

UV-LED vs. conventional UV Technology

Is LED the UV technology of the future?

An objective comparison between LED and UV technology

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Is LED the UV technology of the future?

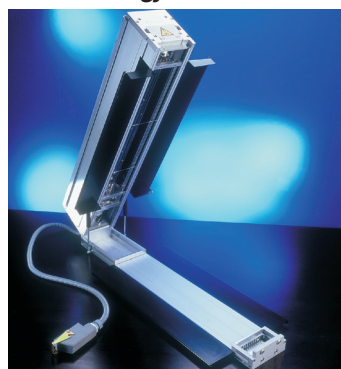
For many years UV technology has been a reliable method for the curing of photo-reactive chemicals. In response to increasing production speeds and new applications, e.g. in the field of 3D, UV lamp technology has also developed. Today, a great variety of different systems are available, each specific to the particular application. Users and providers of chemistry are constantly developing new applications for UV curing. Their innovative ideas often mean increasing demands on UV curing devices – where sometimes conventional UV technology has reached its technical limits. Thus, within the recent years, a completely new branch of UV technology has developed: UV LEDs.

This report provides the reader with an objective comparison between both technologies, UV and UV LED. It should help the user determine to what extent LEDs can provide an alternative to conventional UV solutions.

Comparison of technologies

The operating technology of conventional UV lamps is based on plasma physics and optics, whereas UV LEDs are based on semiconductor technology and optics.

UV technology

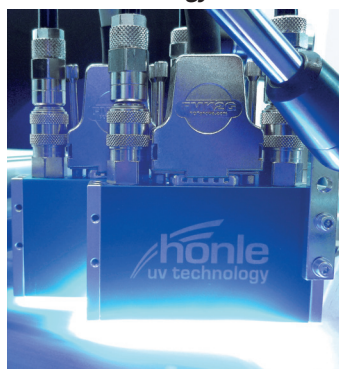


UV print unit for web materials

A high-voltage arc between two electrodes leads to the vaporization of mercury and any optional doping within the lamp. A continuous UV spectrum between 200 nm and 450 nm is emitted.

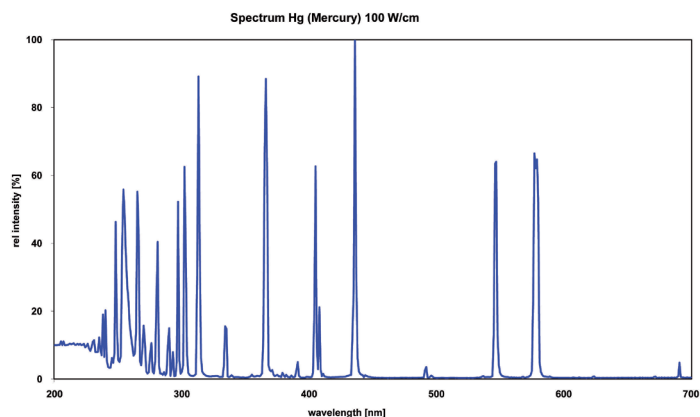
A continuous UV spectrum between 200 nm and 450 nm is emitted.

UV LED technology



LED Powerline

LEDs are based on semiconductor technology. Specific wavelengths are directly emitted by the current input. The spectrum is a quasi-monochromatic radiation in defined wavelengths, e.g. 365nm, 385nm or 405nm.



These technological differences lead to the following characteristics:

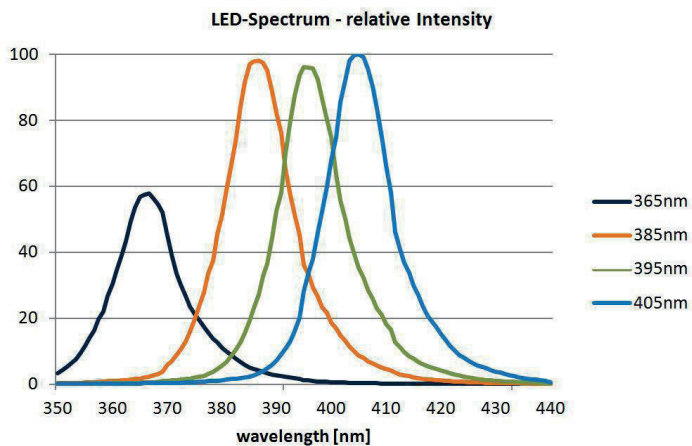
Medium-pressure lamps

| | |
|-------------------|---|
| wavelength [nm] | spectrum between 200 and 400 |
| ozone generation | yes |
| thermal radiation | yes |
| effectivity | ca. 30 % |
| required space | depends on application |
| operation | warm-up phase standby-mode (15-40%) shutter needed |
| cooling | air and/or water |
| typical lamp life | 1.000 - 5.000 h |
| maintenance | Easy control via UV measurement device. During maintenance only one irradiator needs to be exchanged for one lamp system. |
| purchase costs | low |

LED

| | |
|-------------------|---|
| wavelength [nm] | 365, 385, 395, 405 no short wavelengths |
| ozone generation | no |
| thermal radiation | no |
| effectivity | 25 - 50% |
| required space | low |
| operation | no warm-up phase instant switch-on and -off no shutter needed |
| cooling | water or air |
| typical lamp life | > 20.000 hours* |
| maintenance | Difficult controlling of the particular dies. In case of a break-down, the complete module needs to be exchanged. |
| purchase costs | higher |

* depending on operating conditions and ambient temperature



Inks, varnishes and adhesives

In conjunction with UV lamp technology, coating formulations have been optimized and adapted to the requirements of conventional UV technology over the past decades. This led to a wide variety of coatings, including low-migration varnishes and inks. So far there are only few optimized systems available for UV LED applications. One reason is due to the lack of suitable raw materials and photo-initiators. Due to the fact that the main emission wavelength of UV LEDs is in the UVA range, only “long-wavelength sensitive” photo-initiators can be used. This can result in insufficient surface curing.

To match the curing properties to those of conventional systems, the concentration of photoinitiators may possibly have to be raised. But such systems can have disadvantages, e.g. yellowing, intense odour or lower production speeds. In addition to this, UV LED formulations are more expensive than conventional UV coatings.

The chemical industry, including the raw-material suppliers, can help to optimize the system; cooperation between equipment, raw-material and coating suppliers is of paramount importance. Suppliers of UV LED curing devices can play a significant role in supporting the chemistry in the following areas:

- technological R&D training for employees
- providing adequate curing devices
- joint projects with end users
- support of raw material suppliers
- continuous further improvements, for example inertisation for LEDs

Fields of applications

LED technology is already well established in several areas. Significant advantages of LEDs in these applications and the possibility to modify the chemistry to the specific emitted wavelengths, lead to their success in these markets. An example of this can be found in the adhesive business.

UV LEDs for adhesive curing

Adhesives are often applied at higher coating weights, or the irradiation needs to occur through an absorbing substrate. Therefore the reactivity of these systems traditionally lies in the UVA and UV visible region. Furthermore, the adhesives do not contain pigments that may influence the curing process. These are the main reasons why the modification of the chemistry to the narrow, longer-wavelength, emission band of LED's has proved successful in this area.

Another advantage that makes it suitable for LED curing, is the relatively slow process speed (compared to print applications). The system technology also offers several benefits compared to conventional UV curing:

- compact assembly size
- no thermal load of substrates (can have a negative influence on chemistry)
- easy handling in cyclical operation
- best effective production due to life-time of LED devices (long life-time)
- effective light shielding to avoid premature curing in the application system

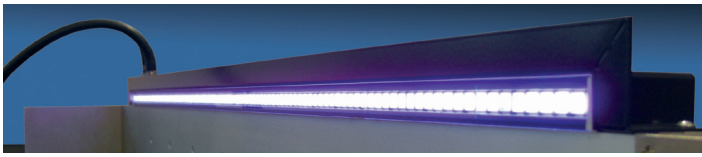
The combination of chemistry and UV LED curing devices is so successful that this application can be seen as a **real driver behind the development of LED curing technology** as a whole.

Based on the positive experiences gained from this application, LED technology has been continuously optimized, developed and transferred into other areas.

LED point and spot curing devices are mainly used for adhesives or conformal coatings.

UV LED curing in printing

Some inkjet applications profit from the advantages offered by LEDs. There are already applications running in the small format area, which benefit from the advantages of smaller dimensions and the cyclic operation mode of LEDs. The LED Powerline was developed for wide format and web printing applications. This LED line can be extended in 40 mm steps. Besides, it is possible to vary the output in 1% steps between 10% and 100%. Another advantage: Complete irradiation cycles can be programmed.

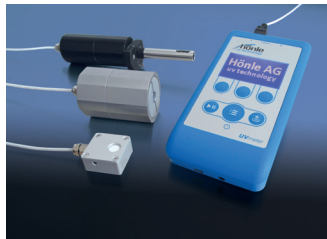


1.000 mm long LED array for printing applications

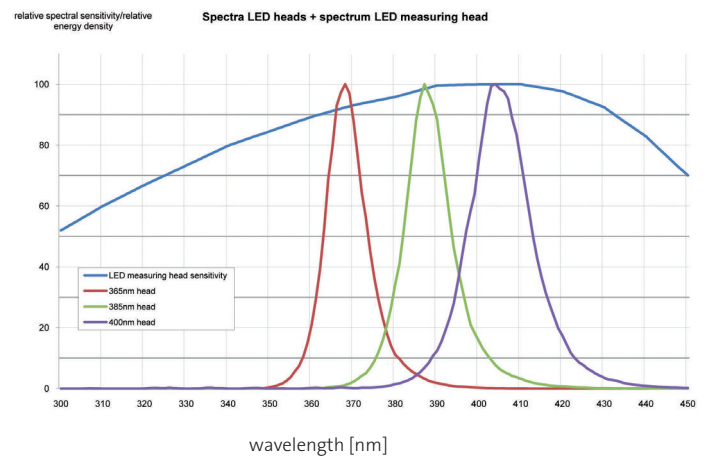
After previous determination of the reactivity of printing ink or coating the LED Powerline can be equipped with the appropriate LED wavelength.

UV LED measurement

UV measurement assures production process security and for research and development, reliable and repeatable test results in the laboratory. The market offers a selection of devices for measuring the intensity and/or the dose with different sensor geometries which can be easily matched to the specific application. The physical classification of the UV spectrum in the UVA region is from 400-315nm, UVB from 315-380nm and UVC from 280-200nm, in most cases the spectral sensitivity of the sensor is adapted accordingly. The specific characteristics of a broad UV spectrum can therefore be analysed in detail. However, LED irradiation units do not produce a broad UV spectrum, but emit narrow bandwidths at specific wavelengths. Therefore, any intensity measurement of these bandwidths with conventional sensors is inaccurate.



To enable the measurement of LED UV units, Dr. Höhle AG has developed a broad band sensor which can measure the intensity and the dose across the bandwidth of all LED-wavelengths from 365 to 405nm - with only one sensor. The UV LED measuring sensor is attached to a standard UV meter which automatically identifies the LED sensor when connected. The measured value for the intensity is displayed in W/cm^2 or mW/cm^2 with a maximum intensity of $30W/cm^2$, for the dose it is displayed in J/cm^2 or mJ/cm^2 .



Conclusion

Compared to conventional UV irradiators, it's clear that LEDs can offer many advantages in a variety of coating applications. However there are some restrictions, governing or preventing the use of LEDs. The benefits of LED curing should be carefully considered, case by case.

Dr. Höhle AG can offer information, advice and technology to assist you in making these decisions. As a specialist in industrial UV technology, Dr. Höhle AG has been successful in the development and production of UV LED curing devices for many years. We have now utilised our significant experience of UV LED curing and applied it to the coating market, through competent training courses, discussions with the equipment suppliers by supporting the chemical industry and end users.

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