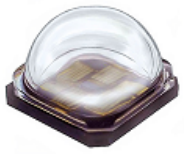
STANLEY ELECTRIC CO.,LTD.

265nm UV-C LED with high disinfection performance: Supporting "safe" and "hygienic" water supply

～Offering industry-leading 200mW light output and hermetically sealed package to resist moisture～

Stanley Electric Co., Ltd. (below referred to Stanley Electric) is now accelerating the development of UV-C LEDs with a wavelength of 265nm. This is for the growing needs of disinfection and the expanding market for this technology due to the threat of infection risk from various bacteria and viruses, including the new coronavirus. In addition to conventional water disinfection using mainly UV lamps, the expanding market includes new applications for air and surface disinfection, e.g. in water purifiers, air conditioners and in-vehicle equipment.

Stanley Electric continues to research and develop UV-C LEDs by utilizing its knowledge in disinfection gained from more than 10 years of experience in the ultraviolet market with UV-CCL (cold cathode lamps), and its optical technology (developing & manufacturing LED) in the automotive headlamp business. As a solution to the social issue of disinfection, they have focused on UV-C LEDs with an emission wavelength of 265nm, which have been confirmed to be particularly effective. And they have launched LEDs with an industry-leading light output of 200mW, aiming for further improvement in disinfection performance.



ZEUDE265

ZHUDE265

- ✓ **200mW high power UV-C LED series with the wavelength of 265nm**
- ✓ **ZEUDE 265 (4 dies LEDs) and ZHUDE 265 (single die LEDs)**
- ✓ **Adopts hermetically sealed packages with domed lenses**

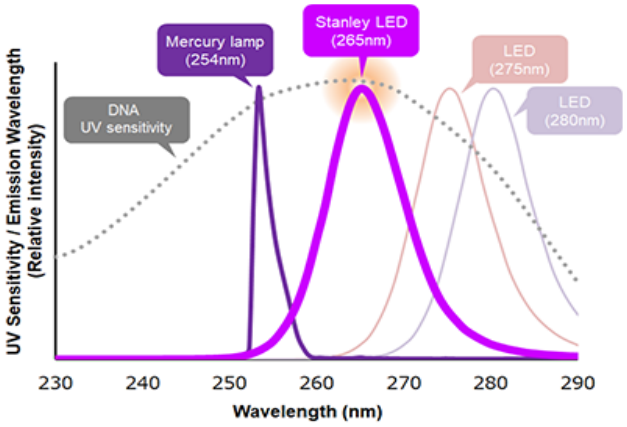
Disinfecting effect of 265nm wavelength

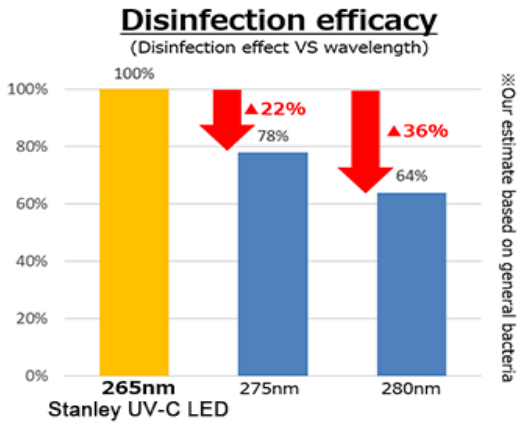
With the spread of new coronavirus infections, UV-C disinfection technology is attracting more attention than ever before. To disinfect with UV-C light, it is necessary to select an appropriate UV-C LEDs that can achieve the adequate disinfection level of the target by considering what the disinfection target is, the distance from light source to target, the amount of heat generated by the light source and so on. Characteristics that significantly contribute to the disinfecting effect include "emission wavelength", "output" and "lifetime" of the UV-C LEDs. It is also important to compare the disinfection power under actual environmental conditions of use, because it is difficult to evaluate the disinfection effect of UV-C LEDs just by checking the specification values listed in the data sheets.

Differences in the disinfection effect due to the emission wavelength

The principle of UV disinfection is the inactivation of micro-organisms by preventing their growth function and taking away their infectivity by attacking their DNA and RNA. DNA, for example, is sensitive to UV light, and sensitivity tends to vary widely with the wavelength of the UV light. Therefore, higher sensitivity to wavelength results in higher disinfection efficacy.

The graphs below show the relationship between the emission spectrum of UV-C LEDs and UV sensitivity of DNA, as well as the disinfection effect of different emission wavelengths. These graphs show that the highest UV sensitivity of DNA is at 265nm among the three wavelengths (265nm, 275nm and 280nm), and the disinfecting effect of 275nm and 280nm is lower than that of the 265nm wavelength.





Methods of checking disinfection performance

The energy (mJ) required for inactivation is defined as “LED intensity x irradiation time”. And the disinfection performance is determined by the following factors: ”①Light output × ②Disinfection efficiency × ③Output maintaining rate during actual usage”.

Since UV-C LEDs generate more heat than conventional LEDs, ③the maintaining rate of the output power during actual usage is an important factor. Therefore, in order to achieve higher disinfection performance, it is important to have "high light output" and "high output maintaining rate at high temperatures" with "emission wavelength of 265nm", where the UV sensitivity of DNA is at its highest.

Characteristics of Stanley Electric's UV-C LED

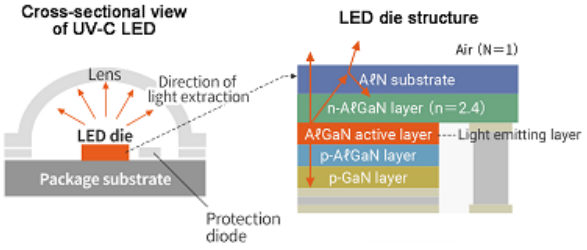
Stanley Electric's UV-C LEDs are designed to replace the mercury lamps, currently used to water disinfection applications such as tap water purifier. Since the main application is assumed to be water disinfection, a hermetically sealed package with high moisture resistance has been adopted. Furthermore, its own technologies were adopted to achieve high disinfection performance and excellent reliability.

The key technologies used to achieve these are described below.

Advantages of Stanley Electric's UV-C LED for applications

★Disinfection performance (Wavelength x High output)+Long lifetime

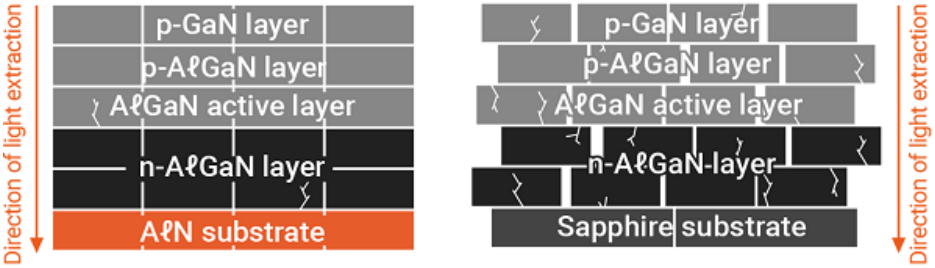
- ✓ Short-time disinfection
- ✓ Additional moisture resistance structure: unnecessary
- ✓ Light source replacement frequency: reduction
- ✓ Light source unit: downsizing
- ✓ Amount of LEDs: reduction
- ✓ Automotive applications
- ✓ Material cost: reduction



LED die: Using substrate material with few crystal defects

Sapphire, which is used in blue LEDs, is often used as the substrate for UV-C LEDs, however its large crystal grain spacing (lattice constant) makes the substrate layer easy to crack, especially at shorter wavelengths such as 265nm. Cracks reduces luminous efficiency, causing the LED die to become hotter and less efficient even when a small current is applied.

To achieve efficient LEDs with an 265nm wavelength, Stanley Electric uses A ℓ N (aluminum nitride) substrates, which are made of aluminum (A ℓ) and nitrogen (N). A ℓ N substrates are characterized by its small crystal grain spacing and a clean stacking structure, resulting in fewer crystal defects and less cracking. However, as the production requires advanced technology, Stanley Electric made HexaTech, which owns the world's leading A ℓ N substrate technology, a subsidiary in 2019 to strengthen the technology and enable in-house production of A ℓ N substrates. And this has promoted the development of high power and efficient LEDs with a 265nm wavelength.



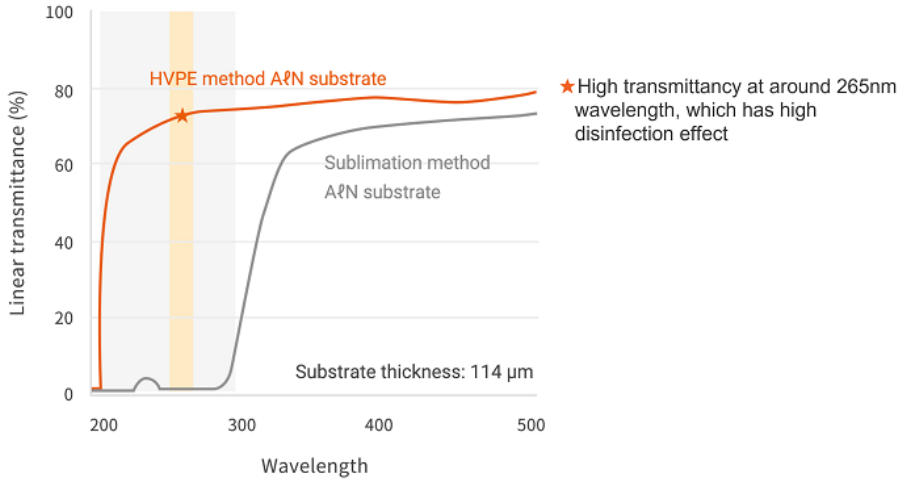
A ℓ N substrate
Small crystals can stack layers neatly, and prevent cracks.

Sapphire substrate
Large crystals cannot stack layers neatly and cracks can spread easily.

LED die: Manufacturing methods to achieve high transmittance layered substrates in spite of their thickness

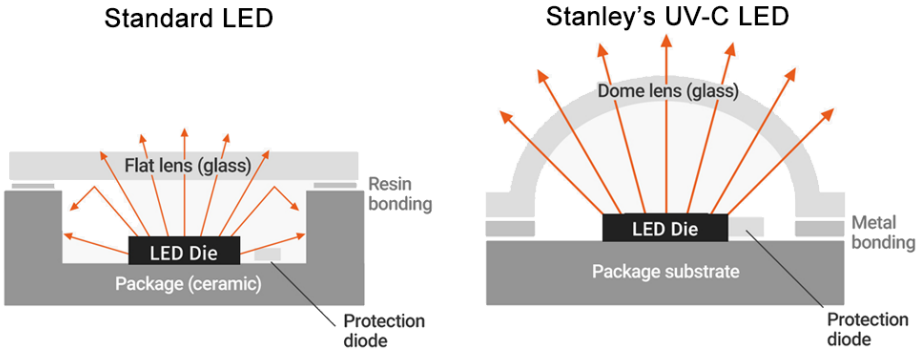
Another technology for LED die is the technology enabling more efficient extraction of the light emitted from the diode (light extraction efficiency). The A ℓ N substrate works like a window for the LED diode, and the higher the transparency, the more light can be extracted. And the thickness of the substrate reduces handling difficulties during the manufacturing process. Therefore, "high transmittance + thickness" are both important factors for the substrates. However, when using the "sublimation method", a common crystal growth method, impurities in the crystal reduce transmittance, and adding thickness also reduces transmittance.

To address this issue, Stanley Electric has adopted a technology known as "HVPE (Hydride Vapor Phase Epitaxy)," to create a highly transparent substrate that still retains its thickness. Compared to conventional "sublimation method", "HVPE method" enables much higher transmittance at wavelengths below 300 nm, allowing light to be extracted more efficiently. Thus, high performance is achieved by extracting the light emitted strongly from the device.



Package structure: Use of domed lens and highly reliable hermetic sealing package

LED packages are required to allow the light outward with minimal loss as much as possible. But the conventional method of bonding a substrate to a flat glass lens poses the problem of considerable light losses. So, Stanley Electric's 265nm UV-C LEDs dealt with this issue by adopting a dome-shaped glass lens. And its structure shows less light loss and attenuation compared to conventional method. (see figure below).



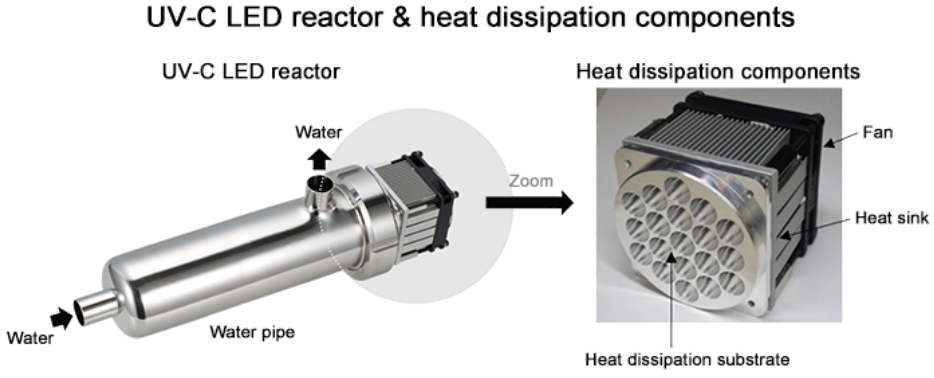
Also UV-C LEDs are easily affected by the external environment. Especially when moisture enters the package, they may not emit light due to sudden failure or a sudden drop in output, so care must be taken against humidity. Stanley Electric's UV-C LEDs ensure high moisture resistance and reliability by adopting a hermetically sealed structure in which the lens and package are sealed by metal, rather than using general resin bonding. The company also guarantees moisture-resistant operation for its products.

Optical technology applied in water disinfection modules

Optical technology developed for automotive headlamps: Thermal management technology

For disinfection products using UV-C LEDs as light sources, the management of heat generated by the LEDs is one of the technical issues to be solved when developing modules or finished products. The power lost by LEDs becomes heat, and this could shorten the life of LEDs. Therefore, thermal management technology of the substrate and modules on which the LEDs are mounted is a key factor.

The heat sink of the UV-C LED reactor uses technology developed for automobile headlamps, which enhance heat dissipation performance while reducing size and weight to the maximum extent possible. The adaptation of this thermal management technology has resulted in compact, lightweight heat-dissipating components that matches the functional characteristics of the UV-C LED reactors.

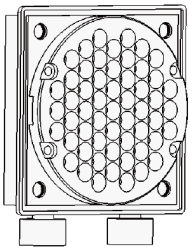


Optical technology developed for automotive headlamps: Optical designs

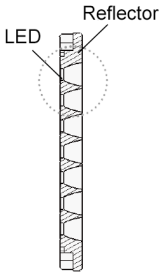
Optical designs for automobile headlamps is also used in the development of UV-C products. While ultraviolet light has a bactericidal effect, it also has negative effects on the human body as well, so it needs to be used safely.

In the UV-C LED reactors mentioned above, reflector technology is used instead of resin-based lenses to control irradiation. Resin lenses cannot be used as they deteriorate due to UV radiation, so the light distribution is controlled by optimizing the reflectors, making it possible to evenly irradiate UV-C radiation to water and others flowing in the pipes.

Optical structure of UV-C LED reactor



LED module

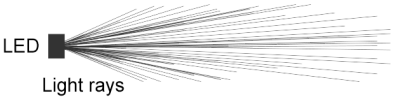


Cross-sectional view of LED module

Image of controlled irradiation with reflector

No reflector

Light is diffused and only irradiated at the area drectly in front.



With reflector

Light is concentrated and irradiated over a distance.

Applications and future uses

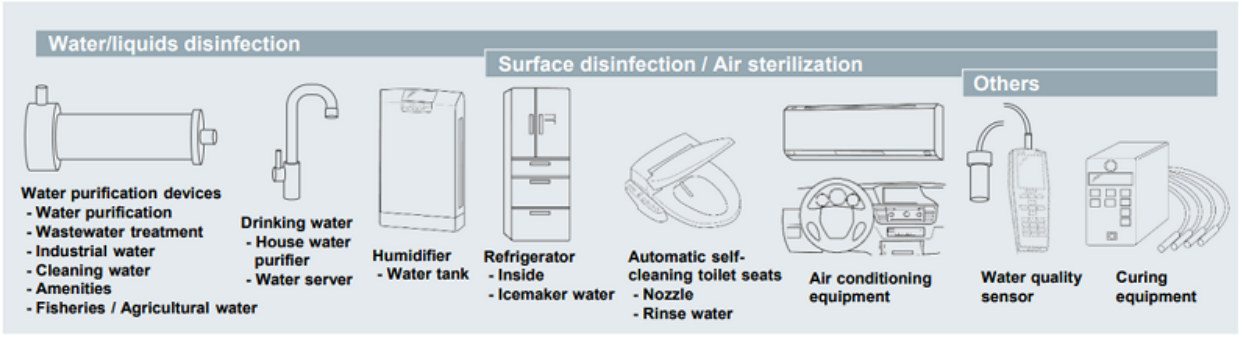
"ZEUDE265" and "ZHUDE265" are the UV-C LED series with a high light output of 200mW. They apply an emission wavelength of 265nm to achieve high disinfection performance. The main applications are water, air, surface disinfection, and are especially expected to replace conventional mercury lamps, which have long been used for water disinfection.

The advantages when compared with mercury lamps are compactness, fast start-up when switched on and resistance to repeated switching on and off, as well as mercury-free, which is an important issue in recent years with regard to environmental issues. It also enables inactivation of harmful micro-organisms and cryptosporidium (which was not possible with chlorine). UV-C disinfection is expected to expand its use in the future as a technology that can provide safe and secure water to the world.

★Advantages over mercury lamps

- ✓ Highly effective emission wavelength for disinfection (LED with 265nm)
- ✓ Compact
- ✓ Mercury-free
- ✓ Fast start-up when switched on
- ✓ Resistant to repeated switching on and off lighting

Applications



Product lineups & Specifications

Part Name			ZEUDE265 (Multi chip)	ZHUDE265 (Single chip)	Units
Basic Characteristics	Wave length	λp	265		nm
	Light output	Po	200		mW
	Forward voltage	V_F	28.0	7.5	V
	Sorting current	I_F	400	1,700	mA
Absolute maximum ratings	Junction temp.	Tj	100	100	℃
	Thermal resistance	$Rth_{(j-s)}$	3.3	3.0	℃/W
	Operating temp.	Topr	-30～+85		℃
	Storage temp.	Tstg	-40～+100		℃
Size		L×W×H	4.1×4.1×3.0		mm

*Specifications listed above are subject to change.
*Junction-Soldering point

Summary

Stanley Electric has produced UV-C LEDs that achieves the industrial-leading level of disinfection performance by combining its technological platform developed for automotive headlamps with its own technologies, including AlN substrates. UV-C LEDs are expected to replace mercury lamps, which have been the standard, as a UV light source and are expected to be used in a variety of applications. At the same time, the challenges are to improve luminous efficiency and further enhancement of the output. Therefore, Stanley Electric will continue to promote further enhancement of the output by utilizing strength of its in-house production system, from light sources to modules and finished products. And they are aiming to acquire greater share of the global market where UV-C LEDs adoption is expected to expand in the future.

For more details...

- 200mW high power UV-C LED series with wavelength of 265nm
- Advantages of Stanley Electric's UV-C technology
- Advantages of Stanley Electric's UV-C LED
- How UV-C works in our daily lives
- AlN NUV (Stanley's UV-C products brand) products
- Inquiries

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