PRO PHOTONIX

Advantages of UV LED Curing Systems

Whitepaper

Optimizing Illumination in **Line Scan Vision Systems**

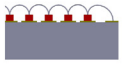
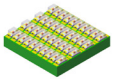
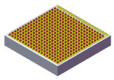
In recent years, UV LED based lamps have started to replace mercury lamps in industrial printers, 3D printers and production lines for curing of adhesives, inks and coatings. This trend is set to continue with Yole Développement estimating the UV LED industry will have a Compound Annual Growth Rate (CAGR) of 40.7%1 between 2014 and 2019. This whitepaper discusses the advantages offered by LED-based systems and the limitations of traditional lamp technologies.

LEDs – A Mature Reliable Technology

LED lamps reliably provide reduced downtime, long lifetimes, and low costs of ownership. LED technology has been a standard technology utilized for decades in commercial and industrial lighting markets and more recently in residential. The emerging UV LED market is leveraging all the expertise and supply chains built up within the wider LED industry to ensure a high performing reliable solution. Due to the sizeable number of well-established LED chip manufacturers, UV LED technology will progressively improve year-on-year leading to devices with more power, reduced cost and increased efficiency as has happened in the preceding decades at visible and infrared LED wavelengths. There is a growing selection of UV LED wavelengths commercially available today in the UV-A ranges with UV-B and UV-C LEDs recently commercialized. UV LEDs will follow a predictable price decline and improved power and efficiency over the next few years.

Flexible Form Factors

LED technology is fundamentally a more compact technology than traditional lamps due to the LED packing densities possible. LEDs can be implemented into various form factors via a number of packaging methods. Chip-on-Board (COB) LED technology describes the mounting of a bare LED chips in direct contact with a substrate to produce LED arrays and is the most popular packaging technology utilized in UV LED lamp manufacture. It is a method of LED packaging which has a number of advantages over conventional LED technologies such as "T-pack" and Surface Mount LEDs (Table 1). A packaged or surface mount LED has an optical lens, bonding wire, electrodes, and resin to encapsulate the LED for protection. Surface Mount Devices offer higher packing density over T-pack though still significantly less density than COB. Due to the small size of the LED chip relative to a packaged LED, COB allows for a much higher packing density than surface mount technology.

LED Type	T-Pack	Surface Mount	Chip on Board
Device Image			
Packed Array (10mm x 10mm)			
Density	9 LEDs	40 LEDs	342 LEDs
Array Power	0.4 Watts	4 Watts	68 Watts

These options allow much greater design flexibility for varying applications, resulting in greater spectrum accuracy and uniformity for the end user. For example, LED substrates can be designed on flexible substrates, on spherical substrates or as in the ProPhotonix COBRA Cure FX Series, the LED chips can be placed with an asymmetric distribution so that a higher distribution of LEDs is located near the edges of a lamp to mitigate shadowing effects. This results in higher intensity and greater uniformity for the user in a smaller space relative to traditional lamps. Today, UV LED lamps are commercially

available in many form factors: for example, compact modular systems, medium sized stackable lamps integrated into production lines or large-scale systems where space is not a major constraint.

Multi-Wavelength Capability

LED technology allows lighting designers to work with any available wavelength, with the added advantage of allowing multiple wavelengths to be packed closely together for optimum blending of the light. LED sources provide users with greater opportunity to optimize their curing system by designing a multi-wavelength system that closely matches the absorption spectrum of the media being cured leading to greater production efficiencies. This spectrum can be designed with finely tuned spectra with precise control and real-time monitoring to ensure repeatable performance throughout the lifetime of the light. Specific sections of the light can be controlled allowing the user to vary the intensity over the illumination area.

Precise Control

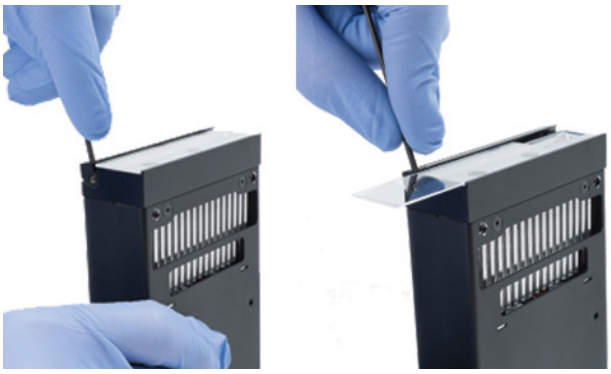
An LED-based system, even with thousands of devices, can be much easier to service than traditional lamps. For example, each of the strings can be individually controlled by individual driver circuitry. This localized control of LEDs allows for more precise adjustment of the LEDs in a lamp to improve overall stability and uniformity. LED lamps can be controlled via analog or digital means. The light-output intensity of LEDs can be precisely controlled to within microseconds, ensuring that the desired emission spectrum is achieved. As a digital technology, LEDs work with multiple communications protocols including Ethernet, I2C, RS485 and Analogue. Communication with the lights can be implemented in special circumstances using optical communication (optical fiber) rather than electronic communication when electronic noise in the working environment is an issue. Due to the ability to monitor and drive each LED segment, the COBRA Cure™ FX Series offers excellent intensity control, ensuring that uniformity and intensity are maintained across varying conditions and over the lifetime of the lamp.

Stability

Using electronic software control, the light-output intensity of the LEDs can be kept stable for a long time. Importantly, this level of control is scalable for systems ranging from a couple of LEDs to thousands of LEDs. From an electrical standpoint, LEDs are also more energy-efficient than mercury lamps, as they operate on low voltages that make them electrically simpler and safer.

Reduced Downtime

For applications where the LED curing lamp is positioned very close to the print surface, a build-up of the printed material on the emitter window can occur over time. Sometimes when the ink leaves the print head it does not hit the substrate surface. Instead it is carried in the air flow and deposits itself over time on the window surface. A second scenario occurs as a result of the close proximity between the substrate and the curing lamps. On occasion, a head strike occurs where a larger than required drop of material gets deposited on the window surface. In both scenarios the material cures on the window of the UV LED module, resulting in blocking of UV light exiting the module. To counteract this, the UV LED lamps windows are routinely cleaned to remove the cured material. The problem with this method is that it leads to scratches on the window surface which can affect the light output. Alternatively, The COBRA Cure FX Series can be specified with a removable window where the window can be quickly exchanged for a new one reducing downtime.



Heat Sensitive substrates

Very little heat is generated from the LED output onto the substrate being cured. This "cold cure" characteristic of LEDs is important for applications where heat sensitive polymer, paper, substrates are utilized. No shutters or high-voltage igniters are required.

Instant-On

LEDs are instant-on, requiring no warmup time, and can be configured to output light in continuous, flashed or pulsed modes across a wide dynamic intensity range while maintaining the desired spectral distribution.

Real-time Monitoring

To ensure stability across the lifetime of the lamp, various monitoring functions can be built-in to the lamp such as thermal monitoring of the LED substrate temperatures, short circuit monitoring, or in-rush voltage protection. Safety features can be built in where the lamp itself or the OEMs system can send commands to the lamp to shut down for protection of personnel or the lamp itself.

Environmentally Friendly

LEDs are more environmentally friendly than traditional technologies because they emit no harmful UVC and do not contain toxic heavy metals, such as mercury. Thus, heavy metal disposal is eliminated. LEDs can also tolerate higher ambient operating conditions than traditional lamp technology. Consistent output over the operating life of a UV LED module can be maintained using software, resulting in a long life expectancy.

Ease of Installation

A key consideration with any new system is the ease of installation into your system. The COBRA Cure FX Series has been designed to optimize the compactness offered by an LED solution. ProPhotonix COBRA Cure FX provides a number of mounting options and industry standard electrical connections to ease integration into systems.

Cost Benefits

Compared with traditional lamp systems, LED systems offer significant benefits over the life of the lamp. Mercury lamps have short lifetimes and so require frequent replacement. This makes the lamps an unsatisfactory tool for production lines where down time may cost thousands or millions in revenue per hour. Operating costs of LED based systems will be lower due to instant-on/off. Maintenance costs will be lower because of the extended life of LEDs. LEDs do not require ancillary components such as filters and venting system. Operating efficiency is improved as a result of the unique control capability of light uniformity, speed of flash and precise spectral output. As a result, while the up-front cost of traditional lamps is relatively cheap, the cost of ownership over their lifetimes is high when you factor in acquisition and running costs, maintenance and environmentally safe disposal.

Conclusion

Selecting the best UV LED curing lamp, the optimum wavelength and utilizing the correct curable media will improve cure quality, increase throughput and deliver consistent performance over time. When considering a UV LED lamp, be aware that significant differences can exist in the optical output, expected lifetime and performance. The LED lamp performance depends on how well the module is designed and manufactured. With more than two decades of experience in the design and manufacture of LED systems for OEMs and fifteen years of experience

in developing UV LED systems, ProPhotonix is well positioned to deliver the optimum UV LED curing system for your application.

Following several years of research as well as extensive customer trials, ProPhotonix has recently launched the COBRA Cure FX Series. The new product range, designed specifically for UV Curing of inks, coatings and adhesives, incorporates decades of expertise in LED technology as well as a number of unique features including the field replaceable window. Offering intensity of up to 16 W/cm2 or up to 42J/cm2 from a compact, fan-cooled system, the COBRA FX Series has been designed to be configurable ensuring that you have the flexibility to select the right solution for your system. To find out more about the COBRA Cure FX Series, visit http://www.prophotonix.com/led-and-laser-products/UV-Solutions/

References

1. UV LEDs: Technology, Manufacturing and Application Trends, 2015, Yole Développement.

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