the fixture for good thermal performance as LED lifetime can be severely compromised by excessive heat. Powering LEDs with an efficient constant-current power source requires expertise not typically associated with traditional light sources and there is, of course, the need to provide environmental sealing and protection against physical damage. All of these considerations add to the challenge of understanding the requirements of various street lighting standards described by CIE, IESNA and others.

It is not without surprise that, given the wide range of secondary optical choices available on the market, designers often choose optics after LED selection is made and mechanical specifications are well defined. This approach, however, can narrow the designer's choice of secondary optics and result in a design that is less than optimal.

It is the purpose of this article to educate readers about secondary optics selection, the differences between symmetric and asymmetric optics and how selection of the right optics at the design stage leads to the use of fewer LEDs, smaller power supplies and, ultimately, a more efficient and less costly fixture to produce. We will focus on optics designed for single-die surface-mount packages with primary lenses because these LEDs couple nicely with secondary optics and provide tremendous design versatility, unlike large COB arrays where all the power and light is contained within a concentrated array and the light is often difficult to efficiently control.

As mentioned earlier, LEDs are capable of delivering up to and beyond 150 lm/w. System losses considered, it is now possible to engineer fixtures that deliver greater than 100 lm/w - better energy efficiency than most traditional light sources. Losses occur in the electronics that "drive" the LEDs, as thermal losses in the LED, and also in the interface between the LED and secondary optics and, if used, tertiary optics.

Secondary optics efficiency is quantified by measuring the light (lumens) emitted from a given LED and then measuring the emitted light after secondary optic attachment. This is typically done in an integrating sphere, such as the one shown in Figure 1. Ask your optics vendor to clarify the test method; it is possible to publish higher efficiency results by measuring the light that leaks out of the sides of the optic. This light is not usable and a proper evaluation requires masking the areas away from the emitting surface. Note that there will always be some light loss when using secondary optics; a properly engineered optic characterized to match the LED should offer 90% or greater efficiency.

e

How much light passes through the optic is obviously of high importance, but of equal importance is getting useable light to the target area; in this case a street, sidewalk, or parking lot. And, in many cases, specifications define zones where light shall not trespass, such as above the lamp head or into nearby residences or businesses. The Illuminating Engineering Society of North America (IESNA) publishes BUG Ratings (backlight, uplight, glare) that define luminaire performance related to light trespass, sky glow, and high angle brightness control.[1] Defining optics selection early in the design cycle allows the designer to engineer a fixture of maximum efficiency that directs light where needed and, in many cases, without the need for inefficient baffles or shrouds to “cut off” the light to meet light trespass guidelines.

The proliferation of LEDs used in roadway lighting applications has led to a proliferation of secondary optics as well. LEDiL’s STRADA family of lenses are a good example; with nine product groups in single position and multi-lens arrays and symmetric and asymmetric light patterns, designers can keep pace with the rapid deployment of new LEDs without having to repeatedly outlay capital funds for new molds. As time-to-market and channel access are often key factors related to winning a city-wide or large lighting contract, a wide selection of readily-available secondary optics engineered by a partner that specializes only in secondary optics is a significant value proposition.

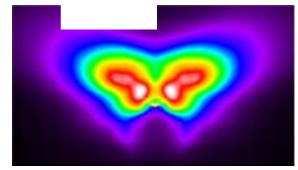
Just as a luminaire manufacturer will fall behind its competition by continuing use of previous generation LEDs, use of the wrong optics will allow the competition to leap ahead. Symmetric lenses, such as the lens shown in Figure 2, are ideally used for retrofitting existing lamp heads. This is due to the fact that most existing lamp heads are designed to distribute the light over a symmetrical area, either through overhead placement of the lamp head or by tilting the lamp head a certain amount (15^{o} tilt is common).

- STRADA-A

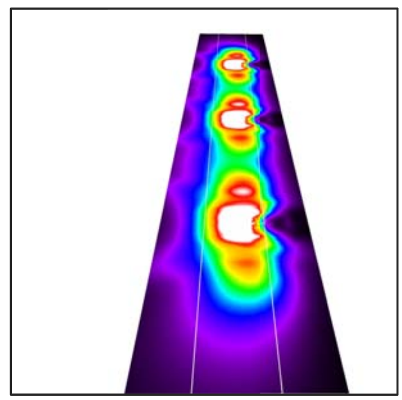
[1] Illuminating Engineering Society web site, http://www.ies.org/store/product/luminaire-classification-system-for-outdoor-luminaires-1103.cfm

Asymmetric lenses, on the other hand, are advantageous for design of new luminaires. These types of lenses, as depicted in Figure 3, are designed with built-in "tilt" to direct or "throw" light forward. Asymmetric lenses, therefore, reduce light trespass behind the mounting pole and/or above the luminaire and also help to reduce glare. Installation of fixtures with asymmetric lenses is easier, too. Work crews do not have to mount the lamp head at a specified mounting angle. Since the light is directed where it is needed long mounting booms can also be eliminated. Figure 3 shows an asymmetrical lens; the batwing pattern emitted by this lens is depicted in Figure 4. Note that the mounting location of the luminaire is not in the center of the pattern; instead, the luminaire is offset at the area below the center – where there is a sharp cutoff of light near where the lighter and darker blue shades meet. This is typically at the curb or sidewalk where the mounting pole is located.

STRADA-FW



Choosing the right optics for a roadway lighting requirement is becoming less challenging as roadway lighting standards continue to evolve and secondary optics companies continue to develop more standard solutions and deeper technical expertise. The ideal optical development partner will assist its customers and provide photometric files in IES or similar format, as well as no-charge applications assistance, design support and simulation of fixture performance. A typical report will provide an illuminance diagram, such as the example in Figure 5 – which displays a simulated street light fixture produced with asymmetric lenses.



ation Example

Once the optimal lenses are chosen, the LED selected and thermal, power, and mounting considerations defined, there are a few more important details that need attention. Installation of a protective cover is often considered for IP sealing and protection against dust, debris and other environmental conditions. Just as you will see reflected light when looking up into a glass of water from an angle, reflected light will result from refraction of wide-angle light from the lensed LEDs to the protective cover. Reflected light is lost light and the amount of light that is lost can be significant; your optical partner should be able to recommend a curved shape to the protective cover to minimize light lost at this interface.

The additional cost of the protective cover, combined with the inherent loss of transmission efficiency, may lead to a potted or sealed design with no cover. This is another reason to specify the secondary optics at the beginning of the design cycle, so that the PCB is designed to optimize application of sealing gaskets or compounds.

Whether or not your design calls for symmetrical or asymmetrical optics, it is important to understand the relationship of popular optical grade plastics in relation to their capabilities to withstand UV radiation, their ability to withstand impact and their UL ratings. STRADA Series lenses are typically molded from UV-stabilized PMMA, an acrylic material with outstanding transmissive properties. Efficiency loss due to UV radiation is minimal over the lifetime of the fixture (less than 2%). Polycarbonate (PC), a thermoplastic material capable of operating at a higher temperature than PMMA, is also less brittle than PMMA and able to meet a higher UL flammability rating. The sacrifice in transmission efficiency; however, is significant unless a UV treated PC is used. The cost of surface treating PC for UV protection is high and often cost-prohibitive. Understanding the intended application will dictate whether or not optics molded from PMMA will meet needs beyond optical performance, or whether tertiary protective covers are needed for environmental protection.

In summary, properly designed optics – characterized to match the LED – are the key to the best fixture designs. Whether a roadway design is best served by symmetric or asymmetric optics, the best time to choose optics is at the beginning of the design process. Starting the design with the selection of optics allows the designer to maximize efficiency of the fixture, to decrease development time, to minimize power consumption, to reduce system cost and improve overall reliability.