

Review

LpR

84

The Global Information Hub

chnologies and Design

Mar/Apr 2021 | Issue

NICHIA Celebrates its 65th Year of Continuous Innovation

Key Experts Shed Light on UV-C Disinfection

New LiFi Communication Standards Open Market Access

INTERVIEW Hiroyoshi OGAWA, NICHIA
COMMENTARY Jan DENNEMAN, Good Light Group
LED TECHNOLOGIES Multi-Chip, Outdoor, Surgical
ECODESIGN Replaceability of Modules
INTELLIGENCE 13-Bit Color Controller

S FOR PREELIFE DO TO THE COURT OF THE COURT

## Innovation United with Sustainability



I am particularly pleased to give you a short introduction to this new LED professional Review (LpR) release. We address some critical topics ranging from light sources to design aspects, communication subjects, and actual implementations in this issue. Inventions and technological progress are the basis for innovation. However, we also know that all developments – today more than ever – must be determined towards quality and, above all, sustainability. In this context, we were pleased to interview Mr. Hiroyoshi OGAWA, President and CEO of NICHIA. We also took the opportunity to send our congratulations on the occasion of NICHIA's 65th anniversary.

The topic of sustainability is complex and has many facets. One viewpoint is interchangeability, as prescribed by the new EU directives and discussed in the article about Replaceability. In cooperation with LightingEurope, we attained chief experts on UV-C disinfection, who provided us with the latest insights in this field. Wireless communication, and LiFi in particular, is a fascinating subject. Now, with standardization plans, there is further momentum towards market implementations. You will also find the link to the LiFi seminar from the International Solid-State Lighting Alliance published on LpS Digital in this release. In addition to all that, we present two specific new developments in the LED sector: New LEDs for outdoor applications and innovations in multi-chip LED packaging.

Smart Controls and Surgical Lighting articles complete the range of topics for technical developments and specific applications.

Finally, I would like to express my sincere thanks to all our contributors.

Enjoy your read and stay healthy!

PS: Call for Papers for the LpS Digital 2021 is open. Take the opportunity to submit your idea for a paper or present your latest innovations <a href="http://www.LpS-Digital.global">http://www.LpS-Digital.global</a>.

Yours Sincerely,

Siegfried Luger

Luger Research e.U., Founder & CEO
LED professional, Trends in Lighting, LpS Digital & Global Lighting Directory
Photonics21, Member of the Board of Stakeholders
International Solid-State Lighting Alliance (ISA), Member of the Board of Advisors
Member of the Good Light Group and the European Photonics Industry Consortiur

## EDITORIAL

## **COMMENTARY**

8 Good Light is as Important as Good Food and Good Air

by Jan DENNEMAN, Chairman of the Good Light Group



Jan DENNEMAN

## **NEWS**

10 International Lighting News



## **LIFI SEMINAR**

20

LpS Digital – Conference & Exhibition



LiFi Seminar organized by the International SSL Alliance (ISA). State-of-the-art LiFi lectures including the keynote lecture by Professor Harald HAAS.

## NICHIA'S 65th ANNIVERSARY – INTERVIEW

22 Hiroyoshi OGAWA, President and CEO of NICHIA

compiled by Editors, LED professional



Hiroyoshi OGAWA

## **ECODESIGN**

30 Replaceability of Light Sources and Separate Control Gears

by Carsten MÖLLERS, Dipl.-Kfm., CEO of Green Gems; Werner MOTZ, Electrical Engineering Technician & Master at BASF



## DISINFECTION

36 UV-C: Disinfection Benefits, Safety, Comfort and Proof Points

by Georg NIEDERMEIER, Dr., EHS Professional at OSRAM; Armin KONRAD, Dr., Senior R&D Director at LEDVANCE; Lukas KASTELEIN, Ing., Standardization and Regulations Professional at Signify



## WIRELESS COMMUNICATION

42 A Closer Look at LiFi Standardization by Musa UNMEHOPA, Head of Ecosystems and Alliances for LiFi at Signify



Musa UNMEHOPA

## **COLOR CONTROLLER**

48 13-Bit RGBW Color Control for Accurate High-Quality Architectural & Stage Lighting

by Keith SZOLUSHA, LED Driver Applications Manager at Analog Devices









## **OUTDOOR LIGHTING**

New LED for Outdoor Lighting

by Markus HOFMANN, DI, Senior Key Expert for General Lighting at Osram Opto Semiconductors



## LED TECHNOLOGY

8 | Multi-Chip LEDs

by Sam ROGERS, Content Writer and Editor at Ushio; Fumihiko ODA, Dr., SSL Sales Strategy Deputy Manager at Ushio





## SURGICAL LIGHTING

62 Why High-End Surgical Lights Have Become Imperative Invasive Equipment by Ashish GUJARATHI, MBA, SEO Analyst at Allied Market Research



ABOUT | IMPRINT

## **ADVERTISING INDEX**

- 1 LpS Digital
- 2 Cree LED
- 3 Helvar
- 5 Seoul Semiconductor
- 9 Röhm
- 11 Cree LED
- 13 Instrument Systems

- 15 LIGITEK
- 17 Toplite
- 18 Trends in Lighting
- 29 LpS Digital
- 35 Repro-Light
- 41 LightingEurope
- 46 International Solid-State Lighting Alliance
- 47 European Photonics Industry Consortium
- 53 Sustainable Eye Health
- 64 Global Lighting Directory
- 65 LED professional
- 67 LED professional Review
- 68 Aalborg University Copenhagen

## Replaceability of Light Sources and Separate Control Gears

With the success of LEDs in general lighting, the time-honored separation of light sources (lamps) and luminaires has been discarded in the designs of LED luminaires. In mass-produced LED luminaires such as panels, downlights and high bays, the lamp and the luminaire have merged into one product. Large operators of commercial real estate, who have to ensure long-term facility operation, have always complained about this fact. A key justification for this design decision was the long life-time of LED light sources. Currently, however, a rethinking process is taking place, which is promoted by new regulations of the European Union.

Experience with the use of even highquality LED luminaires shows failure rates of 0.2% per 1,000 hours of operation, which cumulates to about 10% after 50,000 hours. The appropriate replacement of these defective luminaires poses major challenges for operators. The luminaire industry has so far reacted to these requirements only very hesitantly. Currently, however, a rethinking process is taking place, which is promoted by new regulations of the EU. The main goals of the EU's Green Deal are CO<sub>2</sub> neutrality by 2050 and the avoidance of waste and pollutants [1].

Disposable luminaires are just not compatible with these goals. The first steps in this direction are embodied in the new EU Regulation 2019/2020, which replaces the previous regulations on the environmentally friendly design of lighting products. This article looks at the regulatory requirements, the benefits of replaceable light sources, the types of replacements and the need for standards, available technical solutions, and the implications for luminaire design and the luminaire industry.

## Requirements of the European Union

The EU considers the extension of the Circular Economy to established economic actors as a crucial contribution to the implementation of a climate-neutral and resource-efficient economy in which growth is decoupled from resource use.

In this context, the ecodesign regulations of energy consumption-relevant products are being expanded to ensure that ecodesign is extended to as broad a product spectrum as possible and contributes to the circular economy. In addition to increasing energy and resource efficiency, the durability, reusability, replaceability and reparability of products are defined as key levers. Added to this is the avoidance of pollutants.

For lighting applications, the EU has taken a first step in this direction with Regulation 2019/2020 EU, laying down ecodesign requirements for light sources and separate control gears [2]. The regulation no longer refers to lamps and luminaires, but more generally to light sources and containing products. Containing products can, for example, be luminaires but all other products that contain (removable) light sources and/or separate control gears, such as refrigerators. The scope of the regulation is thus considerably broader than before.

Article 4 paragraph 1 of the regulation requires the replaceability of light sources and separate control gears devices in containing products with generally available tools without permanent damage to the product (and describes exceptions), paragraph 2 contains information on whether replacement can be carried out by end users or only by qualified persons or not and paragraph 3, their dismantling from containing products at end of life.

For the information of whether the replacement of the light source or the separate control gear in containing products can be performed by the end user or only by qualified persons or not at all; LightingEurope has developed new pictograms (**Figure 1**) [3].

The Regulation will apply from 01 September 2021 and Article 9 of the Regulation already stipulates that the Commission will carry out a review against the background of technical progress by 25 December 2024 at the latest, particularly with regard to f) the definition of additional product requirements for resource efficiency in accordance with the principles of the circular economy, in particular with regard to the possibility of removal and the replaceability of light sources and control gear.

Another important aspect of the regulation is the prohibition on market placement of most compact fluorescent lamps with integrated ballast from 01 September 2021 and most T8 fluorescent lamps from 01 September 2023 from the definition of ecodesign requirements in Article 3 in conjunction with Annex II Table 1 (here energy efficiency requirements). This means that, as was previously the case with incandescent lamps and halogen lamps, widely installed light sources may no longer be placed on the market, which creates pressure to act, especially for large operators of real estate.

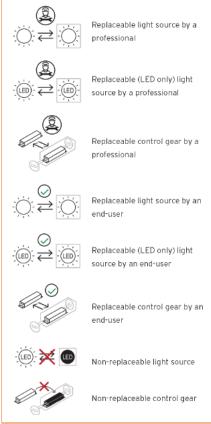


Figure 1: Replaceability of light sources and separate control gear

In addition to the regulations on product design (ecodesign), Directive 2011/65/EU on the restriction of the use of certain hazardous substances (the so-called RoHS II Directive) has a significant influence on the permissibility of placing products on the European market [4].

Due to their mercury content, fluorescent lamps are in the focus of the EU Commission, which is currently considering not extending or allowing to expire the exemptions for fluorescent lamps (Annex III) for the strict limit values of this directive (0.1% mercury (Hg) in homogeneous materials according to Annex I). In this case, most T5 fluorescent lamps and compact fluorescent lamps without integrated ballast will also be phased out.

## Pros and Cons of LED Light Source Replaceability

Before the LED era, the replaceability of light sources was taken for granted as standardized and socketed lamps; lamps and luminaires were sold separately. Today, LED lamps with conventional bases (known as retrofits) continue to bridge the gap between the old and new worlds.

This tradition was disrupted with the introduction of LEDs as a light source for general lighting. Particularly for professional mass applications, luminaires were introduced to the market with the LED light source permanently installed in the luminaire, such as panels, downlights and high bays. The luminaire industry has emphasized to operators the long life of the LED light source, and many operators have readily taken advantage of the significant energy savings and short payback periods. In recent years, LED luminaires have become more and more affordable, so that today they are, in some cases, below the price level of the old luminaire technology.

Operators have had to experience problems with adequate replacements when luminaires fail in the field, and as luminaire prices have declined, luminaire mounting and dismounting costs have become increasingly significant. The luminaire industry can sell a new luminaire at the end of the LED light source's life; at best, the operator must bear the cost of this one entire new luminaire, as well as its disassembly and reassembly costs. Lacking an alternative, many operators had not considered the resulting opportunity cost.

The specific arithmetic for the operator depends on numerous parameters, such as the lighting duration and the remaining useful life of the property. The longer the remaining useful life and the longer the lighting period per year, the more economical luminaires with replaceable lamps become for the operator. The calculation becomes more advantageous if the luminous flux loss of the installed LED solution and the efficiency increase of a new LED light source at a later replacement time are included.

The above makes it clear that an operator of a property, thinking long term, should compare the Total Costs of Ownership (TCO) for both a solution with and without replaceable LED light source (and control gear) over a life cycle of the LED light source.

The actual assessment of the environmental impact of luminaires with replaceable light sources (and control gear) compared to non-replaceable ones is no less complex, as this has to consider the entire life cycle from the production phase to the use phase to the disposal phase (Life Cycle Assessment LCA). The results of such LCAs (e.g. from the Repro-light research project) show that the use phase has a significant impact on our environment, but that the replaceability of components and recyclability also play a role. Replaceable LED light sources must therefore not be at an efficiency disadvantage compared to non-replaceable light sources from an environmental point of view.

Since the service life of the light source in practice rarely corresponds to the service life of the luminaire, two cases must be distinguished in the case of replaceable LED light sources. If the service life of the luminaire exceeds that of the light source, the light source has to be replaced and the question arises whether the old light source can be repaired or recycled. In the opposite case, the question of re-use of the light source arises. Beyond economic efficiency and environmental aspects, there are numerous other aspects that speak in favor of replaceable light sources. From the operator's point of view, for example, the change in color temperature when there is a change of user (e.g. in the office) or change of season (e.g. in retail) can be of interest. For the luminaire manufacturer, product complexity can be reduced by the factors of color temperature and color rendering, depending on the type of replaceability of the light source, which can significantly increase the degree of prefabrication in the mass production of downlights, for example.

Since the reform of the liability for defects under sales law in Germany on 01 January 2018 (§ 439 and § 475 BGB), luminaire manufacturers are obliged to bear the removal and reinstallation costs in the event of a defective luminaire. If the defect is due to the LED light source, the luminaire manufacturer can keep the defect removal costs low with the help of replaceable light sources and satisfy the customer quickly and easily by supplying replacements.

## Different Types of Replaceability

Regulation 2019/2020 EU distinguishes in Article 4(2) between the replaceability of light sources and control gear with commonly available tools by the end user or by qualified personnel. This refers to replace-



ment in the field and not replacement at the manufacturer's factory. Light source replacement at the manufacturer's facility is a rare consideration due to disassembly and reassembly and round-trip transportation.

The replacement of light sources requires that safety is guaranteed (protection against electric shock), the light source is protected against improper handling and damage (e.g. ESD) and the thermal, mechanical as well as electrical connection between the luminaire and the light source is guaranteed (cf. ZVEI information on the replaceability of LED light sources 2017 [5]).

When light sources are replaced by the end user, these boundary conditions can only be guaranteed in practice by capped lamps. Otherwise, replacement of the LED light source at the point of use can only be carried out by qualified specialist personnel, provided that the manufacturer has provided for this via appropriate LED modules, which are connected via terminals or connectors, for example, and can be replaced without changing the operational, safety and application properties of the luminaire.

For the operator, the cost of replacing the light source is a crucial factor, as this can easily exceed the cost of the light source. Therefore, it is not only the question of who can carry out the replacement that is important, but also how long the replacement will take in the specific structural situation. Here, LED lamps are likely to often have an advantage over LED modules. In addition to the question of whether the light sources can be replaced by the end user or only by qualified personnel, it is of considerable importance from the operator's point of view whether standardized LED lamps and LED modules are used or not. With nonstandardized LED lamps and LED modules, the operator usually enters into a long-term dependency on one manufacturer.

Under the two aspects of replaceability and standardization, the matrix for light sources is as shown in **Table 1**. Non-replaceable light sources are not listed.

Light Source	Replaceable by End User	Replaceable only by Qualified Persons
Standardized	Standardized LED Lamp	Standardized LED Module
Non-	Non-	Non-
standardized	standardized LED Lamp	standardized LED Module

Table 1: Replaceability and standardization of light sources

Standardization of LED lamps ideally relates to two aspects, the socket & lam-

pholder system and the light source itself. Sockets of lamps and the lampholders in luminaires are standardized by the International Electrotechnical Committee (IEC). The international manufacturer consortium ZHAGA deals with the interfaces for LED modules and lamps, control gear and sensors, which are important for integration in luminaires.

## **Standards**

## **Advantages of Standards**

In the old world of conventional lighting technology, luminaires without standardized lamps were unthinkable. Until the inefficient lamps were phased out, operators could rely on being able to buy them again many years later. Lamp manufacturers were able to produce their lamps in high volumes at low cost because of the high degree of standardization.

This situation has changed fundamentally with LED technology. Apart from LED retrofits (LED lamps with bases from conventional lighting technology), luminaire manufacturers have been able to push through luminaires with permanently installed LED light sources in commercial mass applications. With the return to the benefits of replaceable light sources in the interest of the environment and operators, the question of standardization again arises. The interoperability of LED lamps and LED modules between different manufacturers is the central argument for standardization.

Standardization can also achieve economies of scale, which are consequently reflected in a low-cost supply of replaceable light sources. The resulting automated mass production promotes the quality of the light sources. Technical risks inherent in the light source are reduced by both standardization and replaceability. The higher volumes of standardized light sources make investments in product and process innovation attractive for manufacturers.

Operators and luminaire manufacturers gain investment security and at the same time flexibility with standardized replaceable light sources. New business models such as Lighting as a Service (LaaS) or even reusability can gain a completely new dynamic through standardized replaceable light sources. All these advantages of standardizing replaceable light sources make a significant contribution to the sustainability of lighting solutions. Against this background, luminaire manufacturers will

have to deal with this topic in the future. In the following, we will show which LED-specific standards are currently available for replaceable linear and point light sources.

## Standards for Replaceable Linear LED Light Sources

Linear light sources represent one of the most important forms in professional lighting. The most common conventional linear light sources are T8 fluorescent lamps with G13 base and T5 fluorescent lamps with G5 base. The decided end of most of the T8 fluorescent lamps on 01 September 2023 (see also [6]) and the impending ban of T5 fluorescent lamps poses great challenges to the operators.

This makes the market's need for appropriate solutions for standardized linear LED light sources all the more urgent. Currently, the standards available for linear LED lamps and LED modules are as shown in **Table 2**. Retrofit solutions based on the G13 base, for example, will not be discussed here.

Linear Light Source	Replaceable by End User	Replaceable only by Qualified Persons
Standardized	Linear LED Lamp Socket / Lampholder: GR6d Lamps: ZHAGA Book 14	Linear LED Module Terminal & Module: ZHAGA Book 21
Non- standardized	e.g. R-Tube	

Table 2: Standards for replaceable linear LED light sources

GR6d is an LED-specific socket & lampholder system for linear lamps according to IEC EN 61001-1 / AMD56:2017, which is designed for up to 2 A 250 V. It is a single-sided electrically contacted system where the mating holder is used for mechanical support and thermal length compensation. A push-in & push-out system simplifies the tool-free insertion and removal of the lamps, while for removal a retaining function still protects against unintentional falling out of the lamps. Electrical parameters (currents or voltages) are defined via a key system in the socket and base.

Based on the GR6d socket & lampholder system, ZHAGA Book 14 defines, among other things, the mechanical interfaces for installing the lamps in luminaires. In particular, the defined lengths L60 (564 mm), L120 (1164 mm) and L150 (1464 mm), which are

based on classic lengths of T5 fluorescent lamps, should be mentioned here. The ZHAGA Book 14 opens up the possibility of integrating light control into the lamps. By replacing suitable lamps, not only the color temperature but also the light distribution of luminaires can be changed as required (cf. **Figure 3**).

The lamps in Figure 3 are self-cooling and the L60 length can easily accommodate 20 W of power per lamp, the L120 40 W and the L150 50 W. The glarefree versions of the lamps (UGR < 19 for 4H8H) achieve a system efficiency (incl. losses of the separate control gear) of up to 155 lm/W (4000 K, Ra 84, Rf 83, Rg 92, R9 16, 25 °C). This efficiency level is on par with today's luminaires with fixed LED light sources. Such an L150 lamp can achieve more than 7500 lm luminous flux and is thus suitable for much more than replacing a luminaire with an 80 W T5 fluorescent tube (5700 lm at 25 °C), where the luminaire efficiency still has to be deducted.



Figure 2: GR6d socket & lampholder system



Figure 3: LOP26 & LOP15 lamps with GR6d socket and different light distributions



Figure 4: Linear LED module with connection element according to ZHAGA Book 21

GR6d based lamps from different manufacturers are now designed to have no glue, solder or cable connections. Therefore, the lamps can be disassembled with conventional tools and the circuit boards can be easily replaced; the lamp itself becomes repairable and very easy to recycle.

ZHAGA Book 21 was designed as a standard for linear LED modules that can only be replaced by qualified persons at the point of use (Figure 4). The connection element (board connector) enables toolfree removal of the board, which can be operated with max. 60 V 2 A (SELV). With ZHAGA Book 26 a non-SELV version is planned. The wiring is done on the back side of the connection element. As a rule, the circuit boards must be self-cooling. ZHAGA defines two board lengths of 2 ft (601 mm) and 4 ft (1219 mm) and a board width of 20 mm. For the 4 ft board, a gross luminous flux of max. 8800 lm is defined (at 1400 mA). The light-directing elements must be installed in the luminaire.

## Standards for Point-shaped LED Light Sources

Point-shaped light sources are used in many downlights, track lights and spotlights. In functional buildings, single-ended compact fluorescent lamps (CLF) were widely used for such luminaires until the early 2010s. Strictly speaking, compact fluorescent lamps are not point-shaped but rod-shaped light sources because of their large dimensions.

From 01 September 2021, compact fluorescent lamps with integrated ballast (CFL-i, base E14, E27 etc.) will have to leave the market throughout the EU. Due to the harmful substance, mercury, contained in compact fluorescent lamps, compact fluorescent lamps without integrated ballast (CLF-ni, base G23, G24-d1, G25-q2, G7 etc.) are also threatened with such a ban (RoHS). This would generate an enormous replacement demand.

For mounting COB LEDs in downlights, track lights and spotlights, ZHAGA Book 10 has become a widely used standard in the lighting industry. ZHAGA Book 10 describes two diameters of round mounting brackets for COB, D50 and D35. The smaller diameter of 35 mm is gaining in importance against the background of the miniaturization of LED luminaires. Unfortunately, COBs installed in this way are difficult to replace in the field, even by qualified specialists. This is due to the fact that the connection elements are not designed for replacement in the installation situation and to the challenge of restoring the thermal interface between COB and heat sink in this situation in a process-safe manner.

Currently, the standards listed in **Table 3** exist for replaceable point-type LED light sources without integrated control gear.

This table is not fully comprehensive but covers the main relevant standards.

Point Light Source	Replaceable by End User	Replaceable by End User
Standardized	Socket & Lampholder: GH36d Diameter 50 mm	ZHAGA Book 5 Diameter 69 mm
Not-yet standard- ized	Socket & Lampholder: GH27d Diameter 35 mm	

Table 3: Standards for replaceable point LED light sources

ZHAGA Book 5 is a socket & lampholder system for point-shaped LED lamps with a total diameter of 69 mm, which is not standardized by IEC. The maximum system power is rated at approximately 40 W.

The GH36d socket & lampholder system picks up the 50 mm diameter defined in ZHAGA Book 10 and is standardized according to IEC 61001-1/A58-2018 (Figure 5). Socket and lampholder are electrically rated up to 2 A 150 V. The thermal management limits the maximum system power to approx. 35 W depending on the connected heat sink. The maximum power can be coded via corresponding keys. A twist & lock system allows the lamp to be easily inserted into or removed from the lampholder.



Figure 5: GH36d lampholder with corresponding LED lamp

A new open system for the lamp (**Figure 6**) allows easy insertion of commercially available COBs with footprints of 19 x 19, 20 x 24 and 17.85 x 17.85 mm, with the COBs held in place in a similar way to modern connecting elements. In this way, the manufacture of the lamp is simplified at every step of the value chain. The lamp system already has two interfaces for reflectors or optics with connection diameters of 50 mm and 40 mm.

Against the background of the miniaturization of luminaires, the new GH27d system

with 35 mm diameter has now been developed analogously to ZHAGA Book 10 (cf. **Figure 7**), which has not yet been standardized. It has the same design as the GH36d lampholder and lamp system and is available for commercially available COB with footprints of 13.5 x 13.5, 12 x 15 and 15.85 x 15.85 mm. The maximum system power is specified at 17 W due to thermal restrictions. Optics or reflectors can be connected via an interface with 35 mm connection diameter.



Figure 6: GH36d lamp system for COB with upper part, lower part and lampholder



Figure 7: GH27d with D35 vs. GH36d with D50

## Implications for Luminaire Designs

The standardized linear and point LED light sources presented here enable a simple modular luminaire design, with the help of which, end users or qualified persons can replace the light sources on site, and also, ideally, without dismounting the luminaire.

For a coherent overall concept, modularization of luminaires must extend to other components. As already required by the 2019/2020 EU regulation, the second important replaceable component must be the separate control gear. And finally, optional sensors are also part of such a system as a third component, at least when they are installed in luminaires (containing products).

On the one hand, standardization of control gear is less advanced than standardization of light sources. On the other hand, separate control gear is usually replaceable by qualified personnel. Some standardization of the dimensions and mounting points of control gear has taken place in ZHAGA Book 13. For the control of such devices, DALI-2 has brought an important advance in terms of cross-manufacturer interoperability of systems (IEC 62386). For the first time, DALI-2 also allows sensors to access the bus and communicate with the master, operating devices and other sensors (multimaster). Although DALI-2 Parts 251, 252 and 253 standardize the memory banks for inventory, energy monitoring and maintenance of luminaires, they do not yet take into account the aspect of replaceability of light sources and control gear.

Programming of control gear has been standardized outside the DALI standard via the LED set standard (ZAHGA Book 22/23) and the NFC standard (ZHAGA Book 24/25). Fundamental aspects of the replaceability of control gear from an EMC point of view are currently being worked out within the framework of the ZHAGA TF-EMC. In view of the high hourly rates of qualified persons, the possibility of simple and, at best, tool-free replacement of operating devices is desirable. For this purpose, (coded) plug systems within a luminaire would be useful.

Such connector systems and interfaces are already defined for dedicated or retrofittable sensors. ZHAGA Book 20 describes these for indoor luminaires and ZHAGA Book 18 for outdoor luminaires. Both communication and power supply between control gear and sensor are standardized via the D4i standard within the DALI organization. The topics of control and sensor technol-

ogy are gaining in importance, not least against the background of the EU's Energy Performance of Buildings Directive (EPBD) 2018/844 [7], which stipulates a Smart Readiness Indicator (SRI) for buildings that also extends to the area of lighting. With the next amendment of the GEG, the German legislator will also have to implement this directive.

The integration of the above aspects into the luminaire design contributes to maintainability, repairability, updateability and upgradeability, thus making luminaires fit for the future and, with a suitable design, also sustainable overall. The luminaire design thus determines the possibilities for circular economy in the area of general lighting, which will have an impact for decades.

However, luminaire manufacturers should not see modular luminaire design exclusively as a contribution to the Circular Economy but should also recognize the opportunities that lie in a reduction in the number of variants, a reduction in inventories, rapid delivery capability via late stage configuration or even mix & match by the customer and, last but not least, an increase in customer satisfaction.

## **Summary and Outlook**

The Green Deal is the future project of the European Union to decouple economic growth from resource consumption and to become climate neutral by 2050. "Do not think the Green Deal is a luxury we cannot afford, it is a lifeline out of the virus [...] Do not fall into the trap that COVID is an excuse to undo things." stated the Vice President of the European Commission Frans Timmermans before the ENVI Committee of the European Parliament on 21 April 2020.

The Circular Economy is the central building block of this project, for which the EU will hold all economic actors accountable. With the 2019/2020 regulation, the EU has taken the first steps for the implementation of this plan in the lighting market and has for the first time in Article 4 required the replaceability of light sources and separate control gear from 01 September 2021.

Manufacturers can still circumvent this replaceability by justifying in their technical documentation why the replacement of the light sources and separate control gear would not make sense. However, according to Article 9 f), additional product requirements are already due in 2024, especially with regard to the possibilities of

removing and replacing light sources and control gear.

The luminaire industry would be well advised to correct the misguided development of LED disposable luminaires over the last decade and to actively shape the development of sustainable luminaires in the new decade. The earlier companies adapt to this, the more likely they are to benefit from this trend reversal.

The article shows that suitable standards and products for replaceable light sources and separate control gear are already available. Others will follow. The first luminaire manufacturers are already offering corresponding modular luminaires. Numerous large operators have been demanding this step for a long time and are planning to align their investment decisions accordingly.

However, the departure from the linear economy also urgently requires closer cooperation between all those involved in the value chain, such as planners, upstream suppliers, manufacturers, wholesalers, installers, contractors, facility managers, operators, recyclers and disposers. There are tremendous opportunities to develop new business models in the wake of this transformation. Technologies as such are rarely disruptive, but mostly the new business models that emerge from them.

## References

- [1] European Commission (2020): The European Green Deal. Communication of 11 March 2020.
- [2] European Commission (2019): Regulation (EU) 2019/2020 of 1 October 2020 laying down ecodesign requirements for light sources and separate control gears. Official Journal of the European Union, 15 Decembere 2019.
- [3] LightingEurope (2020): Guidelines for the application of Commission Regulation (EU) 2019/2020. Version 2 of 06 October 2020.
- [4] European Parliament and European Council (2011): Directive 2011/65/EU of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. Official Journal of the European Union, 01 July 2011.
- [5] ZVEI White Paper (2017): The Replaceability of LED Light Sources. May 2017.
- [6] Mordziol, Christoph (2019): Abschied von der T8 Lampe (Departure from the T8 lamp). In: Elektro Praktiker 06/2019, 07/2019 and 10/2019.
- [7] European Parliament and European Council (2018): Directive (EU) 2018/844 of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. Official Journal of the European Union, 19 June 2018.



## AUTHOR: Carsten MÖLLERS, Dipl.-Kfm.

Carsten MÖLLERS, born in 1968, studied economics at the WWU Münster with a focus on business informatics. Then started his career as a consultant with PWC, later interim management and managing director in the automotive supply industry. His current focus is on the development of companies in the field of Solid State Lighting and Internet of Things as well as the support of Open Source projects.



### **AUTHOR: Werner MOTZ**

Werner Motz, born in 1964, completed his training as a master electrician in Kaiserslautern and acquired an additional qualification as a technician in the field of environmental protection. Mr. Motz worked for 8 years in the electrician trades as well as in industry, where he gained relevant experience in the fields of electrical installation, switchgear construction and mechanical engineering. He joined BASF SE in 1989 and has since held various positions focusing on electrical engineering, electrical installations, lighting, fire protection and energy efficiency. Currently, he is active in interdisciplinary planning, installation and maintenance of measures and projects. In addition, he is responsible for a wide range of existing installations as an electrical installation supervisor (EAV). His special interest lies in the sustainable use of current lighting technologies.



# Initiating Transformation in the European Lighting Industry

Repro-light is a European research project that aims to support the European lighting industry in moving towards a more sustainable and competitive future.



www.repro-light.eu







Cover May/June 2021 | LpR 85

## **Questions and Comments**

Please don't hesitate to send us your opinions or ask questions about articles you have read. We appreciate your feedback and will feature it in a subsequent issue.

editors@led-professional.com

## **Annual Subscriptions**

## LpR Digital Magazine

- eMagazine (PDF download)
- 6 Issues per Year (Bi-monthly)
- Full Archive Access (all previous eMagazine issues)
- EUR 78.80

## LpR Printed & Digital Magazine

- Print Magazine including shipping
- eMagazine (PDF download) 6 Issues per Year (Bi-monthly)
- Full Archive Access
- (all previous eMagazine issues)
- Shipping costs included
- EUR 97.80

## Subscribe

https://www.led-professional.com/sub scription

## Advertise

https://www.led-professional.com/adv

## **PRFVIFW** May/June 2021 | LpR 85

## Commentary

Good Light, Human-Centric Lighting

### Interview

Leading LED Manufacturer

High-Power White Light with Laser Technology

## Design

**Customized Solutions** 

## Thermal Management

Color Conversion of Phosphors

## Disinfection

**UV-C LED Solutions** 

## Controls

Dimmable High-Voltage Linear LED Driver

## Updates

Lighting News, LpS-Digital

## DEADLINES | LpR 85

## AD CLOSE

APRIL 30, 2021

## MATERIAL DUE

APRIL 30, 2021

## DIGITAL PUBLICATION

MAY 15, 2021

## PRINT PUBLICATION

MAY 31, 2021

## ENQUIRIES | LpR 85

editors@led-professional.com, info@lugerresearch.com

## **Imprint**

## LED professional Review (LpR) ISSN 1993-890X

## **Publishing Company**

Luger Research e.U. | © 2001-2021 Institute for Innovation & Technology Moosmahdstrasse 30, A-6850 Dornbirn, Austria, Europe  $info@lugerresearch.com \mid www.lugerresearch.com$ P +43 5572 39 44 89 | F +43 5572 39 44 89 90

### Publisher

Siegfried Luger +43 699 1133 5570

s.luger@lugerresearch.com

**Editors** 

Arno Grabher-Meyer +43 5572 394489 70

a.g-m@led-professional.com

+43 5572 394489 70 Dr. Günther Sejkora

g.sejkora@lugerresearch.com

+43 5572 394489 21 Sarah Toward

sarah.toward@lugerresearch.com

+43 5572 394489 70 F. Arturo Farina

editors@led-professional.com

Theresa König +43 5572 394489 70

theresa.koenig@led-professional.com

Art & Design

Sarah Luger +43 680 2305 445

hallo@moments-of-aha.com

Account Manager

Christine Luger +43 699 1133 5520

c.luger@lugerresearch.com

China, Hong-Kong

Lolo Young +852 9792 2081

lolo@castintl.com

Germany

Armin Wezel +49 30526 891 92

armin@eurokom-media.de

India

Priyanka Rai +91 124 4787331

priyanka.rai@binarysemantics.com

South Korea

Jung-Won Suh +82 2 78 58222

sinsegi@sinsegimedia.info

Taiwan

Leon Chen +886 2 256 81 786-10 Jeon@jkmedia.com.tw

Benelux, France, Ireland, Scandinavia, UK

+44 1923 85 25 37 Zena Coupé zena@expomedia.biz

USA & Canada

+1 218 686 6438 Leslev Harmoning

lesley@lhmediainc.com

## Copyrights – Luger Research e.U.

The editors make every reasonable effort to verify the information published, but Luger Research e.U. assumes no responsibility for the validity of any manufacturers, non profit organizations or individuals claims or statements. Luger Research e.U. does not assume and hereby disclaims any liability to any person for any loss or damage caused by errors or omissions in the material contained herein, regardless of whether such errors result from negligence, accident or any other cause whatsoever. You may not copy, reproduce, republish, download, post, broadcast, transmit, make available to the public, or otherwise use LED professional Review (LpR) content without prior written consent from Luger Research e.U.

© 2001-2021 Luger Research e.U. - Institute for Innovation & Technology - VAT No. ATU50928705, EORI No. ATEOS1000046213, Commercial Register FN316464p, Regional Court Feldkirch, Austria,

Europe

# The Global Information Hub for Lighting Technologies & Design

LED professional is the comprehensive publication and platform, connecting experts in the design, testing and production of the latest lighting technologies information from around the world.

TUNABLE WHITE TECHNOLO

INTRODUCTION OF ON-BBL TUNABLE WHITE TECHNOLOGY

## Introduction of On-BBL Tunable White Technology

In a traditional tunable white solution with a combination of warm white LEDs and cool white LEDs, the chromaticity point moves linearly on the syx chromaticity diagram, while the black body locus (BBL) is curved. Due to the curvature of the BBL, especially under 3000 K CCT, the emission color withdraws from "white" with a certain range when adjusting the emission color, and it is impractical to prolong the range of correlated color temperature (CCT) toward 2000 K CCT. Tomokazu Nada, Managing Director at ZIGEN Lighting Solution, proposes a new "On-BBL Tunable White" technology that makes the chromaticity point draw an upward curve along the BBL by 2-channel control. This technology expands the possibilities of tunable white LEDs by allowing the CCT range to be set from 2000 K sunset color.

### Introduction

After LED technology was adopted in lighting, a tunable while feature that can adjust emission color from warm while to cool white was provided in various lighting applic cations. And now, a tunable while feature is being increasingly adopted for circadian mythm lighting.

Generally, emission colors of tunable white LEDs are actived with a combination of a werm white LED and a cool white LED. The generated chromaticity points are located on the straight line between the chromaticity points of facts source.

On the other hand, the set of white points claws an upward ourse called the black body loos (BEL), on which the chromatic hyportias of nature (Byth, like the sun, fise and sites are located. Thus, the farther away the chromaticity points of the two (gift sources are, the more offlout it is for the chromaticity points of the niesed light to follow the BBL.

For example, if a warm white LED is 2000 K CCT and a cool white LED is 5000 K CCT and both are located on the BBL, the generated chromaticity points in the middle range are more than 7 steps away from the BBL as shown in Figure 1. Such chromaticity points are proposed.

In order to keep an emission color white, a chromaticity point of a tunable white LED is

required to trace the BBL on the xy chromaticity diagram as disely as possible. For this reason, a color range of a tunable white is usually set to the range where the BBL is relatively linear on the xy chromatic ity diagram, such as from 2700 K CCT to SNOR K CCT or a premiser range.

However, those days, dim to warm LED technology is becoming popular in lighting and popular in on warso of the importance of the 2000 K CCT Surset Color for comfort and sophisticated lighting distribution. Not only that, 2000 K color is said to be very important for condain righting. Thus, it is ideal to implement 2000 K CCT in thrustic while sighting applications, in thrustic while sighting applications, the spille the problem of the chromaticity point.

One technology to solve this problem is BOR+WI FO solveion

Note that W (whate color) is necessary on top of PSE (etc., green, bus) for a light-on point (present) and point (present) and point (present) and point (present) and color of the RSE (LED are separate from each row, the contributed spectrum and color quatity of the generated fight become poor. This mares that RSE exclusion cannot be used for general splitting applications. By using the RSE4 with colution, the drouble point can be set at the terrheat point on the xy orthoroisty degram, including along the RSE4 by controlled yearing such RSE4. By and W LED output, 1-beaver, when using the RSE4 w such on, each LED output the RSE4 w such on, each LED output.

a white color. Therefore monitoring intensity from each LED and adjusting outputs is nacessary dening operation. The monitoring and adjustment of each LED output is quite complicated and costs are high. Thus, most turnable write LED solutions have, so for, used a combination of warm white LEDs and cool white LEDs, but this is

In this stricle a new technology of tunable white, which starts from 2000 K CCT with out the problem of the chromaticity point, even by 2 change control is presented.

### Basics of Color Mixing

A white LED device typically emiss with a single CCT and is stable over temperature or current, because

- The wavelength of emission light from a blue LED chip is less susceptible to hear and operating current.
- Phosphor is improved to emit stable spectrum over temperature.

And stable emission color is actually one of the adventages of LED lighting. On the other hand, for adhishing tunible white characteristics, it is necessary to arrange a least two sats of white LEDs with officer of worm white LEDs and cost white LEDs with officer of worm white LEDs and cost white LEDs. By adjusting the current basics between

More than 31,500 Readers

In practice, the chromaticity point is of the mixed light can be expressed by following formular, using the chromaticity point  $(x,y)_{\rm south}$  and the luminous intensity  $L_{\rm south}$  of the warm white LEDs, the chromaticity point  $(x,y)_{\rm south}$  and the luminous intensity  $L_{\rm south}$  of the cool white LEDs.

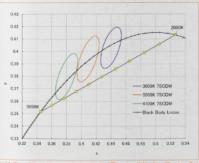
 $(x, y)_{\text{mixed}} = \frac{(x, y)_{\text{norm}} \cdot L_{\text{norm}} + (x, y)_{\text{cold}} \cdot L_{\text{cold}}}{L_{\text{norm}} + L_{\text{cold}}}$ (1)

As can be seen from the above formula, the chromaticity point of the mixed light moves linearly between the chromaticity points of the cool white LEDs and that of the cool white LEDs and the cool white the cool white LEDs and the cool white LED string B: connected with a co

white channel
 LED string C: connected with both warm

See schematic in Figure

The LED strings consist of LEDs connected in series, where the LEDs are LED chips or LED packages. The LED chips in the mortile are negligible of the same base to



the xy chromaticity diagram

or of LED string A is set second color of LED string B is set in the first product ampendue range. One pair of electrode terminals connected to LED string A is a warm white channel, and the other pair of electrode terminate connected to LED string B is a cool white channel.

LED strings A and B are individual LED strings has they are the are they are the are they are they are they are the are they are they are they are they are they are they are the are they are they are they are the are they are the are they are the are the are the are they are the are they are the are they are the are they are the are the are th

With this constitution, when a current is applied to either charred, one of the individual LED steings and the common LED steing and the common LED steing. The LED module. For example, the LED module either a mixed legit from LED module either a mixed legit from LED module either a mixed legit from LED module either a fixed legit from LED module either a mixed right from LED module either a mixed right from LED module either the control is applied to the cold white dharmal. When a current is applied to both charmals, a current is applied to both charmals, a current is applied to both charmals, a current is applied to both charmals. A legit and legit legit and legit legi

The current balance among LED strings A, B and C changes according to the current balance between the warm white channel and the cool white channel, and the current

## GET YOUR

FREE E-MAGAZINE SAMPLE

www.led-professional.com/free