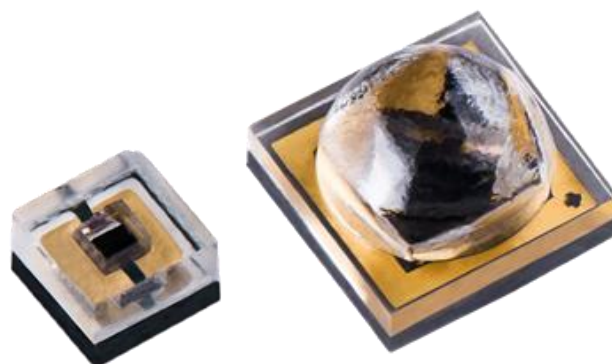


UV-C LEDs for Disinfection and Sterilization



Luminus UV-C 1313 and 3535 280nm devices

Summary

Luminus' ultraviolet portfolio includes UV-A, and UV-C LEDs in a range of power options and package configurations to support the broadest use across a range of industries. Radiation in the UV-C range is described as being germicidal and having a wavelength between 200 nm and 280 nm. UV-B with a range of 280nm to 315nm is commonly used for phototherapy and vitamin D production, and UV-A, with a range from 315 nm to 400nm is typically used for curing applications in industry. Radiation above 400 nm is in the visible range of light and may also have some germicidal capabilities over extended periods of time. Bacteria, viruses and fungi may be targeted for disinfection or sterilization; collectively we refer to these as germs.

Advantages of Luminus UV-C LEDs

- The technology is very effective and can be easily targeted.
- It does not alter water quality.
- It's a relatively inexpensive technology to and offers low operating costs.
- The footprint is extremely small allowing integration into a broad range of applications.
- The technology is easy to operate.
- No chemicals are used or added.
- Disinfection is very fast.

Ultraviolet Light for Disinfection and Sterilization

Though the generally accepted wavelength range for UV-C is 200 nm to 280 nm, researchers now consider the ultraviolet germicidal range to extend to 300 nm. Exposure to germicidal light initiates a photochemical reaction within germs that destroys their DNA, RNA and/or proteins, which in turn renders them unable to replicate. While it is not the case that the germs are ‘killed’, a colony of germs is effectively destroyed as a result of the exposure. The degree to which a colony is impacted is the sterility assurance level (SAL). In the laboratory setting, this is a logarithmic measurement and may be reported as 1 Log to 6 Log. The common representation of these measurements is as a percent effectiveness as shown in Table 1. The typical example is for a colony of one million germs. The effective percentage is commonly published on the packaging of household cleaning solutions. A 6 Log, or 99.9999% elimination of germs is generally considered to be the level required for sterilization in a medical facility.

Table 1: Sterility Assurance Levels on a colony of 1M germs.

| | Number of germs remaining | Germicidal effectiveness |
|-------|---------------------------|--------------------------|
| 1 Log | 100,000 | 90% reduction |
| 2 Log | 10,000 | 99% reduction |
| 3 Log | 1,000 | 99.9% reduction |
| 4 Log | 100 | 99.99% reduction |
| 5 Log | 10 | 99.999% reduction |
| 6 Log | 1 | 99.9999% reduction |

Germicidal effectiveness of Luminus UV-C chip technology.

To support the design-in of Luminus' UVC LEDs into applications, an antimicrobial efficacy study was conducted to evaluate the ability of Luminus' UV-C LEDs to inactivate microorganisms common to our daily life. The microorganisms included in the study were E. Coli, Staphylococcus Aureu (MRSA) and Monilia Albican. The inactivation of the microorganisms was evaluated under different drive currents, treatment time conditions, and distance. Treatment of the inoculated surfaces and the UV-C module test was performed by CMA & CNAS certified laboratory - SSCTA Chemical Lab in Qingdao City, China.

Material & Methods

The test microorganisms consisted of E. Coli ATCC 25922, Staphylococcus aureu (MRSA) ATCC 6538 and Monilia Albican ATCC 10231. Each test organism was cultured separately and ahead of each designed test. The inoculation area on the coupons was 16 cm² in size, placed under the UV-C LED module. The UV-C LED module, consisted of LED chips that emit radiant power between 276 nm and 283 nm and provide surface disinfection capabilities. The UV-C LED module was placed from 10 mm through 100 mm above the inoculated coupon with the specified drive current and treatment time for each microorganism. An untreated control of all microorganisms was included in the study. Following the UVC LED treatment, the inoculated 16 cm² plates were incubated for 48 hours before a count was performed and recorded as CFU/sq cm.

Results

The controls of all three microorganisms, E. Coli, Staphylococcus Aureu (MRSA) and Monilia Albican were all in the targeted 4 log reduction range, with 99.99% of disinfection results. The count performed after 48 hours shows that the UV-C module successfully disabled the DNA & RNA of the microorganism rendering it unable to replicate. The results shown in Table 2 demonstrate successful disinfection of E. Coli & Staphylococcus Aureu (MRSA) with both 278 nm and 280 nm modules with drive current set to 100 mA and a shorter duration of 10 seconds.

Table 2: Surface Efficacy Test Configuration Results

| Microorganism | Drive Current (mA) | Setup Distance | Module Wave-length | Treatment Time (secs) | Untreated Control (CFU/plate) | After Treatment (CFU/plate) | Log Reduction | Efficiency (%) |
|---|--------------------|----------------|--------------------|-----------------------|-------------------------------|-----------------------------|---------------|----------------|
| Escherichia coli ATCC 25922 | 100 | 10mm | 278nm | 20 | 1.86 x 10 ⁶ | < 1 | ≥3.00 | > 99.99 |
| | 350 | 10mm | 278nm | 20 | 1.53 x 10 ⁶ | < 1 | ≥3.00 | >99.99 |
| | 350 | 100mm | 278nm | 20 | 1.29 x 10 ⁶ | < 1 | ≥3.00 | >99.99 |
| Staphylococcus Aureu (MRSA) ATCC 6538 | 350 | 10mm | 278nm | 20 | 1.49 x 10 ⁶ | < 1 | ≥3.00 | >99.99 |
| | 350 | 10mm | 278nm | 10 | 1.50 x 10 ⁶ | < 1 | ≥3.00 | >99.99 |
| | 350 | 10mm | 282nm | 20 | 1.13 x 10 ⁶ | < 1 | ≥3.00 | >99.99 |
| Monilia Albican ATCC 10231 | 350 | 10mm | 278nm | 20 | 1.13 x 10 ⁶ | < 1 | ≥3.00 | >99.99% |

Conclusion

The test configurations included in this study, consisting of wavelengths, drive currents and treatment times, were effective at reducing levels of all microorganisms tested at 4 log. The lower drive current and treatment times were still able to demonstrate successful disinfection of 99.99%. The module used for antimicrobial efficacy test produced 29.26 mW @ 100 mA and 117 mW @ 350 mA drive current.