

White LEDs – Light Emitting Diodes – appeared on the market in the mid 1960s and soon became the focus of the large illuminant manufacturers. Continuously developed since then, they are increasingly gaining acceptance for illumination applications.

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Due to their extraordinary properties LEDs are eminently suitable for illumination applications in the fields of Machine Vision and Stereo Microscopy.

- ▶ LEDs are very reliable, long-lasting illuminants with low maintenance requirements. As DC voltage components they do not show 100 Hz flickering – unwanted beats or overlapping when using CCD cameras do not arise.
- ▶ LEDs can be continuously dimmed down to zero percent light. Their „instant start“ property facilitates strobe operation as well as externally triggered pulse operation.
- ▶ Insensitivity to motion and vibration as well as their low weight make it possible to use LEDs in moving Machine Vision applications (for example on robotic arms).

Similar to fiber optic light guides, because of their small size, LEDs can



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White LEDs

Extraordinary illuminants brighten up the industry

be used to produce special illumination components that provide optimum contrasting for specimens in Machine Vision and Microscopy (ringlights, lightlines, backlights etc.). Through their excellent electronic controllability these illuminations possess properties which would be difficult to achieve using fiber optics:

- ▶ It is easy to develop LED components, for example ringlights, that can be controlled in segments. In this way a significant contrast enhancement is achieved compared with full circle illumination. The rotation of the light segments around the specimen also conveys a feeling of space, especially when viewed on a monitor.

- ▶ When steering several illumination components via a common control unit it is easy to generate mixed light and to quickly switch over between different types of illumination without difficulty (for example „brightfield _ darkfield“ or „incident light _ transmitted light“).

- ▶ Last but not least intelligent control units make it possible to completely control the LED illuminations by PC. This facilitates exact specification of illumination settings as well as archiving and reproducible reloading.

The devil is in the detail

Due to a flood of at times contradictory articles and product brochures, unfortunately over the past few years often a distorted image of LEDs has arisen:

„LEDs illuminate with constant brightness over a lifetime of 100,000 hours, without generating any heat worth mentioning. Anyone who knows how to handle a soldering iron can manufacture LED illuminations.“

This must be countered with the fact that detailed analysis of the properties of LEDs and the resulting consequences for designing illumination components represent an absolutely vital foundation for the development of long-lasting, high-quality LED systems!

Statistical reliability

The reliability of LEDs is, as is the case with many electronic components, specified by the MTBF data (mean time between failure).

Using the MTBF, the statistical mean time between two LED failures, and with the help of the expected operating hours, the annual failure rate of the LEDs can be calculated.

To determine the MTBF a large number of components are operated over a limited time span. In doing so the reasons for failure are based on pure statistics.

“You test, for example, 1,000 LEDs over a period of 100 hours. If no LED fails then the MTBF is more than 100,000 hours.“

Currently, many white LED types are specified with a MTBF of 100,000 hours! In the case of continuous operation over a year, corresponding to 8760 operating hours, the resulting annual failure rate is 8.76% (8760 hrs operating time / 100,000 hrs MTBF)!

► In order to avoid a whole LED cluster in an illumination component failing when one individual LED suffers open circuit failure, the LEDs should not be operated simply in a row, but rather wired as a matrix.

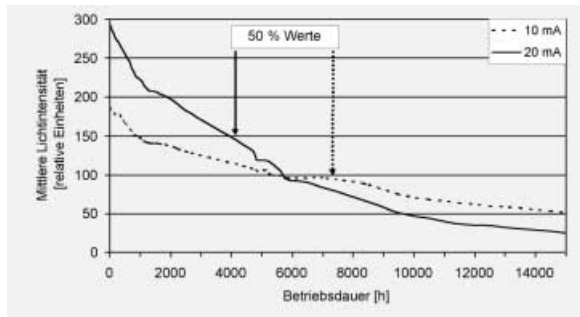
► Electrostatic discharges can cause LEDs to fail. LED illuminations should be designed in such a way, that electrostatic discharges are drained off not through the LEDs but over the housing.

Lifetime measurements up to the actual failure of a large number of components, usual standard with halogen lamps, are largely not carried out on LEDs! Thus LED lifetimes are normally not specified. Impermissible confusion of MTBF specifications with LED lifetimes leads to these rumors of eleven years respectively 100,000 hrs operation time!

Well-cooled ... lasts longer

When determining the MTBF and annual failure rate the drop in brightness of LEDs due to aging (degradation) is not taken into consideration at all! Degradation occurs with all types of LED, but to a greater extent with white LEDs, as the fluorescent dyes contained in them fade over time and the epoxy material of the LED lens cap also becomes cloudy.

The degradation noticeably increases when the LEDs are subjected to rising ambient temperatures and amperage. In particular, when the maximum temperature



Brightness reduction of white Nichia LEDs, NSPW Series, amperage 10 mA or 20 mA, TU=60°C, endurance test conducted by Schott Glas

specified by the LED manufacturers is exceeded the drop in brightness due to aging accelerates drastically.

The results of an endurance test carried out by SCHOTT can be seen below. They clearly show the increased degradation of the LEDs operated with 20 mA, where the maximum ambient temperature permitted had already been exceeded, compared with the light diodes driven with 10 mA!

Assuming that in the field of Machine Vision / Microscopy LEDs have to be replaced after a too severe drop in brightness, then the lifetime of LED illuminations can be defined as the time period, after which the light intensity of an LED illumination component, under constant ambient and operating conditions, has dropped down to 50% of the initial value!

► This „fifty percent lifetime“ depends to a large extent on the design of the LED component! It is extremely important to design LED illuminations in a manner that the

heat generated during operation is efficiently channeled away from the LEDs.

► With the aid of a temperature measurement system in the LED illumination component and a logic evaluation board that links these values to the LED amperage, an efficient thermostatic guard is created. According to the application, when the maximum temperature is reached this can automatically dim or switch off the LED component, give off a warning signal or activate forced ventilation.

► Brightness fluctuations are often undesirable in Machine Vision applications. Using a brightness measurement system integrated in the LED components and a connected light feedback control, the degradation can be compensated for and a constant brightness of the LED illumination achieved.

► Too strong an energy deposit in the externally triggered pulse operation or strobe operation accelerates degradation and LED failures. Intelligent LED controllers, therefore, monitor whether the pulse intensities and pulse intervals permitted in the specifications are kept to.

► High-quality white LED illuminations with thermostatic guards currently achieve 50 percent lifetimes of around 5,000 to 10,000 hrs operating time. So with white LED illuminations the exchangeability of the light diodes within the framework of a service should be made possible!

Blue, yellow, white...

White LEDs contain a blue semiconductor chip in which a yellow fluorescent phosphor is embedded. An impression of white results from the interaction of both spectra. Because of the blue excitation peak

the color temperature of white LEDs is often above 9,000K.

By carefully specifying the chromaticity coordinate class of LEDs color temperatures under 6,000K can be achieved in the area of illumination, which is very close to 5,600 K, the color temperature of daylight.

With increasing degradation the chromaticity coordinate of white LEDs moves unsystematically in the direction of bluish or yellowish. The previously described actions to reduce the degradation help to slow down this color shift.

As white LED illuminations do not come close to achieving the color rendering index of halogen light, for applications requiring realistic color rendering, fiber optic illuminations with halogen reflector lamps should be used.

Compliance with ... laser standards

LED systems sold in Europe must conform with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and bear the CE Conformity Mark. In the case of illuminations for Machine Vision and Microscopy applications this means that the standards IEC 61010-1 and IEC 61326-1 relating to electrical laboratory appliances have to be adhered to.

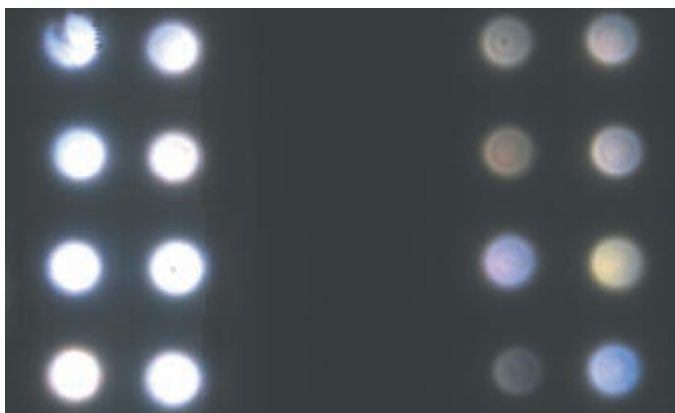
What is less known is that every LED illumination also has to be classified in accordance with the standard IEC 60825-1 „Safety of laser products“!

► When developing LED illuminations care should be taken that they comply with Laser Class 1. LED components assigned to other laser classes must bear warning labels and require design measures that prevent the user or service staff being exposed to laser radiation above the limit values of Laser Class 1.

► Every LED illumination must be evaluated individually. To get a Class 1 LED component it is not sufficient to simply use Class 1 LEDs.

Dependent on the design of the illumination groups of the contained LEDs might exceed the maximum exposure levels even if each single LED complies with Laser Class 1.

► The operating instructions for any kind of LED illumination must explicitly include the assigned laser class!



Color location drift of white Nichia LEDs, NSPW Series, after 15000 hours in operation at TU=60°C. Amperage „left“ 10 mA, „right“ 20 mA. Intensified degradation and color location drift, as well as total failure in the right-hand half of the picture, due to exceeding of the maximum temperature permitted for 20 mA