Press release
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LED lighting in art

On high-fidelity rendering of light

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LED lighting: curse or blessing? For a long time, there had been rather fierce discussions about this topic. But in the end it was the positive experience obtained from practical application of the technology in museums and, among others, the ground-breaking scientific studies by Zumtobel that have removed final doubts about this milestone in the production of light. Light generated by semiconductors has finally entered the world of museums in 2012 and impresses above all with new prospects, such as the modification of light colours within a light source with very good colour rendering properties (Tunable White).

The continuous dynamic development of optical semiconductor technology offers undreamt-of possibilities for the interaction between people and art objects. However, it also provides new challenges and opportunities for museum and lighting experts, and not only from a technical point of view. Lately, the discussion regarding LED technology has been dominated by two issues in particular: what chances do LED spotlights offer to present exhibits in the right light and, thus, to make a positive contribution to the perceptive world of visitors to museums? Are light-emitting diodes indeed a revolution in terms of damage prevention to exhibits, or do they perhaps deprive future generations of their cultural heritage? Thanks to comprehensive research and studies, lighting expert Zumtobel has found answers to precisely these questions that are based on sound scientific knowledge.

Picasso brings it to light – the high quality of LEDs in museums

Zumtobel has commissioned the Lighting Technology Department of Darmstadt University of Technology to conduct a survey that deals with this very issue. Evaluation parameters of particular relevance for art objects were especially important. These include both the electrical and photometric properties of luminaires, including light colour, spectral radiation distribution, colour rendering, illuminance, potential damage, the electrical installed load and, above all, the uniformity with which the painting is illuminated, since this is a measure of the quality of presentation. Two spotlights (LED and halogen), an LED arc used for indirect lighting and an

LED module were analysed in the laboratory. Following measurement, the damage potential of the luminaires according to CIE 157:2004[i] was evaluated. A field test should then confirm the determined values specifically for practical application.

For the field test, the study managers installed two different light sources, one after the other, directed onto Pablo Picasso's drawing "Harlequin" from 1916. One spot was equipped with conventional tungsten halogen lamp technology, the other with LED light sources. In the LED luminaire, light colour and luminous intensity were set via a control system from 2700 K to 6500 K, or from warm white to cool white (Tunable White). The analysis of the halogen spotlight is also based on its dimmed and non-dimmed state. For the "Harlequin", Picasso used a thin, lightly wavy paper attached to a heavy carrier paper. Since this technique, in terms of final composition, is most similar to rag paper, the characteristics of this type of paper were used by the study managers as a reference for evaluating the damage caused.

The results of the field study confirm Zumtobel's research work in the field of LED lighting. Basically, with comparable colour temperatures, potential damage caused by the LED spotlight in the laboratory is significantly lower; and this applies to all materials specified in CIE 157:2004 such as rag paper, textiles, water colours on paper rag as well as oil colours on canvas and newspaper. Due to the lower potential damage caused by LED spotlights, possible radiation duration with most materials can be increased by around 50 % and with newspaper by as much as 300 %. The measurements performed on the Picasso drawing also confirmed these results. Only with higher colour temperatures (from approximately 3250 K) do radiation times become comparable to the halogen lighting at 2050 K.

- The dimmed halogen spotlight generates white light with very low colour temperature, comparable to candlelight. Current supply must therefore be increased to create brilliant white light. The high illuminance generated in this way not only increased the potential damage, but also has a negative impact on the energy balance.

- By dimming the halogen spotlight to the required illuminance level, the light colour is shifted from 2900 K to 2000 K. This value impairs the stability of perception. With the LED spotlight, on the other hand, the illuminance level can be adjusted without the light colour being impaired.

- When it comes to colour rendering, both halogen and LED spotlights demonstrate very good values of Ra > 90. Only at higher colour temperatures such as 6500 K (cool white) is colour

rendering reduced to Ra 84 in the LED spotlight. Colours are thus rendered similarly well with both lamp types.

- The evaluation of the illuminance levels has shown that the halogen luminaire illuminating the “Harlequin” shows irregularities that are also revealed to observers. This criterion must, however, not be overvalued, because the uniform presentation of a painting is not always aimed at. Instead, an exhibit can be properly presented with intentionally implemented bright/dark zones as well.
- Input of electrical energy with the LED spotlight is around 50 % less than with a halogen spotlight; in the undimmed range it is as much as 30 %, which may amount to decisive potential energy savings.

The benefits of light-emitting diodes, such as long service life combined with low maintenance, high energy savings potential as well as impressive and simultaneously gentle presentation of exhibits, are undisputed. Another important aspect, however, comes to the fore because of the Zumtobel study: thanks to innovative technologies, it is now possible to enhance the effect of art objects on people. LED light enhances the power of expression, since not only luminance levels but also light colours can be finely tuned to specific exhibits according to colour or material – by pressing a button and without the need to replace lamps.[1]

A symbiosis of light and art – the Tunable White revolution

A painting with many fine grades of red will shine with its saturated colours and contrasts, but only if the light source as well as the selection and positioning of luminaires are perfectly matched to the prevailing ambient conditions. To achieve the best quality of perception, a light spectrum should be used for an art object that is characterised mainly by the long-wave, reddish spectral range, as light is able to reproduce those colours especially intensively and precisely that exist in its own spectrum.

When an art object is illuminated, the artist's colour selection, the location of creation and the lighting conditions prevailing at the time of creation (daylight or artificial lighting) must also be considered. These factors sometimes require completely different light colours and spectral distributions. This variation depth can, however, never be fully met by only one luminaire and lamp type. In practice though, often one spotlight or lamp type is used for an entire art gallery

[1] s. fact box 1: “The colour rendering index and its significance” following the press release as further reading material

as a compromise solution with mean intermediate white light colour and very good colour rendering. A pioneering alternative in this regard has come from semiconductor technology. A widely defined, finely tuned light spectrum can be individually adjusted to each object via LED luminaires with identical design – at the press of a button, with outstanding colour rendering and with optimum luminance of the exhibit. With modifiable white light, i.e. variations in light intensities and colours (Tunable White), works of art with mainly bluish or reddish colours or different materials can be equivalently presented without the need to exchange the lamps or spotlights.

In this way, a museum is ideally equipped for the future: when exhibitions are changed, the light is quickly adapted to new art works according to the wishes of the artist or curator and with relatively low maintenance effort. The lighting can be finely tuned in a way that was technically not feasible until recently. Using modifiable white light emitted by the same LED lighting solution, it is now possible to implement this quality of perception and equivalent display of art in a manner that can only be described in one word: perfection.

Incomparable: today's LED and yesterday's LED

However, another problem has resulted from the high development speed of semiconductor light sources: studies continue to be published that are based on obsolete technological standards, thus causing further uncertainty regarding colour rendering and potential damage with respect to LEDs.[2]

Warm white LEDs demonstrate the lowest peak in the low-wavelength, high-energy range. They therefore have a lower damage factor than LEDs with a high blue component (cool white). LEDs with warm white light quality have recently progressed rapidly in terms of development with colour rendering and efficiency. In addition, spotlights incorporating Tunable White technology provide new approaches: luminaires with adjustable white light colours ranging from low to high Kelvin values, i.e. warm white to cool white, can be precisely adapted to exhibits in fine gradations along the Planckian curve. The lowest Kelvin value (warm white) is set in the case of highly sensitive works of art, without any losses in terms of the luminaires' very good colour rendering. Lighting concepts incorporating Tunable White thus offer a variety of options for perfect adjustment to the art object and the needs of human perception.

[2] s. fact box 2: “Discussions on the use and quality of LEDs in museums” following the press release as further reading material

Adequate exposure to light – responsibility for the future

When discussing the potential damaging effects of light, in addition to spectral distribution, there are also other decisive factors of influence regarding lighting intensity and duration of exposure. For this purpose, Zumtobel provides also innovative solutions involving intelligent lighting management systems.

Lighting management ensures that exhibits are exposed to perfect light: on the one hand, by providing luminance levels that are necessary to ensure a good perception process and, on the other hand, by incorporating presence detectors that monitor the presence of visitors. Switch-on and switch-off times can be defined for specific times of the day. Management of blinds and daylight sensors ensures that only as much daylight is permitted to enter as is absolutely necessary, resulting in an ideal balance between architecture, human well-being, exhibits and energy costs.

Moreover, LED technology is the perfect solution to be integrated in lighting management systems. The semiconductors are not impacted by frequent switch-on and switch-off processes e.g. due to presence detection, or by frequent dimming. The desired lighting level is immediately available without annoying start-up times. In addition, undesired colour shifting or modification of the quality of colour rendering as may occur during dimming with conventional technology are not applicable with semiconductors, as is unrestrictedly confirmed by the study results of Darmstadt University of Technology.

This also means that the use of lighting management systems is an even more important topic to discuss than the subject of potential damage from LED lighting, for these systems help to save valuable energy without any limitations in terms of visual or emotional quality of light. Environmentally conscious art enjoyment and gentle exposure to light are thus harmoniously combined. In this way, museums that use resources sparingly and handle cultural assets gently can take responsibility in two ways, ensuring an authentic presentation of art works by implementing integral lighting concepts.

Zumtobel. The Light.

Fact box 1:

The colour rendering index and its significance

Photometrically definable values such as light colour and colour rendering can never completely meet the nuances of the individual human perception system, but are merely

arithmetical indications. With the specification of only one value (e.g. CRI or Ra > 90), the question often remains open for users as to which colours are rendered excellently and where deficits must be expected. The high colour rendering index of a light source that can be successfully achieved with conventional lamps, and for some time now also with LED, is not to be equated with optimum colour perception by an observer, as it was originally intended by the artist. It is also a fact that these photometric evaluation systems can never fully describe an individual's subjective perception.

What is more, the colour rendering index used now for almost half a century is deemed to be unsuitable by experts to specify the quality of LED technology.[ii] With this evaluation method, LEDs are more poorly classified than is actually the case with the human perceptual system. For these reasons, new evaluation methods are being discussed at the moment such as the CQS value (Color Quality Scale).[iii] Daylight seems not always to be the best solution either. Works of art that were created with the lighting provided by incandescent lamps or even earlier with candlelight in dark parlours lose their power of expression in natural light.

Fact box 2:

Discussions on the use and quality of LEDs in museums

In the initial years of LEDs, experts proclaimed semiconductor technology to be especially gentle on exhibits in terms of conservational aspects. No damage from UV or IR radiation, and no additional protective filters required. In reality, LEDs have genuinely defined milestones with regard to the gentle illumination of exhibits.

Nevertheless, spectral distribution in the visible wavelength range from 380 nm to 780 nm was not sufficiently observed in the beginning. The shorter the wavelength of radiation, the more damaging it is for art objects, depending on material and absorption behaviour. This is why it did not take long for critical voices to be raised asking whether the peak in the low-wavelength, high-energy blue spectral range, that is more or less pronounced with white LEDs, could contribute to the damage of exhibits.[iv] This differing composition of the spectral distribution comes from the fact that white LEDs in most cases are based on light produced from blue LEDs with the use of phosphor layers. However, potential damage comprises the entire spectral range, from 380 nm to 780 nm. In particular, an article by Steven Weintraub, a well-known conservator from New York, has finally done away with any doubts on the part of

unsure museum managers. His fundamentally reasoned summary: LEDs cause less potential damage than conventionally used light sources, especially in the warm white Kelvin range.[v]

Brief profile

Zumtobel is a leading international supplier of integral lighting solutions that enable people to experience the interplay of light and architecture. As a leader in innovation, the luminaire manufacturer provides a comprehensive range of high-quality luminaires and lighting management systems for the most varied application areas of professional interior lighting – including offices and educational facilities, presentation and retail, hotels and wellness, health and care, art and culture as well as industry and engineering. Zumtobel is a brand of the Zumtobel group with its head office in Dornbirn, Vorarlberg (Austria).

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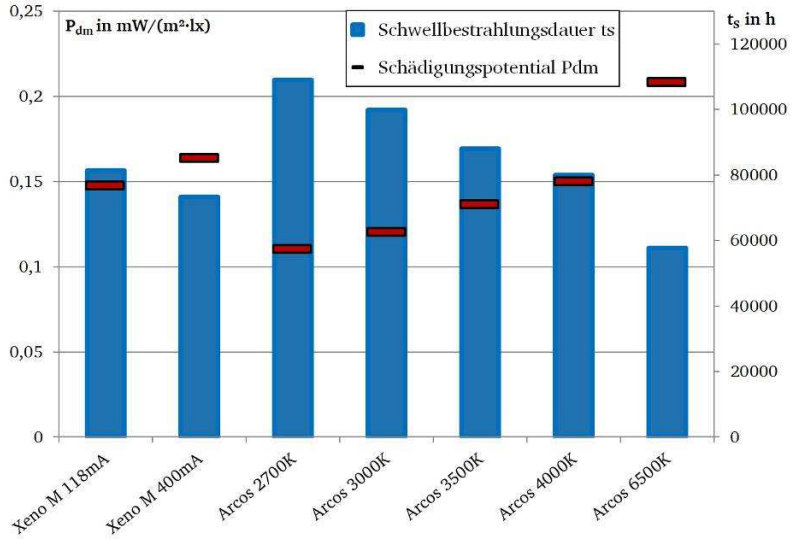
Captions

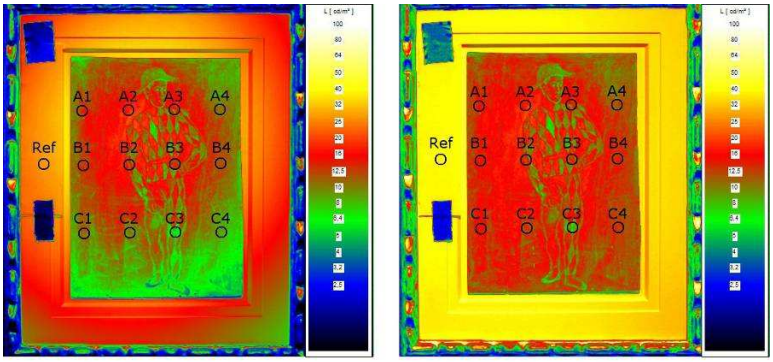
Caption 1: ©Zumtobel

Test method as part of Zumtobel's study based on the "Harlequin" drawing.

Caption 2: ©Darmstadt University of Technology

Damage potential and threshold radiation duration – XENO halogen spotlight and ARCOS LED spotlight in various light colours.





Halogenstrahler LED-Strahler

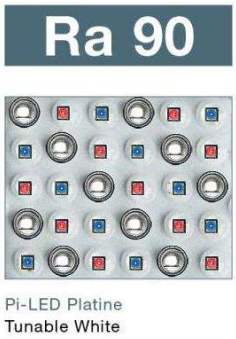
Caption 3: ©Darmstadt University of Technology

Results of the photometric measurement of Picasso's "Harlequin" based on halogen

and LED lighting (luminance recordings).

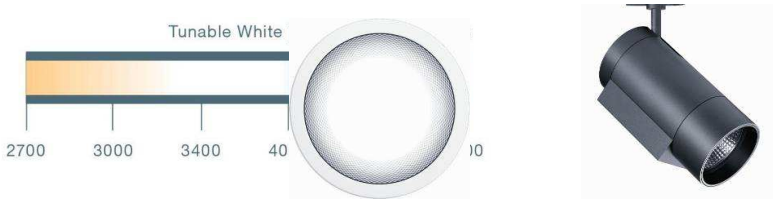
Caption 4: 4a ©Philipp Schoenborn Munich
Gentle and impressive presentation of Hans Holbein’s Virgin of Mercy using Zumtobel's Microtools LED lighting system.

Caption 5: ©Zumtobel
Example of a Tunable White PI-LED circuit board with very good colour rendering.



Caption 6: ©Zumtobel

Tunable White technology has been successfully incorporated into Zumtobel's product range, e.g. the Arcos LED spotlight system and the Panos Infinity LED downlight. Thanks to Tunable White, the light colour can be perfectly adjusted to exhibits and architectural structures.



Caption 7: ©Zumtobel

Spectral distribution of the various light colours (Arcos spotlight with Tunable White technology).

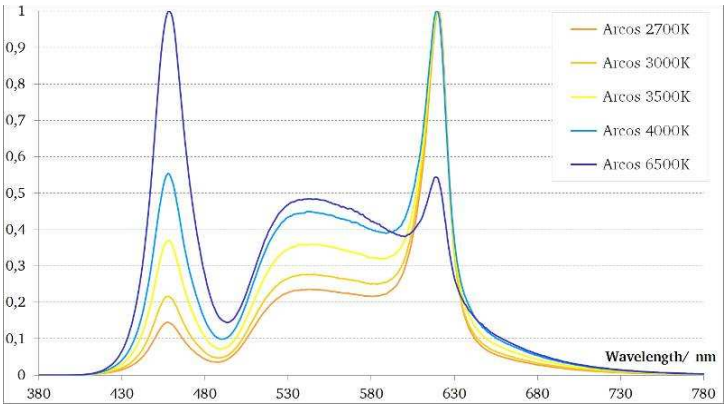
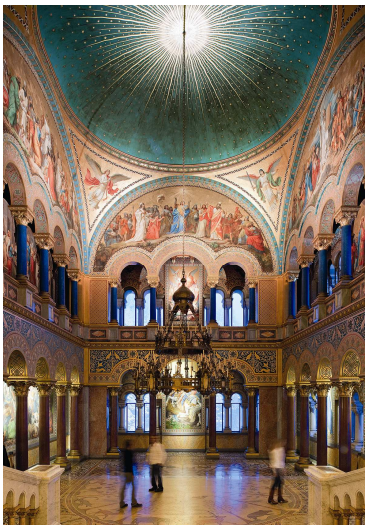


Bild 8: ©Zumtobel

Neuschwanstein Castle: thanks to LED luminaires, Zumtobel managed to implement gentle illumination of the works of art to preserve them for future generations.



[i] CIE 157:2004 Control of damage to museum objects by optical radiation
[ii] CIE 177:2007 Colour rendering of white LED light sources. In addition, several international trials (e.g. also NIST) confirm that the colour rendering index used until now does not equate to perception and thus LEDs are evaluated too negatively. Alternative evaluation systems are currently being searched for.
[iii] http://www.nist.gov/pml/div685/grp05/vision_color.cfm
[iv] Dale Paul Kronkright, 30 March 2010, “Caution urged when considering LED light sources for light sensitive materials”
[v] Steven Weintraub, Art Preservation Services, 28 April 2010, “Comments regarding LEDs and the risk to light sensitive materials”