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THE SCHOTT TECHNOLOGY MAGAZINE 2021

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Extract
Ceramic Converters

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Magic material

Ceramic converters for laser-pumped phosphor light sources pave the way to laser light technology with the highest luminance in the smallest spaces.

TEXT: THILO HORVATITSCH

SCHOTT manufactures both dynamic (left) and static converters (below).

Zap! When laser high beam light is emitted from a car headlight, it shines twice as far into the night as its LED counterpart. The laser-pumped phosphor light sources used for this purpose can generate light of the highest intensity on a few tenths of a square millimeter. Installed in state-of-the-art digital projectors, these light sources illuminate cinema screens with a diagonal of 20 meters and more. The lighting technology is considered to be trend-setting in research and industry. Its trump card: maximum luminance in the smallest spaces.

Luminance indicates how brightly the eye perceives luminous surfaces. It is measured in candela per square meter (cd/m²), the intensity of a surface per unit area. A clear 100-watt bulb reaches 10 million cd/m², the glaring midday sun around 1.6 billion. Modern laser-phosphor light sources can achieve significantly higher values today. This makes them ideal for concentrated illumination of limited areas – ideal not only for search or stage lights and projectors, but also for machine vision applications, microscopes or fiber optic devices such as endoscopes.

The trend is headed towards ever higher luminance levels with miniaturized technology. SCHOTT is accelerating this journey with an advanced material: fluorescent ceramics. What do they achieve when used for laser-pumped phosphor light sources? This light technology requires the conversion of laser light. It hits a phosphor and stimulates it to glow. For example, blue laser light is converted into yellow light. SCHOTT uses the same kind of doped crystalline phosphor that every LED light source contains for this purpose. "But unlike the conventional organically embedded phosphor powders, our material is prepared as completely inorganic fluorescent ceramics," explains Dr. Volker Hagemann, Senior Manager Applications at SCHOTT Advanced Optics. "It is more resistant to aging, allows more light to be generated in a minimal amount of space and enables even higher luminance levels with the best heat management."

Thanks to the bulk of the converter being made of solid ceramic, it can withstand temperatures of over 1,000 degrees Celsius, while phosphors in organic bonds such as silicone can only withstand temperatures of under 160 degrees Celsius. This and the excellent thermal conductivity are decisive factors in increasing performance because higher and higher luminance also leads to higher and higher temperatures.

SCHOTT has developed converter materials for yellow and green light on this basis, especially for laser-phosphor wheels in digital projectors. Here, the converted laser light is color-filtered to cover the entire color space of digital projection. The rotation of the phosphor wheels ensures their cooling and enables luminances of over 2.5 billion cd/m². The wheels can thus withstand more than 500 watts of laser light.

Static converters that enable extremely compact designs are the latest SCHOTT innovation. The ceramic material is soldered onto a heat spreader in order to dissipate the heat sustainably and to achieve the highest efficiency and reliability. The front and back of the ceramics are given special anti-reflective and metal coatings for optimal light control and heat dissipation. The converter components withstand a high permanent irradiance of more than 50 watts per square millimeter and enable luminances of up to 1.5 billion cd/m². The latter applies to hair-thin material thicknesses of 100 micrometers, which enable particularly good heat dissipation.

Material and process developers have refined a sophisticated industrial production process from nanopowder to sintered ceramics. Today, we can manufacture tailor-made products for various laser applications," says Dr. Hagemann. SCHOTT has been working on tapping into this new class of materials and its applications for years – and it remains exciting. "We are constantly working on increasing customer benefits, whether through thinner converter plates, new geometries, coatings or new classes of materials." ●

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Dr. Volker Hagemann,
Senior Manager Application Ceramic Converters

ADJACENCIES

Exceeding performance limits

SCHOTT has been supporting the disruptive change in lighting for more than 100 years.

How did the development projects become a product?
We were able to draw on outstanding expertise in powder processing, hot forming, coating and optical measurement technology at SCHOTT and combine it with our ceramics and optical know-how in a new project. This allowed us to quickly adapt the ceramics to the requirement profiles of the first customers and to provide samples very quickly for the development of the first laser-phosphor light sources. Product development and the transition to mass production was then achieved in close cooperation with our customers.

What fascinates you about converter ceramics?
Their application potential. Ceramics can withstand several 100 watts of laser power. They help generate light that is actually brighter than the sun. It is precisely because of such outstanding performance that we look beyond the boundaries of our glass materials group – and deal with adjacent materials, so-called 'adjacencies.'

Why does a glass manufacturer even deal with ceramics?
We always keep an eye on market requirements and want to expand performance limits. Glass is naturally in competition with other materials. Already more than ten years ago, SCHOTT was interested in ceramics as an optical, transparent material because it can complement the range of properties of glass and glass-ceramics in terms of strength, its refractive index and dispersion.

Ceramic light converters are quite popular due to their other properties, however.
Even back then, development projects were already revealing the qualities of ceramics as light converters. The material impressed us with its good conversion efficiency and its thermal properties. This was also of interest to us because

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