Application Note

Selecting Optics for an LED System

This technical note is intended to provide an introduction to beam shaping optical components which can be used with Violumas LEDs.

September 22, 2025

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Overview

This technical note is intended to provide an introduction to beam shaping optical components which can be used with Violumas LEDs.

Intended Audience

- Product developers intending to use Violumas LED products
- Violumas technical Sales Engineers providing support to potential customers

Scope

This technical note is aimed to provide product designers with an introduction to optics, their purpose, and the factors which need to be considered when using different types of optics.

Disclaimer

This resource is intended for engineers using Violumas LED products. Product designers are solely responsible for selecting the appropriate Violumas products and ensuring that the applicable standards and safety requirements are met. Violumas cannot be held responsible for any damage caused by following these guidelines.

Introduction to LED Optics

Bare die, light-emitting diodes (LEDs) without any optics typically emit light at a wide angle, between 120 to 140 deg. This implies that the light is not focused, and the intensity would drop significantly after a certain distance from the LED. Depending on the application, optics are used to make the optical system work more effectively and to focus the LED beam to a smaller spot. External optics allow for beam shaping to create different light distributions with the same bare chip LED(s). While quartz/fused silica lenses or low-cost silicone lenses are the most popular optics used for UV LEDs, aluminum reflector options may also be available in certain cases. Beam-shaping for UV LEDs may be achieved by using lenses and reflectors or a combination of optics.

Selection of UV-transparent and reflective materials is dependent on the spectral characteristics, UV stability, refractive index, thermal performance and the associated costs.

Beam shaping optics, if forming a complete seal around the LEDs can, therefore, protect from ingress as well. Even if beam angle control is not a requirement, flat windows can be used to protect the LED or the LED array. Figure 1 shows an example of a chip-on-board LED with a fused silica lens.

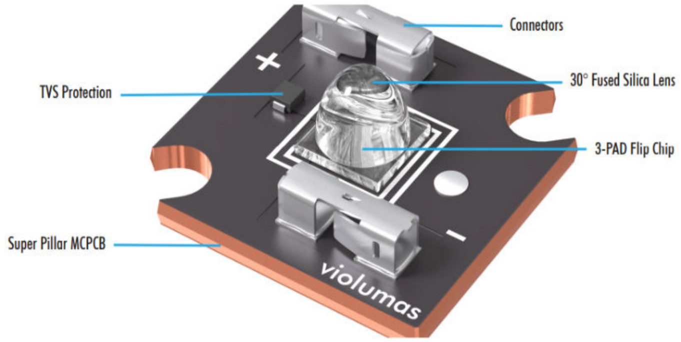


Figure 1: An LED COB with a fused silica lens

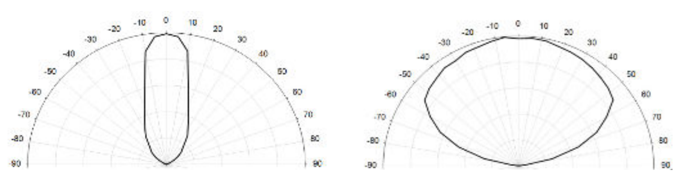
In this note we will look at various options which may be accessible as beam shaping elements for Violumas products. We will also discuss how these optics can have an impact on the design process.

Options to consider

Beam angle options

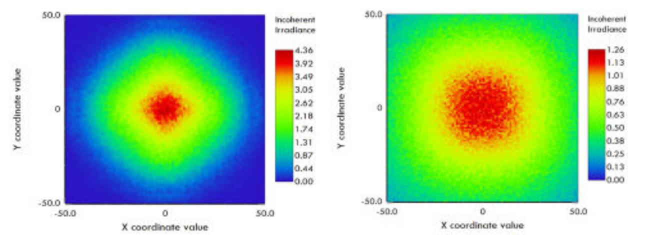
Beam angle is defined as the angle at which the intensity drops to 50% of the value at the central angle. A wider beam angle implies a larger spot size, and a narrow beam angle provides more focused light. While using narrower beam angles may appear more effective, it can also lead to hotspots if the distance between the LED source and the detection surface is short. For longer working distances, narrow beam angles can allow for a more focused light. Beam angle for an LED product can be determined from the radiation pattern typically provided with the LED specifications. Figure 2 shows the radiation pattern of an LED with a 30° beam angle and a 130° beam angle lens.

Figure 3 shows a comparison of irradiance distributions of a 265 nm LED with two different beam angles- 60° and 135° at a throw distance of 50 mm.



(a) (b)

Figure 2: Radiation Pattern of an LED with (a) 30 deg beam angle lens and (b) a 135 deg beam angle lens

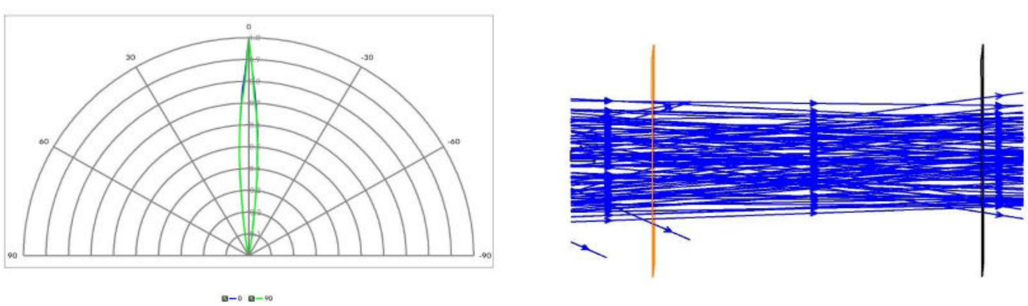


(a) (b)

Figure 3: Irradiance distribution of an LED with (a) a 60° lens and (b) a bare die with 135° deg beam angle

The distribution with the 60° lens is more focused in a certain area while the flat lens is more distributed. So, when it comes to uniformity a larger beam angle may yield better results at shorter distances. But for longer distances it is often better to use a narrower beam angle to reduce side emission losses emerging from a larger divergence angle with greater side emissions. In order to determine which lens would be appropriate for a certain application, optical simulations may be performed to determine obtainable intensities and uniformity over a target area. Optical modeling is particularly useful for LED array designs, as overlapping emissions of individual LEDs should be taken into consideration when selecting the appropriate lens type. In cases such as curing, high intensities may be required over a small area and so narrow beam angles may be more effective. However, for applications such as disinfection, a large area distributed source may be necessary.

Another example where optics can significantly aid in reducing losses is where we need to couple light into a fiber. In this case the light should be almost fully collimated or with low divergence. Figure 4 shows the radiation pattern from a very narrow beam angle lens (10 deg beam angle) along with a ray diagram showing how the light beam is almost collimated.



(a) (b)

Figure 4: Radiation Pattern of an LED with (a) a 10° lens and (b) a ray diagram showing low divergence with this lens as the rays are propagated along the distance.

Since the lens is creating a beam with low divergence, the light loss at farther distances is minimized.

Figure 5 shows the irradiance distribution at a distance of 50 mm with a 10 deg lens vs a 120 deg beam angle lens. It can be seen that the peak power as well as the total power are highly attenuated with a larger beam angle lens.

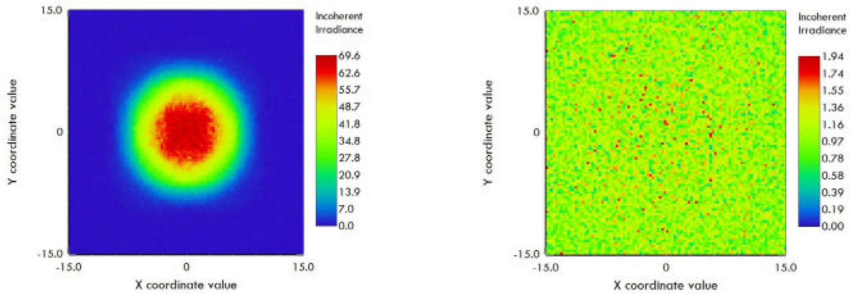
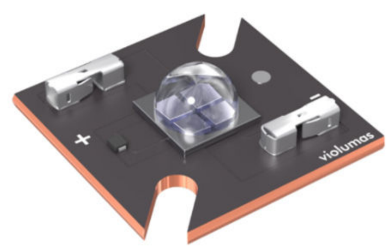


Figure 5: Simulated irradiance distribution at a distance of 50 mm with a 10 deg lens vs a 120 deg beam angle lens.

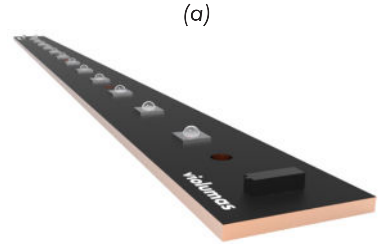
Single Lensed LED or a Lensed Array

Optics play a crucial role in optimizing the design and performance of LED-based systems, particularly by influencing how light is directed. Incorporating optics may help in reducing the total number of LEDs required for a specific application. By strategically managing how light is focused or spread, optics ensure more efficient use of each LED's output, which can aid in cost savings and reduced energy consumption. When using Violumas products, the following two approaches may be considered:

- **Single Lens for Multiple LEDs:** This approach simplifies the design by minimizing the number of optical components. It is particularly advantageous for compact systems with limited space. An example of this is Violumas' VC2X2 (4-chip) COB (chip-on-board) product, where four LED chips are enclosed within a single lens, resulting in a single source like distribution. This design is ideal for applications where a broader or more uniform light field is needed, such as disinfection over a larger area.
- **Individual Lenses for Each LED:** This method allows for greater control over the direction and intensity of light emitted by each chip. It is often used in applications requiring precise beam shaping, focused lighting, or customizable designs. For example, for a curing application it may be useful to have a wider beam angle at the center and a narrow beam angle at the edges to ensure uniform illumination. This is only possible by using individual lenses for each LED.



(a)



(b)

Figure 6: Violumas' products:
(a) a 2x2 UVLED COB with a single lens
(b) 12x1 light bar product with an individually lensed array

The choice between these two approaches ultimately depends on the application-specific requirements. Factors such as the desired light distribution pattern, the physical constraints of the design, cost considerations, and the intended use case play important roles in determining the optimal configuration. Figure 6(a) illustrates the single-lens design of the VC2X2 product, highlighting its simplicity, while Figure 6(b) demonstrates the standard light bar with individual lenses, emphasizing precision and control.

Use of Reflectors

Reflectors provide another alternative to designers of LED products to reduce the wide-angle emissions. These reflectors may be custom-made or may be available off-the-shelf depending on the requirements. While lenses use the refraction phenomenon from the material to focus the light, reflectors are made of specialized materials such as aluminum which can reflect wavelengths in the UV range. Figure 5 shows an example of a reflector optic with a UV LED. Figure 7 (a) shows the schematic and Figure 7(b) shows the actual UV LED with reflector and a heatsink. Such a reflector can aid in reducing beam angles- in this case to approximately 15° as shown in Figure 7(c). The irradiance distribution will be very focused with such a design as evident in Figure 7(d).

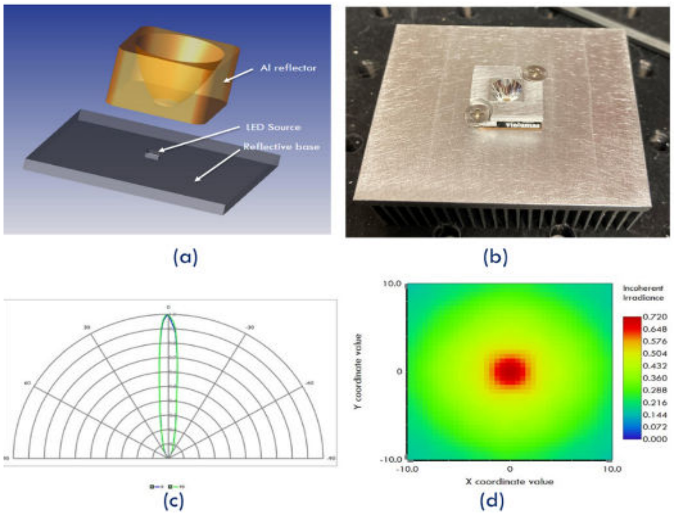


Figure 7: Reflector option with Violumas LED including schematic, product, and ray profiles.

Reflector options are available upon request for some Violumas products. Please contact the Sales team for further information.

Custom Optics

In addition to standard options, custom optics can be designed to cater to specific applications. These may include customized reflectors, TIR lenses or a combination of both to obtain the desired irradiance, uniformity and desired performance as per the customer's requirements.

Custom optics offer several advantages and can help in reducing costs, if designed optimally:

- **Tailored Light Distribution:** Custom optics enable designers to precisely control beam angles, intensity distribution, and uniformity, ensuring the light meets the exact needs of the application.
- **Enhanced Performance:** By optimizing optical efficiency and reducing losses, custom optics improve overall system performance and energy efficiency.
- **Adaptation to mechanical constraints:** Custom optics can be designed to fit into specific form factors, allowing for optimal system integration.

For example, custom lenses can help in reducing beam angles to < 10 deg and can be combined with reflectors as well for fiber optic applications. Fly-eye lenses may be used in photolithography systems used for semiconductor fabrication. Custom designed fly-eye lenses can homogenize the light beam from the light source, ensuring even exposure of the photoresist layer on the wafer.

Our Services

Violumas offers advanced optical simulation services to help customers design and optimize lens systems tailored to their specific applications. The company specializes in various lens types, including custom lenses, Total Internal Reflection (TIR) lenses, and hybrid optical solutions. By leveraging state-of-the-art simulation tools, Violumas supports the development of innovative lighting solutions across industries, such disinfection, spectroscopy and curing.

Violumas offers lensed LEDs from 10 to 135 degree in its standard products and can offer custom solutions based on specific applications.

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Have more questions?

If you have questions that are not answered in this document, please contact the Violumas team.

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