violumas
High Power UV LED Solutions

Boston Electronics

Application Note

Ultra-Narrow Beam Lenses for UV LED Systems

This technical application note provides information on Violumas' ultra-narrow beam lenses and their use in UV LED systems. It introduces the underlying optical principles, key performance considerations, and potential applications of Violumas' ultra-narrow beam angle – the Viobeam Product. The document is intended to help users understand how these lenses can be used to achieve precise, focused UV illumination in demanding applications.

Ultra-Narrow Beam Lenses for UV LED Systems

Overview

This technical application note provides information on Violumas' ultra-narrow beam lenses and their use in UV LED systems. It introduces the underlying optical principles, key performance considerations, and potential applications of Violumas' ultra-narrow beam angle – the Viobeam Product. The document is intended to help users understand how these lenses can be used to achieve precise, focused UV illumination in demanding applications.

Intended Audience

- Engineers and technologists using Violumas LED products
- Violumas technical Sales Engineers providing support to potential customers

Scope

This technical note provides an overview of ultra-narrow beam lenses, including their optical characteristics, benefits, and potential applications in UV LED systems. Recommendations for lens selection and utilization are provided where applicable.

These recommendations are intended as general technical guidance and should be used in conjunction with applicable industry standards, established engineering practices, and application-specific requirements. Proper optical, thermal, mechanical, and electrical considerations should be evaluated when integrating the Viobeam product into a UV LED system.

Disclaimer

This guide is designed for engineers working with Violumas' LED products. It is the sole responsibility of product designers to choose suitable products and to comply with all relevant standards and safety regulations. Violumas' liability does not extend to any damage or warranty problems that may arise from adherence to these recommendations.

Introduction

Ultra-narrow beam lenses are critical in applications where precise, high-intensity UV illumination is required, and advancements in Total Internal Reflection (TIR) optics have made this level of control increasingly achievable. TIR lenses have revolutionized lighting by enabling high efficiency, precision, and tailored light distribution, which is especially important in UV LED systems where device efficiencies are inherently lower. By leveraging TIR design principles, the VioBeam-1X1 product from Violumas is engineered to focus UV light into extremely tight beam angles, maximizing irradiance and improving overall system performance. This combination of optical efficiency and beam control makes such solutions ideal for demanding applications including semiconductor processing, advanced UV curing, and inspection systems, where controlled light delivery directly impacts performance and throughput.

TIR Optics

TIR lenses combine refraction and reflection to capture and direct light from the source, ensuring minimal loss and high control over the beam profile.

The LED source is placed at the center of the TIR lens. The inside curved surface refracts the light and the total internal reflection inside the lens at the glass-air interface guides the light to the external aperture. As seen in Figure 1, the widely distributed LED irradiation is refracted and converted into a much narrower controlled distribution. Using the TIR lens may allow for LED beam angle reduction from 130-140° to less than 10°.

Figure 2 shows the beam angle profile for a TIR and a 60°.

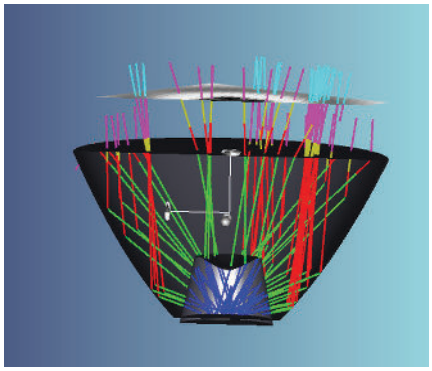
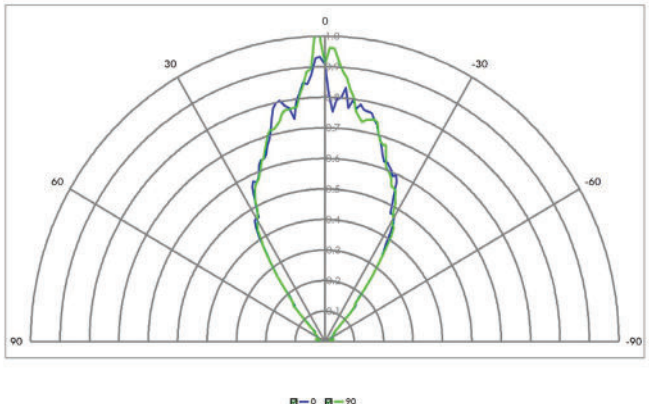
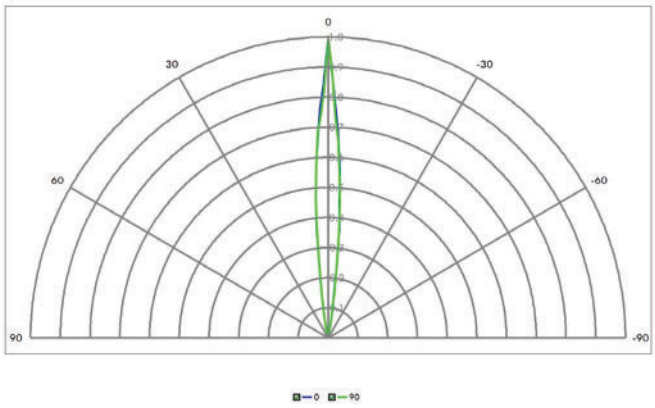


Fig 1: A TIR lens is shown as simulated in a ray tracing software. Ray segments have been colored as they hit various surfaces.



Beam angle profile for a 60° beam angle lens



Beam profile for a TIR lens with a 10° beam angle

Fig. 2. Comparison of beam angle profiles for a 60° and a TIR lens.

While the beam angle profile is a great indicator of light distribution through a lens, optical simulations can provide specific information about intensities within a target area at a certain throw distance.

VioBeam-1X1 Key Features

Optimized for UV LEDs: Designed specifically to compensate for the lower efficiency of UV LEDs, ensuring maximum photon delivery to the target.

High Optical Efficiency: Made from fused silica, the TIR optic is designed to minimize light loss and deliver more usable light compared to standard optics.

Compact Form Factor: Easy integration into existing UV LED modules and custom optical systems.

The following figures compare the performance of the VioBeam-1X1-265-V2 (10° beam angle) with the VC1X1C48LX-265-V2 (140° beam angle, no lens) at different throw distances. The simulations assume that the same 265nm die was utilized in both LEDs with equivalent operating conditions.

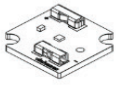
VioBeam-1X1-265-V2 Specifications

Electro-Optical Characteristics at I_F = 700mA and T_A = 25°C

Parameter	Symbol	Unit	Min	Typical	Max
Peak Wavelength	λ_P	nm	260	265	270
Forward Voltage	V_F	V	5.8	6.2	6.8
Radiant Flux	P_O	mW	90	115	145

VC1X1C48LX-265-V2 Specifications

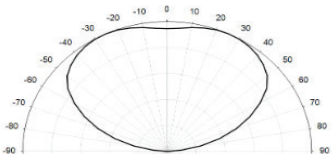
VC1X1C48LX-265-V2 | Mid Power 265nm COB (Bare Die)



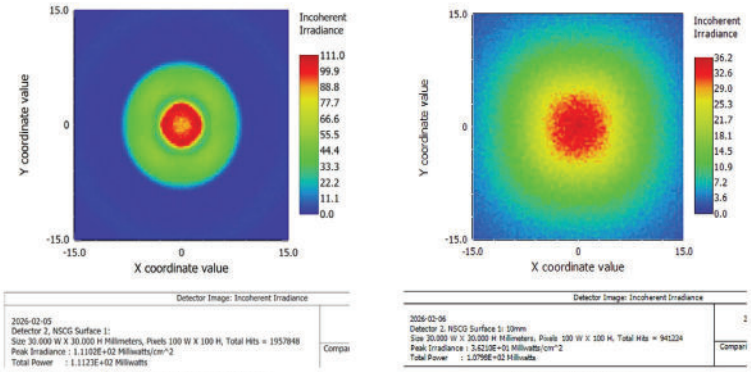
Product Specifications (I_F=700mA and T_A=25°C)

Parameter	Symbol	Unit	Min	Typical	Max
Radiant Flux	P_o	mW	125	155	190
Radiant Angle	2Φ1/2	Degree	-	140	-

Radiation Pattern



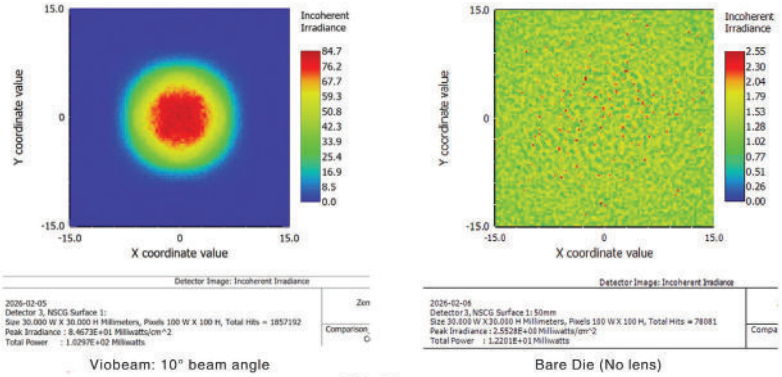
TD =10mm



Viobeam: 10° beam angle Bare Die (No lens)

Fig. 3a

TD=50 mm



Viobeam: 10° beam angle Bare Die (No lens)

Fig. 3b

TD=100mm

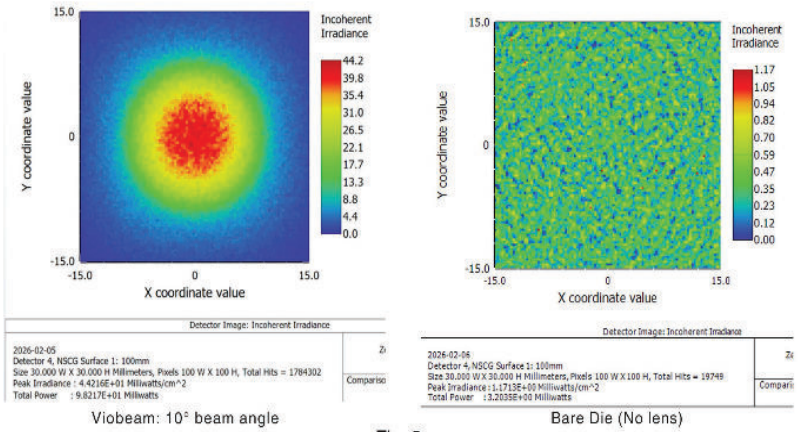


Fig. 3c

TD=200mm

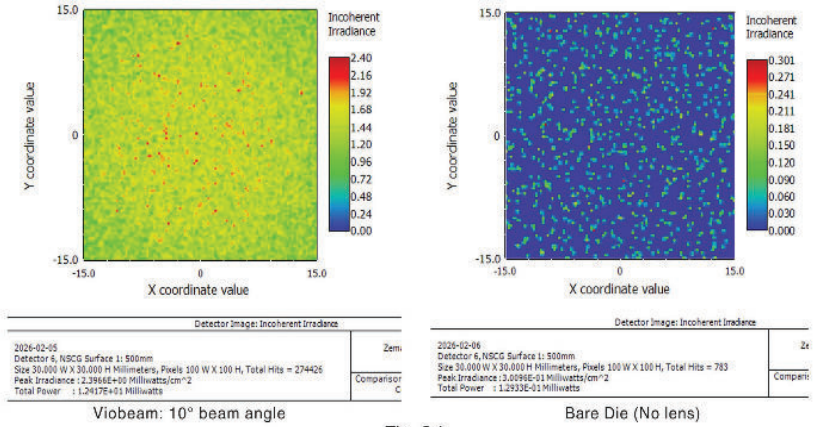


Fig. 3d

Fig. 3. (a-d) Simulated Irradiance intensities from 10mm to 200mm with VC1X1C48LX-265-V2 (pictured on the right side) and VioBeam-1X1-265-V2 (pictured on the left side) for the same detector area (30 mm x 30 mm).

This table shows the total power collected at the detector with the VioBeam-1X1-265-V2 vs. VC1X1C48LX-265-V2 (bare die LED). While the total radiant flux for the VC1X1C48LX-265-V2 is higher than that of the VioBeam-1X1-265-V2, due to less divergence, more light is collected by the VioBeam-1X1-265-V2 as compared to the bare die LED over long throw distances.

This implies that VioBeam-1X1 series is well-suited for long-throw distance applications.

Throw Distance (mm)	VioBeam-1X1-265-V2 Total Power (mW)	VC1X1C48LX-265-V2 Total Power (mW)	Comparison (%)
10	111.2	108.0	3%
50	103	12.20	744%
100	98.22	3.204	2966%
200	59.63	0.8098	7264%
500	12.42	0.1293	9506%

It can be seen from the irradiance diagrams that the TIR lens is able to maintain the total power within a target area of 5mm x 5mm at longer distances. Due to high divergence, the flat lens drops in total power at longer distances.

For UV LED applications, TIR lenses must be designed to withstand high-energy UV light, maintain high optical transmission, and shape the beam as needed. TIR lenses are commonly utilized for visible lighting applications and are most often manufactured with PMMA material. In the case of UV LEDs, particularly for wavelengths shorter than 365nm, fused silica optics are ideal for minimal transmission losses and material degradation.

Applications of VioBeam-1X1 LEDs

The precision and efficiency of TIR lenses used in LEDs such as the VioBeam-1X1 make them very useful in a wide range of UV LED applications across industries:

1. Disinfection and Sterilization

TIR lenses can be used in UVC LED systems for disinfecting air, water, and surfaces. By focusing the UV light into a narrow beam or distributing it evenly, these lenses enhance the effectiveness of germicidal systems. Applications include:

- Air purification systems for HVAC units.
- Water treatment systems for residential, industrial, and municipal use.

2. UV Curing

In UV spot curing applications, TIR lenses can focus UVA light to cure adhesives, coatings, and inks with precision. They may be used in

- 3D printing processes to solidify resin layers.
- Industrial assembly lines for bonding and sealing.
- Printing systems for instant ink curing in packaging and graphic industries.

3. Analytical and Scientific Instruments

TIR enables ultra-narrow beams and so allows for precision in all scientific and spectroscopy applications such as:

- **Spectrometers:** For fluorescence excitation and chemical analysis.
- **Forensic Tools:** Detecting biological evidence and counterfeit materials.
- **Optical fiber coupling:** TIR lenses may be optimized for high NA, allowing them to capture light from a wide angular range and focus it into the fiber's small core.

Advantages of VioBeam-1X1 LEDs

The use of TIR lenses like the VioBeam-1X1 offer several key advantages:

1. High Optical Efficiency

The VioBeam-1X1 LED captures and directs nearly all emitted light, minimizing losses and maximizing output. This is especially important in UV applications where efficiency directly impacts performance and light is required in a small, targeted area.

2. Precision Collimation and Control

TIR lenses enable precise control over beam angles and light distribution, ensuring the UV light is focused where it is needed most.

3. Compact and Lightweight Design

The effect of multiple lenses combined in a single component, reducing the need for multiple optical elements and allowing for compact, lightweight designs.

4. Customization

TIR lenses can be tailored to specific UV LED applications, with different beam angles, offering flexibility in beam shaping, wavelength optimization, and material selection.

Product Integration for VioBeam-1X1 LEDs

- **Precise Alignment:** Violumas ensures that lens is centered on the UV LED emitter for optimal beam shape and intensity.
- **Thermal Considerations:** While Viobeam lenses are UV-transparent and thermally stable, maintaining proper LED cooling ensures consistent optical performance. The patented 3-PAD technology from Violumas aids in reducing the junction temperature to improve optical output and lifetimes
- **Mounting:** Lenses can be mounted directly to standard COBs or custom housings using mechanical holders or adhesive bonding.
- **Multi-LED Arrays:** VioBeam-1X1 LEDs can also be used in an array. Both thermal, mechanical and electrical considerations must be included when designing LED arrays with TIR optics.

Fig. 4. Picture of an array

Conclusion

Ultra-narrow beam TIR optics fundamentally change how UV LED systems are designed, shifting the focus from total output power to usable irradiance at the target. Violumas' VioBeam-1X1 Series enables this shift, making high-performance UV systems viable at distances where traditional optics fail. Higher target intensities at longer distances make TIR lenses practical for many applications.

Have more questions?

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

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