The importance of the CRI for well-being and perception

Triphosphor with long-term stability and a large red component as the key for new applications provides balanced, adequate lighting for human perception.

For evolution biologists, it is beyond question that a spectrum similar to sunlight offers advantages for perception. The atmosphere only has a "window" for radiation between 400 nm and 800 nm (and for radio waves). Evolution and the adaptation of biological structures, and with this the organs for visual perception, have taken place under these conditions. The eye has adapted itself to the optimal exploitation of daylight.[1)]

A continuous spectrum similar to sunlight offers advantages for colour differentiation. Specific tasks can be better implemented, eye strain and resulting fatigue are reduced. Similarly the influence of the quality of light on people's subjective sense of well-being can be demonstrated - even though this is not always physiologically clear.

With a colour temperature of between 2,000 K and 8,000 K, the sunlight spectrum corresponds largely to the Planckian radiator spectrum. The CIE method[2)] applied since 1974 for defining the CRI (Colour Rendering Index) uses this fact and compares the

Fig. 1: Comparison between depiction with high CRI (left) and low CRI (right)

spectra of light sources with that of the Planckian radiator or with daylight at 6,500 K. A light source that radiates this spectrum with the corresponding colour temperature has a CRI of 100. As a standard, the general CRI (R_a8) is used with eight reference colours of low and medium saturation (see fig.1).

The calculation formula of the CIE method for standardisation of the results does not however sufficiently consider various aspects such as the shifting of the chromaticity coordinates along the Planckian locus or the direction of the chromatic deviation of the values measured. The implementation of new technologies, e.g. for model printouts, makes clear the limitations of the CIE evaluation method. With the assessment of LEDs, these CIE method deficiencies also consistently lead to worse results than with an evaluation by test subjects.

Due to the eye sensitivity curve, the theoretically attainable efficiency limits (in lumens/watt) correlate to the spectral distribution of light. With an optimised spectral configuration it is therefore theoretically possible to attain approximately 400lm/w at a colour temperature of 3,000 K and a CRI of 40. With a CRI of 90 however, 330lm/w are possible, and with a CRI of over 95 only about 250lm/ware possible. This reduced efficiency is also attributable to a large extent to the lower and upper limits of the visible spectrum, where the eye sensitivity curve significantly declines (purple, red). This could possibly lead to neglecting these areas in order to attain a higher efficiency.

An omission of these areas however leads to a yellow tint. This problem is somewhat reduced with lighting having a high CRI where greater visual clarity renders objects more natural and 10-40% brighter.

Until now, white LEDs - especially warm white LEDs - only attained a CRI of between 60 and 85. In addition, no white LEDs with a large red component were developed, as the efficiency or stability of red phosphor could not be sufficiently guaranteed. In the past, predominantly one-band or two-band phosphors were used. The absent red component led to an unsatisfactory colour rendition of red tones even with a high CRI (see fig. 2).

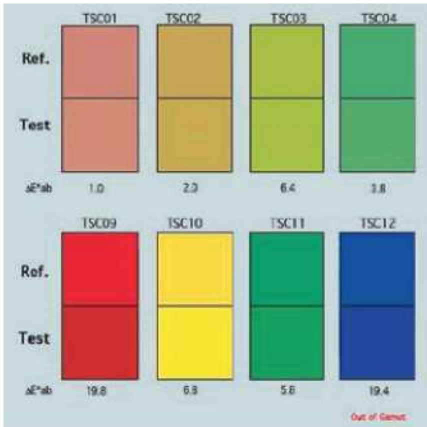

Fig. 2: Typical colour shift of white LEDs with absent red component (partial colour rendition index for the R9 standard colour – strong red - lies between 30-40).

The absent red component is a major drawback for numerous applications. For high-quality lighting, for example for shops, museums, display cabinets and within medical environments (e.g. for surgery), LEDs of various colour temperatures - even coloured LEDs where necessary - had to be combined and consequently controlled variably.

In the new powerXED by LEXEDIS, a three-band phosphor has been implemented with good long-term stability, a good light output ratio and a large red component. For the R9 standard colour (strong red), the partial colour rendition index is 80 (4200K); this could therefore be doubled in comparison to conventional technologies. Because of the homogenous spectral colour distribution attained well into the red area, a typical CRI of 85 (3000K) and >90 (4200K) is achieved.

The powerXED also takes advantage of Zero Colour Binning developed by LEXEDIS, ensuring that with the use of several LEDs no visible difference in colour temperature and colour rendition occurs. The electronic design of the controller has also been simplified, and numerous new applications and design options are made possible with compact dimensions of 2.5 mm x 2.5 mm x 0.6 mm and the available standard correlated colour temperatures of 3,000 K, 4,200 K, 5,700 K and 6,500 K.

Application areas in which high CRI values are required and where powerXED can be optimally used are medical applications such as operating theatres, museums, shopping malls, shops, and numerous types of direct or indirect lighting for advertising purposes.

Fig. 4: LEXEDIS presses ahead with LED development at the Jennersdorf Technology Park in Austria, and is presenting the powerXED high-efficiency digital light source with a CRI of 90.

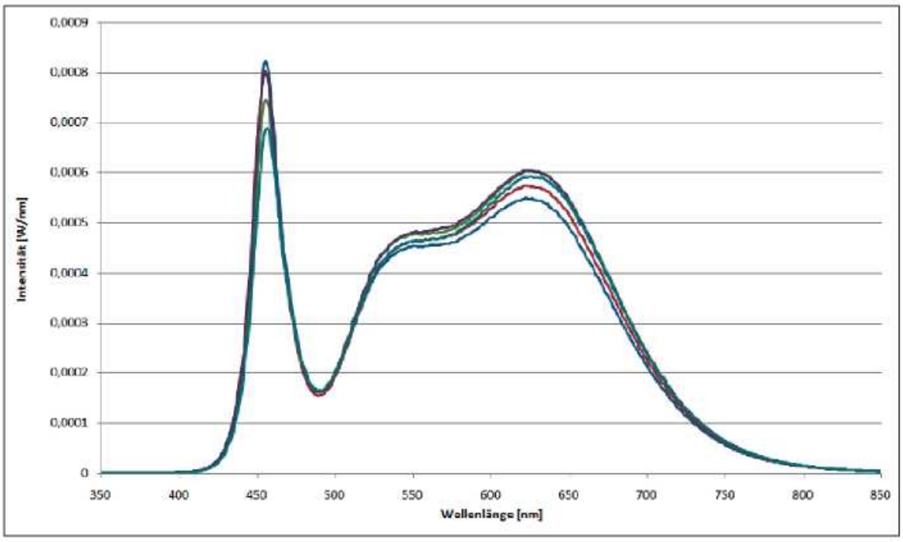

Fig. 3: powerXED spectrum with three-band emission at colour temperatures of 3,800 K to 4,200 K.

1) Lorenz K., 1943; v. Ditfurth, 1972
2) CIE = Commission Internationale de l'Éclairage
3) Schanda J. and team, 2001
4) Yoshi Ohno, 2004; Maria R. Thompson, Una-May O'Reilly, 2006; Bretschneider E., 2007
5) Kanaya, S. and team, 1979; Aston, S.M and team, 1969; Boyce, P.R., 1977

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