June 16, 2021

SCHOTT Ceramic Converters

Five Things to Know About Ceramic Converters

Introduction

SCHOTT Academy of Optics is a free, online seminar series designed to take your industry knowledge and expertise to new levels.

Throughout the series, you will learn from leading glass and material experts as they cover various topics pertaining to the optics industry.

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For digital projectors and other lighting applications that require a high light output, laser pumped phosphor light engines are the best light source. Because there is no efficient way to directly achieve green light, converter materials are typically used to transform blue laser light into green light as well as orange, yellow, or white. In this article, we'll discuss five things you need to know about converters offered by SCHOTT.

1. What are the benefits of ceramic and how do these converters work?

SCHOTT's converters are based on a ceramic material that contains dopants that transform blue laser light to a broad spectrum, allowing other colors. Heat management is a key consideration because the conversion process generates heat, which increases when higher laser powers are used. We use ceramic to make our converters because it exhibits better thermal behavior than other materials, allowing heat to be removed quickly and easily.

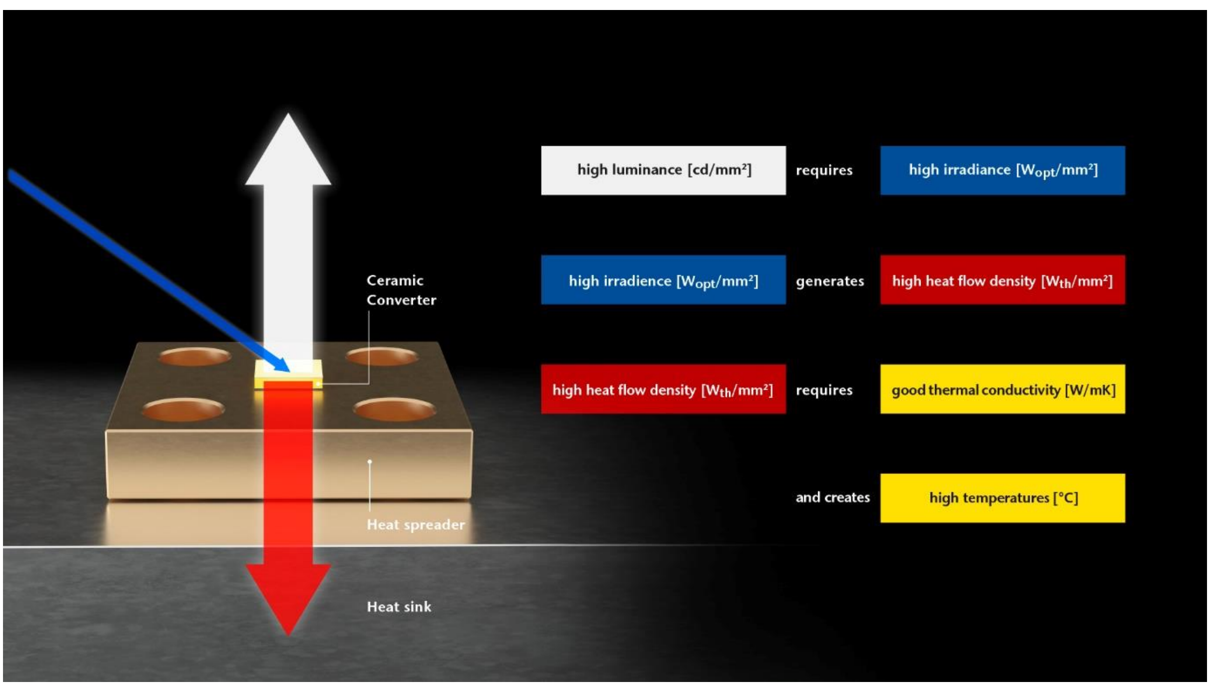

Figure 1: Laser pumped phosphor light sources is the technology of choice to generate the highest luminance. Irradiate the phosphor with blue laser light and the phosphor transforms the blue photons of the laser into yellow photons via photoluminescence.

Our ceramic materials are processed at temperatures above 1000 °C, which means they exhibit a high temperature damage threshold that is robust to even high laser powers. The result is bright, high luminance output. Because of the raw materials and processes used to make these ceramic converters, these converters come with a long lifetime and the benefit of being easy to use.

2. What options are available for SCHOTT's converters?

Converters come in either static or dynamic versions. Static converters offer irradiance levels up to 50 W/mm^2 and are useful for making very compact system designs without moving parts and less noise. The most common format is a ceramic die bonded onto a plated copper that acts as a heat spreader. Static converters can be used to convert blue light to green, white, yellow, or red-shifted yellow.

Dynamic converters are available in rings, C-shapes, or segments that produce green, yellow, and red-shifted yellow. SCHOTT offers different formats up to very large rings, which are necessary to dissipate heat when higher laser powers are used for high-luminance applications. Optional anti-reflection coatings are also available for dynamic converters.

Figure 2: SCHOTT's static ceramic converters

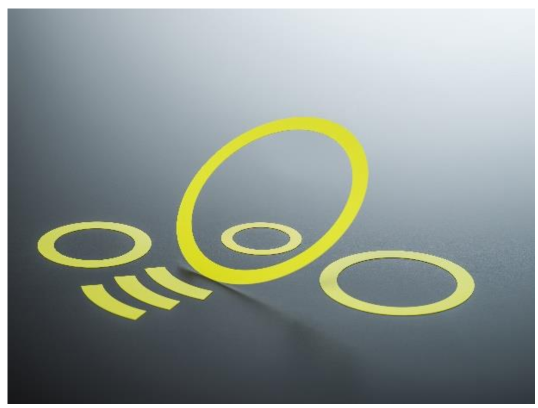

Figure 3: SCHOTT's dynamic ceramic converters

SCHOTT's years of expertise in glass and ceramics, combined with the fact that the entire value chain is under our control, allows us to customize converters to meet a variety of customer needs. We can also support customers with simulations to aid in this process.

3. What is etendue and how does it influence luminance in projectors and other applications?

In everyday life, making the illumination area larger will increase the light flux. However, the situation is completely different in a projector because of the etendue limitation. Etendue can be understood as the geometrical boundaries—in terms of area and angular space—of a system that need to be illuminated.

In a projector, the imaging chip used to create the displayed image accepts light in a specified area and with a specific acceptance angle, or numerical aperture. When the chip is illuminated with a small light spot from a static converter, the light will perfectly illuminate the system if the optics and spot size of the converter are designed to fit the area of the imaging chip and its angular boundaries.

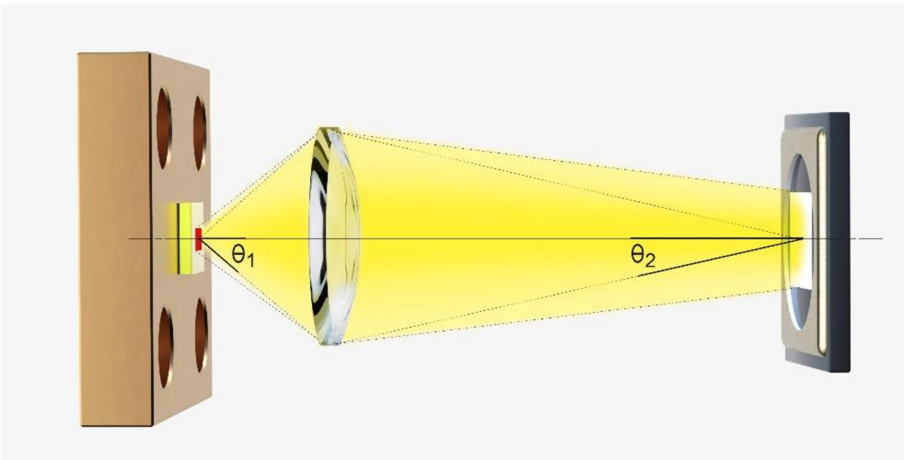

Figure 4: A simplified beam path showing a light spot that is emitted from a static converter and that illuminated an imaging chip.

Because of the etendue limit, making the light emitting area larger does not generate higher flux light because the extra light does not illuminate the chip.

For this reason, the only way to increase the flux is to increase the luminance—the output of light area and angle from this emitter. However, increasing luminance requires an increase in laser power, which causes a higher temperature load. This requires a converter made from a material such as ceramic with excellent thermal properties and with good heat dissipation via a good bonding to a heat spreader.

4. How do I select a converter to achieve the best performance for etendue-limited applications?

Application requirements are important when deciding whether to use a dynamic or static converter. Static converters are usually used for lower power projectors while dynamic, or ring-based, solutions are more often used for the high-power projectors often found in large venues or cinemas. SCHOTT has numerical models that can help customers decide the best converter for a specific setup and application.

For static converters, the die thickness affects the thermal resistance of the static converter. The spot size and the input power of the laser are decisive, and the irradiance limit is an especially important characteristic. For high-luminance requirements, large phosphor wheels are usually the best choice because the wheel cools itself while spinning fast. Besides that, the spinning distributes the laser power across the racetrack of the phosphor wheel, lowering thermal resistance and enabling a high luminance. For wheel diameters smaller than 50 millimeters—which typically corresponds to about ~80 W of laser power — a static converter could achieve the same, or even better, results as a dynamic ring-on-wheel design.

The converter's irradiance limit strongly depends on the material used. SCHOTT's broad portfolio of materials allows the best material to be used for a specific application. When selecting a material, there are a few things to keep in mind. Materials that produce white light generally have lower efficacy because less blue light is used for conversion. Materials producing standard yellow and standard white have different irradiance limits, but similar maximum flux. Materials can be red shifted but this creates a lower irradiance limit due to a lower thermal quenching temperature.

5. What else is important for achieving the highest irradiance limit?

Other factors can also affect the irradiance limit. For example, the irradiance limit for small laser spots is higher than that for large spots because lateral heat spreading supports cooling for smaller spots. Environmental conditions are another important consideration, and investing in cooling can help increase the irradiance limit. Finally, for pulsed applications such as 1-DLP chips, increasing the pulse frequency can boost peak luminance because the peak and average temperatures of the system get closer.

Want to learn more about ceramic converters?

For more information and resources on ceramic converters, visit our website:
www.schott.com/ceramic-converter.

If you have any questions or need project support, feel free to contact us: info.optics@schott.com.